

IT Infrastructure Management: A Digital Services Context

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Abstract

Managing IT infrastructure is essential for organizations to effectively deliver digital services. This study focuses on addressing the complexities associated with digital services, and integrations while incorporating the latest technology into the IT infrastructure. To effectively tackle the challenges, a four-step approach is proposed. Firstly, a comprehensive understanding of the industrial problem is necessary. Secondly, trends and developments in the field should be predicted and their impact assessed. Thirdly, methods and practices should be developed to address the challenges posed by the multitude and complexity of IT infrastructure. Lastly, the proposed solutions should be evaluated in a real-world environment. This research outlines the methodology and tentative plan for the next three years of doctoral studies.

Keywords

IT Infrastructure, Digital Services, Change Adoption, Change Management, Challenges, Mitigation Techniques


1. Introduction

Due to rapidly evolving technological infrastructure, IT products and services are released more often than ever before. This ever-changing context puts tremendous pressure on organization managers to plan, implement, and adopt new technology solutions in accommodating such changes. IT Infrastructure (ITI) is a shared platform for all enterprises to build their specific information systems. Rainer and Prince [1] defined ITI as “a combination of technology, hardware, and software that provides services to a range of applications and users, and it is usually managed by the IT group”. The authors emphasize two perspectives of the human ITI: i) managing the infrastructure and, ii) deciding about the goals and capabilities of the infrastructure. A well-designed ITI enables the delivery of secure, reliable, and scalable digital services, and applications to end-users that are also adaptable for future needs [2].

Considering the management aspects, of ITI, there are several challenges such as security, scalability, and performance among others due to changing business needs. To keep up with these dynamics, ITI must evolve and adopt new trends and technologies (e.g., cloud computing, edge computing, hyper-converged infrastructure, machine learning, zero trust security, and AI) that can enhance security, scalability, efficiency, reliability, and flexibility. However, the adoption and management of the latest technologies itself brings in new challenges which fall into four main categories i.e., organizational, environmental, technical, and security levels [3]. Moreover, organizations also encounter challenges like resistance to change, cost, and lack of skilled IT staff [4]. The most challenging task is to manage different types of information technology systems and infrastructure effectively, where practices, policies, processes, and guidance must be created to succeed because they ultimately decide the direction and applications. This causes new needs for IT management that go far beyond current approaches and standards (e.g., DevOps and Infrastructure-as-Code [5], Zero Trust [6], ISO 27000, ISO/IEC 20000 [7], ITIL, and TOGAF [8] which offer some

ICSOB '23: 14th International Conference on Software Business, November 27–29, 2023, Lahti, Finland


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 CEUR Workshop Proceedings (CEUR-WS.org)

guidance, but they provide only normative and theoretical base for IT service management. The goal of this study is to develop a practical approach to help IT professionals build and manage ITI more efficiently while adopting and managing emerging technologies.

Analysis of the existing research identified several gaps in the state of the art, for instance, the existing proposals are mostly focused on the providers of the infrastructure, such as operators, device manufacturers, and global digital giants, and the solutions for individual businesses and their use cases are almost nonexistent. Moreover, the challenges such as explosively increasing complexity, heterogeneity, security, and flexibility among others with the deployment of IT products and services have not been made explicit thoroughly. It is relevant to mention that some of these for example security, scalability, and complexity are enumerated in research agendas for smart services and connected products [9][10][11]. There are attempts at providing comprehensive IT management methodologies that could solve many of the problems listed above, see for example [12], but a lot of empirical and theoretical work is needed here.

The success of the new network technologies will be dependent on the capability, skills, and practices of users and customers who need to improve their business and adapt to the management of complexity, extremely high number of devices, integrations, and services at all levels of the network and their IT landscape. In our proposal, we want to tackle these issues and create understanding, principles, and solutions to manage the ever more complex and heterogeneous enterprise infrastructure due to rapid technological changes.

The rest of the paper is organized as follows: Section 2 presents the overall research process. Section 3 presents the planned research timeline. Finally, Section 4 presents expected contributions and future directions.

2. Research Process

This dissertation research aims to find out how enterprises handle the challenges due to the growing complexity and dynamic environment caused by rapid technological changes in their ITI. Moreover, this study intended to provide a framework and best practices to overcome the gap or open issues in the field of study.

The main research question addressed in this research is “*How can enterprises cope with the challenges posed by the increasing complexity of IT infrastructures?*”. The main research question is further divided into four sub-questions.

Q.1 What challenges arise while adopting and managing the ever-changing context within enterprise IT infrastructure?

Q.2 What best practices exist in the state of the art for addressing the challenges of technical infrastructure?

Q.3 How does the increasing complexity of technical infrastructure affect the management and decision-making in enterprises? Moreover, what kind of managerial skills are required?

Q.4 What kind of new methods and practices are needed for managing complexity due to technological changes in IT infrastructure?

2.1. Data collection

Data is to be collected during two rounds. Semi-structured interviews were conducted in both rounds. The main topic considered during the interviews is about identifying (i) the motivational factor towards adopting the change (ii) the challenges faced due to change adoption, and change management, and (iii) best practices to resolve the address challenges within ITI management.

Phase 1 (Feb 2023 to June 2023): The data was collected across two countries (Finland and Pakistan) from 17 organizations during the first phase. The educational sector was targeted, particularly HEIs, and interviews were conducted with IT professionals working at HEIs. To collect

data from Finland universities, a list of CIO and IT managers with email addresses and phone numbers was compiled by visiting websites and social media accounts e.g., LinkedIn of the target universities. We succeeded in collecting data from eight Finnish universities by scheduling online sessions via Teams. In the case of Pakistani universities, we used personal contacts to reach concerned IT managers. We approached 20 Pakistani universities and succeeded in collecting data from 9 of them.

Phase 2 (Sep 2023 to Jan 2024): Data collection is still being processed in this phase. To collect data, Finnish industries are targeted, which are providing multiple digital services to their customers. Then collected the email IDs and contact numbers of IT professionals (e.g., CIOs, IT managers, service managers, etc.) of the targeted industries and sent them invitations through Email and LinkedIn for conducting interviews. Moreover, Interviewees are being recruited based on personal contacts as well.

2.2. Research Method

This study follows the grounded theory method. It is a qualitative inductive research method where one can generate theories from data and analyze the experiences and practices lived by people in a context. By using this methodology, we can get an understanding of how people see and resolve problems [13][14]. This research will follow Strauss and Corbin’s grounded theory version [15]. In the first conference paper, we used thematic analysis to understand and categorize the data. The whole research process is given in Figure 1.

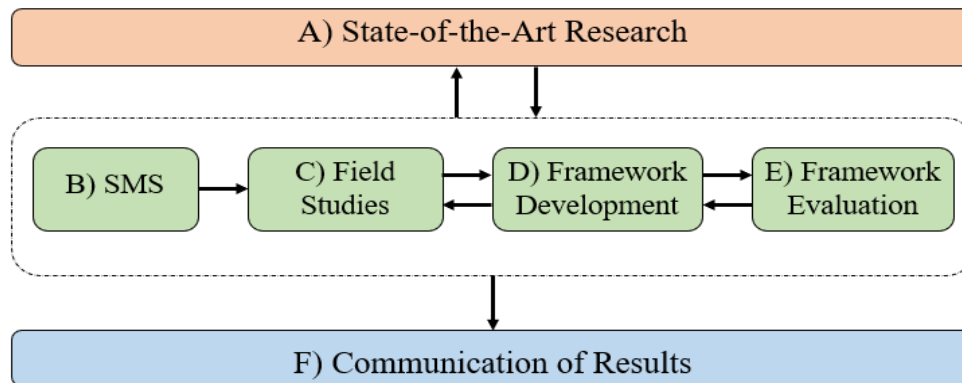


Figure 1: Research Process

In the following section, each of the research phases from A to F is described, to give an overview of the planned activities and which methods, are already used and expected to use in the future. In the first phase, the exploration of the **State-of-the-Art Research (A)** was completed. The state of the art in this study concerning ITI management in the context of the latest technologies is constantly evolving and expanding. The themes investigated during the (A) stage were discussed in Section 1. Overall, the state of the art in research is centered around leveraging emerging technologies to enhance the efficiency, scalability, and security of ITI management. The (A) stage receives updates as this research progresses to the later stages.

During the second stage **(B) Systematic Mapping Study (SMS)** was completed. This SMS concluded by finalizing 57 papers which were discussing the management aspect of ITI. Firstly, this study identified the main research focus of the ITI concerning management in existing articles. Secondly, it addressed the main challenges that create problems within the management of ITI. Thirdly this study provided solutions or guidelines that were proposed in existing studies.

Additionally, this study identified the contribution method, research paper, research method, publication type, and research trends by following the guidelines and classification scheme of Peterson et al. [16]. The SMS used first and second-order coding to analyze text fragments from selected papers. This analysis is equivalent to the 1st grounded theory level.

The third phase **Field Studies (C)** is still ongoing. It has three parts of data collection. In the first part, data was collected by using semi-structured questionnaires from two countries (17 organizations), Finland, and Pakistan. The target was only the educational sector, particularly HEIs, and mainly interviewed IT professionals. Coding and analysis of data are done by using a thematic analysis approach. This study addressed mainly motivational factors and challenges while adopting emerging technologies in the IT sector of HEIs (concerning Q1).

The second part of data collection is under process. For this time, only Finnish industries were targeted to collect the data, who are providing digital services to the users. The interview process with IT professionals (e.g., Chief information officer, IT manager, Service manager, etc.) is ongoing. 16 interviews have already been conducted, and this process will continue until the saturation point is met. The main objective of this study is to understand the current trends and problems in ITI management by observing the practices and actual ITI within industrial IT sectors. Moreover, this study is trying to understand the main challenges faced during the change adoption and change management process and what mitigation techniques are following to tackle the addressed challenges (concerning Q1 and Q2). It is expected to submit the result of this study to an information system journal.

In the third part data will be collected to identify the specific skills needed to manage the organizational implications resulting from the increasing complexity due to the adoption of new technologies in enterprise ITI. One of the objectives of this study is to support management control and decision-making in the organization (concerning Q3).

In the **Framework Development (D)** phase, the coding rounds will follow which are presented in grounded theory. Starting from the results of the literature review study and the emerging focus of ITI management in different contexts will try to analyze things from all perspectives. Then will identify the common actions, factors, and challenges from the findings of the first, second, and third studies by doing a cross-reference. This cross-referencing of data will let to understand their relationships, causes, and effects which help us to reach grounded categories of the study. Using the knowledge and theory base constructed with questions a) b) and c), we develop new methods, practices, and solutions for the management of the future enterprise ITI. Because this is based on earlier phases, the final form of the new methods is not yet clear. The solutions may improve existing methods, they may contain innovations, or they may be based on new kinds of strategies found and established in earlier phases of research.

The **Framework Evaluation (E)** phase will critically evaluate the developed framework within the specific context of an industrial case study. So, researchers can ensure that their theory is robust, and the study's findings are applicable and meaningful to the real-world challenges and opportunities faced by industries.

The last phase **Communication of Results (F)** has been initiated and occurs in parallel to the previous phases. We are targeting a journal paper to submit the results of the data collection part 2 study. One paper has been accepted to be published in CENTERIS - International Conference on Enterprise Information Systems, which discusses the challenges and motivational factors in adopting new technologies in depth within HEIs.

3. Planned Timeline

This section presents the planned activities of the research until the dissertation. This is an early-stage PhD submission to the retreat. Each Activity is written down in an action column and marked

with an “X” in the cell representing that an activity will be carried out in a semester or year (see Table 1). Right now, the plan is to conduct interviews for Data Collection Part 2 and will find out what types of challenges are there and their causes and effects by using grounded theory methodology.

Table 1
The planned timeline for the actions during the Ph.D. process

Action	Fall 2022	Spring 2023	Fall 2023	Spring 2024	Fall 2024	Spring 2025	Fall 2025	Spring 2026
Problem identification	X							
Literature review	X	X	X					
Gap Identification	X	X	X	X	X			
Data collection 1		X				X		
Data collection 2			X	X		X		
Data collection 3					X	X		
Finalizing							X	
Dissertation								X

Other than publications, there is a requirement for attainment of 40 ECTS in the LUT university and 23 ECTS have been attained until now. The doctoral studies are estimated to be completed in May 2026.

4. Expected Contributions

The dissertation takes a different approach by looking at real-world needs and solutions for dealing with the increasing complexity of diverse devices and services from the perspective of rather than purely relying on technology. Surprisingly, there has been limited research on enterprise infrastructure management [17][18] in the past decade. This may be due to the topic not falling easily into a silo of e.g., software engineering or information systems to allow for fast publications.

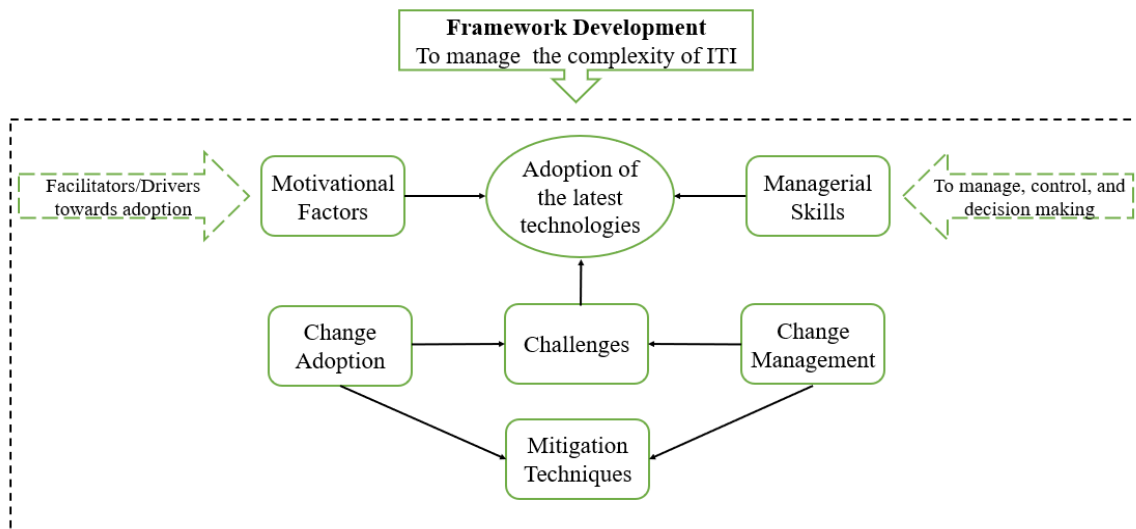


Figure 2: Framework

New methods, theories, and algorithms will be developed based on the latest technologies (e.g., AI, cloud computing, blockchain, zero trust security, etc.) to effectively manage the increasing complexity of digital services within enterprises (see Figure 2). These methods and principles will be based on scientific observation and theory development. Their evaluation and validation offer more evidence of their value.

This research allows organizations to understand challenges, predict trends, and address complexity in adopting new technologies. It helps organizations to optimize ITI, improve security, enhance scalability, and deliver reliable digital services to end-users. The contribution has great potential both in research and in practice.

Acknowledgments

This study is funded by the Higher Education Commission (HEC), Pakistan #1(2)/HRD/OSS-III/2022/HEC/233.

References

- [1] Rainer, R. K., & Prince, B. (2021), "Introduction to information systems", John Wiley & Sons.
- [2] Sirkemaa, S. J. (2019). Key Perspectives in Information Technology Infrastructure Management. *Journal of Advances in Information Technology* Vol, 10(3).
- [3] Tariq, M. I., Tayyaba, S., Rasheed, H., & Ashraf, M. W. (2017, March). Factors influencing the cloud computing adoption in higher education institutions of Punjab, Pakistan. In 2017 International Conference on Communication, Computing and Digital Systems (C-CODE) (pp. 179-184). IEEE.
- [4] Primasari, C. H., & Setyohadi, D. B. (2018, October). Improvement of information technology infrastructure in higher education using IT balanced scorecard. In 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (pp. 619-624). IEEE.

- [5] Artac, M., Borovssak, T., Di Nitto, E., Guerriero, M., & Tamburri, D. A. (2017). DevOps: introducing infrastructure-as-code. 2017 IEEE/ACM 39th International Conference on Software Engineering Companion (ICSE-C)
- [6] Rose, S., Borchert, O., Mitchell, S., & Connelly, S. (2020). Zero trust architecture.
- [7] Santosa, I., & Mulyana, R. (2023). The IT Services Management Architecture Design for Large and Medium-sized Companies based on ITIL 4 and TOGAF Framework. *JOIV: International Journal on Informatics Visualization*, 7(1), 30-36.
- [8] Vasquez, J. D. (2023). ISO/IEC 27000. *High Tech-Engineering Journal*, 3(2), 80-84.
- [9] Chowdhury, M. Z., Shahjalal, M., Ahmed, S., & Jang, Y. M. (2020). 6G wireless communication systems: Applications, requirements, technologies, challenges, and research directions. *IEEE Open Journal of the Communications Society*, 1, 957-975.
- [10] Varghese, B., Wang, N., Barbhuiya, S., Kilpatrick, P., & Nikolopoulos, D. S. (2016). Challenges and opportunities in edge computing. 2016 IEEE International Conference on Smart Cloud (SmartCloud)
- [11] Das, R., & Inuwa, M. M. (2023). A review on fog computing: issues, characteristics, challenges, and potential applications. *Telematics and Informatics Reports*, 100049.
- [12] Samiei, E., & Habibi, J. (2022). Toward a Comprehensive IT Management Methodology. *IEEE Engineering Management Review*, 50(1), 168-185. <https://doi.org/10.1109/EMR.2021.3133804>
- [13] Glaser, Barney G., and Anselm L. Strauss. *The discovery of grounded theory: Strategies for qualitative research*. Routledge, 2017.
- [14] Adolph, Steve, Wendy Hall, and Philippe Kruchten. "A methodological leg to stand on: lessons learned using grounded theory to study software development." *Proceedings of the 2008 conference of the Center for Advanced Studies on Collaborative Research: meeting of minds*. 2008.
- [15] Corbin, Juliet, and Anselm Strauss. *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage Publications, 2014.
- [16] Petersen, K., Feldt, R., Mujtaba, S., & Mattsson, M. (2008), "Systematic mapping studies in software engineering", In 12th International Conference on Evaluation and Assessment in Software Engineering (EASE) 12, pp.1-10.
- [17] Chung, H. M., & McLeod, G. (2002). Enterprise architecture, implementation, and infrastructure management. *Proceedings of the 35th Annual Hawaii International Conference on System Sciences*
- [18] Gampfer, F., Jürgens, A., Müller, M., & Buchkremer, R. (2018). Past, current, and future trends in enterprise architecture—A view beyond the horizon. *Computers in Industry*, 100, 70-84.