SAARLAND UNIVERSITY

Faculty of Mathematics and Computer Science
Department of Computer Science
MASTER THESIS

"at the mercy of somebody else's support infrastructure": Navigating the Cloudscapes of Higher Education

submitted by
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Declarations

I hereby declare that the work presented in this master's thesis is entirely my own effort, except where otherwise acknowledged.

I further declare that the interviews conducted as part of this study were performed with the utmost professionalism and ethical considerations. All participants were provided with information regarding the purpose of the study, and their consent was obtained prior to their involvement. The data collected has been treated with confidentiality, and the identity of participants has been anonymized to ensure privacy and compliance with ethical standards.

I acknowledge the contributions of all individuals who directly or indirectly supported this research, including those who participated in the interviews and assisted in the participant recruitment process. Any external sources of information or assistance have been duly cited in the bibliography.

This thesis represents the culmination of my academic endeavours, and I affirm its authenticity and originality. I am aware of the consequences of academic dishonesty and hereby pledge that this work is an honest and truthful representation of my research.

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Abstract

The rapidly evolving landscape of the Information Technology (IT) industry is currently witnessing a profound transition towards the widespread adoption of Cloud Hosted Environments, a trend that is equally pervasive within the academic domain. This seismic shift has gained unprecedented momentum, notably catalyzed by the global COVID-19 pandemic. During these challenging times, Cloud Hosted solutions emerged as important tools, demonstrating their efficacy in facilitating distance education and ensuring the continuity of academic activities.

This paradigm shift holds particular significance for universities, which have swiftly embraced Cloud Hosted Environments to meet the dynamic challenges posed by the pandemic. Beyond its immediate applications in facilitating remote learning, the advantages of Cloud Hosted solutions have become increasingly evident, prompting a reevaluation of traditional IT infrastructures within academic institutions. As a result, the trajectory towards cloud adoption is poised to persist well beyond the confines of the pandemic, reshaping the landscape of higher education IT.

Against this backdrop, this research project sets out to decipher the intricate motivations and considerations that propel universities towards embracing cloud technologies. The investigation aims to unravel the underlying factors that steer institutions through the decision-making processes associated with cloud migration. By dissecting the multifaceted aspects of this academic cloud odyssey, the thesis seeks to provide a comprehensive understanding of the intricate interplay between universities and cloud technologies.

The primary focus is on discerning why universities, as bastions of knowledge and innovation, are gravitating towards the cloud and the factors that influence their strategic decisions. Through an in-depth exploration of diverse themes, including the origins of this transformative journey, the decision-making matrix, the challenges inherent in the migration process, and the governance of data in the cloud and self-hosted choices, this project aspires to offer valuable insights that extend beyond the immediate challenges posed by the pandemic.

By delving into the human element of this technological shift, the research aims to capture the perspectives, attitudes, and cultural dynamics within university IT departments. It seeks to uncover how security, privacy, and broader IT culture are evolving in response to the integration of cloud technologies, providing a holistic understanding of the transformative impact on academic institutions.

In essence, this project strives to serve as a beacon, guiding universities and IT practitioners through the complexities of cloud adoption. By deciphering the motives that propel universities towards cloud-hosted environments, this research contributes to the broader discourse on the future of academic IT infrastructures, paving the way for informed decision-making and strategic planning in an era defined by technological evolution.

Contents

Chapter 1
Introduction

In the dynamic landscape of higher education, the recent surge in Cloud Hosted Environments has not only been a response to immediate needs but has become a strategic restructuring initiative [43, 56, 61]. Universities, traditionally a bastion of innovation and knowledge dissemination, are not immune to this transformative wave. As universities increasingly embrace cloud-hosted solutions, the motivations, decision-making processes, and challenges encountered during this migration become subjects of paramount importance.

The implications of this ongoing trend raise critical questions about the fundamental nature and purpose of higher education institutions. The thesis explores the human factors of cloud migration in universities, and in doing so, it lays the groundwork for a broader discussion on whether universities are perceived as serving broader social, political, and cultural objectives integral to democracy. The investigation prompts reflection on whether these institutions are increasingly regarded as utilitarian entities focused primarily on generating quantifiable learning outcomes and workforce productivity gains [61]. This perspective introduces an important dimension urging a more comprehensive consideration of the multifaceted challenges and implications associated with the intersection of digital technologies, commercialization, and the overarching objectives of higher education institutions as they navigate the complex path to post-pandemic recovery.

1.1 What is Cloud Computing?

The roots of cloud computing can be traced back to the 1960s when the concept of time-sharing became popular via Remote Job Entry (RJE) [1], enabling multiple users to access a single computer simultaneously. However, the contemporary notion of cloud computing, involving the delivery of computing resources over the internet, was initially formulated in the late 1990s. The term "cloud computing" was coined by computer scientist Ramnath Chellappa [18] in 1997 when he articulated the emerging paradigm of delivering computing services via the internet. Nonetheless, it was not until the

mid-2000s, marked by the rise in virtualization and the evolution of web services, that cloud computing gained traction as a commercial concept [6, 31, 45, 42].

Cloud computing represents a paradigm that facilitates widespread and convenient access to computing resources over networks. National Institute of Standards and Technology (NIST) defines "cloud computing" as *"a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"* [43]. It operates on a model that allows users to tap into a shared pool of configurable resources, including networks, servers, storage, applications, and services, as needed. The important characteristic of this model is its on-demand nature, where users can rapidly provision and release these resources with minimal effort in terms of management or interaction with service providers.

At its core, the cloud model is defined by five essential characteristics. It's not merely a one-size-fits-all approach; rather, it offers versatility through three distinct service models and flexibility with four deployment models [43]. This structure allows users to tailor their cloud experience based on specific needs, enabling a dynamic and tailored computing environment.

The characteristics include attributes such as on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service [43]. On-demand self-service empowers users to independently provision computing resources as needed, while broad network access ensures accessibility from various devices and locations. Resource pooling makes use of the multi-tenant model where resources are dynamically assigned and reassigned based on demand. Rapid elasticity allows for the quick scaling up or down of resources, and measured service enables the monitoring and optimization of resource usage.

Within this paradigm, three distinct service models define the type of services offered [43]. These include Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS). IaaS provides virtualized computing resources over the Internet, PaaS offers a platform allowing customers to develop, run, and manage applications without dealing with the complexity of infrastructure, and SaaS delivers software applications over the Internet on a subscription basis.

Additionally, cloud computing is characterized by four deployment models, each representing a specific way in which cloud services can be implemented [43]. These deployment models are Public Cloud, Private Cloud, Hybrid Cloud, and Community Cloud. Public Cloud services are made available to the general public or a large industry group. Private Cloud services are dedicated to a specific organization. Hybrid Cloud combines elements of both public and private clouds, and Community Cloud serves a specific community with shared interests and computing requirements.

1.2 The Move to Cloud

As per a survey conducted by EDUCAUSE - a non-profit organisation - in 2009, the majority of higher educational institutions expressed a keen interest in transitioning to cloud services [59]. Some of the European and American nations have taken steps towards adopting cloud technology, emphasizing the formulation and implementation of national strategies dedicated to delivering IT solutions to their respective stakeholders. Over the past few years, there also has been a significant transformation in the landscape of office applications [60]. Leading office suites, including Microsoft Office 365, Google Drive, and initiatives like LibreOffice Online, are actively embracing cloud platforms. This shift enables seamless collaboration among multiple editors, automatic real-time storage in cloud or internal network servers, and convenient browser access without the need for software installation.

Cloud Computing offers various advantages over the conventional self-hosted (on-premise) infrastructure. The key factors that influence the adoption of cloud computing are cost considerations, as well as the flexibility and convenience associated with the delivery of computing services [24]. Many perceive cloud computing as holding significant potential for reducing IT costs for organizations, freeing them from the responsibility of locally installing and maintaining applications [37]. Others emphasize the cost benefits derived from the pay-as-you-go model [38]. Moreover, a significant portion of the costs linked to maintaining an IT infrastructure arises from electricity consumption, necessary for powering hardware like PCs, servers, switches, backup drives, etc., and the associated cooling required to counteract the heat generated by these components. Cloud computing is positioned to address these expenses, potentially resulting in a decrease in both energy-related costs and labour expenditures [55]. Beyond cost considerations, other factors that influence cloud adoption include scalability, flexibility, agility, enhanced management of IT resources, a sharper business focus, increased efficiency, heightened reliability and availability, swift development, deployment, and change management, improved performance, and greater mobility [16].

Furthermore, due to the COVID-19 Pandemic, how individuals engage in work and education underwent significant transformations, as a substantial number of people increasingly depended on the Internet and online tools to fulfil their daily tasks [25]. This shift resulted in a noticeable 15-20% change in Internet traffic within the first week of lockdown. There was a remarkable surge in the usage of Zoom and Teams, with a substantial increase in traffic volume ranging from 20 to 450 times [34]. Moreover, in the past year, a lot of discussion revolved around the adoption of Zoom as the 'de facto' standard for remote education. It wasn't until educational institutions exerted pressure on Zoom, prompted by investor concerns, that the company began addressing privacy and security issues systematically [27]. Despite this, universities that chose Zoom for their lectures essentially limited students' options to either using Zoom and consenting to the processing of their personal data or abstaining from participating in lectures [26].

Amid all the concerns, there is a notable absence of thorough qualitative analyses of cloud adoption within academia that explore technological shifts, challenges, and the impact of the pandemic to contribute to a holistic understanding of cloud adoption in higher education. We address this gap (as discussed further in Chapter 2) by acknowledging the complex interplay between individuals and processes in decisions regarding cloud adoption. Through thorough qualitative analysis, we aim to delve into the motivations,

challenges, and opportunities within universities, considering the impact of technological shifts and global events. The objective is to enhance understanding and insight into the dynamics of cloud adoption in higher education, providing a more comprehensive perspective on the subject. The narrative unfolds across multiple themes and sub-themes, each representing a facet of the intricate tapestry that is the modern digital ecosystem.

1.3 Thesis Outline

The subsequent chapters of this thesis are organized as follows: In Chapter 2, an exploration of related work provides a comprehensive background to contextualize the study and reveals the research gap. Chapter 3 describes the methodology, encompassing the study design, research questions, data collection, analysis methods, and ethical considerations. Chapter 4 presents the results, revealing five thematic dimensions and their respective subthemes, that elaborate on the influencing factors, procedural intricacies, challenges faced, and the critical aspects of security, privacy, and the human dynamics inherent in IT work. In addition to the five themes identified, another section emerged, offering additional insights into the data. Moving forward, Chapter 5 intertwines discussions and limitations, synthesizing findings to address the research questions while exploring additional relevant aspects. Subsequently, Chapter 6 culminates the thesis by amalgamating the conclusion and future work, providing a comprehensive overview of key insights and potential implications for the field of cloud adoption in higher education.

Chapter 2
Related Work

In this section, we discuss the existing research that helps us build the foundation of our study design. Our research includes various dimensions such as service migration, factors that influence the entire decision-making process and the role of privacy and security. Through this section, we aim to provide a comprehensive understanding of the current state of knowledge, identify gaps, and set the context for our research.

Meeting the demands and acquiring hardware and software can turn out to be costly. Therefore there is a need to optimise the cost. One such issue was identified and worked upon in the research by Okai et al. [46]. The author presented a brief insight into the benefits of migrating to cloud solutions and briefly spoke about the challenges the universities face while migrating to cloud-hosted solutions. The authors proposed a migration model which consists of strategic guidelines to overcome the challenges that were identified. However, the gathering of the factors i.e. the qualitative research, that led to the generation of this framework is not explained. Furthermore, the authors tested the proposed model on a university which resulted in a successful and better migration to the cloud-hosted solutions. The authors also highlighted the unique approach utilised by the cloud-hosted solutions - providing IT resources on a pay-per-use basis which the author believes helped in optimising costs. They concluded that the adoption of cloud technology simplifies the complexity of IT services, speeds up processes, and elevates the quality of service provision.

The study conducted by Shauib et al. [51] in 2019, revealed that despite the existing effective migrating frameworks/models, adopting cloud-hosted solutions is still a challenge within a lot of organisations. Initially, the authors point out how cloud-hosted solutions have emerged as a transformative technology which helps in enhancing business goals. Nevertheless, numerous organizations, particularly Small and Medium Enterprises, exhibit reluctance when it comes to transitioning to cloud-hosted solutions. The authors then dive deep into the challenges associated with migration and the factors that contribute to the entire decision-making process. They note that the organisations lack a well-defined model that would suit their business and workforce to handle the could-hosted solutions. The results of the study indicate that technical factors, organizational factors, and certain external factors have a positive impact on cloud adoption.

While the above studies provide valuable insights into the migration process, the challenges faced and the factors that influence the decision, it is important to acknowledge the limitations and developments in the field that have occurred since these studies were conducted. Firstly, the research by Okai et al. [46]. dates back to 2014. IT is a rapidly evolving field which has undergone significant changes with new technologies emerging and transforming the landscape of cloud-hosted solutions. Moreover, a paradigm shift has occurred in recent years due to the COVID-19 global pandemic. To what extent the pandemic might have influenced cloud adoption in universities and the underlying decision-making process is still largely unexplored. Secondly, the study conducted by Shuaib et al. [51]. represents the perspectives, factors, and challenges encountered by organizations during the migration to cloud-based solutions. However, it is important to note that universities may operate in various environments and have a unique set of requirements. This can result in different perspectives and factors that influence their decisions to (not) migrate and challenges encountered while adopting cloud-hosted solutions.

Another notable limitation of the existing work is the lack of qualitative research. Many studies use quantitative or literature review as their research methodology which may overlook the rich and nuanced insights that a qualitative study would provide. A qualitative study can explore why the factors play an important role and how the universities are trying to overcome the challenges.

We did find some traces of qualitative research in the study conducted by Ali [7] in 2019 where the author dived deep into the characteristics of the cloud-hosted solutions that influence the decision-making process of universities. The study also provided valuable insights into what the universities think are the risks of migrating to cloud-hosted solutions. The research concluded that the universities decided to migrate to cloud-hosted solutions due to characteristics such as Broad Network Access, Measured Service, On-demand Self-Service, Rapid Elasticity, and Resource Pooling. However, certain risk factors such as Privacy, Security, Surety, and Trust played a role in the decision-making process. While the risks seemed to be important, the rapidly changing technology might have swayed their decision to migrate from on-premise to a cloud-hosted solution. While this study adds another dimension to the discussion, it has a limited scope as it involves participants from only two universities in the UK. Hence, further qualitative research from a broader and more diverse sample would help in developing a more comprehensive understanding of cloud computing adoption in higher education.

A recent study conducted by Gröber et al. [29] offers a unique perspective on how some organisations opt to self-host the services rather than relying on cloud-hosted solutions. In the digital age, where cloud solutions are plentiful, self-hosters take responsibility for data management, security, and service reliability. This research addresses several key parameters like - the motivation of users who opt for self-hosted solutions, the challenges encountered, and the security mindset behind deploying self-hosted solutions. During the study, 994 users of the NextCloud suite were surveyed, with 41 self-hosters interviewed after. The study highlights the diverse range of factors, challenges, practices, and behaviours among users. However, there are some limitations to the study. As with previous papers mentioned above, the participants in this study represented an organization. Additionally, the research primarily focused on successful self-hosting installations, which may have overlooked fatal roadblocks or challenges that users may encounter during their self-hosting journey.

Another recent study, by Fiebig et al. [26], provides an interesting dimension to the entire discussion over the migration of universities to public cloud-hosted solutions and its potential implications for privacy and academic freedom. The authors state that the emergence of remote education due to the COVID-19 pandemic which is often referred to as the 'zoomification' [26] of higher education, has raised concerns about the control of student data and the privacy of researchers and students in this new digital landscape. This study analyses the migration of universities to public clouds between January 2015 and October 2022 which includes the list of the universities listed in the Times Higher Education (THE) Top 100. The results of this study conclude that the cloud adoption pattern varies significantly between the countries. While one group (The Top 100, USA, UK and Netherlands) frequently outsourced University services and migrated to the cloud, the other group (Germany, Austria, Switzerland and France) showed minimal movement to the cloud. The study also notes that this transition began long before the pandemic. Interestingly, this study concludes by highlighting the broader implication of the transition on individual privacy and questions academic independence and integrity. While the study provides valuable insights and highlights some important key points for academics to ponder upon, it still lacks the qualitative perspective and in-depth analysis. Qualitative research can provide valuable insights into the motivations, experiences, and perspectives of key stakeholders, offering a more comprehensive understanding of the complex dynamics surrounding the adoption of cloud-hosted solutions in higher education.

In conclusion, the landscape of cloud adoption in higher education is multifaceted, as revealed by an exploration of existing research. While studies like those by Okai et al. [46] and Shuaib et al. [51] shed light on the challenges and benefits of migrating to cloud solutions, it's evident that there's still much to be understood, especially within the unique context of universities. The qualitative dimensions provided by studies like Mohammed Ali's [7] and Gröber et al. [29] offer valuable insights into the motivations and concerns surrounding cloud adoption. However, there remains a gap in comprehensive research that encompasses the rapidly evolving IT domain and the profound impact of the COVID-19 pandemic on educational technology landscapes.

Past research shows that the cloud adoption decisions within universities are intricately tied to both people and processes. Gaining in-depth insights can illuminate this interplay and its influence on adoption. Qualitative analysis will help in understanding the motivations and factors that influence the decision-making process, the challenges that universities face and the impact of recent global events, providing a more holistic view of the phenomenon.

This thesis aims to bridge these gaps in literature through a current, in-depth analysis of cloud adoption in the education sector. It will examine shifts in the technological landscape and the influence of the recent global pandemic. By centring the experiences of people and delving into their motivations, challenges, and opportunities specific to universities, the thesis aims to contribute to a deeper understanding of cloud adoption in higher education institutions and its implications in the current digital era.

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Chapter 3
Methodology

In this chapter, we outline the research design aimed at unravelling the human factors influencing cloud adoption in universities. To achieve this goal, we adopt a qualitative approach, focusing on understanding the perspectives and experiences of individuals involved in the adoption process. Qualitative research is chosen for its effectiveness in exploring complex and nuanced topics, ensuring a comprehensive grasp of the factors influencing cloud adoption [57].

3.1 Research Questions

The research questions guiding this study were as follows:

1. What were the factors that influenced the decision to choose cloud/self-hosting solutions?
2. What challenges were encountered that led to migration and how was the experience of service migration?
3. How do privacy and security considerations influence the decision to migrate to cloud Infrastructure?

3.2 Ethical Considerations

Ethical considerations were given utmost importance throughout the research process to ensure the rights, well-being, and confidentiality of the participants. The following measures were taken to address ethical considerations:

3.2.1 Ethical Approval

The study obtained approval from the ethical review board of the Faculty of Mathematics and Computer Science at Saarland University, ensuring compliance with ethical guidelines and regulations. We ensured that the research adhered to the approved protocols throughout the study, maintaining the highest possible ethical standards in data collection, analysis, and reporting.

We took several specific steps to ensure adherence to high ethical standards in our research project. Initially, we drafted a comprehensive research proposal that outlined the research objectives, data collection procedures (including semi-structured interviews), data storage and the potential benefits and risks to participants. The research proposal was then submitted, along with the informed consent form and all supporting documents, to the ethics committee for review. This ethics committee consisted of experts from various fields, including ethics, research methodology, and the specific domain of the study. Their expertise and diverse perspectives ensured a thorough evaluation of our research design and the ethical safeguards we had in place to protect the participants' rights and well-being.

In some instances, they contacted us to seek additional clarification on certain aspects of our research, specifically regarding the duration of data storage and data processing. Upon receiving the request for further clarification, we promptly provided detailed information about how the data would be stored and processed throughout the research and afterwards. We explained our data management plan, emphasizing data security and confidentiality measures. We assured the committee that all personally identifiable information would be anonymized and kept secure.

We also elaborated on the duration of data storage, specifying that the data would be retained for a limited period (14 days after the interview) necessary to complete the audio transcription. Afterwards, the data would be securely and permanently deleted, ensuring that participants' information remained confidential even after the research was concluded. Once the ethics committee was satisfied with the ethical rigour of our research design, they granted us ethical approval to proceed with the study.

3.2.2 Informed Consent

Before the interviews, participants were provided with detailed information about the study, its purpose, the expected involvement and also about the researchers who are conducting the study (us). They were invited to ask questions and clarify any concerns before providing informed consent. Participants were assured that their participation was voluntary and informed of their right to withdraw from the study at any given time. For the full Informed Consent Form, please refer to the Appendix A.

3.2.3 Confidentiality and Anonymity

To protect the participant's identities and ensure confidentiality, all identifying information, such as names and specific organizational details, was removed or replaced with pseudonyms. The audio-recorded interviews and transcripts were stored on the self-hosted instance. The collected data were treated with strict confidentiality, and access was limited to the members of the research team.

3.2.4 Data Security and Privacy

All digital data, including audio recordings, transcripts and consent forms, were stored on a password-protected self-hosted instance. Following the transcription of the audio recordings, a strict timeline was set to ensure that the transcriptions were completed within 14 days of the recording. Once the transcriptions were finalized and verified for accuracy, the original audio recordings were securely deleted from all devices and storage systems. This step was taken to eliminate any remaining copies of the audio data, further protecting the participant's confidentiality and privacy.

3.2.5 Transparency and Consent for Publication

Participants were informed about the possibility of their anonymized data being included in the final thesis document or any subsequent publications resulting from the research. They were assured that their identities would remain confidential and that their input would be presented in a manner that respected their privacy and anonymity.

3.3 Data Collection

We divide the Data Collection phase into the preparation phase and the actual data collection phase. The preparation phase consisted of formulating a study design. Since we do not have a hardbound definition of self-hosted and cloud-hosted environments, we begin our study design by defining them (ref Appendix C), our research questions, our study approach and identifying potential participants. We divided our set of potential participants into three categories - **People operating IT at a university (for example - sysadmins), People with a managerial role in University IT (for example - IT dept. Heads, Directors of Data Centers at universities) and People with an administrative/leadership role for the whole university (for example - (Vice-)Deans/Chancellors, CISOs, CIOs).**

For this project, we chose to utilize a semi-structured Interview methodology. Semi-structured interviews were chosen as the primary method of data collection due to their ability to provide rich, detailed, and contextualized information regarding migration challenges and decision-making processes [39]. The semi-structured nature of the interviews allowed for flexibility, enabling participants to express their thoughts, experiences, and expectations in their own words. The interviews were conducted online by using the BigBlueButton [33] as the video conferencing platform, which is GDPR-compliant and self-hosted.

3.3.1 Pilot Study and Interview Structure

Before conducting the interviews, a set of open-ended questions and follow-up prompts were prepared based on the research objectives and the relevant literature (ref Appendix D for complete interview design). These questions served as a guide during the interviews while also allowing for the spontaneous exploration of additional topics or themes that emerged during the conversations. The initial interview guide was pilot-tested and adjusted with a few participants to ensure clarity and relevance.

Here's a description of the pilot study that preceded our main research on interviews:

- **Number of Pilot Interviews:** We conducted five pilot interviews.
- **Pilot Study Design:** Each pilot interview involved selecting participants who shared similar characteristics to the target population or had a basic knowledge and understanding of the main study. These participants were subjected to a mock interview setting, and we audio-recorded the interviews for later analysis.
- **Pilot Study Objectives:** We aim to:
    1. Test the interview questions: We wanted to ensure that the questions were clear, relevant, and capable of eliciting the desired information from the participants.
    2. Evaluate the interview process: We assessed how smoothly the interviews were conducted, identified any potential bottlenecks or difficulties faced by the interviewer or interviewees, and ensured that the timing was appropriate.
    3. Assess the data collection platform: We examined the effectiveness of the data collection platform i.e.BigBlueButton.

3.3.2 Recruitment

A snowballing sampling technique was employed to select participants who possessed experience and expertise in migration processes or were involved in the decision-making process. The sample aimed to include individuals from different universities worldwide to capture a diverse range of perspectives and experiences. Participants were approached through professional networks, referrals, and direct contact, with an explanation of the study's purpose and the voluntary nature of their participation. Informed consent was obtained from each participant before the interviews were conducted (ref Appendix A). A total of 18 participants were interviewed, ensuring a rich and comprehensive dataset for analysis.

Name	Country	Profession	Gender
P01	Germany	Managerial role	∅
P02	Germany	Managerial role	∅
P03	Germany	Administrative/Leadership role	∅
P04	Germany	Administrative/Leadership role	Male
P05	Netherlands	Managerial role	Male
P06	UK	Managerial role	Male
P07	Germany	Administrative/Leadership role	Male
P08	Germany	Managerial role	∅
P09	Switzerland	Operational Role	Male
P10	South Africa	Administrative/Leadership role	Female
P11	South Africa	Administrative/Leadership role	Male
P12	USA	Administrative/Leadership role	Male
P13	USA	Managerial role	Male
P14	Australia	Administrative/Leadership role	Male
P15	Canada	Administrative/Leadership role	Male
P16	Canada	Administrative/Leadership role	Female
P17	Malaysia	Administrative/Leadership role	Female
P18	USA	Operational Role	Male

Table 3.1: List of all Participants. ∅ = no answer given

3.3.3 Interviews

The interviews were audio-recorded with the participant's consent, allowing for accurate capturing and preservation of the data. The interview sessions were conducted by two researchers, one serving as the main interviewer, leading the conversation, and the other researcher actively listening and occasionally assisting with follow-up questions.

The interviews were conducted between 28 March 2023 and 25 August 2023, encompassing a five-month period. They varied in duration, typically lasting between 20 minutes to an hour, depending on the depth of the participant's experiences and the richness of the data shared. Upon realizing that we had gathered sufficient data capable of narrating a rich, complex, and multi-faceted story, we decided to conclude the data collection phase [14].

While our findings offer valuable insights within the context studied, researchers aiming to apply our results to different geographical areas should exercise caution, considering potential variations in managerial, operational, and administrative practices. Our study serves as a foundation for exploration in specific regions but does not claim universality across diverse global contexts. This limitation will be further explained in Section 5.3

3.3.4 Challenges

The data collection phase presented several challenges that impacted the process of gathering contact information from the websites. These challenges can be attributed to various factors.

Firstly, the structure of the websites posed navigation difficulties. Poorly organized menus, unclear labelling, and complex website structures made it time-consuming and labour-intensive to navigate through the pages to find the contact details of potential participants.

Additionally, the usage of various job titles within the same region, as well as across different regions, added another layer of complexity. This inconsistency in job titles made it challenging to determine the appropriate individuals to contact for potential participation in the study. Deciphering the exact role or responsibility of each individual became a daunting task, further adding to the difficulty of collecting accurate contact information.

The challenges encountered during the data collection phase were compounded by a notably low response rate. Despite reaching out to a substantial pool of 328 individuals, only 18 agreed to participate in the study. This low response rate underscores the difficulty in recruiting participants. While it is well-known that operational personnel often contend with demanding workloads [35], individuals in administrative and managerial positions similarly face significant time constraints. Consequently, recruiting participants for the interviews proved to be exceptionally challenging, reflecting the inherent difficulties in engaging professionals across various roles within the targeted universities.

3.4 Data Analysis

Reflexive thematic analysis is not a rigid step-by-step procedure but rather a theoretically flexible way of analysing the data [12]. It does demand a deliberate and thoughtful approach [11] to not only understand that you are doing it and why you are doing it but to explain the series of choices that you make throughout the research [11, 58].

Reflexive Thematic analysis, as a qualitative research method, encompasses both inductive and deductive approaches, each offering distinct pathways to interpret and understand the data [13]. The inductive method is characterized by its emphasis on allowing themes and patterns to emerge organically from the data itself, without predefined categories or preconceived notions [13]. In the inductive framework, coding and theme development are guided by the content of the data, enabling a nuanced exploration of participants' experiences and perspectives. In contrast, the deductive approach relies on pre-established concepts or theoretical frameworks to guide the coding and theme development process. Our choice of an inductive approach aligns with the exploratory nature of our research, facilitating a deep and contextually rich understanding of the phenomena under investigation. **This methodological choice underscores our commitment to letting the data speak for itself, allowing for the discovery of novel insights and themes that may not have been anticipated at the outset of the study [41]**.

Reflexive Thematic Analysis process involved several iterative steps to ensure a comprehensive exploration of the research questions. However, the inherently subjective and context-dependent nature of qualitative research is evident in this study. This is further elaborated in Section 5.3

Below, I elucidate these strategic choices for each phase of the analysis, reflecting on the thoughtfulness and rigour that underpinned the study's methodological approach [11].

3.4.1 Phase 1: Familiarising yourself with the dataset

Phase 1 of the study began with the transcription of the interviews. The audio-recorded interviews were transcribed **'re'-presenting** the participant's responses in their own words [28]. **The transcripts served as the primary data source for analysis.**

The interview recordings were initially transcribed using Web Whisper Plus [49], an audio transcription tool based on open-source technology. The tool was self-hosted and the transcriptions were stored in a folder with limited access to ensure the privacy of the participants. This tool facilitated the conversion of the audio recordings into written text, providing an initial transcript for each interview. However, recognizing the importance of accuracy, integrity and ensuring the reliability of the transcriptions, a thorough manual review of each transcript was conducted. This involved listening to the audio recordings repeatedly while simultaneously reading through the transcriptions, meticulously checking for any errors or discrepancies. **It is also important to note that this tool could not transcribe all the interviews due to changes in the accent and dialects of the language. Those interviews were transcribed completely manually.**

During transcription, verbal cues were also added to capture changes in the tone and emphasis that might not be apparent from the text alone, thus enhancing the richness and accuracy of the recorded dialogues [10]. For instance - *"(laughs) Non-ideal way is*

somebody shows up at a meeting." The transcription was followed by anonymisation of the transcripts to remove any identifying information and ensure that the data is presented in a way that cannot be linked back to individual participants. The anonymization process involved the systematic removal of personally identifiable information (PII) from the transcripts to safeguard the privacy of individual participants. This included the exclusion of details such as job titles, university names, and any other information that could potentially identify a specific participant. By implementing this thorough anonymization, we ensured that the data presented in the transcripts could not be linked back to individual participants, thereby maintaining confidentiality and ethical standards throughout the research.

3.4.2 Phase 2: Coding

Coding refers to labelling the data. As mentioned above, an inductive approach was followed to code the data. Every kind of data that was important and looked interesting was coded i.e. there was data that answered our research question and there was extra data which was interesting, often adding a philosophical element that helps in the broader reflection of the topic. Both, semantic and latent approach was used to code transcripts [15]. For example:

1. Semantic/Direct Codes - *cloud migration decision-making stakeholders: CIO*
2. Latent/Indirect codes - *dynamics changing as the IT team now is playing the role of a facilitator rather than operator or creator*

To enhance accuracy and rigour, a subset of the transcripts was independently coded by a postdoctoral researcher and any discrepancies were resolved through discussion and consensus. These codes were then mapped into broader categories which helped in highlighting the overarching themes and patterns within the data. **We discovered a total of 218 primary codes, with some of them branching out further into sub-codes.**

3.4.3 Phase 3: Generating initial themes

In this phase, grouping and categorizing the codes was done to develop overarching themes and patterns.

Initially, similar codes were clustered based on their shared ideas. To understand the data more easily, a visual representation of the clusters in the form of a mindmap was opted. Figma[1] was used to create mindmaps digitally and understand the relationships between individual codes and clusters. Codes that stated similar ideas were combined into one code to remove redundancy. The clusters that shared the same idea were then further combined into buckets of themes. This step helped in better representing the data's richness and diversity concisely.

Additionally, during this phase, the process of identifying potential themes began by grouping the code buckets. These groupings were driven by a deeper understanding of the data and the identification of common threads that connected various code buckets (see Figure 3.1 for an example of a code cluster). These groupings were conceived as potential themes that could encompass and encapsulate the essence of the data.

[1]Figma Website - https://www.figma.com/

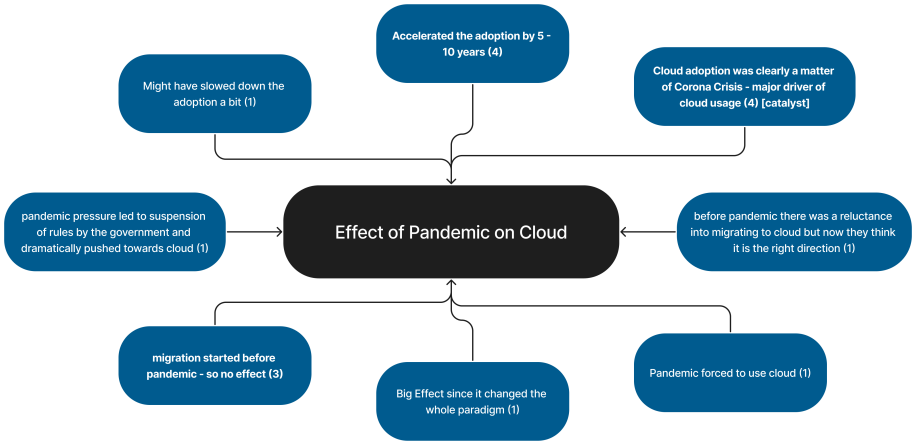

Figure 3.1: A code cluster

For instance, We had the code - *"Historisch Gewachsen" by individual needs and curiosity of researchers* which was grouped under *"Other factors"* which further contributed to the *"Drivers of [Product/Service] Migration"* bucket. This integration of codes and the formation of buckets allowed for the emergence of a potential overarching theme known as *"The Decision Matrix."*

Following this categorization, an abstraction process ensued, offering a panoramic overview of the entire codebook (see Figure 3.2). Notably, this abstraction featured a hierarchical arrangement, with the most frequently occurring codes assuming larger representations, while the less frequent ones were proportionally scaled down. This strategic visualization not only enhanced the accessibility of the codebook but also provided a nuanced understanding of the data landscape, allowing for the identification of key patterns and trends.

3.4.4 Phase 4: Developing and reviewing themes

A strategic process was undertaken in the fourth phase of thematic analysis, focused on developing and reviewing themes. The initial step involved the segregation of code clusters based on the pertinent research questions. This categorization facilitated a clear understanding of the thematic content associated with each research query and highlighted additional data contributing to the overarching narrative. **To accentuate the significance of frequently occurring codes, a deliberate approach was employed: codes reiterated three times or more were distinctly marked as bold.** This emphasis aimed to underscore the salience of these recurrent themes in the dataset. Subsequently, the process of constructing a cohesive narrative commenced, with these frequent codes serving as a starting point around which meaningful stories, herein referred to as themes, were systematically woven. This meticulous approach ensured both clarity and rigour in the development and review of themes, contributing to the overall depth and coherence of the thematic analysis.

Theme	Sub-theme(s)
Origins of a Cloud Odyssey: How it all began	• The Ecosystem • Cloud Provider Preference – The AWS inclination – Embracing Azure – Unanticipated Journey with GCP – Alternatives beyond the Conventional – Embracing a Multi-Vendor Strategy – Zoom: Pandemic Pivot • University's Guide to Cloud Integration – Cloud Strategy and Diverse Spectrum of Stakeholders
The Decision Matrix: Factors, Choices, and Decision-Makers	• Factors – Cloud Conundrum or the Optimal Mix – Grounded in Tradition: Factors Anchoring Self-Hosted Environments – Pandemic Paradigm • Choices – Commercial Services vs. In-House Infrastructure – In-House Autonomy vs. External Dependence • Decision-Makers – The (in)formal process of decision-making – Students as Stakeholders
The Migration Odyssey: Process and the Challenges in Migration	• The Uncertain and Complex Cost Equation • People-Centric Transition – Financial Operational Mindset – Workforce Dynamics and Skill Gap • Data Migration Challenges • In-Depth Insights Shared • The (in)formal process
Guardians of Data: Navigating Governance in Cloud and Self-Hosting Choices	• The Digital Rebels - Resisting the Migration to Cloud Services • "Yes, It's Not Quite Compliant, But the Risk is Limited" - The Pragmatic Optimists • Productivity Driven Pragmatists
The Human Element: Perspectives on Security, Privacy, and IT Culture	• Cultural Shift and Human Dynamics in IT • A Spectrum of Perspectives
Additional Insights on University Dynamics	• University staff training for cloud migration • Local political influence • Role of community support in cloud migration • Role of trust

Table 3.2: Theme and Sub-theme(s)

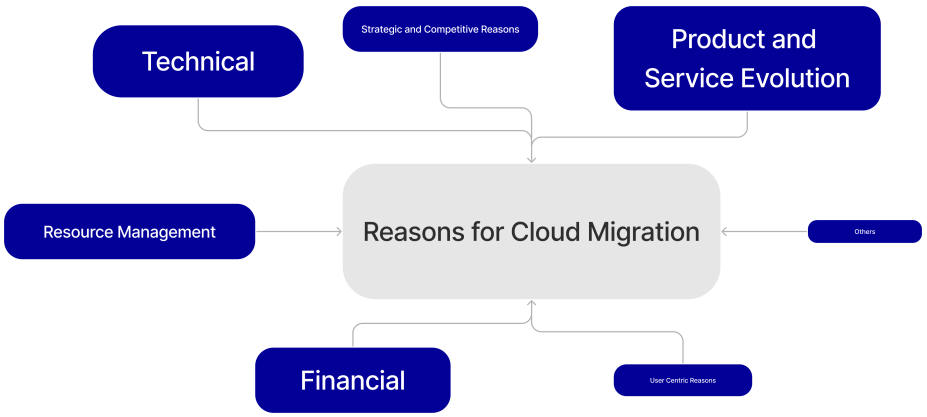

Figure 3.2: Abstracted view of a code cluster

3.4.5 Phase 5 and 6: Refining, defining and naming themes & Writing

In the dynamic interplay of Phases 4, and 5 – refining, defining, and naming themes, followed by the process of Writing Up – what initially appeared as a linear progression evolved into a cyclic and iterative undertaking.

Initially, I commenced the narrative-building process by jotting down discernible aspects of the stories, frequently oscillating between the transcripts and the assigned codes to intricately interlace the unfolding narrative. However, as the narrative took shape, it became apparent that certain codes found better alignment within alternative themes or sub-themes. This realization prompted a revisitation of the thematic structure, leading to the incorporation of three additional themes to enhance the narrative's comprehensiveness. This iterative and reflective process underscored the dynamic nature of the thematic analysis, emphasizing the fluid interplay between data interpretation and theme refinement to ensure a robust and nuanced representation of the research findings. Table 3.4.4 (below) encapsulates the refined and final list of themes and sub-themes generated through the entire thematic analysis process.

Researcher Reflexivity: Additionally, it is crucial to acknowledge the role of researcher reflexivity in shaping the analysis. As a computer engineer with a background in cloud technology, my direct interactions with participants provided valuable insights into the technical aspects of our analysis. This expertise allowed for a nuanced understanding of the challenges and opportunities presented by cloud adoption within higher education institutions. Additionally, our team included individuals with extensive experience in system administration and qualitative research methods. Their contributions were instrumental in contextualizing the data within the broader technological and qualitative research landscapes. By leveraging our collective knowledge and perspectives, we were able to approach the data analysis process with rigour and depth, enriching the interpretation of our findings.

Chapter 4
Results

4.1 Origins of a Cloud Odyssey: How it all began

In the era of 'zoomifcation' of higher education [26], universities worldwide are reevaluating their infrastructural paradigms to align with the demands of modern education and research. This theme explores the university's current infrastructural setup—be it self-hosted, cloud-hosted, or a hybrid amalgamation. We aim to dive deep into the strategic rationale that guides the choice of infrastructure, the selection of cloud providers, and the guidelines that map universities' IT infrastructure development.

4.1.1 The Ecosystem

In the foundational landscape of the university's infrastructure, a portion remains almost self-hosted, as indicated by Participants P02, P03, P04, P07, P17, and the computer science department of the university of P18. This self-hosting inclination underscores a traditional approach where universities maintain a degree of autonomy and control over their digital resources. On the other hand, we do observe the adaptation of a hybrid model. The blend of both: self-hosted and cloud-hosted infrastructure is embraced by the universities of the Participants P01, P06, P08, P09, P10, P11, P13, P15, P16, and P18. A transition towards a cloud-centric infrastructure is noted by participants P12 and P14.

Participant P18 describes the difference between the Computer Science department's infrastructure of their university and the broader university infrastructure.

I[2]: So if I understood you correctly, the department runs like 100% on-prem currently as of now?
P18: Yeah.
I: And the university is like a hybrid infrastructure?
P18: Yes, I would say most of the student-facing services though are hosted off campus.

[2]In these transcript snippets, "I" represents the interviewer, while "PX" represents the participants.

Participant P18 confirms that the department operates entirely on-premises (self-hosted) infrastructure, indicating that all their computing resources and services are hosted within their physical location. However, when discussing the university as a whole, Participant P18 introduces the concept of a hybrid infrastructure. While the department is fully on-premises, Participant P18 notes that most of the student-facing services at the university are hosted off-campus.

Participant P03 highlights a decentralized approach to cloud management within the university, emphasizing that the cloud instances and usage are not centrally managed but are instead handled independently by each faculty.

P03: "So that means we have quite an important number of cloud instances and usage, but it's not centrally managed. Every faculty is doing it on their own."

Participant P03 highlights a decentralized approach to cloud management within the university, emphasizing that the cloud instances and usage are not centrally managed but are instead handled independently by each faculty. The participant's statement, *"Every faculty is doing it on their own,"* suggests that each academic unit or department is responsible for making decisions regarding cloud usage, selecting cloud instances, and managing associated resources independently. While this approach offers localized control and responsiveness to user needs, it may also present challenges in terms of overall coordination, standardization, and optimization of cloud resources across the organization. The lack of central management implies that there may be variations in practices, configurations, and resource utilization strategies among different faculties.

Participant P05, who holds the position of project manager at an agency bridging the gap between universities and cloud providers, adds another layer to the discussion by explaining the role played by the go-betweens during the transition of the university infrastructure.

P05: "Without our involvement, universities would have to handle the procurement process themselves, which is a lengthy procedure.

In response to the question about why universities require an intermediary to interact with cloud providers, Participant P05 outlined that universities would otherwise need to manage the procurement process independently. Companies or mediums that act as a bridge between cloud providers and universities are not conveniences but necessities. They streamline the procurement process, which, if undertaken internally, presents a time-intensive and complex undertaking. By uniting all National research and education networks (NRENs) in Europe, the agency serves as a collective force, enabling negotiations for contracts that benefit universities by providing them with the established agreements used by cloud service providers. Participant P01 supports the lengthy procedure notion by stating:

P01:" Yeah, it's difficult to talk about welcoming legal challenges because those challenges are consuming more and more of our working hours we are spending on those. "

Participant P01 acknowledges how they spend more than the required working hours over the legal challenges. Through these go-betweens, the universities can navigate the complexity of procurement with greater agility, ensuring that their digital infrastructure

is both current and competitive. Furthermore, Participant P13 sheds light on the lengthy procurement process that the universities generally have to go through.

P13: "We have from a procurement standpoint, I think there was a realization that I mean, no joke. If I had a...if I had a procurement for a piece of software services solution, it would certainly take me at least six months to get jumped to jump off through all the hoops, have our contracting office look at the contract negotiations, get that over to our legal department, who's absolutely swamped all the time. Our university is very risk-averse. You know, it's you know, the balance is completely out of whack. So there's a lot of redlining. There's a lot of back and forth. There are lines in the sand that are drawn with contracts where if the vendor doesn't say like arbitration occurs in the state of <Name of the State>, which is where we're located. Like if they refuse that and they say no <Name of the City>, we're like, okay, we're done. Thanks. Stuff like that. Like, okay, I guess we kind of needed that software, but that's whatever. So six, yeah, six months would not be an unreasonable amount of time for people to get some."

From a procurement standpoint, Participant P13 emphasizes the significant time investment required, citing that acquiring a software services solution could take a minimum of six months. The hurdles involve navigating through various stages, including contract negotiations, legal department scrutiny, and dealing with the university's risk-averse nature. Participant P13 paints a picture of a meticulous process characterized by redlining, extensive back-and-forth interactions, and the drawing of lines in the sand regarding contract terms. The university's risk aversion is a dominant factor, influencing decisions and contributing to the lengthy procurement timeline. Participant P13 highlights specific scenarios, like the insistence on arbitration occurring within the state of their location, and how deviations from such preferences can lead to discontinuation of the procurement process, even if the need for the software is apparent.

Summary: Participants P02, P03, P04, P07, P17, and P18 [the Computer Science Department] favour a predominantly self-hosted model, reflecting a traditional stance emphasizing autonomy. Conversely, participants P01, P06, P08, P09, P10, P11, P13, P15, P16, and P18 [the university] adopt a hybrid approach, combining self-hosted and cloud-hosted infrastructure elements. Additionally, participants P12 and P14 signal a notable shift towards a more cloud-centric infrastructure. The role of go-betweens is highlighted by participants P05, P01, and P13.

4.1.2 Cloud Provider Preferences and Rationales

This sub-theme highlights the considerations and motivations behind the adoption of specific cloud platforms

4.1.2.1 The AWS Inclination

When the university looks at options of cloud providers available that suit their requirements, Amazon Web Services (AWS) stands out as one of the top picks as mentioned by participants P06, P11, P14, and P12. However, the way the university started using AWS was pretty rushed. Participant P13 describes it as a *"hair on fire"* situation.

P13: "The way that we onboarded AWS was kind of a hair-on-fire. Somebody needed to get this up and running. So we kind of threw it together, found a contract that we could use as a vehicle and provisioned it."

This term suggests an urgent, perhaps not fully strategized, onboarding of AWS, leveraging an existing contract as a quick means to an end. This hasty integration indicates a possible gap in deliberate planning, driven by an immediate need rather than a calculated strategy. Further entrenching AWS's position within the university's infrastructure is the evolution of the central IT department's skill set.

P14: "So that, I think our, most of our cloud skillset is AWS centric, to be honest. So we have our biggest knowledge base is around AWS. And also I think our cloud architecture is probably the most mature in AWS. So all the small bits and pieces that, I think there was some application from a faculty that was lifted over a few months ago. And that goes, AWS is the default for that. "

Participant P14 notes that the university's cloud skillset has become predominantly AWS-centric. The migration process inadvertently leaned towards AWS. In the early stages, AWS became the default choice, leading to the unintentional development of a significant skill set focused on AWS within the university's IT infrastructure. This observation suggests that the existing expertise and resources within the university's IT staff have been tailored to leverage AWS to its full potential, thus creating a self-reinforcing cycle where initial choices in provider selection shape the skill development and subsequent preferences.

4.1.2.2 Embracing Azure

Microsoft Azure emerges as another significant choice in the university's cloud provider portfolio, with participants P14, P10, and P15 acknowledging its usage. The selection of Azure by the university is not only reflective of a diversification strategy in their cloud services but also indicative of the changing nature of Microsoft products and how these changes have impacted the university's digital infrastructure and services.

The introduction of Azure is particularly contextualized by 3 Participants P01, P07, P09, P11, P13, P10, and P16, who narrate a shift necessitated by the evolution of Microsoft's product offerings.

P13: "With Microsoft, that kind of was the tail that wagged the dog because we were migrating from all of our on-premise Microsoft solutions, Exchange, that kind of thing. And Microsoft said, hey, we have this thing called, well, I can't remember what it was called, live at EDU. It went through a couple of different iterations. This is all on the cloud. By the way, it hangs off this thing called Azure. Don't worry about that right now. And we're like, wait, what? And they're like, oh, yeah, it's just hosting the directory. You don't have to care about that for now. And then we had to start caring about it because, you know, they really had this huge push for cloud and they started saying, oh, yeah, you can build, you know, subscriptions and all this other stuff. And we're like, okay, I guess since we were managing that other piece, we'll have to manage this piece as well. We kind of got roped into that as well."

Participant P13 provides a candid exposition of this transition, describing it as being led by the *"tail wagging the dog."* This metaphor captures the reactive nature of the

university's decision-making, propelled by Microsoft's strategic push towards cloud solutions. The participant recounts the migration from on-premise Microsoft solutions to cloud-based services, which was initially presented as a simple hosting change for directory services but gradually expanded into a broader commitment to Azure.

The narrative reflects a somewhat reactive engagement with the cloud, indicating that the university was initially unprepared for the extent of the cloud integration initiated by Microsoft. The participant's account reveals a scenario where the university, while initially passive or incidental in its engagement with Azure, found itself increasingly integrated with the platform as Microsoft's cloud-first strategy unfolded. The participant conveys a sense of surprise and a lack of initial awareness regarding the cloud aspect, specifically Azure.

4.1.2.3 Unanticipated Journey with GCP

Google Cloud Platform's (GCP) integration into the university's cloud architecture, as articulated by participant P13, was not a result of a strategic decision but rather an incidental development.

P13: "GCP came in, honestly enough, near the back door. We took on service ownership of Google Workspace as a email, calendaring, collaborative tool set and managing the identity and access management through their Google directory. And then we realized after we took on service ownership, which was a couple of years down the road after the thing had been brought up, that Google had turned on the ability for people to sequence GCP projects. (I: Ah!) We're like, wait, what? This was a real problem in other schools and other schools started to sound the alarm bell and we went and we're like, hey, yeah, you're right, they're doing it. And we're like, we better like wrap some, put this in a box or something like that. So it was a real wake-up shock to us. So we basically turned off the ability for anybody to create projects. We had to go build out this, you know, requestable item for them to manage it. We had to identify everybody who was already occurring costs, people who had, what do they call it? Whether they had spending deficits, I mean, students, alumni, retiree, like anybody who had a Google account was able to do this. And so we call shenanigans on Google. We had to kind of throw that in a penalty box and it has very little usage. You really keep it around for the software as a service portion of that."

Describing GCP's entry as coming in *"near the back door,"* Participant P13 details how the university initially adopted Google Workspace for its email, calendaring, and collaborative tools, inadvertently leading to the unsanctioned use of GCP services. This realization prompted a scramble to regain control, highlighting the unforeseen challenges of shadow IT where services are used without formal approval or oversight. The narrative of GCP's introduction is marked by a reactive approach to governance, as the university grappled with the implications of unregulated project creation and associated costs. This led to a swift and strict containment strategy, effectively placing GCP usage within strict boundaries to prevent unmanaged spending and to align with institutional governance policies. In tandem, Participant P14 offers a reflective perspective on GCP's capabilities, acknowledging its strengths, particularly in data analytics.

P14: "But we were actually starting to spin up some small things in GCP last year just to sort of get our heads around it. I've done a bit of work in GCP in a previous job and I think it's an excellent platform. But the question is, what benefit would it give us now? Because effectively there is really nothing in GCP that we couldn't get in one or the other two. If we look at, I think

GCP is excellent for data reporting analytics, for example, the BigQuery is great, but you can, Azure has got matching capabilities that we can draw from which we have now. I think maybe Amazon is a little bit weaker at that point. So there's really no benefit for us right now to do anything major in GCP."

Participant P14 reflects on the university's initial foray into GCP, which seems to be driven by exploratory intent rather than an immediate need. This participant, drawing from previous experience, recognizes GCP's strengths—particularly praising its data analytics capabilities like BigQuery[3], which is noted for its powerful data warehousing and analytics features. Yet, Participant P14 remains pragmatic, evaluating the potential overlap between GCP's offerings and those available from AWS and Azure, which the university already utilizes.

This contemplative stance suggests that the university's cloud strategy is not about adopting every available technology but rather about seeking meaningful additions that offer distinct advantages. Participant P14's comparison of GCP with Azure's similar capabilities indicates an analytical approach to technology adoption, one that considers the balance of innovation against practicality and seeks to avoid redundant systems that do not add unique value.

4.1.2.4 Alternatives beyond the Conventional

In the varied landscape of cloud services, the university's narrative extends beyond the big players to include providers like Oracle and Huawei, each chosen for distinct strategic reasons.

Participants P10 and P16 highlight the university's transition to Oracle cloud services, suggesting that this move was influenced by the vendors' shift of their solutions to the cloud. The decision to migrate from on-premise solutions to cloud-based services was largely driven by the providers' initiative to transition their products to the cloud, consequently prompting the university to follow suit in the migration process. Thus, the vendors' migration of their solutions played a role in leading the university to embrace cloud services.

Huawei Cloud is mentioned by Participant P10 as a solution for the university's back-ups. This is particularly noteworthy because it highlights a willingness to incorporate a provider that may not be as commonly referenced as the big players like AWS, Azure, and GCP. By incorporating Oracle and Huawei Cloud, the university demonstrates a multifaceted cloud strategy that is not solely reliant on the largest providers but is open to adopting various solutions that offer specific benefits or meet particular criteria.

4.1.2.5 Embracing a Multi-Vendor Strategy

As evidenced by the diverse cloud choices stated above, it is apparent that universities are progressively embracing a multi-vendor approach for their cloud-hosted infrastructure requirements.

[3]BigQuery serves as a comprehensive, fully-managed enterprise data warehouse, facilitating the effective management and analysis of data through its integrated capabilities, including machine learning, geospatial analysis, and business intelligence features [53].

P14:" ..... good logic for having a balanced vendor strategy when it comes to cloud. You don't want to put all your eggs in the same bag."

P11: "Our cloud services are hybrid in that they are not hosted by one service provider. They are hosted by more than one service provider."

Participant P14 articulates the reason for a balanced vendor strategy, highlighting the risk management principle of not placing *"all your eggs in the same bag."* This suggests a cautious approach to avoid vendor lock-in [47], where the dependency on a single cloud provider could pose risks in terms of service outages, pricing changes, or contractual constraints. A balanced strategy allows the university to mitigate these risks by spreading its cloud-based services across multiple providers. Participant P11 supports this strategy by noting the hybrid nature of the university's cloud services, which are dispersed across more than one service provider.

P06: "The direction of travel, as our sort of general sort of policy suggests, is more and more towards cloud services. ..... you know if it's clear that what we want isn't available as a cloud service then we might still do something in-house."

The perspective shared by Participant P06, emphasizing a willingness to consider in-house solutions if the desired functionality is not available as a cloud service, aligns with a strategic and adaptive approach to technology adoption. Notably, this approach contrasts with the behaviour observed in some EU nations, where there is often a tendency to prioritize in-house solutions before turning to cloud services. In the context of the EU nations, there is a common trend of organizations preferring in-house solutions as a primary option. This may be influenced by factors such as data privacy concerns, regulatory considerations, and a historical reliance on traditional on-premise infrastructure. The contrast highlights regional variations in the decision-making processes related to cloud adoption, reflecting different attitudes towards the balance between in-house and cloud-based solutions.

4.1.2.6 Zoom: Pandemic Pivot

The universities that predominantly rely on self-hosted infrastructure, represented by Participants P02, P03, P04, P07, P17, and P18, exhibit a consistent preference for managing their own systems. However, an interesting deviation from this trend emerges when it comes to video conferencing solutions. Zoom, a cloud-hosted service, stands out as the sole exception in their otherwise self-hosted environment. This adoption of Zoom was largely catalyzed by the pressing demands imposed by the COVID-19 pandemic.

P02:" We use Zoom because during the Corona pandemic, there was a lot of pressure to introduce this system. "

P03: "So we have lectures with 500 and more students. And this is a volume which can't be handled by BigBlueButton. So for that, we need to have another system. And during Corona crisis, Zoom has been selected as a video conference system for teaching and lecturing."

Participants shed light on the pivotal role played by the pandemic-induced circumstances in steering their decision towards Zoom. Participant P03 underscores the challenge posed by the high volume of students in lectures, a demand that self-hosted solutions like Big-

BlueButton [4] couldn't adequately address. In response, the university sought out Zoom as a cloud-based alternative capable of handling the scale required for large lectures. Participant P02 echoes this sentiment, emphasizing the intense pressure during the pandemic as a driving force behind the swift introduction of Zoom.

P04: "Zoom contract directly with the company Zoom, but we have done it only for a very short period of time due to the emergency situation in the pandemic and the lockdowns."

Moreover, Participant P04 revealed a temporary contract with Zoom, directly engaging with the company due to the emergency situation posed by the pandemic and subsequent lockdowns. This short-term adoption highlights the agility and adaptability universities demonstrated in response to unforeseen challenges.

P07: "So very early in the pandemic, more or less one week after the first lockdown in, what was that, mid-March 2020, we had a decision at hand that we will not further go into using on-premise video conferencing software like Jitsi and Big Blue Button that we had set up because we saw tremendous quality issues with that and scalability issues intrinsically to that video conference software and we made the decision to go to Zoom."

Participant P07 provides further insights into the decision-making process, narrating a shift from on-premise solutions like Jitsi and Big Blue Button to Zoom. The transition was prompted by perceived quality and scalability issues with the former, coupled with a swift decision made just one week after the initial pandemic lockdowns in mid-March 2020.

When questioned about the specific choice of Zoom amid a plethora of available alternatives, participants articulated a blend of pragmatic considerations and personal experiences that shaped their decisions.

P07: "We didn't want to do Microsoft Teams because that forces you into the Microsoft Cloud. .... And when it further on, the other alternatives, we didn't have WebEx before, so why choose WebEx over Zoom when WebEx is more expensive and less capable. And the same thing for BlueGene or whatever. So choosing one of those software products would have not brought any advantage and prices would rather have been higher than for Zoom. And with Zoom, it was a very good decision because more or less all the other universities followed suit and did the same thing and went for Zoom. So it became the de facto standard."

Participant P07 sheds light on the decision-making process, emphasizing a strategic evaluation of the available options. The dismissal of Microsoft Teams was rooted in a desire to avoid entanglement with the Microsoft Cloud. The scrutiny extended to other alternatives like WebEx and BlueGene, with considerations of cost-effectiveness and capability playing pivotal roles. The decisive factor, however, was the cascading effect of universities collectively opting for Zoom. Participant P07 notes that Zoom emerged as the de facto standard due to widespread adoption, creating a compelling case for its selection.

P02: " ..... And there was Zoom and the users had their private experiences with Zoom and therefore they had the argument yeah zoom is working we use it now and this was the reason by introducing Zoom parallel to Jitsi and Big Blue Button."

[4] BigBlueButton is an open-source self-hosted software application crafted for virtual classrooms, specifically tailored for online education [33]

P07: "People had experiences with Zoom, good experiences, and they were available and they did exactly what we needed."

Participant P02 sheds light on the influence of users' prior experiences with Zoom. Users advocated for Zoom based on positive past experiences, making a case for its adoption parallel to existing solutions like Jitsi and Big Blue Button. Participant P07 further reinforces this by highlighting that people had positive encounters with Zoom. The platform's reliability and alignment with their specific needs further solidified its appeal.

However, this adoption was not without challenges. Participant P02 acknowledged that Zoom is not GDPR compliant, and the decision to use it during the pandemic was due to user pressure. However, the issue of GDPR compliance became more prominent when the Data Protection Officer (DPO) conducted a thorough investigation. Participant P02 elaborated on the DPO's findings, stating, *"there was a big investigation of the data protection officer Germany, and there's a long list of the non-GDPR compliance of Zoom."* The prohibition enforced by the German data protection authority led to a decision to discontinue the use of such video conferencing systems in the future. The evidence supporting Zoom's non-compliance was documented extensively, as Participant P02 explained, *"there's a document, and it's I think 20 pages, and it's very detailed why you can't use Zoom, WebEx, and so on, and it's really detailed, explaining where the problems are."*

The initial decision to adopt Zoom was significantly driven by user pressure, as Participant P02 highlighted, *"This decision for Zoom was really a user decision because there are some users quite louder than others."* The familiarity of the university's administration staff with Zoom in their private use further influenced the decision to introduce it at the university.

However, replacing Zoom poses a substantial challenge. Despite acknowledging that Zoom is currently preferred due to certain technical advantages, Participant P02 expressed confidence in the new system, OpenTalk, reaching comparable parameters. The intention is to eventually phase out Zoom, marking a significant challenge in transitioning to an alternative video conferencing system.

Adding complexity, there's an anticipation of a considerable increase in Zoom prices. Participant P02 stated, *"Nevertheless, it's also a reality the prices for Zoom will dramatically increase."* The current cost-effective licenses, supported during the COVID period, are expected to surge in the upcoming contract renewal. The era of affordable Zoom licenses for universities seems to be drawing to a close.

While acknowledging user preferences, Participant P02 emphasized the need for a balanced approach, stating, *"Users can always say we want to use Zoom but when the users don't have any money, nobody can."* This reflects a pragmatic understanding that, despite user preferences, budget constraints and the availability of alternative technically sound solutions may guide the ultimate choice of the university's video conferencing platform.

Summary: Amazon Web Services (AWS) emerged rapidly, described as a "hair on fire" onboarding driven by immediate needs rather than deliberate strategy. Azure, propelled by Microsoft's product evolution, became integral, embodying a reactive adaptation to industry shifts. Google Cloud Platform (GCP) entered incidentally, revealing governance challenges but also recognition of its analytics strengths. Oracle and Huawei Cloud additions reflect strategic choices beyond major players, embracing a multi-vendor strategy. The university's cloud-first policy underscores a transformative shift, prioritizing cloud solutions. The adoption of Zoom amid self-hosted infrastructure aligns with pandemic-induced demands, revealing a shift driven by immediate necessities. While user preferences initially favoured Zoom, GDPR compliance challenges and anticipations of increased costs pose hurdles.

4.1.3 University's Guide to Cloud Integration

From the dynamic interplay of cloud service providers to the proactive cloud-first policy, the next logical inquiry is whether these decisions are guided by a comprehensive strategic framework. This sub-theme investigates the existence and content of a master document or set of guidelines that delineate the university's vision and tactical roadmap for IT infrastructure development, with a particular focus on cloud computing.

As the university navigates through a landscape rich with technological possibilities, the presence of a strategy or framework document would serve as a critical touchstone. Such a document would not only affirm the intent behind the migration but also provide a structured approach to its execution, ensuring that each cloud adoption aligns with the overarching goals of the institution. This sub-theme seeks to uncover how the university codifies its IT principles, the strategic foresight into its infrastructure's evolution, and the systematic considerations concerning cloud integration.

P13: "And we also have a fairly well-defined standards and policies from a university infrastructure standpoint."

Participant P13 indicates that the decisions related to cloud factors are influenced by a foundation of well-defined standards and policies within the university's self-hosted infrastructure framework. The use of the term *"well-defined standards"* implies a clear and established set of criteria that govern various aspects of the university's infrastructure, possibly encompassing security, performance, compliance, and other relevant factors. These standards provide a benchmark against which decisions related to cloud services can be evaluated, ensuring alignment with the overall goals and requirements of the institution. By referring to *"policies from a university infrastructure standpoint,"* Participant P13 highlights that the decision-making process is not only informed by technical considerations but also shaped by the broader institutional context. This integration of standards and policies reflects a strategic approach to cloud adoption, emphasizing consistency, coherence, and adherence to established norms within the university's infrastructure ecosystem.

P14: "We have a cloud platform team who looks after the, who looks after both the, the ongoing [something] and operations of it, but also the, the evolving cloud architecture collaboration with, with the, the cyber guys. So it's, it's cloud, cloud, cloud platform team and cyber."

The cloud platform team, mentioned by Participant P14, is responsible for the operational maintenance and the ongoing evolution of cloud architecture. This team works in collaboration with cybersecurity specialists to ensure that the cloud infrastructure is not only effective but also secure. This collaborative approach indicates that the university's cloud strategy is a cross-functional effort, integrating technical operations with security considerations.

P15: "There is a security plan, a formal security plan at <name-of-university>. I can't share it with you but it's formal and it deals with if you will it deals with that which we expose to the university as a whole and that which we use to address situations inside the department and inside how we preserve services."

Participant P15 speaks of a formal security plan. This document is not just a reactionary measure for when issues arise but serves as a proactive blueprint that dictates how data is managed and protected across the university. It implies a strategy that is cognizant of the risks inherent in exposing data to the cloud and the need for specific protocols to manage these risks at both the university-wide level and within individual departments.

When we asked Participant P14 about the factors considered by decision-makers, they highlighted a risk-based approach and regular audits as crucial elements.

P14: "Oh, that's a good question. I don't really know. And I think we've got, we, we, there is, we try and manage, we try and approach things from a risk-based approach, risk-based way. And we're also, we also get audited on this on a regular basis. So we, we have to make sure that not only the documentation is up to, up to snuff, but also that the reality that the documentation actually describes is where it needs to be."

Participant P14's reference to a risk-based approach and regular audits illustrates a dynamic and responsive strategy. This suggests that the university's cloud strategy is not static but is regularly reviewed and adapted in light of new risks, technological advancements, and audit feedback. This iterative approach ensures that the strategy remains relevant and robust.

P14: "I'm not sure they had, I don't think they had that when they started doing the migration three or four or five years ago, but we have various documents, support cloud strategy. Obviously, the, the, we have a big cyber transformation program, an uplift program that's been running for a number of years. And that sort of provided the, the security thinking and the architectural maturity that we put on top of it, we built in. And it also, we have a cloud, cloud uplift program that's running to make sure that we that we've got, you know, got the right, right architecture, right, right kit, right tooling, where it needs to be. And so I wouldn't say that there is one cloud strategy document, because effectively cloud is, you know, that's how we do business now. So it's, it's just, it's, I wouldn't call it a commodity, but it's, it's, it's the foundation of what we do for the most part."

Participant P14 describes a scenario where the cloud strategy is not confined to a singular document but is represented through various evolving documents that have materialized post-migration. This indicates that the university's cloud strategy is an evolving construct, one that has developed reactively in response to the growing centrality of cloud services in the university's operations. The reference to a *"big cyber transformation program"* and a *"cloud uplift program"* suggests that the university is actively engaged

in enhancing its cloud capabilities and security posture. This ongoing development of documentation and strategic programs reflects an understanding that cloud computing is not a static field and that the university's approach to it must be agile and adaptable.

P13: "I guess the adoption of cloud at the university has been mostly organically developed because of a lack of a unified cloud adoption strategy at the CIO level, I'll say, chief information officer. We do have now, and I could point you probably to the white paper, which explains what the best practices are around, you know, NIST, cloud adoption, things like that.

Participant P13 provides context to this narrative by highlighting the organic development of cloud adoption, which began without a unified strategy from the university's chief information officer (CIO). The white paper mentioned by Participant P13, which delineates best practices for NIST [43] cloud adoption, suggests an initiative to create a more structured approach to cloud integration. However, the lack of a directive to use this white paper as a template for an organized cloud strategy implies that the university's approach to cloud adoption has been more emergent than prescriptive.

4.1.3.1 Cloud Strategy and Diverse Spectrum of Stakeholders

When probing the participants about the process and the stakeholders involved in shaping the university's cloud strategy, various perspectives emerge. Participant P04 provides a detailed breakdown of the developmental phases of their cloud strategy.

P04: "Yes, of course. This is my responsibility and I have developed a plan for the whole process of developing the cloud strategy. I have defined three phases. Currently, we are still in the first phase, but this will be closed soon."

The first phase, currently ongoing, involves individual discussions with stakeholders to gather their wishes, requirements, and demands. This information serves as the foundation for a preliminary structure—a table of contents for the future cloud strategy. Moving into the second phase, group discussions with stakeholders from different domains will take place. This collaborative approach aims to create a guideline, essentially a checklist, outlining the dimensions to be considered when adopting or applying for a new cloud service. By the end of this phase, a draft is expected, marking a critical milestone by July or August. The subsequent third phase involves a more extensive development process, including rounds of talks with stakeholders. This phase aims to create blacklists and whitelists for cloud-based services, offering a nuanced approach to permissible and restricted cloud usage. Whereas, Participant P03 sheds light on a workshop-based approach, where diverse perspectives are brought to the table.

P03: "So the process was to have several workshops, where everybody is bringing his or her own perspectives. And that we develop kind of guidelines first and then frame our vision and then break it down into a strategy, into roadmap.

The initial step involves formulating guidelines, framing the vision, and subsequently crafting a strategy and roadmap. Notably, stakeholders, including the CIO office, data centre personnel, and the Center for Scientific Computing, contribute to these discussions. The varying viewpoints become evident, with the CIO office exploring diverse options, the data centre leaning towards internal services, and the Scientific Computing Center prioritizing large-scale internal computing environments. Participant P12, from

the legal team's perspective, highlights a meticulous approach to evaluating potential cloud service providers.

P12: "I would say that from the legal team's perspective, they're ultimately going to look at the terms and conditions, the legal frameworks, the controls, and they're going to look at it from a legal standpoint, things like indemnification and other key kinds of legal constructs to really assess whether those are compatible with how the institution does business. So, they go into it looking at it for specific things that they're interested in. How do they handle data breaches? How do they handle damages related to those things? How do they handle notifications if there's an incident? What's their obligation to notify? All those kinds of things are really where they're focused."

Participant P12 highlights a meticulous approach used by their legal team to evaluate potential cloud service providers. The focus lies on scrutinizing terms and conditions, legal frameworks, and controls, all through the lens of legal considerations such as indemnification. Their assessment aims to align these aspects with the institution's business practices. The legal team delves into the nitty-gritty, examining how a provider handles critical issues like data breaches, associated damages, and incident notifications. This reveals a strategic emphasis on ensuring compatibility between the legal constructs of the chosen service and the institution's operational needs. Participant P12 further emphasizes the significant concern of the Chief Information Security Officer (CISO) regarding the overall security of the environment.

P12: "Um, our CISO is really concerned about how do we ensure the overall security of the environment? You know, what are the types of, um, you know, controls, network visibility, um, security around, you know, access and various kinds of network controls and parameters. So they're, they're kind of interested more in the technical nitty-gritty of how it happened. That's where their focus is."

The focus revolves around understanding and ensuring various aspects such as controls, network visibility, and security measures related to access and network parameters. Participant P12 points out that the CISO is particularly interested in delving into the technical details and intricacies of how security is maintained, highlighting a hands-on approach to comprehending the security landscape.

Furthermore, Participant P10 provides a critical perspective on the current document outlining the cloud strategy. The dissatisfaction stems from the document being perceived as *"flimsy"* and lacking a comprehensive vision. Participant P10 expresses concerns about the document's focus on merely shifting the learning management to the cloud and adopting infrastructure as a service without a clear roadmap for the future. The participant highlights the absence of strategic considerations for where the education market is heading and how the university plans to position itself.

P10: "Uh...It's flimsy. It's saying, oh, let's just move the learning management to cloud. Let's adopt an infrastructure as a service. And then we'll host it ourselves. But it also doesn't say, (I: Uh huh) if we're doing that, what are we saying about where the market is going? Where's education, higher education going? How are we going to find ourselves doing platform as a service? Where will we do platform as a service and why? Where will we do software as a service and why? Why would we keep to infrastructure as a service if we can move things to platform as a service because that would just make us more competitive. And then we can focus our cloud engineers on designing our solutions. And then we don't have to worry about the maintenance, because that's, we're quite happy to pay someone else to do that. So it isn't a well-thought-out

document. And that's why we're just taking it back to the drawing board and saying, guys, let's just rethink this from a perspective of what makes us competitive. There are a lot of other universities, private universities that are eating into our student, potential student cohort from an enrollment perspective. And we need to nip that in the bud by improving our student experience, attracting more students, and really, therefore, creating more funding for the university. So that's why I don't like that document. It's not related to where the university strategy says we should be going. It doesn't address the problems that the university has, enrollment, service experience, student success rates, research enablement. Yeah."

Participant P10 emphasizes the need for a more forward-thinking approach, explaining how the document doesn't explore opportunities like platform as a service and software as a service. The participant suggests that embracing these alternatives could enhance competitiveness and allow the university's cloud engineers to focus on designing solutions rather than getting entangled in maintenance concerns. The dissatisfaction also ties back to the broader university strategy, with Participant P10 stressing the importance of aligning the cloud strategy with the university's goals. The participant identifies key challenges, such as competition from other universities and the need to enhance the student experience, attract more students, and secure additional funding.

P13: "So our acceptable use policy, if you go look at it, it's publicly available, it is archaic. (I: Okay) And it doesn't talk about cloud, it doesn't factor in cloud, it doesn't explain, it's still mostly self-hosted on-premise centric, I guess. Maybe not so much in the words, but just the assumptions it's making."

Participant P13 draws attention to the limitations and outdated nature of the organization's acceptable use policy. The participant characterizes the policy as *"archaic"* and points out its inadequacy in addressing cloud-related considerations. The participant notes that the policy doesn't *"talk about cloud"* and fails to incorporate the nuances and specificities associated with cloud computing. The term *"self-hosted on-premise centric"* suggests that the policy is rooted in a mindset that assumes a traditional, locally managed infrastructure, and this perspective may not align with the diverse and dynamic nature of cloud-based services. Participant P13 implies that while the wording of the policy may not explicitly favour on-premise solutions, the underlying assumptions embedded in the policy are oriented toward a non-cloud environment. This misalignment underscores the need for revisiting and updating the policy to encompass the evolving landscape of technology, especially the increasing reliance on cloud services.

Adding to this strategic narrative, Participant P06 sheds light on a strategic policy that significantly influences the university's approach to its digital infrastructure—the *"cloud-first policy."*

P06: "Cloud-first policy which basically as I understand it means that when we are looking to establish all setup or update certain policies, we should firstly consider whether the decent cloud options to choose from, from running these services before."

Participant P06 discusses the university's *"cloud-first policy,"* which mandates that cloud options be considered preferentially over maintaining in-house solutions. Participant P06's statement reveals that the university is actively encouraging a mindset where cloud solutions are the default consideration. This doesn't simply mean choosing cloud services for every new need; rather, it reflects a strategic orientation that prioritizes the evaluation of cloud services' suitability first. The policy indicates a transformative shift

in the university's IT culture towards embracing the cloud as a primary resource for service deployment. When asked about why the university has a cloud-first policy in place, Participant P06 provided insight into the stakeholders' perspective that led to having the cloud-first policy.

P06:"Umm, because people who are quite senior here in the organisation tend to look at the general big picture, kind of view of things and their idea is that it is much more effective and efficient if we use cloud services. But they ain't necessarily see the economics of every single services run within the institution."

Participant P06 points out that senior figures in the organization prioritize the overarching advantages and efficiency gains associated with adopting cloud services. However, there seems to be a perspective regarding the economic evaluation of each specific service implemented within the university. This implies that while the broader organizational strategy may favour cloud adoption for efficiency, a more detailed assessment of the economic implications at the service level may not receive the same level of attention.

The stakeholder perspectives in the cloud strategy development process showcase a spectrum of attitudes within the university units. The CIO office appears open-minded, actively evaluating diverse options. In contrast, the data centre leans towards caution, displaying hesitancy in embracing cloud solutions and emphasizing internal self-hosted services. The Center for Scientific Computing, dealing with large computing environments, currently prioritizes internal service provisioning. Other participants also identified a range of contributors, including Business Analysts, the CIO, CISO, CTO, the contracting and procurement department, digital officers, the enterprise architecture team, the head of the computer centre, the infrastructure management team, IT leaders, management committee, ministry, Project Managers, security office, senior executive committee, some researchers, and the university board. This diversity in perspectives suggests that cloud strategy development is navigating through a landscape where different units within the university harbour distinct preferences and concerns.

As we delved into the cloud strategies of various participants, it became evident that while some universities had well-defined approaches, others faced challenges stemming from a lack of a coherent cloud strategy.

P04: "At the moment it was just ad hoc requests to the rectorate as well as to the staff council and the data privacy and protection officer and they were not following any procedures and for that reason there was a decision that we need such a cloud strategy to have a procedure that we can follow in the future because we believe in the future you'll have much more requests for a cloud-based services."

Participant P04 highlighted the necessity of a cloud strategy, sharing that prior to its formulation, requests for cloud-based services were ad hoc, lacking a standardized procedure. The expectation is that as cloud usage grows, a structured strategy will provide a roadmap for handling the anticipated surge in requests.

P03: "That's also my challenge. And also what we are suffering, we don't have or didn't have so far a cloud strategy. We don't have a cloud management framework or tools. We don't have specific cloud security concepts. It's more or less based on an individual basis. So everybody who's using cloud is doing it on its or her own intent."

On a contrasting note, Participant P03 expressed challenges arising from the absence of a dedicated cloud strategy, management framework, tools, and security concepts. The use of cloud resources was characterized as more individualized, lacking a unified approach. This decentralized usage pattern underscores the need for an overarching strategy to guide decision-making and ensure a cohesive and secure cloud environment.

P01:"... So we started to deal with that with our on-premise solutions. But we did not look too much into the cloud operation yet because it's not a significant proportion of the operation we are doing at the moment. ..... So we are hoping that the providers are dealing with that and we do not have any specific strategy for that at the moment."

Participant P01 detailed a reactive approach to security, primarily focusing on on-premise infrastructure. The lack of a specific strategy for addressing cloud-related issues was attributed to the current insignificance of cloud operations within their overall activities. The participant expressed reliance on cloud service providers to handle security concerns, highlighting the need for a more proactive stance.

Reasons for the lack of cloud security strategy document were also rooted in practical challenges. Participant P03 mentioned a kickoff for the cloud security strategy at the university level but cited a postponement due to a lack of availability and time constraints. Participant P18, working independently, pointed to staffing limitations as a major hindrance to documenting a detailed strategy. Participant P17 emphasized a shift in focus, with the current priority being on migration rather than developing a comprehensive security strategy.

P17: "Because my conern now is more, actually I shouldn't answer like this but frankly speaking, my concern is more on the strategy for migrating. As I mentioned just now the security, I'm just putting my 10% concentration on my security. My 90 concentration is on my migration plan and making the user experience, at least the power value of the user experience must be the same or better than the last time."

According to Participant P17, a significant part of their concern lies in ensuring a seamless migration process. The participant stated that, while security is acknowledged (noted as the 10% concentration), the majority of their attention—90%—is directed towards the migration plan. This underscores the immediate importance placed on transitioning to cloud services efficiently. The participant's emphasis on maintaining or improving the user experience suggests a strategic focus on minimizing disruptions and optimizing performance during the migration process. While the participant acknowledged the importance of security (the 10% concentration), the current institutional priority appears to be on achieving a successful and user-friendly migration. This strategic choice might be influenced by factors such as time constraints, resource availability, or specific institutional objectives, where migrating to the cloud is a more immediate concern than formulating an extensive security strategy.

When we asked the participants who have already migrated or are in a phase of migrating to the cloud if they have any security strategy or document concerning their cloud-hosted infrastructure, their responses provided insights into various aspects of data security, governance frameworks, service-specific policies, and the utilization of established IT frameworks to create the document.

P12: "Yeah, we have a data security strategy. It's on our website. It's called <name-of-policy>, one word, <website-of-the-university>, and it kind of outlines our broad level data controls and security controls for different data classifications, whether that's on cloud or premise or laptops or anything else, and kind of puts some detail around that. There's also something in <acronym-of-the-university>'s broader policy handbook that also outlines data policies for <acronym-of-the-university> as well at a very high level, but kind of puts some parameters around that additionally. Our policy handbook is public."

Participant P12 highlighted the existence of a comprehensive data security strategy, accessible on the university's website. Named "<name-of-policy>", this strategy outlines broad-level data controls and security measures for different data classifications, whether stored on the cloud, on-premises, or on laptops. Participant P12 emphasized the public availability of the policy handbook, which further delineates data policies for the university at a high level, offering transparency and accessibility.

P16: "Yeah, so the IT governance pieces are documented and then the proposal is a template. So people know some of the things. It's a continuous improvement activity. So as we mature and learn from our implementations, we keep adding additional elements or components to the proposal in the process. There's also a guideline what should come through governance. So that's set up as a scorecard of sorts."

In the context of IT governance, Participant P16 shared that the IT governance pieces are well-documented, and a proposal template is in place to guide users through the process. This continuous improvement activity involves updating the proposal template based on the university's evolving understanding and maturity in cloud implementations. Additionally, a guideline exists to determine the aspects that should undergo governance, providing a structured approach through a scorecard.

Participant P06 shed light on service-specific privacy and security policies by stating, *"Again, they have to be adapted to what a particular service is being used for. .... So it's the different services we provide have very different levels of security and policies that apply to that service."*. Participant P06 highlighted the importance of tailoring privacy and security policies to match the specific requirements of individual services. Emphasizing the need for adaptation based on each service's purpose, Participant P06 underlined the diversity in security and policy considerations across the various services provided. This approach acknowledges that different services inherently warrant distinct levels of security measures and policies.

Moreover, Participant P18 provided insights into the university's security strategy, revealing the incorporation of the ITIL (Information Technology Infrastructure Library) [8] framework into the process of drafting security strategies.

P18: "They use some very formal procedures because they have a – it's a large universities and a large amount of IT. So they have ITIL. They use ITIL. Is that the – it's a process framework for IT. And they are very strict about that, but I don't have – I don't access those documents. I don't have them. I just know that they must have them because they have a group of people that all have to stay on the same page. In order to do that, you have to have sort of official policies."

Participant P18's reference to the ITIL [8] framework provides insight into the procedural rigour behind the university's IT governance. The Chief Information Security Officer and their team within the campus IT universities adhere to formal procedures

outlined in ITIL, a process framework for IT. While specific documents were not accessible to Participant P18, the emphasis on the importance of official policies and procedures was highlighted. Lastly, Participant P10 provides insights into the university's security posture improvement plan.

P10: "From a security perspective, we're working on a security strategy. But what we've done for now (I: Uh huh) is we know what are the weaknesses in our environment from a digital security. And so we have created a roadmap for how we address those weaknesses and where we need to be better at. We also know where we are fairly good at. And so we're saying, okay, we're good in these areas, but then let's find the opportunities for continuous improvement. (I: Uh huh) So we have a very clear security posture improvement plan. And whilst we are implementing it, we're also saying let's put together a digital security strategy"

Participant P10 revealed that there is an ongoing effort to develop a security strategy. In the interim, a roadmap has been established that addresses the identified weaknesses and areas of strength in the digital security environment. This roadmap serves as a guide for continuous improvement, emphasizing the university's clear posture improvement plan. The participant also mentioned the simultaneous development of a digital security strategy that aligns security initiatives with overarching institutional goals.

When probing the stakeholders involved in shaping the security strategies and their respective perspectives, a diverse array of roles and departments within the university emerged. The central IT team, as articulated by Participants P07 and P12, assumes a critical role in focusing on controls implemented by various providers, aiming for transparency and compliance. The Chief Auditor, represented by Participant P12, brings a specific perspective centred on assessing controls, and compliance expectations, and ensuring that external entities fulfil their obligations.

P12: "The Institute auditors focused on different things. They're focused more on the controls of the various providers. How do we get a level of transparency and understanding of their controls? How do they assess those controls? Whether they're SOC reports, SOC 2, how do they show us that they're compliant with the expectations that they're supposed to be fulfilling? We have the ability to come to us as the IT department and ask us all those questions when we operate things, but when somebody else is operating things, we're not. How do they do that? So their question really becomes, how do we ensure that those folks at <acronym-of-the-university>, you know, doing business with, and depends on for our business are fulfilling their obligations. So they come at it from a very specific standpoint around compliance."

The CIO as stated by Participants P07 and P11 and the Chief Information Security Officer (CISO) stated by Participant P12 play important roles, each contributing unique insights into security strategies. The data centre, led by Participant P04, is intricately involved in crafting strategy and framework documents, emphasizing its central role in the security landscape. Legal considerations are well represented, by the legal team as stated by Participants P06 and P12. The Office of General Counsel stated by Participant P12, focuses on the compatibility of legal constructs with the institution's business practices. The sponsored research office, as outlined by Participant P12, concentrates on ensuring that security measures align with research commitments, emphasizing compatibility with data privacy requirements in the context of grants and research awards. This multifaceted engagement highlights the collaborative and comprehensive approach the university takes, involving a spectrum of roles, from administrative heads and procurement teams to those directly engaged in running and overseeing services.

Summary: The examination of the university's cloud integration strategy uncovers diverse stakeholder perspectives, evolving approaches, and strategic considerations. Participants reveal well-defined cloud strategies and meticulous governance frameworks, while others express challenges due to the absence of a coherent strategy, relying on ad hoc approaches. Stakeholders, including the CIO office, legal teams, and data centres, contribute distinct viewpoints, highlighting the need for a collaborative and cross-functional approach to cloud strategy development. The narrative emphasizes the iterative nature of strategy development, integration with university-wide objectives, and the dynamic landscape of security considerations, enriching the understanding of the university's cloud journey. Variations in priorities emerge, with some participants prioritizing migration plans over comprehensive security strategies, reflecting the evolving nature of cloud adoption within the university's operational landscape. Additionally, the data suggests that the university's cloud strategy primarily originates from management/CIO offices rather than being solely a technical decision driven by IT requirements. While there is a strategic direction set by management, the adoption and implementation of cloud services often involve a blend of top-down strategy and bottom-up responses to specific requirements. Senior figures within the organization, such as CIOs and other leaders, significantly shape the strategic direction toward cloud adoption. This aligns with observations from Section 4.1.2, where participants highlight the influence of senior management in driving cloud strategies. The strategic decisions regarding cloud adoption are often motivated by broader organizational goals, efficiency considerations, and the evolving landscape of technology. The *"cloud-first policy"* mentioned by Participant P06 reflects a paradigm shift imposed by management, encouraging a mindset where cloud solutions are the default consideration. The data indicates that the decision to embrace the cloud is more about aligning with organizational objectives and industry trends than being solely driven by specific technical requirements.

4.2 The Decision Matrix: Factors, Choices, and Decision-Makers

This theme delves into the landscape of decision-making processes surrounding IT infrastructure within the universities. This exploration is guided by three key components: Factors, Choices, and Stakeholders. While exploring the Factors, the focus is on understanding the considerations that propel universities to embrace cloud-hosted or hybrid environments, the decision-making dynamics leading to continuing with the self-hosted environments, and the impact of the pandemic on infrastructure choices. The sub-theme Choices involves discussing the options available to the universities as they navigate the complex terrain of IT infrastructure. Lastly, the theme explores the formal and informal dimensions of decision-making processes and identifies the diverse group of Stakeholders who contribute to shaping the trajectory of IT infrastructure within the universities.

4.2.1 Factors

In this section, we explore the diverse factors influencing the adoption of cloud solutions in higher education institutions. These factors encompass a wide range of considerations, including the challenges posed by outdated legacy infrastructure, the imperative for scalability, availability, and robust disaster recovery, and the strategic sequencing of migrating critical production systems to the cloud. Additionally, we delve into the role of technology trends, connectivity capabilities, and the dynamic nature of cloud services in motivating migration decisions. Furthermore, we examine the interplay of budget constraints, job security concerns, and the appeal of self-hosting as an alternative to cloud adoption. Lastly, we discuss the varied perspectives on the influence of the pandemic on cloud migration, highlighting both direct and indirect impacts on adoption decisions within universities. Through these insights, we gain a comprehensive understanding of the multifaceted factors shaping the cloud adoption landscape in higher education.

4.2.1.1 Cloud Conundrum or the Optimal Mix

The journey towards cloud migration is often guided by a complex interplay of factors. Predominant among these are the considerations related to hardware cost and overall expenditure. Seven participants highlighted the significance of this factor, emphasizing the financial implications associated with maintaining on-premise infrastructure.

Participant P05 highlights the stark contrast between on-premise hardware management and cloud-based solutions:

P05: "Then you have to do this on-premise and you have to buy you own hardware and you have to manage your own hardware and you have to patch your own hardware and you have to wait for a long time and you get the hardware delivered and then you do that in the cloud you can do that in a minute. And if you don't need any more in the cloud you just stop it. And if you buy the hardware you still have the hardware and they will be unused."

Participant P05's insights underscore the advantages of cloud solutions, particularly their agility and cost-efficiency. Cloud services provide the ability to swiftly provision resources as needed and release them when they are no longer required [43]. This stands in stark contrast to traditional on-premise approaches, where acquiring and maintaining hardware can be time-consuming and resource-intensive.

P15: "If it has a dollar to spend, it would rather spend it on academic things like laboratories or more space for students or something like that, other than having an internal cloud, no matter how low in cost because of the tip-in cost to do it with real money."

Participant P15 expresses a preference for allocating financial resources to academic priorities, such as laboratories and student space, rather than investing in an internal cloud infrastructure. The participant suggests that despite the potential cost-effectiveness of an internal cloud, the university prioritizes spending on academic necessities over building and maintaining an internal cloud system.

Decision-Making Factors and Considerations

Participant P13 offers insights into the considerations before migrating to the cloud.

P13: "We would probably say, is that does the vendor have a native cloud solution that you wanna look at? Rather than take their local on-premise self-hosted solution and throwing up a bunch of VMs and a VPN or something like that and trying to do it yourself in the cloud, pretty sure the vendor has figured out a better way to do that, a cheaper way to do that. Maybe they don't push those savings to you, but there has to be a conversation early on between migration and refactoring or re-sequencing. Because the idea of lift and shift while appealing to a lot of departments does not play out well when it comes to the cost calculations. Can't just say, hey, these servers are this big, let's just go sequence the same thing up in the cloud. That's a recipe for disaster and sticker shock[5]"

The participant advises checking if the vendor offers a native cloud solution. This suggests that utilizing a solution specifically designed for cloud environments by the vendor might be more efficient and cost-effective than attempting to migrate a local on-premise solution to the cloud. Furthermore, Participant P13 strongly discourages a *"lift and shift"* approach, where on-premise solutions are simply transferred to the cloud without modification. The participant points out that this method may not be cost-effective and could lead to *"disaster and sticker shock."*

Complementing this perspective, Participant P14 offers a practical view of the challenges posed by managing resources, especially in the context of numerous small tasks:

P14: "Lots of... there's a long tail, so lots of small things. It's not... it's not a... it's not sustainable to do that and manage that in your own data centre. Keeping the kid up to date."

These insights collectively highlight the transformational potential of cloud migration, with agility and cost-efficiency being key drivers.

License cost comparison between on-premise and cloud solutions adds to the list, as highlighted by Participant P17 - *"Uhh what would be the license cost on the cloud and what will be the license cost here. And then .. that's one. "* The participant draws attention to the critical consideration of licensing expenses, probing into the costs associated with both on-cloud and on-premise scenarios. Participant P13 further adds to the discussion stating,

P13: "The licensing confuses them quite often, especially with Microsoft. Microsoft uses licensing kind of, I'd say adversarially when it comes to trying to host Windows solutions on other people's clouds."

In particular, the intricacies of licensing, especially in the context of Microsoft solutions, can be a source of confusion. Participant P13 suggests that Microsoft's licensing practices, when it comes to hosting Windows solutions on external clouds, can be perceived as adversarial. This implies that navigating the licensing landscape, particularly with certain vendors, poses a notable hurdle during the migration process. The ambiguity and complexities surrounding licensing add a layer of intricacy to the decision-making and execution of cloud migration strategies. Not only in cloud environments but also in on-premise settings, participants encounter license-specific challenges.

[5]shock or dismay experienced by the potential buyers of a particular product on discovering its high or increased price[48].

P01:" So typical technical challenges we are facing is more about inappropriate hardware or inappropriate licensing terms. "

Participant P01 pointed out that a prevalent issue revolves around the appropriateness of hardware and licensing terms. This observation implies that the challenges extend beyond the cloud domain and are rooted in fundamental aspects of technology infrastructure, irrespective of the deployment model. The mention of *"inappropriate hardware"* suggests potential mismatches between system requirements and the existing hardware, while the reference to *"licensing terms"* indicates complexities related to software licensing agreements. Participant P01's identification of these challenges emphasizes the broad spectrum of technical considerations faced by participants, highlighting the significance of addressing infrastructure-related issues both in cloud and on-premise IT environments.

Participant P04's input highlights another important factor — the necessity for substantial infrastructure, particularly for tasks such as in-depth data analysis and various artificial intelligence (AI) applications like deep learning and machine learning. As Participant P04 succinctly puts it:

P04: "some services also require huge infrastructure for example for in-depth data analysis or any types of artificial intelligence, deep learning or machine learning and yeah this is quite difficult to offer and run on your own servers."

This perspective resonates with the challenge outlined by Participant P05, emphasizing that maintaining and supporting in-house data centres becomes increasingly challenging when considering the substantial infrastructure demands of advanced analytical and AI tasks. In essence, Participant P04's observation further underscores the complexity of the hardware cost and infrastructure management factors in the context of cloud migration decisions. However, it's essential to note that not all participants share the same opinion on cloud adoption, particularly concerning cost implications.

Participant P14 introduces a contrasting view by stating:

P14: "Many of the assumptions that that program started out with had to do with cost savings, which I think in 2023 or even in 2019 or 2018, people have come to realize that there actually, there were no cost savings to be had here. There are gains, but cost probably isn't one of them."

This perspective underscores that although migrating to the cloud can bring about several benefits, such as increased efficiency and scalability, the initial expectations of significant cost savings may not prove accurate over time. Participant P07's comment explains the financial dynamics at play over longer terms.

P07: "Initially, the price tag could be interesting. It's very clear that in the long term, prices of commercial cloud providers will be higher than what we have to invest in CapEx and OpEx into our own infrastructure."

Commercial cloud providers may offer initial cost advantages, making them appear appealing from a short-term budget perspective (initial attraction). However, in the long term, they anticipate that costs associated with commercial cloud providers will surpass the investments required for maintaining in-house infrastructure. In parallel, Participant P15 articulates an understanding of the economic benefits associated with having their local cloud infrastructure, as opposed to relying on major cloud service providers like AWS.

P15: "I'll give you an example. If somebody was going to buy a standard unit of compute from Amazon Web Services, by standard unit of compute, I mean, a server with eight gigabytes of memory and two processors, that would probably be last time I checked about $80 per month or something like that. If universities can host that and provide that services for about 10 to $15 a month to a user. 'So there are significant economic benefits to having our own local cloud."

The participant provides an example, stating that universities could potentially offer computing services at a lower cost ($10 to $15 per month) compared to the price of the same services from a major cloud provider (approximately $80 per month). However, despite recognizing these economic advantages, the participant notes that they are still relying on major cloud service providers.

In the context of the **cost** being a significant driver for cloud adoption, Participant P12 provides yet another dimension to the discussion - the cost of the workforce. They mention the competitive labour market and the challenge of keeping talents and resources within the institution. As Participant P12 aptly states,

P12: "And I'd say the other one is, particularly for us, and this is speaking as <acronym-of-the-university>, it's really become difficult in a competitive labour market to keep those talents and those resources you need to run that business well. It's been really hard to keep them on staff. We would bring people in, we would train them, they would leave for better opportunities with a cloud provider or more lucrative financial opportunities outside higher education."

Participant P12 highlights the difficulties universities face in retaining skilled personnel needed to manage on-premise infrastructure. The competitive landscape, particularly in the context of cloud technology, makes it challenging for the university to retain talented staff members. The mention of training individuals who subsequently leave for better opportunities with cloud providers or more financially lucrative options outside higher education underscores the impact of external factors on talent retention within the university. This aligns with the observations made by Participant P05 regarding the challenges of managing in-house hardware. The problem of retaining talented staff members further complicates the task of universities in keeping up with the constantly evolving technology, providing reliable infrastructure, and supporting emerging technologies. This can lead to a lack of staff for managing in-house infrastructure, which aligns with the earlier identified challenge. Previous work has noted this effect in the context of system administration, explaining that changing jobs is vital to career advancement in this field [35].

The availability of services plays another important role in the cloud versus on-premise dilemma, as Participant P01 points out:

P01: ".... and you do not have necessarily the same level of availability as you might get from a cloud-hosted service"

This highlights another factor influencing the decision-making process, underscoring the trade-offs universities face when choosing between on-premise and cloud-based solutions. Participant P01 recognises that cloud-hosted services often offer a higher level of availability compared to alternative hosting arrangements. Participant P18's insights add depth to this perspective as the participant states:

P18: "Well, here again, it's a simple question. If you want to run your own campus support applications on a rented Kubernetes cloud or rented OpenStack virtual machines, you still have to have skilled programmers and system administrators in order to do that. But if you purchase a service like Blackboard or ServiceNow, then all you have to have is somebody who knows how to dial 1-800-HELP-DESK, right?" But then you're at the mercy of somebody else's support infrastructure.

Participant P18 acknowledges that the decision to run campus support applications on a rented cloud or virtual machines still necessitates skilled programmers and system administrators. In contrast, purchasing services like Blackboard[6] or ServiceNow [50] simplifies the technical expertise required. This directly aligns with P01's point about different levels of availability. When connected with the perspective of Participant P05, these insights paint a comprehensive picture of the decision-making landscape. The complexities of factors like hardware cost, infrastructure requirements, staff retention challenges, and service availability all interplay in the decision matrix.

Shift in Operational Dynamics

Participant P01 adds to this discussion by stating the shift in the nature of support requirements in contemporary settings compared to two decades ago.

P01: "So you need a wider kind of support and in general need to deal with more people and more different problems as you did for instance, 20 years ago."

The participant underscores the necessity for a broader and more extensive support framework, emphasizing the need to engage with a larger number of individuals and address a diverse range of issues. The use of a *"wider kind of support"* suggests a need for a more expansive and inclusive approach to addressing the challenges and demands of the current environment. The participant implies that the support landscape has expanded beyond its previous scope, requiring a response to a greater variety of issues. The phrase *"deal with more people and more different problems"* underscores the increased diversity and volume of challenges encountered, indicating that support roles now involve interactions with a larger user base dealing with a broader array of issues.

However, Participant P18 introduces a caveat – the dependency on someone else's support infrastructure. This emphasizes the potential trade-off of relinquishing control over certain aspects of service maintenance and troubleshooting when relying on external service providers. Participant P18 further highlights the advantages of purchasing services from external providers, particularly in terms of eliminating the need for local equipment maintenance and associated skill requirements by stating that:

P18: "When you buy these services from somebody else, you don't have to maintain your local equipment and you don't have to have people with skills to manage it. All you have to have is somebody who's known to the service provider's tech support line. (I: Mm-hmm) Which is fine as long as nothing ever breaks."

This perspective addresses the challenge of insufficient staff resources by proposing a solution that involves delegating hardware maintenance and technical expertise re-

[6]Blackboard, Now known as Anthology - exclusive, holistic EdTech ecosystem—including a CRM, SIS, and LMS [32]

quirements to third-party service providers, as previously mentioned by Participant P12. However, Participant P18's statement adds a layer of complexityesting that while this approach has its advantages, it also introduces a level of dependence. The statement, *"Which is fine as long as nothing ever breaks,"* implies that reliance on external services comes with the risk of service disruptions beyond an institution's immediate control. Participant P18 further adds to the discussion by stating that:

P18: "It's a question of cost and risk and convenience. And it's the convenience of the cloud weighed against the cost and the security of the cloud. And they have to make their own decisions."

Participant P18's mention of the convenience factor attracts the universities as they often offer streamlined access to a wide range of services and reduced administrative burden. These advantages can significantly enhance an institution's operational efficiency and agility. However, Participant P18 also emphasizes the need to weigh this convenience against the cost and security considerations associated with the cloud. Cost considerations encompass not only the immediate financial implications but also the long-term financial sustainability of cloud adoption. Universities must carefully evaluate the total cost of ownership and assess whether the convenience gained outweighs the expenses incurred. It brings up the important question of **whether the convenience and reliability of cloud-hosted services outweigh any concerns related to cost, data security, and control.**

P18:" Yeah, so basically there's a... When you go into the cloud, you suffer the possibility of things like this and you're at the mercy of the cloud provider and all the people that the cloud provider depends on to avoid these kinds of things and to solve them quickly when they happen. So. "

Participant P18 draws attention to a significant trade-off associated with utilizing cloud services, specifically highlighting the potential risk of circular dependencies leading to login failures. The participant explains that when a university migrates to the cloud, it exposes itself to the possibility of such issues, becoming reliant on both the cloud provider and the network of dependencies associated with the provider to prevent and resolve these challenges promptly. The term *"circular dependencies"* suggests a situation where multiple components or services depend on each other in a loop, and this interdependence can lead to complications, particularly in the context of user authentication and login processes. Participant P18 points out that this trade-off between convenience (of using cloud services) and the potential risks involves being at the mercy of the cloud provider and its network of dependencies.

In addition to the multifaceted landscape of factors already known, there is another set of factors that adds another layer which weighs into the decision matrix. Participant P03, hailing from a business environment, offers an insightful perspective:

P03: "I'm coming from a business environment. So I think when you have pressure to be fast, agile, and cost-efficient, you're much faster to go to the cloud. And the universities had to focus much more on formal considerations than on objective, clearly hard facts."

Participant P03 emphasizes that in business-driven contexts, the need for speed, agility, and cost efficiency often propels universities toward cloud adoption. In such settings, the urgency to achieve competitive advantages and deliver results faster makes the cloud an attractive solution. This perspective underscores how external pressures from

the business world can significantly impact cloud migration decisions within higher education. This observation aligns with findings from Fiebig et al.'s research [26], which noted a similar pattern in certain countries. In these cases, organizational alignment resulted in the replacement of academic leaders by administrators and business managers overseeing university operations. These new managers facilitated the importation and integration of enterprise tools and culture into the core of public education, fostering increased cloud adoption.

Participant P10 adds another dimension by highlighting the impact of business drivers on the cloud adoption decision:

P10: "So I think for as long as your business drivers are different, which they are with contact universities, we will think about cloud differently."

P10 notes that the considerations around cloud adoption may differ when the underlying business drivers vary, such as in the context of contact universities. These new insights bring forth a compelling layer to the decision-making process. They emphasize that the landscape of cloud migration in higher education universities is not uniform but rather influenced by a diverse array of factors driven by both the academic and business realms. The intricate interplay between these perspectives enriches our understanding of the complex web of considerations that universities grapple with when making cloud migration decisions.

On the other hand, Participant P16 sheds light on their multifaceted motivations for cloud migration, emphasizing that cost is not the sole driving factor.

P16: "So we're really not highlighting cost is the main reason. A lot of it is security. It's about redundancy. it's about stability, it's about flexibility and a number of those reasons behind our choices."

As stated by Participant P16, the decision to transition to the cloud is anchored in a strategic combination of considerations, with a predominant focus on security, redundancy, stability, and flexibility. By leveraging cloud services, universities seek to enhance the stability of their IT infrastructure. This can encompass aspects such as robustness, reliability, and the ability to withstand potential challenges or disruptions. Flexibility is positioned as an additional motivator for cloud migration. The inherent flexibility of cloud environments allows universities to adapt swiftly to changing requirements, scale resources as needed, and optimize their IT infrastructure based on evolving business demands. The acknowledgement of security, redundancy, stability, and flexibility as key drivers suggests a holistic approach to cloud adoption—one that encompasses various facets of universities' needs and priorities.

In a related context, Participant P01 contributes to the discussion by highlighting the ease of integrating cloud services into existing workflows by stating that for *"various cloud services, usually the integration into the different workflows is not that complicated."* The perception here is that the integration process is generally straightforward when incorporating various cloud services into different operational processes. This ease of integration can be a compelling factor for universities seeking to minimize disruptions and seamlessly transition to cloud-based solutions. Participant P01 sheds light on the changing landscape of user expectations after integrating cloud services, highlighting potential challenges arising from variations in access rights and contextual differences.

P01: "So users might expect certain things because they are available in the realm of their private Microsoft account or with the Microsoft account they acquired from some institutions they are cooperating with. But if your own institution sets totally different access rights and rights to operate or to be able to use certain applications or not, those expectations can be really confusing for every site because the user of course is kind of expecting he or she will get everything at her fingertips, what she thinks she needs at the moment and doesn't necessarily realize that it pretty much depends on in which context role or whatever she is operating. So there we will, I would expect to see quite some challenges in the domain regarding users need to rethink and relearn, administrators need to relearn and so on."

Participant P01 points out that users may have certain expectations based on their experiences with private Microsoft accounts or accounts associated with collaborating institutions. However, the participant notes that institutions may set different access rights and operational privileges, leading to potential confusion for users. The discrepancy in access rights and the varying permissions granted by different institutions can create a scenario where users expect a seamless experience but encounter differences based on their operating context or roles within their own institution. Participant P01 emphasizes that users may anticipate having everything at their fingertips, reflecting the convenience and accessibility associated with cloud services. Yet, the participant anticipates challenges arising from the need for users and administrators to rethink and relearn their approaches to account for these contextual variations.

P13: "I mean, there's a myriad of reasons for individuals to start looking at the cloud. Some researchers needed or realized that cloud provided more elasticity, more scaling. They had grants they wanted to throw, you know, hundreds of GPUs at. University didn't have that on-premise or self-hosted. "

Participant P13 notes that the cloud becomes a compelling solution for researchers who seek to harness additional power, such as deploying hundreds of GPUs (Graphics Processing Units), especially when such capabilities may be limited in an on-premise or self-hosted environment provided by the university. Furthermore, Participant P14 highlights how the cloud provides a workbench where users can seamlessly spin up their own workloads. This self-service model empowers users to dictate the specifications of their workloads, offering a level of control and flexibility that was previously unimaginable.

P14:" What the cloud gives us is an opportunity for us to provide you with a workbench where you can spin up your own workloads. I wanted to, what I want to run on it, this is the, these are the specifications and off you go. So I think that's the self-serve type and self-monitoring aspect of it that is a really attractive dimension of cloud where you can get your own kit stood up in minutes and you can turn it off and turn it back on. You can monitor the cost, you see the performance, you can, yeah, it gives control to either an end user or an application owner that was nowhere to be seen in the old world. Sort of removes that whole infrastructure element, makes it very, yeah, it's abstracted from you."

Participant P14 emphasizes how the cloud is capable of providing users with real-time visibility into their workloads and how this enables users to monitor performance metrics, gain insights into resource utilization, and make informed decisions, all in the quest for a more efficient and optimized computing environment. Participant P14 also underlines how cloud platforms facilitate the swift and tailored provisioning of resources.

Whether it's computing power or storage, users can navigate the cloud's landscape to obtain the resources they need promptly without hampering their existing workflows. Moreover, cloud migration drives a transformative shift in ownership and control, as stated by Participant P14. Cloud platforms bestow a heightened sense of control and ownership upon end users and application owners alike. This decentralization of control marks a departure from the traditional infrastructure paradigm and enters into a new era where resource management takes on a more dynamic and user-centric form. In tandem, Participant P13 draws attention to a significant factor in cloud computing—the gap between cloud vendor promises and the actual realities of implementation.

P13: "People have this unrealistic expectation. I also think early on in cloud, that may have been a well-worn axiom that cloud vendors talk about elasticity and scaling out and scaling up and how you can finish your grant research in a week instead of a year because we have all these great solutions and on-demand or reserve instances. You may save some money. That "MAY" usually does not become a reality if you do it wrong."

Participant P13 recalls a historical perspective, mentioning that in the early stages of cloud computing, there was a prevalent belief in the transformative power of cloud solutions. The participant cites examples like elasticity, scaling capabilities, and the potential for accelerated research, facilitated by on-demand or reserved instances. However, Participant P13 introduces a note of caution, highlighting the discrepancy between what vendors may promise and the actual outcomes, particularly if the implementation is not done correctly. The participant uses the term "unrealistic expectation" to characterize the overly optimistic outlook that some individuals or organizations may have regarding the transformative potential of cloud services. Participant P13 emphasizes the conditional nature of potential cost savings, noting that the promised benefits may not materialize if the implementation is flawed or lacks proper planning.

Continuing the discussion, Participant P11 delves into the motivations behind the decision to migrate to the cloud, shedding light on the challenges posed by legacy infrastructure.

P11: "Yeah, the challenge has always been the legacy infrastructure gets old and obsolete and to replace it takes ages to actually wait for these things to come. And it's easy on cloud where there is a scaling and there is most of the drivers for this was scaling the risks of DR, the risk of availability and the risk of making sure that the infrastructure is appropriate for the services that we require for the university. So it was the drivers that made us adopt the cloud options."

According to Participant P11, the perpetual struggle with ageing and obsolete legacy infrastructure prompted the exploration of cloud-based alternatives. This echoes a common sentiment in the IT landscape, where traditional on-premises solutions often face delays in replacement due to lengthy procurement cycles and technological obsolescence. Cloud Technology, as articulated by Participant P11, offers a compelling solution to these challenges, primarily driven by three key factors: scalability, availability, and robust disaster recovery (DR) capabilities. Unlike the lengthy timelines associated with replacing on-premises infrastructure, the cloud provides a swift and adaptable solution, allowing the organization to scale resources according to demand.

Furthermore, the emphasis on risk mitigation, especially in terms of disaster recovery and ensuring high availability, emerges as another driver. Participant P11 emphasizes the importance of crafting an infrastructure that is not only responsive to current service

requirements but is also resilient in the face of unforeseen disruptions. This highlights a strategic shift towards cloud solutions that inherently embed scalability and robust disaster recovery mechanisms, offering a more agile and responsive approach to infrastructure management. Additionally, system architecture compatibility is important too, as Participant P17 underscores:

P17:" What was the number of user access to the system? High Availability, your RPO [Recovery Point], whether you need replication, data replication is required or not and all those things you have to look it, especially the architecture of the system. Once you understand the architecture of the system, you have to find the provider who can able to provide the nearest architecture to your system"

Participant P17 emphasizes the importance of understanding system architecture compatibility, asserting that the closest match of the Cloud Service Provider's (CSP) system architecture to the university's needs is crucial. This consideration encompasses aspects such as the number of users accessing the system, high availability, recovery point objectives (RPO), and the necessity for data replication. The participant underscores the significance of aligning the chosen CSP with the specific architecture requirements of the university's systems.

Scalability stands as another important factor as stated by the Participants P05 and P07. Participant P05 succinctly points out the importance of scalability and flexibility, *"So scalable and flexible is important for them."*, signalling that these aspects hold significant value in the decision-making process. Participant P07 echoes this sentiment by stating *"And it should be very scalable so that we could seamlessly add new resources to the system."*, emphasizing the need for a highly scalable infrastructure that allows seamless addition of new resources to the system.

P01: "Then we need to check how much work space such a system will most probably consume in the future, how much energy it will consume, what kind of networking connections it will require to operate properly and so on and so on"

Participant P01 brings attention to the consideration of energy consumption. The decision-makers need to assess how much workspace a system is likely to consume in the future, the anticipated energy consumption, and the networking connections required for optimal operation. This factor underscores the importance of sustainability and resource efficiency in the decision-making matrix.

Service hosting, elucidated by Participant P01, introduces another layer of decision criteria. As the participant succinctly puts it, *" But then we check if that system can properly get hosted, that system can properly get connected to the internet or to the local network."*, emphasizing the need to assess whether a system can be appropriately hosted and connected, considering its compatibility with both the Internet and local networks. This criterion ensures that the chosen cloud solution aligns seamlessly with the hosting requirements, fostering effective integration into the existing technological ecosystem. Participant P17 adds to this discussion by emphasizing that system criticality and user demand for specific systems also play a role.

P17:"....whatever we are doing is we have to look at the what are the critical system, what is system that highly demand by the users, you know. So once we see that ,then you already know oh ya this system needs another setup. ..... But already we have the plan so generally we will start moving our most critical production system, currently on-premise, that will start moving to cloud soon. "

Participant P17 articulates that once the evaluation of criticality and user demand is conducted, a clear understanding emerges about which systems necessitate alternative setups. Importantly, Participant P17 reveals a proactive approach, stating that there is already a plan in place. This signifies a structured and premeditated strategy for cloud migration. The participant further outlines that the initial focus is on transitioning the most critical production systems, currently housed on-premise, to the cloud. This strategic sequencing indicates a deliberate effort to prioritize migrating systems with the highest impact and importance to the university's operations. Participant P12 further contributes to the discussion by stating another factor for cloud migration by emphasizing the dynamic and innovation-driven nature of cloud services.

P12:"And so in terms of, I think one of the biggest dynamics we've seen with the shift to cloud is they're producing new features, new capabilities, all sorts of new exciting stuff, kind of on a month or quarterly or annual basis. And they're really driving those cycles of innovation or updates and enhancements."

The fundamental shift described by Participant P12 underlines the agility and rapid evolution inherent in cloud platforms. Unlike traditional on-premises solutions, where updates and feature enhancements may occur infrequently and with substantial lead times, the cloud ecosystem operates on a much more accelerated timeline. The cloud service providers, as highlighted by Participant P12, introduce new features and capabilities at regular intervals—ranging from monthly to quarterly or even annually.

Participants also highlighted the significance of integrated technology trends and connectivity capabilities as drivers for cloud migration. Participant P11 underlines the impact of technology trends and the need to modernize and adapt to changing requirements:

P11: ".... and also the technology trends is a second big driver of that..... But it's also caused by scenarios where maybe the infrastructure on-premise was some legacy application. So if we no longer need to continue that legacy application, then we can't. So we no longer use it. And if ever there's anything new, we want to do cloud where feasible."

Technology trends play a substantial role in the decision-making process. Universities must consider the latest advancements and ensure their systems can keep pace with evolving technology landscapes. The participant also highlights that the decision to move to the cloud is sometimes influenced by scenarios where on-premise infrastructure involves outdated legacy applications. If these legacy applications are no longer needed, the motivation to continue using on-premise infrastructure diminishes. In such cases, the preference is to leverage cloud solutions whenever possible for new requirements or initiatives. This perspective suggests a pragmatic approach, favouring the cloud for its flexibility and adaptability, especially when compared to maintaining outdated legacy applications on-premise. Participant P06 highlights the significance of APIs and integration:

P06: "We would certainly be interested in the kind of APIs, application programming interfaces that any third-party provider can provide. Often we need to do integrations between different systems that we have. And that means that a third-party cloud software provider needs to provide a programmatic way for us to interact with the solution that they've got so we can move data around, pull it out, do things with it, connect services together, and that kind of thing."

APIs and integration capabilities enable universities to connect and interact with cloud solutions seamlessly, facilitating data sharing and service integration. Incorporating these insights into the broader narrative, we see that integrated technology trends and connectivity capabilities form yet another layer in the intricate decision matrix.

Cultural and Historical Drivers

Expanding on the factors influencing the decision, we delve into another factor that provides a unique perspective on cloud migration within higher education universities—"Historisch Gewachsen" driven by user and university requirements. As articulated by Participant P03:

P03: "It's, in German we say, 'historisch gewachsen', so it's historically grown and there was no strategy behind it. It was just driven by needs, individual needs and the curiosity of researchers."

Participant P03 introduces the term *"historisch gewachsen,"* translated as "historically grown" in German, to describe the organic evolution of cloud adoption. This expression conveys that the development of cloud usage within the university has not been guided by a preconceived strategy but has rather unfolded over time in response to the dynamic and individual needs of researchers. It highlights a process driven by curiosity and a genuine necessity. This historical growth is a testament to the flexibility and adaptability of cloud solutions in addressing the specific needs and curiosities of those within the academic community. Participant P13 further illuminates this perspective with a real-world example:

P13: "Some people just wanted to do it for educational reasons. They heard about cloud. They wanted to try it out. They wanted to kick the tires. ..... There were probably researcher demands for more instantaneous capacity or the ability to rent a lot more infrastructure that the university had available. ..... And somehow Google was sponsoring their work and giving them like GCP credits. And so like kind of forcing them into their, you know, like backdoor kind of cloud. Like this person showed up with a bunch of like, you know, scratch-off cards that say you have a thousand, you know, compute hours. And we're like, what is this? What are you doing? Things like that."

The scenario described by Participant P13 vividly illustrates how external incentives and resources, such as cloud credits, can drive the adoption of cloud solutions within the academic environment. For some individuals, the journey to the cloud began with curiosity and the desire to explore. The availability of credits and support acted as the catalyst for cloud adoption, even if it was not originally part of the institution's strategic plan. Participant P13 also suggests that researchers within the university community expressed a need for more instantaneous capacity and a larger infrastructure than what the existing on-premises setup could provide. Participant P08 adds to this by discussing the rigidity and demands of users.

P08:"And there is this, how should I say it, this attempt by users to express their opinion, and to demand certain things from us, by looking at what our systems cannot do and present it as indispensable."

The participant describes a situation where users express their expectations and demands by highlighting the limitations of existing systems and framing certain features as indispensable. Users, in their pursuit of improved functionality, may identify gaps in the current system and articulate these as essential needs. When integrating these factors into the broader narrative, we observe that migration to the cloud-hosted infrastructure is **not always a top-down strategic decision** but can emerge from the organic growth of needs and the influence of external partnerships.

Participant P17 articulates a practical challenge tied to traditional backup methods, underscoring a shift from the old 'tape' practices to cloud computing.

P17: "That is quite hassleful and then we are using another location for us to store the tape and tape also is like you have to purchase and after than you just have to throw it away, the tapes. Its a bit, um..., how to say it quite old ways la. So now we are looking at mainly our backup, our daily backup, weekly backup, monthly backup, yearly backup to cloud computing."

According to Participant P17, the hassle and inefficiency associated with storing physical tapes, coupled with the cost implications and environmental concerns, prompted a reevaluation of their backup strategy. The inconveniences of the old ways are not merely technical; they also touch upon operational costs, environmental sustainability, and the overall efficiency of backup processes. Participant P06 outlines another reason for considering cloud migration, emphasizing challenges related to the ageing of the original source code.

P06: "So, we have had this issue that I described before where we've had other people who've tried to step in and take over the running of it, but they weren't the people who did the original code. So, it's always been a bit harder for them to change things, fix bugs when they occur, and deal with other things as the kind of – the original source code has aged, and new challenges have come along. So, we've been gradually trying to kind of develop the service piecemeal, fix issues with it, but it's become harder and harder to sustain and maintain the original piece of software. So, last year, I think it was decided that we would try and move this particular service into the cloud."

According to participant P06, the original source code has become increasingly difficult to maintain and update, leading to issues in fixing bugs and addressing new challenges that have emerged over time. This narrative sheds light on the long-term sustainability and adaptability challenges associated with on-premises solutions, especially when they rely on ageing source code. The difficulties faced by individuals who did not contribute to the original code in making necessary modifications is a common challenge in legacy systems. Cloud environments offer opportunities for modernization, scalability, and easier maintenance, making it a viable solution for addressing the challenges associated with outdated on-premises systems.

Participant P01 adds another dimension to the discussion by elaborating their reason behind adopting a hybrid infrastructure model, emphasizing the pragmatic approach driven by financial considerations and the desire to expand service offerings.

P01: "It's simply hybrid because some of the services we want to offer, we cannot really afford to do it by our own. Like for instance, the Nextcloud service, we are getting it from some other university and we are paying them for offering such a service. The other thing is that, for instance, for research purposes, we are running our own cloud infrastructure, meaning that we are offering infrastructure as a service so that research institutes, groups, projects do not need to run their own base level infrastructure, like server rooms and operating machines, but just can grab some differently sized virtual machines and use them for their own purposes. So what we are trying to achieve is to broaden our offerings with the given infrastructure we have at the moment."

In the context of hybrid infrastructure, Participant P10 points out that the university adopts a hybrid model because there are certain services it wishes to provide but cannot afford to implement independently. The example of the Nextcloud service highlights the university's decision to leverage services from another institution, underscoring a cost-effective strategy to access needed functionalities without investing extensively in proprietary infrastructure. Furthermore, P01 introduces the concept of offering infrastructure as a service for research purposes. In this scenario, the university operates its own cloud infrastructure, providing a platform where research institutes, groups, and projects can access virtual machines without the need to manage their own underlying infrastructure. This aligns with the university's goal of broadening its service offerings without requiring individual entities to maintain server rooms and operating machines.

From Participant P13's perspective, four important factors form the four pillars of the decision-making conundrum. The participant provides a comprehensive overview of these influential factors:

P13: "One is identity and access management. So, they're utilizing enterprise credentials that are managed at the university level rather than rolling their own identities. Security. So, how do you manage event logging and security logs and who responds to them? Networking. So, that everybody doesn't have to roll their own network and they can come back and, you know, act like they're on campus networking. And then billing, management, alarms, controls like that. So, those kind of four pillars kind of hold up the house."

The first pillar highlighted is Identity and Access Management (IAM). Participant P13 underscores the strategic decision to leverage enterprise credentials managed at the university level. This approach signifies a centralization of identity management, opting for a university-wide system instead of creating and managing individual identities for various services. Such a centralized approach enhances security and streamlines access control. The second critical pillar revolves around security considerations. Participant P13 delves into the intricacies of managing event logging and security logs. This emphasizes a proactive approach to security, ensuring that events are logged, monitored, and responded to effectively. By addressing the 'who responds to them' aspect, Participant P13 touches upon the crucial human element in the security ecosystem, recognizing the importance of a well-defined incident response mechanism. Networking emerges as the third pillar, emphasizing the need for a shared infrastructure. The envisioned strategy revolves around fostering a unified campus network experience, promoting collaboration, and streamlining data exchange. The final pillar encapsulates a spectrum of considerations including billing, management, alarms, and various controls. This encompasses the broader operational and administrative aspects of cloud utilization. Participant P13 points to the need for a robust billing structure, effective management practices, and alert mechanisms. These components collectively contribute to the overall governance and operational efficiency of the cloud environment.

Security and Compliance in Cloud Adoption

Expanding on the Security narrative, Participant P12 delves into the weighty considerations surrounding data ownership, legalities, and privacy. The participant highlights the distinctive culture of privacy at their university, acknowledging the discussions that extend beyond legal frameworks.

P12: "I would say one of the biggest ones in our environment, it'll kind of vary from place to place, but <acronym-of-the-university> has a very strong culture of privacy. There's a lot of deep discussion around not only the legalities but other kinds of considerations around, if you don't own your data, what does that mean? Or if your data sits in someone else's data centre. So there is a tremendous amount of discussion and consideration given to privacy and <acronym-of-the-university>'s role as custodian or steward for its information, legally and otherwise. So that was something that was a huge cultural consideration for us."

The important question of data ownership emerges, prompting reflections on the implications if an entity does not own its data. This extends to the scenario where data resides in someone else's data centre, intensifying the need for thorough contemplation. The participant underscores the institution's role as a custodian or steward of information, not only in legal terms but also as a reflection of its cultural ethos. The acknowledgement of privacy as a "huge cultural consideration" indicates its pervasive influence on decision-making processes within the university.

Participant P06 seamlessly extends the discourse on security by highlighting the critical role of security requirements as non-functional imperatives. This lens widens the focus beyond mere functionality, delving into the infrastructure's capability to handle sensitive data.

P06: "You'll also have security requirements. They're usually considered to be non-functional requirements i.e. what the kind of the infrastructure that is hosting it, whether it can meet the requirements for handling sensitive data and things like that. There's lots of personal data that's held in university systems. So we need to make sure that whoever we trust with that data has clear practices and processes in place to deal with any data breaches, anything like that."

Participant P06 underscores the critical nature of personal data stored in these systems, emphasizing the need for a trustworthy entity with established practices and processes to manage potential data breaches. The participant's concern centres around ensuring that the chosen infrastructure provider adheres to robust measures in safeguarding sensitive information, reflecting a clear awareness of the potential risks and the importance of stringent data protection protocols within the university context.

Participant P04 further reinforces the significance of data privacy and protection within the broader security narrative.

P04: "But I assume that the vast majority of cloud services, maybe 90% of all existing cloud services will not be included, not in the whitelist and not in the blacklist because it always depends on the specific scenario and specific type of data that will be used with the cloud service. That means you can use one cloud service easily without specific types of data, whereas if you would like to involve very personal, for example, medical personal data, then you cannot use the same cloud service. And for that reason, the services cannot be on the white or on the blacklist, but there has to be a differentiated analysis for which use case the service should be used."

Participant P04 elucidates that while certain cloud services may be seamlessly compatible with non-sensitive data, the scenario changes when dealing with highly personal information such as medical records. In such instances, the same cloud service may not be deemed suitable. Consequently, Participant P04 stresses the need for a tailored and differentiated analysis, asserting that each use case warrants careful evaluation to ascertain the appropriateness of a particular cloud service based on the nature of the data it is intended to handle. Furthermore, Participant P06 unequivocally states that security and privacy requirements are non-negotiable.

P06: "So security and privacy we generally, if you can't meet the requirements there then it's a no-go. So if a service looks fantastic and the users love it but it's not going to be able to meet the security requirements then you know that's gone, it's out"

If a service fails to meet these stringent security standards, regardless of its other merits, it is deemed unsuitable and excluded from consideration. This unwavering commitment to security highlights its important role in shaping decisions related to the adoption of cloud services. In response to the question about the minimum security level, Participant P06 emphasizes the need to scrutinize the infrastructure's capability to handle sensitive data and other pertinent factors.

P06: "You'll also have security requirements. They're usually considered to be non-functional requirements i.e. what the kind of the infrastructure that is hosting it, whether it can meet the requirements for handling sensitive data and things like that. There's lots of personal data that's held in university systems. So we need to make sure that whoever we trust with that data has clear practices and processes in place to deal with any data breaches, anything like that."

Participant P06 underlines the importance of entrusting data to entities with clear practices and processes in place to manage potential breaches or other security issues. Building upon this, Participant P13 delves into the existing security standards, classifying data into low, medium, and high-risk categories.

P13:" yeah, so we have some security standards that identify different levels of data security. So, there's a low, medium, high risk. So like if you're if you're handling, you know, credit card information or social security numbers or FERPA information from a student perspective, they have different risk classifications that are associated different security controls. And that's we have that information on our website. Those kinds of things. PCI like credit card information is like super, super constrained and you don't want to even deal with it and things like that. We're starting to investigate how HIPAA, so the Health Information Privacy Act stuff works at the university. Some people say that we have HIPAA data. Some people say we don't have HIPAA data. I'm not sure who to believe. So those are parts of the procurement process. The security office gets to weigh in on that kind of stuff."

Participant P13 elucidates that different types of sensitive information, such as credit card details or FERPA [2] data, come with distinct risk classifications, each associated with specific security controls. Participant P13 further mentions the scrutiny of HIPAA [3] data within the university, revealing the ongoing exploration into compliance. The uncertainty regarding the presence of sensitive data and the need to verify its status underscores the thoroughness of the procurement process. The security office plays a crucial role in evaluating and providing insights into compliance with regulations such as PCI [5], and HIPAA [3], ensuring that the university maintains a robust and secure data environment.

Non-Technical Elements

Amid the multitude of considerations, project methodologies and working timescales emerge as non-technical elements in shaping the decision-making landscape.

P06: "We would certainly ask about, in a tender, about the kind of timescales that people can work with, the project methodologies that they're going to be using to actually implement the new service, the number of people who are going to be involved, who is going to be providing support to users in some cases that might be our own staff. In some cases, it will be the people providing the cloud services themselves who provide user support. So we'll want to know when user support is available, whether it's 24 hours a day, how it's done, whether there's a real human being who can answer questions, or whether there's telephone support, whether support is provided over holiday periods. All of these kinds of things are very much factored into the decisions about what cloud services we might actually go with."

Participant P06 underscores the importance of understanding how the new service will be introduced, the strategies that will be employed, and the overall framework guiding the implementation process. This emphasis on methodologies reflects a sophisticated understanding that the success of a cloud service goes beyond its technical specifications; it hinges on the robustness of the methodologies employed throughout its deployment. The participant further delves into the human factor, considering the number of individuals involved in the implementation process. The choice between relying on internal staff or the cloud service provider for user support becomes a strategic consideration. The nature of support, whether it is manned by real human beings, the availability of telephone support, and coverage during holiday periods—all these elements constitute integral facets of the decision-making calculus. Moreover, a shift in user expectations is noted when it comes to problem resolution. Participant P01 also describes a shift in the character of how services are operated, highlighting changes from both the user and administrator perspectives.

P01: "So we've seen a couple of outages of the service or user complaints or that certain functions did not respond well or responded weirdly. And we need to report that and wait to get it fixed on the other side. ..... And that will change, or that is to be expected to be seen more in the future when more and more services get cloudified. And that of course will change the expectations or not necessarily the expectations. But so the own feeling of sovereignty will change. "

In the traditional model where services were hosted internally, the university was directly responsible for the services. If issues arose, the responsible administrator could be identified and tasked with fixing the problem. However, with the move to cloud services, the participant notes a more indirect approach. Users, accustomed to seeking on-site help, now need to channel their complaints upstream to the cloud operator. This change in operational dynamics introduces a delay in issue resolution, as the university is no longer in direct control of the hosted services. The participant acknowledges instances of outages, user complaints, or functions behaving unexpectedly, which need to be reported and await resolution from the cloud operator. The participant anticipates that as more services get "cloudified," this indirect approach to issue resolution is likely to become more common. The statement about the changing feeling of sovereignty suggests that the sense of control and direct responsibility that comes with hosting services internally diminishes in the cloud model.

Summary: The challenges of outdated legacy infrastructure, coupled with the imperative for scalability, availability, and robust disaster recovery, drive the adoption of cloud solutions. System architecture compatibility, scalability, and sustainability considerations further shape the decision matrix. The strategic sequencing of migrating critical production systems to the cloud reflects a deliberate and proactive approach. Technology trends, connectivity capabilities, and the dynamic nature of cloud services contribute to the motivation for migration. Additionally, the organic growth of cloud adoption, termed "historisch gewachsen," highlights the role of individual needs and external incentives, such as cloud credits, in shaping the university's cloud journey. Security emerges as a non-negotiable factor, with considerations spanning data ownership, legalities, privacy, and adherence to stringent security standards. Beyond technical specifications, project methodologies, working timescales, and user support frameworks are integral elements influencing cloud service decisions, underscoring the holistic nature of the cloud adoption process in higher education institutions.

4.2.1.2 Grounded in Tradition: Factors Anchoring Self-Hosted Environments

The hesitancy of universities to move to the cloud is rooted in several key factors, as highlighted by participants.

Participant P02 provided valuable insights into one of the fundamental reasons universities often choose to stick with self-hosting—budget constraints. *"and our advantage was that we have a lot of know-how but not much money"*. According to P02, the financial aspect plays an important role in decision-making, with limited funding being a common challenge faced by universities. This limitation, despite possessing considerable expertise, forces universities to make resource allocation decisions based on financial constraints.

P14: "So if we have some aspects of high-performance some biomedical research with instruments generating large geometry that has to be processed. And that would probably be a question of edge computing and fibre, rather than trying to attempt doing it in the cloud, because you wouldn't get the performance out of it and it would be really expensive."

Participant P14 highlights that certain aspects of high-performance computing, particularly those related to biomedical research with instruments generating large datasets, are better suited for on-premise infrastructure. In this context, edge computing and fibre connectivity are mentioned as more suitable alternatives for achieving the required performance, as opposed to attempting these computations in the cloud. This indicates that considerations of performance, cost-effectiveness, and specific requirements influence the decision to keep certain aspects on-premises rather than migrating them to the cloud.

Participant P05 shed light on a significant reason behind universities' reluctance to transition to the cloud - the complexity of the existing infrastructure within data centres.

P05: "I think it erm it has to do with a defect that they all have very old infrastructure for about so 30 to 40 years already. So the situation they have, the infrastructure they have built up since that time is very complex. And often they don't know how items are related to each other. So they are afraid then they move one service from on-premise to the cloud that could affect other services that they are not aware of. (I: Okay) That makes migration complex for them."

According to P05, the hesitation is deeply rooted in the fact that many university data centres are working with infrastructure that has been in place for a considerable period—somewhere in the ballpark of 30 to 40 years. This long-standing infrastructure is complex, and the fear exists that moving just one service to the cloud might set off a chain reaction, affecting other services in ways that are not fully understood. The fear of the unknown intricacies of their own infrastructure creates a perception that the migration process is risky and complex. Participant P08 elaborates on the same notion stating,

P18: "The problem with computers is that they're also anonymous. I mean, they're not things that you can touch even when you are running on-premise services. It's all little blips of electricity inside of a hunk of metal. And the possibility for things to go wrong and be very hard to perceive when they're going wrong is quite high. So it's easy, it's just to think, well, nothing will ever go wrong."

Participant P18 highlights the anonymity and complexity associated with computers, emphasizing that they are not tangible entities that can be touched. The participant describes computers as composed of *"little blips of electricity"* within a metal framework, emphasizing the abstract nature of these machines. The participant suggests that, even in the case of on-premise services, the intangible and intricate nature of the technology can pose challenges. And this in turn makes the migration more difficult.

In addition to this, Participant P03 highlighted another crucial factor—the fear of losing jobs among data centre staff.

P03: "a kind of fear that they will lose their position, their job and that their expertise they have built in the last years that it's no longer relevant. So it's kind of a fear what they have."

Participant P03 noted that staff members fear that their expertise, built over years of managing on-premise infrastructure, could become obsolete in a cloud-centric environment. This fear not only revolves around job security but also reflects concerns about the potential devaluation of the skills they have honed over the years. Furthermore, Participant P03 emphasized a prevalent lack of *information and understanding* about cloud technologies among existing data centre staff. The unfamiliarity with cloud concepts, services, and operational models contributes to the hesitation and makes the prospect of migration seem daunting. The gap in knowledge serves as a barrier to entry, hindering the adoption of cloud solutions. To add to the complexity, Participant P06 pointed out the critical need for trained support staff.

P06: "A lot of the time with cloud services, the reason why the universities weren't want to run themselves the things in-house is because you need the support team to do it. A lot of services, you might need one or two support people to actually keep the software up-to-date and do the kind of, I mean make sure that the infrastructure that it rests on and everything remains up-to-date and is working correctly. That takes some staff time, it doesn't take a huge amount of staff time and that leads you with issues. If one of your staff members you know has updated the service leaves support the service leaves then there is a problem because you might be running

with a kind of single source of failure and it can take time to bring people and train them to the extent where they can provide the same kind of support. So that's always a concern I think for the universities."

According to Participant P06, running services in-house requires a support team to ensure software and infrastructure are consistently up-to-date. The reluctance to migrate stems from concerns about the availability of skilled personnel who can effectively maintain the cloud-based services. The potential challenge of finding and training replacements in case of staff turnover adds an element of risk that institutions may be hesitant to undertake.

Participant P18 shed light on an interesting aspect that contributes to the persistence of self-hosting solutions in university settings—the ability to reuse old hardware, particularly when utilizing Linux.

P18: "And especially running Linux, you can run Linux on really old hardware. It doesn't seem to break down the way Windows hardware breaks down. And that's funny because it's the same hardware. And so we do get by with a lot of old hardware and a lot of things. And we don't spend any money on anything."

According to Participant P18, Linux exhibits remarkable compatibility with older hardware, allowing universities to extend the lifespan of their equipment. Unlike Windows hardware, Linux runs efficiently on ageing machines, offering a cost-effective solution for universities with limited budgets. This strategy enables universities to manage existing resources, emphasizing the economic advantages of self-hosting with Linux. Moreover, Participant P08 highlighted another compelling reason for universities to lean towards self-hosting—the high degree of integration of systems.

P08: "What has actually always spoken for our solution is the high degree of integration of the systems."

Participant P08 emphasized that the seamless connectivity and integration of various systems have been a longstanding advantage of their chosen self-hosting solution. This integration aspect adds significant value, allowing universities to maintain a cohesive and interconnected IT environment, a critical factor in the decision to persist with self-hosting solutions. Participant P08 also brought forth a notable consideration for self-hosting—the reduced dependency on external factors and individuals.

P08: "There are a few things that are almost as expensive as with Microsoft. But you are a little less dependent at this point."

According to Participant P08, while there are certain aspects that can be almost as expensive as Microsoft, the level of dependence is somewhat diminished. This observation underscores the autonomy that self-hosting can provide to universities, offering a degree of control over factors that might otherwise be more reliant on external entities. Continuing this discussion, Participant P08 expressed a sentiment that echoes among some university personnel regarding frustration with the negotiation behaviour of major cloud service providers.

P08: "Where you say, "Now a tipping point has been reached. We are annoyed about the negotiation behaviour of the big systems, but the fit is no longer the one we want."

Participant P08 highlighted a tipping point where the annoyance with negotiation behaviour, coupled with a misfit in expectations, has led to a reassessment of the cloud solution's viability.

P03: "And the third thing is that there were decisions taken by the board in the past, which clearly said that certain services are not going into the cloud."

Additionally, Participant P03 shed light on historical decisions made by the university's board that explicitly dictated certain services would not be migrated to the cloud. Furthermore, Participant P08 introduced a grassroots strategy deeply embedded within the university's culture, emphasizing the importance of IT security.

P08:"for example, it was discussed again recently, the keyword "IT security", how we can be attacked at the University of <University Town>. If you look at the incidents in the past, it has actually shown that it was always the lever of the big commercial systems or almost always, there are still exceptions, which were actually the door opener for corresponding activities [meaning: security breaches]. For example, we are well protect... Relatively, well, we are not really protected, I think, but it is still an additional hurdle [for attackers]. These arguments are accessible to the university management and they are now also supporting our strategy. Massively. How should I put it? It's not a formalized strategy, but a formulated strategy, which has grown like grassroots and has actually penetrated into the management level."

The argument being presented by Participant P08 is that the university's practice of self-hosting serves as an additional obstacle for potential attackers since past security incidents have often been associated with major commercial systems. The grassroots approach to security has naturally spread to upper management levels and gained significant support as a result. **This highlights how the university's distinct security approach has not only been developed from the ground up but has also been endorsed by higher levels of the organization.**

Furthermore, Participant P07 emphasized the importance of self-hosting for the university, driven by a focus on digital sovereignty and the desire to have control over their own resources and data. *P07: "We are focusing on digital sovereignty and having things in our own hands"*. This approach aligns with the university's strategy of maintaining autonomy in its digital operations.

P04:"No, no no. Actually, the main concern is how the enterprise is handling data privacy and protection. And that is what we always ask the enterprises and in most cases the enterprises are not willing to sign any contract with specific descriptions about that and for that reasons many enterprises are out for the game for us, out of the competition. Because if they cannot guarantee precise data handling then we cannot sign the contract with them."

The participant emphasizes that the primary concern lies in how enterprises handle data privacy and protection. Participant P04 clarifies that their university consistently seeks detailed contracts from enterprises. These contracts should explicitly outline the measures and practices employed by enterprises to ensure precise data handling. The participant underscores the proactive approach taken by their university and points out that many enterprises are unwilling to sign contracts with specific descriptions of their data handling practices. Consequently, this stringent criterion becomes a determining factor, causing numerous enterprises to be excluded from consideration, reinforcing the

critical importance of robust data privacy and protection standards in their decision-making process. Furthermore, Participant P04 provides insights into the consideration of data types for cloud storage.

Summary: Budget constraints, often exacerbated by limited funding despite possessing considerable expertise, emerged as a fundamental reason for universities to opt for self-hosting. The complexity of existing infrastructure within university data centres, some in operation for 30 to 40 years, instils fear of potential disruptions during cloud migration. Job security concerns among data centre staff, coupled with a lack of understanding and information about cloud technologies, contribute to hesitancy. The need for trained support staff, potential staff turnover risks, and the ability to reuse old hardware, particularly with Linux, further underline the appeal of self-hosting. Additionally, the integration of systems, reduced dependency on external factors, frustration with major cloud service providers' negotiation behaviour, historical board decisions, and a grassroots security strategy contribute to the resilience of self-hosting. Digital sovereignty, control over resources, and stringent data privacy standards are emphasized as critical considerations, influencing the university's decision-making processes.

4.2.1.3 Pandemic Paradigm

When we asked about the role of the pandemic in shaping their infrastructure choices, participants' responses unveiled a noteworthy perspective on the interplay between the global pandemic induced lockdowns and cloud migration in universities. The diverse range of viewpoints provides a comprehensive understanding of the factors at play during this transformative period.

P05:"No, before pandemic. We we started this service in 2016 and there was no pandemic. It has nothing to do with pandemic this."

P06: "Not really, I don't think so."

P18: "I don't see it here."

P14: "No, I don't think it had any effect or impact on the decision or the, I could have possibly slowed it down a bit, I think."

Participants P05, P06, P18, and P14 expressed that the pandemic did not directly influence their decision to migrate to the cloud. Participant P14 acknowledged that while the pandemic might have slowed down the process, it wasn't a determining factor.

On the flip side, Participant P03 unequivocally attributes the increased adoption of cloud services to the COVID-19 pandemic.

P03: "The cloud adoption was clearly a matter of fact of the Corona crisis."

I: So there was no pre-plan or no previous strategy that could lead to adaptation of cloud before the pandemic even happened?

P03: "No, the pandemic was a major driver of cloud usage indeed. Yes."

The lack of a pre-existing strategy or plan for cloud adoption before the pandemic underscores the reactive nature of the decision. The participant emphasizes that cloud adoption became a practical necessity during the crisis rather than a premeditated strategy or planned initiative.

P11:" Well, for us, it accelerated the adoption"

Participant P11 acknowledges that the pandemic served as an accelerator for the adoption of cloud technologies in their context. The urgency created by the crisis likely expedited decision-making and implementation processes related to cloud solutions.

P13: "Oh, it was a HUGE (Stressed) motivator for very specific segments of our university work. ..... It was a catalyst, I would say more."

Participant P13 emphasizes the magnitude of the pandemic's influence, describing it as a *"HUGE motivator"* and characterizing it as a catalyst for specific segments of university work. The stressed emphasis on huge suggests the profound effect the pandemic had on motivating the adoption of cloud technologies in their scenario.

P10: "I think COVID just fast-tracked everything. In 2020, the university was forced to use Cloud "

Participant P10 concurs with the sentiment that COVID-19 acted as a catalyst, expediting various aspects of cloud adoption. The use of the term *"fast-tracked"* reinforces the idea that the pandemic accelerated the timeline for implementing cloud solutions at the university.

P17: "Definitely, yes, I would say a big YES [stressed] for this. Yeah, it is it is. Because that is why I said pandemic has changed the whole paradigm of the how people see the system"

Participant P17 too provides an affirmation, expressing a "big YES". The use of such strong language underscores the transformative effect the crisis had on reshaping the paradigm of how people perceive and engage with systems.

P15:" Yes, actually it's been, it's certainly sped things up."

Participant P15 concurs that the pandemic has accelerated the pace of cloud adoption, using the phrase *"certainly sped things up."* This suggests a consensus that the crisis acted as a catalyst, expediting the integration of cloud technologies.

P16:" Yes, it's rapidly increased it. Because actually, the pandemic advanced a number of our adoption capabilities. People didn't have a choice. "

Participant P16 echoes these sentiments, stating that the pandemic has *"rapidly increased"* cloud adoption. The acknowledgement that people didn't have a choice implies that the circumstances created by the pandemic necessitated a swift advancement in adopting cloud capabilities.

Participant P12 provides a detailed and insightful perspective on how the COVID-19 pandemic significantly accelerated the adoption of cloud technology. The participant expresses a strong belief that the pandemic acted as a catalyst, advancing cloud adoption by a substantial timeframe—specifically, *"by probably five to 10 years."*

P12: "Yes, yes. I think the pandemic accelerated the adoption of cloud technology by probably five to 10 years. Um, and it simply came down to when the pandemic happens, we saw this ourselves. Um, you know, there, because of supply chain challenges around hardware, particularly, you know, most of the hardware supply chain depends on China. Um, when they shut down, there was just no ability for us to get servers or storage or anything. In fact, most of the world couldn't get any of that at that point, right? They were all cut off at once. And, uh, you know, at that point we didn't have any alternatives. Like, you know, we were getting turnaround times, like we would call, uh, Dell or Cisco, you know, our partners that we use for hardware. And they were giving us, you know, they were telling us in say, April, May of 2020, that it could be years, you know, at least 18 to 24 months to be able to get, you know, uh, hardware out of China. And they just didn't have any options for us. And of course, everybody was trying to get stuff at that point. So it was a very competitive landscape. So we, and most organizations pivoted to the cloud in a hurry because we didn't have a choice. It was either that or nothing. So, you know, most organizations that, you know, would have preferred to take a more measured approach or they had concerns about the risks or all sorts of other stuff, even federal controls around the use of cloud all got pretty much put pushed to the side, even by the government. Because they understood that there was no other alternative."

Participant P12 recounts the practical challenges faced during the pandemic, notably disruptions in the hardware supply chain, with dependencies on China. These disruptions led to severe constraints in acquiring essential hardware components such as servers and storage. The participant emphasised that during this period, traditional alternatives were not viable, and even well-established partners like Dell and Cisco were unable to provide timely solutions. Facing a critical shortage of hardware and the prospect of extended turnaround times, organizations, including the participants, were compelled to pivot to cloud solutions rapidly. The urgency of the situation left little room for a measured approach, and concerns about risks, regulations, and federal controls were, to a large extent, overridden by the necessity for immediate alternatives.

Summary: Participants' responses regarding the influence of the pandemic on cloud migration in universities present a varied perspective. While some participants assert that the pandemic had no direct impact on their cloud adoption decisions, others acknowledge the catalyst role of the pandemic. Participant P12 provides a detailed account of how supply chain challenges during the pandemic, particularly in the hardware domain dependent on China, forced a rapid shift to cloud solutions. This urgency, driven by the unavailability of traditional alternatives, overrode concerns about risks and regulations, prompting organizations to pivot to the cloud swiftly.

4.2.2 Choices

After examining the various factors that influence the decision-making process for cloud migration, it's clear that these universities work in an environment, where needs can change unexpectedly. In this subtheme, we will focus on the strategic decisions and alternatives available to these universities as they navigate the cloud migration landscape.

4.2.2.1 Commercial Services vs. In-House Infrastructure

One of the crucial choices that universities face is whether to use commercial suppliers' well-developed services, which are often available at a lower cost. Participant P06 highlights the rationale behind this choice:

P06: "So the things like our Electronic research Notebook, things like the um Data repository, we have got agreements with the commercial suppliers of them. They basically mean that it is much cheaper for us to use their well-developed services, which they can apply the same kind of services across multiple universities. Therefore, we get some kind of economy and scale doing so."

According to Participant P06, using commercial services that can be shared across multiple universities can provide cost-efficiency and scalability benefits. This choice is motivated by a desire to make the most of available resources while optimizing the budget. On the other hand, Participant P13's viewpoint emphasizes another critical choice driven by budget considerations. Participant P13 mentions:

P13: "I mean, it was because they had funding to do it. They thought it was going to be cheaper. They didn't have the infrastructure on campus to do it. I mean, there's a myriad of reasons for individuals to start looking at the cloud. Some researchers needed or realized that the cloud provided more elasticity, more scaling. They had grants they wanted to throw, you know, hundreds of GPUs at. The university didn't have that on-premise or self-hosted."

Participant P13's perspective highlights how financial considerations, infrastructure limitations, and research requirements can drive the decision to migrate to the cloud. In these cases, universities are prompted to explore the cloud due to the budget they have available and the need for scalable, elastic resources. Participant P13's observation sheds light on the notion that vendors can sometimes lead universities down the path of cloud migration, whether they had intended to or not:

P13: "... because all these vendors are just cloud-only now. They won't sell you software to run locally. Vendors that are pushing it rather than us."

This highlights how vendor-driven migration can be a compelling choice, as vendors increasingly shift towards cloud-only solutions. Many vendors now exclusively offer cloud-based solutions, eliminating the option to purchase software for local use. Essentially, the vendors themselves are nudging universities towards the cloud. Participant P16 supports this notion by mentioning:

P16: "But we've been moving in that way, partly driven by our vendors, partly driven by the opportunity to have maybe simpler implementations. So yeah. So I would say that it's not necessarily we've chosen one over the other. It is just part of the reality of the work that's unfolding."

The acknowledgement of being driven "partly by vendors" implies that external forces, as seen above, technology providers or industry trends, play a role in shaping the university's technological landscape. Vendors may introduce new solutions, and features, or migrate their products to the cloud dragging the universities along. The mention of "simpler implementations" highlights a key consideration in technology adoption. As seen in Section 4.2.1.1, universities often seek solutions that streamline processes, reduce complexity, and enhance overall efficiency. Furthermore, the phrase "not necessarily chosen one over the other" suggests that the university's decision is not characterized by a strict binary choice between options but rather evolves organically based on the evolving landscape and emerging opportunities. The characterization of this approach as "part of the reality of the work that's unfolding" indicates a pragmatic stance, acknowledging that the university's technological journey is shaped by practical considerations, ongoing developments, and the evolving nature of their work environment.

Continuing this discussion, it is evident that the change in the nature of products and services also plays a compelling role in universities' cloud migration choices. Participant P01 highlights this by stating:

P01: "Because the product we are procuring is changing its character, and it's getting more and more cloud-hosted."

Participants P04 and P16 reinforce this by sharing a specific example:

P16: "One, that's where some services are offered. So as an example, our email environment is now within Microsoft fully in the cloud."

P04: "Externally, we have the challenge that we are aware that several companies are now changing to cloud-based services only."

The inevitability of cloud adoption in certain cases becomes evident. P15 echoes this sentiment:

P15: "And the second one is the fact that the service that we're after would only be offered to us in the cloud."

Essentially, the vendors themselves are nudging universities towards the cloud. This is particularly true as vendors increasingly shift towards cloud-only solutions. universities might be compelled to migrate to the cloud due to the evolving nature of the products and services they rely on. However, there are limitations to universities' dependency on commercial vendors. As Participant P18 aptly states:

P18:"But then you have a major service that's down in the students or down and out, or you get really financially threatened by a service contract renewal. And then you have to force all of your faculty to switch from say Blackboard to Brightspace when they've already got their things all set up in Blackboard. And then sometimes these companies even charge to migrate. And so you end up in all sorts of financial exposure, shall we say, for the advantage of not having to have the same skill level in your IT organization as if you were running your own stuff."

Participant P18 highlights challenges associated with relying on external service providers, specifically in the context of a major service outage or financial pressures during service

contract renewals. The participant mentions scenarios where institutions may be compelled to switch platforms, causing disruption for faculty members who have already set up their materials in the existing system. Additionally, P18 notes the potential financial burden of migration, with some companies charging fees for the process. The participant suggests a trade-off between the convenience of not requiring a high skill level within the organization for certain IT tasks and the financial and operational risks associated with dependency on external services.

P18:"In other words, once they had us hooked, they thought they could take advantage of the fact that it would be painful to change to a new provider. And they thought they could get us to pay a lot of money for it. So in both cases, both Blackboard and ServiceNow was switched to somebody else. There's a lot of effort involved with that. It's difficult."

Participant P18 provides insights into the challenges faced by the university when switching from one service provider to another. The participant mentions two specific cases: Blackboard and ServiceNow. According to Participant P18, once the university was already using these services, the providers seemingly took advantage of the perceived difficulty and potential cost associated with changing to a new provider. The participant highlights the significant effort involved in such transitions and notes the complexities.

If the vendor decides to change pricing, and terms, or discontinue a service, the institution might find itself in a challenging position. This dependency can limit the institution's control over its technology stack and can result in disruptions or unexpected costs if the vendor's strategy changes. Another limitation of relying on commercial vendors is that universities may have limited control over their systems and data.

Participant P16 further adds to the discussion by stating,

P16: "I think the biggest challenge for people is understanding what's changing in terms of control if I can say it like that. So when we move to these systems, we don't have the same ability to customize. The intention is truly to move to a system and then adapt and adopt the workflows and processes, yes, with some configuration, but you don't have as much control."

Customization and system modifications may be restricted, as the vendor typically manages the core functionality of the service. Participant P14 also sheds light on some of these concerns, emphasizing the potential risks associated with relinquishing control to vendors:

P14: "And with the idea that the vendor was sort of going to manage the hosting and the technology management up to custom code and configuration level. And again, I think this is one of those things that are a result of immaturity on both sides. Because I think the assumption was that this was kind of a SaaS deal, right? So we're setting this up as a software as a service. Which it's clearly not, because this was a hyper-customized application that they've been building layer upon layer of custom code on this for years. And now you're handing that over to the software vendor who first of all doesn't necessarily understand the inner workings of the university or the rationale behind the layers that are there in the first place or the business processes behind it. And the university is still accountable. So you've sort of relinquished control over some of the most critical elements of your whole enterprise system fleet."

This perspective underscores that the choice to rely on vendors for cloud migration can lead to a loss of control over critical enterprise systems and customizations. It also

highlights the potential mismatch between vendor capabilities and the unique intricacies of the institution's operations.

Participant P08 underscores another challenge, emphasizing the gap in understanding between providers and the universities they serve:

P08: ".....the providers are missing, in my opinion, the university 'smell.' They don't know what we need at this point."

As pointed out by the participant, it is important to understand that vendors may not always fully understand the requirements. Each institution has a unique "university smell" that represents its distinct character and requirements. When universities opt for vendor-driven cloud migration, they may face challenges in aligning these services with their specific demands.

The concerns expressed by Participant P14 about relinquishing control over critical elements of the enterprise system fleet, along with Participant P08's observation about the providers' understanding of institutional needs, further highlight the potential disconnect between vendors and universities. This disconnect can result in inefficiencies and the need for extensive customization, which may negate the benefits of adopting commercial services.

However, not all participants share the same opinion. While Participant P08 emphasizes the gap in understanding between cloud providers and universities, Participant P06 provides a contrasting perspective. According to Participant P06, there is a positive trend where cloud providers, particularly the developers of Software as a Service (SAAS) offerings, are enhancing their ability to meet the specific requirements of universities.

P06: "So in some ways, it's the developers of the SAAS services, the cloud services themselves, who are getting better at meeting university requirements."

Participant P06 sheds light on the evolving landscape, suggesting that cloud service developers are becoming better at addressing the unique needs of university environments. This implies a proactive effort on the part of cloud providers to bridge the understanding gap and tailor their services to align better with the distinct characteristics of educational institutions. The contrasting viewpoints between Participants P08 and P06 highlight the dynamic nature of the relationship between universities and cloud providers. While challenges persist, there is a sense of optimism expressed by Participant P06 regarding the continuous improvement in the ability of cloud services to meet the diverse and evolving requirements of university users.

Participant P13 adds another dimension to this discussion by providing valuable insights into the management of multiple cloud service providers, highlighting the intricacies and challenges faced by universities in deciding whether to work with a single provider or engage multiple vendors.

P13: "But they each, honestly, they each have their own beardness when it comes to AWS accounts, Microsoft subscriptions, GCP projects. They have their own organisational structures, the way that things are broken out or delegated. So they're all kind of bespoke. We have to reinvent the wheel for each one of those, unfortunately and annoyingly."

This observation underscores the inherent challenges that arise when educational universities rely on multiple cloud service providers. Each provider often has its unique organisational structures, management protocols, and distinct nuances. Managing these diverse cloud accounts can be a complex and time-consuming endeavour, as it often requires reinventing processes and adapting to the idiosyncrasies of each provider.

The above discussion shows that cloud solutions aren't always the best fit for every scenario. Participants have voiced concerns about the viability and sustainability of cloud solutions. Participant P14 succinctly highlights the limitations of cloud adoption, noting that it often lacks the economic and performance advantages that some universities require:

P14: "It's [cloud] not a viable concept. So, yeah, I think it costs performance, you name it. It just didn't have the economics or the sustainability to do it."

Participant P14's perspective highlights that cloud solutions may not align with the performance, economics, or sustainability needs of every institution. This raises the question of whether self-hosting might offer a more suitable alternative. A key reason some universities refrain from migrating to the cloud is the belief that open-source systems provide better adaptability to different hardware and situations compared to industry software.

On the flip side, not all participants share the same opinion on the viability of the cloud. Participant P17 emphasises the imperative nature of transitioning to the cloud. Reflecting on the past two decades, during which the organization operated within the confines of a traditional data centre, Participant P17 vividly portrays a radical paradigm shift.

P17: "That is like you know that 20 years or 20-25 years we have the data centre and now the things have been, the paradigm has been changed. So, now we have cloud computing, where people can do things from anywhere and everywhere and all those things. So now cloud computing definitely is essential. We are certainly looking into cloud computing at the moment."

The conventional model of a centralized data centre is undergoing a transformation in response to this paradigm shift. Cloud computing emerges as the contemporary solution, aligning seamlessly with the evolving needs of the dynamic and interconnected world. Participant P17 keenly recognizes the core change in the way work is conducted—a paradigm where individuals can effortlessly engage with computing resources from any location, breaking free from the limitations of physical boundaries. In this altered landscape, cloud computing isn't just an alternative; it's a vital component for staying relevant in the face of evolving times. The flexibility it offers in terms of geography, as highlighted by Participant P17, resonates with the ethos of our modern age, where accessibility and connectivity take precedence.

Amid the calculus of choices, Participant P10 sheds light on another dimension: the tangible impact on students and the broader university community, intricately interwoven with the efficiency of deployment timelines.

P10: "If I have to choose to say, I can either put the solution on on-prem, but it's going to take me another six months because I've got to identify it, then I've got to go buy it, and then I've got to configure it, or I can cut out the whole procurement leg of buying the physical infrastructure.

I can spin an environment on our tenant on Azure, and then I can focus on configuring this product, and then bring the service into operations so that the academics or the students can consume it. That's what drives my decision."

The participant articulates a decisive consideration: the temporal dynamics of deploying solutions, drawing a sharp contrast between on-premise and cloud-based approaches. Participant P10 succinctly outlines the choice dilemma: the prospect of a protracted six-month trajectory for on-premise deployment versus the expeditious alternative of cloud instantiation. The driving force behind this decision-making process is crystal clear — the need for swift service delivery. Participant P10 navigates through the intricacies of procurement, from identification to configuration, underscoring the time-intensive nature of traditional on-premise setups. The cloud, in this narrative, emerges as a beacon of efficiency, enabling the participant to bypass the cumbersome procurement leg and rapidly spin up an environment on Azure.

P10:" Can I get the service out faster? Who is going to use the service? How does it impact the student? How does it make us more successful with students? How does it improve the experience that the student will have of our systems? If the answer is putting this on Cloud, we can get this done faster, and we can really focus on what we need to be focusing on instead of other nitty-gritties that can drive the service experience to our students or academics, then Cloud is a no-brainer. That is what we should be doing."

The emphasis on speed is not arbitrary; it is tethered to the ultimate goal of positively impacting students and the academic community. Participant P03 also supports this notion by stating - *"Speed. So self-hosting just takes some time to buy the equipment, to install it and so on."* . Apart from speed, Participant P10's decision-making paradigm revolves around questions of service utility: How does the chosen solution affect students? Does it enhance the overall university experience? Can it be swiftly operationalized to serve the academic and student communities? The participant's language echoes a sense of urgency and pragmatism, emphasizing the importance of focusing on core objectives rather than being entangled in operational intricacies. Cloud adoption, in this context, is not merely a technical choice but a strategic one, driven by a commitment to expeditious service delivery and an unwavering dedication to improving the user experience for both students and academics.

Expanding on this narrative, Participant P12 adds another perspective - the desire to break free from the relentless demand to "keep the lights on."

P12: "I think for us, all of our time and most IT organizations, more than 80% of their time is spent on running things, on keeping the lights on. That's where they spend all their time and money. And in particular, that's where their people spend all their time. We saw cloud as a way to really transition a lot of that run, keeping the lights on responsibility away from the IT organization, which we thought would allow us to both free up resources and focus and time and attention to more meaningful problems that needed IT engagement"

As stated by Participant P12, this constant battle with operational tasks consumes not just time but also the potential for more meaningful engagements. Cloud migration, in this context, emerges as a liberator, offering a chance to break free from the shackles of routine responsibilities. The cloud, in its essence, becomes a catalyst for transformation, releasing resources and attention that can be redirected to solving intricate problems, sparking innovation, and contributing to endeavours that carry deeper significance.

However, Participant P18 highlights the persistent challenges associated with the vagueness and complexity of the internet, even when leveraging cloud solutions that promise co-location and reliability.

P18: "So this is sort of thematic of the vagueness of our whole internet in terms of things that aren't supposed to happen and things that have obscure causes and the question of being able to figure out how to fix something when it's broken. Think of all the layers between our university and Blackboard, even if it's a student sitting off campus, there's a hundred different things that could be wrong if one student or a hundred students or the entire student body can't get to a service. Cloud proposes to solve that by being co-located and geo-located and all of these kinds of things, but it can still go badly."

The vagueness is elaborated upon, referring to occurrences that aren't supposed to happen and problems with obscure causes. This characterization suggests a level of unpredictability and ambiguity in the functioning of the internet, leading to difficulties in understanding and addressing issues when they arise. The example given involves the layers between the university and Blackboard, a learning management system. Participant P18 emphasizes that even with the promises of cloud solutions, which aim to address issues through co-location and geo-location, problems can still occur. The complexity of the internet is illustrated by the numerous factors that could potentially go wrong, impacting students' access to services.

4.2.2.2 In-House Autonomy vs. External Dependence

P08: "We simply have platforms in the open-source area, in my opinion, that have a much better fit for what we do in teaching than what happens in the commercial area."

Participant P08's perspective underscores the adaptability and customizability that open-source systems can offer. The ability to tailor solutions to specific teaching and research needs is a compelling reason for universities to consider self-hosting. Participant P08 goes on to emphasize the adaptability of open-source tools to research projects:

P08: "And I'd also claim that the fact of the adaptability of the tools to certain research projects. We can make something available very quickly with our building blocks, which others only have in the standard software, for example. Well, they have more options for that. But we can also adapt very well to projects. That might actually have an impact."

This adaptability not only aligns with the unique requirements of research projects but also accelerates the availability of solutions.

P18: "Now the university, like I've said, I believe their motivator is they don't like to have to maintain hardware. They don't like to have to run to campus in the middle of the night if a critical service goes down. So they're handing it off to external people and they pay for services as opposed to pay for salaries. And they overall perceive that this works for them. And like I've said, I personally feel that they're a little bit exposed because of that. They don't have the skills to step in when there's a real bad mess and they don't have any control because it's all somewhere else. So those are the choices really. These salesmen come in with their shiny brochures about their service and you wanna just sign on the dotted line and hope for the best."

Participant P18 suggests that the university's primary motivation for outsourcing is the desire to avoid the responsibilities associated with maintaining hardware and dealing with critical service issues. Instead, the university opts to transfer these tasks to external service providers, paying for services rather than hiring in-house personnel. Participant P18 articulates the university's perspective that this outsourcing model is advantageous, as it eliminates the need for on-site hardware management and the burden of responding to service disruptions. However, the participant expressed their personal belief that this approach leaves the university somewhat vulnerable. The perceived exposure arises from a potential lack of skills to handle severe issues independently and a sense of diminished control due to the externalization of services. The participant outlines the choices faced by the university when presented with service offerings from external vendors. Participant P18 introduces a cautious perspective, cautioning against the temptation to hastily embrace solutions presented by persuasive sales representatives, emphasizing the importance of thorough consideration before committing to external services.

Moreover, the statement underscores a conflict of interest arising from the geographical distribution of control. The mention of *"it's all somewhere else"* implies that the cloud systems or components critical to the university's functioning are hosted externally, beyond the direct control of the IT administrators. This dynamic introduces a potential conflict between the administrators' responsibility for system management and their limited control over crucial elements situated outside their immediate sphere of influence.

Participant P06 expresses their perspective on cost considerations, emphasizing the dynamic nature of the equation.

P06: "But equation is changing all the time. And maybe in the few years down the line from now it does work out more cost-effective in some cases to umm host these services in the cloud. But in the moment, the overall cost of doing so and some of the issues around the kind of payment structures that the cloud providers work to preferences, you might end up with egress charges for moving data umm which makes it unpredictable. We prefer the predictability, the better, the better value really of running these services on-site."

Their words, *"equation is changing all the time"* highlight the evolving landscape of cloud services and suggest an awareness of the fluidity in the cost dynamics associated with hosting services in the cloud. The participant introduces a temporal dimension by considering the possibility that "in a few years down the line," hosting services in the cloud might become more cost-effective in certain cases. This forward-looking stance reflects an understanding of the potential evolution of cost structures and technology trends in the cloud space. However, the present moment is characterized by concerns related to the overall cost and issues surrounding payment structures, such as egress charges for moving data. The preference for predictability and better value in running services on-site indicates a desire for stability and clarity in cost management.

Participant P07 provides a compelling narrative around the strategic utilization of open-source technologies in the creation and hosting of on-premise cloud infrastructure. This perspective unfolds as a conscious and informed decision, shaped by the need for adaptability, seamless migration, and the intrinsic benefits embedded in open-source solutions.

P07: "We encountered that time and again before, always when we had to migrate from an old platform to a new technology and so we now decided to go for a technology that has the migration to new hardware built in so that we don't have to change anything in the logic univer-

sities of the data but we can seamlessly exchange the underlying hardware to newer generations. And that's basically the idea behind cloud technology. The technologies that we use, they are developed by the hyperscalers like Amazon, Google and so on. So we use their own technologies that are usually open source as the basis for our on-premises cloud..... We wanted to do that open source-based so that we also have the code base in our hands and can make adjustment and fixes ourselves so that we can ensure long-term availability and maintainability of this service"

The participant begins by highlighting the recurrent challenges encountered during transitions from older platforms to new technologies. In response to these challenges, a strategic shift is discerned – a decision to embrace a technology framework inherently equipped for the migration to new hardware. The underlying principle is clear: the ability to seamlessly exchange the hardware infrastructure while maintaining data integrity and operational continuity. Participant P07 further underscores a key facet of their approach – the reliance on technologies developed by hyperscalers such as Amazon and Google. Importantly, these technologies, often open-source in nature, serve as the foundational elements for their on-premise cloud.

Expanding the discussion further, self-hosting in higher education universities emerges as a strategic choice that is deeply rooted in institutional expertise, capable staff, and the unique advantages it offers. Participant P02 provides valuable insights into the reasons for self-hosting:

P02: "And especially our members are very highly educated to serve these IT services by our own. That means we have a very big know-how to do this and therefore we don't have any reasons to search for cloud solutions."

Participant P02 highlights that the institution's existing knowledge base and well-educated staff are key strengths that negate the need to explore cloud solutions. This expertise allows the institution to confidently manage IT services internally. Participant P02 further emphasizes the importance of competent staff:

P02: ".....we have the big advantage to have a lot of competent staff which can administrate such systems."

This participant's viewpoint underscores the value of having a workforce that can effectively administer and maintain complex IT systems. The presence of competent staff acts as a cornerstone for self-hosting, reducing the reliance on external cloud solutions. Participant P08 adds depth to the discussion by pointing out the level of comfort and advantages achieved through self-hosting with open-source solutions:

P08: "We have reached a luxury level there that the teacher just goes to the lecture hall, doesn't care about anything, and the systems run. That is not so comfortable with many other systems. We can't do some things for that again."

Participant P08's perspective reveals the high level of comfort and efficiency attained with self-hosting. This comfort significantly simplifies teaching and administration processes, allowing educators to focus on their core responsibilities without the need to constantly monitor external cloud services. Furthermore, Participant P08 underscores the importance of the mutual understanding and support of teachers and students in improving open-source solutions and making them work:

P08: ".....considering the comparison between open source and buying software, rent software, they would say, 'Yes, we are for open source.' There is a very wide range. And we are lucky that the students heavily support such a liberal approach."

This participant highlights the collaborative nature of open-source solutions and the willingness of both educators and students to contribute to their improvement. Such an approach fosters a strong sense of community and collective responsibility, creating a supportive ecosystem for self-hosting. However, Participant P08 discusses the challenges faced when introducing open-source office products like LibreOffice.

P08:" We see that because it has nothing to do with the idea of open source or not open source, and spoiled by commercial systems. If you look at the office products, LibreOffice and Co., they are now a bit worse in terms of aesthetics, but a lot is just in the systems. Convincing people about functionality is not the problem. The problem will be, and we experience this in the competition between learning platforms in <Federal State of the University>, if a university has only gone in one direction and a huge number of people have learned how to deal with it, then it is extremely difficult."

While acknowledging that the technical disparities between open-source and commercial systems may not be the primary issue, the participant highlights the difficulty of convincing individuals to adopt a new system, especially when a large number of people have become accustomed to an existing direction. Participant P08's perspective aligns with the notion that habits and user familiarity with specific systems can create formidable barriers to the adoption of new technologies or platforms.

P18: "And I don't think that we're talking about this here, but it basically comes down to one small issue with both OpenStack and Kubernetes, which is that the networking is very hard to comprehend. So if I could get past that logical hurdle, then we would be in large scale local cloud deployment."

Participant P18 also identifies a specific challenge in the context of self-hosting environments, particularly when using OpenStack and Kubernetes. The participant points out that the networking aspect of both OpenStack and Kubernetes is challenging to comprehend. This challenge serves as a logical hurdle that needs to be overcome for the successful deployment of a large-scale local cloud. The statement reflects a common difficulty faced by organizations and individuals when dealing with complex cloud infrastructure technologies. Networking in the context of OpenStack and Kubernetes involves configuring and managing connections between different components, and it often requires a deep understanding of the underlying principles.

I: So in terms of effectiveness, the open-source strategy is partly even superior to commercial offerings.

P08: Yes, definitely.

Additionally, Participant P08 expresses a clear affirmation that, in terms of effectiveness, the open-source strategy is considered, at least in part, superior to commercial offerings. This assertion indicates a positive evaluation of the efficacy of open-source solutions compared to their proprietary counterparts.

Furthermore, Participant P08's perspective introduces an intriguing dimension to the discussion, shedding light on how open-source solutions can mitigate dependence on limited, oligopolistic markets, thus enhancing an institution's flexibility and autonomy. Participant P08 states:

P08: "And if you look at what they publish, then that is also their goal in a limited, oligopolistic market. And if everyone in such a market that does not grow, increases their prices, then the prices will increase overall, if there is no chance to change providers. That's why we don't feel so tied down when we use a lot of open source."

Participant P08's insight highlights a crucial point - the impact of market dynamics and price increases in a limited, oligopolistic market. In such an environment, where a few dominant providers hold sway, costs can escalate as a result of limited competition. However, universities that heavily rely on open-source solutions are not as tied down to the dynamics of these providers. Open source often comes with cost predictability and the ability to adapt and customize solutions to avoid price shocks.

This viewpoint also highlights the significance of strategic autonomy and preventing vendor lock-in scenarios. Universities can have more control over their technology stack by utilizing open-source solutions, which reduces their dependence on external vendors and providers in a limited market. Embracing open-source solutions can help mitigate the risk of vendor lock-in, empowering universities to seamlessly transition between providers or make changes as required.

Participant P08 further provides insights into the considerations around market participants and security in the context of public government institutions, specifically state-owned non-commercial organizations like universities. The participant acknowledges the significant role of public institutions in determining the market and highlights a perceived advantage in terms of security and ethos within these institutions.

P08: "The question is only who are the market participants. And the market is determined also determined by public government institutions [State Owned non-Commercial Organizations, like Universities]. And there I have a certain guarantee that the stuff stays where it comes from. Because there is also a corresponding work ethos and because there is a lot of control, more than anywhere else. I do believe that a huge IT security staff like Microsoft can better protect the cloud. Probably even better than we do in the open-source area or in our local clouds. Because it's just more staff, more brain, that is available. Opposed to that are our, as I said, special structures that don't occur everywhere. Which are not so well suited for hacking. And, you have to be honest, a high motivation from employees who stand for this open source idea. Last Thursday, Friday, we did a workshop with the so-called <Association Providing IT Services to Universities in that Federal State> That's an IT group that provides us here in <Federal State of the University>, similar to the Academic Cloud, with software development. And I'm always amazed, because we don't pay the best salaries and we may sometimes have funny working conditions. The people who work there, and that's how I want them to be for the data center and for the <University IT Development Center>, they are committed to delivering their work here in these areas and not to run on shareholder value. This motivation also leads to the fact that they really get a lot out of themselves. That they sometimes grow out of themselves. I don't want to distort this to a fairytale now. But I think that's also a production advantage in the open source area, with which we may compensate for some things with a huge store like Microsoft, which can live off the resources, then maybe lacks in this form."

Participant P08 expresses confidence in the security measures of major IT providers, such as Microsoft, attributing their effectiveness to a large IT security staff and substantial resources. However, the participant introduces a contrasting perspective by emphasizing the unique structures and characteristics of state-owned institutions. These structures, according to Participant P08, may not be as susceptible to hacking and offer a distinctive advantage.

The participant acknowledges the potential superiority of a large IT provider like Microsoft in terms of resources and security capabilities. Still, Participant P08 introduces an essential factor—employee motivation tied to the open-source ethos. The commitment of employees to the idea of open source and their dedication to delivering work to public institutions rather than chasing shareholder value are presented as valuable assets. Participant P08 suggests that this motivation contributes to a production advantage in the open-source domain, allowing these institutions to compensate for certain aspects that a massive entity like Microsoft might lack in this specific form. Furthermore, Participant P08 states that,

P08: "That this idea, we're doing something for the common good and that's for everyone. ..... But the private sec... er government sector is also part of a market economy. And in that sense, it's said that research teaching is an area that should be independent, or at least independent of private economy. "

Participant P08 acknowledges that while academia is not a monolithic entity with a specific political ideology, there is a recognition that research and teaching, as components of societal capital, should ideally remain independent of purely market-driven interests.

Furthermore, When asked about the connection between the organizational climate and the support needed for IT in the success of research at a university, participant P08 provides insights into the distinct organizational climate found in academic settings.

P08: That's the point. It's primarily about a different kind of organizational climate that can be found. Because they all... Well, we also have our conflicts, I don't want to talk about everything green or purple or wonderful here. But there's a different kind of solidarity than I–I have also worked in the "free economy" .... And it's a different climate. I can tell you that. .... But this push is not there and it helps us [here at the university]. ..... It's at least related. I would have to think about whether it is actually a mechanism that connects things. It's a very similar way of thinking. With open source it's just like in scientific research, at least in independent research that is not product-driven and patent-oriented. It's just this culture of passing on and sharing together. ..... It's somehow a different openness.

Participant P08 acknowledges that, despite occasional conflicts, there is a unique sense of solidarity in the academic environment, different from their experiences in the corporate world. The participant draws parallels between the open-source culture and the ethos of scientific research, especially in independent research not driven by product or patent considerations. Participant P08 emphasizes the culture of sharing and collaboration inherent in both open-source development and academic research. This culture is seen as a mechanism that connects various aspects, fostering a mindset of passing on knowledge and working together. Participant P08's remarks highlight the significance of a collaborative and sharing culture in academic institutions, particularly in the context of IT and research support. The comparison with the private sector underscores the distinct

openness and collaborative ethos that characterizes academic environments.

Summary: Participants state the nature of decision-making and how it is influenced by factors such as cost efficiency, scalability, vendor-driven initiatives, and the desire to break free from routine operational responsibilities. The use of open-source technologies for self-hosting becomes a recurrent theme, with participants emphasizing adaptability, customizability, and the ability to seamlessly migrate to new hardware. The temporal dynamics of cost considerations in the cloud, evolving technology landscapes, and the level of expertise within the universities also shape the decision. Furthermore, the autonomy gained through self-hosting with open-source solutions is seen as a means to avoid vendor lock-in, providing universities with more control over their technology stack and reducing dependence on external providers in oligopolistic markets.

4.2.3 Decision Makers

Some universities lean towards cloud solutions under the influence of third-party vendors or due to some technical and financial factors, while others find strength in self-hosting, backed by well-educated staff, open-source systems and its flexibility to adapt. As universities grapple with the critical choices (refer to Section 4.2.2) that shape their cloud migration strategy, they navigate the intricate realm of processes, encompassing user requirement gathering, decision-making, and the involvement of various stakeholders. Participant P06 provides insights into a meticulous formal approach.

P06:": Yes. So the user requirements to, in order to go to tender and put out a tender document, an invitation to tender, we need to have a pretty good understanding of what we're looking for from the actual end users of whichever service we're doing.

Before initiating a tender, the institution invests a couple of months in interviewing researchers across disciplines and career stages, ensuring a comprehensive understanding. Conversations with internal staff and key figures, such as the vice provost for research, contribute to grasping vital needs and desirable features. These requirements are then crystallized into tender documents, inviting commercial providers to present solutions. The subsequent evaluation and scoring ensure the chosen solution aligns with the user-centric prerequisites. The process extends beyond procurement; during implementation, careful consideration is given to preparing users for any practice changes, aiming for buy-in and overcoming inherent scepticism. Participant P11 outlines a business process team's role in defining requirements.

P11: "Yes, there is a process defined by the business process team. The business process team whose job is to get requirements and consider the current processes in the space and then use that to define what functionalities are expected from what the users are looking for. And then we take it to the architecture team for decision-making."

This specialized business process team takes on the role of extracting user requirements by scrutinizing existing processes within the domain. Their task extends beyond mere data collection; they strategically define functionalities based on the users' expectations.

This process ensures a thorough understanding of what is needed and expected from the cloud service. Once these crystallized requirements are in hand, the journey moves to the architecture team for decision-making. This transition marks a crucial juncture where the abstract needs identified by the business process team are translated into actionable strategies by the architecture team. The collaborative interplay between these teams emphasizes a holistic approach—integrating user needs with architectural feasibility. On the flip side, Participant P01 sheds light on an informal approach to user requirements.

P01:"Yes, yes. For instance, if we need to procure a future HPC system, then we talk to the users of the system, collect their requirements and then discuss internally where the system will get set up, how many racks are required for that, how those racks need to get wired, what the amount of cooling is required and so on. So that is then internally discussed with the various stakeholders and is that pretty much agreed upon then a kind of not really formal process is started. But then it is finally discussed within that mentioned round and kind of signed off within that premium setting."

In scenarios like procuring an HPC (High-performance computing) system, the institution engages users to gather requirements. Internal discussions follow, covering aspects from system setup to cooling needs. While not explicitly formal, this process involves discussions with various stakeholders and culminates in a round of agreement and sign-off, creating an effective yet less structured approach. Continuing this narrative, Participant P02 introduces the dimension of compliance and documentation in decision-making.

P02: "If you want to introduce a new system then we have to fulfill all requirements and then we are checked by the staff council, we are checked by the data protection officer and the document... there are required documents we have to create when we introduce a new system and these documents are stored in a... it's a staff counsel, it's a data protection officer and there's not such a general document when we're introducing the system if you look for cloud or for self-hosted etc. Because when we want to introduce a new system, like I mentioned before, we check which systems are available, can we do it by our own, can't we do it and under which conditions we can do this. And then we have to discuss with the staff counsel and the data protection officer for any solutions and we are happy that we can provide at the moment all our systems at the university but I cannot guarantee that it will be forever but at the moment we are happy that we can do this."

The steps involve fulfilling specific requirements, undergoing scrutiny from both the staff council and the data protection officer, and generating necessary documents. Participant P02 emphasizes the absence of a universal document for system introduction, highlighting the need for tailored considerations based on factors like cloud or self-hosted options. The participant describes a meticulous evaluation process when deciding whether to introduce a new system. They assess the available systems, determine the feasibility of in-house implementation, and engage in discussions with the staff council and data protection officer to find suitable solutions.

When inquired about the involvement of users, such as students, in the decision-making process, Participant P17 highlighted a proactive approach in gathering feedback on the Information and Communication Technology (ICT) solutions provided.

P17: "we do sent email to get their feedback on our ICT solution, you know the ICT system solution that we provide it to them. So how good it is, what is their performance. They give us the feedback whether the system is slow and all those things. Whether the system has alot of bugs. We do have this once in a year. This is part of our quality assurance. So we sent this email campus wide to students and staff to collect this information. "

Participant P17 explained that campus-wide emails are regularly dispatched as part of a comprehensive strategy to collect user opinions and insights. These emails serve as a channel for students and staff to express their experiences with the ICT system, providing valuable information on its performance, potential issues such as system slowness or bugs, and overall satisfaction. This feedback-gathering initiative occurs annually and is integral to the institution's quality assurance practices. This inclusive and feedback-driven approach aligns with best practices in ensuring that the IT systems effectively meet the needs and expectations of the diverse user base within the campus community.

In tandem with this, Participant P01 also provides insights into general user understanding and adoption of cloud support. The participant emphasizes the increasing familiarity and adoption of browser-based tools and external services among users, noting that many users find it convenient to perform tasks within the browser. This indicates a positive reception of tools accessible through web browsers, likely contributing to the ease of collaboration.

P01:" So many users are well adopted to use, for instance, browser-based tools and do stuff within the browser and to log on to some external service. So that is not necessarily as a big deal. And because of that increasing amount of collaboration, many actually welcome the availability of such tools. ..... But on the other hand side, users are more and more getting used to that service model as they are using or as they are experiencing such service models in their private environments as well."

Furthermore, P01 highlights that users are becoming more accustomed to service models in their private environments, suggesting that experiences with cloud-based services in personal settings influence user expectations and comfort levels in professional or educational contexts.

4.2.3.1 The (In)Formal Process of Decision-Making

As we continue our exploration of the decision matrix, the focus shifts to the decision-making processes that guide universities through the complex landscape of technology adoption. Participant P07 sheds light on the structured approach to decision-making through the IT steering board.

P07: "To bring a proposal to the IT steering board or... So basically we make concepts in central IT, we have organized discussion meetings or board meetings with the other IT support units in the faculties. After that we have a wider hearing with working groups on this topic, with especially the researchers. We have those working groups on e-science infrastructure and on high-performance computing. And after these discussions we come up with proposals for the IT steering board. And the IT steering board either takes a decision that the IT units then follow or in certain cases it also needs a subsequent decision by the rectorate is added to make it more official if that is necessary."

The process involves conceptualization in central IT, discussions with IT support units, and wider hearings with working groups, especially researchers. Proposals are then presented to the IT steering board, whose decisions are followed by IT units. In some cases, subsequent decisions by the rectorate may be required for official endorsement.

This multistep process ensures thorough consideration of proposals, incorporating input from various stakeholders, and aligning decisions with broader institutional goals. In parallel, Participant P13 provides insights into the procurement dynamics influencing decision-making.

P13:" So through the procurement process, they have to, the department has to fill out a form and they have to state what type of data is going to be kind of exchanged with the vendor. Or in this case, you know, if they go and they build into the cloud. ..... It's through our procurement, our contracting and procurement department, which has this little bit of a rider that the security office is involved with. So some of the questions go to the security office and they ask for additional information, if the vendor is web-based, you know, some security controls and things like that. I wish there were additional kind of gatekeeping functions to that procurement process and we've asked for those."

Departments must complete forms detailing the type of data exchanged with vendors, especially in the context of cloud integration. This formal procedure is overseen by the contracting and procurement department, with a security office adding an additional layer. The security office steps in to assess the vendor's security controls, particularly for web-based solutions. Participant P13 expresses a desire for enhanced gatekeeping functions in the procurement process, emphasizing the ongoing efforts to reinforce security controls and information exchange.

P03:" that we look first, if there are services in the public cloud. And then if there's no appropriate public cloud, we will try and establish a community cloud, which is a shared cloud environment. And if this also doesn't exist, or if there's a specific reason to do it locally, then it will be self-hosted. So these are the three levels. The first level is public cloud, the second level is community cloud, and the third level is local hosting and provisioning."

Participant P03 articulates a methodical strategy for cloud deployment, structured into three distinct levels of consideration. The first tier in this hierarchical approach is the public cloud, where the university prioritizes exploring services offered by external cloud providers. This initial level emphasizes the scalability and accessibility associated with public cloud environments. Moving to the second tier, Participant P03 introduces the concept of a community cloud, characterized as a shared cloud environment. This level signifies a collaborative platform, ideally suited for situations where public cloud services may not align with the university's requirements. The emphasis here is on a controlled and cooperative cloud environment shared among entities with similar interests. The third and final tier in the hierarchy involves local hosting and provisioning. In instances where neither public nor community cloud options prove suitable, or when specific reasons mandate localized control, the university opts for self-hosting. This level implies the deployment of cloud services using the university's internal infrastructure.

Participant P02 provides valuable insights into the technical and procedural aspects of decision-making in the technology adoption process.

P02:" And when we have a technical solution, we build up test systems, it's self-hosted to realize the technical requirements or the feature requirements of the users. ..... When we start the test phase, the most important fact at the beginning is from technical point of view, can we serve such a system and can we realize the wanted feature set? And at this point, no user has access to any of the system. Only our administration or our administrators have access to the system at this point. And when we have realized the technical point of view and the feature set,

then we adapt the data protection and the privacy conditions. And when we can realize or we can guarantee the privacy, from this point, some test users get access to the system. Not before, it's too critical."

The process begins with identifying a technical solution, followed by creating self-hosted test systems to meet the technical and user feature requirements. An essential step involves optimizing data protection, with a particular focus on access control. This emphasizes determining who can access what information and establishing storage durations for data. The subsequent test phase is highlighted as a critical stage, involving different user groups to assess the developed system. Notably, the data protection officer and the staff council play a role during this phase. Their involvement ensures that privacy, security, and usability aspects are thoroughly examined before moving forward. This collaborative approach underscores the commitment to aligning the system with privacy and data protection regulations.

Furthermore, Participant P02 emphasizes the meticulous consideration of technical feasibility and feature realization at the initial stages of the test phase. During this period, only administrators have access to the system. Privacy and data protection conditions are adapted once the technical aspects are established, ensuring a secure and privacy-compliant environment. Access is then gradually extended to test users after guaranteeing privacy, underscoring a cautious and privacy-conscious approach. Participant P16 provides valuable insight into the decision-making processes by describing two contrasting approaches to the implementation of new systems, which have a direct bearing on cloud migration strategies.

P16: "And then it would go through a standard, large system implementation life cycle, maybe starting with procurement, there'd be business analysis, procurement, contract signing, implementation, adoption, and then operational outputs, which could include support models and SLAs, et cetera. So, and there's checkpoints through that back to governance as well."

In an ideal way, the decision-making process adheres to a structured and comprehensive system implementation life cycle. This formal process typically involves multiple phases, starting with procurement and followed by various stages such as business analysis, contract signing, implementation, adoption, and operational outputs. These outputs encompass essential aspects like support models and Service Level Agreements (SLAs). Participant P16 underscores the existence of checkpoints within this structured approach that ensure alignment with governance requirements. In essence, the ideal way involves careful planning, thorough analysis, and well-defined processes to govern the adoption of new systems or technologies. However, the discussion takes an intriguing turn when Participant P16 shares the non-ideal way of decision-making, which highlights the dynamic and sometimes unpredictable nature of decision processes. Participant P16 humorously illustrates the non-ideal scenario with a real-world example:

P16: "(laughs) Non-ideal way is somebody shows up at a meeting. Let me give you a real-world example. Last week, [my team] tells me that they're launching a mobile app for wayfinding on campus and it's not had any of those. That's the non-ideal way. (all laughing)"

This glimpse into the non-ideal way underscores the ever-present challenges of maintaining a structured approach in the fast-paced world of higher education universities. It highlights how spontaneous decisions can lead to complex implications, touching on aspects like cybersecurity, ownership, costs, and support models. Participant P16 em-

phasizes that such non-ideal occurrences are commonplace, underscoring the dynamic nature of decision-making within the institution. While Participant P16 humorously shed light on the non-ideal way of decision-making, Participant P04 further contributes to this discussion by highlighting the existing informal practices within their university.

P04:". At the moment it was just ad hoc requests to the rectorate as well as to the staff council and the data privacy and protection officer and they were not following any procedures. ..... And these four cloud services are only possible due to permission by our rectorate. That means for each cloud service, at the moment, you have to ask for a permission. And the permission is given by the rectorate only after agreement and consensus between the staff councils as well as the data protection and privacy officer and the rectorate."

Participant P04 reveals that, currently, there are ad hoc requests to the rectorate, staff council, and the data privacy and protection officer without following any established procedures. The permission for cloud services is granted by the rectorate, necessitating a request for each service. The process involves seeking agreement and consensus between the staff councils, the data protection and privacy officer, and the rectorate, emphasizing a somewhat informal approach to decision-making. Participant P01 echoes the same informal way of decision-making:

P01: "we have no kind of formal governance structures where system administrators play a certain defined role. But we have some institutions like in administrators forum where questions, ideas, concepts are getting exchanged and so they are voicing certain demands or concerns or whatever. And those concerns or requests might take into account at some other level or getting handled within the decision-making structure within the computer center or so on. But it's not necessarily formalized. There are some more formalized exchanges between the faculty and the CIO at the moment with the idea to have a better understanding of the general demand of the involved people within the university."

There exists an informal administrators forum where exchanges of questions, ideas, and concepts take place. While these informal channels allow for the expression of demands and concerns, they lack a formalized structure. Participant P01 acknowledges some more formalized exchanges between the faculty and the Chief Information Officer (CIO) but notes that the understanding of general demands within the university is not necessarily formalized. Participant P02 adds another layer to the discussion by introducing the notion that decisions, especially related to the adoption of technology like video conferencing systems, can be influenced by personal experiences.

P02: " It was a direct decision of the administration. ..... I don't know it. I would say they have used zoom with private accounts before the pandemic and they used it because we did not have any video conferencing systems at the university. It was not necessary before COVID. And therefore each user decided for one solution and they paid it privately and then we had to build any systems in I think when starting COVID we had four or six weeks to build up complete remote infrastructure for the university for the lectures and so on. And we built up Big Blue Button and we built up Jitsi. But it was not finally tuned in such a short time. And there was zoom and the users had their private experiences with zoom and therefore they had the argument yeah zoom is working we use it now and this was the reason by introducing zoom parallel to Jitsi and Big Blue Button."

Participant P02 describes a scenario where the introduction of Zoom was a direct decision by the administration. The choice was driven by the fact that users had prior

personal experiences with Zoom before the pandemic, and it was already in use with private accounts. The rapid need for a remote infrastructure during COVID prompted the quick setup of BigBlueButton and Jitsi, alongside the adoption of Zoom based on users' familiarity and positive past experiences.

P07: "People had experiences with Zoom, good experiences, and they were available and they did exactly what we needed."

Participant P07's statement also reflects the role of personal experience in decision-making. By highlighting positive experiences with Zoom, Participant P07 emphasizes how these firsthand encounters shaped perceptions and influenced the decision-making process. Personal experiences often carry a weight of reliability, as individuals tend to rely on what has worked well for them in the past. In this context, the positive encounters with Zoom likely played a role in the decision to choose it as a solution, showcasing the impact of user satisfaction and practical functionality in shaping decisions.

The discussion on decision-making within the university ecosystem further unfolds as Participant P13 highlights two critical challenges: the lack of communication and collaboration between departments regarding procurement decisions and the potential repercussions of decision-makers lacking technical understanding.

P13:"Like we have departments that come out and they say, hey, we need an email solution. Or like we have an email solution. Why are you asking for another one? And it's some little esoteric thing they want that we could probably suffice and things like that. But they come out and they ask for those things. And typically we don't hear that at all. We've asked to be included in that workflow. And we've just been told, you know, it's going to just slow down the process even more. They should know what's available at the university. If you did your job right, that kind of stuff."

There is a disconnect where departments independently request solutions without comprehensive knowledge of existing resources. Participant P13 expresses frustration with instances where departments request seemingly unnecessary solutions or features without considering available alternatives. Despite expressing the desire to be included in the workflow and contribute to informed decision-making, Participant P13 notes resistance, with concerns about potential delays in the process. The overarching sentiment is that departments should be aware of the available resources within the university, and a lack of collaboration hampers the efficiency of the decision-making process. Participant P13 continues to shed light on another critical aspect: the lack of technical understanding among decision-makers.

P13: "And you can just say, all right, we're gonna we're gonna attest to it, our DDD, our dean director department heads gonna sign off on the risks. Go ahead. At least they told us about it. And it wasn't completely in the shadows. That has its own repercussions because dean director department heads don't understand any of the technical ramifications of what they're signing off on."

Participant P13 sheds light on the issue by expressing how the departments independently request solutions without a holistic understanding of available resources and how the lack of collaboration hampers efficiency. Participant P13 also points out the challenge of decision-makers, such as deans, directors, and department heads, lacking a deep understanding of the technical ramifications associated with the systems they approve.

Participant P13 suggests that decision-makers may sign off on risks without fully comprehending the technical intricacies, leading to potential issues and unsupported systems.

The exploration of decision-making processes within the university reveals a diverse array of primary stakeholders who wield influence and accountability. These primary decision-makers range from high-level executives such as Vice Presidents to the Chief Financial Officer, CIO, and even the State Minister for Research, State Staff Council and University Rectorate each bringing their perspective to the decision table. The narrative expands to include governance constructs, faculty members, heads of departments, and key officers like Data Protection and Privacy Chiefs. Their roles underscore the significance of privacy and security considerations in the decision matrix. Beyond the primary decision-makers, we also encountered secondary stakeholders who may not hold direct accountability but significantly influence change and migration.

P17: "So basically stakeholders are more influencer. I can take them as influencer because we are trying to please them eventually. The whole, everybody, are trying to please your customers right. So we are working thing to make the users or the stakeholders to have a better user experience and also we are driving things according to our strategic plan"

Participant P17 brings a human touch to the discussion, framing stakeholders as influencers collectively striving to enhance user experience and align decisions with the university's strategic plan.

Summary: The lack of effective communication and collaboration between departments regarding procurement decisions is identified as a significant hurdle. Departments often independently request solutions without comprehensive knowledge of existing resources, leading to potential inefficiencies. Despite the desire for inclusion in decision-making workflows, resistance and concerns about delays persist. Additionally, the issue of decision-makers lacking technical understanding is underscored. Decision-makers, including deans, directors, and department heads, may sign off on risks without fully grasping the technical intricacies, posing potential challenges for system implementation. The narrative also emphasizes the diverse array of primary stakeholders, ranging from high-level executives to governance structures, faculty members, and key officers, each contributing their perspective to the decision-making process. The role of stakeholders as influencers, collectively working to enhance user experience and align decisions with the university's strategic plan, adds a human-centric dimension to the complex landscape of decision-making within the university ecosystem. Additionally, informal decision-making processes are prevalent within the university's procurement framework, as revealed by participant insights. Ad hoc requests to the rectorate, staff council, and the data privacy and protection officer occur without following established procedures, highlighting a need for formalization. Although some formalized exchanges exist between faculty and the Chief Information Officer (CIO), the understanding of general demands within the university remains informal. Personal experiences also influence decision-making, as evidenced by the adoption of Zoom based on users' familiarity and positive past experiences, alongside the rapid setup of alternative platforms like BigBlueButton and Jitsi during the COVID-19 pandemic.

4.2.3.2 Students as Stakeholders

In this section we deep-dive into insights share by P18 regarding the distinctions between the Computer Science department's infrastructure of the university and the broader university infrastructure. Initially, the participant delved into the use of cloud technology within the academic setting, specifically highlighting its integration into the master's program. As part of this program, the IT administrator associated with it is actively pursuing certifications in AWS, signifying a commitment to incorporating cloud services into the curriculum. The participant revealed, *"We do have a new master's program ..... And they are working on cloud because of that. And the administrator, IT administrator associated with that is getting certifications in AWS and whatnot."*

In the discussion, it was disclosed that instructors often utilize platforms like Google or AWS to provide virtual instances for students in operating systems and kernel programming classes, allowing practical, hands-on experience with root access. However, this approach is not without challenges, as resource limitations and funding constraints sometimes impede students' progress when they exhaust their allocated quotas. The participant highlighted, *"The limitations have been encountered there with respect to how much time. It's a limited resource and there's no funding to get a larger amount of resource for the students. So sometimes they consume their entire quota and then they can't progress with the course."*

Additionally, historical issues related to email verification for virtual machines were mentioned, emphasizing practical hurdles in using cloud platforms for academic purposes. The participant noted, *"It's a limited resource and there's no funding to get a larger amount of resource for the students. So sometimes they consume their entire quota and then they can't progress with the course. The other problem that we ran into a long time ago was that the students couldn't use their university email address to register for a virtual machine on Google because of something that had to do with age verification."*

In response to these challenges, the department is contemplating the establishment of an on-premise cloud infrastructure, employing technologies like Kubernetes to enhance control and flexibility within the Computer Science department's educational environment. The participant explained, *"So now one thing going beyond that is to say that as a department that's teaching concepts of cloud, we are looking to have local, like an on-premise inside the CS department infrastructure cloud, like Kubernetes deployments, both for student activities and instructional activities and also for core infrastructure. "*

Participant P18 continued the discussion by expressing a contrasting perspective on the suitability of cloud services for computer science students. The participant revealed, *"I actually inherited this computer science infrastructure from somebody who came before me and had implemented it all. And that was 12 years ago that I took this over. But really when something breaks, I can fix it. I don't have to call and wait for somebody to call me back."*

This hands-on approach to problem-solving is presented as a significant advantage over the cloud approach, particularly in the context of universities. The participant characterized the need to rely on external support as a *"potential disadvantage of the cloud approach for the universities, especially, but for anybody."* The participant highlighted the inconvenience of having to contact someone outside the immediate environment, stating, *"You know, you have to call somebody else somewhere else to get it fixed."*

Furthermore, the participant emphasized that this external support model *"doesn't really work so well"* for computer science instruction, suggesting that the nature of the department requires a more immediate and direct resolution of issues. The participant acknowledged that while this approach *"may work okay for the art department,"* it is less effective in the specific context of computer science education.

Participant P18 continued by highlighting the unique requirements for computer science instruction, emphasizing the need for a specialized infrastructure. The participant explained, *"We needed, I mean, for the rest of the university runs Windows, we run Linux."* This distinction in operating systems necessitated the implementation of specialized file servers tailored to the requirements of a Linux-based environment.

The participant further elucidated the department's decision to run its own network infrastructure, including DNS (Domain Name System) and DHCP (Dynamic Host Configuration Protocol). These decisions were motivated by the demands of research and research collaboration, which require a nimble and responsive network infrastructure. The participant emphasized, *"And I maintain to this day that for computer science instruction, you need to have this kind of, what's the word? Nimble, you need to be nimble and responsive in order to keep up with the rapidly changing field of computer science."*

This necessity for agility in adapting to the dynamic landscape of computer science serves as a motivator for the department's approach to its infrastructure. The participant continued by drawing parallels between the department's historical need for adaptability and the ongoing consideration of an on-premise cloud solution. The participant expressed similar concerns for the on-premise cloud solution, stating, *"And going into the on-premise cloud, exactly the same concern."*

Participant P18 introduces the concept of hybrid cloud solutions, describing a model that combines on-premise infrastructure with external cloud providers. The participant articulates, *"Now there's all these hybrid ideas where you could have your on-premise cloud and then you could break out into some provider that provides the same Kubernetes that you have on-premise and run some of your stuff out there."*

The term "hybrid cloud" refers to an IT architecture that incorporates some degree of workload portability, orchestration, and management across two or more environments, which can include on-premise data centres, private clouds, and public clouds. In this context, the participant envisions a scenario where the Computer Science department could leverage an on-premise cloud infrastructure, likely utilizing technologies such as Kubernetes for container orchestration. Simultaneously, they could extend their capabilities by utilizing external cloud providers that offer compatible Kubernetes services.

The use of the phrase *"break out into some provider"* suggests the ability to seamlessly integrate external cloud resources into their existing on-premise environment. This approach allows the department to benefit from the advantages of both on-premise and cloud solutions, combining the control and customization of local infrastructure with the scalability and flexibility offered by external cloud services.

The mention of running *"some of your stuff out there"* implies a selective use of external cloud resources for specific workloads or tasks. This flexibility allows the department to optimize resource allocation, choosing the most suitable environment for different aspects of their computing needs.

Participant P18 sheds light on the distinctive nature of the Computer Science department within the university setting. The participant expresses, *"And then there's computer science, who, because of what we do, is doing something completely different, and we don't fit in."* This observation underscores the unique challenges and requirements that set computer science apart from other departments. The participant humorously highlights the department's tendency to make unconventional requests, stating, *"I'm always asking them for something that nobody else would ever ask them for. (both laughing)"* The participant characterizes the interaction as a *"delicate process,"* hinting at the complex considerations involved in meeting the specialized requirements of the Computer Science department within the university's infrastructure.

The participant then provides an analogy, comparing the field of computer science to a child who doesn't just play with toys but has a knack for breaking them. *"And that's sort of how computer science is, I would imagine, anywhere because we can't just play with our toys, we have to break them. (both laughing)"* This playful yet insightful analogy captures the essence of the experimental and exploratory nature of computer science. The department, in its pursuit of innovation and advancement, often engages in activities that may seem unconventional or even disruptive.

Participant P18 further delves into the challenges posed by the anonymity associated with the internet and cloud computing. The participant acknowledges, *"So this is another aspect of that anonymity of computers in general, and the cloud overall makes it just a step worse."* This observation highlights the participant's concern that the cloud exacerbates the potential for anonymity-related issues, emphasizing the fine line that exists in navigating these challenges.

The participant discusses a specific example related to version control systems, expressing a preference for an on-premise cloud-based GitLab over GitHub due to the desire for greater control and privacy. However, the participant notes that even with this preference, students may still choose to publish their work on GitHub, making it accessible to a wider audience, including potential employers. This raises ethical questions about the intersection of academic work and public visibility.

The participant delves into the philosophical implications, recognizing that some employers request to see students' work from their academic experiences, leading students to make their projects public. The participant reflects on the dichotomy between a genuine desire to learn and the temptation to seek the right answers without truly understanding the material. The participant raises a crucial question: *"The real problem is whether you want to learn or whether you just want to get the right answers."* The statement suggests a concern about the ease with which individuals can access and share information on the internet, potentially compromising the integrity of the learning process. The participant expresses a philosophical perspective on intellectual honesty, noting that the anonymity of the internet and the cloud can make dishonest practices more convenient. The participant suggests, *"It makes it much easier to be dishonest, I guess you could say."* The participant extends this concern to broader societal issues, drawing parallels between academic dishonesty and instances of misrepresentation on social media platforms. The statement humorously touches on scenarios where individuals may pretend to be someone they are not or seek quick solutions to complex problems with minimal effort.

P18:"We have a VPN that all the students can sign into on campus. But I found that most of the students don't have the VPN client installed and don't know how to use it because they never have to."

Participant P18 highlights an interesting observation regarding the usage of Virtual Private Networks (VPN) by students in the university setting. The participant suggests that despite the availability of a VPN for on-campus use, a significant number of students do not engage with it. The reasons provided for this phenomenon include students not having the VPN client installed and a lack of familiarity with its usage, primarily because they have not encountered situations that necessitate its use. The participant's observation raises questions about the perceived necessity of VPNs among students. If students do not perceive a need for VPN usage within the campus environment, it reflects a divergence between the provision of this technology and its integration into the students' routine. This could be influenced by factors such as the nature of academic activities, the types of applications or services students commonly use, and the general awareness or education about the benefits of VPNs.

The statement also hints at the broader trend where users might not proactively adopt security measures unless explicitly required or if the perceived benefits are not immediately apparent in their day-to-day activities. It underscores the importance of not only providing technological solutions but also ensuring that users are informed about their purpose and encouraged to integrate them into their digital practices.

Furthermore, Participant P18 elaborates on the compliance measures related to cybersecurity policies, using SSH access at the university as an example. The participant states, *"We comply with their policies. We just had to restrict SSH access to the campus, only inside the VPN."* The decision to limit SSH access to within the VPN is noted as a response to directives from cyber insurance providers, indicating the university's adherence to external security requirements.

The participant acknowledges the significance of SSH as a primary service relied upon by the computer science department, emphasizing its importance in their workflow. The decision to restrict SSH (Secure Shell) access exclusively through the VPN is described as a source of hardship, leading to some resistance from students who were accustomed to accessing SSH without the VPN. The participant notes, *"There was a little bit of yelling and screaming when the students couldn't SSH in without connecting to the VPN. As I told you, most of them never connected to the VPN, but the cyber insurance folks are making us do that, and, you know, what are you going to do?"* The mention of "cyber insurance folks" underscores the influence external entities, such as insurance companies, can have on shaping cybersecurity policies within educational institutions. Despite the challenges and student resistance, the participant emphasizes the need to comply with these external requirements.

We are also sceptical about the effectiveness of this security measure that Participant P18 states and question the logic behind enforcing VPN-only access for SSH, which their "cyber folks" speak about. The decision to route SSH access through the VPN is a less practical solution and may potentially lead to workarounds and unintended consequences, such as individuals finding alternative ways to SSH into the campus network. Rather than that an SSH connection (with key authentication + 2FA, possibly) is more feasible and could potentially offer a more secure alternative. However, the insurance company's insistence on VPN-only access overrides this option.

Summary: Participant P18 provides valuable insights into the unique challenges and considerations faced by the Computer Science department within the university's infrastructure. The participant discusses the integration of cloud technology into the master's program, emphasizing the commitment to AWS certifications for the IT administrator. Challenges arise in practical classes, where resource limitations on platforms like Google and AWS hinder students' progress. The department contemplates an on-premise cloud infrastructure, particularly using Kubernetes, to enhance control and flexibility. Participant P18 contrasts the hands-on approach of managing the department's infrastructure with the potential drawbacks of relying on external support in cloud solutions, particularly emphasizing the need for nimbleness in computer science instruction. The participant introduces the concept of a hybrid cloud model, combining on-premise infrastructure with external cloud providers, allowing flexibility in resource allocation. Participant P18 also highlights the distinctive nature of computer science education, emphasizing the department's unique requirements for Linux-based systems and specialized network infrastructure. The challenges of anonymity in cloud computing and concerns about academic honesty in an internet-driven learning environment are explored. The observation about students' limited use of the on-campus VPN raises questions about the perceived necessity of security measures. Additionally, compliance measures related to SSH access and the influence of cyber insurance providers on policy decisions are discussed.

4.3 The Migration Odyssey: Process and the Challenges in Migration

After gaining insights into decision-making factors, choices, and stakeholders involved in transitioning to cloud services, the next step is to delve into the process of migration and challenges faced pre-, post-, and during migration. The transition is not merely a matter of shifting data and processes; it involves a complex web of financial, operational, and cultural considerations that demand careful analysis. In this theme, we aim to explore challenges that have emerged from the shared insights of various participants, giving us a deeper understanding of the whole migration journey.

4.3.1 The Uncertain and Complex Cost Equation

A major paradigm shift was a transformation in the way universities handled their IT systems and finances. But, as with any change, it came with its fair share of challenges, surprises, and sticker shocks. However, one recurring theme in this quest for progress is the underestimation of the cost of system changes. This became evident through the voices of various participants in our study. Participant P08 aptly highlighted this issue when they stated:

P08: "I think these processes are often underestimated, what it costs to actually go through such a system change for the whole university. Some colleagues have tried it with campus management systems. Maybe it's even possible there because not that many people are strongly affected [by such a change] and those tangentially affected, they learn around it. Usually, that's the inhibiting reason why it's not possible. Not because of conviction, but because of the personnel effort of the change management process on this level. It's considerable. It's huge."

The complexity of managing a university-wide system change, such as transitioning to the cloud, often extends far beyond what initial estimates may suggest. The inhibiting reason is not a lack of conviction but rather the considerable personnel effort required to manage change at this level.

Participant P13 emphasized by stating that *"we really have to change our thinking and modelling when it comes to financials"* elaborating on the need for a shift in thought process and models concerning finance, indicating that the change in the financial model from CapEx to OpEx is not well understood. In traditional IT setups, most costs are considered capital expenses (CapEx), with infrastructure and hardware being long-term investments. However, with cloud technology, expenses are operational (OpEx), and you pay for what you use, much like a utility bill. It's not just a matter of shifting expenses; it involves re-designing the entire cost and funding model of the university. As Participant P14 stated, *"You're moving from a CapEx-based cost model to an OpEx-based cost model, which many universities are not really prepared for."* This transition requires a deep reevaluation of financial strategies.

The cloud, touted as a saviour for modern IT infrastructure, is not without its challenges. Participant P14 noted that the cost equation for cloud services is often not well understood. Moreover, participants like Participant P06 expressed concerns about payment structures and unpredictable egress charges associated with cloud providers. Participant P06 pointed out, *"some of the issues around the kind of payment structures that the cloud providers work to preferences, you might end up with egress charges for moving data umm which makes it unpredictable."*

Participant P17 reinforced the importance of cost calculations, effectiveness, and the potential for delays due to them. They highlighted that precise predictions can be elusive, especially when estimating egress costs. They noted, *"also cost calculation, cost-effectiveness and all those things that we have calculated but makes us slight delay for us to start looking into IaaS."* P06 also shared their perspective, stating,

P06: "where we keep a regular tab on the kind of prices that you can get from Amazon, from Azure, and these kinds of things. So when we do a refresh of our storage service or high-performance computing services, we will have a pretty good idea already before we even get started, whether it's even a question we need to ask in terms of cost, whether cloud has become cheap enough to be seriously considered as an option, or whether it hasn't, and as yet it hasn't."

Migrating to the cloud presents several challenges, one being the complex calculation of costs. Participant P12 explained how, when detailed modelling was done, financial teams realized the gap in their planning, as they typically operate on multi-year horizons. This highlights the dynamic and evolving nature of cloud costs, which can be challenging to predict. Participant P13 expressed disappointment in the lack of clarity from major cloud providers about the cost of their solutions. The uncertainty in the costs associated with the cloud can be frustrating, as universities want to have a clear understanding of their

expenses upfront. Another concern is the variable nature of cloud costs, as mentioned by Participant P13. Even with thorough calculations, it can be challenging to predict actual egress costs accurately. This variability can lead to budget bursts, where the actual expenses exceed initial estimates. Participant P13 shared a similar experience.

P13: "And a couple years ago, they said, you know what? Unlimited storage, that's not a thing we're going to do anymore. We're going to start charging you some realistic costs. And we've been working for two years to try to figure out how we're going to slap quotas on people, convince researchers to either get rid of old data or push them to colder storage solutions, which maybe cost less, because everybody had this expectation that data was free and unlimited and they could drink from the well all day, and no vendor – all vendors are going to get rid of that unlimited model. So it's sticker shock in that case."

In Participant P13's statement, there is a reflection on a significant shift in the cloud storage paradigm that occurred a couple of years ago. The cloud provider, which initially offered unlimited storage, decided to abandon this model, introducing realistic costs for storage usage [52]. This decision prompted a two-year effort within the university to grapple with the challenges of implementing storage quotas and encouraging researchers to either discard old data or opt for more cost-effective, colder storage solutions. Participant P13 underscores the difficulty in shifting the mindset of users who had become accustomed to the notion of free and limitless data storage, expressing the challenges associated with managing expectations in the face of evolving cloud service models. The reference to "sticker shock" suggests that the transition from unlimited to metered storage incurred unexpected financial considerations, highlighting the complexities universities face in adapting to changing cloud service structures and the necessity of aligning user expectations with the evolving cost landscape. Furthermore, Participant P13 also shared another surprising encounter with cloud costs, saying,

P13: "We had a project with Microsoft and they said, "Oh, don't worry. It's not going to cost you anything, as long as you run with a little asterisk. And this is as long as you run under a 50 gig consumption rate within a month or something like that." And then we just blew past it. Just absolutely blew past it. We're like, "Oh, should we have expected that?" And they just shrugged their shoulders. They're like, "Nah, nobody knew." I'm like, "Well, that's how you make a couple thousand dollars in a month. Turn that off."

Participant P17 further emphasized that while the operational and initial costs may be similar between CapEx and OpEx models, it's the egress costs that can be significantly higher in the cloud. This should be considered when making financial decisions. Participant P13 emphasized this point, saying, *"So that is a sticker shock to people, even though we have data egress waivers with all the big three, it's a surprise to customers when they go out and we provision accounts for them and they say, 'Hey, I actually had to pay for the network through a point.'"*

P17: "the Cloud Service Providers become more like, because now they are like islands you know each one of them are different different setups. Even between them if they can have a shared enviornment or something like you know I can use anything, I can put one system here and I can put another system there in any of the CSPs. They can talk to each other without any issue [communication of the systems in different CSP with each other] then I think it would be wonderful and that definetly will take some time for them to do this. And also the entire CSP provider can look into the cost, very reasonable cost and I think that would really speed up the migration. "

Participant P17 envisions a future where Cloud Service Providers (CSPs) evolve to become more interconnected and standardized, facilitating seamless communication between systems hosted on different CSPs. Participant P17 expresses the idea that the current state of CSPs is like islands, each with its distinct setup. The emphasis is on achieving interoperability between different CSPs, allowing for efficient communication between systems hosted on separate platforms. Participant P17 acknowledges that realizing this vision would require time, recognizing the complexity involved in establishing such a shared environment across diverse CSPs. However, the participant suggests that the benefits would be significant, especially in terms of accelerating migration to the cloud. The mention of "reasonable cost" implies that not only should the communication between CSPs improve, but the overall cost structure should also be favourable, further incentivizing universities to migrate.

I: So how do you overcome this entire challenge of pricing and making people understand?

P13: So it's a lot of training. And we right now we're usually push that over to the vendors and some are better and some are worse at that. Vendors can also be kind of a frenemy, I'll say. Familiar with that term? (I: ya) ..... So training, training, outreach, documentation, and then programmatic.

I: What do you exactly mean by documentation and programmatic?

P13: So we have built out through this tool called ServiceNow, which is our help desk solution. So when somebody wants to come and they want to provision AWS, GCP, or Azure, that's our three cloud vendors that we support. They can come in, they can look at the knowledge base articles related to it. They can create a provisioning request, which explains your rights and responsibilities, how billing works, what you can and can't do in the cloud environment, identify all the interested parties, set up the billing alarms in AWS's case. And we have built out an automation process in the background to systematize most of that account creation, at least for AWS. AWS is our big, it was the first one in the door. It's the largest one of the three.

Participant P13 provides a comprehensive response to the challenge of pricing and user understanding in the context of cloud services. The participant outlines various strategies and tools employed by their organization to address these challenges. Training is highlighted as a key component, with an acknowledgement that vendors vary in their effectiveness at providing training. Participant P13 introduces the term *"frenemy"* to describe the complex relationship with vendors, illustrating a scenario where a vendor (Google) sponsored individual researchers, potentially creating challenges for the overall university's cloud strategy.

To manage this complexity, the participant describes the implementation of a procurement process, looping in multiple stakeholders such as department heads, billing contacts, and even departmental IT. This ensures that individuals seeking to use cloud services follow proper procedures and align with the university's guidelines. Documentation and programmatic approaches play a role. Participant P13 mentions using ServiceNow, a help desk solution, to create a structured process for cloud provisioning. This includes knowledge base articles, provisioning requests, and automation processes for account creation, especially in the case of AWS.

Furthermore, Participant P13 discusses the importance of setting up billing alarms in AWS to monitor and control costs. The participant highlights the challenges faced by AWS and contrasts it with a more favourable experience with Microsoft, emphasizing the importance of collaboration and understanding from cloud providers.

Participant P17's uncertainty about the cost structure of crucial elements, particularly the firewall provided by Cloud Service Providers (CSPs), echoes a broader challenge. The participant admits to not fully understanding how the CSPs' firewalls fit into the cost structure.

P17: " What about this how about this is there a firewall even in my cloud set up I am still not really looking into how they set up their firewall because we know how we set up a firewall, where is the Wall, is there a daily monitoring on the data that comes in or the transaction. We have it in our set up which is on premise. But whether the vendor providing this cloud computing environment environment, there is going to be additional charge for it. Whether there firewall works or not, whether they could be anything, DDoS attack on the cloud or not, I am not sure. We have not experienced. And I also have not discussed this with respect cost, whether it is included or not. I have to do the further discussion with them. I understand how the security set up is on premise, but if you ask me in the cloud, I am still not very sure how it is going to be and all those things."

Despite having a well-established understanding of on-premise firewall configurations, the participant expresses uncertainty about the cloud counterpart. Questions loom over the specifics: Is there a firewall in the cloud setup? How is it configured? Is there constant monitoring of incoming data and transactions? While the on-premise system has these security measures in place, the participant acknowledges a lack of clarity regarding the cloud provider's practices. Additionally, the participant highlights the potential for additional charges related to cloud firewall services and the unknowns, such as susceptibility to DDoS (Distributed Denial-of-Service) attacks. The participant emphasizes the need for further discussions with the cloud vendor to understand the details of cloud security setups and associated costs. **This lack of awareness raises a pivotal question: Is there comprehensive security planning undertaken before migration?**

Understanding the complexities of these services is essential for making informed decisions about cloud migration.

P18: "It's a question of cost and risk and convenience. And it's the convenience of the cloud weighed against the cost and the security of the cloud. And they have to make their own decisions."

The decision to migrate to the cloud involves a delicate balance of cost, risk, and convenience, as emphasized by Participant P18. This balance must be carefully weighed to ensure that universities make informed choices regarding their IT infrastructure. Participant P06 also provides insights into cost considerations, specifically in the context of hosting research data storage.

P06:" It very much depends on what service it is. So the research data storage service we run, because it deals with very large volumes of data over the extended periods of time. The cost of doing this with a one of the major cloud providers, ummm, works out very exensive to do it. It is much more cost effective to host the data in-house or in our hardware in our own data center. "

According to them, the decision on where to host this service depends significantly on the nature of the service itself. In the case of research data storage, which involves handling substantial volumes of data over extended periods, the participant suggests that hosting it with one of the major cloud providers would be a wrong choice financially. The participant concludes that, for research data storage specifically, it is more cost-effective to host the data in-house or within their own hardware infrastructure in their data centre. This decision likely stems from a careful assessment of the specific requirements, costs, and performance considerations associated with managing large volumes of research data. Navigating the migration challenges involves another hurdle—convincing the management to greenlight the budget. As Participant P17 puts it,

P17: "Another thing is even for us to convince our management when getting the budget, our management definitely asks things to do comparative studies and all those things but the thing is we have to try that before you can be very confident on these things because you never know how that works in the cloud. Isn't it?"

There's a need for confidence in presenting the budget to management. The process often involves conducting comparative studies, but the catch lies in the unpredictable nature of cloud dynamics. The uncertainties make pre-testing essential to build that much-needed confidence in the budget approval discussions.

The challenges associated with migrating to the cloud go beyond just financial considerations. As we've seen from the participants, the transition is a complex endeavour that requires a comprehensive understanding of the operational, financial, and human aspects involved. When asked about the experience of the migration process, Participant P07 adds: *"It was time-consuming and cost a lot of workforce."* Participant P07 succinctly pointed out that cloud migration is not just about money; it also demands a significant workforce. The transition, while promising, is not without its logistical hurdles. It's a transition that requires not just financial acumen but also a deep understanding of the operational mindset necessary to equate dynamic costs. We discuss this next in the "People-Centric Transition" subtheme, which underscores the critical role of personnel in the cloud migration process.

Summary: The exploration of university IT system transformations reveals a paradigm shift, introducing challenges in understanding and estimating the costs associated with cloud adoption. Participants highlight the underestimation of expenses in system changes, emphasizing the considerable personnel effort required for university-wide transitions. The financial shift from CapEx to OpEx, a fundamental change in cost and funding models, is underscored, posing challenges in thinking and modeling for financial teams. Concerns arise regarding the cloud's cost equation, with participants expressing uncertainties about payment structures, egress charges, and the overall understanding of cloud costs. Issues related to the variability and unpredictability of cloud expenses, particularly egress costs, are emphasized. Participants stress the need for comprehensive security planning and highlight complexities in assessing cloud firewall configurations. Balancing cost, risk, and convenience is crucial in decision-making, as participants note the necessity of understanding the intricacies before migration. The significance of in-house hosting for specific services, such as research data storage, is highlighted for cost-effectiveness. Convincing management for budget approval involves conducting pre-tests due to the unpredictable nature of cloud dynamics. The challenges extend beyond financial considerations, encompassing operational, human, and logistical aspects, emphasizing the time-consuming and workforce-intensive nature of cloud migration.

4.3.2 People-Centric Transition

In this section, we delve into the people-centric transition to cloud migration, examining various facets of the process. We start by exploring the financial operational mindset, where challenges arise due to the absence of an operational understanding of dynamic cloud costs. Additionally, we discuss the workforce dynamics and skill gap, highlighting the need for specialized cloud engineering skills and the challenges universities face in adapting to the new cloud-oriented culture.

4.3.2.1 Financial Operational Mindset

Participant P13 underscored that a significant obstacle to cloud migration is the absence of an operational mindset to comprehend dynamic costs. Many individuals, particularly those within the research and IT departments, are accustomed to running on-premises servers without incurring additional costs for network usage and power. However, cloud costs are more dynamic and detailed, leading to confusion and reluctance.

P13:"They don't have the, in my experience, they don't have the operational mindset to equate dynamic costs to potentially what they're doing. They can run a Dell to you server all day, all night and not incur any costs because they're not paying for the network. They're not paying for the power in a data center, most likely. Everything is accruable inside an AWS bill. They're like, "Wait, what? Why did you break this down to the number of transactions in this database?" Because that's the way it's priced out."

Traditionally, when running an on-premises server, there are fixed costs for hardware and infrastructure. Running a server 24/7 doesn't result in additional expenses because you're not directly paying for network usage or power. However, in the cloud, every-

thing is itemized and reflected in the billing. This fundamental shift can be perplexing for those accustomed to traditional IT setups. One of the key barriers to cloud adoption is the difficulty in equating the potential costs of what a university or individual wants to do in the cloud until they've actually implemented it. By that point, it may be too late, and the costs could spiral out of control. Participant P13 highlights a real-world issue where departments sometimes unknowingly run up significant bills. For example, they mention cases where departments spun up more virtual GPUs (Graphics Processing Units) than necessary or granted too many permissions to users, leading to abuse and cost escalation. These instances have led to financial setbacks, which are both unexpected and undesirable.

Participant P18 further touches on an important aspect of migration and cloud technology. Switching platforms and migrating data is indeed a challenging task and often comes with its own set of costs. Companies may even charge for migration services, which can add to the *"financial exposure"* of the universities.

P18: "And then sometimes these companies even charge to migrate. And so you end up in all sorts of financial exposure, shall we say, for the advantage of not having to have the same skill level in your IT universities as if you were running your own stuff. (I: Uh huh) Now, of course, I might be biased because I have been running all of my own stuff."

Participant P18 hints that sometimes the expense of migration may not justify the advantages of not having to maintain the same skill level in IT universities. In other words, the initial allure of outsourcing certain aspects of IT to cloud providers may not always be financially practical in the long run. This concept of financial exposure ties into the situation described by Participant P13, where the cost of cloud services was deemed to be unsustainable.

P13: "And we backed off of that and we said, well, maybe that's untenable."

Participant P13's observation reflects how the financial burden lead universities to reconsider and even revert to on-premises solutions. The decision to roll back from the cloud can be influenced by the sticker shock that results from the unexpectedly high costs. Participant P13 highlights another critical challenge in cloud migration: the lack of understanding about cloud costing, especially among researchers and faculty members.

P13:"You point a researcher or a faculty researcher at the Amazon's cost calculator and they absolutely just fall over backwards. They're like, "We have no idea what you're talking about. What's an IOP?" It's like we need customer relationship managers in between the customer and the vendor because there needs to be some sort of translation matrix. What do you want to do? This is how you do it. This is what it'll cost."

When these individuals are confronted with Amazon's cost calculator or similar tools, they often find themselves utterly perplexed. Terms like "IOP" (Input/Output Operations Per Second) might sound like jargon to those unfamiliar with cloud computing. Participant P12 further adds to this discussion by providing valuable insight into how this challenge extends beyond the IT department and is a cultural shift for the entire university.

P12: "I would say the harder part was probably more around finances and understanding the way this works and what it costs. And even beyond the IT universities, IT universities are part of broader universities that have financial folks and all sorts of other folks. It was a big, big cultural shift for them, particularly when you run an IT universities, most of your costs are capital costs, right?..... You pay Amazon a bill, it's like paying your electric bill. And you can't depreciate that, you can't capitalize that. And in larger universities, that has a lot of financial implications. And most universities, their financial folks are not prepared to deal with it. It's a big adjustment for them."

In traditional IT setups, most costs are considered capital expenses (CapEx), with infrastructure and hardware being long-term investments. However, with cloud technology, expenses are operational (OpEx), and you pay for what you use, much like a utility bill. Participant P12 aptly likens paying an Amazon bill to paying an electric bill, where you can't depreciate or capitalize the costs. This shift from capital to operational expenses is a big adjustment and has profound financial implications, particularly in larger universities.

P12: "And most universities, their financial folks are not prepared to deal with it. It's a big adjustment for them. And even though we made that transition, excuse me, five, six, seven years ago now, our financial people have only in the last year started to fully understand what it means."

A key takeaway from Participant P12's insights is the time it takes for universities to adapt to the new financial paradigm of cloud services. To address this, there's a need for extensive training, as mentioned by Participant P13. Training is essential for helping staff understand cloud technology and its dynamic costing.

P13: "So it's a lot of training. And we right now we're usually push that over to the vendors and some are better and some are worse at that. Vendors can also be kind of a frenemy, I'll say."

However, Participant P13 also indicated that training is often pushed onto the cloud vendors, and not all of them are equally effective at providing it. This insight underscores the importance of thoroughly evaluating cloud vendors not only based on their technological capabilities but also on their capacity to support and educate universities through the migration process. Participant P13 also suggests that there's a need for a bridge between the customer (in this case, researchers or faculty members) and the cloud service provider. Participant P13 raises a compelling idea: the need for a new role within IT universities, referred to as a "value engineer" or "cost engineer." This role can act as a translator in systematically managing costs, particularly during the process of migrating to the cloud.

P13: "a value engineer or cost engineer. Like, I think we need like a new title for some, IT people who sit there and help departments, like systematically, systematize like costs and figure out, you know, hey, this migration is gonna cost you this much. You know, if you refactor or redesign, it's gonna cost you this much. And moving to these different services in the long run, like Lambda or something like that, or function or something like that will save you money. So, maybe a cross between an IT engineer and accountant. I don't know. Seems we need them.....I would really love to hire some people, but I don't know what the position description would look like. I think some of our people who are doing more of the cloud side work in our different units within the division have part of that in their playbook now. Maybe it's not part of their official position description or title, but they're figuring out that they have to do that because of the

budget constraints or demands. Like how do we do this better? How do we do this faster? How do we do this cheaper? (I: Okay.) I can imagine a full-time equivalent doing that or being the go-to person in either a unit level or a division level, just like project management, things like that."

The role of a value engineer or cost engineer would bridge the gap between IT and finance. It's a position that would be responsible for helping departments understand and systematize the costs associated with migration. This includes estimating the costs of the migration, understanding the financial implications of refactoring or redesigning systems, and identifying opportunities to save money in the long run by choosing different services or technologies. The unique aspect of this role is that it would require a cross between an IT engineer and an accountant. It combines technical knowledge with a deep understanding of financial principles. These individuals would essentially be experts in managing cloud costs effectively. The idea presented by Participant P13 underscores the growing need for expertise in cloud financial management. Cloud costs can be complex and dynamic, and universities need individuals who can navigate these intricacies and provide guidance on optimizing cloud expenses.

4.3.2.2 Workforce Dynamics and Skill Gap

In tandem with this need for financial expertise, migration to the cloud often brings forth challenges related to workforce dynamics. Participant P12 sheds light on a significant aspect of this challenge, noting that universities may face the necessity of layoffs in one area while simultaneously hiring in another. The balance is crucial for realizing the full benefits of cost optimization in the cloud.

P12: "You're faced with having to do reductions or layoffs in one area and hiring in another. And I think that's one of the biggest struggles with all of this is in order to really take advantage of those savings, you need to make some difficult decisions around your workforce. And we did that, we've been doing that, and we have seen tremendous benefits, but I don't wanna say that didn't come without some difficulty. It is hard to really change your workforce. It's one of the most difficult things that any leader faces."

Participant P12 reflects on the difficulty inherent in making such workforce changes, acknowledging the tough decisions that leaders must grapple with to leverage the savings offered by cloud migration. While the move to the cloud can bring about substantial benefits, the transition is not without its complexities, particularly when it comes to reshaping the workforce. Participant P12's insights underscore the nature of these challenges and the leadership considerations involved in navigating this transformative process. Continuing this discussion, Participant P14 sheds light on a common hurdle—the necessity to onboard individuals with proficient cloud engineering skills.

P14: "But that's been a, that's a hard experience because in order for you to do that, you need good cloud engineering skills. And the team that brought, that migrated the data center into the cloud were old school infrastructure people. They didn't necessarily have the finely tuned engineering skills for doing the right thing in AWS or Azure. So we'd have to hire those people to get it done."

Participant P14 describes this experience as demanding since executing a successful migration requires a team well-versed in the complex working of cloud platforms like AWS or Azure. In their case, the existing team primarily comprised traditional infrastructure experts, lacking the finely tuned engineering skills essential for the nuances of cloud environments. As a result, hiring professionals with the right cloud engineering expertise became a crucial component in navigating the migration journey.

Adding another layer to the challenges, Participant P10 emphasizes a skills shortage in managing the transition effectively by stating, *"But we have a skills shortage on how to manage that transition"*. Participant P10's statement underscores the broader issue of universities grappling with a scarcity of expertise in orchestrating a seamless move to the cloud. This shortage amplifies the complexities associated with ensuring a smooth transition, further underscoring the intricate nature of the migration process. As universities face the need for specialized skills, the quest for qualified professionals becomes a significant hurdle in the path to successful cloud adoption. Participant P10 outlines a strategic approach to address the evolving needs of their university in this context.

P10: "My other way of tackling it is to bring in skills that bring a lot of cloud experience. So I'm about to bring on board a head of infrastructure with a lot of background on cloud services, how to manage them, how to create a cloud centre of excellence, how to upskill and reskill the teams in those areas, and how to really transform the team from data centre operators to cloud engineers."

Participant P10 emphasizes the intent to transition their team from traditional data centre operators to cloud engineers, indicating a proactive response to the changing technological landscape. The participant's plan involves the recruitment of a leader for the infrastructure domain who possesses substantial expertise in cloud services. This decision reflects a deliberate effort to inject specialized knowledge into the university, tapping into the experience of an individual well-versed in managing cloud environments. Furthermore, the participant underscores the broader objective of establishing a *"cloud centre of excellence."* This concept implies a dedicated hub within the university focused on fostering expertise, best practices, and innovation in cloud-related endeavours. It signifies a commitment to not only adapt to cloud technologies but to excel in their implementation. Additionally, the plans to invest to upskill and reskill the existing teams highlight a holistic approach to workforce development and acknowledge the importance of cultivating internal expertise to navigate the transition to cloud engineering.

In a parallel narrative, Participant P11 delves into the cultural shift needed within the universities, especially in acclimating to cloud usage.

P11: "But basically for us, it was more of changing the culture internally in the universities to be familiar with the use of cloud. That also includes even the budgeting component, because remember, in the old days, the budgeting for infrastructure was a CapEx budget in terms of financial rules. And now when you use the OpEx budget in terms of cloud, you need to educate your finance people so that they understand how things are done in the cloud space in terms of contracting, in terms of payments, as well as when you actually get an invoice from them. It's not stuff that you pay upfront kind of thing, you only pay when you've used the stuff. So it was a big change of mindset that became more appropriate."

Participant P11 points out that beyond technical adjustments, cultural change encompasses financial aspects as well. Transitioning from the traditional CapEx budgeting model to the OpEx budgeting model in the cloud necessitates educating internal stake-

holders, particularly those handling finances. This shift in budgeting approach is not just a procedural change but a transformation in mindset. Participant P11 highlights that this cultural shift is crucial for effective cloud utilization, involving education on contractual agreements, payment structures, and invoice handling. When queried about the significance of familiarizing people with the cloud, Participant P11 stresses the need for support from key players like the CFO and other stakeholders.

P11: "You need support from the CFO who understands how payments are done. You need support from your stakeholders who understand what it means when you put stuff on cloud, what it means when you access it, what it means when you do payments so that they understand the whole cloud environment so it becomes easy for you to operate with the cloud service providers and not having to get challenges from internal stakeholders."

Understanding how payments, access, and operations function in the cloud environment is paramount. Participant P11 emphasizes that this familiarity is vital to cultivating a smooth operational relationship with cloud service providers and to avoid internal challenges from stakeholders. It's not just about adopting new technology; it's about embedding a cloud-oriented mindset throughout the university's fabric. In tandem with this, Participant P10 sheds light on the challenges associated with change management across the university. Central to this challenge is the task of effectively communicating the migration message and rallying stakeholders to prioritize this transformative journey.

P10: "So getting that change management message across and bringing our stakeholders with us on the journey. And then them also prioritizing it because they've got other work responsibilities, and they'll always tell you that they're too busy and they're busy doing this and they're busy doing that. So now you end up falling behind on the project because our change management hasn't gone as well. We could have done better if we had, as part of the change management, gotten them to commit to full-time allocation on the project, to migrate to cloud, and not have competing operational responsibilities. (I: Okay) So, yeah, I would say those are the challenges that I've seen so far."

The complexity lies not only in delivering the change management message but also in securing commitment from stakeholders amidst their existing work responsibilities. The perennial struggle emerges when stakeholders contend that they are occupied with various tasks, potentially hindering the migration progress. Participant P10 acknowledges the impact of insufficient change management, leading to delays in the project timeline.

In retrospect, Participant P10 suggests that a more robust change management strategy could have involved securing full-time commitments from stakeholders exclusively for the migration project. This would entail a commitment to prioritizing the migration over other operational responsibilities, ensuring a more seamless and dedicated approach to the cloud migration endeavour. The challenges outlined by Participant P10 illuminate the human side of migration, emphasizing the critical role of effective communication, stakeholder engagement, and commitment in successfully steering the university through this transformative journey.

Participant P10 introduces another important aspect — the necessity for a mindset shift among stakeholders. This challenge revolves around the inherent difficulty in conveying the unique value proposition and differentiators of cloud technology.

P10: "It's really around how we need to get all our stakeholders to understand the differentiator of cloud."

Participant P10 mentions the role of garnering understanding and support from stakeholders, acknowledging the distinct advantages that cloud migration brings. The challenge extends beyond the technical realm, delving into the realm of perception, comprehension, and embracing change. The difficulty lies in elucidating why the cloud is not merely a technological shift but a strategic move that holds transformative potential. Participant P10 recognizes the importance of overcoming this hurdle and aligning stakeholders with the vision and potential benefits of cloud migration. The mention of *"differentiator of cloud"* underscores the need for stakeholders to recognize the competitive edge and novel opportunities that cloud technology can unlock for universities.

Continuing this discussion, Participant P06 introduces another layer by emphasizing the important role of preparing individuals for the impending transition. Highlighting the multifaceted nature of the challenge, Participant P06 identifies two key facets — policies and communications.

P06: "But the biggest challenges are in many respects the actual policies and the communications and the preparing people for the new change."

Firstly, addressing the challenge of policies involves navigating the intricate web of regulations, guidelines, and university protocols that govern the migration process. The need for alignment with existing policies and the formulation of new ones tailored to the cloud environment adds a layer of complexity to the migration endeavour.

P06: "Perhaps even more significant challenge is the communications of the work that we're doing in preparing our researchers, so the users of the service, for how they were going to be using the new one, which is still a work in progress."

Secondly, communication emerges as a significant hurdle. Participant P06 underscores the importance of effectively communicating the intricacies of the migration process, not only to internal stakeholders but also to the end-users — the researchers. This extends beyond a mere technical transition; it encompasses a comprehensive understanding and adaptation to the new workflows and tools that will be integral to their research activities. Participant P06 extends the dialogue by acknowledging that perhaps an even more substantial challenge lies in communicating the ongoing work to prepare researchers and users for the impending changes. The continuous evolution of the new system adds an additional layer of complexity, requiring dynamic and adaptable communication strategies.

Participant P16 sheds light on a fundamental migration challenge tied to adapting and adopting changes in workflows and processes. The crux of this challenge lies in the paradigm shift regarding control — a key aspect for individuals accustomed to a higher degree of customization in on-premises systems. The transition to cloud systems necessitates relinquishing some control over customization. Participant P16 articulates that the intention is to move towards standardized systems, where adaptation and adoption of workflows occur with configurations. This change, however, signifies a reduction in the level of control that individuals might have been accustomed to in the on-premises environment.

P16:" I think the biggest challenge for people is understanding what's changing in terms of control, if I can say it like that. So when we move to these systems, we don't have the same ability to customize. The intention is truly to move to a system and then adapt and adopt the workflows and processes, yes, with some configuration, but you don't have as much control. So, and that does require the business side of the institution to be more involved because it's their processes, it's their workflows."

An intriguing dimension of this challenge is the increased involvement of the business side of the institution. As workflows and processes become integral to the business, the transition prompts a shift in responsibilities. The business side, which may not have been deeply involved in technical aspects before, is now required to play a more active role in shaping and adapting these workflows. Participant P16's insights underscore a broader university's change — a realignment of roles and responsibilities that stems from the shift in control dynamics during the migration process. This challenge not only pertains to technological adjustments but extends into the university's fabric, requiring a holistic and collaborative approach to navigate the evolving landscape of workflows and processes in the cloud environment.

Furthermore, Participant P17 sheds light on another people-centric challenge — how the variance in technology usage between on-premises systems and cloud environments introduces a significant learning curve for the IT team involved in the migration process.

P17: "So for us to use this technology, the cloud providers must also support these technologies. Because sometime you find the cloud providers are not able to support these backup technology what we wanted. Example - I am using Commvault but cloud providers are not using this techology. It's okay for me to use something else but again we have to start learning. My team has to learn the whole thing new because cloud technology it depends right, its different technology and different mechanism to use so its a learning curve for my team to learn la because different providers have a different backup solution."

Participant P17 highlights by giving an example: the compatibility of backup technologies between on-premises setups and cloud providers. In some instances, cloud providers may not support the exact backup technology used by the universities. Participant P17 emphasizes that this necessitates a learning curve for the IT team. Transitioning from one technology stack to another involves acquiring new skills, understanding different mechanisms, and adapting to the nuances of cloud-based solutions. As universities embrace cloud technologies, facilitating continuous education and skill development becomes crucial to overcoming the learning curves associated with diverse cloud provider offerings. The journey toward a successful migration, therefore, involves not only technological adjustments but also a commitment to fostering a culture of continuous learning within the IT workforce. Adding to this, Participant P01 highlights the inherent challenges faced by members of their facility, emphasizing the dynamic and evolving nature of their work environment

P01: "Of course, it could be kind of challenging or complicated for some of the members of our facility to deal with all those ongoing changes because the workplace description pretty much needs to change all the time. And the tasks they are dealing with are changing all the time."

Participant P01 acknowledges that coping with continuous changes can be challenging and complex for certain team members. The mention of *"challenging or complicated"* implies that the ongoing changes pose difficulties that extend beyond routine adjustments,

suggesting a level of complexity that requires active adaptation and flexibility from the team members. The workplace is characterized by a state of flux, where job roles and responsibilities are subject to frequent modifications.

Furthermore, echoing the sentiment encapsulated in the title of this thesis, Participant P16 vividly portrays the experience of being *"at the mercy of somebody else's infrastructure"*. Participant P16 elaborates on the lack of control over the upgrade and refresh cycles imposed by vendors. In this scenario, universities find themselves at dependent on the cloud providers like Microsoft, whose continuous releases introduce a dynamic element to the technology landscape.

P16:And then the other challenge of course is now you are at the mercy of the upgrade or refresh cycles of the vendor. You don't get to plan some of those things. Microsoft is a wonderful example of that 'cause they keep releasing stuff all the time. So how do you build out support? What are the expectations? Who gets access? All of those pieces, we feel like quite often we're trying to race after them versus us being able to control some of those rollouts."

The challenge manifests in a reactive stance among system administrators, as they find themselves navigating and adapting to the constant influx of updates rather than proactively planning and implementing changes. Participant P16's characterization of feeling like they are *"trying to race after them"* encapsulates the urgency and responsiveness demanded by the dynamic upgrade cycles set by vendors. This challenge underscores the shift in the traditional paradigm where on-premises systems often allowed universities more autonomy in determining the timing and nature of system upgrades. In the cloud environment, this autonomy is ceded to the vendors, necessitating a recalibration of universities' expectations, support structures, and access protocols.

Participant P18 offers an intriguing perspective on the cloud migration dilemma by advocating for the retention of a university's own cloud infrastructure on-premises. This approach is driven by several key factors.

P18: "And that's one of the other reasons why I would prefer to run my own cloud infrastructure on-premise and figure out the security things. Not only does it employ more highly educated people. people, locally to maintain it, but it also is a fixed cost because you know what you're gonna pay your people."

Firstly, it's highlighted that running one's own cloud infrastructure enables the employment of highly educated personnel. This implies that universities can have a specialized and skilled workforce on hand to manage and maintain their cloud infrastructure. These experts can not only handle the technical aspects but also navigate the complexities of cloud security effectively(as stated in the above theme as well). Furthermore, Participant P18 mentions that employing these experts locally to maintain the infrastructure can be advantageous. Having on-site experts can provide a sense of security, control, and accessibility that might not be available when relying on external cloud providers. It also allows for more immediate response and customization of the cloud infrastructure to suit a university's specific needs. One of the key benefits emphasized in this perspective is the predictability of costs. By running cloud infrastructure on-premises, universities can establish fixed costs related to personnel and maintenance. Unlike the variable and potentially unpredictable costs associated with third-party cloud providers, this approach provides financial stability and a clear understanding of budgetary requirements.

Summary: Participants highlighted the struggle of individuals, particularly in research and IT departments, to adapt to the dynamic and detailed nature of cloud costs, emphasizing the need for a new role, such as a "value engineer" or "cost engineer," to bridge the gap between IT and finance. The shift from on-premises to cloud services also poses financial exposure risks, and the migration process itself can incur additional expenses. Furthermore, challenges in workforce dynamics include the need for layoffs in one area while hiring in another, skills shortages in cloud engineering, and the time required for universities to adapt to the new financial paradigm. Participants also underscored the crucial role of cultural shifts, emphasizing the importance of educating stakeholders, particularly finance teams, on cloud billing and budgeting. Additionally, communication challenges, change management, and the necessity for a mindset shift among stakeholders were highlighted as key hurdles. The learning curve associated with new technologies, the lack of control over upgrade cycles imposed by vendors, and alternative perspectives on running cloud infrastructure on-premises for security and cost predictability were also discussed.

4.3.3 Data Migration Challenges

While cost and people-centric challenges were major components of the cloud migration journey, universities also grappled with additional challenges, one of which was data migration. One of the prominent challenges in data migration, as expressed by participants P17 and P07, is the risk of data loss during the transition from one hardware platform to another.

P17: "My 90% of the concern is to make sure the user experience is good there is no data loss or lesser data loss"

Participant P17 emphasizes the importance of ensuring a seamless user experience during migration, with minimal to no data loss. This concern highlights that user data is not only valuable but also integral to the university's operations. Data loss can disrupt services, result in user dissatisfaction, and even lead to inefficiencies.

P07: "they produce petabytes of data and moving that from one old platform to a new platform is always very problematic and usually also you encounter situations where you lose data because due to different kind of file systems or whatever, you have problems moving that from the old platform to the new platform"

Participant P07 shares a practical example of this issue, particularly in universities dealing with vast amounts of data, such as petabytes. The complexities of moving such enormous data volumes from an old platform to a new one can lead to problems, especially when different file systems and data structures are involved. This complexity can sometimes result in data loss, which can be a significant setback.

P07: "So hopefully with the new platform that we have, we will not face any more challenges because we don't have to migrate the data on a more or less logical level but we can do it on a more fundamental level. We just obsolete old boxes and add new resources and have the storage software like Zeph automatically allocate and redistribute data blocks to the new system. So this should eliminate the problem of actively migrating data."

However, Participant P07 also provides a glimpse of a potential solution. They discuss a new platform that allows data migration on a more fundamental level. By obsolete old hardware and introducing new resources, with storage software handling data allocation and redistribution automatically, the challenges of actively migrating data can be mitigated. This approach aims to reduce the risk of data loss and provides a more efficient and reliable solution for universities. Participant P04 presents an interesting counterpoint to the challenges of data migration in the cloud. In contrast to the potential data loss and complexities associated with cloud migration, this perspective highlights the reasons for self-hosting data.

P04: "And finally, on top of that we have also our internal regulations that are stating that the transfer of personal related data is only allowed in using <name-of-product> and any on-premise installations. And for that reason we have not many options here to select and approve cloud-based services."

One of the key reasons cited by Participant P04 is internal regulations that restrict the transfer of personal data. This signifies the importance of data privacy and compliance within the universities. In cases where a university is bound by such regulations, self-hosting data on on-premise installations and using specific products can be a means to ensure data security and compliance with these internal rules. This perspective underlines that data migration decisions are not solely based on the technical challenges and advantages of cloud migration. university's policies, regulations, and data privacy requirements play a pivotal role in shaping the choice to self-host data.

Participants P07 and P06 introduce a critical consideration in the context of data migration and cloud technology: the avoidance of vendor lock-in. Vendor lock-in refers to a situation where a university becomes heavily reliant on a particular cloud service provider to the extent that migrating away from that provider becomes impractical or cost-prohibitive.

P07: "Apart from that, once you are invested in such a cloud service, it's hard to move out of that again. So you are stuck with them. ..... When we are talking about our research data, we currently have, I don't know, 4 or 5 petabytes of research data in our on-premises cloud infrastructure. If we move all that stuff to some commercial cloud provider, how should we transfer that to some other cloud provider then? This is a lot of data and once you have it in some location, you are more or less stuck with that location"

Participant P07 raises concerns about the substantial amount of research data stored in their on-premises cloud infrastructure, highlighting the challenges of migrating such massive data volumes to a different commercial cloud provider. Once data is locked into a specific location or cloud service, transitioning to another provider becomes complex and potentially costly. This underscores the long-term commitment and potential limitations that can come with choosing a particular cloud provider.

P06: "and there will usually be requirements around things like ensuring that there's no vendor lock-in so that we can actually change a service provider in the future if we're getting poor performance, but we can still make sure that we can get all our information out in a way that we can put it into a replacement service in the future."

Participant P06 adds to this perspective, emphasizing the importance of ensuring there's no vendor lock-in when adopting cloud services. It's crucial for universities to have the flexibility to switch service providers in the future, especially if performance issues or other concerns arise. Avoiding vendor lock-in allows universities to maintain control over their data and applications, ensuring that they can be seamlessly transferred to alternative providers when needed.

Participant P17 articulates significant data migration challenges related to the integration of diverse systems present on various platforms with the cloud. The complex web of integrated systems, each operating on different platforms, adds layers of complexity to the migration process.

P17:" Second was our integration within the system. All our systems are different different platform and very highly integrated. so when we start moving to cloud, we have to start looking int how we are establish the integration points which is already there and sometime certain integration like you know reading the database is not possible. So you have to start pushing all the data to APIs, which is that system parties are not ready to move to API. So these are the things that concern me about the migration."

One prominent challenge highlighted by Participant P17 is the limitations in reading databases directly during the integration process. This limitation prompts the need to shift the approach towards pushing data through APIs (Application Programming Interfaces). However, this shift encounters resistance from certain system parties who are not prepared to embrace API-based integration. The reluctance to transition to API-based integration poses a considerable hurdle in the migration journey. Participant P17's insights bring attention to the delicate balance required in harmonizing diverse systems and overcoming resistance to new integration methods.

Participant P13 points out another data migration challenge by highlighting the issue of *"lack of data governance"*. The absence of robust data governance practices creates a scenario where the universities grapple with challenges related to data classification, ownership, and control. This lack of governance can lead to unanticipated complexities during migration, as there might not be clear guidelines on how data should be handled, secured, and managed in the cloud environment. In addition to this, Participant P06 introduces another facet of the data migration challenges, emphasizing the need for change in policy decisions.

P06: "There are other decisions to be made, such as what of the data that we have in the original solution are we going to simply bring across and migrate to the new solution as is? Or are there certain bits of data which are now so old and so messy that we simply get rid of that and we ask our users to go and repeat or to enter in afresh the information into the new system? So there's a lot of policy decisions about how we actually introduce the new users to the service because it is essentially a different service. So it's more than purely a technical challenge."

According to Participant P06, decisions need to be made about the data from the original solution. The universities must determine whether to migrate all existing data as is, or whether to eliminate certain outdated and messy data, prompting users to re-enter or update information in the new system. Furthermore, Participant P03 emphasises the need to obtain transparency from cloud service providers regarding data hosting, types of data collected, and data usage.

P03:" So what we need to do is we need to get transparency from the providers first. So where do they host the data, which kind of data, what do they do with the data and so on. And then we need to get the approvals from our data protection office. And sometimes they are very, how to say, picky or sophisticated in applying the data protection law."

The universities face the task of seeking detailed information on where the data is hosted, the nature of the data being stored, and the provider's data handling practices. This need for transparency is further compounded by the requirement to secure approvals from the data protection office, which, according to Participant P03, can be meticulous and sophisticated in applying data protection laws. In conjunction with this challenge, Participant P03 also underscores the ongoing process of validating compliance with data protection laws.

P03: "So we are still in the phase to migrate. One challenge is that we have to clearly the data protection law. So when going to the cloud we need to validate which data are going to the cloud, where are they hosted and so on."

As the universities progress through the migration phase, a key challenge involves a thorough examination of how the data protection laws align with cloud migration. This validation process includes scrutinizing the types of data destined for the cloud, their hosting locations, and other pertinent considerations. The intricate interplay between data protection laws and cloud migration necessitates careful evaluation to ensure alignment and adherence to legal frameworks.

Summary: Participants express concerns about the risk of data loss during the transition to new hardware platforms, emphasizing the importance of maintaining a seamless user experience. Issues related to the scale of data, differing file systems, and the complexity of migration processes are highlighted, with potential solutions involving fundamental-level migration. Participants also underscore the impact of internal regulations on data transfer, leading some universities to opt for self-hosting to ensure compliance. Vendor lock-in emerges as a significant concern, emphasizing the long-term commitment and potential limitations tied to a specific cloud service provider. Integration complexities due to diverse systems and resistance to API-based integration present further challenges. Additionally, participants address issues such as lack of data governance, policy decisions on data migration, and the need for transparency and compliance with data protection laws.

4.3.4 In-Depth Insights Shared

When participants were probed about their experiences with service migration, a comprehensive narrative unfolded through Participant P14's insights. Participant P14 delves into the multifaceted challenges encountered during the cloud migration journey.

P14: "We are, but slowly. It can't be done at once. So, for example, if you've done a lift and shift to the cloud and you now have thousands of virtual servers running there, exactly as they would have in the old data centre... You're effectively running a slightly more expensive version of what you used to. And also you have no control of the consumption there effectively. "

Participant P14 acknowledges the gradual nature of overcoming these challenges, emphasizing the impracticality of an instantaneous transformation. A key concern highlighted is the potential replication of the on-premises environment in the cloud, leading to increased costs, and no control on the consumption of the resources.

P14: "So what we've had to do is to basically start a very aggressive modernization initiative to control through everything, put some tools on top of... we put cloud management tools on top of it to give the application owners the ability to better understand the consumption and performance of their workloads."

Participant P14 outlines a strategic approach to tackle this issue, involving an aggressive modernization initiative, leveraging cloud management tools, and embracing containerization. The participant articulates a strategic response to migration challenges, shedding light on initiatives such as aggressive modernization, containerization, and the adoption of cloud-native DevOps practices.

P14:"Another thing is things like containerization obviously wasn't a concept that existed in the data center. So we've gone on a broad campaign to containerize a lot, where that makes sense. One example we had in one area, I think we had about 20, what used to be 20 servers used as sandboxes for IT staff and for business staff to basically run experiments or do their own little sandboxing. That was moved over to AWS lock, stock and barrel, costing about 65K a year because they were just up running 24/7. So what we did there was effectively just containerize the stack and make that a pay-for-play approach with the select users who would be using the old sandboxes. You can spin up a container and it just rolls up all of it. And then you kill it when you're done. And we've cut the cost down from 65K a year to maybe three, four or five. So I think that approach, and we've done the same with areas where we had applications running in our cloud, but they might have been something that a faculty or a researcher were managing. In many cases, those applications or applications and middleware wasn't being patched, we would like. So we've containerized that as well to sort of bring a bit more, make it a little bit less vulnerable."

Participant P14 describes a significant shift in their approach to managing resources, particularly through the adoption of containerization. Traditionally, the concept of containerization was absent in their data centre practices. Participant P14 highlights a specific example involving the migration of 20 servers, previously utilized as sandboxes for IT and business experimentation, to AWS. This move incurred an annual cost of approximately 65K due to continuous 24/7 operation. In response, the universities embraced containerization, introducing a pay-for-play model for select users accessing the sandboxes. This containerization strategy proved instrumental in cost reduction, slashing the annual expenditure to a more manageable range of three to five thousand dollars. Furthermore, the participant extends the application of containerization to areas with cloud-hosted applications overseen by faculty or researchers. In these cases, containerization served as a solution to address patching challenges, enhancing overall system resilience and reducing vulnerability. The narrative underscores the adaptability of containerization in optimizing resource management, controlling costs, and fortifying the security posture of cloud-hosted applications.

P14: "So I think, yeah, there is a, in order to do that, we obviously need to have really good cloud engineering skills, which we didn't have, and we've had to hire those people, and also contractors and consultants to a large extent, and that's been costly, but it's kind of something that you're going to have to do. We're also going pretty aggressive on DevOps overall, so anything new we build, we try and build on a proper cloud-native stack. The last two big development projects we did, we used CDK and serverless architecture, so it's a different game, and it's not, you need, it's new IT, you need, it's not the same as old, right."

Participant P14 emphasizes the significance of cloud engineering skills, necessitating recruitment and collaboration with external experts. Participant P14 also underscores the continuous evolution required for success in the cloud environment, pushing universities to embrace new IT paradigms and invest in skill development. This exploration into service migration experiences not only highlights the challenges faced by universities but also underscores the strategic manoeuvres employed to navigate the evolving landscape of cloud computing. Furthermore, when asked about the experience of migration, participant P14 provided insightful reflections on the process.

P14: "The migration itself is not very hard actually... the challenge is afterwards when you realize that what you've put in there isn't good enough for the environment that you put it in, and it needs changing and adapting. So the actual migration itself is not where the, it's not where you've, the challenges are. "

The participant characterizes the migration itself as relatively uncomplicated, emphasizing the ease of the lift-and-shift phase. According to them, this initial stage involves straightforward relocation without significant challenges. However, Participant P14 introduces a critical nuance by highlighting that the true complexity emerges in the post-migration phase. It becomes apparent that the deployed infrastructure may not align seamlessly with the new cloud environment, necessitating subsequent modifications and adaptations.

I remember I worked at <Name-of-University> seven or eight years ago, and we migrated out of that data centre in, you know, start to finish in, I think, less than nine months, and all of it, and that was, that was massive. It was a really big footprint, and, you know, very few issues as a result of the actual lift and shift. But then, and then you think you've succeeded, all right, it's job done now, but you realise that that's, you've done five percent, and the real work starts now. "

Drawing on personal experience from their tenure at a previous institution, Participant P14 recounts a large-scale migration from a data centre. The migration, covering the entire process from start to finish, was accomplished in an impressive timeframe of less than nine months. Despite the magnitude of this undertaking, Participant P14 notes that the lift-and-shift operation itself encountered minimal issues, contributing to a perception of success. However, Participant P14 realises a critical perspective—while the migration process may constitute a significant milestone, it represents only a fraction of the overall journey. The participant metaphorically states that succeeding in the migration is akin to accomplishing five per cent of the entire endeavour. The subsequent realization is that the substantial work lies ahead, post-migration. This insight underscores the iterative and ongoing nature of cloud adoption, emphasizing that the immediate post-migration period demands focused attention to address evolving requirements, optimize configurations, and adapt the infrastructure to the cloud's dynamic nature.

When asked about overcoming challenges faced by users during the cloud migration process, Participant P03 provides insights into three key strategies. These strategies are geared towards fostering a positive mindset, addressing concerns, and ensuring a smooth transition for university staff.

P03: "Yes. So what we need to do is, first thing we need to train the people so that they know what is cloud, how to do it. Second, we need to have a clear vision statement to say, okay, we are cloud positive, and we consider cloud, and under which circumstances we consider cloud. And then we need to address also the fear of the people to say, okay, you won't lose your job as server administrator, even if all the infrastructure goes into the cloud or may go to the cloud."

Firstly, the participant emphasis on training staff to enhance their understanding of cloud technology. By providing education on what the cloud entails and how to navigate it, the university aims to empower its workforce with the skills needed for the changing IT landscape. This aligns with the broader theme observed in university settings, emphasizing the importance of preparing individuals for the transition through training and awareness programs. Secondly, the university aims to have a clear vision statement. This vision statement serves as a guiding principle, declaring the university's stance on cloud adoption and outlining the circumstances under which cloud solutions are considered. Such clarity in vision can act as a unifying force, ensuring that all stakeholders within the university community are on the same page regarding the strategic direction of IT infrastructure.

However, perhaps the most important aspect is the acknowledgement and addressing of staff fears. Transitioning to the cloud can evoke uncertainties, especially regarding job roles. Universities take a proactive stance in reassuring staff that their roles remain integral, emphasizing that the adoption of cloud technology is not a threat but an opportunity for growth. This human-centric approach aims to create a supportive environment where staff members feel valued and secure amid technological changes.

Participants P01 and Participant P08 both underscore the significance of organizational challenges compared to technical challenges. P01 succinctly captures this sentiment by stating, *"But often the technical challenges are less than the actual organizational challenges."* This implies that, in the context of IT initiatives, the hurdles stemming from organizational aspects tend to outweigh those arising from technical complexities. The statement suggests a recognition that navigating and managing organizational dynamics poses a greater challenge than addressing the technical intricacies associated with IT implementations.

Furthermore, Participant P17 provides a real-world example highlighting the challenges encountered during a Proof of Concept (PoC) that seemed promising on paper but revealed issues during testing.

P17: "For example I could say like a recently we have done a PoC. Before we do the PoC everything looks fine on the paper but when we tested it, there is a you know network contigent you know congestion that where we are not able to push all our data on time for us to you know retrive our system. Like you know when you copy the data, the file is very big."

The participant specifically mentions a network-related challenge, specifically "network contingent congestion," that affected the timely transfer of data, making it difficult to retrieve the system. The example underscores the importance of practical testing and

validation beyond theoretical planning. While the PoC appeared fine in the planning stage, the actual implementation exposed a limitation related to network congestion. The mention of being unable to push all the data on time emphasizes the impact on system performance and data transfer speed. Participant P17 also suggests that the deployment of cloud services may not always align precisely with the specifications outlined.

P17: "It is not same as what is written in the specification and all. Sometimes even the service provider find a lot of magics, lot of unknown things during the deployment. I think its fairly new."

The participant highlights that service providers may encounter unexpected challenges or discover unanticipated factors during the deployment process. This observation underscores the evolving and dynamic nature of cloud technologies, where the deployment landscape can be subject to uncertainties and unforeseen complexities.

When asked about if there were some instances where migrating to the cloud did not seem a feasible option and they had to migrate back to self-hosted infrastructure, Participant P01 shared their experience by stating,

P14: "No, but there are some... I mean, there's clearly situations where things have been not working great. But never to the point where we were moving it back. Simply because moving it back would be probably even more... would be worse."

Participant P14 acknowledges that while there have been situations where things in the current setup have not been working optimally, the issues have not reached a severity where the decision to revert or move back to a previous state was considered. The participant suggests that the challenges faced in the current setup, while not ideal, are perceived as preferable to the potential difficulties or disadvantages that might arise from reverting to a previous configuration.

Furthermore, Participant P17 continues the discussion by expressing their perspective on different cloud service models, specifically focusing on Platform as a Service (PaaS) and Software as a Service (SaaS).

P17: "Platform as service I think its much easier. It comes with its platform and that guys have already done their homework, its fine. Platform as service I think its much easier. I find its much easier. But if its a software as a service and you know, lets say you have a traditional system and you could deploy your system or you set up your postgress environment."

Participant P17 states that Platform as a Service (PaaS) is considered much easier. PaaS typically provides a platform that includes infrastructure, middleware, and development tools, simplifying the deployment and management of applications. The participant appreciates the fact that the PaaS provider has already done the necessary groundwork, making it easier for users to work with. In contrast, the participant highlights the potential complexity associated with Software as a Service (SaaS), especially when dealing with traditional systems. The example mentions deploying a system and setting up a PostgreSQL environment, suggesting the challenges that might be encountered in a SaaS context where users are more directly involved in configuring and managing software applications.

In the end, Participant P17 emphasizes the ongoing nature of managing on-premise solutions, *" Even on-premise, it is a continuous thing"*. Participant states that even after about five years of stabilization efforts, there is a continuous need to fine-tune servers and address various aspects of on-premise infrastructure. This observation underscores the dynamic and iterative nature of IT management, whether in on-premise or cloud environments. But, Participant P17 expresses a personal expectation regarding the performance of cloud hosting compared to their current hosting environment (data centre) by stating, *"My personal expectation is that it should be faster than my current hosting i.e my current data centre."*

Summary: The gradual nature of overcoming challenges is emphasized, with concerns raised about potentially replicating on-premises environments in the cloud. A strategic approach involving aggressive modernization, containerization, and cloud-native DevOps practices is detailed to optimize resource management and control costs. The recruitment of cloud engineering skills is recognized as crucial for success. The iterative nature of cloud adoption is underscored, with post-migration complexities requiring ongoing adaptation to the dynamic cloud environment. A shift in mindset is highlighted as key to overcoming challenges, with strategies including staff training, a clear vision statement, and addressing employee fears to ensure a smooth transition. Organizational challenges are deemed more significant than technical complexities in the context of IT initiatives. Real-world examples reveal unexpected issues during Proof of Concept testing and the dynamic nature of cloud deployment. Instances where reverting to self-hosted infrastructure was not deemed feasible are acknowledged, emphasizing the commitment to address challenges within the existing setup. The continuous need for fine-tuning in both on-premise and cloud environments is recognized, with expectations of improved performance in cloud hosting compared to traditional data centres.

4.3.5 The (In)Formal Process

Having delved into the challenges universities face—ranging from cost considerations and workforce transitions to data migration complexities—during the migration process, let's now explore the journey itself. Participant insights shed light on the nature of these processes, revealing a dynamic landscape that adapts to the unique contours of each migration endeavour.

When probed about their migration process, Participant P13 provides a candid glimpse into their informal yet pragmatic approach to the migration process.

P13: "I guess informally, if you were to schedule a consultation with us, we would try to understand what you're intending to do and align you with one of our support engineers between the vendors. We have enterprise support, we have the Cadillac of support for AWS. We have very fine support with Microsoft. Google is a lot less functional. (laughing) But we would say, "Hey, we're not the subject matter experts here. We can provide you some general guidance. We don't have best practices 'cause everyone is kind of, every migration is kind of its own individual snowflake, to be honest. (I: Mm-hmm.) And maybe migration isn't the best path, but here, talk to these vendors. Then the vendors will say, "We don't know how much it costs to run it." (laughing)"

They mentioned the process of scheduling a consultation, where the focus is on understanding the client's intentions and connecting them with a suitable support engineer from various vendors. The participant highlights the availability of enterprise support, emphasizing the quality of support for AWS and Microsoft, with a humorous remark about Google's functionality. Participant P13 acknowledges the uniqueness of each migration, dismissing the idea of having one-size-fits-all best practices. The participant leans towards collaborative discussions with vendors, recognizing the inherent complexity of migration endeavours. Intriguingly, when probed about the existence or development of a formal process, Participant P13 provided insight into the near future, suggesting that a formalized migration process might not be on the horizon. Participant P01 further adds to the discussion by stating,

P01: "We do not have a formal decision-making process for that. So the decision-making structure within the <name-of-university> was comparably dated. So the head of the computer centre, the old head of the computer centre who was a professor in the computer science department as well, retired a year ago and he was in the same position as the CIO of the university. But he didn't fill at all this position. So pretty much those strategic decisions, we didn't learn about those. So he was part of the rectorate, so was in the university administration but we didn't learn much about what he actually did there. And I don't know if he actually reported on what we would like to be discussed within the rectorate from our side. So it was pretty opaque to us and strategy development and decision-making either did not take place or we didn't really learn about that."

Participant P01 sheds light on the organizational dynamics related to decision-making processes within the university, highlighting a lack of formalized structures and transparency in the decision-making hierarchy. The participant describes the decision-making structure as comparably dated, with the head of the computer centre, who also held the position of the CIO, retiring a year ago. The absence of a successor to the retired head of the computer centre, coupled with the participant's assertion that strategic decisions were not effectively communicated, points to a potential miscommunication within the hierarchy. The opaque nature of strategy development and decision-making processes suggests a gap in information flow between the administrative level (rectorate) and the operational level (computer centre). The participant uses the term *"pretty opaque"* to characterize the lack of transparency in understanding strategic decisions and actions taken at the administrative level. The phrase *"either did not take place or we didn't really learn about that"* implies a level of uncertainty or lack of awareness regarding the actual occurrence and communication of strategic decisions within the university.

Participant P05 adds another facet to the conversation, shedding light on a prevalent practice in the migration landscape.

P05: "Normally, they do with cloud provider. So they hire consultants from cloud provider to help with these migrations. they are often not able to do the kinds of migration by themselves because they don't have the necessary knowledge to do themselves."

When asked about their migration process, Participant P05 unveils a tendency to collaborate with cloud providers by hiring migration consultants. This external assistance is attributed to the perceived lack of in-house knowledge required for intricate migration tasks. This approach, while practical, underscores the challenges universities face in independently executing complex migrations due to a lack of internal proficiency. Participant P12 underscores the importance of thorough financial modelling in the decision-making

process before embarking on the migration journey.

P12:"Sure, so financially, we kind of did a lot of modelling, which put into real tangible terms, what the impact was of the shift to the new model, really kind of worked with our leadership and our executive team to get their understanding."

The mention of *"a lot of modelling"* suggests a rigorous approach to understanding and quantifying the financial implications of the shift. This financial modelling likely involved various scenarios and variables to comprehensively assess the impact of transitioning to the new model. The mention of putting the impact "into real tangible terms" indicates a desire for concrete and measurable insights. By translating the potential consequences of the shift into tangible metrics, the university could have gained a clearer understanding of the financial landscape associated with the migration. Moreover, the collaborative aspect of working with leadership and the executive team suggests a collective effort to ensure a shared understanding of the financial aspects involved. This collaboration is crucial for aligning the organization's strategic goals with the financial realities associated with the migration.

Lastly, Participant P09 adds another dimension to the discussion by revealing a practice within the organization where researchers independently utilize cloud hosting for testing purposes without involving the knowledge or intervention of IT administrators or staff.

P09: "On the other hand, if they want to try something out, then we go to the cloud. Because then, yeah, it's not worth it getting our own machine, then they can test. Yeah. And, and, and yeah, we're not, we're not that big. So that's why, until now, we are, we are using some cloud services. Some, I know some people do computing at Amazon, at Google."

Participant P09 suggests that when researchers need to explore or test something, they opt for cloud services. The participant acknowledges the organization's size, indicating that, due to its scale, using cloud services becomes a practical and efficient alternative for testing scenarios. By stating, *"We're not that big,"* Participant P09 implies that the university's size influences the decision to turn to cloud services for testing, emphasizing the cost-effectiveness and flexibility offered by the cloud in such contexts.

Summary: Participant insights showcase an informal yet pragmatic approach to migration, characterized by collaborative consultations with vendors and an acknowledgement of the individuality of each migration endeavour. The absence of one-size-fits-all best practices is highlighted, with a reliance on vendor discussions to navigate the inherent complexities of the process. Concerning the formalization of migration processes, insights from participants indicate a lack of established decision-making structures within universities. Organizational dynamics suggest a dated and opaque decision-making hierarchy, with strategic decisions often undisclosed or not effectively communicated to the operational level. External expertise becomes a prominent feature, with universities commonly engaging consultants from cloud providers due to perceived knowledge gaps in executing intricate migrations independently. Financial modelling emerges as a crucial aspect, with a participant emphasizing a rigorous approach to understanding and quantifying the financial implications of migration. The collaborative nature of working with leadership underscores the collective effort to align strategic goals with the financial realities of the migration process.

4.4 Guardians of Data: Navigating Governance in Cloud and Self-Hosting Choices

Theme 3, "Guardians of Data," delves into the intricate world of data and infrastructure security management. This theme provides a comprehensive understanding of the measures taken to safeguard critical data assets and the strategies employed to ensure the security of cloud and/or self-hosting solutions.

4.4.1 The Digital Rebels - Resisting the Migration to Cloud Services

This subtheme explores the resolute stance of a group we term "digital rebels," who resist the ubiquitous migration to cloud services. Their resoluteness originates from a profound scepticism towards the promises of cloud technology. This subtheme delves into their narratives, revealing their commitment to preserving data autonomy and privacy through self-hosting. It unearths the motivations, challenges, and underlying philosophy that drives these guardians of data to spurn cloud services in favour of self-hosting, ultimately underscoring the resistance to contemporary cloud trends.

Participant P05 sheds light on the distinctive data privacy culture that exists, particularly concerning cloud services, drawing a distinction between EU and non-EU providers, primarily American ones. This perspective showcases the significant concerns surrounding data privacy, especially as it pertains to the reach of U.S. intelligence agencies.

P05:"erm.... On the privacy part of using clouds.
I: Um, could you elaborate more on that?
P05: Em.. that's because the big American cloud providers as Microsoft, Amazon, Google, the NSA in the United States all this can er.. reach to the er... data.
I: Okay.
P05: So that there is sometimes discussion in Netherlands that we see that more and more universities are doubting if they still want to put their data in these big American cloud providers.

I: Okay. How do you overcome this challenge?
P05: We can't overcome that that that use their decision. We can't change that. They are right that NSA can ask for data in these clouds."

Participant P05 emphasizes that major American cloud providers, such as Microsoft, Amazon, and Google, are subject to the NSA's (National Security Agency) authority in the United States. The concern here is that the NSA's reach extends to data hosted within these cloud providers. This leads to a growing sentiment within the Netherlands, and presumably in other European countries, that universities and universities are beginning to doubt the wisdom of entrusting their data to these major American cloud providers. They recognize that the perceived ability of the NSA to access data within these clouds is a significant and immutable factor driving this decision-making.

In the discussion about the decision not to migrate to cloud services, a crucial factor that stands out is the issue of compliance with GDPR and state laws. As Participant P04 astutely observes:

P04: "Well I believe the big problem is that the enterprises are offering cloud-based services without any consideration and any reflection of GDPR. They simply do not care about the requirements that GDPR is setting and that is a big problem."

Participant P04 highlights a critical issue where certain cloud service providers fail to align with GDPR requirements. GDPR is a stringent set of data protection regulations aimed at safeguarding individuals' privacy and data rights in the European Union. When cloud providers disregard these regulations, it jeopardizes the privacy and security of personal data, making it legally challenging to entrust them with sensitive information. Participant P04 further underscores the gravity of the situation, asserting,

P04: "Well in our opinion some of them are illegal and that's why we cannot follow that.
I: So illegal because it doesn't fit into the GDPR laws?
P04: Either GDPR or our internal laws in the state <name-of-state> or not fitting to our internal guidelines that personal related data cannot be transferred externally except in the in <name-of-product> and yeah."

The term *"illegal"* signifies a breach of legal boundaries and regulatory requirements. The assertion of illegality reflects the gravity of the issue and the potential legal consequences associated with using such services. In addition to GDPR, Participant P04 also mentions concerns regarding compliance with internal state laws and university guidelines. The refusal to migrate data to the cloud is not solely rooted in GDPR but extends to any internal laws specific to the participant's state and university policies. Participant P02 stressed that while using cloud services within the European Union might be feasible from a technical standpoint, it becomes problematic due to data protection issues. Participant P02 asserts,

P02:"When we use cloud services in the European Union that would be possible but as a problem for the data protection but the most of relevant or interesting services are not located in the European Union and therefore we did not as this was the non-technical factor to decide against cloud services."

This statement underscores their emphasis on data protection and its influence on their decision-making process. Moreover, Participant P07 raised a significant point regarding the potential loss of data accessibility in the event of changing political relations between countries.

P07: "And relying on getting cheap cloud services from somewhere else, from the United States or China or whatever, might be for some a good and cheap solution. But on the other hand, if anything goes wrong and relationships with those countries providing cloud providers have their bases, when those relationships go bad, then you're really bad off because you no longer have your data accessible."

While obtaining cost-effective cloud services from other countries might seem appealing, Participant P07 highlighted the inherent risk. If diplomatic relationships turn sour, the university could face challenges in maintaining access to its data. This concern underlines the intricate geopolitical factors that universities must consider when deciding on cloud migration. Participant P02 continues to emphasize the significance of data protection as a non-technical factor, especially in the context of cloud services hosted outside the European Union, particularly in the United States. They elaborate,

P02:"Yeah the non-technical factor is in fact the data protection problem because with data protection we have a really big problem in particular when cloud services are hosted over the sea in the United States. This is a really big problem and to solve or to don't get this problem we don't want to use the US American cloud services"

Participant P08 chimes in, adding another layer to the concerns regarding data location and data security. They raise doubts about the security of data stored in the United States and suggest that the risk of data theft may be similar to or even greater than the risks associated with other countries, such as Russia and China. Participant P08 adds:

P08: "And then all the stuff is still in the USA and they steal... Well, you don't know, but they won't steal that much less than the Russians and the Chinese. So there might be a chance of turning around."

This assertion highlights the apprehension about data security and data sovereignty in the context of cloud services hosted in the United States, thereby contributing to their decision against migration. Participant P01 further adds to this discussion by raising the issue of trust and privacy concerning major cloud service providers such as Microsoft, Google, and Amazon. Participant P01 acknowledges the uncertainty surrounding how these companies handle users' data.

P01: "Of course, you never know what companies like Microsoft, Google, Amazon and so on do to your data. So you typically forge some agreements with them and hope for the best that they don't misuse it or let some third-party services look into that data and so on. So the NSA threat of course is lingering pretty much above everything but that doesn't necessarily mean that you are secured against that if you operate your own service."

They explain that users often enter agreements with these providers, hoping that their data won't be misused or accessed by third parties. The looming threat of government agencies, like the NSA, adds an element of unease to the discussion. Participant P01 suggests that even though individuals may operate their own services, it doesn't necessarily guarantee security against potential breaches or unauthorized access. This

sentiment reflects the complex dynamics of trust and privacy in the cloud. Participant P02 echoes these concerns, particularly emphasizing the apprehension about privacy and data protection. Participant P07 emphasizes the pivotal issue that arises when a university relinquishes control of its data to third-party cloud providers.

P07: "When we give it out of hand to some commercial cloud provider, we no longer have data in our own hands. It can happen that they are doing things with that data that we do not know and that we couldn't even identify that something is going on there. Of course, we can have contracts that forbid that, but when it comes to contracts you can believe them or you cannot believe them. The Patriot Act in the US enables or even forces commercial cloud providers to make data accessible to US authorities. There is not yet a follow-up agreement between the European Union and the US on that. So we see a legal problem in using public cloud services, especially from the United States for this."

This relinquishment of control raises the spectre of uncertainty regarding the handling of the data and the potential for unauthorized or unknown actions being taken with it. Participant P07 underscores the legal dimension of this issue by pointing out that contracts, while they may prohibit certain actions, don't necessarily guarantee compliance. They mention the Patriot Act in the United States [4], which empowers or obligates commercial cloud providers to grant access to data to U.S. authorities. Importantly, Participant P07 highlights the absence of a subsequent agreement between the European Union and the United States regarding this issue, resulting in a legal challenge. This legal dilemma forms a significant concern, particularly when considering the use of public cloud services, especially those originating from the United States.

Participant P02 expresses a genuine fear regarding the usage of data stored in cloud services by saying that *"I'm really afraid about the usage of data that's stored in the cloud services."* They further articulate a significant apprehension related to the fear of data breaches and unauthorized access to sensitive data within cloud services. They specifically point to AWS, a prominent cloud service provider, and highlight a scenario where documents containing encryption keys are stored. Participant P02 expresses deep concern by stating,

P02: "For instance, the AWS service, when there are documents where your keys are stored and so on, and then you can see that some Amazon administrators have access to the keys. Then I know this access to these keys, you have access to the data. I'm really afraid."

This statement underscores a core worry related to cloud services – the potential for privileged access by service providers, which, if misused or compromised, could lead to unauthorized access to critical data. When asked about their future plans to migrate to the cloud, Participant P02's response is resolute: *"No, we don't do so because we see a lot of lawful problems with cloud infrastructures and a lot of problems with data protection."* This response reaffirms their decision not to migrate to the cloud, underlining the pivotal role of concerns regarding data breaches and access control in shaping their stance against cloud adoption. The fear of exposing sensitive information and the associated legal and data protection issues emerge as driving factors in their decision-making process.

Participant P08 provides a compelling rationale for their reluctance to migrate to the cloud. They emphasize the historical perspective, stating that past incidents have demonstrated that commercial systems, particularly the larger ones, have consistently been the primary targets for cyberattacks. They state,

P08:"And under many aspects, for example, it was discussed again recently, the keyword "IT security", how we can be attacked at the University of <University Town>. If you look at the incidents in the past, it has actually shown that it was always the lever of the big commercial systems or almost always, there are still exceptions, which were actually the door opener for corresponding activities [meaning: security breaches]."

In essence, this perspective highlights a fundamental concern about the security of data and systems in the cloud. Participant P08's viewpoint suggests that migrating to the cloud might expose universities to a higher risk of being targeted by cyberattacks, based on the historical track record of commercial systems as attractive entry points for malicious activities. This history of attacks serves as a pivotal factor in their decision-making process, leading to a cautious stance towards cloud migration.

Participant P04 highlights a critical concern within the decision-making process regarding cloud adoption: the handling of data privacy and protection by enterprises. They emphasize the importance of clear, specific contracts that describe how data privacy and protection will be ensured. However, Participant P04 expresses frustration, noting that many enterprises are unwilling to sign such contracts. This hesitancy on the part of enterprises leads to a significant number of them being deemed unsuitable for collaboration. Participant P04 asserts,

P04: "Actually, the main concern is how the enterprise is handling data privacy and protection. And that is what we always ask the enterprises and in most cases the enterprises are not willing to sign any contract with specific descriptions about that and for that reasons many enterprises are out for the game for us, out of the competition. Because if they cannot guarantee precise data handling then we cannot sign the contract with them."

This perspective underscores the paramount importance of data privacy and protection in cloud decision-making, ultimately leading to the exclusion of certain enterprises from consideration. Throughout the interview with Participant P08, the discussion revolved around the pivotal issues of privacy and security. At the onset, it was underscored that these concerns are of paramount importance. The participant emphasized that with self-hosted solutions, data control remains in-house, providing a clear advantage. In contrast, with cloud solutions, a lingering uncertainty exists concerning the whereabouts of the data.

The question arises **could cloud solutions be enhanced if providers exerted more effort to document their practices, ultimately fostering a more secure environment?** The response provided by Participant P08 is insightful: *"That's exactly the question. Whether they do it, whether they want to reveal it at all. Because those who do it have so much power that they don't necessarily have to. I mean that politically."* This viewpoint points to the complex power dynamics at play, where cloud providers, wielding substantial influence, may not feel compelled to disclose their operational details.

Participant P08 goes on to highlight the influence of political authorities in this context. They posit that if a country's government demands access to data, cloud providers may have little recourse but to comply. Even assurances of data localization or protection may not suffice, as the participant questions,

P08: "Honestly, who gives you the security that there is no breakthrough and that you can't get it? So to leave that to the authorities. You can argue about that."

This viewpoint underscores the intricate interplay of power dynamics, data control, and data privacy. It questions the ultimate custodian of data security, with a keen awareness of the potential influences of both political entities and corporate giants. It reflects the ongoing debate about the locus of authority in safeguarding data – a debate that is emblematic of the multifaceted nature of data governance in today's digital landscape.

Participant P15 offers another dimension to this issue, emphasizing a rigorous process of privacy and security evaluation for applications that are candidates for cloud deployment. They describe how potential applications undergo a thorough privacy and security audit, with executive board approval contingent upon the outcomes of this evaluation. Any issues or non-compliance with provincial or federal laws can prevent an application from moving forward. Participant P15's statement,

P15: "When we look at somebody that wants to have an application in the Cloud, it goes through a privacy and a security audit, an investigation, if you will, and then it gets presented to an executive board for approval. If there's any issues whatsoever or if it's contrary to provincial or federal law, then it doesn't go forward."

This highlights the meticulous scrutiny of cloud services to ensure adherence to privacy and security standards, indicating the high stakes associated with data privacy and protection. Both participants collectively emphasize the central role of data privacy and security considerations as non-negotiable elements of cloud adoption. Participant P06 adds depth to this narrative by addressing the importance of infrastructure in handling sensitive data.

P06: "What the kind of the infrastructure that is hosting it, whether it can meet the requirements for handling sensitive data and things like that. There's lots of personal data that's held in university systems. So we need to make sure that whoever we trust with that data has clear practices and processes in place to deal with any data breaches, anything like that."

They emphasize the need for clear practices and processes, especially for university systems that contain significant amounts of personal data. P06's viewpoint underscores the critical importance of trust and security in choosing where to store and process sensitive information. The perspective of Participant P07 complements these views by highlighting the critical role of long-term sustainability and data control in their decision to use self-hosted systems exclusively. They note that *"the key objectives in designing this was that it was long-term sustainable, that it was on-premises and not giving away data to any commercial provider"*. The choice to keep data on-premises and not entrust it to commercial providers aligns with the broader theme of data privacy and control. This indicates that the concern for data privacy and data ownership plays a significant role in determining the deployment of systems and services.

Summary: Participants highlight the role of data autonomy and privacy in their decision to opt for self-hosting over cloud adoption. Concerns centre around data privacy culture, particularly in the context of major American cloud providers subject to the reach of U.S. intelligence agencies, raising apprehensions about data security and compliance with GDPR and state laws. The refusal to migrate is rooted in a fear of potential data breaches, unauthorized access, and legal complications associated with cloud services. Participants expressed frustration with enterprises unwilling to sign specific contracts ensuring data privacy.

4.4.2 "Yes, It's Not Quite Compliant, But the Risk is Limited" - The Pragmatic Optimists

Within the complex landscape of data governance, the pragmatism of trade-offs between GDPR compliance, IT security, and functionality is a recurring theme. Participants P08 and P03 provide insight into the intricate decision-making processes universities undertake when grappling with these critical considerations.

Participant P08 exemplifies this dilemma, expressing reservations about using products that may not be fully compliant with GDPR. They acknowledge the temptation to strike a balance between compliance and risk, stating,

P08: "I have to be honest, I find it very questionable to use other products. Because you can of course choose the trick about the risk balance and say, "Yes, it's not quite compliant, but the risk is limited." We don't want that. There, other locations [universities] budged under pressure from the user. And I can't rule out that this will happen to us at some point, when a corresponding political constellation of teachers says, "We really want this now." ..... That's a problem for us. That opens up the flanks in some places."

Although, Participant P08 firmly asserts their stance against such compromises but highlights the potential influence of user demands and political factors. This indicates a concern about maintaining a consistent and robust approach to data protection.

Participant P03 highlights the perpetual challenge of balancing IT security, data protection, and functionality.

P03: "Yeah, it's always a kind of balancing IT security, data protection, and functionality. And based on these three criteria, we need to decide on the board level what to do. And yes, indeed, there were decisions, which would not have been taken based on the GDPR law, but which have been taken against that due to IT security reasons and functionality reasons."

Participants P08 and P03 illustrate the intricate decision-making process where universities must consider IT security, data protection, and functionality when making choices. In doing so, they acknowledge that decisions may sometimes lean away from strict GDPR compliance in favour of IT security and functionality. This highlights the inherent trade-offs universities face when attempting to harmonize these critical aspects. Participant P17 further adds depth to this discussion by acknowledging the difficulty of achieving equilibrium between security and performance. Participant P17 articulates,

P17: "When you are doing something new, you really want to make the project good, you must set your priority. I understand security is a priority no doubt on it, but when it comes to things to move, security. That is what I say, security and performance are two things that are difficult to balance. When you are too secure, how to say, you don't let go, you don't really know how to perform well. Because you are wanting to secure things, you put a lot of locks and you are not letting people to enter, the room because you have layers of locks. But you want to let people come in easily also and take care of the security. So so it's difficult to balance security and performance."

Participant P17's analogy of locking down a room with layers of locks while simultaneously wanting to facilitate easy access captures the essence of this dilemma. The need to protect data and systems competes with the requirement for seamless and efficient functionality. This challenge is emblematic of the broader struggle faced by universities as they strive to maintain high levels of data security without compromising the performance of their systems.

Participant P12 offers a compelling perspective on the dynamics of cloud adoption within their university, where security and privacy emerged as the paramount concerns. This underscores the challenging balance universities must strike between the benefits of the cloud and their obligation to safeguard sensitive data.

P12: "I would say one of the biggest ones in our environment, it'll kind of vary from place to place, but <acronym-of-the-university> has a very strong culture of privacy. There's a lot of deep discussion around not only the legalities but other kinds of considerations around, if you don't own your data, what does that mean? Or if your data sits in someone else's data centre. So there is a tremendous amount of discussion and consideration given to privacy and <acronym-of-the-university>'s role as custodian or steward for its information, legally and otherwise. So that was something that was a huge cultural consideration for us."

Participant P12 starts by highlighting their university's strong culture of privacy. They emphasize the deep discussions surrounding not only the legal aspects of data ownership but also broader considerations about the implications of data residing in third-party data centres. This reflects the institution's commitment to privacy and its role as the custodian of information. Despite these substantial privacy concerns, Participant P12 acknowledges the inevitability of the cloud's role in transforming their industry and the institution's competitive position.

P12: "And I think they ultimately, the decision we kind of came to was whether we like it or not, this is a change in our industry and the institution, if it defines itself as a world leader in technology and engineering and science, then we have to figure out how to embrace these capabilities, even if it's not perfect, even if it's not ideal for us. The alternative is worse. The alternative is not being able to maintain our leading-edge position or competitive dynamics. And so I think we decided to go down the cloud road anyway, but because from a competitive standpoint, there's no level of investment <acronym-of-the-university> is going to be able to make that's going to allow us to keep pace with what the cloud was doing."

They indicate that the institution's identity as a leader in technology, engineering, and science demands adaptation to cloud capabilities, even if not perfect or ideal. Participant P12 acknowledges that refraining from cloud adoption could diminish their competitive edge. Consequently, they make the strategic decision to embark on the cloud journey, understanding that the competitive dynamics necessitate such a move, even while acknowledging the challenges associated with data privacy and security.

Summary: In navigating the complexities of data governance, participants shed light on the intricate decision-making processes universities face concerning GDPR compliance, IT security, and functionality. The pragmatic approach to trade-offs is exemplified by concerns about using non-compliant products while acknowledging the potential influence of user demands and political factors. Balancing IT security, data protection, and functionality emerges as a perpetual challenge, with decisions sometimes deviating from strict GDPR compliance for practical reasons. The difficulty of balancing security and performance is vividly illustrated, emphasizing the ongoing dilemma universities confront. Additionally, the paramount importance of privacy culture is highlighted, with a recognition of the inevitability of cloud adoption for competitive positioning despite associated privacy concerns.

4.4.3 Productivity Driven Pragmatists

Participant P13 provides a candid view of the challenging path that cloud users within the university follow when attempting to implement preferred cloud solutions. This journey is fraught with complexities, including security and integration concerns. Participant P13 describes the common scenario where cloud users, in a bid to expedite their projects, bypass official procurement processes due to the anticipation of delays or potential rejection. In some cases, they may plead ignorance or obtain signatures from higher authorities, such as deans or department heads, assuming the security risks personally. This approach is driven by the urgency to get things done and a practical awareness of the bureaucratic hurdles that can accompany official procedures.

P13: "So expect that it's going to be in limbo for six months, you know, or it can't integrate with our IDP. So you can't use enterprise credentials. So that's a that's a no, no. Or the security office asks for a heck vet security document that the vendor has no idea what you're actually talking about. You know, all those kinds of those are all those are all real world cases. So that rather than get, you know, the their vendor of choice just kind of dumped on, they just go and try to implement it. Whatever mechanisms they can, they use like a purchasing card, which is like a credit card for a small amount of money. They plead ignorance that they didn't realize they had to go through contracting and procurement. They their dean director of department head signs off on a security risks saying they'll take it on themselves because they have to get it done. And they they know they know either, you know, at the back of their mind or at the forefront of the mind that if they really wanted to jump through all the hoops that they should, they're going to get a no. (I: Mm hmm) That happens. And then they come to us when something doesn't work and they're like, hey, can you help us? And we're like, where does this come from? Speaking of adventures."

However, when these unofficially implemented solutions encounter challenges, the cloud users turn to the IT department for assistance. Participant P13 characterizes this as a familiar pattern, where cloud users seek help from IT professionals when confronted with problems arising from unofficial implementations. The key challenge, as Participant P13 explains, is that the preferred vendors or solutions chosen by cloud users may not align with the university's security and integration requirements. This can lead to rejection by official channels, compelling cloud users to seek workarounds in the first place.

In the realm of cloud adoption, Participant P12 provides an insightful perspective on the typical trade-off that universities face. This trade-off doesn't necessarily revolve around using the cloud or not but rather centres around selecting from different cloud offerings. The crux of this decision is the balance between cost and security considerations.

P12:"So I'd say the trade-off we usually end up making isn't whether we can or can't use cloud. It's what kinds of specific cloud offerings do we need to use? And each of those has different costs. So if you use regular AWS, that's much cheaper than using GovCloud. Uh, GovCloud is, you know, much more expensive. So I'd say the trade-off we usually make is, you know, we don't want to use those more expensive solutions unless we absolutely have to. And so there are situations where the security requirements do necessitate our use of those services and then we use them. Uh, but yeah, that's, that's probably where we see the trade-off play out the most."

Participant P12 elucidates that the trade-off often emerges when determining which specific cloud offerings are most suitable for their needs. Each cloud offering comes with different cost structures and varying levels of security. For instance, Participant P12 contrasts regular AWS with GovCloud, highlighting that the latter is considerably more expensive. The trade-off, as described by Participant P12, is a strategic choice that revolves around minimizing expenses while meeting security requirements. The participant underscores that the preference is to avoid more expensive solutions unless it becomes an absolute necessity. In cases where stringent security requirements dictate the use of these more costly services, they are implemented. Therefore, the trade-off primarily manifests in the selection of cloud offerings that align with the universities's financial constraints and security needs.

Participant P18 sheds light on another perspective from the local IT teams who are involved in managing and maintaining university infrastructure. Their viewpoint reveals a positive aspect of cloud services – how they are appreciated for their role in facilitating remote access and enhancing security.

P18:"And the local IT people kind of like these cloud services because we did have a cyber attack a couple years ago. So they're in the process of clamping down on access from off-campus and moving these services out into the cloud means that the students don't actually have to access campus network in order to get to them."

Participant P18 indicates that local IT teams hold a favourable view of cloud services. One of the key reasons for this appreciation is the ability of cloud services to enable remote access to university resources. This has become increasingly important, particularly in the context of the global shift towards remote work and learning. Participant P18 alludes to a cyber attack that occurred a couple of years ago, which has prompted the local IT teams to intensify security measures by restricting access from off-campus locations. Cloud services offer a solution by allowing students to access these resources without relying on the on-campus network. This decentralization results in a reduced burden on the on-campus network, as fewer individuals are simultaneously accessing it. This decrease in network traffic not only enhances the overall efficiency of the network but also allows institutions to implement more robust restrictions and security measures. With fewer users relying on the campus network for resource access, administrators can tailor and fortify security protocols, ensuring a safer and more controlled digital environment for students and faculty alike.

Summary: Cloud users often navigate a challenging path, implementing preferred solutions unofficially due to anticipated delays or rejections in official procurement processes. This pragmatic approach, driven by the urgency to expedite projects, may involve bypassing bureaucratic hurdles and assuming security risks personally. However, when these unofficial solutions encounter issues, cloud users turn to IT departments for assistance, creating a familiar pattern of seeking help after implementation. Another perspective emphasizes the trade-off universities face when selecting specific cloud offerings, focusing on the balance between cost and security considerations. This trade-off revolves around the strategic choice of minimizing expenses while meeting stringent security requirements, especially when opting for more expensive cloud services becomes a necessity. Additionally, local IT teams appreciate cloud services for facilitating remote access, particularly in response to heightened security measures following a cyber attack. This positive aspect underscores the role of cloud services in enhancing security and providing flexibility for off-campus access to university resources.

4.5 The Human Element: Perspectives on Security, Privacy, and IT Culture

As universities pivot towards the cloud, the complexities and nuances of this transition go far beyond the realm of hardware and software. One critical aspect that emerges at the forefront of this migration is the human element.

Within the broader theme of "The Human Element," this section delves into the perspectives of the participants on the matters of security, privacy, and IT culture. These perspectives offer invaluable insights into why universities are migrating to the cloud and the intricate factors they meticulously consider before making this transition. The "Human Element" in this context becomes a compelling narrative that weaves together the technological transformation and the human perspectives that drive it.

4.5.1 Cultural Shift and Human Dynamics in IT Work

Participant P16, for instance, shares the experience of racing to keep pace with the ever-evolving IT field.

P16: "Microsoft is a wonderful example of that 'cause they keep releasing stuff all the time. So how do you build out support? What are the expectations? Who gets access? All of those pieces, we feel like quite often we're trying to race after them versus us being able to control some of those rollouts."

The analogy to industry giants like Microsoft and their continuous release of new technologies vividly portrays the relentless nature of this change. It's akin to trying to catch a speeding train while it's still in motion. This perspective highlights the sheer dynamism of the IT industry, where IT professionals find themselves in a constant sprint to understand, adopt, and adapt. The participant's voice reflects a sentiment often echoed by those dealing with technological evolution – a need for proactive strategies to cope with

the fast pace of innovation. Participant P12 introduces a profound shift in the role and mission of IT universities.

P12: "And that's a huge implication for your workforce. It's a huge implication for the mission of your IT universities. What is it we do after that? What are we here for? You know, what role do we play? We're playing more of the role of a facilitator than an operator and creator. ..... And so I think our role as IT universities is fundamentally changing in this process and that's just a huge cultural shift."

The nature of the IT department's role is in flux. These questions reveal a fundamental transformation in the mission and purpose of IT universities. The participant observes a cultural shift as IT universities evolve from being traditional operators and creators to facilitators in the cloud adoption process. It's a transition from building and maintaining to guiding and enabling. Participant P12 also emphasizes that the migration to the cloud is not only a technical shift but also a cultural change.

P12: "This is a cultural change. This isn't a technical change. This is a fundamental change in how IT services are provided to your constituents, right, how they're operated, procured, how they're provided, everything."

This perspective underscores that the impact extends beyond the technical aspects of how IT services are delivered, operated, and procured. The use of the term "cultural change" suggests that the shift to the cloud involves redefining the university's approach to IT, by not only bringing in a change in the tools and technologies but also in the mindset and practices.

P16: "Good, I mean, it's a change management activity, so it needs strong communication and strong planning"

Participant P16 echoes this sentiment by characterizing cloud migration as a *"change management activity."* This resonates with the human aspect of change—it's not just about new technologies; it's about people. The mention of *"strong communication and strong planning"* indicates that successful cloud migration requires not just technological adjustments but a concerted effort to guide and align people within the organization. Participant P16 adds another layer to the evolving narrative, addressing the profound shift of work from IT to end-users.

P16: "So, and that does require the business side of the institution to be more involved because it's their processes, it's their workflows. And in the case, I just, I'll keep using Slate 'cause it's such a great example of what's changing. The configuration aspect of it can't rest with IT, it's got to go back to the unit. So I think it's that change management and the challenge around people understanding they are going to be doing a lot of the work that they might've once anticipated the IT team would do."

This perspective highlights the growing role of end-users in managing and configuring IT solutions. It underscores the necessity for a collaborative approach where the business side of the institution becomes more deeply involved in defining its processes and workflows, in stark contrast to the traditional role of IT. Participant P08 offers a profound perspective on the challenge of transitioning a university's IT culture when many individuals have already become accustomed to the current system:

P08: "We see that because it has nothing to do with the idea of open source or not open source, and spoiled by commercial systems. If you look at the office products, LibreOffice and Co., they are now a bit worse in terms of aesthetics, but a lot is just in the systems. Convincing people about functionality is not the problem. The problem will be, and we experience this in the competition between learning platforms in <Federal State of the University>, if a university has only gone in one direction and a huge number of people have learned how to deal with it, then it is extremely difficult."

This perspective highlights the university's challenge in shifting established practices and systems, emphasizing the importance of change management and the complexities of convincing individuals to embrace new functionality. Participant P17 adds another layer to the narrative by underscoring the changing tolerance capacity of users.

P17: "Those days people can tolerate IT Faultiness or IT - In availability in IT services for a longer period of time but nowadays people are being very impatient. The services also, they became very crucial. So actually the challenges, it has been became a challenge because of this change in paradigm"

The way people view IT has changed dramatically. In the past, it was common to put up with IT issues and downtimes, but now, people have little patience for these disruptions. IT services have become essential, and this change means IT professionals and universities face new challenges. Furthermore Participant P03 emphasis on communication and transparency by highlighting the importance of keeping users informed throughout the cloud migration process. Elaborating on the same theme, Participant P17 further adds:

P17: "Second I find as I say the user experience. So demands from users has been increased due to which we cannot look into the risk of our assets of our data centre anymore. People have no patience to let us check our risks of the assets in our data centre anymore. "

The rise in user expectations has made it difficult to rely on traditional methods, such as assessing risks within on-premise data centres. These methods are seen as impractical and incompatible with the low tolerance or patience of users for sudden changes. According to Participant P17, cloud migration is a good solution to meet user expectations, provide seamless experiences, and keep up with the rapid pace of technological evolution in educational institutions.

P03:"Okay. So for the other users, I think it's more or less transparent. So transparent in the sense they see and they are being communicated what's happening, but they don't see or perceive any changes or any impact. So service is continuously ongoing without any downtime or limited downtime and so on. But we communicate a lot to communicate to the users, okay, what's happening."

The use of terms like *"transparent"* and *"communicated"* suggests a user-centric approach, ensuring that university users are kept in the loop about the changes happening in the background. This approach aims to minimize disruptions and maintain a seamless user experience in the academic environment. The mention of continuous service with limited downtime aligns with the idea of providing a smooth transition for users, reinforcing the commitment to transparency and communication within the university community. Participant P11 extends the people-centric approach by describing an awareness program designed to prepare individuals in the university for the transition to the cloud.

P11:" Well, what I did for my environment was to create an awareness program as well as send some of the stakeholders or key stakeholders for training on AWS. For example, AWS provided free training for our users so that they have a basic understanding of how cloud works and I think that helped a lot in terms of adoption and support. It's more of putting in a program in place in which you explain besides the courses that are provided by the service providers. It's more of to explain what is cloud "

The initiative involves sending key stakeholders, possibly academic and administrative staff, for training on AWS, a major cloud service provider. This proactive step reflects a commitment to equipping university stakeholders with the knowledge and skills necessary for cloud adoption. This reveals a thoughtful approach to managing the human side of the migration within the university, recognizing that understanding the basics of cloud technology is crucial for user acceptance and support.

Participant P13 effectively summarized the user's perspective of central IT with the phrase *"the land of slow and no,"* capturing the common belief that central IT are known for being overly cautious and sometimes hesitant, which can slow down progress. This reputation spreads throughout universities, painting central IT as a bottleneck where new ideas and initiatives often stall and struggle to come to fruition. Participant P13 further highlights the tension between the users' immediate needs and the IT department's capacity to respond.

P13: "They're slow to do anything because they have so many things on their plates and your priority is not our priority. So maybe it's going to happen very slowly and not according to your timetable because it's the most critical thing on your map, but not division of IT."

There is a fundamental disconnect between what users deem urgent and the IT department's capacity to deliver. The *"many things on their plates"* illustrates the overwhelming demand placed on IT resources, which, in turn, dictates a hierarchy of priorities that may not align with user expectations. This misalignment not only delays specific initiatives but also cultivates a perception that can hinder the adoption of technology solutions. The balancing act between meeting user demands and managing the IT department's workload is critical to avoid a *"tug-of-war"* that impacts the university's decisions and attitudes towards technology adoption. Participant P18 reveals a particular philosophy that echoes through the corridors of IT culture.

P18: "So, and in truth, personal philosophy, I'd find that that's a thing in a lot of the world is that you design something for when it works and you never think about how to deal with it when it breaks. You know what I mean?(I:Yeah) And then when it does break, everybody's like, oh, no, that's not supposed to happen."

The notion of designing systems predominantly for when they work, while overlooking what happens when they don't, is a common sentiment among IT professionals. It's like building a ship with a focus on smooth sailing while neglecting the lifeboats. The perspective exposes a tendency to prioritize optimal functioning, often at the expense of preparing for system failures. This narrative shines a spotlight on the culture that prevails in IT and underscores the necessity for a paradigm shift – one that values resilience and preparedness as much as seamless operation. Finally, participant P16 introduces a thought-provoking question:

P16: "So as people are suggesting a need, probably a variety of things, but in terms of so one of it is capacity. Do we have the capacity to do these projects? Does the institution as a group of individuals have the capacity to absorb the change? Because every IT system implementation, big or small, requires a change management piece and people can only take so much."

The participant specifically highlights two dimensions of capacity: the technical capacity to undertake projects and the organizational or human capacity to absorb the associated changes. The emphasis on capacity revolves around the idea that implementing IT systems, regardless of their scale, necessitates a change management component. The participant suggests that there are limits to the amount of change individuals within the institution can effectively absorb. This perspective underscores the recognition that successful IT system implementations go beyond technical considerations; they require a thoughtful approach to managing organizational change and ensuring that individuals within the institution can adapt to and accommodate the changes introduced by the projects.

Summary: Participants express the challenges of keeping pace with the rapid evolution of technologies, using industry giants like Microsoft as examples. There is a profound shift in the role and mission of IT departments within universities, moving from traditional operators and creators to facilitators in the cloud adoption process. The transformation is not just technical but also cultural, requiring a fundamental change in how IT services are provided. Cloud migration is characterized as a change management activity, necessitating strong communication and planning. Additionally, there is an acknowledgement of the growing role of end-users in managing and configuring IT solutions, signifying a collaborative approach with the business side of the institution. The category also addresses the challenge of shifting established practices and systems, emphasizing the importance of change management, user-centric approaches, and a people-focused mindset. Participants recognize the need for proactive strategies to cope with the fast pace of innovation, and the narrative underscores a broader shift in the IT culture toward resilience and preparedness.

4.5.2 A Spectrum of Perspectives

The journey towards cloud adoption in universities is a path filled with diverse perspectives, each adding its unique hue to the canvas of transformation. These perspectives reflect a broad spectrum of attitudes, from cautious scepticism to unwavering optimism. Each viewpoint contributes to our understanding of the intricacies and challenges associated with cloud technology in the higher education sector.

The Optimistic Visionaries

P12: "It's a great opportunity. I think people should approach it from the standpoint that it's a tremendous opportunity and for, for, for good things for your organization, really, really good things, uh, but it's going to be a challenge."

Participant P12 expresses a perspective on cloud migration that frames it as a significant opportunity for organizational improvement. The participant emphasizes the positive aspects, stating that people should approach cloud migration as a tremendous opportunity

that can bring about substantial benefits for the university. This positive outlook suggests that cloud migration is seen as a strategic move that can lead to positive outcomes and advancements. However, Participant P12 also acknowledges the challenges associated with cloud migration, stating that it's going to be a challenge. This recognition underscores the participant's awareness that while the potential benefits are substantial, the process of migrating to the cloud involves difficulties and complexities that organizations must navigate.

P14: "It's an absolute, absolute game changer for any business that many people haven't actually realized yet,"

Some participants are ardent supporters of cloud adoption, believing it to be a ***"game changer"*** for businesses. Participant P14's perspective resonates with optimism, highlighting the profound transformation cloud technology can bring. Their belief in the cloud's potential to revolutionize operations in academia reflects a sense of excitement and anticipation.

P06: "I mean I tend to agree with the policy that if there is a good cloud solution which is affordable, you know, the university can get value for money from that, then that's a good thing."

Others adopt a more practical standpoint, recognizing the value of a good and affordable cloud solution. Participant P06 emphasizes the importance of affordability and value for money. This perspective underlines the pragmatic view that, if suitable, cloud solutions can bring substantial benefits to universities.

P15: "Well, I think we're looking at replacing our data center. And so we're making those decisions right now as to what the future lies 10 and 20 years from now, because if you're gonna build a data center, that's how long that fixed costs would be amortized against. So our analysis, and it's my opinion as well, but our analysis indicates that we will continue to move to the cloud such that probably by the early 2030s, the majority of what we're running will be cloud-based."

Another group looks at cloud adoption as a way to replace traditional data centres and prepare for the future. Participant P15's viewpoint embodies a forward-looking perspective, as universities make decisions with an eye on the long-term future. Their insights are indicative of a proactive stance towards technology.

P14: "And I think what it, what it does do is flip the, it flips the paradigm from the sort of large IT assumption that we need all these big enterprise tools and platforms to, no, you don't. You can actually build it all this yourself very quickly and easily if you do it in a proper cloud native approach."

Participant P14 introduces a paradigm shift by advocating for a "cloud-native approach." This perspective emphasizes the ability to build IT solutions quickly and easily using cloud-native techniques, challenging the reliance on large enterprise tools and platforms.

P16: "Overall, I would say it's very positive. If we do our due diligence, if we plan very well, if we mitigate for risks, if we communicate the outcomes and set expectations, I think it can be very positive for our universities."

Participant P16 conveys an overall positive outlook on cloud adoption in universities. The participant emphasizes the importance of due diligence, careful planning, risk mitigation, and effective communication in ensuring the success of cloud adoption. This perspective reflects a strategic and optimistic approach to implementing cloud technology.

P03: "So my conviction is that we will see at universities apart, which will be more public cloud, professional cloud, and then there will be an environment which will be more on a scientific cloud, which is delivered and hosted by other universities or research centers."

Participant P03 expresses conviction in the rise of different types of cloud services in universities, including public, professional, and scientific cloud offerings. This viewpoint suggests a forward-looking approach to cloud adoption in academia.

P17: " Reluctant, yes, if you ask me now its much better, much open but if you ask me 3 years before then no. People are seem reluctant at that, that is the right word reluctant, that is 3 years ago. But now, No"

Participant P17 provides a succinct yet insightful perspective on the shifting attitudes toward cloud migration over time, particularly noting a change from reluctance in the past to a more positive and open stance in the present. Participant P17 acknowledges a historical reluctance toward cloud migration, stating that people were hesitant or unwilling to embrace the shift to the cloud. The participant indicates a positive change in the current outlook, suggesting that the reluctance observed in the past is no longer present. The use of phrases like *"much better"* and *"much open"* implies a more favourable and accepting attitude toward cloud migration at the present time. Elaborating more, participant P17 balances their optimism with a degree of scepticism.

P17: "But in terms of my user experience untill now, I am looking for something really good, really better, thats how I look forward and so far I am very positive that things would be better."

Participant P17, while looking forward to better experiences, acknowledges that there's room for improvement. This balanced view highlights the anticipation of progress while acknowledging the need for growth.

The Realistic Adopters

P08: "But it's already quite widespread."

Participant P08 provides a realistic view of the current state of cloud adoption, recognizing that it's already widespread. This viewpoint aligns with the acknowledgement of the present state of affairs and the direction in which universities are moving.

P11: "You are certain that its availability will always be there. Whereas if you are on premise, if power went off and your generators didn't kick in, the students would have issues with access. So it's important that the universities have adopted cloud, because it gives them the opportunity for DR, it gives them the opportunity for availability, it gives them opportunity for access from anywhere, without necessarily having to worry about maybe there was an outage in an environment and you don't have access. So I support it, and I think it's a good thing to do. And I'm

not suggesting that every cloud solution is ideal for universities. Maybe researchers may find that it's just expensive, maybe for researchers, maybe they need an on-premise kind of solution. But generally, I'm of the opinion that cloud is mitigated against a lot of risks for the universities, particularly for learning, teaching and research, which requires live presence every time, because students are studying every time."

Participant P11 expresses a strong belief in the reliability of cloud technology for universities, emphasizing that it ensures constant availability which is not always possible with on-premise solutions, especially during power outages. They argue that cloud adoption is beneficial for disaster recovery, and consistent access, and it allows users to connect from anywhere without worrying about local outages. While supportive of the cloud, the participant acknowledges it may not be perfect for every scenario, noting that some researchers might find it costly and perhaps an on-premise solution might be more suitable for them. Nonetheless, they are convinced that for the core activities of learning, teaching, and research, which require a consistent online presence, the cloud significantly reduces risks for universities.

The Cautious Skeptics

P07: "So I'm very sceptic against cloud service providers as they are now. Probably in, I don't know, 30 years from now, things will have changed and this kind of service will have reached a maturity and standardization and also plurality and regulation, level of regulation that will make it a no-brainer to use such cloud services for all your infrastructure. But for the next two decades at least, I think it's a very relevant thing to have complete control over data in your own hands."

Participant P07 raises a flag of caution, expressing scepticism about cloud service providers. Their viewpoint emphasizes the importance of data control, particularly in the coming decades. It reflects a concern about the level of control and regulation in the cloud environment.

P07: "But for the next two decades at least, I think it's a very relevant thing to have the complete control over data in your own hands."

This perspective, foreseeing a long road ahead for cloud service maturity and standardization, emphasizes the need for complete data control over the next few decades.

P13: "I feel trepidatious, but it is an adventure and it's a challenge and it's kind of what I get paid for a little bit. So I'm cautiously optimistic."

Participant P13 embodies a sense of adventure and challenge, even in the face of trepidation. They acknowledge the caution while embracing the adventurous spirit, which can often be a hallmark of technology adoption.

P13: "Yeah, yeah, I think it's a necessary tool set in our utility belt. I don't think a lot of people really understand it, including myself, fully because it is a constantly evolving set of services. It can be used for good or for ill. And we don't – and universities, especially our university, does not have the ability to pivot when it comes to a financial and budgetary standpoint to fully utilize it. I'll say it that way."

Participant P13 emphasizes the importance of understanding the evolving cloud landscape and its potential for good or ill. This perspective recognizes the dynamic nature of cloud services and the need for careful consideration of their implications.

The Efficiency Admirers

P14:"The, the speed and the cost effectiveness and efficiency is mind boggling."

The speed, cost-effectiveness, and efficiency of cloud solutions leave a deep impression on Participant P14, highlighting the positive impact of cloud technology on university operations. This perspective reinforces the notion that cloud technology is a force multiplier.

P02:"I think in general, cloud services could serve you a service in a very short time with high quality."

Participant P02 believes that cloud services have the potential to deliver high-quality solutions in a very short time. This perspective highlights the efficiency and agility of cloud technology, making it a valuable asset for universities looking for rapid, quality services.

The Prudent Decision-Makers

P18: "And I would say maybe in terms of the idea of the cloud, small businesses maybe have an advantage as long as the cost is reasonable. Because you don't have to have an IT person when you're running a business that has three employees total. On the other hand, I'm not sure that cloud is the answer for anything and everything. And the question of not having your data in your own house and having it be at risk because of that, or risk of even not being able to pay and losing access to your data. It's a thing that everybody should think twice about. And it's that little thing under the asterisk that we don't ever think about. It's like, oh, gee, that sounds good. Let's do it. What could possibly go wrong? So, yeah."

Participant P18 suggests that small universities with minimal IT needs might find cloud solutions advantageous. This perspective brings attention to the potential benefits of the cloud for universities with limited IT resources. Participant P18, however, also advises caution. They highlight the importance of weighing the trade-offs between the convenience of the cloud and the associated costs and security considerations.

Summary: In conclusion, Optimistic Visionaries see it as a game-changer, while Realistic Adopters acknowledge its widespread use. Cautious Skeptics express concerns about data control, and Efficiency Admirers highlight its mind-boggling efficiency. Prudent Decision-Makers suggest careful consideration, emphasizing the need to balance convenience with costs and security. The diverse attitudes and varied viewpoints underscore the complex decision-making process that universities encounter while embracing cloud technology.

4.6 Additional Insights on University Dynamics

4.6.1 Teaching staff training amid cloud migration

P10: "There's a lot of courses that are facilitated on how to teach online. What does it mean to have online presence? Where that is being done very well, the student satisfaction is also showing because the sentiment is positive and it's higher, and because students feel that they're getting attention."

Participant P10 discusses the positive correlation between effective online teaching practices and student satisfaction. The participant shares how they are connecting the teachers with the courses aimed at how to teach online, emphasizing the importance of understanding what it means to establish a compelling online presence. Participant P10 also states that when online teaching is executed proficiently, resulting in a strong online presence, student satisfaction tends to be higher. The sentiment is described as positive, indicating that students perceive the learning experience favourably. The key factor contributing to this positive sentiment is the student's perception that they are receiving attention in the online learning environment.

4.6.2 Local political influence

P08: "There, other locations [universities] budged under pressure from the user. And I can't rule out that this will happen to us at some point, when a corresponding political constellation of teachers says, "We really want this now." And there it also works against us, for example, that IT <Federal State of the University> [state-owned IT supplier] has now certified MS Teams, so to say, as compliant. That's a problem for us. That opens up the flanks in some places."

Participant P08 discusses the potential influence of user pressure and political considerations on the adoption of specific technologies within the university context. The participant mentions that in other locations (universities), decisions may have been influenced by pressure from users, suggesting that user preferences and demands can play a role in technology adoption. Participant P08 also raises the possibility that their own institution may face similar pressure in the future if there is a strong demand from teachers. The participant highlights that the certification of Microsoft Teams by the state-owned IT supplier creates challenges for them, indicating that external certifications and approvals can impact the options available within the university's IT landscape.

4.6.3 Role of community support in cloud migration

P01:" So to learn from others on how to deal with certain issues, with certain problems or what kind of service are advisable or what kind of companies you don't want to do any deals with because others had problematic experiences with those. So we are trying to exchange with many others so to be hopefully up to date on what is going on in the demand, what is the typical step to take to offer a certain service or to achieve a certain result or to answer certain requests."

Participant P01 emphasizes the importance of learning from others within the community to address various issues and challenges related to IT services. The participant discusses the value of exchanging information with peers to gain insights into dealing with specific problems, selecting suitable services, and avoiding companies with prob-

lematic reputations based on others' experiences. The collaborative approach described by Participant P01 suggests a commitment to staying informed and leveraging collective knowledge within the community. This type of information exchange can contribute to staying up-to-date on industry trends, best practices, and potential pitfalls, ultimately helping the participant's organization make informed decisions and improve its IT services.

P01: "But yeah, so, but in general, they are typically solvable because usually regarding most of the services products, we are using, you have a good community or widespread community. So that lots of information is available on the internet. And those issues are typically getting solved."

Participant P01 expresses confidence in addressing challenges related to the services and products used by the university, emphasizing that these challenges are typically solvable. The participant attributes this solvability to the presence of a good community or a widespread community associated with most of the services and products. Participant P01 further notes that there is ample information available on the internet, contributing to the resolution of issues. It suggests that the university leverages community knowledge and online information to troubleshoot and resolve issues related to the services and products it employs.

4.6.4 Role of trust

P01: "So it's all about trust and proper legal agreements than actually operating stuff on-premise or within the cloud. ..... you need to trust the operators of the services but they might be more professional than your own personnel you got to actually operate the service"

Participant P01 underscores the significance of trust and well-defined legal agreements in the context of operating services, whether on-premise or in the cloud. The participant highlights that the key factor is not the location of the operation but the trustworthiness and professionalism of the service operators. This perspective suggests that entrusting services to external providers, whether cloud-based or on-premise, requires a robust foundation of trust and clear legal agreements to ensure the reliability and professionalism of the service operators.

Chapter 5
Discussion

In this chapter, we address the research questions and then delve into the discussions surrounding the factors influencing the decision-making process regarding cloud and self-hosting solutions, as well as the challenges encountered during migration and the implications of privacy and security considerations. We explore key themes such as the role of security in decision-making, vendor-led cloud migrations, privacy concerns, and the historical context of cloud adoption within higher education institutions. Additionally, we examine the concept of vendor lock-in and the recurrence of challenges from legacy systems to cloud migration. Finally, we outline the limitations of our study, including researcher bias, subjectivity, generalizability, definition ambiguity, and participant bias, to provide a comprehensive understanding of the scope and context of our findings.

5.1 Answering the Research Questions

5.1.1 What were the factors that influenced the decision to choose cloud/self-hosting solutions?

The decision-making process is complex and multifaceted, with participants highlighting various factors influencing the choice between cloud and self-hosting solutions. Budget constraints, concerns about outdated legacy infrastructure, scalability requirements, disaster recovery considerations, and the need for robust system architecture contribute to the adoption (or not) of cloud solutions (refer to Sections 4.2.1.1, 4.2.1.2). Additionally, the strategic sequencing of migrating critical production systems, technology trends, connectivity capabilities, and the dynamic nature of cloud services play pivotal roles. Security emerges as another important factor, encompassing data ownership, legalities, privacy, and adherence to stringent security standards (refer to Section 4.4). Beyond technical specifications, project methodologies, working timescales, and user support frameworks are integral elements influencing the decision-making process (refer to Section 4.5). The desire for digital sovereignty, control over resources, and adherence to stringent data privacy standards also significantly shape the decision matrix (refer to Section 4.4).

5.1.2 What challenges were encountered that led to migration and how was the experience of service migration?

The migration journey is fraught with challenges, and participants highlight a paradigm shift introducing complexities in understanding and estimating the costs associated with cloud adoption (refer to Section 4.3.1). Challenges include underestimation of expenses, financial shifts from CapEx to OpEx, concerns about payment structures and egress charges, and the overall understanding of cloud costs. Issues related to the variability and unpredictability of cloud expenses, especially egress costs, are emphasized. The challenges extend beyond financial considerations, encompassing operational, human, and logistical aspects, emphasizing the time-consuming and workforce-intensive nature of cloud migration (refer to Section 4.3.2). Concerns about data loss during the transition, vendor lock-in, integration complexities, resistance to API-based integration, and issues related to internal regulations on data transfer are also significant (refer to Section 4.3.3). Participants express concerns about the risk of data loss during the transition to new hardware platforms and emphasize the importance of maintaining a seamless user experience. The challenges involve the scale of data, differing file systems, and the complexity of migration processes, with potential solutions involving fundamental-level migration. Vendor lock-in emerges as a significant concern, emphasizing the long-term commitment and potential limitations tied to a specific cloud service provider.

5.1.3 How do privacy and security considerations influence the decision to migrate to cloud Infrastructure?

Privacy and security considerations play a crucial role in the decision-making process related to cloud infrastructure migration. Concerns about data autonomy, privacy culture, and apprehensions about the reach of U.S. intelligence agencies influence decisions to opt for self-hosting over cloud adoption (refer to Section 4.4). Participants express fears of potential data breaches, unauthorized access, and legal complications associated with cloud services. GDPR compliance challenges, anticipated increased costs, and the preference for maintaining control over resources contribute to hesitancy towards cloud adoption. Data security and compliance with data protection laws are integral to decision-making, with a refusal to migrate rooted in a fear of potential data breaches and legal complications associated with cloud services. Participants highlight the role of data autonomy and privacy in their decision to opt for self-hosting over cloud adoption, emphasizing concerns about data security and compliance with GDPR and state laws. Frustration with enterprises unwilling to sign specific contracts ensuring data privacy is expressed, underlining the importance of maintaining control over data and ensuring adherence to privacy standards.

5.2 Discussion

5.2.1 Is security merely an illusion?

As we unravel the factors influencing the decision-making process, an important question arises: Is security merely an illusion?

While participants talk about numbers factors like cost, availability, scalability, flexibility, and workforce needs, security doesn't seem to be one of the main factors. It's only when we directly ask participants about privacy and security, the conversation plunges into the depths of security and the concerns surrounding it. This finding prompts reflections on how we incorporate security into our decision-making. The delayed appearance of security makes us ponder if security is treated more like a response to a problem than a central consideration, which then creates and maintains the illusion of security.

5.2.2 Navigating Vendor-Led Cloud Migrations

The narratives shared by participants vividly depict universities entangled in the complex process of cloud migration, with cloud service vendors taking a lead role in steering this transformative journey. The entry of Amazon Web Services (AWS) is characterized by a sense of urgency, akin to a "hair on fire," reflecting a swift and imperative adoption primarily driven by immediate needs rather than a meticulously planned strategy. Similarly, the narrative surrounding the adoption of Microsoft Azure introduces a different dimension—the chain of '(semi) forced cloud migration.' Described metaphorically as "the tail wagging the dog," the university's shift to Azure reflects a situation where external factors, particularly Microsoft's cloud-first strategy, played a significant role in shaping the cloud adoption strategy. This highlights the potential risks of dependencies on closed-source solutions, contributing to a scenario of semi-forced cloud migration. Google Cloud Platform (GCP) sneaking in through the "back door" sheds light on governance challenges, suggesting that its inclusion may be more intentional than merely accidental.

These metaphors provoke reflection on the balance of autonomy that universities maintain in steering their cloud migration journey amidst the dominant influence of vendors. **To what extent do universities retain autonomy in shaping their cloud migration journey when vendors seem to play a leading role?** An observation in [35] reveals a shift in work dynamics driven by the urgent need to facilitate a rapid transition to remote work, potentially indicating a focus on short-term solutions to address immediate challenges. This prompts us to question whether universities, in the face of unplanned migrations, might be prioritizing immediate solutions over strategic foresight, and what repercussions this might hold for the enduring sustainability of their cloud infrastructure.

Whether universities, in the face of these unplanned migrations, view themselves merely as passengers being pulled along by the vendors, or if they actively shape the course of their cloud journey. What mechanisms are in place to transform reactive responses into proactive strategies? How do universities leverage the knowledge gained from these unplanned migrations to inform future decisions and establish a more intentional pathway toward cloud integration? Such questions provide important directions for future work, discussed below in Section 6.2.

5.2.3 Vendor Lock-in

The concept of 'vendor lock-in' emerges as a significant consequence of vendor-led migrations. This phenomenon refers to the dependency on a specific cloud provider, AWS, which can indeed be likened to a technology "trap," where the university becomes heavily reliant on a single company's services and infrastructure, potentially limiting flexibility and creating challenges for future transitions.

The metaphorical imagery of a "hair on fire" situation with Amazon Web Services (AWS), the "tail wagging the dog" scenario with Microsoft Azure, and Google Cloud Platform (GCP) sneaking in through the "back door" further underscore the potential risks of such dependencies. The move towards a multi-vendor strategy, driven by the philosophy of "Not putting all the eggs in the same basket," represents an attempt to mitigate vendor lock-in risks. However, this strategy does not entirely alleviate the challenges and introduces a new phenomenon known as 'cloud lock-in.' As exemplified by the discontinuation of free unlimited cloud storage by Google [52], universities may find themselves dependent on cloud services even when terms and conditions change. Participant P13's experience underscores how such changes can impact universities, necessitating adjustments and potentially introducing additional complexities.

The broader implications of cloud adoption and its impact on market dynamics and price increases in a limited, oligopolistic market, prompt a critical examination of the power dynamics within higher education. The shift from 'mere owners of information' to 'owners of the infrastructures of society ' [54] introduces concerns about the influence of big tech monopolies. While the economic advantages offered by cloud companies align with the economized management of universities, they also introduce power shifts [44]. Universities, focusing on cost-cutting, inadvertently contribute to the competition and potential replacement by major tech companies. This shift raises concerns about the influence of big tech on educational policies, values, and research agendas, underscoring the need for a critical examination of the implicate ions of 'platform capitalism' on the core functions of universities [54, 17, 30].

5.2.4 Legacy to Cloud, Déjà Vu?

The results obtained from participant interviews shed light on the multifaceted factors influencing the adoption of cloud solutions within higher education institutions, particularly the concept of historisch gewachsen i.e. historically grown nature of cloud migration. As articulated by Participant P03 in 4.2.1.1, the evolution of cloud usage lacked a predefined strategy, instead unfolding over time in response to individual needs and the curiosity of researchers.

This concept aligns with our observations regarding the state of legacy systems [i.e. the self-hosted systems]. The legacy systems were built without proper documentation, effective knowledge transfer, or a comprehensive understanding of the entire system [19, 36, 40]. The lack of a structured approach resulted in technical complexities and challenges that persist in the present. Interestingly, our conversations with the participants drew parallels between the historical growth of legacy systems and the initial stages of cloud adoption within the academic environment. The tendency to start small in the cloud, focusing on isolated components, resembles the approach taken during the creation of legacy systems as mentioned earlier.

This observation serves as a reflective juncture emerging from our data analysis. It prompts contemplation on the trajectory ahead, highlighting insights into our current state and acknowledging our historical roots. The recurrence of similar challenges in the evolution from legacy systems to cloud adoption suggests a noteworthy continuity of patterns. This can be - firstly - attributed to a lack of comprehensive understanding of existing (legacy/organically grown systems) which lack supporting documentation (probably because there were no incentives to create it) and were passed down from "experienced elders" and hence, stays untouched because "don't fix what is not broken" [35] and - secondly - leads to the repetition of the same thing when creating new cloud systems as the underlying working culture has not really changed or learned from the past. Notably, it raises questions about the prospect of improvement in our approaches: **Are we genuinely learning from our past experiences, or are we inadvertently replicating familiar pitfalls in a different context?**

The juxtaposition of participant perspectives and our reflections underscores the need for a more strategic and conscious approach to cloud adoption. Learning from the historical growth of legacy systems, it becomes imperative to avoid replicating patterns that have previously led to technical debt and operational challenges. Addressing this issue goes beyond technical solutions; it requires a shift in mindset and organizational culture to break free from the cycle of repeating mistakes and reinventing solutions.

5.3 Limitations

1. **Participant Bias:** While conducting this study, it is essential to acknowledge the presence of participant bias, particularly in the forms of social desirability [9] and recall bias [23]. To mitigate these biases, careful attention was given to creating a supportive and non-judgmental research environment, emphasizing anonymity and confidentiality. Despite these efforts, it is crucial to recognize that some degree of bias may still persist, and readers should interpret the findings with an awareness of these limitations.

2. **Researcher Bias:** It is essential to acknowledge the potential influence of researcher bias, which can manifest in various forms such as selection bias [20], confirmation bias [22] and leading question bias (if the questions divert the interview in one particular direction). To mitigate these biases, rigorous research design, transparent methodology, and systematic data analysis techniques were employed. Furthermore, self-awareness of potential biases and ongoing reflexivity were maintained throughout the research process to enhance the validity and reliability of the study.

3. **Inherent Subjectivity:** The interpretations and themes unveiled are intricately woven with the researchers' perspectives and biases, despite the inclusion of reflexivity in the analysis. It is crucial to recognize and navigate the inherent subjectivity embedded in qualitative research. While subjectivity serves as a limitation, it concurrently holds value by integrating the human researchers' perspectives, thereby enhancing the analysis with nuance and reflection often absent in quantitative approaches. Personal experiences, such as the researcher's background as a computer science student engaged in cloud technology, contribute to a more nuanced understanding during both data collection and analysis. Moreover, to introduce diverse viewpoints into the project, multiple individuals with varying experiences

in the field contribute their perspectives. This inclusion of different voices adds a valuable layer of depth and breadth to the research, ensuring a comprehensive exploration of the subject matter.

4. **Definition Ambiguity:** Despite efforts to provide clear definitions (see Appendix C), the terms "cloud-hosted" and "self-hosted" can still be interpreted differently by participants, leading to potential ambiguity in responses. However, we made a proactive effort to mitigate this by providing clear definitions at the beginning of each interview to establish a common understanding, minimizing potential misinterpretations. To mitigate this concern, clear definitions were presented at the beginning of each interview, and participants were explicitly asked if they were on the same page with these definitions. In cases where participants expressed uncertainty, additional explanations were provided to ensure a shared understanding.

5. **Generalizability:** While conducting qualitative research, it is essential to recognize that the findings may not readily generalize to a broader population, particularly individuals in managerial, operational, and administrative roles within university settings. The limited sample size of 18 participants, primarily representing countries such as Germany, the USA, Canada, South Africa, Australia, Malaysia, the Netherlands, Switzerland, and the UK, introduces a potential geographical bias. With a predominant focus on European and North American participants (14 out of 18), the study's outcomes may not fully capture the global diversity within this context. Despite this limitation, efforts were made to mitigate bias by actively seeking diverse perspectives across cultural, economic, and technological spectrums, enriching the study within the defined scope. It is also important to understand that qualitative studies is centred on attaining a profound understanding of socio-technological phenomena within specific contexts, prioritizing depth over broad generalization.

Chapter 6
Conclusion and Future Work

6.1 Conclusion

In the realm of higher education, the decision-making processes surrounding the adoption of cloud and self-hosting solutions are complex, multifaceted, and deeply influenced by a myriad of factors. This qualitative research journey delves into the experiences and perspectives of key stakeholders within university IT environments, unravelling the complex matrix of motivations, migration challenges, and considerations that shape the trajectory of technological infrastructure.

The decision to choose between cloud and self-hosting solutions emerges as a multifaceted process influenced by diverse factors. Budget constraints, concerns about outdated legacy infrastructure, scalability requirements, disaster recovery considerations, and the need for robust system architecture emerge as one set of important factors that influence the decision. Security, data ownership, legalities, and privacy considerations emerge as another set of factors in the decision matrix. The strategic sequencing of migrating critical systems, technology trends, and the dynamic nature of cloud services also play crucial roles. Furthermore, the desire for digital sovereignty, control over resources, and adherence to stringent data privacy standards significantly shape decision-making.

The migration journey is characterized by complexities in understanding and estimating the costs associated with cloud adoption. Challenges range from financial considerations to operational, human, and logistical aspects. The underestimation of expenses, financial shifts from CapEx to OpEx, concerns about payment structures and egress charges, and issues related to data loss, vendor lock-in, and integration complexities are intricately woven into the migration narrative. Participants underscore the time-consuming and workforce-intensive nature of cloud migration, emphasizing the need for a strategic and proactive approach.

Privacy and security considerations emerge as powerful influencers in the decision to migrate to cloud infrastructure. Concerns about data autonomy, privacy culture,

and apprehensions about the reach of U.S. intelligence agencies influence decisions to opt for self-hosting over cloud adoption. GDPR compliance challenges, anticipated increased costs, and the preference for maintaining control over resources contribute to hesitancy towards cloud adoption. The study highlights the delicate balance universities must strike between data protection laws, IT security, and functionality, acknowledging the pragmatic trade-offs and ongoing dilemmas. Moreover, the study reflects on the question of whether security is treated more as a response to a problem than a central consideration in decision-making. The delayed appearance of security concerns prompts an exploration of whether security is perceived as an illusion, maintained only in response to challenges rather than being a proactive and integral part of the decision matrix.

The study's exploration of the role of digital technologies, particularly cloud services, in navigating the challenges posed by the COVID-19 pandemic provides a contemporary lens. While some participants assert that the pandemic had no direct impact on their cloud adoption decisions, others acknowledge the catalyst role of the pandemic. The urgency driven by supply chain challenges and the unavailability of traditional alternatives forced a rapid shift to cloud solutions, exemplifying the adaptive nature of decision-making in response to external crises.

The study also unravelled the strategic nuances of cloud integration within universities, showcasing varied perspectives and evolving approaches. The lack of established decision-making structures, reliance on external expertise, and financial modelling complexities were evident. Organizational dynamics and communication challenges highlighted the need for a collaborative and cross-functional approach to cloud strategy development.

Throughout the study, a human-centric dimension emerged, emphasizing the role of stakeholders, the evolving nature of IT departments, and the collaborative efforts required for successful cloud adoption. The findings shed light on the pragmatic approaches, trade-offs, and iterative nature of decision-making within the dynamic landscape of higher education IT. Moreover, the narratives reveal a fundamental cultural shift in the role of IT universities—from being operators and creators to facilitators in the cloud adoption process. This transition is described not only as a technical change but as a comprehensive cultural transformation that redefines how IT services are provided, operated, and procured within the university community. The concept of cultural change underscores the necessity of reshaping the mindset, practices, and approaches toward IT, aligning with the evolving nature of higher education IT.

The study also highlights the evolution of university IT systems and the transformative impact of cloud adoption. It uncovers the strategic directions set by management, the collaborative efforts of stakeholders, and the cultural shifts necessary to embrace the changing landscape of technology. The narrative underscores the need for a holistic, cross-functional approach to cloud strategy development, aligning with broader organizational goals.

Vendor-led cloud migrations, characterized by metaphors such as "hair on fire," "tail wagging the dog," and "back door" entry, unveil the complexities of university entanglement with major cloud service providers. Vendor lock-in emerges as a significant consequence, raising concerns about dependency on a specific provider and potential limitations on flexibility. The shift from 'mere owners of information' to 'owners of the infrastructures of society' introduces concerns about the influence of big tech on educational policies,

values, and research agendas, prompting a critical examination of the implications of 'platform capitalism' on higher education.

In conclusion, this study provides valuable insights into the dynamic landscape of cloud adoption within university IT environments. By uncovering diverse perspectives, challenges, and strategic considerations through firsthand experiences, the research lays the groundwork for further exploration and refinement of cloud strategies. This work contributes more than just a framework; it offers a comprehensive overview of cloud migration processes in universities, serving as a crucial resource for informed decision-making. Notably, it addresses the identified research gap by delving into the real experiences of individuals, bridging the divide between theoretical frameworks and practical insights. As universities navigate the intricacies of technological transformations, the findings presented herein guide decision-makers, acknowledging the delicate balance between innovation, security, and privacy in the digital age.

6.2 Future Work

Future research might expand the geographical scope of the study to include a more diverse range of countries and cultural contexts. This can offer a broader understanding of how regional factors, legal frameworks, and cultural nuances shape the decision-making processes related to cloud adoption.

Understanding how universities perceive their role in the cloud journey—whether as passive passengers or active architects—and delving into the mechanisms that transform reactive responses into proactive strategies would provide valuable insights. This could involve examining the negotiation processes, vendor relationships, and the influence universities wield in shaping their technological trajectories.

Unplanned migrations, such as those triggered by external crises like the COVID-19 pandemic, present a unique lens through which universities navigate challenges. Future work could delve deeper into how universities learn from these unplanned experiences, transforming them into opportunities for knowledge acquisition and strategy refinement. Exploring mechanisms for translating reactive adaptations into intentional and proactive strategies could be a focal point.

Investigating the post-migration experiences and outcomes within universities could shed light on the effectiveness of chosen strategies. Examining factors such as system performance, user satisfaction, and ongoing challenges would contribute to a holistic understanding. Future research might delve into user satisfaction, challenges faced by different user groups, and the impact of cloud technologies on the overall user experience within academic institutions.

Investigating how universities leverage the knowledge gained from their cloud journeys to inform future decisions and strategies is paramount. Understanding the mechanisms of knowledge transfer within the institution, from IT departments to senior management and across departments, would contribute to the development of best practices and more informed decision-making frameworks.

Future research could also focus on the development and effectiveness of policy and governance frameworks related to cloud adoption in higher education. This includes examining how universities formulate, implement, and iterate on policies to ensure compliance, security, and strategic alignment.

In addition to the identified areas for future research, a crucial avenue that warrants exploration is the end-user perspective within the context of cloud adoption in higher education. Understanding the experiences and perceptions of university staff and students as end users could provide valuable insights into the impact of cloud technologies on their daily activities and overall satisfaction. Investigating how end users interact with cloud-based systems, their preferences, challenges faced, and suggestions for improvement would contribute to a more comprehensive understanding of the holistic implications of cloud adoption. Moreover, exploring the role of end users in driving the demand for specific cloud services or features could unveil key considerations for enhancing user engagement and tailoring cloud solutions to meet the diverse needs of the academic community.

Furthermore, with the growing emphasis on environmental sustainability, future research could explore the environmental impact of cloud adoption in higher education. Assessing the carbon footprint of cloud infrastructures and investigating strategies for universities to adopt environmentally friendly practices within their IT strategies would align with global sustainability goals [21].

Bibliography

[1] Network Specifications for Remote Job Entry and Remote Job Output Retrieval at UCSB. RFC 105 (1971). DOI:http://dx.doi.org/10.17487/RFC0105

[2] Family Educational Rights and Privacy Act. Public Law 93-380, 20 U.S.C. § 1232g (1974). https://studentprivacy.ed.gov/faq/what-ferpa

[3] Health Insurance Portability and Accountability Act. Public Law 104-191, 110 Stat. 1936 (1996). https://www.hhs.gov/hipaa/index.html

[4] USA PATRIOT Act. Public Law 107-56, 115 Stat. 272 (2001). https://www.congress.gov/bill/107th-congress/usa-patriot-act/

[5] Payment Card Industry Data Security Standard. PCI Security Standards Council (2004). https://www.pcisecuritystandards.org/

[6] Cluster Exploratory (CluE). (2008). https://www.nsf.gov/pubs/2008/nsf08560/nsf08560.htm (accessed: 2023-12-20).

[7] Mohammed Ali. 2019. Cloud Computing at a Cross Road: Quality and Risks in Higher Education. *Advances in Internet of Things* 9 (July 2019), 17. DOI:http://dx.doi.org/10.4236/ait.2019.93003

[8] AXELOS. What is ITIL? https://www.axelos.com/certifications/itil-service-management/what-is-itil (2021). (accessed: 2023-11-07).

[9] Nicole Bergen and Ronald Labonté. 2020. "Everything Is Perfect, and We Have No Problems": Detecting and Limiting Social Desirability Bias in Qualitative Research. *Qualitative Health Research* 30, 5 (2020), 783–792. DOI:http://dx.doi.org/10.1177/1049732319889354 PMID: 31830860.

[10] Cindy Bird. 2005. How I Stopped Dreading and Learned to Love Transcription. *Qualitative Inquiry* 11 (April 2005), 226–248. DOI:http://dx.doi.org/10.1177/1077800404273413

[11] Professor Virginia Braun and Dr Victoria Clarke. Thematic Analysis - an introduction. (2018). https://youtu.be/5zFcC10vOVY

[12] Virginia Braun and Victoria Clarke. 2019. Reflecting on reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health* 11, 4 (2019), 589–597. DOI:http://dx.doi.org/10.1080/2159676X.2019.1628806

[13] Virginia Braun and Victoria Clarke. 2021a. Conceptual and design thinking for thematic analysis. *Qualitative Psychology* 9 (May 2021). DOI:http://dx.doi.org/10.1037/qup0000196

[14] Virginia Braun and Victoria Clarke. 2021b. To saturate or not to saturate? Questioning data saturation as a useful concept for thematic analysis and sample-size rationales. *Qualitative Research in Sport, Exercise and Health* 13, 2 (2021), 201–216. DOI:http://dx.doi.org/10.1080/2159676X.2019.1704846

[15] Virginia Braun and Victoria Clarke. Thematic Analysis. (2024). https://www.thematicanalysis.net/ (accessed: 2023-07-09).

[16] Mariana Carroll, Paula Kotzé, and Alta van der Merwe. 2011. Secure cloud computing: Benefits, risks and controls. *2011 Information Security for South Africa* (2011), 1–9. https://api.semanticscholar.org/CorpusID:6208118

[17] Linda Castañeda and Neil Selwyn. 2018. More than tools? Making sense of the ongoing digitizations of higher education. *International Journal of Educational Technology in Higher Education* 15, 1 (2018), 22. DOI:http://dx.doi.org/10.1186/s41239-018-0109-y

[18] Ramnath Chellapp. 1997. *Intermediaries in Cloud-Computing: A New Computing Paradigm*. Presented at INFORMS Meeting, Dallas.

[19] James Crotty and Ivan Horrocks. 2017. Managing legacy system costs: A case study of a meta-assessment model to identify solutions in a large financial services company. *Applied Computing and Informatics* 13, 2 (2017), 175–183. DOI:http://dx.doi.org/https://doi.org/10.1016/j.aci.2016.12.001

[20] Nunan D, Bankhead C, and Aronson JK. Catalogue of Bias Collaboration, Selection bias. Catalogue Of Bias. (2017). http://www.catalogofbias.org/biases/selection-bias/ (accessed: 2023-03-08).

[21] UN DESA. The Sustainable Development Goals Report 2023: Special Edition - July. (2023). https://unstats.un.org/sdgs/report/2023/ (accessed: 2023-03-08).

[22] Spencer EA and Heneghan C. Catalogue of Bias Collaboration. Confirmation bias. In: Catalogue Of Bias. (2018). http://www.catalogueofbiases.org/biases/confirmationbias (accessed: 2023-03-08).

[23] Spencer EA, Brassey J, and Mahtani K. Catalogue of Bias Collaboration, Recall bias. In: Catalogue Of Bias. (2017). https://www.catalogueofbiases.org/biases/recall-bias (accessed: 2023-03-08).

[24] Hakan Erdogmus. 2009. Cloud Computing: Does Nirvana Hide behind the Nebula? *IEEE Software* 26, 2 (2009), 4–6. DOI:http://dx.doi.org/10.1109/MS.2009.31

[25] Anja Feldmann, Oliver Gasser, Franziska Lichtblau, Enric Pujol, Ingmar Poese, Christoph Dietzel, Daniel Wagner, Matthias Wichtlhuber, Juan Tapiador, Narseo Vallina-Rodriguez, Oliver Hohlfeld, and Georgios Smaragdakis. 2020. The Lockdown Effect: Implications of the COVID-19 Pandemic on Internet Traffic. In *Proceedings of the ACM Internet Measurement Conference*. Association for Computing Machinery, New York, NY, USA, 1–18. DOI:http://dx.doi.org/10.1145/3419394.3423658

[26] Tobias Fiebig, Seda F. Gürses, Carlos Hernandez Gañán, Erna Kotkamp, Fernando Kuipers, Martina Lindorfer, Menghua Prisse, and Taritha Sari. 2021. Heads in the Clouds: Measuring the Implications of Universities Migrating to Public Clouds. *CoRR* abs/2104.09462 (2021). https://arxiv.org/abs/2104.09462

[27] Matthew Finnegan. Zoom hit by investor lawsuit as security, privacy concerns mount. (2020). https://shorturl.at/nY058 (accessed: 2023-11-27).

[28] Judith Green, Maria Franquiz, and Carol Dixon. 1997. Myth of the objective transcript. *TESOL Quarterly* 31 (March 1997), 172–176. DOI:http://dx.doi.org/10.2307/3587984

[29] Lea Gröber, Rafael Mrowczynski, Nimisha Vijay, Daphne A. Muller, Adrian Dabrowski, and Katharina Krombholz. 2023. To Cloud or not to Cloud: A Qualitative Study on Self-Hosters' Motivation, Operation, and Security Mindset. In *32nd USENIX Security Symposium (USENIX Security 23)*. USENIX Association, Anaheim, CA, 2491–2508. https://www.usenix.org/conference/usenixsecurity23/presentation/grober

[30] Richard Hall and Bernd Stahl. 2012. Against Commodification: The University, Cognitive Capitalism and Emergent Technologies. *tripleC: Communication, Capitalism Critique. Open Access Journal for a Global Sustainable Information Society* 10 (May 2012), 184–202. DOI:http://dx.doi.org/10.31269/triplec.v10i2.378

[31] Miguel Helft. Netflix to Deliver Movies to the PC. (2007). https://www.nytimes.com/2007/01/16/technology/16netflix.html (accessed: 2023-12-20).

[32] Anthology Inc. About Us. https://www.anthology.com/about-us (2023). (accessed: 2023-11-27).

[33] BigBlueButton Inc. About BigBlueButton. (2024). https://bigbluebutton.org/open-source-project/about/ (accessed: 2023-11-22).

[34] Mehdi Karamollahi, Carey Williamson, and Martin Arlitt. 2022. Zoomiversity: A Case Study of Pandemic Effects on Post-secondary Teaching and Learning. In *Passive and Active Measurement*. Springer International Publishing, 573–599.

[35] Mannat Kaur, Simon Parkin, Marijn Janssen, and Tobias Fiebig. 2022. "I Needed to Solve Their Overwhelmness": How System Administration Work Was Affected by COVID-19. *Proc. ACM Hum.-Comput. Interact.* 6, CSCW2, Article 390 (November 2022), 30 pages. DOI:http://dx.doi.org/10.1145/3555115

[36] Ravi Khadka, Belfrit V. Batlajery, Amir M. Saeidi, Slinger Jansen, and Jurriaan Hage. 2014. How do professionals perceive legacy systems and software modernization?. In *Proceedings of the 36th International Conference on Software Engineering (ICSE 2014)*. Association for Computing Machinery, New York, NY, USA, 36–47. DOI:http://dx.doi.org/10.1145/2568225.2568318

[37] Neal Leavitt. 2009. Is Cloud Computing Really Ready for Prime Time? *IEEE Computer* 42 (January 2009), 15–20. DOI:http://dx.doi.org/10.1109/MC.2009.20

[38] Geng Lin, David Fu, Jinzy Zhu, and Glenn Dasmalchi. 2009. Cloud Computing: IT as a Service. *IT Professional* 11 (March 2009), 10–13. DOI:http://dx.doi.org/10.1109/MITP.2009.22

[39] Robyn Longhurst. 2009. *Interviews: In-Depth, Semi-Structured*. 580–584. DOI:http://dx.doi.org/10.1016/B978-008044910-4.00458-2

[40] Srinivas Malladi, G. Ramakrishna, K. Rao, and E Babu. 2016. Analysis of Legacy System in Software Application Development: A Comparative Survey. *International Journal of Electrical and Computer Engineering (IJECE)* 6 (February 2016), 292–297. DOI:http://dx.doi.org/10.11591/ijece.v6i1.8367

[41] Natasha S. Mauthner and Andrea Doucet. 2003. Reflexive Accounts and Accounts of Reflexivity in Qualitative Data Analysis. *Sociology* 37, 3 (2003), 413–431. DOI: http://dx.doi.org/10.1177/00380385030373002

[42] Paul McDonald. Introducing Google App Engine + our new blog. (2008). https://googleappengine.blogspot.com/2008/04/introducing-google-app-engine-our-new.html (accessed: 2023-12-20).

[43] Peter Mell and Timothy Grance. The NIST Definition of Cloud Computing. (September 2011). DOI:http://dx.doi.org/https://doi.org/10.6028/NIST.SP.800-145

[44] Tanner Mirrlees and Shahid Alvi. 2020. *EdTech Inc.: Selling, automating and globalizing higher education in the Digital age*. Routledge.

[45] Mahmoud Naghshineh, R. Ratnaparkhiand Donna Dillenberger, Jim Doran, Chitra Dorai, L. Anderson, Giovanni Pacifici, Jane Snowdon, A. Azagury, M. VanderWiele, and Yaron Wolfsthal. 2009. IBM Research Division cloud computing initiative. *IBM Journal of Research and Development* 53, 4 (2009), 1:1–1:10. DOI:http://dx.doi.org/10.1147/JRD.2009.5429055

[46] Safiya Okai, Mueen Uddin, Amad Arshad, Raed Alsaqour, and Asadullah Shah. 2014. Cloud Computing Adoption Model for Universities to Increase ICT Proficiency. *SAGE Open* 4, 3 (2014), 2158244014546461. DOI:http://dx.doi.org/10.1177/2158244014546461

[47] Justice Opara-Martins, R. Sahandi, and Feng Tian. 2016. Critical analysis of vendor lock-in and its impact on cloud computing migration: a business perspective. *Journal of Cloud Computing* 5 (April 2016). DOI:http://dx.doi.org/10.1186/s13677-016-0054-z

[48] Oxford English Dictionary. sticker shock, n. (September 2023). https://www.oed.com/dictionary/sticker-shock_n

[49] pluja. Web Whisper Plus. (2023). https://codeberg.org/pluja/web-whisper-plus

[50] ServiceNow. https://www.servicenow.com/solutions/industry/education.html (2023). (accessed: 2023-11-27).

[51] Mohammed Shuaib, Abdus Samad, Shadab Alam, and Shams Siddiqui. 2019. *Why Adopting Cloud Is Still a Challenge?—A Review on Issues and Challenges for Cloud Migration in Organizations*. 387–399. DOI:http://dx.doi.org/10.1007/978-981-13-5934-7_35

[52] Shantanu Sinha. More options for learning with Google Workspace for Education. (2021). https://blog.google/outreach-initiatives/education/google-workspace-for-education/ (accessed: 2023-12-15).

[53] Google Cloud Developers Site. BigQuery overview. (Last Updated: 2023). https://cloud.google.com/bigquery/docs/introduction (accessed: 2023-11-22).

[54] Nick Srnicek. 2017. *Platform Capitalism.* Wiley Sons.

[55] Nabil Sultan. 2010. Cloud computing for education: A new dawn? *International Journal of Information Management* 30, 2 (2010), 109–116. DOI:http://dx.doi.org/https://doi.org/10.1016/j.ijinfomgt.2009.09.004

[56] Jayachander Surbiryala and Chunming Rong. 2019. Cloud Computing: History and Overview. 1–7. DOI:http://dx.doi.org/10.1109/CloudSummit47114.2019.00007

[57] S. Tenny, J. M. Brannan, and G. D Brannan. 2022. *Qualitative Study*. StatPearls Publishing, Chapter Introduction. https://www.ncbi.nlm.nih.gov/books/NBK470395/

[58] Lisa R. Trainor and Andrea Bundon. 2020. Developing the craft: reflexive accounts of doing reflexive thematic analysis. *Qualitative Research in Sport, Exercise and Health* 13 (2020), 705 – 726. https://api.semanticscholar.org/CorpusID:228833867

[59] Shel Waggener and Bradley Wheeler. 2009. Above-Campus Services: Shaping the Promise of Cloud Computing for Higher Education. *EDUCAUSE Review* 44 (2009).

[60] Dominik Wermke, Nicolas Huaman, Christian Stransky, Niklas Busch, Yasemin Acar, and Sascha Fahl. 2020. Cloudy with a Chance of Misconceptions: Exploring Users' Perceptions and Expectations of Security and Privacy in Cloud Office Suites. In *Sixteenth Symposium on Usable Privacy and Security (SOUPS 2020)*. USENIX Association, 359–377. https://www.usenix.org/conference/soups2020/presentation/wermke

[61] Ben Williamson and Anna Hogan. 2021. *Pandemic Privatisation in Higher Education: Edtech and University Reform*. Education International. https://shorturl.at/fJX23

Appendix

A Informed Consent Form

Taking part in the study :

1. I have read and understood the study information, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.
2. I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.
3. I understand that taking part in the study involves one-on-one recorded interviews accompanied with written notes, remotely conducted. The recording will be transcribed using Amberscript, a GDPR-compliant and ISO27001 & ISO9001 certified data processor. After processing, Audio files will be deleted and only text without any personally identifiable information redacted will be stored.
4. I understand that personal information collected about me that can identify me, such as e.g. my name or workplace, will not be shared beyond the study team and the data processors as outlined in point (3) above.

Use of the information in the study:

1. I understand that the information I provide will be used for academic reports and scientific publications.
2. I understand that personal information collected about me that can identify me, such as e.g. my name or workplace, will not be shared beyond the study team.
3. I agree that excerpts from my interview can be anonymously quoted in research outputs.

B Project Description in the Consent Form

One of the most significant trends in the IT industry is the shift to a Cloud-Hosted Environment, and universities are not far from adapting to this trend. While cloud adoption is moving at an unprecedented pace, especially during this COVID-19 pandemic, the transition to Cloud Hosted in universities has proven to be one of the effective solutions for distance education. Due to certain significant advantages of Cloud Hosted, particularly in distance education, its usage by universities will be significant in the post-COVID-19 period. **This project aims to decode the objectives behind the migration of universities to the cloud. We also aim to understand how and which factors they consider before migrating to the cloud.**

C Definitions presented to the participant during Interview

What do we mean by Self-Hosted Infrastructure

Using services which are installed and running on hardware (in a data centre or on-site) owned by your organisation or a group of organisations (collaborative initiatives) and managing the software application/services with an in-house team, or team from the joint collaborative.

- The university IT staff running a NextCloud installation on servers in the university's data centre, even though there is a NextCloud support contract.
- Several universities share resources to run a webmail and groupware system jointly used by all of them
- DFN providing email filtering services.

What do we mean by Cloud-Hosted Infrastructure

Using the services which are running on infrastructure owned or controlled by a large cloud company, e.g., Microsoft, Google, or Amazon. This includes services indirectly depending on that infrastructure, i.e. when you use a Software-as-a-Service web- application, and the company you buy it from runs it in the Amazon cloud.

- Renting virtual machines for machine learning/data analytics tasks from Amazon.
- Having a Microsoft Azure 'on-site private cloud' and running services on there.
- Buying a moodle/learning management system as Software-as-a-Service from a company that ultimately runs it on Amazon EC2 infrastructure.

D Interview Structure

The semi-structured interview began with a general question (A), and then the interviewer explored each mentioned topic by asking the interviewee to elaborate. Transition to the next section (B, C, or D) occurred either when no new topics emerged or when the interviewee naturally moved on to a new section. In such cases, the interviewer allowed the interviewee to continue and returned to the previous section when relevant.

A. Starting Question:
    1. Can you describe your IT infrastructure? What are the most important components?
B. When they do not mention about Self-Hosted/Cloud Hosted in Block A then:
    1. Does cloud infrastructure play a role in this composition?
    2. [Yes] What type of Cloud Hosted models do you use?
C. Slide explaining our understanding of the terms - Cloud and Self Hosted is presented to the participant.

D. If they haven't opted for any Cloud Hosted then:

   1. Are you planning to introduce a Cloud-hosted Resource in your organisation?
   2. [Yes] Why type of Cloud Hosted Resources do you plan to opt for?
   3. So far, how has your experience been with the current Self-Hosting services?

E. If they have opted for Hybrid Solution:

   1. What led you to opt for this Hybrid solution?
   2. [If they don't describe challenges] Could you go into more detail about <challenge>?
   3. Did you overcome the challenges?
   4. [If Yes] How did you overcome the challenges?

F. If Migration did not happen at all then:

   1. Are there any challenges that you are currently facing with your current Self/Cloud hosted solution?
   2. How do you overcome these challenges?
   3. Do you wish to migrate to a Cloud-Hosted Solution?
   4. May I inquire about what is hindering your progress?

G. If Service Migration happened from Self Hosting to Cloud then:

   1. Did you encounter any challenges while using Self-Hosted services which led you to migrate to Cloud-Hosted services?
   2. [Yes] Could you describe those challenges?
   3. What was your experience of service migration?
   4. Could you describe the challenges that you faced during service migration?
   5. Did you overcome the challenges?
   6. [If Yes] How did you overcome the challenges?

H. If Service Migration happened from Cloud to Self Hosting then:

   1. What prompted the migration back to Self-hosting solutions?
   2. Were there also any issues that you encountered while using Cloud-Hosted services?
   3. [Yes] Could you describe those issues in detail
   4. What was your experience of service migration?
   5. Could you describe the challenges that you faced during service migration?
   6. Did you overcome the challenges?
   7. [If Yes] How did you overcome the challenges?

I. Questions concerning their Decision-Making Process:

   1. Can you explain to me the decision-making process behind choosing your current Self/Cloud-Hosted services?
   2. Who were the stakeholders that were involved in the decision-making process?

3. [Technical/Non-Technical] What important factors were considered during the entire decision-making process?
4. Could you go into more detail about how these factors were collected?
5. Who determined the factors as important?

J. Question on Privacy and Security:

1. What role do privacy and security considerations play in the decision-making process?
2. Do you have a general strategy or framework document concerning your IT infrastructure's development and/or concerning your cloud strategy?
3. Which part of the organization is in charge of creating and maintaining that document?
4. Can you describe who the stakeholders are and the perspectives they involve?
5. Is there a process which involves these stakeholders while decision making? [Yes] Could you elaborate on the process?
6. In that document, what role do privacy and security considerations play while drafting that document?

K. Wrap-Up Questions:

1. In your opinion, has the pandemic impacted the adoption of cloud infrastructure in your university?
2. What is your personal opinion regarding cloud adoption in universities?

L. Example neutral continuation prompts:

- Oh, that sounds interesting could you please elaborate?
- Could you go into more detail about that?
- Sorry, could you explain what you mean with . . . ?
- What do you mean with . . . ?
- Why do you say . . . ?
- What is . . . ?

E Codebook

The codebook has been condensed to include only the codes pertinent to the research questions, while also emphasizing other crucial facets of the research findings. The unreferenced codes have been meticulously documented and reported, dispersed across different sections as presented in the Results (see Chapter 4.)

Table 1: Overview of our codebook containing 96 codes.

IT Infrastructure							
Cloud Adoption Models		**Cloud Service Providers (CSPs)**		**Zoom**		**Cloud Adoption Strategy**	
Self-Hosted	6	Large Scale AWS	4	GDPR Compliance Issues	5	Cloud-first policy	3
Cloud-Hosted	2	Large Scale Azure	3	Pandemic Pressure	4	Multi-Vendor Strategy	3
Hybrid	10	Large Scale GCP	1	User Pressure	3	Pandemic-induced adoption	7

Infrastructure Strategy							
Cloud Strategy		**Security Strategy**		**Challenges**		**Stakeholders**	
Defined based on self-hosted parameters	1	Existence of Formal Security Plan	3	Time Constraints	1	Managerial Roles	14
Collaboration between teams	1	Roadmap of Security Strategy	1	Staffing Limitations	2	Administrative Roles	13
Risk-Based Approach	1	Lack of Security Strategy	1	Focus on Migration	1	Operational Roles	4

Decision and Dynamics between Decision-Makers							
Sticking to Self-Hosted Infrastructure		**Migration to Cloud-Hosted Infrastructure**		**Decision-Making Process**		**Dynamics between Decision-Makers**	
Cost - Limited Funding	9	Legacy Infrastructure Challenges	11	Formal Approach	6	Lack of Effective Communication	2
Digital Sovereignty and Data Privacy	4	Change in Product Nature	8	Informal Approach	4	Lack of Technical Understanding	2
GDPR/State Law Violations	3	Functionality and User Requirements	8	Personal Experience in Decision-Making	2	Lack of Collaboration	2

Service/Product Migration							
Process		**Cost Challenge**		**Concerns**		**People-Centric Transition**	
Lack of Formalized Migration Process	4	Uncertainties about Cloud Costs	10	Loss of Data while Migrating	3	Bridging Gap between IT and Finance	5
Collaborative Consultations	3	Cost - Workforce and Technology	4	Vendor Lock-in and Integration Complexities	3	Mindset Shift	6
Outsourcing	2	Financial Model Shift	3	Data Governance, Compliance	4	Lack of Operational Mindset	4

Guardians of Data - Theme							
Data Privacy and Compliance		**Security and Trust**		**Data Control and Governance**		**Implementation Challenges and Trade-offs**	
Patriot Act of USA	5	Lack of Trust in Major CSPs	3	Relinquishment of Control	3	Balancing GDPR Compliance, IT Security	4
Non-Compliance with GDPR	3	Concerns about Data Theft	2	Legal Challenges related to Data Access	2	Trade-off between Cost and Security	3
Potential Loss of Data Accessibility	2	Fear of Data Breaches	4	Uncertainty about Data Location	2	Difficulty in Achieving Equilibrium	1

Human Theme			
Cultural Shift in IT Universities		**A Spectrum of Perspectives**	
Adaptation to IT Industry Changes	4	Positive Outlook	4
User-Centric Approach	5	Strategic Decision Making	3
Challenges in IT Culture Shift	3	User-Centric	2
Shift of Work from IT to End-Users	2	Caution and Scepticism	3