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Infrastructure as a service adoption model for South African universities using thematic analysis

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Background: South African universities are dealing with concerning socio-economic issues and budgetary limits that affect university operations negatively. It is no longer viable for most universities to purchase and maintain information technology (IT) infrastructure systems while also keeping up with the ever-changing technology across the world.

Objectives: The aim of this article is to explore the benefits that come with infrastructure as a service (IaaS), as compared to the on-premises model that is currently used by most South African universities.

Method: This article adopts both transaction cost theory (TCT) and diffusion of innovation theory (DOI) as the underpinning theories. The interpretivist paradigm was applied to gain a comprehensive understanding of how university management perceives IaaS adoption.

Results: The results introduce three new and critical factors that need to be considered by university managers whenever they want to move their on-premises IT model to cloud IaaS: trust, security and attitude.

Conclusion: The research finds that IaaS offers advantages in scalability, flexibility, accessibility and on-demand deployment. These findings underscore the importance of addressing barriers to IaaS adoption within the specific context of South African universities.

Contribution: The findings of this article add to the cloud computing literature, by presenting a new model that IT decision-makers can utilise when considering moving their on-premises IT infrastructure to IaaS in South African universities. The article recommends that future research could expand the number of universities from which data are collected.

Keywords: infrastructure as a service; cloud computing; institution of higher learning; thematic analysis; client server model.

Introduction

Since IBM introduced the first mainframe computer in the 1950s, the evolution of infrastructure delivery models can be traced back to that time (Wright 2018). Large corporations utilise mainframe computers to run complicated applications and to handle large amounts of data from census, industrial and consumer statistics, as well as for enterprise resource planning and transaction processing. Personal computers (PCs) have more or less replicated this processing power, which was capable of performing mainframe tasks, despite their size and cost. The peer-to-peer network paradigm was later established, allowing PCs to share resources (Navimipour & Milani 2014). There was a limit to the number of PCs that could be connected to this model.

Internet availability and affordability make it easier for information to be processed, stored and delivered, resulting in a reduction in the reliance on this model. Organisations such as universities mostly use the client and server model for storing, processing and delivering information on premises (Paterson et al. 2022) First-generation infrastructure models were based on this model. There have been numerous challenges along the way, such as integration, efficient deployment and scalability challenges (Petcu et al. 2016), which have resulted in a substantial escalation in hardware maintenance costs and a substantial increase in expenses. In addition to static hard disk storage and slower central processing units (CPUs), the current on-premises infrastructure delivery model has several shortcomings.

With the current infrastructure model, maintaining hardware and operating system software is no longer economically viable, causing that companies must purchase and support all of their machines (George & Sagayarajan 2023). It has been demonstrated in several studies that current methods for meeting business requirements are ineffective (Haddara, Gøthesen & Langseth 2022).

In recent times, there has been a notable rise in spending on information technology (IT) hardware, software and electricity. The traditional on-premises infrastructure model revealed limitations, prompting businesses to seek an application delivery approach that promises improved advantages, reduced infrastructure expenses and increased operational availability.

It is critical for enterprises to investigate novel technologies that are more efficient and accessible than old infrastructure approaches. Universities are among the institutions impacted by traditional infrastructure model difficulties (Treve 2021). During peak times, such as student registration periods, universities face these challenges, with their current infrastructures not being adequate to meet the demands. The maintenance of infrastructure that facilitates the delivery of accurate and relevant information at universities is becoming increasingly complex and expensive (Khan et al. 2023). Constrained budgets combined with these challenges have resulted in businesses seeking technologically innovative ways to deliver effective information technology (IT) services (Ko, Chen et al. 2020).

In response, organisations are turning to infrastructure as a service (IaaS) as a means of efficiently delivering quality services within diminishing budgets (Wulf et al. 2021). This was seen particularly in the times of coronavirus disease 2019 (COVID-19) pandemic, where institutions relied heavily on cloud infrastructures to deliver learning digitally (Almelhi 2021). An organisation can now rent services that are managed outside the organisation by a cloud provider, instead of traditionally investing in information and communications technology (ICT) infrastructure resources. With IaaS, administrative tasks can also be automated, resources can be dynamically scaled, and resource virtualisation is possible (Омельченко and Ролік 2022).

Infrastructure as a service is a computational infrastructure that is delivered and managed over the internet (Suliman & Madinah 2021). Infrastructure as a service enables users to adjust their resources according to demand, paying solely for what they utilise. It allows businesses to sidestep the expenses and intricacies linked with buying and overseeing physical servers and data centre infrastructures. Each resource has its own service component, requiring users to only rent the necessary components for a specified period. The cloud provider oversees infrastructure management, while users handle the procurement, installation, configuration and deployment of their software, operating systems, middleware and applications. Alongside software as a service (SaaS) and platform as a service (PaaS), IaaS stands as one of the three primary cloud service offerings (Wulf et al. 2021).

The term 'cloud computing' is defined as the application of IT to facilitate widespread, convenient, readily accessible network access through the internet as a product (Sharma, Gupta & Acharya 2020). There will be more than $1 trillion of IT expenditures devoted to switching to cloud computing systems by year 2020 (Welter, Gartner & Wright 2016). The adoption of IaaS may be hampered by a number of factors, such as a solution to these adoption issues may be necessary. The article investigates and deliberates on the potential enhancements in the efficacy of managing university ICT infrastructure through the implementation of IaaS.

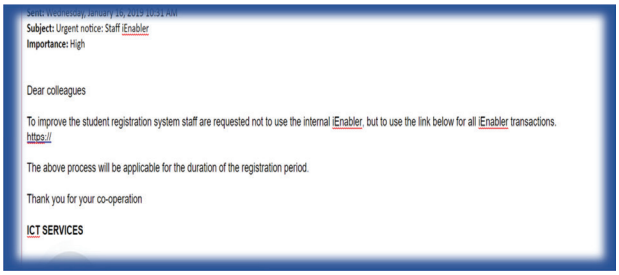
Background

Universities spend a significant amount of money on IT and modern infrastructure (StatsSA 2022). To keep this infrastructure running, there is a push for increased efficiency and greater utilisation of new and existing IT assets. Students, lecturers, administrative personnel, developers and researchers are the primary consumers of university infrastructure (Sultan 2010). Traditionally, the hardware and software needed to meet these users' needs are managed by an IT services department, usually based onsite. A specialised team of IT staff oversees the regular provision of IT services on a daily basis (Duralia 2019; Sultan 2010).

During peak times, like student registration or the release of student results, universities have a high level of infrastructure usage. During certain moments, the systems are overloaded to the point of significantly slowing down. Significant financial investments are dedicated to maintaining and improving aspects such as software licensing, data protection, ensuring business continuity, upgrading computer hardware and overall technological infrastructure to align with evolving organisational needs (Joslin 2023; Lee 2013). Considering that the current hardware is not scalable, the information from iEnabler shown in Figure 1 emphasises the need for more hardware to assist the infrastructure of the organisation or university concerned.

As a result of IaaS technology, IT costs can be reduced, technology availability is increased and scalability is increased (Islam et al. 2023; Miller & Pegah 2007). Moothoor and Bhatt (2009), and Habashi, Yousefi and Jeddi (2021) suggested that IaaS on demand and reservation can provide a variety of solutions for various service environments, in terms of which universities can:

- reduce expenses by implementing IaaS, ensuring that the yearly expenses for acquiring and upkeeping a Virtual Computing Lab (VCL) do not surpass 21% of the expenses incurred with its conventional equivalent


Subject: Urgent notice: Staff iEnabler
Importance: High

Dear colleagues

To improve the student registration system staff are requested not to use the internal iEnabler, but to use the link below for all iEnabler transactions.
https://

The above process will be applicable for the duration of the registration period.

Thank you for your co-operation

ICT SERVICES

FIGURE 1: Communiqué from iEnabler during peak time.

- provide more professional and research resources to students
- improve IT agility in order to assist teaching and learning
- overcome various lab administration challenges
- expand the reach of distance education.

Universities can typically offer students affordable and swift access to professional computing environments through the utilisation of VCL (Tornatzky, Fleischer & Chakrabarti 1990; Zaturrahmi, Festiyed & Ellizar 2020).

Institutions have the capability to establish multiple virtual parallel computing setups simultaneously within an IaaS framework. Beijing University of Technology reports that each environment can be deployed within approximately 30 min. By adopting this approach, the university managed to reduce physical resource expenses by 35%–50%, alongside enhancing computer performance and throughput (Moothoor & Bhatt 2009). Academic institutions may satisfy their exact storage demands in minutes with IaaS storage. If an academic institution chooses to double its storage capacity, this upgrade will occur rapidly, without the need for bidding, purchasing, downtime or additional IT support. Similarly, any reduction in capacity will also be swiftly implemented (Golightly et al. 2022).

However, not all the universities in South Africa perform the same function. The Centre for Higher Education Transformation (CHET) published a report in 2010 (Cloete, Bailey & Maassen 2011) in which South African universities were classified into several clusters based on their general aims. The purpose of each South African university was determined by referencing various data sources listed as follows:

- The Higher Education Information Management System (HEMIS) gathers information regarding both faculty and students.
- Information regarding scholarly publications.
- Financial records of universities and colleges.

The data for this article came from the preliminary findings of the main study. According to CHET, University E was classified as a research-intensive (RIC) university (red cluster). This university was discovered to be actively involved in postgraduate activities, with the majority of academics holding Master's and Doctoral degrees having a strong research output. After combining with 'previously disadvantaged' tertiary institutions, this South African university's performance dropped (Tornatzky et al. 1990). This university, on the other hand, has a high level of postgraduate enrollment in Science, Technology and Engineering (Tornatzky et al. 1990). According to the CHET assessment (Cloete, Bailey & Maassen 2011), this university provides 'occupation-ready' education to some previously disadvantaged students. This information may be used by the university's top management to make an informed choice on IaaS deployment. The data were gathered between September 2023 and October 2023 through in-person interviews. One interview was performed via email, the participant's preferred mode. Table 1 shows the participants' detailed demographic information and universities classifications. The survey included 11 IT infrastructure professionals from five South African universities who had prior experience in adopting and use of cloud computing services. Only individuals with IT-related qualifications and more than 5 years of experience in the field of IT were considered.

Problem statement and objectives

South African universities still use a client server design that is not dynamically scalable and is inaccessible from outside the university. Universities face these issues during peak times, such as registration periods, and the current infrastructure is insufficient to meet demand. The current on-premises infrastructure within universities that assists in the delivery of correct and relevant information is getting increasingly complex and costly (Sekwakwa & Mokwena 2015). This model is prohibitively expensive and quickly becomes obsolete, resulting in a high total cost of ownership (Sousa et al. 2021). These constraints, combined with increasing service demand and a limited budget, have led businesses to seek technologically inventive ways to supply efficient IT services at lower rates, such as IaaS.

Infrastructure as a service is one of cloud computing's three core services, along with SaaS and PaaS (Park, Lee & Park 2022; Zissis & Lekkas 2012). Infrastructure as a service promises to shift enterprises away from the traditional manner of investing in ICT infrastructure resources and towards a paradigm in which the organisation can rent services handled outside the organisation by a cloud provider (Tsvuura, Mbawuya & Ngulube 2021). Infrastructure as a service also offers the possibility of automated administrative activities, dynamic scalability and platform virtualisation of resources that are immediately available when needed (Shimba 2010).

TABLE 1: Demographic characteristics of the universities and participants.

University code	Number of respondents	Respondents' pseudonyms	Category	Age (years)	Gender	Qualifications
University A	3	A, B, C	Comprehensive	40–50 50–60	Male	Bachelor's degree Doctoral degree
University B	2	E, F	University of technology	30–40 30–40	Male	Bachelor's degree Bachelor's degree
University C	2	G, H	Traditional university	30–40 30–40	Male	Bachelor's degree Bachelor's degree
University D	2	I, J	University of technology	30–40 30–40	Male	IT diploma IT diploma
University E	1	K	Traditional university	50–60	Male	Doctoral degree

Furthermore, the adoption rate of IaaS at South African universities is still quite low, highlighting the need to identify the elements that may contribute to IaaS acceptance. With the expectation that universities will use cutting-edge technology, and especially given the scarcity of studies on the subject, it makes sense to investigate the understanding of the stakeholders' perspectives on cloud information security (Owusu-Ansah, Budu & Budu 2021; Sultan 2010). The following research questions gave rise to the need to get the necessary understanding of this matter:

What are the views of top management within higher institution of learning in South African regarding infrastructure as a service and how does it affect adoption decision?

This main research question is divided into the following sub-questions:

- *What factors are needed for establishing an improved efficiency infrastructure as a service within higher institutions of learning?* The aim of this question is to grasp the perspectives of IT managers concerning the factors impacting the adoption of IaaS, as well as how senior management assesses the decision of whether or not to embrace IaaS.
- *What are the views of key stakeholders within South African universities with regard to the slow performance of the current client server model?* The purpose of this question is to understand how top management views the current infrastructure's performance, given the unique operational context of participating universities.

This article aims to gain a better understanding of the university management regarding the adoption of IaaS within institution of higher learning.

Theoretical foundation

This article viewed the decision to adopt IaaS from two lens. Firstly, the decision is viewed through the lens of outsourcing, provided the outsourcing theories were explored. Secondly, the decision is viewed through the technological innovation within institution, in which innovation theories are investigated to help this article to establish the article's theoretical foundations. The theoretical viewpoints were then used to create an Infrastructure Adoption Model (IAM) for this article, which explains how adoption and implementing of IaaS model can increase the efficiency of university ICT infrastructure. Transaction cost theory (TCT) and diffusion of innovation theory (DOI) were adopted as the theoretical underpinnings for this article investigation.

Several scholars, such as O'Callaghan, Adapa and Buisman (2020), Hendricks and Mwapwele (2023), Zerbini et al. (2022) and Faisal and Idris (2020), have recognised the spread of innovation theory in a variety of ways as part of their studies. This article will leverage on the three primary DOI constructs (relative advantage, complexity and compatibility) from Lutfi et al. (2022), as well as two external constructs (security and awareness) from the literature to form part of the foundation basis for this article.

Relative advantage of adopting infrastructure as a service

Relative advantage in this article refers to the extent to which a new innovation is regarded to be superior to its predecessor, which is frequently messured in terms of economic contribution, social prestige, convenience and satisfaction (Farooq & Ullah 2021). Khayer et al. (2020) also state that relative advantage is an important aspect in determining the impact of an innovation to an organisation. This article examines how much the decision to move the university on-premises to IaaS would be preferable than sticking with their current model. According to Chen, Li and Chen (2021), relative advantage has a positive relationship with adoption rates of new technology if its done correctly.

Complexity of infrastructure as a service

According to Rogers (1983) and Isa et al. (2020), complexity is 'the degree to which an innovation is perceived as relatively difficult to understand and use by users within an organization'. As stated by Chen et al. (2021), complexity is one of the DOI constructs. Some researches discovered that a complicated innovation could necessitate additional work and higher implementation in terms of technical and operational abilities to increase its chances to be accepted by communities (Cooper & Zmud 1990; Windeler & Jungmann 2022). Infrastructure as a service requires a computer machine with internet access; this concept gives users the impression that IaaS services are simpler to use, driving them to move their service. Universities may be hesitant to move to IaaS if they believe it is a complex technology to understand and implement. Given the magnitude of change that widespread adoption of IaaS may bring universities, some may see it as a barrier to adopt.

Compatibility of infrastructure as a service

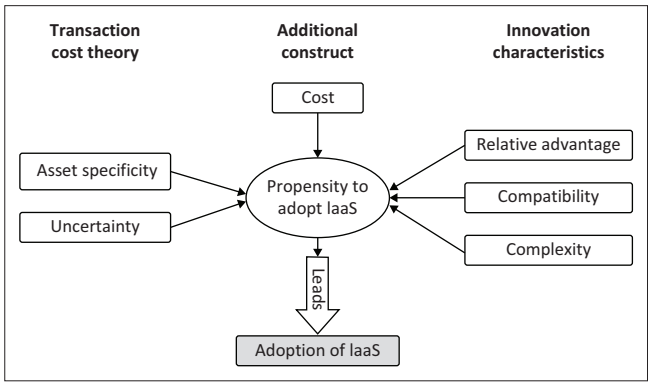
Compatibility in the context of this article refers to how well an innovation connects with prospective IaaS adopters' existing values, prior experience and present demands (Warner et al. 2022). The perceived interoperability of users has a significant impact on their uptake concerning the adoption of IaaS. According to a study conducted by Yoon, Lim and Park (2020), compatibility is an important element influencing new technology adoption. Staff and students who spend the majority of their time online researching and using related technologies are more likely to use IaaS (Alashhab et al. 2021). In the context of IaaS adoption, it might be argued that compatibility has a positive impact on the acceptance of new invention such as IaaS. According to Zendehdel and Paim (2015) and Chatterjee et al. (2021), an invention's compatibility with a preceding concept can either accelerate or hinder its acceptance by an organisation.

University propensity to adopt infrastructure as a service

Propensity is a thought that encompasses the motivating elements that drive behaviour that influences a particular decision (Aripin, Haryaman & Sikki 2024). According to Porter and Rigby (2021), propensities are indicators influencing how certain individuals within an organisation are willing to try a new phenomenon, and how much effort they are willing to put out in order to accomplish that behaviour. According to the studies by Porter and Rigby (2021), the primary impediment to any new technological development is a lack of willingness from users to adopt it. The stronger an individual's goal, the more likely he or she is to use the desire to move to a new technology. In this article, the university's propersity to move to IaaS depends on the university's willingness and desire to move.

The TCT hypothesis opposes that persistent performance disparities between organisations can be traced to fundamentally diverse 'bundles' (Cuypers et al. 2021) or portfolios of resources that organisations utilise to implement their strategic goals. The structure of the organisation resource arrangement has the ability to provide long-term competitive advantage (Azeem et al. 2021). According to this idea, most corporations attempt to acquire or create resources early in order to accumulate the resources required to implement their strategic goals and to establish long-term competitive advantage. This occurs mostly when the company's current resource portfolio is insufficient to implement its succesful plan and/or is incapable of creating a sustained competitive advantage (Mahdi & Nassar 2021).

In conclusion, combining both TCT and DOI theories will improve an organisational transactional cost and resource based on IT business; this will imply that: (1) a lack of resources within South African universities to achieve or sustain competitive advantage will motivate engagement in IT innovation adoption and (2) the decision to adopt new IT innovations will be influenced by both universities' needs to keep up with the technological trends and its current lack of resources. Overall, the implications from a TCT perspective are complementary with three previous constructs established by innovation diffusion theory as illustrated by Figure 2.



IaaS, infrastructure as a service.

FIGURE 2: Conceptual model.

Research methods and design

This study focused on senior management's perspectives on the subject of implementing IaaS within institutions of higher learning. An exploratory research design is used, together with an interpretative research paradigm (Stebbins 2001). The primary goal of explanatory research is to find any causal relationships between the topics related to the study problem (Elliott and Timulak 2021). Through questionnaires, exploratory research is used to understand organisations' opinions about IaaS adoption, with the goal of comprehending factors that could either prompt or deter their acceptance. The interpretive paradigm supports the view that reality is produced by subjective perceptions and predictions (Littlejohn & Foss 2010).

To thoroughly grasp and analyse the data, the researcher employs rigorous inquiry processes, given the challenging nature of measuring these variables. As decision-makers in that area, the following experts were interviewed: three technical managers, two IT directors, two IT infrastructure operating managers, two IT architects, one IT planning team leader and one system administrator. For validating respondents' opinions about IaaS adoption in South African universities, these categorisations were used: age wise, 90% of the participants were in their 40s, and 5% in their 50s. About 60% of participants had a Bachelor's degree, 20% had IT diplomas and 20% had Doctoral degrees. All participants were males. Each interview lasted 45–60 min.

Thematic analysis

A thematic analysis was used to assess the interview data once they had been transcribed. Thematic analysis enables researchers to systematically identify, analyse and report on patterns or themes in qualitative data. The primary goal of adopting a qualitative technique in data analysis is to find new meaningful terms, patterns and themes in a semantic fashion (Braun & Clarke 2006). The main objective of using qualitative methods in data analysis is to uncover fresh, significant terms, patterns and themes in a semantic fashion. The following six-phased thematic analysis strategy was implemented to effectively discover and identify thematic patterns accurately.

Process of analysis

The researchers transcribed and read the first few interviews, which became even more apparent. During the analysis phases; however, both a theoretical and data-driven approach were used, which complement each other. Rather than seeking out predetermined themes from the data using a theoretical framework upfront, the themes emerged primarily from the data. Brotman et al. (2013) used subjective, situated knowledge (or contextual data) during their data collection phase to construct themes inductively. The article compared the raw data to the theory in the relevant literature to identify any relevant themes.

Throughout all six phases of the analysis, this hermeneutic cycle has been utilised multiple times, focusing on the identification of latent rather than semantic themes (Martens, Walterbusch & Teuteberg 2012). The article contextualises the data through these inductive-based contributions, resulting in themes and interview questions not found in the literature. Detailed information regarding the mechanisms that constitute the actual analysis process and their application in the different phases is provided in the following sections.

Phase one: Familiarisation with the data

As previously mentioned, phase one was acknowledged as a crucial step in the analysis procedure, serving as the cornerstone for all subsequent analytical tasks. This phase provided the researcher with the chance to familiarise themselves with the data. Personally transcribing all interview recordings enabled the researcher to gain insight into the data. Throughout this phase, the researcher compiled a list of pertinent concepts that eventually contributed to the development of emerging themes. Consequently, this initial phase facilitated the implementation of phase two, as some preliminary data analysis had already been conducted.

Phase two: Coding

The article undertook the task of coding the entire transcribed data. This process involved constructing a framework that encapsulated all the information relevant to the study, extending beyond just the fundamental concepts of IaaS adoption. Each interview transcript was meticulously analysed, referencing the list generated in the first phase to ensure comprehensive coverage. Initial coding was particularly important to ensure that no pertinent information was overlooked. Consequently, specific codes were assigned to individual data extracts. The third column in Table 2 provides references to each participant's transcript. Additionally, some codes were associated with multiple data extracts, as shown in Table 3.

Data extracted from the transcript are indicated in column one of Table 1, while one code is indicated for summarising the data extracted. In column three, the navigation is for the pages of each participant, for the data extracted. In Table 3, column two indicates data extraction. Instead of interpreting any extracted data, phase two aimed at developing a coding framework based on participants' views, rather than interpreting any extracted data.

Phase three: Searching for themes

The article identified all candidate themes, as well as all the associated subthemes. It is necessary to identify each participant per origin of code using the alphabetic character (in column three), as well as assist with further analysis. Phase four included the refinement of the candidate themes, the use of university data and the collection of associated data extracts. During this phase, the article focused on forming as many candidates' themes as possible, not eliminating any.

Phase four: Reviewing themes

In phase four, the researcher checked the themes of the candidates and refined the transcripts to match the coded extracts. The researcher modified the themes of candidates by assigning each of them a key term or code. The evaluation process continued throughout compiling the whole data set. As a result of this procedure, the identified themes were tested against the whole data set, and the participants' meanings were captured.

TABLE 2: Data extraction.

Data extract	Code	Trans line ref.
The primary concern regarding transitioning our data to the cloud revolves around internet connectivity. Without reliable connectivity, we risk being unable to work. Hence, maintaining in-house or on-premises infrastructure seems preferable, as it ensures operability even during connectivity issues.	• Connectivity issues • On-premises housing	1
While the benefits of cloud adoption are apparent, reliance on a cloud provider poses challenges, especially if they experience downtime. Moreover, our staff lacks technical expertise in cloud computing, necessitating comprehensive training before considering adoption. As information is vital to our university, entrusting it to a cloud provider requires assurances of security and integrity.	• Knowledge of cloud computing • User's attitude	2
Uncertainty persists regarding the location and control of our data in the cloud, raising concerns about tampering. Assurance of data safety is paramount for adoption. Financial constraints within the country also pose a risk, as delayed payments could lead to service interruptions. Given our experience with managing internal challenges, relying solely on cloud services seems premature.	• Trust issues • Transparency issues • Security issues	3
A hybrid approach, wherein some data are stored in the cloud while maintaining on-premises solutions as backup, seems prudent. This mitigates risks until our country establishes its own data centres, providing greater control and certainty over our data's whereabouts.	• Constant interruption issues • Availability issues	4
The primary concern regarding transitioning our data to the cloud revolves around internet connectivity. Without reliable connectivity, we risk being unable to work. Hence, maintaining in-house or on-premises infrastructure seems preferable, as it ensures operability even during connectivity issues.	• Trust issues • Hybrid model deployment • The location of data location challenges	5

TABLE 3: Data extracts classified under the same code.

Data extract from participants	Code
'… The sole concern casting doubt on our adoption of cloud computing is the challenges pertaining to bandwidth and electricity. Given the persisting electricity shortages in our country, resolving these issues must take precedence before we can contemplate embracing cloud computing.'	• Uncertainty issues
'The concerning fact about cloud computing is that the providers still have some sort of control of cloud infrastructure that makes us not to have full controll, the cloud providers still have all the control of which data set in which country our data will be placed.'	• Asset specification challenges
'What if we decide to sign a contract today with one of the cloud service providers, and laterwe discover that their services are no longer fit for our needs? Sometimes is difficult to get of the contract, we will be stuck with this service because we signed a contract. Only if we know is safe to do so, then if we feel our data is not safe we can pull out at any time.'	• Security challenges

During the process of themes refinement, certain themes had to be renamed, removed or merged with other participating candidate themes to make a true meaning of the themes.

Phase five: Defining and naming themes

As suggested by Clarke and Braun (2013), the researcher constructed the final thematic map based on phase four (the refined themes) after reviewing all the interview transcripts. As a result, the two major themes that emerged ('Trust in IaaS' and 'Attitude towards IaaS') do not overlap, which is demonstrated by the absence of a relationship between them. As a result of phase five, the researcher and reader should be able to interpret the data extracts and their association with the themes.

Phase six: Producing the report

In the sixth phase, the article finalised the analysis of the results, constructing a narrative derived from the researcher's personal interpretations of the data:

- The themes discerned and the corresponding excerpts of data they pertain to.
- The circumstances surrounding the inclusion of these data excerpts.
- The operational environment of each university and the degree to which they have embraced IaaS.

TABLE 4: Extract from the candidates' theme.

Participants knowledge of IaaS	Relatively the advantage that comes with the adoption of IaaS	If IaaS is reliable and secure but there is still a risk of adopting the service.
	SLA's needs to be clarified beforehand the compatibility of IaaS.	Thorough cost-effective analysis needs to be performed.

IaaS, infrastructure as a service; SLA, service level agreement.

TABLE 5: Refined themes with data collated from extracts.

Refined theme	Data extracts
• Participants' attitude towards the adoption of IaaS	'It is not safe to put your information with someone you don't even know; which country they are operation from. It is like taking out your own heart and giving it to someone to look after it.' (Interviewee F, University B, age 30–40 years old)

IaaS, infrastructure as a service.

Within each participating university, the contextual differences among the participants are emphasised. Besides interpreting the relationship between these statements or explaining the operational context of these participants, this narrative also provided participatory statements to support the arguments. The main theme, subthemes and resultant narrative based on the literature references from the previous chapters are presented.

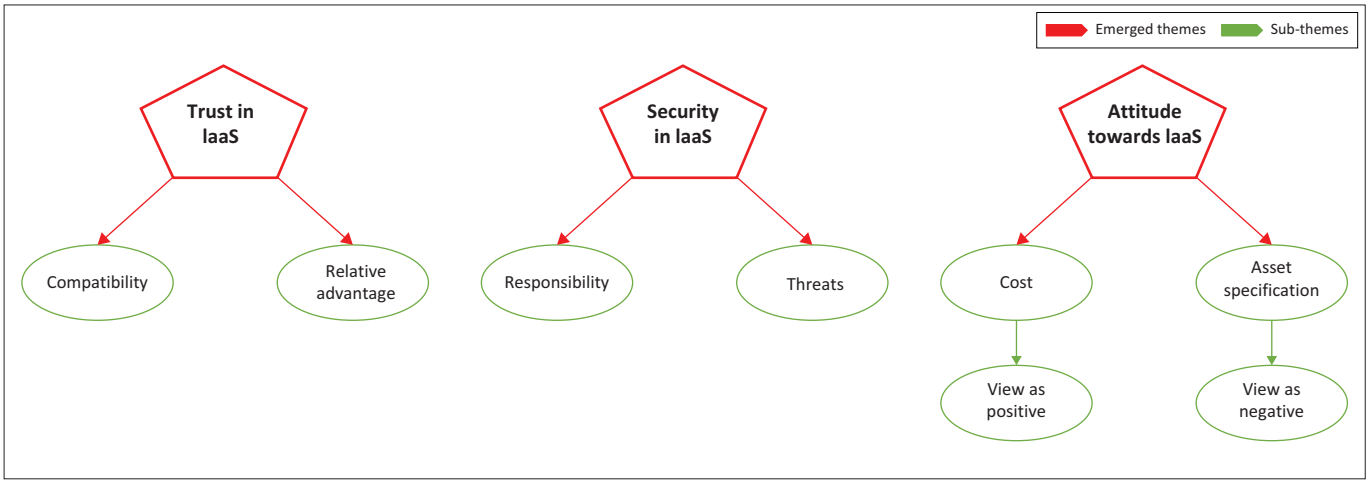
The thematic map: Using thematic maps to communicate stages, research progress and results, whether they are uncertain or final, is a powerful tool. By using maps as guiding tools in research, they can reveal the gaps in data or the appropriateness of class intervals. Furthermore, these maps may reveal previously unsuspected connections and similarities. According to Clarke and Braun (2013), geographers display their research data on thematic maps and gain new insights from them. Figure 3 illustrates the thematic map that guided the development of the adoption model for this study. Its purpose is to aid in completing a final project, to document it, to store knowledge and, above all, to communicate it. This study developed an IaaS adoption model (ISAM) based on a thematic map (Figure 3) that employed all prior themes and emerging themes throughout the analysis results of this article; it reveals how university ICT infrastructure management can be improved for improved efficiency.

Contextual background of the universities

Using the collected data primarily from a South African university, this article provides additional background information about the universities concerned and the appropriate information to interpret all the identified themes from the transcript.

University A

Brotman et al. (2013) deem University A as being a comprehensive university. Participants from University A articulated sophisticated perspectives on the utilisation of



IaaS, infrastructure as a service.

FIGURE 3: Thematic map.

cloud computing within their institution, given its focus on research. The fact that they used multiple cloud services reflected their understanding of this phenomenon, which made their views even more appealing – the reason being that these cloud using computing decision-makers had very clear and well-defined ideas about what was needed.

As a result, the participants at this university are well versed in cloud infrastructure. The researcher often had a difficulty in distinguishing participants based on their operating context during the interviews. Their plan of adopting IaaS may also be negatively affected by TELNET connectivity. Participants took into account that internet connectivity is improving. With connectivity improving at a rapid pace, and with free WiFi available in certain areas in the region, the university's location was not a hindrance to IaaS adoption.

University B

Using private cloud computing for some time, University B has one of the largest user populations across its five geographically dispersed campuses. In addition to working on the university infrastructure, the university employs a system administrator who has some interesting views on IaaS adoption. A public cloud adoption plan has been adopted by the university despite any concerns about IaaS adoption. According to the participants' understanding of cloud computing, it was a management decision to implement it. They also felt that they would not be able to operate their system if their service provider was to go down.

As evidenced by the interview data, this university intends to deploy all cloud computing services (IaaS, SaaS and PaaS) across all university systems, including its satellite campuses. As they already use some cloud computing services, this makes sense. The following concerns came to light in the data gathering interviews.

University C

Over the three campuses, University C has a large number of students and staff. University C offers a wide range of undergraduate and postgraduate programmes. Its historical background indicates that University C has produced many politicians over the years. University C has decided to remain with the current client-server model after thoroughly evaluating the posible adoption of IaaS. During the interviews, participants highlighted a diverse range of potential obstacles associated with the implementation of IaaS.

University D

With two campuses in the same province, University D has a large amount of undergraduates and postgraduates. University D understands cloud computing, having used it for years. Their cloud applications have been moved to the cloud, and a dedicated technician is deployed to manage them. To move up to 80% of applications to cloud computing, the university eagerly awaits cloud providers to build the data warehouse in the country. This university has decided to fully integrate cloud computing into their university, despite concerns surrounding cloud computing adoption by other universities. Participant H stated that this was a great financial benefit; the university is able to save some money.

It is clear from the interviews, however, that the university does not intend to move all of its applications to the cloud, but to maintain some core systems in-house. The university will also manage its own infrastructure with hybrid deployment. As a result of the university using the cloud, and the fact that they see it as beneficial, these participants provided a unique perspective.

University E

University E is a traditional, previously advantaged university in South Africa that has fewer research outputs. Participants from University E declined the invitation for one-on-one interviews with the researcher. These participants expressed some mature views regarding IaaS adoption at their university. It has not been fully implemented yet, but the adoption process has been partially completed. University E is still exploring the possibility of extending other cloud computing services. Among the adoption concerns raised by them are unreliability and unpredictable internet resilience to a lesser degree.

The narrative

The previous segment of the article outlined various contextual distinctions among the universities involved. Now, attention shifts towards elucidating the narrative and introducing the conceptual framework, specifically addressing the trust-related concerns surrounding the adoption of cloud computing in higher education. The authors plan to explore additional elements of the thematic map unrelated to trust in their future research endeavours.

Trust in the infrastructure as a service

In the data transcript analysis, 'trust' is identified as a new, emerging theme. The term 'trust' refers to the participant's perception and understanding of IaaS adoption (Martens et al. 2012). Trusts can also be classified into two categories, namely internal and external trust. 'Internal trust' refers to trust between different parties within the organisation, in this study the university.

Throughout the investigative journey detailed in this article, the majority of participants frequently discussed their level of confidence, shaped by their inclination towards adopting IaaS within their university settings. It is important to emphasise that the perceived unreliability of cloud computing is determined by the accessibility and availability of IaaS and is influenced by various factors connected to accessing cloud services (Itu et al. 2012). As indicated below, the theme or concept emerged when participants were asked:

Have you adopted IaaS, or will you adopt it in the near future?

One participant responded by stating that: '… One individual expressed distrust in cloud computing due to concerns about bandwidth and electricity issues, especially in a country with unreliable electricity' (Interviewee A, University A, age 40–50 years old). They suggested that resolving these issues would make them more open to considering cloud computing. Another participant emphasised that trust cannot be bought but must be earned through giving something a chance. Trust is subjective and influenced by personal experiences, beliefs, gender, age, and previous unsatisfactory encounters.

Other trust relationships within universities, including that of the accounts department and top management, as well as IT infrastructure managers, are more sophisticated than the trust between cloud provider and subscriber. Trust relationships are established on assumptions under certain conditions concerning cloud providers. These conditions include the following:

- The cloud provider possesses a favourable reputation.
- The cloud provider is regarded as substantial in scale.
- Subscribers perceive the providers as seasoned and well established.
- The level of transparency exhibited by the providers is satisfactory.
- Other organisations have already embraced their cloud services.

This article identified trust as a vital aspect that must be integrated into the ultimate IaaS adoption model. Despite not being explicitly stated, trust consistently emerged as a key focus throughout the interview research guide, highlighting its significance.

Security issues

The emergence of the 'security' theme in response to a question about stumbling blocks in the adoption of IaaS highlights the significant concerns and considerations regarding security in cloud computing environments. It underscores the critical importance of addressing security issues when discussing cloud adoption, especially in contexts such as universities where sensitive data and information are frequently handled. Participants' responses suggest that security is not only a consideration but also a top priority for cloud providers and organisations contemplating migration to cloud environments.

According to one participant, 'security issues need to be addressed before we make an agreement, so we must participate in that evaluation process' (Interviewee B, University A, age 30–40 years old). The statement contains the following three keynote messages:

> '[*M*]ost of the time we are left behind, but now we have to deal with the problem after management makes deals with external service providers. Migrating to IaaS requires management to involve all stakeholders, especially IT technicians. Second, decisions are made by different committees and aren't communicated adequately to the people tasked with making them. IT technicians are especially responsible for infrastructure and cloud adoption. Furthermore, the university appears to lack an in-depth investigation of IaaS users' knowledge. Research intensive universities should give graduates and academics the chance to share their insights on infrastructure security.' (Interviewee B, 30–40 years old, ICT Infrastructure Manager, University A)

Consequently, the evaluators of cloud infrastructure solutions and future beneficiaries do not communicate internally. It is crucial that postgraduate students and academics understand and participate in the infrastructure security process, even though they trust the decision-making committees. There is uncertainty among participants about how an evaluation process committee will ensure cloud-based information security, so they said that they must participate in the process of establishing it. Participants' perceptions of infrastructure security and trust have been positively influenced by the confidence and experience they gained with traditional infrastructure. Data from the interviews indicated levels of trust and showed that participants' attitudes towards cloud infrastructure security affected their decision to use IaaS.

As Sarwar and Khan (2013) noted, security comes first when organisations consider cloud computing adoption. When adopting cloud computing services, ensuring that sensitive information is protected is crucial. A perspective on information systems (IS) security policy violations within an organisation could also be interpreted as paradoxes (Njenga & Oyebisi 2018). In addition, Itu et al. (2012) and Kuada, Olesen and Henten (2012) indicated that most countries, especially in Africa, fail to comply with the data protection laws when compared to developed nations. In this way, cloud-based environments are increasingly reliant on security.

Even though University D participants did not mention specific security incidents, some of them (e.g. Participant J) created their own incident reports that monitor all cloud applications. Universities A and B use the cloud partially, and this study found that information security concerns about confidentiality, integrity and accessibility of cloud-based information are viewed negatively at both universities. In some organisations, cloud services are not widely utilised, so they do not view these factors as a big concern (Bamiah & Brohi 2011).

Attitude towards infrastructure as a service

Experience and temperament are responsible for making an individual's attitude what it is (Reece et al. 2024). In the context of this research, a stakeholder's attitude can be defined as their level of readiness to adopt IaaS in the light of their experiences and other factors. It appears that participants may also differ in their opinions regarding the adoption of IaaS at South African universities, depending on their experiences and mindsets. Compared to middle-level managers, some senior managers seemed to understand IaaS better than others.

As the respondents' understanding and knowledge of IaaS are shaped by their attitude, attitudes are strongly related to trust and security. According to one participant, University B is willing to invest in cloud computing as they have strategies to adopt cloud computing: 'In spite of not following up on the implementation strategy, we're exploring the possibility of adopting cloud computing' (Interviewee C, University B, age 30–40 years). Nevertheless, another participant stated that 'cloud computing would cause us to lose some jobs, which is why it's a cautious process' (Interviewee D, University B, age 30–40 years old). A challenge in the discovery of this article remains the issues of the support from top management, organisational size and readiness for IaaS adoption. These issues must be addressed prior to adoption of IaaS.

Presentation and discussion of results from the priority themes

As part of developing a final conceptual model, some of the priority themes from thematic map were included in the final creation. The priority themes that were included are asset specification, uncertainty, cost, relative advantage, compatibility and complexity, as they were also affirmed by the respondents. Some of the themes were eliminated as they were not seen significant because of the fact that they do not form part of the final adoption model of IaaS. Despite the participants not being able to distinguish their differences as applied in this study context, compatibility and complexity were merged into one theme called compatibility. Participants were able to view the adoption of IaaS, together with the emerging themes, as part of the final IaaS adoption model. Listed in the following sections are participants' responses to the six important themes.

Relative advantage

Among participants, cloud computing is viewed as providing ubiquitous, convenient, on-demand access to the network. Remote access was regarded by participants as a major benefit, as employees are able to work remotely, from home. By doing so, the organisation saves resources, such as electricity, which would otherwise be consumed.

One participant, Interviewee D, emphasised that the benefits of transitioning to the cloud outweigh the traditional model, citing cost as a significant factor. Managing in-house infrastructure for tasks like student and staff emails incurred high costs, which were alleviated by moving to the cloud. Unlike traditional networking, where one pays for everything including hardware, installation and maintenance regardless of resource usage, cloud computing operates on a pay-as-you-go model. This means users only pay for the computing resources they actually use, reducing unnecessary expenses associated with traditional infrastructure.

Participant A shared frustrations with the limitations of traditional infrastructure, particularly during peak times like registration periods. University systems often struggle to meet demand, causing delays and inconveniences for students, parents and staff. Additionally, access to university systems is restricted to on-campus locations, hindering productivity and causing frustration. These challenges highlight the need for more flexible and scalable solutions like cloud computing to better meet the demands of modern work and education environments.

Compatibility of infrastructure as a service

A company's IaaS adoption must be compatible with its operational processes and strategic objectives. Applications can be moved easily between different cloud-service providers thanks to compatibility, no matter where they are, what operating system they use or what format they use. Organisations need to find compatibility with their operational needs when adopting cloud computing services with its benefits and costs (Low, Chen & Wu 2011). Participants may not adopt any particular innovation if compatibility has not been addressed. In order to change the working process drastically, the organisation may also have to invest enormously; this can affect the organisation's budget. A negative attitude may affect the adoption of an innovation if it requires staff to change their normal working procedures (Zaltman & Lin 1971).

This article's findings are consistent with what Jennett et al. (2003) have stated, namely that compatibility is critical in the process of transitioning IT services to a cloud model. The findings are supplemented by the findings of Njenga and Oyebisi (2018), who studied 'when third-party technology innovation becomes a threat to information systems'. Their findings suggested that when outsourcing, there should be compatibility in terms of worker involvement and moral views, as this can pose a threat to information systems.

Uncertainty

While extensive research has explored uncertainty across diverse fields like Computational Biology, Economics, Physics and Social Sciences, there has been limited focus on uncertainty specifically within cloud computing. Cloud computing adoption involves grappling with different kinds of uncertainties, such as performance, security and reliability. Uncertainty can be seen as the divide between what is known and what is unknown. Participants' responses on whether South African universities adopt cloud computing are shaped by their uncertainties. To gain insight into these uncertainties, participants were asked the following question to understand their reservations about adopting IaaS.

What are your plans in adopting infrastructure as a service at your university?

During the interviews, participants indicated that they were uncertain whether or not they would move to cloud computing, or whether or not they would adopt cloud computing. From a strategic standpoint, the current infrastructure is uncertain. Furthermore, participants were unable to confirm whether a strategic plan had been rolled out by their university ICT. The

IT infrastructure division and university management, therefore, have communication barriers.

Interviewee F, the individual, mentioned:

> 'During a meeting, I raised the topic of transitioning to the cloud, but no progress has been made in the two years since then. Here, discussions often occur without any subsequent actions, and sometimes changes happen without us being informed. Currently, there's mention of a strategic plan to shift to the cloud, but there's a lack of concrete implementation strategies. Management has expressed uncertainties about cloud computing and indicated they are hesitant to move our data or even consider transitioning to the cloud.' (Interviewee F, University B, age 30–40 years old)

The article's findings align with those of a researcher who proposed communication awareness to address limitations in current strategies for managing uncertainty within the cloud computing model (Alkhanak & Khan 2015). Several participants echoed similar sentiments expressed by scholars, emphasising the need to clarify uncertainties surrounding IaaS. These concerns indicate a strong desire among participants to adopt IaaS within their universities. Despite some expressing reservations about issues like internet connectivity uncertainty and security, they still recognise the potential of cloud technology and believe it to be the future.

Cost

According to the literature review, cost refers to the way resources are organised to maximise efficiency, thereby achieving the goal of value for money, and IaaS performance should not be adversely affected by unforeseen transaction costs. Therefore, when adopting IaaS, it is important to strike a balance between the transaction costs and adoption benefits. Participants stressed the importance of balancing transaction costs with adoption benefits. Clearly, it is necessary to balance transaction costs and adoption benefits before entering into any service provider agreement.

One participant (Interviewee E) indicated that two methods could be used to assess transaction costs and adoption benefits. They said that cloud computing enables organisations to focus more on core competencies and eliminate initial infrastructure investments. According to Interviewee F:

> '… [Y]ou do not have to worry about your storage, networking, servers, or virtualization because you can adapt the IaaS hardware requirements … we can then focus on the software we need that reduces capital investment and operations expenses …' (Interviewee F, University B, age 30–40 years old)

In addition, Interviewee F mentioned as follows that IaaS solutions could reduce costs significantly for higher education institutions, along with regularisation: 'Let us imagine that the government provides cloud services to all universities in SA in all nine provinces … that will mean we will now be able to save even more'. Interviewee J expressed as follows that unexpected costs may be mitigated as soon as all services are moved to cloud providers:

> '… [*A*]s technology evolves, we might find that we don't need a particular service anymore, which requires scaling it down from the services we contracted; and once that is done, the service provider may force us to pay for the remaining contract term or purchase another service with them, and that will clearly affect our costs.' (Interviewee J, University D, 30–40 years old)

Businesses should continuously evaluate economic conditions to improve efficiency, monitoring their own business priorities (Dhiman et al. 2010).

This was previously identified in their studies as a driving force for cloud adoption. Overall, the study indicates that the participants' expertise is not in the area of organisational cost–benefit balancing and transaction cost evaluation; however, the results indicate that IaaS adoption is positively influenced by cost implications (Schaffer et al. 2009).

Infrastructure as a Service Adoption Model for South African universities

The final Infrastructure as a Service Adoption Model (ISAM) was developed based on the analysis of identified themes, with a focus on prioritising key themes. These themes were integrated into the ISAM's development process, as depicted in the accompanying Figure 4.

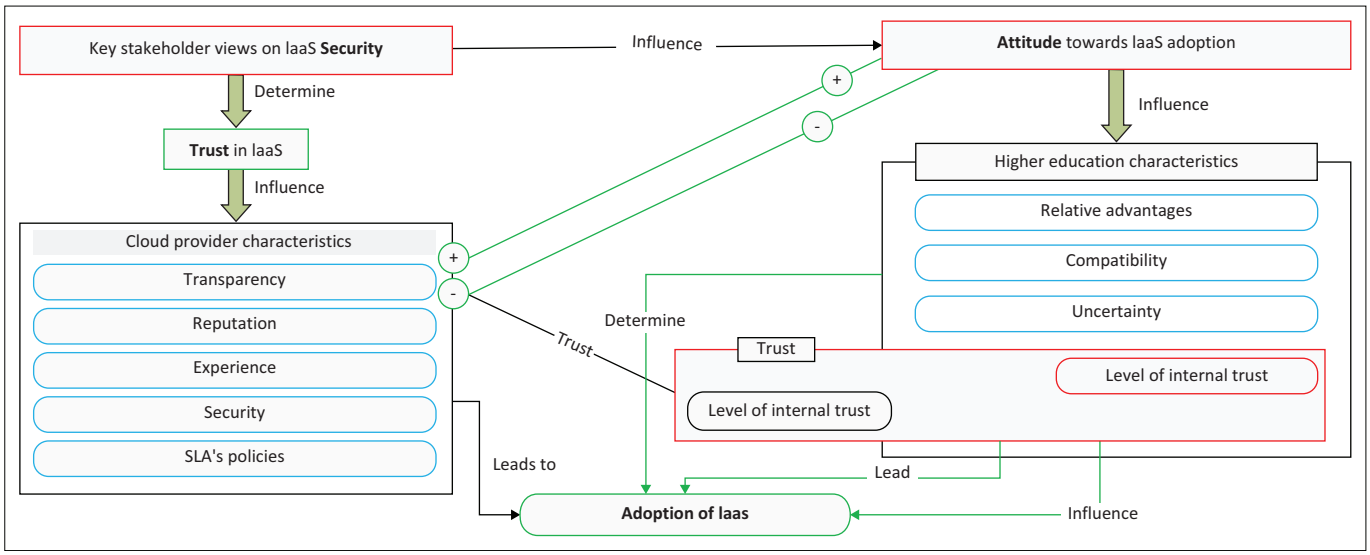
Recommendations

The research article used outsourcing theories to the study of cloud computing, allowing an organisation to analyse the elements that influence IaaS adoption. This article advises that the established model be utilised as a reference for enterprises in general, and universities in particular, while embracing cloud computing from an outsourcing perspective. It establishes a fundamental framework that future researchers can build upon to expand their studies on giving IT decision-makers with guidance when considering implementing IaaS in their businesses.

Universities considering the adoption of any of the cloud services can use the recommendations that the article has highlighted from the data analysis. In order to implement a successful project, open communication is essential. All stakeholders need to be involved in the adoption process. They should be involved in the early stages of the process. The cloud service's users, IT personnel and the cloud provider should be key stakeholders. Executing the following actions in adopting IaaS may improve ICT infrastructure management efficiency as follows:

- *Engage with the ICT services department:* According to the ICT division, top managers were making decisions that ICT services would be expected to support. As explained by a participant:

  > 'We are often called to meetings and told that you must start using a particular system without our involvement and we must support it when it gives us trouble, and that doesn't sit well with us.' (Interviewee F, University B, age 30–40 years old)



IaaS, infrastructure as a service; SLA's, service level agreements.

FIGURE 4: Infrastructure as a service adoption model (ISAM).

To establish a forum for discussing technical matters, top management can meet regularly with cloud providers.

- *Engage with intended users:* From the beginning, university management should involve the users of the system. Because the users will use the system, they should be involved to ensure that the system is tailor-made according to their requirements as users. In addition to training, awareness campaigns should be conducted on the proposed technology, focusing on its relative advantages.
- *Engage with the providers of the cloud:* Universities need to engage with cloud providers effectively, given the different business models. Many established cloud consortia in South Africa focus specifically on universities. Universities that want to use IaaS can benefit from such platforms.
- *Employ and train staff members on cloud usage:* It will be easier for universities to adopt IaaS with the assistance of a cloud expert. Based on the results of this study, it appears that it is a requirement, rather than a recommendation, that such a staff member must be appointed within the university. A staff member such as this should also be responsible for reviewing Service Level Agreements (SLAs) and communicating with all key stakeholders. The services of this cloud provider staff member or specialist on internal and external information on data exchange would need to be shared by the cloud users. University adoption of cloud services will always be threatened by the concern about the safety of information if they do not employ or train such a person.
- *Categorising university's information from critical to suitability information:* As suggested by participants, moving students' email addresses to the cloud, even if hacked, several hours of no notice, in this instance, are not regarded as that important. Before adopting IaaS, it is important to separate critical information from suitability information, as they are regarded as critical systems.
- *Cost-analysis performance:* IaaS may have cost implications. Some participants stated that 'Cloud computing looks cheap, but you may discover it isn't as cheap as it seems'. It is important to deal with cost implications intensively before a university begins to adopt cloud computing.
- *Building data centres within South African borders:* Location of data in the cloud has been a concern to many participants. There was some discussion of establishing a shared data centre that would store data from all universities in South Africa and serve as a community cloud as well. The main South African internet service provider, TELKOM, saw this as an opportunity. It is important to do further research before universities begin the adoption process. The article interested in South African data centres will benefit from this recommendation.

Conclusion

In the academic era, IaaS appears to be the emerging computing model that could improve the efficiency of any university ICT infrastructure if considered. Adopting IaaS appears to have numerous advantages as compared to the on-premises model. Although the multiple benefits of IaaS adoption could enhance the effectiveness of the university's ICT infrastructure, the results of this article indicate that IaaS adoption should not be adopted blindly, and a researched model should be followed as a guide. Inadequate preceding research and planning may result in a bad implementation process and, as a result, a loss of trust from cloud providers and institutions. As a result, before deciding to implement IaaS, the university administration's decision must be properly investigated by involving all stakeholders and with both leading and hindering elements extensively examined. This study seeks to better comprehend the university administration's perspective on choosing to implement IaaS. Such perspectives may lead to increased efficiency in university ICT infrastructure management.

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Competing interest

The author declares that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Author's contributions

M.N.M. contributed to the design and implementation of the article, to the analysis of the results and to the writing of the article.

Ethical considerations

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Data availability

The data that support the findings of this study are available from the corresponding author, M.N.M., upon reasonable request.

Disclaimer

The views and opinions expressed in this article are those of the author and are the product of professional research. It does not necessarily reflect the official policy or position of any affiliated institution, funder, agency or that of the publisher. The author is responsible for this article's results, findings and content.

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