A Roadmap for Cloud Computing Migration in Yemeni Universities Using the ROCCA Model

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Abstract:

This paper explores the implementation of cloud computing in Yemeni universities, leveraging insights from the Roadmap for Cloud Computing Adoption (ROCCA) model to address the unique needs of academic institutions. Cloud computing offers significant benefits, including scalability, cost efficiency, enhanced collaboration, and improved access to resources, which are essential for supporting research, teaching, and administrative functions. However, the migration to cloud computing presents challenges such as data security, regulatory compliance, and managing diverse workloads. To address these complexities, this paper proposes a tailored framework for cloud computing migration, spanning the entire lifecycle from analysis and design to adoption, migration, and management. The findings underscore that a well-planned and executed cloud computing strategy can enhance institutional flexibility, security, and operational efficiency, enabling higher education institutions to fully harness the transformative potential of cloud technologies while mitigating associated risks. This framework provides actionable guidelines and best practices to support academic institutions in achieving a successful and sustainable transition to cloud-based systems.

Keywords: cloud computing, Roadmap for Cloud Computing Adoption (ROCCA), Yemeni universities.

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خارطة طريق للانتقال إلى الحوسبة السحابية في الجامعات اليمنية باستخدام نموذج ROCCA

الملخص:

يستكشف هذا البحث تنفيذ الحوسبة السحابية في الجامعات اليمنية، مستفيدًا من رؤى نموذج خارطة الطريق لتبني الحوسبة السحابية (ROCCA) لمعالجة الاحتياجات الفريدة للمؤسسات الأكاديمية. تقدم الحوسبة السحابية فوائد كبيرة، بما في ذلك قابلية التوسع، وكفاءة التكلفة، والتعاون المعزز، وتحسين الوصول إلى الموارد، والتي تعد ضرورية لدعم البحث والتدريس والوظائف الإدارية. ومع ذلك، فإن الانتقال إلى الحوسبة السحابية يطرح تحديات مثل أمن البيانات، والامتثال التنظيمي، وإدارة أحمال العمل المتنوعة. لمعالجة هذه التعقيدات، يقترح هذا البحث إطارًا مصممًا خصيصًا لهجرة الحوسبة السحابية، يمتد على مدار دورة الحياة بأكملها من التحليل والتصميم إلى التبني والهجرة والإدارة. تؤكد النتائج أن استراتيجية الحوسبة السحابية المخطط لها والمنفذة جيدًا يمكن أن تعزز المرونة المؤسسية والأمن والكفاءة التشغيلية، مما يمكن مؤسسات التعليم العالي من الاستفادة الكاملة من الإمكانات التحويلية لتقنيات الحوسبة السحابية مع التخفيف من المخاطر المرتبطة بها. يوفر هذا الإطار إرشادات عملية وأفضل الممارسات لدعم المؤسسات الأكاديمية في تحقيق انتقال ناجح ومستدام إلى الأنظمة القائمة على السحابة.

الكلمات المفتاحية: الحوسبة السحابية، خارطة الطريق لتبني الحوسبة السحابية (ROCCA)، الجامعات اليمنية.

1. Introduction

Cloud computing has emerged as a transformative force, revolutionizing the way academic institutions operate. It provides a dynamic and cost-effective alternative to traditional on-premises infrastructure, enabling seamless access to resources and fostering collaboration among students, faculty, and researchers. According to the National Institute of Standards and Technology (NIST) [1], cloud computing is defined as "the on-demand delivery of computing resources over the internet, characterized by scalability, cost efficiency, and accessibility, and includes various deployment and service models".

Cloud deployment models include public clouds, which are hosted by third-party providers and shared among multiple organizations, offering cost-efficiency and scalability; private clouds, which are dedicated to a single organization, providing enhanced control and security; hybrid clouds, which combine public and private clouds to balance scalability with security; and community clouds, which organizations share with common objectives, such as academic or research institutions.

In terms of service models, Infrastructure as a Service (IaaS) provides virtualized infrastructure, reducing the need for hardware maintenance; Platform as a Service (PaaS) offers a platform for application development without requiring management of the underlying infrastructure; and Software as a Service (SaaS) delivers ready-to-use applications via the web, enhancing productivity and collaboration.

Organizations across many sectors increasingly leverage cloud computing to enhance efficiency and improve system performance. However, its adoption is accompanied by significant technical challenges. According to [2], these challenges can be categorized into three groups: usage barriers (e.g., data lock-in, performance unpredictability), development bottlenecks (e.g., scaling difficulties, bugs in distributed systems), and business obstacles (e.g., data security, service availability). These issues highlight the need for strategic planning to ensure successful cloud implementation.

High availability is a critical requirement for universities, particularly when managing large volumes of data. Achieving this is challenging without advanced technological solutions. Cloud computing addresses this by providing scalable and reliable platforms that ensure uninterrupted service delivery. Schubert and Jeffery [3] emphasize that cloud computing operates

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on utility computing principles, offering cost-effective, self-service, and pay-as-you-go models. These features reduce administrative costs, improve resource utilization, and enable on-demand access to resources, minimizing the need for significant upfront infrastructure investments.

A systematic approach, such as the cloud roadmap proposed by Mattoon [4], is essential for effective cloud adoption, as it aligns organizational goals, mitigates risks, and coordinates program- and project-level efforts to maximize value. Cloud computing transforms IT investment paradigms by converting capital expenditure (CapEx) into operational expenditure (OpEx), reducing infrastructure costs, enhancing scalability, and eliminating the need for physical data centers, making it a preferred solution for resource-constrained regions like Yemen.

Cloud computing enables organizations to outsource IT services, improving maintenance, security, and scalability while reducing upfront costs; however, its adoption in Yemen remains limited, with existing models primarily targeting large enterprises and governments, leaving SMEs and universities underserved, as noted by Perdana and Suharjito [5].

The rest of this paper is organized as follows: Section 2 lists the previous studies on adoption in universities, especially those using the ROCCA model. Section 3 presents the cloud computing migration roadmap stages, while Section 4 presents a suggested checklist template for cloud computing implementation in Yemeni universities. Finally, Section 6 concludes the paper.

2. Related Works

The concept of cloud computing, first proposed by John McCarthy in 1960, envisioned computing as a public utility [6]. This vision has evolved into a transformative technology that underpins global IT ecosystems, offering centralized solutions for data storage, scalability, and operational efficiency. However, many organizations, including universities, struggle with fragmented IT infrastructure, which complicates maintenance and data backup processes. This paper attempts to address these issues by developing a cloud computing adoption model for universities in Yemen using the Roadmap for Cloud Computing Adoption (ROCCA) framework, which encompasses five key dimensions: Readiness, Organization, Cloud Strategy, Cloud Architecture, and Cloud Adoption.

Several studies have explored cloud computing adoption in various contexts [7-13]. For instance, Khmidah [8] implement private cloud infrastructure and Infrastructure as a Service (IaaS) at the Islamic University of Indonesia without a formal adoption framework. Similarly, Fardani [7] employed public cloud and Software as a Service (SaaS) models using the ROCCA framework for SMEs, while [14] adopted hybrid cloud and SaaS models in SMEs. The above-mentioned studies collectively demonstrate the adaptability of cloud computing across sectors, from education to government and healthcare.

The ROCCA framework, initially developed by Faith Shimba [15], provides a structured roadmap for organizations transitioning to cloud computing. Its applicability has been demonstrated in various studies, such as its implementation at PT Matrica Consulting Service [5] and its integration with TOGAF 9.2 in a government agency [16]. These applications highlight the framework's effectiveness in addressing technical and organizational challenges, making it a suitable candidate for university environments.

3. Cloud Migration Lifecycle

The ROCCA (Roadmap for Cloud Computing Adoption) Model provides a structured, five-stage approach to cloud adoption, tailored to organizational needs. It is particularly effective for higher education institutions (HEIs) and universities, which face unique challenges such as limited budgets, growing data volumes, and the need for high availability. The ROCCA model consists of five stages: analysis, design, adoption, migration, and management. These stages ensure a systematic transition to cloud computing, enhancing operational efficiency and supporting both academic and administrative functions.

A. Analysis Stage

The analysis stage is foundational, identifying institutional requirements and aligning them with cloud computing capabilities. For universities, this involves assessing the need for web-based platforms or software to support academic and administrative functions, such as learning management systems (LMS), research repositories, and student information systems. Key stakeholders, including IT departments, programmers, and communication centers, are interviewed to gather data on budget, human resources, deployment timelines, technological needs, and data security [17].

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A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis is conducted to evaluate organizational capabilities, anticipate challenges, and strategize for cloud adoption. This tool helps universities leverage strengths, address weaknesses, capitalize on opportunities, and mitigate external threats [18, 19]. For example, open-source platforms like Ubuntu may be prioritized for cost-effectiveness and flexibility. Security, legal, and regulatory compliance, particularly concerning data privacy and intellectual property rights, are also evaluated. External risks, such as data breaches, are mitigated through robust measures like firewalls, multi-factor authentication, and encryption.

B. Design Stage

The design stage focuses on conceptualizing the cloud infrastructure, budget planning, and strategizing adoption and migration processes [15]. Based on the analysis results, universities select appropriate cloud technologies, such as Python-based applications for academic tools, ensuring compatibility with existing systems. Cost planning, adoption strategies, and migration processes are developed, with a pilot project used to assess the effectiveness of the proposed cloud solution.

This stage also identifies which applications will be migrated to the new infrastructure [20]. For instance, a university may prioritize migrating student records, research data, and administrative tools. The design includes consolidating multiple physical servers into a single virtual server, optimizing workload distribution, and ensuring seamless integration with existing systems. Vendor selection is guided by the ability to meet institutional requirements, including scalability, security, and compliance with educational standards. A trial period is essential to validate the functionality of the cloud infrastructure before full deployment, ensuring minimal disruption to academic activities.

C. Adoption Stage

The adoption stage prepares the IT infrastructure for cloud integration [15, 20]. This includes selecting software, configuring servers with recommended hardware specifications, and setting up clusters, routing, and firewalls. The goal is to create a robust and secure cloud environment that supports the organization's operational needs. For universities, this may involve migrating student records, research data, and administrative tools to the cloud.

Once preparations are complete, the migration stage is initiated, following a predefined plan. A trial run is conducted to verify the stability and performance

of the cloud infrastructure before it is made accessible to users. Collaboration with the IT department is crucial, as they are responsible for managing the network infrastructure and ensuring data integrity. The migration process is scheduled during periods of low activity, such as semester breaks, to minimize disruption to academic operations.

D. Migration Stage

The migration stage is the core of the cloud adoption process, involving the transfer of applications and data from physical servers to virtual servers [15]. Virtual servers are created with default specifications, and access is granted to application owners. Various migration methods are employed, with logical backup recommended for applications independent of others. This ensures minimal disruption and efficient data transfer.

For universities, this involves logical backups of data from physical servers and transferring supporting data to secure cloud storage. Applications are migrated using master software stored in the IT department's repository, simplifying the process to primarily data migration. Post-migration, the new cloud infrastructure is operationalized, and users regain access to applications and data. The implementation of cloud computing enhances operational efficiency by streamlining data access and reducing reliance on physical servers.

E. Management Stage

The final stage of the ROCCA model is management, which involves overseeing the cloud infrastructure post-implementation [15]. For universities, this stage marks the successful deployment of a private or hybrid cloud with SaaS capabilities [21, 22]. The migration process is validated by confirming that users can access applications without discrepancies in data [23]. Administrative access is granted to key stakeholders, such as department heads and IT administrators, facilitating collaborative management of the cloud infrastructure.

To enhance the IT department's proficiency, training sessions and user manuals are provided, ensuring that staff can effectively manage the new system. A testing period follows the application upload, during which the IT department performs maintenance tasks and addresses any issues. Continuous monitoring and user support are essential to address potential issues and ensure the system's long-term success. The IT department assumes

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responsibility for user support, monitoring, and control, ensuring the smooth operation of the cloud infrastructure.

Figure 1 illustrates the stages of the ROCCA Model with details for each stage, which provides a structured approach to cloud adoption.

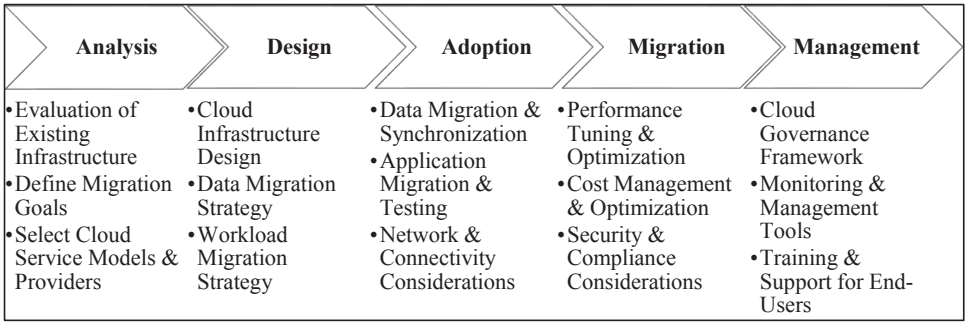

Figure 1: ROCCA Model

3.1. Key Considerations for Cloud Adoption in Universities

Cloud adoption in universities necessitates careful consideration of vendor lock-in risks [23] and service model selection, as these risks vary across models. IaaS presents a low lock-in risk, providing users with greater control over their technological environment. In contrast, PaaS poses a higher risk due to its reliance on provider-specific platforms for application development, though this risk can be mitigated through well-documented code [24]. SaaS carries the highest lock-in risk, as it depends entirely on proprietary applications and data formats controlled by the service provider. While on-premise private clouds ensure institutional control over sensitive applications, external clouds offer convenience for non-critical tasks. SaaS is best suited for standardized applications, PaaS requires code adjustments during migration, and IaaS facilitates seamless provider transitions. Balancing lock-in risks, deployment strategies, and institutional priorities is crucial for effective cloud adoption in universities, particularly for Yemeni universities considering cloud computing implementation.

4. Implementation ROCCA Model

The framework for implementing cloud computing in Yemeni universities is grounded in the study of Al-Hashedi et al. [12], which analyzed the adoption of cloud computing in Yemeni universities using validated measures derived from the Diffusion of Innovation Theory (DOI) and Technology Organizational Environment (TOE) framework.

As shown in Table 1, the Importance and Performance Map Analysis (IPMA) evaluated the following constructs: Relative advantage (RA), Compatibility (CM), Complexity (CX), Technology Readiness (TR), Security Concerns (SC), Top Management Support (TMS), Government Support (GS), and Competitive Pressures (CP). These validated constructs served as checklist items for the framework, which was developed through a synthesis of literature reviews and expert input, structured as a weighted checklist adapted from prior frameworks [25].

Table 1: IPMA results [12]

Constructs	RA	CM	CX	TR	SC	TMS	GS	CP
Important (Total Effect)	0.273	0.199	-0.073	0.207	-0.167	0.388	0.064	0.091
Performances (Index Values)	56.952	65.104	55.863	59.624	60.315	60.769	61.058	62.106

The checklist evaluates user feedback using a five-point Likert scale, with construct weights adjusted based on IPMA scores. The Importance-Performance Map Analysis (IPMA) extends Partial Least Squares Structural Equation Modeling (PLS-SEM) by assessing both the importance (overall effects on adoption) and performance (latent variable scores) of each construct. The framework is designed to support ICT decision-makers and cloud computing service providers in assessing cloud computing adoption and understanding the critical factors necessary for successful implementation in Yemeni universities.

Table 2: Weighted Checklist Template

Constructs	IPMA	Category Weight	No. of Items	Item Score (1-5)	Feedback Score (%)	Construct Score (%)	Overall Score (%)
Relative Advantage							
Compatibility							
Complexity							
Technology Readiness							
Security Concerns							
Top Management Support							

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Table 2: Continued

Constructs	IPMA	Category Weight	No. of Items	Item Score (1-5)	Feedback Score (%)	Construct Score (%)	Overall Score (%)
Government Support							
Competitive Pressure							
Total IMPA							

Category Weight = IMPA of construct / ∑(IMPA Scores of All Constructs)
No. of Items = (no of items for constructs)
Item Score (1-5) = ((Item Score×100 /5) ÷ No. of Items)
Feedback Score = Sums all Item Score / Category Weight
Construct Score = Category Weight× Feedback Score /100
Overall Score= Sums all Construct Score

Using the checklist template shown in Table 2, user can assess the framework of cloud computing migration and get the overall score, which helps decision makers in the Yemeni universities to make the right decision to migrate to cloud computing.

5. Conclusions

The modified ROCCA adoption model provides a systematic and adaptable framework for implementing cloud computing in Yemeni universities. By addressing the unique needs of academic environments, this model ensures alignment with institutional goals, enhances operational efficiency and supports academic and administrative functions. The analysis stage identifies institutional requirements, while the design stage facilitates strategic planning and vendor selection. The adoption and migration stages enable a seamless transition to the cloud, and the management stage ensures sustained operational efficiency. The systematic approach of the ROCCA model, combined with necessary modifications, underscores its effectiveness in supporting the digital transformation of Yemeni universities.

References

[1] P. Mell and T. Grance, "The NIST definition of cloud computing: Recommendations of the National Institute of Standards and Technology," National Institute of Standards and Technology, Gaithersburg, MD, 2011. [Online]. Available: http://faculty.winthrop.edu/domanm/csci411/Handouts/NIST.pdf

[2] M. Tangori, "Cloud Computing: Obstacles and Opportunities," *International Journal*, vol. 5, no. 12, 2015.

[3] L. Schubert and K. Jeffery, "Advances in clouds: Research in future cloud computing," European Union, 2012.

[4] S. Mattoon and J. Baty, "Creating a Roadmap to Cloud Computing, Release 3.0," Oracle, Austin, Texas, 2013. [Online]. Available: https://www.oracle.com/technetwork/topics/entarch/oracle-pg-cloud-roadmap-r3-0-1940183.pdf

[5] P. A. Perdana and S. Suharjito, "Cloud Computing Impelementation Using Model Roadmap for Cloud Computing Adoption (ROCCA) on IT Consultant Industry," *ComTech: Computer, Mathematics and Engineering Applications*, vol. 8, no. 3, pp. 145-153, 2017.

[6] M. Hamdaqa and L. Tahvildari, "Cloud computing uncovered: a research landscape," *Advances in computers*, vol. 86, pp. 41-85, 2012.

[7] A. Fardani and K. Surendro, "Strategi adopsi teknologi informasi berbasis cloud computing untuk usaha kecil dan menengah di Indonesia," in *Seminar Nasional Aplikasi Teknologi Informasi (SNATI)*, Yogyakarta, Indonesia, 2011.

[8] N. N. Khamidah, N. Sulistianingsih, and I. V. Paputungan, "Wacana Cloud Computing di Universitas Islam Indonesia," in *Seminar Nasional Aplikasi Teknologi Informasi (SNATI)*, Yogyakarta, Indonesia, 2010.

[9] A. K. Alhazmi, "Cloud adoption in HEIs: A multi-theoretical framework integrating TOE, TRA, and FVT," *Journal of Science and Technology*, vol. 29, no. 1, pp. 1-10, 2024.

[10] Y. A. M. Qasem, R. Abdullah, Y. Y. Jusoh, R. Atan, and S. Asadi, "Cloud Computing Adoption in Higher Education Institutions: A Systematic Review," I*EEE Access*, vol. 7, pp. 63722-63744, 2019, doi: 10.1109/ACCESS.2019.2916234.

[11] M. A. Al-Sharafi, Q. AlAjmi, M. Al-Emran, Y. A. M. Qasem, and Y. M. Aldheleai, "Cloud Computing Adoption in Higher Education: An Integrated Theoretical Model," in *Recent Advances in Technology Acceptance Models and Theories*, M. Al-Emran and K. Shaalan Eds. Cham: Springer International Publishing, 2021, pp. 191-209.

[12] A. Al-Hashedi, N. Almekhlafi, M. T. B. Othman, and A. Ghallab, "An Integrated Theoretical Model for Cloud Computing Adoption in *Universities of Yemen," in 2024 1st International Conference on Emerging Technologies for Dependable Internet of Things (ICETI)*, 2024: IEEE, pp. 1-7.

https://doi.org/10.59222/ustjet.3.2.5

[13] N. Almekhlafi, A. Al-Hashedi, A. M. Mohsen, and M. T. B. Othman, "Cloud computing awareness among practitioners in Yemeni universities: an exploratory study," *Journal of Science and Technology*, vol. 23, no. 1, pp. 1-15, 2018.

[14] A. Hamzah, "Studi kasus penerapan Roadmap for Cloud Computing Adoption (ROCCA) pada usaha mikro kecil dan menengah," Universitas Gadjah Mada, 2012.

[15] F. Shimba, "Cloud computing: Strategies for cloud computing adoption," Master's thesis, Technological University Dublin, Dublin, Ireland, 2010.

[16] N. Anggraini and N. Legowo, "Cloud computing adoption strategic planning using ROCCA and TOGAF 9.2: A study in government agency," *Procedia Computer Science*, vol. 161, pp. 1316-1324, 2019.

[17] L. S. Riza, J. Ajdari, and M. Hamiti, "Challenges of Adoption of Cloud Computing Solutions in Higher Education: Case Study Republic of Kosovo," in *2023 46th MIPRO ICT and Electronics Convention (MIPRO)*, 2023: IEEE, pp. 613-618.

[18] H. Wang, J. Wu, M. Muhedaner, and S. Maihemuti, "College students online education evaluation through SWOT analysis during covid-19," *Ieee Access*, vol. 10, pp. 88371-88385, 2022.

[19] A. A. Mohamed, "Unlocking the Potential of Cloud Computing in Healthcare: A Comprehensive SWOT Analysis of Stakeholder Readiness and Implementation Challenges," *International Journal of Advanced Computer Science & Applications*, vol. 15, no. 12, 2024.

[20] J. W. Rittinghouse and J. F. Ransome, *Cloud computing: implementation, management, and security*. CRC press, 2017.

[21] A. Alharthi, M. Alassafi, A. Alzahrani, R. Walters, and G. Wills, "Critical success factors for cloud migration in higher education institutions: a conceptual framework," I*nternational Journal of Intelligent Computing Research*, vol. 8, no. 1, pp. 817-825, 2017.

[22] H. Aydin, "A study of cloud computing adoption in universities as a guideline to cloud migration," *Sage Open*, vol. 11, no. 3, p. 21582440211030280, 2021.

[23] N. Mohammad, "Data Integrity and Cost Optimization in Cloud Migration," *International Journal of Information Technology & Management Information System (IJITMIS)*, vol. 12, pp. 44-56, 2021.

[24] C. Computing, "Developing an Enterprise Cloud Computing Strategy," 2009.

[25] M. Shanmugam, Y. Y. Jusoh, M. A. Jabar, and R. N. H. Nor, "Measuring Continuance Participation in Online Communities," J*ournal of Theoretical & Applied Information Technology*, vol. 95, no. 15, pp. 3513-3522, 2017.

https://doi.org/10.59222/ustjet.3.2.5