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A GUIDE TO CLOUD MIGRATION, A STUDY OF CLOUD COMPUTING ADOPTION IN UNIVERSITIES

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Abstract: Universities encounter numerous obstacles in their information and communications technology activities, including financial expenses, licencing, and software and hardware administration (ICT). Universities can provide smart, safe, and fluent services to their teachers, students, researchers, information technology (IT) personnel, and administrators by addressing these hurdles. Cloud computing may be able to help with these issues. At terms of online education, economic crisis, globalization, and high and continuously changing requirements, the shift to cloud computing in universities is a critical step, particularly during the COVID-19 period. Cloud computing has the potential to help institutions quickly solve challenges related to the Corona Virus outbreak. The goal of this study was to determine the position of Turkish universities in the cloud computing space and to offer an abstract hybrid cloud framework for these institutions. The study included a descriptive method and a survey technique. The data was analyzed using the SPSS programme. In the analysis, percentage, frequency, and chi-square statistics were used. The present conditions and challenges in the usage of the cloud service model in universities were attempted to be recognized as a consequence of the research, and a road map for fixing these problems was put up. In this regard, a hybrid paradigm for implementing cloud computing in universities has been presented in order to help them overcome their highlighted obstacles. The findings are primarily meant to serve as a guide for colleges interested in adopting cloud computing.

Keywords: Universities, Cloud Computing, Higher Education, Education

Introduction

Universities in the information age use modern information technology (IT) to meet the needs and expectations of their consumers. Universities must make an effort to structure themselves according to the demands of new IT and to technologically refresh themselves. Cloud computing is one of the most well-known new technologies these days. This technology has numerous applications in the industries of finance, health, insurance, automobile, and military, as well as in colleges.

Many institutions are experiencing an IT revolution as a result of cloud computing. The recent significant growth in the number of universities in Turkey has created a number of concerns about the quality of university information services. Cloud computing will allow universities with restricted budgets to take advantage of information services without having to make additional financial investments in ICT resources. Knowledge can be managed effectively with cloud apps in higher education to improve academic achievement, effectiveness, and efficiency in universities.

The COVID-19 dilemma has recently impacted universities as well. They were briefly shuttered during this time, forced to halt their face-to-face education, moved classes to online learning, and cancelled excursions that included events like conferences. It's fair to say that, especially during the COVID-19 outbreak, reliance on cloud computing services has grown dramatically (Alashhab et al., 2020). In the COVID-19 epidemic, several education sectors and universities converted to online learning settings to prevent the disease from spreading (Chaka, 2020; Chen et al., 2020). Software is purchased by the education sector in order to sustain distance education. In this context, cloud computing technologies provide a variety of services. Universities can leverage the cloud computing service model to deliver information services that meet the needs of their users. Because of several key advantages of cloud computing, especially in remote education, the usage of the cloud computing service model by universities will continue to be an important topic in the post-COVID-19 future. The goal of this study is to assess where universities in Turkey stand in terms of cloud computing and to offer abstract hybrid cloud architecture for incorporating cloud computing into universities in order to address the university's highlighted difficulties. The study's "Literature Discussion" section provides a review of the theoretical and conceptual backdrop, while the "Purpose, Scope, and Method of the Study" section details the research methodology. The study's findings are examined in the section "Findings and Evaluation." The provided framework is described in the section "An Abstract Hybrid Cloud Framework for Universities," while the conclusion and recommendations are listed in the last section.

Literature Review

Cloud Computing

In the information era, cloud computing is what electricity is in industrial civilization (Carr, 2014). Cloud computing entails offering computing services (such as server, storage, database, network, software, analysis, and machine intelligence) over the internet in order to provide faster creative, flexible resources and economic scaling (Seyrek, 2018). Cloud computing is a distribution strategy that allows applications and services to be accessed in a massive data centre architecture regardless of time, geography, or platform (Sevli, 2020). The need for more computing capacity has pushed scalable computing and distributed computing forward (Chetty & Buyya, 2019). A lot of services must be developed and deployed in order to establish a grid (Buyya et al., 2017). Cloud computing can be described as a model based on current technologies such as virtualization and grid computing. Computational grids were created with the goal of pooling geographically distant resources to provide processing power (Abramson et al., 2002). By leveraging a dependable and scalable infrastructure, cloud computing allows information services to be offered as advanced and scalable applications (Mirzaolu, 2013). Those who have used web programmes such as Gmail, Wikipedia, Hotmail, or Twitter can be considered cloud computing experts (Mirashe & Kalyankar, 2016). Through the internet, cloud computing allows users to access information from anywhere and at any time (Henkolu & Külcü, 2013). It is a system in which application data is stored in the cloud and mobile devices serve as a simple user interface. Cloud computing is defined by the National Institute of Standards and Technology (NIST) as a model in which services and sources are accessed with minimal management effort and service provider contact (Liu et al., 2019). Business application capabilities emerge as sophisticated services that may be accessed across a network in cloud computing (Buyya et al., 2019).

Features of Cloud Computing are listed below:

- On – demand Self – Service: The ability to use information resources automatically in accordance with computational resource utilization rates and performance.
- Broad Network Access: Users' ability to access Cloud resources via a variety of devices and computer networks, in addition to computers.
- Resource Pooling: The capacity for numerous cloud users to share information resources such as a computer network, server, operating system, database, and computer applications.
- Rapid Elasticity: Cloud computing can provide resources to users when they are most needed. Users can consume resources when they need them and release them for other users when they're done, thanks to this characteristic of cloud computing.
- Measured Service: Users' capacity to optimize resource use based on how they use cloud resources and how well they function. Cloud services can be charged at the same time with this capability. Users only pay for the cloud resources they utilize in this way.

The "Cloud User," "Cloud Controller," "Cloud Service Provider," "Cloud Agent," and "Cloud Carrier" elements in NIST's cloud conceptual reference model must all be present in a cloud structure (Sevli, 2017). The service models are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS). Cloud computing deployment models include public, private, communal, and hybrid clouds (Goyal, 2019).

Cloud Computing and Universities

Knowledge, which is the most fundamental and basic resource of the information society, shapes all participants in the information society. And knowledge production is one of the fundamental dynamics of this civilization (Bell, 1976; Masuda, 1990). Societies that cannot access, utilise, manage, or benefit from the power of knowledge will have to live up to the standards of the industrial and maybe agricultural societies in the age of knowledge, in which information has achieved strategic worth in and of itself. Developed countries, sometimes known as information societies, make the most of the power of information technology. Countries that make the most of information technology grow stronger and expand their dominance, whereas those that do not plan for and invest in this field grow poorer (akn, 2014). Today, rapid technological advancements have altered the production and delivery of IT services. The variety of information produced, stored, and exchanged in electronic environments has increased in recent years, and access to information has become time and location agnostic.

It is clear that the production and presentation of information services will continue to be an unavoidable fact as long as IT development and change occur. Factors such as the widespread use of computers and the internet in all sectors of society, the diversification of information sources, the user's ability to access information from anywhere, and the shift in the communication environment from the traditional to the electronic have changed the profile of today's information user and raised their expectations (zenç Uçak, 2014). Universities are the most important determinants of social growth in the information society. Education and research are the most significant functions of a university (Celik, 2000). The purposes of universities can be divided into four categories (Cakin, 1983):

• To improve the level of technical and scientific knowledge,

• To train qualified personnel required by society,

• To boost the intellectual power and culture of students, and

• To raise the commonality and standard of the society in which it serves.

Universities encounter numerous hurdles when providing information services, including budget constraints, licence issues, and software and hardware integration and management. The significance of cloud computing, especially for institutions with financial constraints, in overcoming these issues and providing an alternative approach to manage information systems in a cost-effective manner is significant. Although personalized learning, cost-effectiveness, elasticity, measurability, accessibility, low carbon emissions, and standardization are some of the benefits of cloud computing in the education field, security, compliance issues, lock – in, reliability, a lack of skills and insufficient cloud service provider support are some of the drawbacks.

Cloud applications such as Google Apps, Dropbox, and Google Apps for Education, Microsoft Office365, and others are already widely used in education. UNESCO recommends some online apps that can be utilized in the field of education, such as Blackboard, CenturyTech, ClassDojo, and Google Classroom (2020). The willingness of universities to use their financial resources cost-effectively and efficiently is at the root of their desire to gain from cloud computing. With cloud computing, several colleges are seeing a change in their information services. Higher education institutions require good IT governance in order to function (Bianchi & Sousa, 2016). If universities fully utilize cloud computing, the traditional university understanding will be obsolete.

Steps to a Successful Cloud Migration

Following a review of Cloud Computing's theoretical and conceptual foundation, the procedures for making a successful shift to the cloud were studied. It's difficult and expensive to move from old systems to cloud platforms (Gholami et al., 2017). In the literature, there are various ways for moving to the cloud. While some studies claim that the steps of learning, organisational evaluation, pilot cloud implementation, cloud preparation assessment, cloud dissemination strategy, and continuous cloud implementation comprise the cloud transition (anl, 2011), others claim that the steps of learning, organisational evaluation, pilot cloud implementation, cloud preparation assessment, cloud dissemination strategy, and continuous cloud implementation comprise the cloud transition (anl, 2011). (Wyld, 2009). According to Takai (2012), the cloud transition consists of the following steps: cloud computing promotion, data centre consolidation, enterprise cloud infrastructure construction, and cloud service submission (Takai, 2012). Pradesh (Pardeshi, 2014) proposed a five-step structure for a smooth transition from traditional to cloud-based systems: confirmation, implementation, choice, knowledge, and persuasion.

In two institutions, Bryant (BU) and Roger Williams (RW), Attaran et al. (2017) identified the three phases of the cloud service adoption strategy for effective cloud implementation (RWU). RWU students, for example, use the Bridges online learning system, which stores all of their course materials on an external cloud hosted by Amazon Web Services (AWS). Bridges lets professors and students to use a variety of personal devices to upload, watch, and download lectures, assignments, grades, and much more via the internet from anywhere with an internet connection.

In Turkey, University ICT structures are being developed

State universities and private universities provide higher education services in Turkey. With their rising numbers and student capabilities, private institutions, which initially entered Turkish Higher Education in 1984, have established their place as a public institution. In terms of management, finance, education and training structure, quality and qualified graduates, and performance status, state and private universities have some structural parallels and differences. In Turkey's existing setup, university IT departments are responsible for meeting the universities'

ICT needs. According to the findings of a study conducted on the websites of university IT departments, university IT departments generally contain the following groups of units (Damar & Coşkun, 2017):

• Network/System: This category includes units that provide technical services such as network installation, computer maintenance, smart card services, and camera-related services. Technical Services Branch Office, Network and System Management, Hardware Branch Office, System and Network Group, Hardware Services, System/Network Services, System Management Unit, Smart Card Unit, Technical Units, Technical Support and Operating Services, Security Camera Systems Unit, IP Power Plant Unit, Administrative and Technical Support Unit, Computer Maintenance and Repair, and Other Information Materials are some of the subunits of it.

• Software/Web Projects: This section contains units in charge of software and web projects. Web Technologies, Web Management Unit, Web Design, Software Unit, Software and Visual Media Services, Web Unit, and Software Branch Manager are the subunits.

• Administrative Financial Affairs: This category comprises administrative units dealing with finance, accounting, and other related issues. Administrative Financial Affairs, Administrative Units, Accrual Works, Works, Administrative Affairs, Administrative Office, Purchasing, and Secretariat are the subunits of Administrative Financial Affairs.

• Help Desk: This refers to the departments with whom users communicate about their hardware and software issues. Communication Unit, Project Support Group, Informatics Branch Office, Mobile and User Accounts, User Support Unit, Workshop, Informatics Group, Hardware Support, and Software Support Unit are the different subunits.

• Project and Personnel Management: This section encompasses all project and personnel management modules. The E-Document and Personnel Coordination Unit, the Informatics Branch Office, the Human Resources Unit, the Process and Governance Group, and the Analysis and Training Branch are among the subunits.

The study's goal, scope, and methodology

The goal of this study is to analyze the current conditions and issues surrounding the usage of the cloud service model at universities, to provide a road map for resolving these issues, and to suggest a cloud computing model in this context. Within the context of this study, major discrepancies between state and private colleges are also revealed.

The following are the study's primary contributions:

• Using the research questions established within the scope of this study, determine and evaluate the current state of universities and their perspectives;

• A literature analysis describing cloud computing at universities and based on research topics;

• A presentation of an abstract hybrid cloud framework for the supply of university information services such as SaaS, IaaS, and PaaS;

• Chi-square tests were used to determine significant differences between public and private colleges; and

• Some recommendations were made based on the literature analysis and study results.

• In this context, emphasizing the importance of cloud computing adoption in overcoming ICT challenges encountered by universities, as well as serving as a roadmap for universities seeking to mitigate these issues to some extent.

In the context of cloud computing implementation, colleges' IT departments are crucial. The study's universe is comprised of university IT departments, as stated in Table 1. According to the statistics in this table, 59.5 percent (105 departments) of university IT departments took part in the study. In total, 72.1 percent of state university IT departments (75 departments) and 41.6 percent of private university IT departments (30 departments) participated in the survey.

As shown in Figure 1, the research questions utilized in the university survey were determined.

The framework offered in this study was based on the results of a literature review conducted in response to these research questions. The goal of the study's first (R1) question was to determine whether people were aware of the cloud computing service paradigm. Universities must understand what the cloud is and what it can provide. From this perspective, it is vital to be familiar with cloud computing technology in order to select the most appropriate cloud model for the university's information services. The study's second (R2) question sought to evaluate whether colleges needed to move their information services to the cloud. Computer gear, software development and licence fees, system heating and cooling costs, and expenditures associated with the hiring of trained ICT staff make up the majority of university expenses. Universities may find cloud computing to be a cost-effective solution. In this environment, it's critical to figure out how colleges assess the costs of hardware, software, energy, and ICT personnel. The reduction in information system expenses is viewed as one of the most important motivations for institutions and companies to switch to cloud computing. One of the most apparent advantages of cloud computing is its cost-effectiveness, which drives all enterprises to adopt and use it. Computer hardware, software, computer network technology, and a variety of other information system technologies are all receiving significant investments nowadays.

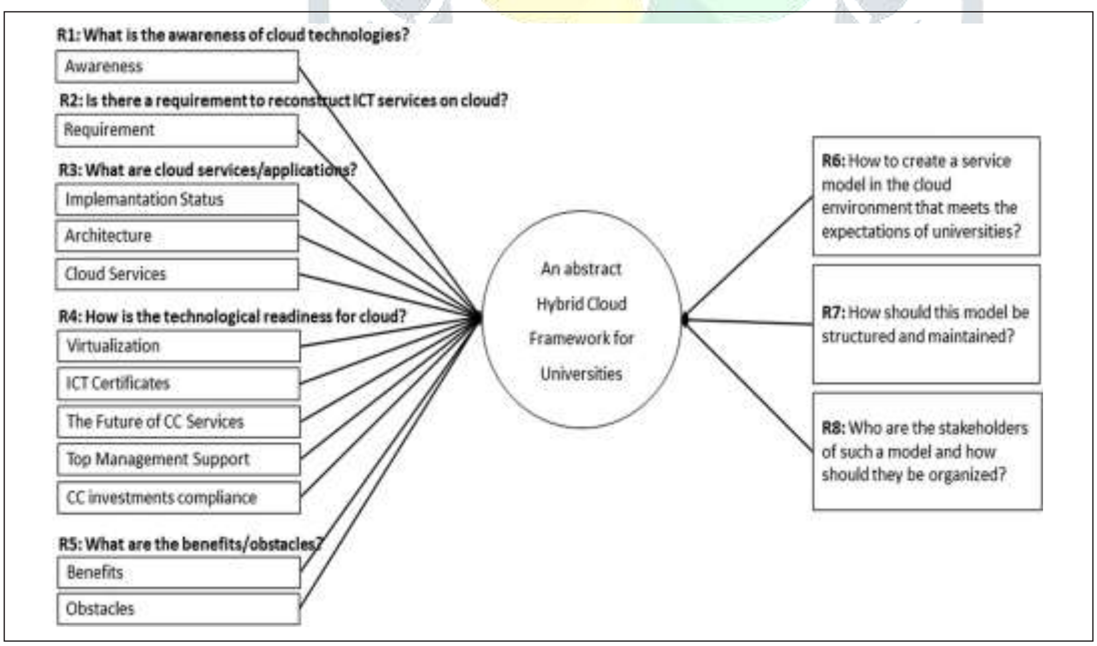


Figure: 1

In addition, the costs of employing IT personnel to operate these systems are a separate line item. These information systems' energy requirements, such as heating and cooling, are also significant expenditures. The study's third (R3) and fourth (R4) questions sought to identify the existing ICT scenario and whether universities are ready for cloud transition in terms of their capabilities. Determining if universities are ready to move to the cloud based on their current capabilities may aid in the choice to do so. As colleges transition from their existing state to the cloud, they must consider the potential consequences of cloud adoption on the organization and compare the two scenarios. They also wish to migrate from a cloud platform to a non-cloud platform by putting alternate plans in place if the cloud platform does not match the adoption process's standards. The questions of which information services are most desired to be transferred to the cloud environment and the potential problems that may be faced in moving information services to the cloud environment will aid in determining university roles in the cloud computing context. Institutions and organizations can use the computer resources they require without having to establish information systems, software, or hardware infrastructures within their own organization thanks to cloud computing platforms that allow them to share them as much as they need. Through cloud computing platforms, a cloud service user can receive and use information from another cloud service provider. In this circumstance, there will be a natural increase in service diversity. The research's fifth (R5) question aims to explore the potential benefits and issues that may arise from migrating library services to the cloud environment. The study's sixth (R6), seventh (R7), and eighth (R8) research topics are all about developing a framework for cloud computing adoption based on the survey findings.

Findings & Evaluation

The data collected from the survey of university IT departments is reviewed in this section of the study. The results of the study were examined statistically under the headings "Awareness," "Requirement," "Cloud Services/ Applications," "Technology Readiness," and "Benefits and Possible Obstacles."

Awareness

In response to the survey question assessing participants' knowledge levels on cloud computing, 28.6% of respondents said their knowledge levels were "Good" (Figure 2). This demonstrates that university knowledge of cloud computing is at an elementary level. It's worth noting that some universities are completely unaware of cloud computing. If "Very good" and "Good" knowledge levels are regarded sufficient, it is clear that over half of the universities (50.5 percent) lack appropriate cloud computing understanding.

In the chi-square test, there was no significant difference (2 = 0.180) between state and private universities in terms of cloud computing competence.

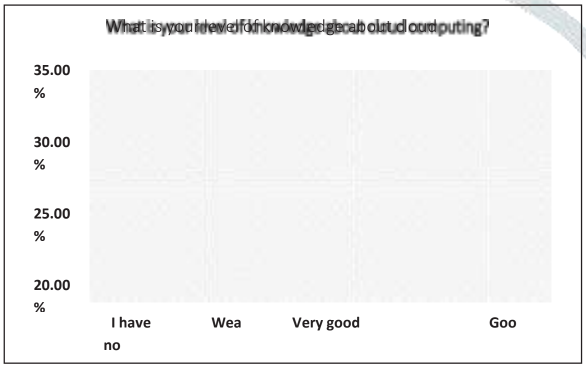


Figure 2: Knowledge levels of Cloud Computing

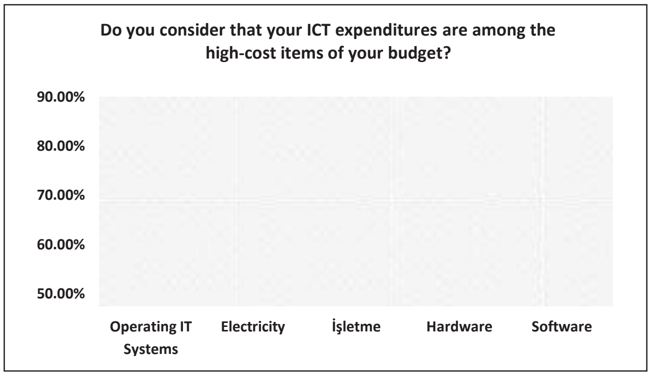


Figure 3

Requirement

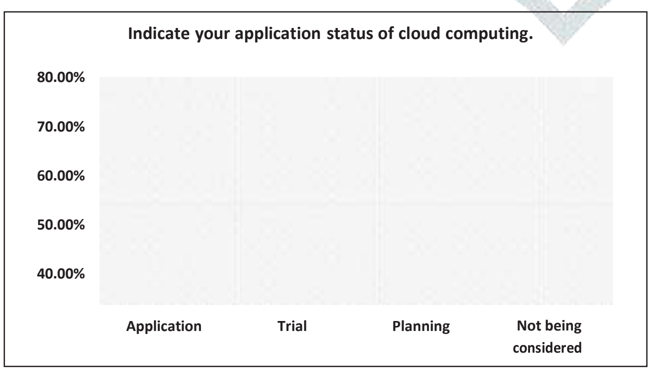
The majority of colleges (79.1%) cited software expenses as the most expensive item in their budgets (Figure 3). Hardware comes in second with 78.0 percent, followed by operation with 65.9%, electricity with 49.6%, and people costs with 49.5 percent. These findings indicate that colleges consider ICT expenses to be among their highest-cost items. This can be interpreted as a sign that institutions require cloud computing. It can be seen that software is the most expensive item. This also relates to the requirement for cloud-based SaaS services

There is no significant difference in perceptions concerning operating (2 = 0.349), electricity (2 = 0.117), software (2 = 0.590), hardware (2 = 0.285), and staff (2 = 0.108) costs, according to the chi-square analysis.

Cloud Applications / Services

The current state of implementation: According to the survey, just 8.8% of respondents now use a cloud model in their colleges (Figure 4). The majority of IT departments (71.4 percent) said they had not considered using cloud computing in their institutions. It's worth noting that the percentage of people who are considering using cloud computing for a trial period is fairly low (6.6 percent).

Figure 4



The current state of cloud architecture: Almost half of the universities (43.5%) said they didn't have a cloud architecture in place (Figure 5). 21.2 percent of the participants had a private cloud architecture, 12.9 percent had a hybrid cloud design, 11.8 percent had a community cloud architecture, and 10.6 percent had a public cloud architecture, according to the findings. Furthermore, the survey results revealed that the majority of respondents did not have Cloud architecture.

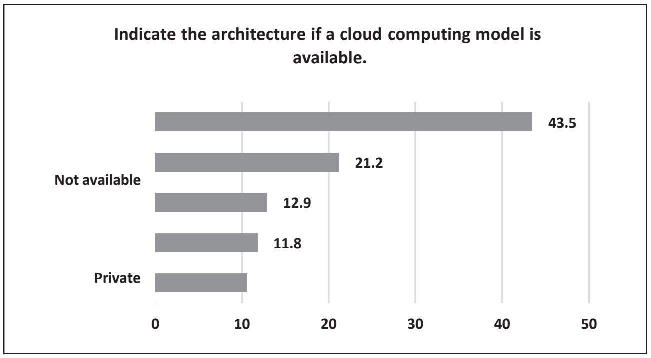


Figure 5

Cloud services: While 11.0 % of IT departments said they use SaaS, 9.9 percent said they use PaaS, and 4.4 percent said they use IaaS, respectively (Figure 6). The majority of respondents (74.7 percent) did not react to this question, indicating that they are unfamiliar with cloud services. Cloud apps are not frequently used, according to the data.

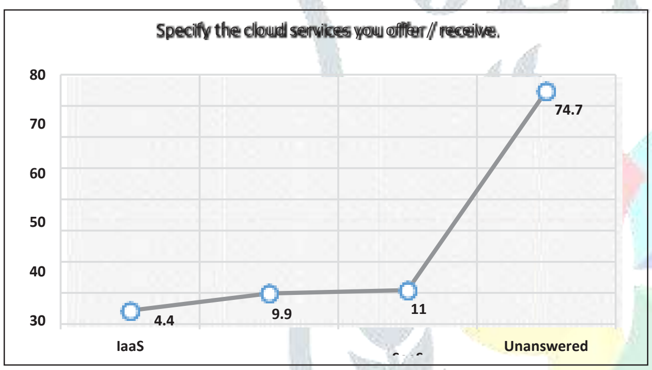


Figure 6

The chi-square test used to examine whether there was a relationship between cloud computing awareness and cloud application utilization revealed a significant relationship (2 = 0.01). The chi-square test also revealed that the use of virtualization technologies and the use of cloud apps had a significant connection (2 = 0.035).

Readiness for Technology

Virtualization technology is being used by the majority of colleges (80.8 percent) (Figure 7). Cloud computing is powered by virtualization, which is a fundamental technology. Universities can be deemed to be prepared for the cloud transition from this perspective.

The chi-square test revealed that cloud computing awareness and the utilization of virtualization technology had a significant connection (2 = 0.034).

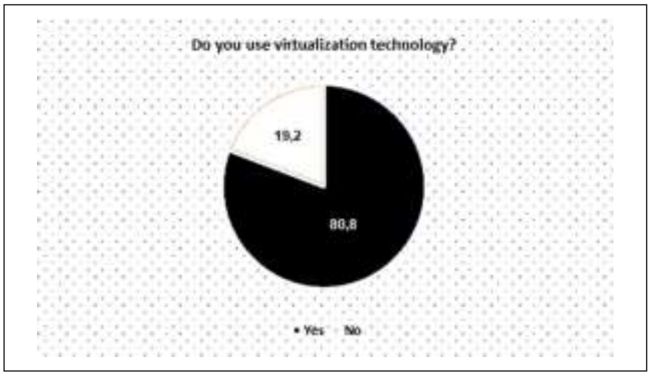


Figure 7

Around half of the universities (47.3%) have ISO/IEC 27001 certification, one-third (35.2%) have ISO/IEC 25599 certification, and a small percentage (17.6%) have both certifications (Table 2). This can be interpreted as universities being unprepared for the cloud transformation from a cybersecurity standpoint.

Table 2. ICT Certificate Status

ICT Certificates	State Univ (YES %)	Private Univ (YES %)	Total (YES %)
ISO/IEC 27001	47.8	45.8	47.3
ISO/IEC 25599	35.8	33.3	35.2
ISO/IEC 27001 and ISO/IEC 25599	16.4	20.8	17.6
Total	100	100	100

Participants in the study were asked if they believe cloud technology will play a significant role in the future (Figure 8A). Cloud technologies are expected to play a significant role in the future, according to the majority of colleges (70.6 percent).

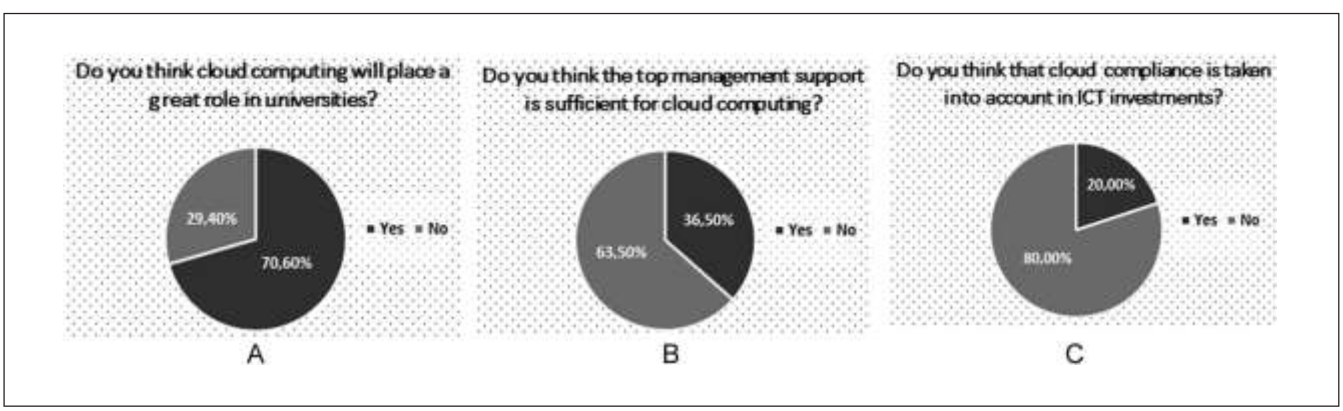


Figure: 8A, 8B, 8C

This can be viewed as a preference for cloud computing among institutions

Participants were asked whether university top management support for cloud computing was sufficient in the poll (Figure 8B). Around a third of the universities (36.5%) believed that senior management support was sufficient. In terms of the cloud computing shift, this can be viewed as a negative condition. Participants were asked if cloud compliance is taken into account in the survey (Figure 8C). Cloud compliance is taken into account by approximately one fifth of institutions (20.0 percent). This can be viewed as a negative circumstance as well.

Advantages and Drawbacks

Participants were asked to list the advantages of cloud computing to colleges (Figure 9). “Service continuity will be assured in natural disasters and unanticipated developments,” 76.5 percent of participants said as the first benefit of cloud computing. This is followed by "service flexibility" (70.6%), "service variety" (69.4%), "paying as much as you use in information services" (65.9%), "decrease in ICT operation and maintenance expenditures" (65.1%), "execution of information services with simpler ICT tools" (62.4%), "less damage to the environment" (58.8%), and "being less dependent on ICT activities" (58.8%). (57.1 percent).

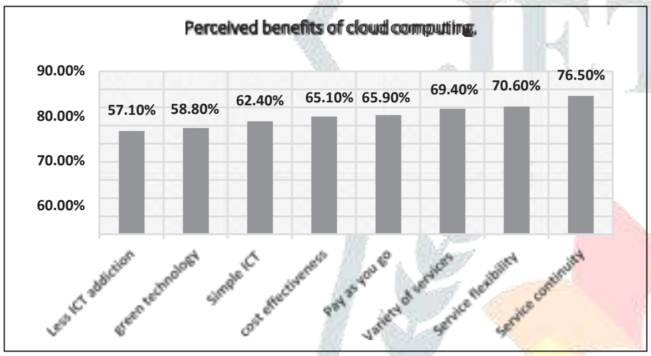
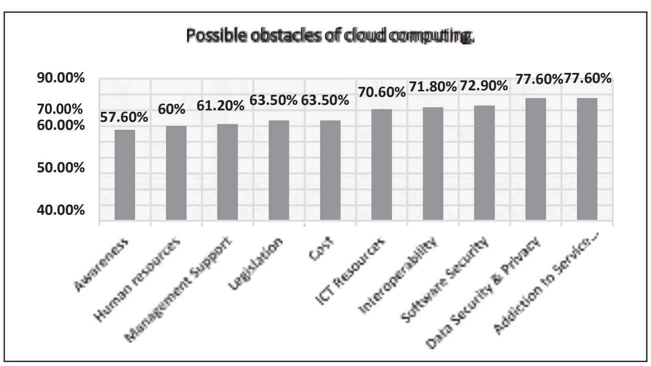


Figure 9

Obstacles

Participants were asked to identify the challenges that cloud computing poses to their institutions (Figure 10). The most critical impediments to cloud computing, according to 77.6% of the participants, are "data security and confidentiality" and "dependence on the cloud service provider." This was followed by perceptions of "software security" (7.9%), "interoperability" (71.8%), "ICT resources" (70.6%), "legislation and expense" (63.5%), "management support" (61.2%), "human resources" (60.0%), and "awareness" (60.0%) as obstacles (57.6 percent).

Figure 10



Abstract Hybrid Cloud Framework: For Universities

A literature review on how to build the model's conceptualization process was conducted as part of the study's scope. There are four sorts of cloud models on the market right now:

"Public Cloud Model," "Private Cloud Model," "Hybrid Cloud Model," and "Community Cloud Model" are all terms used to describe different types of cloud computing (Goyal, 2015). Distinct models for different cloud computing categories have been developed by academics and researchers for cloud computing adoption. The popularity of cloud computing and cloud applications in education has been emphasized in several studies (M. B. Ali, 2019; K. E. Ali et al., 2018; Alonso-Monsalve et al., 2018; Juma & Tjahyanto, 2019; Pardeshi, 2014; Rao et al., 2013; Sabi et al., 2016). In cloud computing design, the NIST suggests four possible cloud organization and management models (Liu et al., 2012). In the adoption of cloud computing, several techniques and outcomes have been employed. Cloud Data Security, Availability and Reliability, Customizable Service Level Agreement, Network Bandwidth, Compatibility, Technical Support, Management Support, Human and Resource Readiness, Complexity, Cost Flexibility, Ease of Use, and Relative Advantage are some of the critical success factors (CSFs) for the effective implementation of cloud-based e-learning at universities and institutes of higher education (Naveed & Ahmad, 2019).

Hybrid clouds have a more complex structure since they combine two or more private, community, or public cloud structures (Goyal, 2015). In his research, K. E.

An abstract hybrid approach for using cloud computing in e-government was presented by Ali et al. (2018) to address e-problems. government's The orchestration between the volunteer platform and the public, private, or hybrid clouds was outlined in the suggested hybrid cloud model by Monsalve et al. (Alonso-Monsalve et al., 2018). To uncover obstacles and recommend solutions to overcome those challenges, Juma and Tjahyanto (2019) created the ITOETAM model, which was a combination of the Technological, Organizational, Environmental (TOE), Technological Acceptance Model (TAM), and Internal,External (I-E) techniques (Juma & Tjahyanto, 2019). Some of the different models used in the literature include ITOETAM (the proposed model for cloud computing adoption challenges in Zanzibar's universities), TOE (the model used previously in cloud challenges), TAM (the model used to solve the challenges of cloud computing), and I-E (the model used to solve challenges in cloud computing) (Juma & Tjahyanto, 2019;Tashkandi & Al-Jabri, 2015). These studies suggest that cloud-based learning models are growing more popular and are being used more frequently. Elhoseny et al. (2018) suggested a novel hybrid cloud-IoT (Internet of Things) paradigm with four basic components: stakeholder devices, stakeholder requests (tasks), cloud broker, and network administrator. CloudSim is used to simulate a suggested architecture based on the hybrid cloud paradigm, which uses both public and private clouds. The Cloud Management System and the Hybrid Cloud are the two key components (Sqalli et al., 2012). In the cloud computing adoption model provided by Okai et al. (2014), universities suggest a roadmap for cloud computing adoption to overcome the hurdles. Microsoft Education Cloud (website creation, file sharing, Word processing, desktop sharing, resource scheduling), Google Education Cloud (Google Mail, Google Sites, Google Docs, Google Video, Google Calendar, Google Talk), Earth Browser (provide real-time data for weather, geological, and other data), Socratica (Science Classrooms to Access Create and Study Modules), VMWare (provide virtual computers), and IBM I (provide virtual computers) are some examples of educational cloud-based applications.

An abstract hybrid cloud framework was presented in this paper (Figure 11). Private University Cloud ("PUC") and Community University Cloud ("CUC") make up the framework. Because it comprises both PUC and CUC, the structure is referred to as a hybrid cloud. The framework's goal is to match universities' expectations in a cloud environment while remaining cost-effective. Educational institutions, instructors, students, IT workers, researchers, IT staff and administrators, learners, educational practitioners, and so on are all stakeholders in the framework. Existing studies in the literature on the subject were investigated throughout the development of the framework. Both the material gathered from the literature and the data received as a result of the survey conducted within the scope of the research were employed in the conceptualization process.

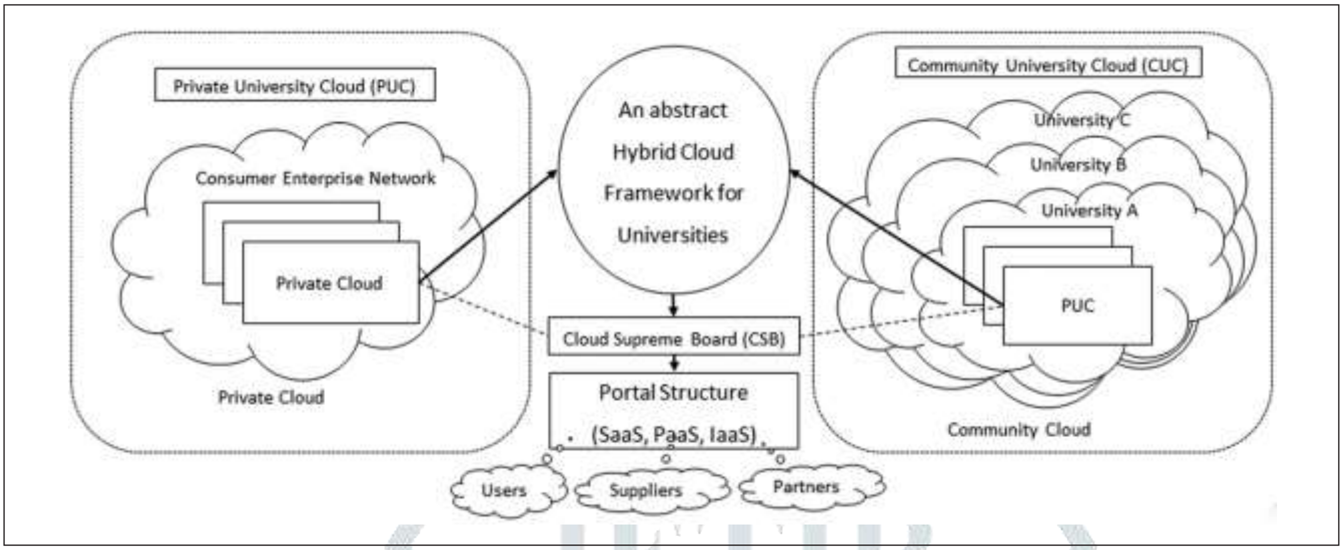


Figure 11

Universities can employ their own private or community cloud technologies in areas where security and privacy are more critical and precautions must be maintained and public cloud technologies in areas where security measures can be reduced. Page 9 PUC Implementation

Implementation of the PUC

PUC is a private cloud that each institution can create using their own IT resources. Data and processes will be managed within each university thanks to PUC. Because it will provide private cloud services, this structure will belong to each university. Each university will be able to provide SaaS, PaaS, and IaaS cloud services to its cloud users by the end of PUC. Instructors, students, researchers, IT employees and administrators, and others who are exclusively at their university use this framework. Universities may develop cloud services inside the service-oriented architecture (SOA) framework in accordance with their consumers' expectations in the context of contemporary technologies such as Web 2.0. Universities will develop their own content for information services in this cloud structure, and will employ their own ways in their own IT structures (databases, web servers, and so on). The priority of services/applications in PUC will be done by each university based on the institution's facts such as network capabilities, transactions, and capacity.

Implementation of the CUC

CUC is a community cloud that hosts member universities' information services. Members of this model's universities will supply services and applications to this cloud. CUC users will be able to access services/applications through the framework's portal structure. They will supply categorized SaaS, PaaS, and IaaS cloud services utilizing their own IT resources. CUC participants will deliver any cloud service or application they want to share with other CUC members in CUC. CUC members determine when and how a cloud service/application is shared. Instructors, students, researchers, IT personnel and administrators, and others who are members of this community cloud structure are CUC cloud users. This concept will deliver cloud services to any university that is a member. Universities will be able to share their resources with other members of the cloud thanks to this framework. Community members will work together to implement technical issues such as disaster recovery and backup procedures. Selected PUC services/applications as well as other cloud services/applications will be included in this structure.

Cloud Supreme Board (CSB)

This board will be developed in collaboration with universities who want to provide cloud-based information services, and it will be responsible for the administrative and technical administration and coordination of university information services in the cloud. If such a board structure can be built in the proposed model, the technical and administrative coordination procedures of cloud information services may be ensured. It is feasible to regulate which cloud services are supplied using this structure, taking into account copyright/licensing restrictions and publisher views. It is hoped that this board would carry out tasks such as ensuring cloud data security and confidentiality, developing cloud computing rules, conducting R&D research on cloud applications, and boosting cloud computing awareness. The suggested structure's responsibilities and authorities inside the model's framework should be backed up by laws or regulations, and technical, organizational, financial, and functional provisions for cloud operation should be made. As a result, the stakeholders who will be part of the committee should be self-sufficient and have the authority to carry out the model's functions by forming subworking groups as needed. Universities should collaborate on this structuring and make the appropriate arrangements to develop a holistic grasp of the cloud software, cloud hardware, and cloud infrastructure requirements required for the technological structuring provided in the model.

Structure of the Portal

Under the proposed model, there is a portal structure. This portal structure will deliver services/applications in PUC or CUC. The model's information services will be delivered via a single hybrid cloud platform. This site will house the information services that will be supplied through this cloud-based architecture. This site will provide information services to university users. The provision of services to be included in the portal structuring and the update of these services by the relevant institutions make it possible to offer information services in the cloud environment.

The Proposed Hybrid Cloud Model's Services/Applications

As shown in Figure 12, the proposed hybrid cloud architecture includes a SaaS, IaaS, and PaaS platform. The model, which is a computer environment, allows data to move and be shared effortlessly between different environments by merging PUC and CUC environments. Both PUC and CUC cloud topologies require SaaS, IaaS, and PaaS cloud services in this architecture. Secret services, dynamic services, and other types of services are available. When computing and processing demand varies, hybrid cloud computing allows colleges to scale their on-premises infrastructure effortlessly.

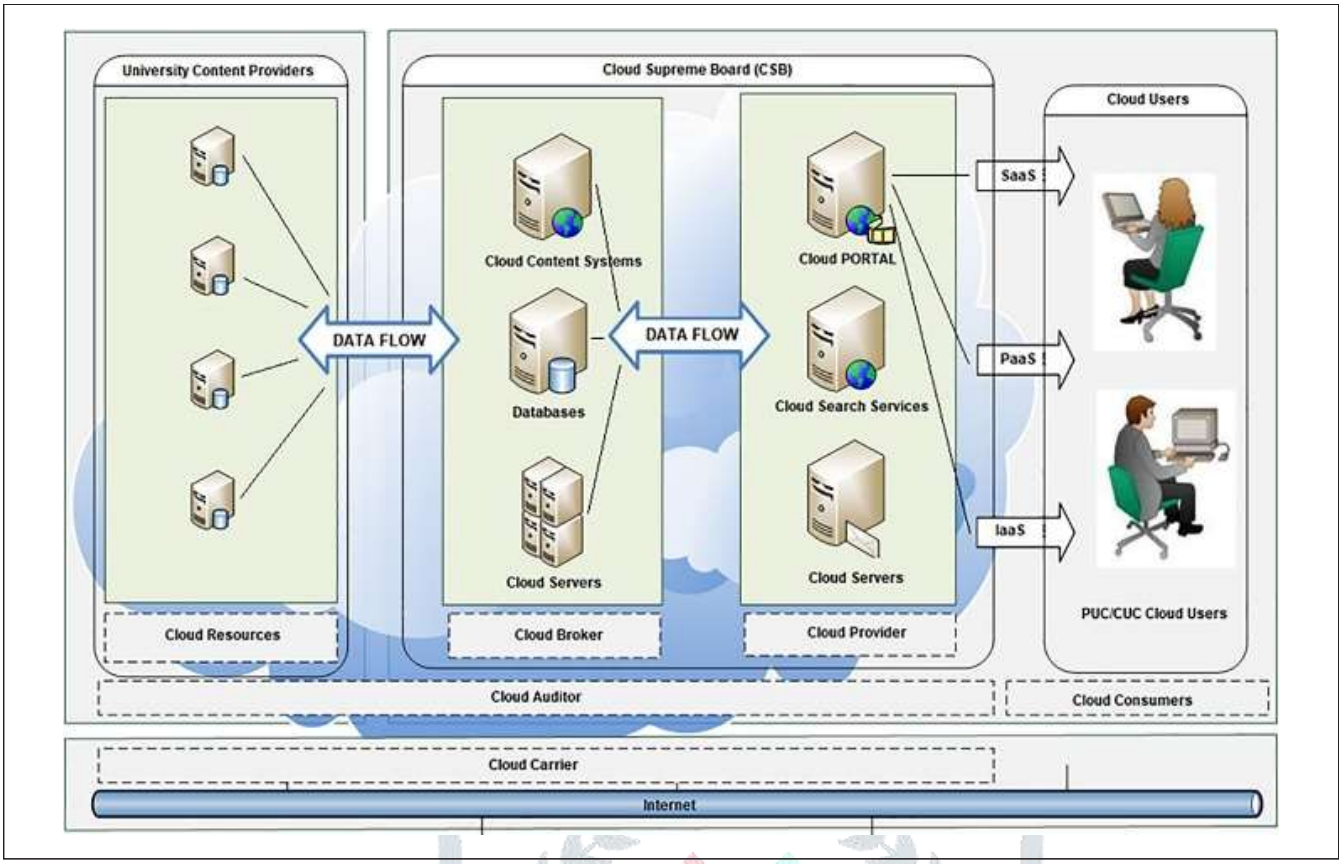


Figure 12

According to the poll, 71.4 percent of IT departments said they had not considered using cloud computing at their institutions. According to the findings of the survey, roughly half of the universities (50.5%) lacked sufficient expertise of cloud computing. It's possible that universities' aversion to cloud computing stems from a lack of understanding of the technology. As a result, the framework's on-premise architecture may allow the model to be built with the help of other universities.

When looking at the survey results, it is clear that the majority of institutions (79.1%) regard software expenditures to be the most expensive item in their budgets. The fact that software expenditures are the highest among the high-cost items in most colleges' budgets demonstrates the need for SaaS cloud services in the first stage. Universities must purchase software to continue distance learning, particularly during the Corona Virus outbreak. SaaS can be used by universities as a solution thanks to cloud computing, which provides consumers with cost-effective alternatives. According to the poll, institutions are already familiar with the SaaS, IaaS, and PaaS series. This can be construed to mean that cloud users are more likely to employ software-intensive applications. In this regard, SaaS services were included in the offered framework, and IaaS and PaaS services were also given priority based on the survey results.

Data will be synced between PUC and CUC infrastructure under this design. For basic and non-sensitive computer operations, universities can use the CUC cloud's flexibility and computing capacity, while keeping their key programmes and data safe behind a university firewall. Each of the PUC and CUC environments in this hybrid cloud architecture has its own set of advantages and applications. Universities can obtain better control over data safety, accessibility, privacy, authenticity, and security for both their IT infrastructure and their users' data, applications, and systems by merging PUC and CUC into a single hybrid cloud.

The framework's cloud users will be able to access both PUC and CUC services at any time and from any location. The services/applications supplied in this structure will be decided by each university administration because PUC is a private cloud with the best control over security criteria. Universities that embrace PUC and CUC will create a pool of shared services and applications that can be accessed through the portal structure.

Conclusion

Universities are progressively utilizing the cloud computing service model, which is one of the most cutting-edge technologies in recent years. Universities are now working on a variety of projects to adopt the cloud computing service paradigm. In terms of online education, economic crisis, globalization, and high and continuously changing needs, moving to the cloud in universities is a significant step. Cloud computing has the potential to play a critical role in resolving the challenges that colleges are experiencing as a result of the Corona Virus.

Knowledge management may be done in an effective method to achieve excellent academic performance and efficiency in institutions with the usage of the cloud. The issue of university cloud computing usage is certainly significant and will continue to be significant, particularly in the post-COVID-19 environment.

Based on the research topics, literature works concentrating on cloud computing in universities were analyzed, and the position of universities in Turkey was determined. The study proposed an abstract hybrid cloud framework with guidance for overcoming the primary issues observed. The current conditions and challenges in the usage of the cloud service model in universities were attempted to be recognized in this context, and some proposals for fixing these problems were drafted. We made some recommendations based on the findings of the investigation. The findings are primarily meant to serve as a guide for colleges interested in adopting cloud computing.

Under the headings "Awareness," "Requirement," "Cloud Services/ Applications," "Technology Readiness," and "Benefits and Obstacles," the survey findings were statistically analyzed:

According to the findings of this study, roughly half of the universities (50.5%) lack appropriate knowledge about cloud computing technologies.

IT expenditures (enterprise electricity, software, hardware, and personnel) are viewed by the majority of IT departments as high-cost items in their budget. This can be seen as a sign that institutions require cloud computing. As a result, an abstract hybrid cloud framework was presented based on this result. The fact that software charges are the most expensive component in most IT departments' budgets shows that SaaS cloud services should be employed first.

Virtualization technology is used by the majority of colleges. ICT security certificates are only required in a tiny percentage of IT departments. Only a small percentage of colleges are now utilizing a cloud-based paradigm. The fact that roughly half of IT departments use a cloud architecture is supported by these findings. Universities believe that top management support for cloud computing is insufficient, and that cloud compliance is not taken into account. These findings indicate that IT teams are not prepared to make the move to the cloud. However, assessments on the future of cloud computing in universities show that they are increasingly adopting cloud computing.

Although certain disadvantages were identified, the majority of IT departments claimed that they agreed with the benefits of cloud computing. The willingness of universities to use their financial resources cost-effectively and efficiently is at the root of their desire to gain from cloud computing.

In the study's chi-square test, there was no significant difference in knowledge level related to cloud computing between state and private colleges (2 = 0.180). There was also no statistically significant change in perceptions of operating (2 = 0.349), electricity (2 = 0.117), software (2 = 0.590), hardware (2 = 0.285), and staff (2 = 0.108) expenditures. On the other hand, a significant association was discovered between cloud computing awareness and cloud application utilization (two-sample t-test, 2 = 0.01). The utilization of virtualization technologies and the use of cloud apps were shown to have a significant connection (2 = 0.035). Furthermore, a strong correlation was discovered between cloud computing understanding and virtualization technology utilization (2 = 0.034).

The study proposed a methodology for identifying and classifying university information services in order to encourage colleges to use cloud technologies. PUC and CUC are two alternative cloud computing patterns in the suggested model. PUC is a private cloud that each university will structure and maintain. CUC is a community cloud that covers the information services of volunteer institutions' PUC cloud services. The cloud services and apps will be supplied via a portal structure in the presented architecture.

The following are the findings of this study:

Despite the widespread need for a cloud environment at universities, there are numerous issues at various levels arising from both internal and external dynamics of universities that stand in the way of its fulfillment.

The level of cloud computing awareness, current capabilities' conformity with such a structure, the level of cloud application usage, and the extent of assistance provided by the university administration all come into play.

It may be conceivable to rearrange ICT in the cloud environment if these issues are resolved.

The following are recommendations based on the study's findings:

Turkey has seen a growth in the number of universities in recent years. These rising colleges will be able to provide information services more cost-effectively thanks to cloud computing. As a result, universities should encourage the use of cloud computing service models. To make greater use of cloud computing in universities, policies should be devised. It is necessary to build a system focused on the usage of the cloud service model in information services. Plans, programmes, budgets, and practises should all support this.

Universities and their IT departments should be more aware of cloud computing. Universities' participation in national and international cloud computing fairs, conferences, and seminars should be enabled and supported in this context. The cloud computing service model should be used to follow national and international studies on the supply of information services. Universities' IT departments can arrange and participate in activities like seminars, workshops, and conferences that allow people to share their knowledge and expertise on cloud computing.

To reap the benefits of cloud computing in universities, support should be provided to cloud entrepreneurs. Compliance with the cloud and its use in ICT investments should be encouraged. Supportive arrangements, such as various tax exemptions, should be promoted when adopting the cloud service model to provide information services to investors, individuals, and institutions. It is important to stimulate the deployment of cloud initiatives in both public and private colleges.

Existing technological development facilities (technoparks, etc.) should be considered as part of the cloud adoption and migration of university information services to the cloud.

Because of the recent significant growth in the number of universities, particularly newly created universities may not have equal possibilities. Purchasing new computer equipment, paying licence fees for automation systems, maintaining and repairing information systems, and employing energy and competent ICT employees are all examples of rising university costs. These colleges, in particular, should be given the option to use the cloud computing service model, which provides ICT services such as transaction and storage infrastructure and allows them to dynamically scale without being bound by location, time, or environment as a cost-cutting measure.

Universities should be encouraged to conduct cloud computing research and development. This will help to make university information services available in the cloud.

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