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Modernization of Legacy Information Technology Systems

Rabie Khabouze
Walden University

Walden University

College of Management and Technology

This is to certify that the doctoral study by

Rabie Khabouze

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Review Committee
Dr. Habib Khan, Committee Chairperson, Information Technology Faculty
Dr. Daniel Wagner, Committee Member, Information Technology Faculty
Dr. Gary Griffith, University Reviewer, Information Technology Faculty

Chief Academic Officer and Provost
Sue Subocz, Ph.D.

Walden University
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Abstract

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MS, Walden University, 2019

MS, Our Lady of The Lake University, 2014

Doctoral Study Submitted in Partial Fulfillment

of the Requirements for the Degree of

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Abstract

Large enterprises spend a large portion of their Information Technology (IT) budget on maintaining their legacy systems. Legacy systems modernization projects are a catalyst for IT architects to save cost, provide new and efficient systems that increase profitability, and create value for their organization. Grounded in sociotechnical systems theory, the purpose of this qualitative multiple case study was to explore strategies IT architects use to modernize their legacy systems. The population included IT architects in large enterprises involved in legacy systems modernization projects, one in healthcare, and one in the financial services industry in the San Antonio-New Braunfels, Texas metropolitan area in the United States. The data collection included interviews with eight IT architects, reviewing 12 organizational documents and pertinent artifacts. Data were analyzed using thematic analysis. Prominent themes included collaboration in modernization projects, systems and process documentation, and resources upskilling and technical training. A key recommendation is for IT architects in large enterprises to ensure that team collaboration, system documentation, and resource technical training are built into all aspects of the legacy systems modernization projects. The implications for positive social change include the potential to bring together individuals with diverse backgrounds and different perspectives and skills to develop trust and build positive relationships during legacy systems modernization projects.

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Dedication

I dedicate this study to parents Ahmed Khabouze and Hadhoum Bakkouch for praying for me day and night. They are my pillars of strength, and they were the first to motivate me to pursue success. They are my biggest fans. Also, to my wonderful wife Sara Khabouze for being incredibly supportive and understanding. I'm grateful for our priceless relationship. I also dedicate this study to my siblings (Samira, Mohammed, Khalid, Mostafa, and Khadija), almost all of them are Ph.D. graduates and university professors who set the bar high. I'm grateful for their love and support.

I dedicate this study to my extended family members, friends, coworkers who showed support. I am grateful for all your encouragement.

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I like to thank my family, friends, and co-workers for their support and encouragement throughout the program. Special Thanks to my dear parents, wife, and siblings who supported me. My committee chair, Dr. Habib Khan; my second committee member, Dr. Daniel Wagner; and my university reviewer, Dr. Gary Griffith. Undertaking this program has challenged me academically, emotionally, and physically. Thank you all for your support, encouragement, and kind understanding.

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Section 1: Foundation of the Study

Background of the Problem

The risks and costs related to a complex information technology (IT) landscape are continuously increasing (Jones et al., 2019; Sarmah, 2018). The complexity of IT, in general, is very subjective and affected by variations in people, tools, and processes (Alamoudi & Kumar, 2017). New technologies emerge in the market every day, and often in large organizations, they are added to older existing systems. There is a growing need to advance existing legacy systems to benefit from new technologies (Vijaya & Venkataraman, 2018). Legacy systems are one of the elements that contribute to IT complexity. A legacy system can be software, a computer, or a storage device that is still in use but has become obsolete (Powner, 2016; Srinivas et al., 2016). Rana and Rahman (2018) defined legacy systems as applications that have been in use for an extended period and are running on obsolete technologies. Many organizations are running unsupported legacy systems and are looking to switch to a highly advanced and supported system (Alsharari et al., 2020). The lack of support exposes the organization to increased cost and security risks. For instance, finding seasoned technology professionals with modern technology expertise is a common challenge (King & Wright, 2017; Lin & Huang, 2020). Enterprises consider their critical legacy systems a barrier to competitiveness because it would be costly to replace them or integrate them with new modern technologies (Rosas et al., 2017). This study explored the strategies that IT architects use to modernize legacy systems in large enterprises.

Problem Statement

Large organizations have systems running on legacy hardware and code, which are inefficient and costly to maintain (Alamoudi & Kumar, 2017; Kaur et al., 2017; Pillay & Njenga, 2021). In 2017, FinCo estimated that the IT department spends between 75% and 80% of its IT annual budget on maintaining its complex IT legacy core systems (Crotty & Horrocks, 2017). The general IT problem is that some IT departments in large enterprises lack strategies to reduce the complexity of their IT landscape. The specific IT problem is that some IT architects in large enterprises lack strategies to modernize legacy systems.

Purpose Statement

The purpose of this qualitative multiple case study is to explore the strategies IT architects in large enterprises use to modernize legacy systems. The population comprises IT architects in two large enterprises involved in legacy systems modernization projects, one in healthcare and one in the financial services industry in the San Antonio-New Braunfels, Texas metropolitan area in the United States. Large enterprises might use the study's findings to understand the benefits of having strategies to modernize legacy systems. This study's outcome may contribute to positive social change by being a factor in economic growth that arises from increased efficiency gained from the modernization of legacy systems.

Nature of the Study

Scientific research adopts quantitative, qualitative, and mixed methods (Busetto et al., 2020; Timans et al., 2019). In the quantitative method, researchers collect data to

confirm or reject hypotheses and verify the relationship between variables (Aspers & Corte, 2019). I did not select quantitative because this study will not establish hypotheses or assess multiple variables' statistical association. The mixed methods approach consists of collecting and analyzing quantitative and qualitative data to answer research questions and hypotheses (Levitt et al., 2018). I did not select mixed methods because I did not construct and test hypotheses in the current study. In the qualitative approach, researchers seek to explore and understand the complex reality and the meaning of events in each context (Rahman, 2016). The qualitative method involves asking participants about their views (Aspers & Corte, 2019). Researchers associate the inductive approach or inductive reasoning to qualitative research that considers the real-world or natural settings in which individuals provide a thorough comprehension of a specific problem (Korstjens & Moser, 2017). Accordingly, the qualitative approach was appropriate for this study because the principal objective was to explore and understand IT architects' strategies to modernize legacy systems from the research participants' view.

Some of the most ubiquitous research designs in qualitative research are phenomenology, ethnography, and case study (Willgens et al., 2016). The phenomenological research design focuses on uncovering individuals' lived experiences about a phenomenon described by the participants (Willgens et al., 2016). I did not select a phenomenological research design because I was interested in understanding the strategies used in the case's organization instead of focusing on the participants' lived experiences. I did not use ethnography, as the intent was to study strategies rather than cultural groups. Researchers use ethnography to study a cultural group in natural settings

over a prolonged time (Webster & Rice, 2019). In a case study, researchers wish to investigate a complex phenomenon in-depth in its natural setting and real-life context (Ridder, 2017; Şimşek et al., 2021). A case study was the most suitable qualitative design to identify and understand IT architects' strategies to modernize legacy systems in an organization.

Research Question

What strategies do IT architects in large enterprises use to modernize legacy systems?

Interview Questions

- How would you describe the operational challenges that IT has faced in the past, maintaining legacy applications and supporting infrastructure? Please explain.
- Describe the challenges caused by legacy systems, and how have you handled them? Please elaborate.
- What is your understanding of the impact of maintaining legacy enterprise systems on the overall IT landscape? Please elaborate.
- How would you characterize the organization's overall preparedness for integrating new modern applications into the existing infrastructure? Please explain.
- To what extent have you documented the process of legacy systems modernization? Please elaborate?
- How do you align your skill sets before taking on a modernization project? Please elaborate

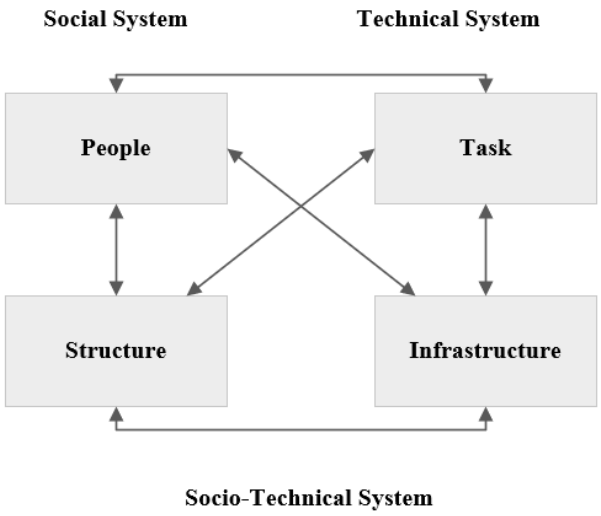
- To what extent have you involved the stakeholders and end-users in the process of legacy systems modernization? Please elaborate?
- What strategies do you use to improve the success rate of modernizing your legacy systems applications to the current IT environment? Please elaborate.
- What strategies contributed the most to the success rate of legacy systems modernization? Please elaborate.

Conceptual Framework

The conceptual framework of this study is sociotechnical systems (STS) theory. STS theory will serve as a lens to explain strategies to modernize legacy systems. Eric Trist and Ken Bamforth coined the STS theory in 1951 (Hughes et al., 2017). The STS model considers the human, organizational, and technological factors of the sociotechnical systems' design and management (Hughes et al., 2017; Pasmore et al., 2019; Ropohl, 1999; Walker, 2015). A fundamental tenet of STS theory is the classification of systems into two primary subsystems: (a) the technology subsystem such as skills, equipment, infrastructure, tools, technology, and related tasks and processes in the workplace; and (b) the social subsystems consisting of individuals, teams, and organizational structure, which comprise authority structures, knowledge, attitudes, and values (Oosthuizen & Pretorius, 2016). Figure 1 represents a graphical model of the STS model and highlights its social and technical subsystems.

Figure 1

Relationships Between Subsystems of STS theory



Note. Adapted from "Assessing the impact of new technology on complex sociotechnical systems," by R. Oosthuizen, and L. Pretorius 2016, South African Journal of Industrial Engineering, 27(2), pp. 15-29 (https://doi.org/10.7166/27-2-1144).

As a conceptual framework, STS theory is significant to this research as the enterprise architecture (EA) practitioners define an enterprise's objectives, strategies, business processes, and associated resources such as information systems and humans. Gellweiler (2020) identified three facets of IT and IT architects: (a) identifying business needs, (b) social tasks like building relationships with business users and stakeholders, and (c) the technology facet that is central like IT portfolio, infrastructure, components, and products. Identifying business needs and building relationships with users and business stakeholders align well with the social and organizational tenets of the STS theory. The technology facet of the IT architect aligns with the technological tenet of the STS theory.

Definition of Terms

Digital transformation. Digital transformation is an IT-enabled transformation phenomenon and a process in which digital technologies create disruptions setting strategic actions from organizations wanting to improve their operational performance while addressing the environment's complexity (Vial, 2020).

IT architects. IT architects are professionals responsible for designing and analyzing the organization's complexity from the information, application, business, and technology perspectives (Ahmad et al., 2020). Architects' function comprises supporting the business-IT strategy, focusing on technology problems, and possessing strong knowledge and background in enterprise architecture to align the IT investments with its business objectives (Figueiredo et al., 2014; Gellweiler, 2020). IT architects can include enterprise architects, data architects, application architects, Solution Architects, systems, and infrastructure architects, as Gellweiler (2020) described.

IT Modernization Strategies. Modernization strategies address current system challenges and plan to build IT systems that are more cost effective to maintain and support business operations. (Vijaya & Venkataraman, 2018).

Large Enterprise. An enterprise is a legal entity that possesses the right to operate independently and perform an economic activity (Robé, 2019). The Organization for Economic Co-operation and Development (2020) classifies enterprises based on the number of employees and corporations, quasi-corporations, or nonprofit institutions. Large enterprises employ more than 250 employees (Litvaj & Makarovič, 2019; Ullrich et al., 2018).

Legacy systems. Legacy Systems are primarily complex and outdated systems that are not upgradable to the latest versions but still an integral part of the business. IT does not define legacy systems by age, and sometimes there are good examples of diverse information systems that cannot integrate with other systems within an IT landscape (Crotty & Horrocks, 2017; Stojkov & Stojanov, 2021). A legacy system is not usually a single component. It can refer to a whole IT stack that can be the front and backend.

Legacy systems modernization: Legacy systems modernization is a program that involves redesigning technology, business processes, and people to alleviate risks, promote adoption, and save maintenance costs. (Vijaya & Venkataraman, 2018).

Assumptions, Limitations, and Delimitations

Assumptions

Assumptions are claims that researchers make stating that some aspects of the research are true, often with little or no evidence (Ramos, 2017). Waldkirch (2020) states that researchers often see assumptions as facts or truth, yet they need to verify them. I assumed that STS theory is an excellent approach for this research because legacy systems are sociotechnical systems that arise from interrelated and interdependent attributes, including people, software, and hardware. Research regards the STS theory as a key to information systems' success (Damodaran et al., 2005). I also assumed that the interviewees possessed a background in legacy systems modernization. Another assumption was that legacy system modernization includes applications, supporting hardware, and people.

Limitations

Limitations are essential to acknowledge (Ross & Bibler Zaidi, 2019). Limitations are weaknesses in the research study and are out of the researcher's control (Ross & Bibler Zaidi, 2019). This study used a qualitative approach. In a qualitative study, researchers can not extend their findings to broader populations with the same level of certainty that a quantitative study can. This is one of the limitations of the current study. Qualitative studies involve small samples, unlike quantitative research (Hammarberg et al., 2016). Another limitation was time and scope constraints; I could not study all industries, knowing that they all operate legacy systems in their IT landscape. Last, the data collection consisted of interview questions and a small number of organizational documents due to security data loss prevention that did not allow sharing for detailed documents, which may have limited the findings.

Delimitations

Research delimitations reflect the researcher's deliberate framing of the case under study, and researchers consider them boundaries that can narrow down the scope of the study (Rule & John, 2015). Delimitations involve a conscious decision on exclusions and inclusions to narrow the study's scope and limit to whom the researchers can generalize the findings (Ross & Bibler Zaidi, 2019). I considered only organizations that went through legacy systems modernization projects. I also considered only organizations that employed IT architects who worked on IT modernization and strategic planning projects.

Significance of the Study

Contribution to Information Technology Practice

This study could be significant to the IT practice because IT architecture practices in large enterprises might use its findings to broaden their knowledge and understanding of strategies to modernize their legacy systems. The study may be valuable to help the IT practice to reduce IT operations and maintenance costs. Modernized technologies are cost effective and can do more with less (Wilburn & Wilburn, 2018). This study's outcome may also help IT practice increase IT agility, improve staff efficiency and productivity, and reduce unplanned outages. The findings may also help reduce unnecessary software and hardware complexity and enable the IT organization to be more innovative and scalable in providing higher value and quality IT services.

Implications for Social Change

The implications for positive social change may encompass advancing society's trust in large enterprises' efficiency in modernized IT systems. At large, the community expects large organizations to provide services competently and reliably (Beckett, 2017). Modernized IT is a powerful engine of societal change (Majchrzal et al., 2016). Organizations use new technologies extensively to deliver better services to their customers (Galvão et al., 2018). As a business grows and profit increases, socially responsible enterprises might increase their contributions toward a more sustainable social and economic community environment and increase salaries.

A Review of the Professional and Academic Literature

The purpose of this qualitative multiple case study is to explore the strategies IT architects in large enterprises use to modernize legacy systems. The body of the literature review for this study includes the analysis and synthesis of academic and professional journal articles relevant to legacy systems modernization issues. This literature review also covers the sociotechnical conceptual framework that drives the study and how IT has approached legacy systems management and modernization. The systematic literature review addresses the different IT architect's roles in legacy systems modernization. Pati and Lorusso (2018) pointed out that the systematic literature review technique relies on collecting, critically evaluating, analyzing, and presenting findings, and providing a process to determine the quality and significance of existing evidence on a research question. Siddaway et al. (2019) suggested that to achieve the goals of a systematic review is by embracing the attitude of a judge and jury rather than a lawyer because judges and juries skeptically evaluate the evidence to deliver the fairest judgment possible and not try to make the best case for one side of the argument.

This study's focus was the strategies IT architects use to modernize legacy systems to cope with the complexity of managing these systems. The literature research's purview and scope included STS theory and current strategies for modernizing legacy systems. The literature search technique ensured I included primarily scholarly articles and was newer than 5 years from the time of the study (2017-2021). I researched relevant databases for peer-reviewed journals and articles. I utilized Walden University Library, Google Scholar, ProQuest Central, EBSCOHost, Academic Search Complete, IEEE

Explore, Springer Link, IEEE Computer Society Digital Library, Science Direct, and ACM Digital Library. To expand the reference sources, I used the Crossref search engine, Ulrich Database, to find relevant peer-reviewed journals and drill down to the reference list of the articles I found. I saved all electronic articles in a folder and a copy on an external drive for safe-keeping. I used reference management software Zotero to manage bibliographic data and related research materials. I selected the "Advanced Search" function to limit the articles to those from 2016 to the present. The keywords were:

- *legacy systems*
- *legacy systems complexity*
- *upgrading legacy systems*
- *IS complexity*
- *IT maintenance cost*
- *migration cost*
- *maintenance cost*
- *legacy systems upgrade*
- *legacy applications*
- *legacy software*
- *legacy infrastructure software*
- *legacy code*
- *migration of legacy systems*
- *IT architects*
- *enterprise architects*

- *sociotechnical theory*
- *qualitative research*
- *case study, software modernization*
- *systems modernization strategies*
- *enterprise architecture*
- *legacy systems modernization*
- *legacy systems in the private sector*

Themes addressed in the literature review are (a) Sociotechnical Systems Theory, (b) supporting theories and a contrasting theory, (c) legacy systems, and (d) enterprise architecture and the role of IT architects. This literature review consists of 241 references: 19 are governmental reports, 251 are journal articles, 99.56 % are peer-reviewed, and 89.47 % are within 5 years of my anticipated graduation date (2022).

Sociotechnical Systems Theory

The STS theory highlights the relevance of the interaction between social and technical subsystems to satisfy their requirements. Torraco (2016) and Papoutsi et al. (2021) noted that the Tavistock Institute conducted studies of coal mining that focused on better understanding the interrelationship between machines and humans and consequently gave rise to the idea of sociotechnical systems. Ibl and Čapek (2017) and Thomassen et al. (2017) considered the STS approach an ambition to design organizations that successfully integrate technological systems, such as information systems, with the social and human systems.

Many researchers' work have addressed integrating the social and technical requirements in systems development and implementation that promotes higher productivity in organizations (Kyriakidis et al., 2018). For example, Bentley et al. (2016) emphasized that the better the integration of the social system with the technological systems, the better results organizations can achieve. Chaudhuri and Jayaram (2019) also stated that social and technical integration positively impacts quality and performance. Kant (2018) pointed out that the STS approach can usher to more user-acceptable systems that provide better value to system design and development stakeholders. STS theory interactions involve interdependently working alongside machines and other individuals (Bednar & Welch, 2020). Tsvetkova et al. (2017) stated that the STS theory progressed to the way people collaborate because of new technological advances. Hinkelmann et al. (2016) emphasized that one of the central factors of STS theory is interactions. Researchers have suggested that communication and collaboration support effective interactions between people and machines in STS theory (Lee et al., 2015). For example, in social media systems, technical systems mediate communication between people in the social network (Oh et al., 2018). Painter et al. (2016) asserted that in organizational settings, engagement with large tasks could lead to labor division between the people involved, which produces task interdependencies.

Because of the interdependencies between technology and humans, communication and collaboration in STSs are essential for efficient work. Körner et al. (2015) pointed that STS theory encourages team collaboration and improves job satisfaction. Behymer and Flach (2016) pointed out that integrating human and

technological capabilities contributes to sociotechnical effectiveness and well-functioning on top of team collaboration. Technical and human resources interact to serve the needs of a collective task is at the core of STS theory.

Legacy enterprise systems are inherently complex, and their modernization forces organizations to examine the business process, organizational structures, and technical systems. Sony and Naik (2020) suggested that enterprises are complex, and researchers should study them entirely. Also, Malatji et al. (2019) and Oosthuizen and Pretorius (2016) recommend using the STS approach to address a complex ecosystem that recognizes the interaction between two subsystems, social humans and technical systems. Addressing the sociotechnical aspects of a legacy system transformation requires a broad knowledge of the business processes' technology.

STS theory enables practitioners to consider the interaction between technology and people in a complex environment. Mujinga et al. (2019) suggested that every organization constitutes a social subsystem employing techniques and tools to provide a service or a product. Also, Hess and Sovacool (2020) and Winby and Mohrman (2018) emphasize that the STS theory recognizes social and technical factors: the synergistic combination of machines, environments, humans, work activities, and organizational processes. Abreu Saurin and Patriarca (2020) stated that researchers consider the technological and social components of the STS theory as a concerted ensemble.

Enterprise systems performance relies on the joint optimization of social and technical subsystems. Cimini et al. (2020) assert that researchers suggested that the STS theory's dimensions interact with each other while the fit between the elements can

impact the system's performance. Jacob et al. (2020) indicated that researchers commonly recognize that the development of systems using a sociotechnical approach leads end users to more likely access these systems to deliver values. Ghaffari et al. (2019) argue that a sociotechnical approach can bestow a thorough frame in which various human-technology interactions in new technologies arise. Integrating the social and technical requirements in systems, development, and implementation promotes better collaboration in organizations. Its integration aims to combine human resources and technologies and the best possible configuration that optimizes productivity.

Organizational culture and social awareness play a vital role in organizational processes as employees can resist change. Ozaydin et al. (2020) assert that STS theory advocates theoretical development while allowing IT to integrate social awareness and organizational culture that are critical in system use. There is a need to help in providing reasons for system changes.

Social Subsystem

The social subsystem is the first subsystem that arises from workers' social interactions, and it concerns the work structure that relates people to the technical subsystem and each other (Qureshi et al., 2019). In response to evolving work demands, the workers in sociotechnical systems adapt their behaviors or actions, collective structures, or relationships. The interactions among people and other STS theory elements are balanced, interrelated entities collaborating with a common purpose (Bednar & Welch, 2020). Social subsystem components include individual and team behaviors, organizational and team culture, management practice, and leadership style. The

evolution of social subsystems is not as fast as technology and business models. Soliman et al. (2018) noted the need for rich interactions between people with capabilities and technology, which they operate within a physical infrastructure underlies various practices such as cross-functional training and teamwork. Hylving and Bygstad (2019) highlighted the importance of teamwork, the human and cultural aspects in organizational change processes, and the significant role of communication in enterprise architecture management.

Ibl and Čapek (2017) noted that motivation, rewards, and a flexible working hours system help achieve higher systems' performance. The social characteristics of the STS theory influence the performance and the engagement of the employees within an organization (Bentley et al., 2016). Besides motivation, collaboration is a crucial characteristic of the social element and influences the overall organizational performance. Painter et al. (2016) identified different social and technical mechanisms that are significant for virtual team coordination of modernization and innovation. Morley and Cashell (2017) noted that modern organizations are often complex entities; often, modern organizations task cross-disciplinary teams to implement change, modernize, and improve work quality and efficiency. Levenda et al. (2019) studied innovation and modernization of energy systems with a sociotechnical systems lens. They highlighted that the dynamic socio-technical factors enabled and constrained the future of energy systems, Levenda et al. (2019) added. El Manzani et al. (2019) believe that the focus of socio-technical systems research so far has been too narrow and that there are new

contexts and issues that could considerably take advantage of sociotechnical systems thinking.

Technical Subsystem

The technical subsystem is the second subsystem that involves the interactions of workers with their technical elements. Ghaffari et al. (2019), Kim et al. (2016), and Qureshi et al. (2019) assert that the technical subsystem focuses on the effective use of technical procedures, tools, and other forms of technologies to acquire inputs and convert them to outputs. Demir et al. (2019) pointed out that the social subsystem would not exist in the same structure and quality without the technical subsystem. The social subsystem depends on the technical subsystem to deliver functionality and create value for clients, such as services and products. Savaget et al. (2019) noted that technical systems hinge on artifacts and obliquely acknowledge social elements' role in innovation and technology modernization. The reliability and performance of technological components are a prerequisite to deal with the complexity and dynamics of STS theory. Ibl and Čapek (2017) considered the system's modifiability and maintainability feature very important during system optimization.

The behavior of employees within an organization determines the efficiency and performance of the organization. Kim et al. (2016) considered that employees' behavior and the technology they use are socio-technical factors that can impact the personal and the organization's productivity. According to Licorish and MacDonell (2017), system boundaries and purposes that relate to interactions between social and technical systems frame the individual's perceptions. Mariani (2019) addressed coordinating in software

development within the STS systems. The technical aspects are equally crucial as exchanging information as they allow actors to collaborate among organizational structures (Alahyari et al., 2017). Technical subsystem elements in sociotechnical environments or systems can influence organizational structure.

Sociotechnical Joint Optimization

Joint optimization combines the social subsystem and the technical subsystem that results in an optimized production environment utilizing the best resources available to an organization (Dainoff et al., 2020). Joint optimization focuses on the goal, not how to achieve the goal. It allows managers and employees flexibility to tailor their mix of human and technical resources to achieve the goal. Pasmore et al. (2019) highlighted that traditional organizations' joint optimization is an internal goal, and future joint optimization will address the external ecosystem.

The idea of joint optimization is not to eliminate the need for human input but rather to provide a roadmap for managers to maximize the results and the best way they see fit (Winby & Mohrman, 2018). Joint optimization is adaptable to changing technologies as technologies improve the socio-technical system will necessarily change to optimize results (Pasmore et al., 2019). Dainoff et al. (2020) identified three fundamental problems in applying human and organizational skills to achieve joint optimization: knowledge representation, knowledge elicitation, and cross-functional integration. The knowledge representation addresses how to present information about a system; knowledge elicitation addresses how to enable information coming from sources such as systems engineers, vendors, systems requirements documents, and the cross-

functional integration that identifies how to enable information to help support collaboration and prevent silos (Dainoff et al., 2020).

Haseeb et al. (2019) suggest that the elements of Industry 4.0, such as big data and the Internet of Things, play a positive role in modernizing information technology that contributes to sustainable business performance. On the other hand, Sestino et al. (2020) concluded that the shift from IT and technical domains to applied engineering and management resulted in a mass of disorganized knowledge. Finally, Sony (2020) asserts that Industry 4.0 is a socio-technical system, and architects should include joint optimization in every phase of its integration.

Trist and Bamforth's early works to recent studies of Pasmore et al. (2019) and Walker (2015) helped identify and clarify the socio-technical principles. According to Curşeu et al. (2021), the pioneers of STS design introduced the core principles of STS theory responsible autonomy, adaptation, and meaningfulness of tasks. As shown in Table 1, Pasmore et al. (2019) further summarized the classic socio-technical system design principles from earlier works of Cherns (1976) and Clegg (2000).

Table 1

Classic Sociotechnical System Design Principles

Principle	Explanation
Wholeness	The work system should be conceived as a set of activities making up a functioning whole rather than collecting individual jobs.
Teams	Consider the workgroup as a central unit in an organization.
Process control	Identify and handle issues as close to their point of origin as possible as they occur.
Self-direction	The system should rely on the internal regulation of individuals by supervisors.
Multiskilling	The underlying design philosophy should be based on the redundancy of functions rather than on the redundancy of parts (multiskilling vs. single skilling).
Discretion	The discretionary component of work is as essential to the success of the system as the prescribed component.
Joint-Optimization	The individual should be viewed as complementary to the machine rather than as an extension of it.
Adaptation	The work design should be variety increasing rather than variety decreasing, meaning that individual and organizational learning is essential to allow organizational adaptation to change.
Meaning	Individual jobs should be designed to support learning, some decision-making level and should be socially recognizable.
Incompletion	Not to consider designs as finished while the organization's context continues to evolve.

Note. Adapted from "Reflections: Sociotechnical systems design and organization change," by W. Pasmore, S. Winby, S. A., Mohrman, and R. Vanasse, 2019, *Journal of Change Management, 19*(2), pp. 67-85 (https://doi.org/10.1080/14697017.2018.1553761).

In IT projects, organizations perceive that a project is a technology, people, and process system. Holman et al. (2018) introduced a wholeness system thinking approach that defines the relation between the system's elements such as interactions and a system as a whole. San Cristóbal et al. (2018) used the term technological complexity to

encompass interdependencies between teams, multiple tasks, technologies, and inputs. Engaging different teams in system modernization projects and treating technologies and people as inseparable parts of the organization is essential for IT architects because of differences in making informed decisions.

Researchers consider the STS theory principles to guide designing new systems while incorporating new information technologies and a set of modern management practices (Imran et al., 2021). Pasmore et al. (2019) stressed that traditional organizations would have a better shot at survival if they knew how to apply these principles. Appelbaum (1997) noted that STS theory principles' implication helps employees hone new skills and knowledge and accommodates the learning needed to make the new system function and succeed. Thomassen et al. (2017) believe that the operative system is one of the foundation principles by which the system and the workers are interdependent. The participation of workers in the design and implementation of systems is most important.

Evolution of STS Theory and Implications

STS theory has a long history, and its founder had the intention to ensure the consideration of the technical and organizational aspects together. During the Industrial Revolution, the United Kingdom (UK) developed large-scale coal mining as it was the essential energy source for the industry in industrial zones in the UK (Phillips, 2018). The British National Coal Board tasked the Tavistock Institute of Human Resources to conduct a comparative study of mines alike, except some, had high productivity and morale. In contrast, others were underperforming and suffered labor issues and a

deteriorating social climate (Trist, 1981). Thus, a core value of the STS approach is to harmonize and balance social and technical systems while optimizing in parallel productivity, worker satisfaction, and safety (Cherns, 1976; Clegg, 2000).

From the mid-19th century through the early 1950s, the classical approaches were Adam Smith's systematic management, Frederick Taylor's scientific management, Max Weber's bureaucracy, Henri Fayol's administrative management, and Daniel McCallum expanding on Smith's systematic management (Őnday, 2016). Pasmore et al. (2019) highlighted that contemporary STS theory promoted better technical performance and quality in people's work lives and inspired researchers in the information systems field. According to Hughes et al. (2017), organizations are increasingly trying to apply the STS approach. As a result, this theory has evolved into an essential theoretical lens in the IT and IS disciplines. Sarker et al. (2019) stated that the STS theory shaped the IS. Sarker et al. (2019) further added that researchers often see the sociotechnical perspective as being potentially adaptable and configurational in how the social and the technical subsystems are linked, thus allowing them to adopt it differently depending on their phenomenon under investigation. Hughes et al. (2017) added that STS theory emerged as a new way of thinking, which precedes the rise of the earliest IS programs that combine the social and technical approaches to solving organizational problems.

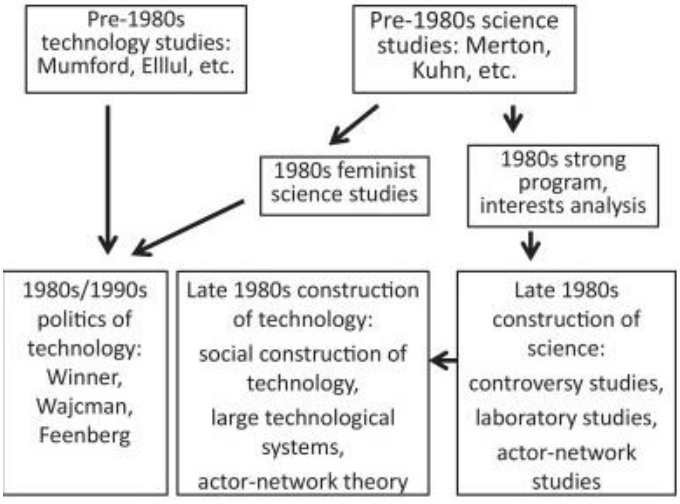
According to Waterson et al. (2015), STS theory focused in the 1960s and 1970s on the impact of technology on work organization and its impact on the quality of working life. In the 1970s, STS theory seemed to reach a high point in popularity (Mumford, 2006; Trist, 1981). Mumford (2006) added that in 1972 the foundation of the

Quality of Working Life occurred to internationalize the socio-technical movement. Pasmore et al. (1982) explored STS theory in multiple organizations and industries and included autonomous workgroups and technical skill development.

Mumford (2006) indicated a lack of interest in STS theory research and implementation in the 1980s and 1990s. Figure 2 represents the different influential approaches in STS theory that Hess and Sovacool (2020) put together to help understand the developments in the 1980s that became known as STS theory. Hess and Sovacool (2020) indicated that scholars such as Jacques Ellul, Herbert Marcuse, and Lewis Mumford developed critical analyses of technology's social, environmental, and political consequences in the mid-twentieth century.

Figure 2

Influential Approaches in STS Theory as of the 1980s



Note. Reprinted from "Reviewing and integrating science and technology studies with energy social science," by D. J. Hess, and B. K. Sovacool, 2020, *Energy Research & Social Science, 65,* Article 101462. (https://doi.org/10.1016/j.erss.2020.101462)

Hornborg (2021) stated that the period of the 1980s and 1990s was significant progress in theorizing the social and technical dimensions. Schubert and Kolb (2021) added that systems design and development and sociological analysis had come together at an interdisciplinary crossroads since the 1980s.

According to Hess and Sovacool (2020), between the 1990s and the early 2020s, STS theory underwent significant changes and focused on five areas: cultural analysis, policy analysis, actor-network theory and performativity, public understanding and engagement, and sociotechnical systems and users. Cultural analysis area covered cultural systems, cultural differences, and practices. Bilodeau and Potvin (2016) stated that policy analysis covered the construction of technical dimensions of policy. According to Caldwell and Dyer (2020), Actor-network theory and performativity focused on heterogeneous networks and agency of all things. Llorente et al., 2019 assert that public understanding and engagement focused on critiquing the deficit model, social movements, and public participation processes. Sovacool and Hess (2017) explain that socio-technical systems' last focus area covers the social construction of technology, extensive technical systems, and technological practices.

Systems Migration and Modernization in STS Theory Context

The legacy system is a highly complex socio-technical system. Gholami et al. (2017) explained that legacy systems comprise many components: legacy application is one component, while hardware, people, skills, and business processes are the other components. All these elements are subject to change. Ngowi and Mvungi (2018) point out that organizations use employees to allow humanistic ideas in the change process.

Ngowi and Mvungi (2018) suggest that the industry rarely uses socio-technical approaches in a highly competitive environment. Amlung et al. (2020) state that successful modernization requires a comprehensive and well-communicated approach that permits organizational and technological changes. Marjanovic et al. (2020) considered skills, capabilities, and leadership for modernizing the organization's systems, motivations and accountabilities, relationships, and networks as the main drivers of modernization and innovation and interacting subsystems of the overall socio-technical system for the healthcare system.

The introduction of cloud and other disruptive innovations while modernizing legacy systems can introduce organizations' problems. Van der Merwe et al. (2018) suggested utilizing an adaptive STS approach that provides a framework for understanding the adoption process and allows organizations to maintain their resilience while being agile. Storey et al. (2020) emphasized that many researchers consider both human and technical aspects of the sociotechnical approach in software development and system migration.

Analysis of Supporting and Contrasting Theories

Supporting Theories

Researchers use various theories to frame their studies on legacy systems modernization and research it from different viewpoints. Previous research used theories such as diffusion of innovation theory and adaptive structuration theory, DeLone and McLean information success model as the theoretical framework for various information systems modernization-related research. Gillani et al. (2020) used combinatorial

technology evolution to address digital manufacturing technologies' modernization from technological, organizational, and environmental contexts. Sociotechnical Systems theory is appropriate for the investigation of strategies IT architects use to modernize legacy systems. The supporting and contrasting theories highlight their constructs and how they relate and support the sociotechnical systems theory and the study of legacy systems modernization but lack the framework and functional constructs to investigate the unique phenomenon of this study.

General Systems Theory. One of the relevant Information Systems theories to study legacy systems is the general systems theory (GST). GST adopts an interdisciplinary approach that plays a significant role in the healthy expansion of the IS discipline (Tarafdar & Davison, 2018). According to Tretter (2019), Ludwig von Bertalanffy founded and promoted GST by emphasizing the interrelationships of components and the system's stability. von Bertalanffy (1972) stated that GST applies to most complex systems. Given the inherently complex nature of many systems, researchers must conceptually model information systems as complex systems. GST describes open systems as a constant two-way exchange with the environment (Yoshida, 2020), while STS theory helps optimize existing production systems and helps organizations cope with change (Sony, 2020). Bashan and Kordova (2021) assert that general systems theory focuses on interactions and relationships between components to understand an entity's organization, functioning, and outcomes. Mattos et al. (2016) and Turner and Baker (2019) stated that Bertalanffy noted that a system is a set of interacting elements classified systems based on their innate characteristics and relationships to the

external environment and defined the fundamental organizational principles of social systems. Blokland and Reniers (2020) noted that general systems theory includes complexity theory, emergent dynamics, cybernetics, dynamic systems theory. Added that GTS provides a string baseline for stakeholders to implement mechanisms to depict characteristics of systems under investigation from different levels of approach.

The similarities between the GST and the STS theory appear to help understand technological and social attributes in modernizing legacy systems. One of the general systems theory principles is that organizations function as a whole (Chatterjee et al., 2020), supporting the STS theory wholeness principle presented in Table 1. Turner and Endres (2017) indicated that viewing systems as a whole enables researchers to address the interactions between elements and understand systemic interrelationships that organizational leaders should understand to improve and maintain systems performance. Chatterjee et al. (2020) summarized the fundamental concepts of GST that support STS, such as subsystems, hierarchy, wholeness, multifinality, open systems, feedback, input-transformation-output, negative entropy, and dynamic equilibrium. Complex IT ecosystems have a vast number of relationships and interactions between subsystems, which affects the changes in IT and business operations. Pike et al. (2018) noted that researchers view subsystems as open systems that interact with the system's environment and engage in exchanges with other subsystems. According to Kotusev and Kurnia (2020), GST views an enterprise as a complex and interrelated system or multiple elements forming a whole. Many researchers leveraged GST as a conceptual framework to analyze EA practices and provide suggestions for interpreting organizations and their

IT landscape as complex systems with interconnected components (Kotusev & Kurnia, 2020). According to Alter (2013), GST provides basic notions for thinking of situations as systems, such as boundary, culture, change, and transformation. STS theory reframes those notions to systems in organizations and therefore is much less general than GST.

Technology Acceptance Model. Another Information Systems theory to consider is Technology Acceptance Model (TAM). As IT struggles to find better ways to introduce the new systems or to upgrade legacy systems, users, on the other hand, might question the negative impact of these systems on the way they do their work, as well as the security of their jobs (Vieitez et al., 2010). This suggests that user acceptance plays an essential role in the success of IT systems, as He et al. (2018) indicated. Often the users' unwillingness to accept technology obstructs the performance of IT and the organization (Davis, 1989). According to Lai (2017), Fred Davis introduced TAM in 1986 for his doctoral proposal and tailored it for modeling users' acceptance of information systems or technologies. Fred Davis developed it specifically for the information systems and technologies to improve user acceptance processes by measuring users' motivations to use new technology and information systems (Lai, 2017). According to Gao and Huang (2019), TAM explains that belief, attitude, intention, and user behavior facilitate a better understanding of technology user behavior. Similarly, Rahimi et al. (2018) indicated that TAM focuses mainly on modeling the behavior of users who decide to adopt the technology or reject it. Liang et al. (2019) used the TAM model to analyze the different factors that influence the adoption of new mobile applications to investigate the human aspects of the technology's adoption. TAM's basic model tests perceived usefulness and

perceived ease of use as two specific beliefs (Lai, 2017). Venkatesh and Davis formed a second version of the model calling it TAM 2, which depicts the influence of the two beliefs on behavior intention that eliminate the attitude construct and extend TAM with social influence and cognitive processes (Lai, 2017).

According to the model deriving from social psychological theories of reasonable action and planned behavior, focus on a person's intention (Rahimi et al., 2018). TAM is one of many theoretical frameworks that researchers use to examine and assess how users decide on new technology adoption (Diop et al., 2019; Koul & Eydgahi, 2017). Many argue that acceptance testing is a requirement in information system development when feedback is critical. The acceptance testing in early phases could reduce development costs and identify likely user adoption and necessary user support (Koul & Eydgahi, 2017). Understanding users' acceptance of new technologies and their social influence is crucial to modernizing legacy systems projects. As Ammenwerth (2019) stated, TAM assesses the likelihood of a successful transition to new technology and the degree to which a user perceives those significant others believe he should use the new modernized system. TAM as a framework could support STS theory in that aspect; however, it focuses more on the usefulness of the new systems rather than its modernization process.

Contrasting Theory

Diffusion of Innovation. One of the contrasting models is the Diffusion of Innovation (DOI) model. LeCraw (2020) defines DOI as a change model that describes adopting an innovation instead of continuing an existing practice. According to Alqatan et al. (2017), Rahman and Sloan (2017), and Sabi et al. (2016), many research conceptual

frameworks combined DOI and TAM. Scott and McGuire (2017) state that Everett Rogers developed the diffusion of innovation theory in 1962 to explain how, why, and the rate at which a service, process, or idea spreads through a social system. Edling and Danks (2018) indicated that DOI helps understand the complex interaction of factors that affect the adoption of new technology. Choi et al. (2018) think that DOI is a dynamic process, with individual adopters working independently within industry settings. The diffusion theory provides an adequate explanation of the relationship between technological innovations and social relations (Petry et al., 2019). According to Dayyala et al. (2020), Rogers broke down the social system into five categories: (a) innovators who are adopters and technology enthusiasts and visionaries, (b) early adopters who are more cautious in adopting new technology, (c) early majority who are deliberate in their thinking and will adopt the technology as soon it is ready to use, (d) late majority who are confident that the new technology is bullet-proof, and (e) laggards who are suspicious of the new technology and resistant to change. Magsamen-Conrad and Dillon (2020) indicated that DOI theory posits that the attributes of innovations affect the adoption of new technology, namely: a) relative advantage, (b) compatibility, (c) complexity, (d) trialability, and (e) observability. Vagnani and Volpe (2017) indicated that in previous research, scholars noted that the extant studies showed conflicting results and variation in the relationship between DOI attributes.

Marjanovic et al. (2020) stated that many research studies addressed how innovation works and the different elements promoting innovations in an organizational context. Few studies addressed the technical perspective to comprehend what needs to

happen to address the technical bottlenecks. Unlike STS theory, Dong (2021) stated that DOI theory focuses on communication channels, interpersonal networks, and social modeling as fundamental elements of the change process. TAM theory states that users' perceived ease of use of new technology and perceived functionality influence the modernization of technology and the user adoption, while DOI relies on social factors (Wang et al., 2019). Sovacool et al. (2020) further suggested that researchers complement adoption models such as DOI with sociotechnical approaches.

In contrast to how researchers use DOI, researchers use STS theory to segregate the interaction between humans and the technology with which they work. For instance, integrating the study of human behaviors during legacy systems modernization may help prevent a failed initiative. Sovacool et al. (2020) indicated that STS theory research is interested in system change. In contrast, DOI focused on niche innovations research, Sovacool et al. (2020) added. According to Scott and McGuire (2017), the primary focus of the diffusion of innovations theory is about the rapid modernization execution and adoption of new technologies. However, DOI does not consider the social systems. At the same time, other researchers noted that social systems such as professional development, training, management, and communication influence the migration to newer technologies and their implementation (Scott & McGuire, 2017). Because of the above concerns, DOI is not the ideal framework for this study.

Legacy Systems

Legacy Systems and Challenges

A legacy system is an old information system that is still in operation; also, it refers to any business-critical system that resists changes and has a high failure rate (Crotty & Horrocks, 2017). Plennert (2018) indicated that there are different terms in the context of legacy systems, such as technical debt, code smell, code decay, and software aging. Gholami et al. (2017) also referred to legacy systems as outdated computer systems that are high maintenance, inflexible to integrate with other technologies. Application is the core of a legacy system that can rapidly become obsolete due to the rapid evolution of technologies. Stojkov and Stojanov (2021) defined a legacy system as an outdated monolithic system that is no longer upgradeable to the latest version. With this definition, Abu Bakar et al. (2020) concluded that all new systems ultimately become legacy. Legacy systems comprise applications, programs, and technologies that run them. Tapia et al. (2020) confirm that legacy applications often follow monolithic architecture design approaches, run on outdated technologies and old infrastructures. Kotusev (2019) believes IT platforms' architectural diversity and complexity increase by the disparate legacy systems' multilayer nature. Eitelhuber et al. (2018) also added that there are sometimes limitations to adding new or editing existing functions.

The new generation of developers and administrators use the word legacy for various reasons; either the development methodology, the programming language used in the systems, or the technology running these systems is outdated (Johann, 2016). Alija (2017) believes that legacy systems play a role in evolving systems toward the business's

requirements that involve new functionalities, upgrades related to new regulations, and enhancement patches. Greenhalgh et al. (2019) asserted that legacy systems no longer satisfy IT organizations' purchase policies in many cases. Seetharama Tantry added that sometimes original vendors are no longer providing support. Lastly, the legacy software and applications are not fitting the IT standards and policies.

Legacy Systems and Maintenance

Maintaining legacy systems is becoming more and more expensive. Seetharama Tantry et al. (2017) stated that organizations need to modernize their legacy systems to new platforms like a cloud to minimize maintenance and operational costs. Attaran (2017) highlighted that cloud computing's cost benefits force some companies that run on traditional systems to reinvest in themselves. Usman Sana and Li (2021) added that cloud computing takes along great opportunities to run cost-effective workflows without the requirements of possessing any setup. Some enterprises rely on legacy systems to run their business but cannot afford to keep their legacy systems running, which becomes a barrier to agility and competitiveness (Rosas et al., 2017). U.S. Government Accountability Office (2019) reports that legacy systems technicians who maintain outdated systems are rare. Therefore, they are in high demand and more expensive (U.S. Government Accountability Office, 2019). Seetharama Tantry et al. (2017) added that maintenance of hardware platforms, of which the manufacturer is out of business, is also part of the challenge whose solutions are always costly. Stevenson and Helmond (2020) state that as software evolves, IT professionals must ensure its integrity while the system and its underlying components have grown in scope and scale. According to Alexandrova

and Rapanotti (2019), legacy systems are generally vital for businesses, and the slightest failure can have painful effects.

When running an obsolete system, a functional modification the business introduces or integration with another more modern system requires time and effort, which is not always available. Knoche and Hasselbring (2018) emphasized that managing legacy systems when planning for scalability can be difficult. Stevenson and Helmond (2020) asserted that scalability issues are not always issues but also management problems. Seetharama Tantry et al. (2017) explained that when adding other technological layers to a legacy system to meet new business rules, the result is more complex. Therefore, the system becomes a fragile system, Seetharama Tantry et al. (2017) added.

The necessary and inevitable evolution of technologies is an excellent opportunity to modernize information systems and IT practices (Gholami et al., 2017). Many applications and underlying structures, despite their unique functions, are now seeing their maintenance and operating costs increase; technological risks such as slower performance, lack of vendor support, and faulty interoperability multiply consequently (Sneed & Verhoef, 2019). Modernizing legacy systems offer the opportunity to acquire more open and more agile information systems. Modernization is crucial to deal with new functionalities such as mobility. Russo et al. (2018) assert that IT modernization allows organizations to develop employees' skills while reducing the risk of scarcity of knowledge, technological complexity, and obsolescence.

IT Staff Skillset

With various technologies and tools, no single IT individual can be up to date across the board. The legacy system's support and maintenance demand a specific set of skills and expertise depending on outdated technologies (Cummings & Janicki, 2021). Honing IT skills is most challenging in skill gaps to technology change's fast pace (Patacsil et al., 2017; Selvanathan et al., 2019). IT talent that maintains these legacy systems is aging out, and a looming skill shortage is a challenge for IT (King & Wright, 2017).

Inadequate vendor and staff support forces organizations to contract IT staff to maintain legacy systems, and it is twice expensive as a full-time employee (King & Wright, 2017). The development of IT shifted the focus of business strategy from physical assets to data and information assets (Millar et al., 2017). IT professionals are crucial in developing and supporting IT capabilities, such as IT innovation and IT-business alignment. Erkmen et al. (2020) indicated that different studies demonstrated a positive relation between IT capability and business performance, and IT capability increases its competitive advantage. However, Erkmen et al. (2020) added that when key IT professionals leave their organization, they tend to turn the existing system they used to manage into a legacy system.

Financial Considerations

Many organizations ask how much to modernize the legacy system, where the question could be how much maintaining these systems costs. Crotty and Horrocks (2017) indicated that the maintenance cost surpasses the modernization costs in many

cases. From infrastructure to licensing, maintaining legacy systems comes at a high price. JosephNg (2018) assert that optimization and maintenance of existing systems are critical determinants of infrastructure spending, and infrastructure investment requires significant capital expenditure. Legacy systems are part of the organization's infrastructure, and the cost of the change and maintenance is significantly high.

Because of the complexity and nested architecture of legacy systems, most of the cost goes into testing multiple subsystems. Verma et al. (2019) explain that reliable systems require infinite testing, leading to increased labor and test costs with time. Crotty and Horrocks (2017) added that regularly re-evaluating the cost of legacy systems and identifying solutions to contain the cost of legacy systems is a must execute for many large enterprises.

Many organizations use the Total Cost of Ownership (TCO) as a well-known process. It helps obtain the most accurate estimate of IT costs. Roda et al. (2019) suggest that many organizations recognize TCO as a strategic tool for the lifecycle management of systems. TCO is part of the life cycle costing (LCC) of a system. Landscheidt and Kans (2016) suggested that the life cycle costing model describes the total investment cost during its life span. Landscheidt and Kans (2016) think that the LLC model determines all high costs to develop various systems' best selection. Legacy systems are less expensive than their alternatives by default.

However, legacy systems will still run parallel to the alternative options, cause maintenance costs, and create a technical or IT debt. The more extended organizations keep legacy systems running and add new features to them, the more technical debt

grows, which puts additional operating and maintenance costs on the organization (Van der Ouderaa et al., 2018). Van der Ouderaa et al. (2018) add that the increased maintenance cost often diverts investment in IT resources and innovation. Yli-Huumo et al. (2016) defined technical debt as an analogy for shortcuts to achieve short-term benefits in time-to-market. In addition to TCO, technical debt is another element to consider when evaluating legacy systems from a financial perspective. Another aspect of a legacy system with a financial burden on some large enterprises, mainly multinational, is compliance. Some organizations find themselves between budget constraints on one hand and innovation pressure and compliance requirements of the General Data Protection Regulation (GDPR; Dove, 2018). GDPR is a complex omnibus data protection law guiding how organizations collect, utilize, and share personal data (Dove, 2018).

Infrastructure

Large enterprises' needs are continually evolving, thus forcing IT and infrastructure to significantly change flexibility with automation and agility in the business process. Khan et al. (2018) suggested that the transformation of legacy infrastructure helps manage the complexity of applications, the performance, and the quality of the services. Niemi and Pekkola (2020) indicated that legacy infrastructure could be hard and sometimes impossible to expand to more exceptional capabilities. This might happen due to the intricate architecture and inflexibility of the supporting infrastructure (Niemi & Pekkola, 2020). On the other hand, cloud computing infrastructure is an alternative to legacy systems for infrastructure flexibility. Cloud computing infrastructure offers competitiveness via cost reduction, better flexibility and

quality, and optimal resource utilization (Attaran, 2017). Quality of the infrastructure is a prerequisite to achieving flexibility, and maintenance is one of the valuable characteristics of infrastructure operation (Zuluaga & Sánchez-Silva, 2020). Legacy systems are often mature in operational processes, vis-à-vis new technologies. The example of the recovery of a legacy system is often part of an organization's routines, unlike a new alternative system.

IT Support

Benitez-Amado et al. (2015) suggested that IT infrastructure's quality increases its performance through talent management and operational environmental sustainability from a sociotechnical perspective. Gholami et al. (20179 noted that IT supports business functions from an IT-Business alignment perspective, and the business drives IT. Gerow et al. (2015) explained that organizations must align business and IT components to reach IT's full potential, namely, business strategy, IT strategy, business infrastructure and processes, and IT infrastructure and operations. As businesses grow, they require new business processes to win competitive advantage and guarantee a stable market position (Bitkowska, 2020). However, these businesses face a problem integrating their legacy systems with new technologies to streamline these business processes. Integrating legacy systems and modern solutions could be a daunting task, especially for large enterprises due to the IT ecosystem's complexity. The Service-oriented architecture (SOA) based modernization of legacy systems could dismiss IT resources. The modernization approaches section addresses SOA-based modernization in more detail.

Systems Enhancement

IT systems enhancement or continuous improvement (CI) is the widely used term to describe the improvement effort of a service, product, or process (Janjić et al., 2019). IT assets and competencies are prerequisites for CI projects. It requires quality infrastructure and solid IT skills, and a competent development team. At the beginning of system deployment, the underlying software and hardware start aging, and their quality deteriorates over time. Choi et al. (2020) pointed out that legacy software grows more prominent with age, and refactoring legacy code is part of continuous improvement that would reverse quality.

The modernization approaches section addresses the refactoring process further in detail. Depending on the CI backlog size, a legacy system might influence the maintenance cost and impede further improvements. Many large enterprises struggle to successfully maintain their backlog and adopt agile methods in their CI process (Heikkilä et al., 2017). Sometimes developers do not have the time to refactor legacy systems in which previous developers used shortcuts. Legacy systems are complicated to apprehend, and program understanding becomes a significant task during maintenance (Seetharama Tantry et al., 2017). Yli-Huumo et al. (2016) emphasized that shortcuts and workarounds could contribute to low system quality and hurt IT resources' productivity.

Some researchers covered the technical challenges of running legacy systems within the IT organization. Satish and Mahendran (2019) listed systems that run Common Business-Oriented Language (COBOL) as an example of a complex legacy system. Many consider COBOL as a legacy programming language (Edwards & King, 2021; Stevenson

& Helmond, 2020). Satish and Mahendran (2019) highlighted the lack of documentation of legacy systems or not updating documentation throughout a legacy system's lifecycle. The term *complexity* has different definitions, and it depends on the topic of the research study (Greenhalgh & Papoutsi, 2018). The computational complexity theory defines complexity as "the needed number of resources for a computer to solve it" (Bossaerts et al., 2018, p. 7). That means measuring the time and effort required to address a given complexity. From that perspective, Moraga and Zhao (2018) think that legacy systems are complex systems since they generally take time and effort to address.

According to Social Security Administration (2017), sometimes, in organizations year after year, new technologies and features are incorporated and patched into existing legacy systems without a thorough redesign; this is a bottleneck and makes it more expensive to deliver the following change. Lowell (2016) thinks that the complexity in outdated systems could apply to such systems' architecture or how employees who manage or design these systems perceive them. Complexity grows over time, requires more research and development, and involves more collaboration (Broekel, 2019). Horman (2017) mentioned that the complexity of legacy systems burdens the organizations that failed to decommission old systems repeatedly and cannot change their internal stakeholders and customers' demands, making it more challenging to modernize.

Some researchers covered the challenges of running legacy systems within the IT landscape. Satish and Mahendran (2019) discussed applications running COBOL as an example of a complex legacy system. Satish and Mahendran (2019) highlighted the lack of documentation of COBOL-based legacy systems or not updating old documentation

throughout the lifecycle of such a system. Satish and Mahendran (2019) suggested using software visualization with a 3D model to understand the complexity of legacy systems, enhancing the maintenance of such systems. Like Satish and Mahendran (2019), Knoche and Hasselbring (2018) studied a legacy system that runs on COBOL. One reason for modernizing these systems was the complexity that prevented IT from delivering new functionalities and features.

The goals of modernizing outdated systems help establish platform-independent interfaces, improve the application's efficiency by eliminating unneeded entry points, and decommission obsolete components. The ultimate objective concerning a COBOL system is to migrate gradually to a more modern language. Knoche and Hasselbring (2018) suggested that microservices could decouple existing software into multiple small components. That decoupling carried limitations, such as not modernizing all the system parts due to some highly proprietary, technologies-based user interfaces.

Enterprise systems are complex, and most of the time, require help from the manufacturer, suppliers, and vendors to add custom features, train employees, and add enhancement (Conteh & Akhtar, 2015). Some of the disadvantages of a legacy ecosystem are inflexibility in development and delivery methods, the longer turnaround to address the business needs, complexity in structure and trouble managing systems, and costly upgrades (Conteh & Akhtar, 2015). A common practice is for organizations to implement on-premises enterprise resource planning (ERP) with the intention that the system will stay in place for a long time. However, maintenance challenges might occur as the

business evolves, and an organization might grow faster than upgrades to the system can be done until it becomes a legacy (Demi & Haddara, 2018).

Difficulty understanding the code, cost to maintain, lack of documentation, degraded performance, lack of expertise, and poor design of the systems are all elements that cause the complexity of legacy systems. (Kaur et al., 2017). Legacy systems can also refer to existing IT assets that have been deployed in the past or came from an IT merger and acquisition. Old age, obsolete languages, lack of consistent documentation, degraded performance, and complex management by individual experts are legacy systems' features (Liang et al., 2017). The consequences of not updating outdated systems have contributed to security risks (Tuptuk & Hailes, 2018), lack of business alignment, staffing issues, and increased costs (Harris, 2019). As the legacy systems age, the maintenance costs increase, becoming more vulnerable to cybersecurity attacks (Harris, 2019). Powner (2016) pointed out that vendors no longer provide patches or support to their hardware and software in some cases, which creates security vulnerabilities and additional costs. An organization might have to pay above the market wage rate to hire experts who can maintain outdated systems (Powner, 2016). Sandborn and Prabhakar (2015) discussed this issue of legacy systems from a human perspective. They suggested that social skills obsolescence is an issue for most organizations that support and maintain legacy systems.

Legacy Systems Modernization and Migration Approaches

Modernizing legacy software systems is a reality of organizations that must improve their operations. Some factors that oblige companies to modernize their information systems are reducing complexity and aligning the business process and the

supporting software systems to drive growth (Aversano et al., 2016; Rajapathirana & Hui, 2018). The legacy systems modernization can be an open-ended course to improve productivity, reduce complexity, and improve business process efficiency (Department of Defense, 2019). Seetharama Tantry et al. (2017) listed various modernization approaches: re-architect or redevelop, remediate or refactor, replatform or rehost, reuse, and replace. The strategies are tailored approaches depending on the business needs and issues. Liang et al. (2017) shed some light on the methods to migrate legacy systems to service-oriented architecture (SOA), such as development freeze, rewrite, replace, wrap, and reengineering.

Re-Architect or Redevelop

The re-architect or redevelop approach involves reverse engineering (Seetharama Tantry et al., 2017). As highlighted in Satish and Mahendran (2019), the re-architect approach helps shift to new application architecture and exploit the new platform's new features and capabilities. Sneed and Verhoef (2019) suggested reimplementing legacy systems that combine automated conversion and complete redevelopment. A reimplementation goal is to revise the technical architecture, replacing the code but keeping the same business functionalities. Some organizations proceed with this approach when replacement and development-from-scratch are expensive, and conversion is not an option (Sneed & Verhoef, 2019). Sneed and Verhoef (2019) argue that automatic conversion of legacy code is the cheapest, surest solution to migrate the code. Sneed and Verhoef (2019) also considered redevelopment as a naïve approach to

migration. This approach requires going back to the end-user and asking for business requirements separate from the existing ones.

Furthermore, Sneed and Verhoef (2019) compared the systems' quality and complexity before and after reimplementation. The reimplementation cost depends on the source system's quality, the documentation, and the staff's quality of doing the work (Sneed & Verhoef, 2019). Significant code rewrites fail, and most of the classic approaches fail (Johann, 2016). Rewriting is a complicated process because of the system's lack of knowledge before changing it (Johann, 2016). It is much easier to attack the system's parts to deliver business value, reduce cost, and incrementally apply innovation that aligns with new business requirements (Johann, 2016). Technical complexity and skills availability are potential barriers to re-architecting and modernizing systems (Yang, 2016).

Remediate or Refactor

A refactoring approach is an approach that transfers inefficient legacy system code or supporting platform without altering external behaviors. Seetharama Tantry et al. (2017) assert that the remediation or refactoring approach enhances and optimizes a legacy system or application that performs poorly. Abu Bakar et al. (2020) described that an organization might have used outdated technologies to implement legacy system components that lead to performance issues and system reliability issues judged by the failure rate increase. Qiu et al. (2014) argue that legacy systems might comprise many components, which means it is expensive to deploy an alternative duplicate of all the

parts. For that reason, Qiu et al. (2014) think that refactoring and enhancing elements that have a more significant impact on the system's reliability is a must.

Kaur et al. (2017) introduced an approach to identify elements of legacy system complexity to refactor the legacy system effectively. The migration from monolithic legacy systems such as ERP demands deep system refactoring (Lenarduzzi et al., 2020). The remediation approach is complicated because large-scale modernization efforts carry a significant risk while developing a structural plan toward implementation (Texas Department of Information Services, 2014). While Zhao and Wang (2019) used the reuse legacy systems approach to create a support tool, they proposed a refactoring approach from one programming language to another that divided business logic into different types and created appropriate refactoring rules for each corresponding type. However, Zhao and Wang (2019) stated that the refactoring approach needs more improvement to be more accurate and automatic.

Replatform or Rehost

Replatform and rehost involve moving a legacy system to a different hosting platform. This approach entails migrating from one platform to another. Zhao and Zhou (2014) indicated that the replatform approach could migrate the system from an on-premises environment to the cloud, such as software-as-service (SaaS), infrastructure-as-a-service (IaaS), and platform-as-a-service (PaaS). According to Attaran (2017), PaaS eliminates the wait to deploy new hardware and software applications. The migration is a technique when selecting the replatform as modernization approaches. Many call this migration approach "lift-and-shift" (Church et al., 2017, p.7).

Migrating a legacy system to the cloud is an organization's strategy to increase performance, productivity, growth, and competitiveness. Cho et al. (2021) suggested that migrating to SaaS can reduce IT service costs and management overhead by discarding redundant applications and integrating them into standard services. The cloud's migration is the movement of data and related components from on-premises infrastructure to the cloud computing infrastructure. Gholami et al. (2017) claimed that cloud migration in system modernization projects is subject to failure due to the lack of grasping and preparing for cloud computing migration. Fairfax County in Virginia started a replatform project in 2018 that eliminated an old data center infrastructure and operational support model and switched to consolidating server and storage environments and cloud-type services, which yielded operational savings and enhanced green IT initiatives (Fairfax County Virginia, 2019). Business owners dread the cloud when it comes to hidden costs. According to Attaran (2017), enterprises are not rushing to move data from their legacy systems to the cloud due to costs might increase rapidly due to customization to meet the business needs. Attaran (2017) added other challenges: governance and control, lack of resources, and expertise.

Reuse

Reuse involves retrieving existing components of the legacy system (Seetharama Tantry et al., 2017). Organizations utilize legacy systems components as business functions that architecturally can provide loosely coupled components (Seetharama Tantry et al., 2017). The migration of the legacy systems to microservices provides the reuse of already established components and integrates new ones. This approach might

lead to cost reduction, a shorter development lifecycle, and lower development risks (Srinivas et al., 2016).

Replace

Replacing involves swapping a legacy system with another one with the same business functions. Seetharama Tantry et al. (2017) suggested it is best to replace a legacy system entirely with a custom application or a commercial solution out of the box. Sneed and Verhoef (2019) conducted quantitative research and focused on reimplementing or replacing legacy systems. According to Sneed and Verhoef (2019), reimplementation is to revise the technical architecture and replace the code but keep the same business architecture. Architects may use this approach when replacement and development from scratch are expensive, and conversion is not an option. McLeod and Gormly (2018) gave the example of large enterprises that replaced their on-premises legacy systems with cloud-based services that showed a substantial monetary advantage against its 3-to-5-year budget, flexibility increase, and avoiding shadow IT. However, McLeod and Gormly (2018) also highlighted that the IT department's primary concern, as a lead decision-maker, was whether the cloud functionalities could scale and meet future business needs. Sneed and Verhoef (2019) demonstrated that the code's automatic change is the cheapest, surest solution to migrating legacy code. Re-development is a naïve approach to migration (Sneed & Verhoef, 2019). This approach requires going back to the end-user and asking for business requirements separate from the existing ones.

Garcés et al. (2018) conducted a case study using an Oracle product called "Oracle forms" as a legacy system. Garcés et al. (2018) used a "white-box

transformation" method to change the application and technology stack without affecting the business functionalities. The methodology focuses more on understanding the legacy application (Garcés et al., 2018). Hustad et al. (2016) highlighted that organizations that migrated from a legacy system to a new enterprise software platform performed customizations to make the transition easier and satisfy employees who wanted to keep the new system's legacy functionalities.

Legacy Systems Modernization Implications

Legacy systems modernization is one of the most challenging activities in IT projects from a technology perspective. Sebastian et al. (2017) think it is not easy for large enterprises to let go of legacy systems, processes, and cultures. Katuu (2020) states that many organizations address the legacy systems modernization by keeping the lights on but later face challenges taking that approach (Katuu, 2020). Entirely changing existing legacy systems is a risky endeavor. Sarmah (2018) discussed in detail the potential migration challenges such as:

- legacy data fitment
- hidden data quality
- data reconciliation
- unexpected load failures of cleansed data
- incomplete data in the target system post-loading due to incompatibility
- availability of load error analysis reports.

Such challenges can make migration efforts more expensive to some organizations, whatever the organizational motivations are. Fahmideh and Beydoun

(2019) defined a decision model for reengineering legacy systems to service-oriented architecture to leverage integration in au lieu of migration in terms of cost. Sometimes the cost of data migration may surpass the post-migration cost savings, perhaps due to resource allocation costs. Lack of resources is one of the challenges that legacy systems modernization faces. Gholami et al. (2017) stated that migrating legacy systems involve technical and non-technical resources. IT architects work closely with project managers and business analysts to support each other in legacy systems migration projects. Gellweiler (2020) asserted that social activities, such as teamwork and relationship building are essential for all architects. Menychtas et al. (2014) think that the modernization of legacy systems to the target environment poses a significant challenge for all stakeholders from the business perspective to adapt their business processes to more modern technology. Greenhalgh et al. (2019) suggested modernization incrementally while considering technological and socio-cultural legacies when modernizing existing systems.

Poor system architecture and a complex IT landscape challenge legacy systems' modernization efforts (Knoche & Hasselbring, 2018). It can be very cumbersome in a tightly coupled legacy system to decouple its different components and dependencies. It makes it challenging to modernize in a step-by-step fashion, which leaves the IT staff with a 'big bang' approach to upgrading and migrating to a newer environment. From the organizational perspective, as critical as technical proficiency is, managing the cultural shift required to embrace the new modernized architecture is the next obstacle to a successful transition (Winsor et al., 2019).

Legacy Systems and Digital Transformation

It is hard to pinpoint a definition of digital transformation as it looks different for every organization. Schallmo et al. (2017) assert that digital transformation has no commonly accepted definition, and some define it as the use of technology to improve enterprises' performance. It is another form of IT modernization and integration of new technologies into all areas of a business. Hausberg et al. (2019) stated that digital transformation happens when the evolution of newer business trends that technology presents drives an organizational transformation. Bashroush and Woods (2017) asserted that digital transformation projects led to significant systems efficiencies and cost savings.

Meanwhile, complex and costly legacy technology is a complete barrier to digital transformation. Verhoef et al. (2019) noted a need for a framework that guides digital transformation to adopt a holistic view of the business ecosystem to address legacy technology concerns. In the same realm, Li (2020) stated that digital transformation requires specific organizational structures.

Digital transformation is a holistic adoption of change across organizational processes, technology, and people from a sociotechnical perspective. According to Legner et al. (2017), digitalization describes different socio-technical phenomena and adopting technology in individual and organizational contexts. According to Butler (2020), fewer large enterprises in finance and retail implement digital transformation and replace their legacy systems. The percentage seems to be very low. Butler (2020) suggested that large organizations such as banks and insurance companies should

carefully consider the cost and benefit of modernizing their existing systems and implement new technologies in an iterative and accumulative way. The reliance on these current legacy systems is one of the biggest headaches in the digital transformation journey.

Information Systems Life Cycle

The life cycle of an information system incorporates all the processes that occur from conception until retirement. An information system consists of all people, machines, and methods involving collecting, processing, and transmitting information (Guo et al., 2020). When we talk about an information system's lifecycle, application lifecycle management (ALM) comes in. ALM is like the software development life cycle (SDLC), but it is more thorough in scope. It is a new paradigm for managing governance, development, maintenance, and decommissioning systems activities (Egwoh & Nonyelum, 2017; Tüzün et al., 2019). However, SDLC focuses more on the development phase encompassing requirements gathering, architecture and design, development, test management, deployment, and operation (Pukdesree, 2017). Gatrell (2016) suggested that organizations often use SDLC and ALM interchangeably, but the scope of ALM is much broader. Many articles in the literature review focus on the SDLC and ALM from a development and implementation perspective. However, very few cover the maintenance beyond the software’s end-of-life and its underlying infrastructure. Legacy systems play a role in the implementation of new information systems. They are essential assets of organizations as they hold business data. Iluore et al. (2020) suggested that asset management is critical to managing organizations' assets regardless of size.

Similar Studies

In this section, I review some of the previous studies with similarities and differences with my study. I identified two studies. In this study, I explored IT architects' strategies to modernize legacy systems in two large enterprises, one in healthcare and one in the financial services industry in the San Antonio-New Braunfels, Texas metropolitan area in the United States. Crotty and Horrocks (2017) used a case study within a large financial service company in the United Kingdom to identify the characteristics of legacy systems and explore the reasons for high costs to maintain and support these systems. Crotty and Horrocks (2017) examined different meta-models that assess and manage legacy systems' costs. Crotty and Horrocks (2017) selected ten senior business and IT executives to participate in a face-to-face questionnaire. The authors highlighted the themes and attribute values: maintainability, architecture, defect rate, maintenance time, system age, operation system versions, security, and system evolution to meet business needs (Crotty & Horrocks, 2017). This study has some similarities to Crotty and Horrocks (2017), such as the target population within a large financial company. The geographical area and the data collection methodology are different. This study uses interviews rather than a questionnaire to fill out, and instead of a single case study, this study is a multiple case study. The participants' roles are different compared to this study. Amlung et al. (2020) used the theory of change as a conceptual framework for their study to address the modernization of healthcare information technology (HIT) systems, unlike this study that uses STS theory. Amlung et al. (2020) conducted semistructured qualitative interviews among a sample of healthcare provider systems that included

various institutions by size, geography, and other characteristics. Amlung et al. (2020) invited 27 professionals from different healthcare organizations across the United States of America, but only 13 agreed to participate. The roles of the participants included Healthcare Directors, Chief Information Officers, IT managers, and Chief medical Informatics officers (Amlung et al., 2020). Unlike in this study, I invited IT architects. Amlung et al. (2020) identified different themes groups: (a) motivating factors to switch HIT systems, (b) deciding to switch and which HIT system to pursue, (c) implementation process, (d) lessons learned from switching HIT, and (e) measures of success.

Enterprise Architecture

EA is an essential discipline for modern enterprises critically dependent on IT (Maissel, 2017). Kotusev (2019) defines EA as a description of an enterprise from an integrated IT and business perspective. Zachman (1987) defined EA as a set of descriptive representations pertinent to the enterprise where an enterprise is any socio-technical organization. Perez-Castillo et al. (2019) and Banaeianjahromi and Smolander (2019) suggested that EA helps organizations assess methods to align them with the business objectives and strategy. Enterprise Architecture has become essential for organizations to address and support modernization projects. EA improves business and IT alignment (Zimmermann et al., 2016). Banaeianjahromi and Smolander (2019) also indicated that organizations employ EA to reduce complexity and improve business-IT alignment. Enterprise architecture practices establish the organization's roadmap to achieve its goals by improving modernization strategies and better information systems

(Abunadi, 2019; Hoffman et al., 2018). Heim et al. (2019) suggested integrating enterprise architecture to enable organizations to manage their IT landscape centrally.

Organizations might introduce many fixes, changes, and workarounds within and between systems to meet business needs. These modifications complicate the existing systems and add to their architectural complexity. Ajer et al. (2021) suggested that EA facilitates fundamentals, such as interoperability, standardization, process support, and data management. EA serves as a blueprint for organizations and provides a holistic view of the business, IT, and overall complexity. Tambo (2016) stated that some researchers describe EA as a transformational agenda where IT architects create a present state and the to-be state of the architecture while fulfilling the business requirements. Banaeianjahromi and Smolander (2016) stated that EA has benefits such as managing complexity, improved change management, and increased interoperability and integration. EA serves as a guideline to modernize legacy systems and better manage their complexity. According to Gong and Janssen (2019), IT strategic planning and other organizational factors impact companies' evolution. Before modernizing legacy systems, IT architects' main task is to understand each legacy system and its relationships from an architectural perspective. EA planning, documentation, and governance contribute to a better understanding of the organization and its components (Niemi & Pekkola, 2020).

Through a set of implementation projects, organizations could transform the as-is architecture to a planned to-be architecture. Hoffman et al. (2018) highlighted that due diligence characteristics of legacy modernization comprise three phases: legacy or as-is analysis, modern or to-be analysis, and strategic planning. The as-is and to-be

architecture is called architecture gap analysis. Mei Mei and Andry (2019) defined the architecture gap analysis as an analytical approach to compare the current state of the architecture and look at the ideal conditions. The legacy or as-is analysis phase highlights legacy systems, the supporting infrastructure, business processes, application, and data architecture. According to Rajabi et al. (2013), based on the as-is analysis, different EA outputs, such as business process improvement and strategy improvement, change to a better product to accommodate the business needs. To-be architecture is the future desired state of enterprise architecture.

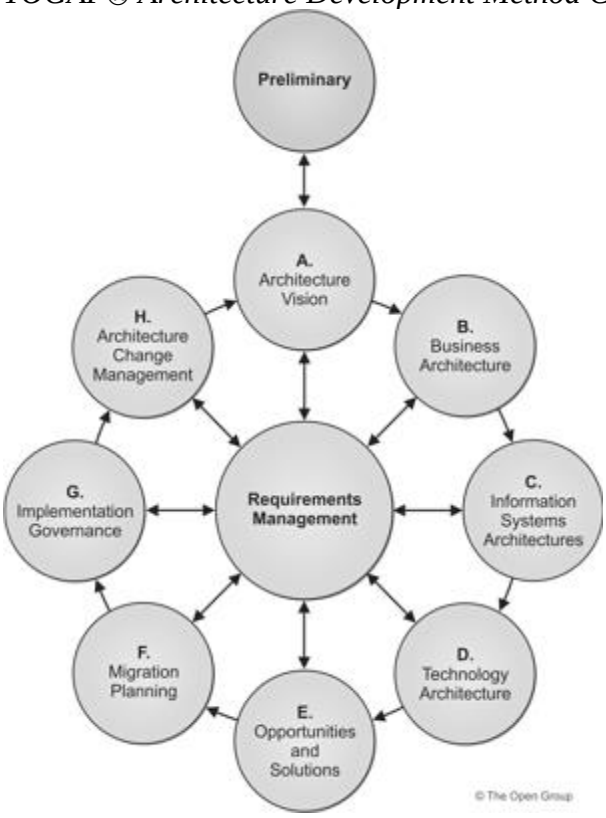
The enterprise architecture frameworks (EAF) delineate all the business processes and the Information systems to fulfill the organizations' mission (Venkatesan & Sridhar, 2019). The EAF simplifies using enterprise architecture (Venkatesan & Sridhar, 2019) within the organizations. Gong and Janssen (2019) suggested that the EA requires constant effort to keep up with the organization's technological developments and the environment. Typically, EA practitioners associate EA with popular EA frameworks (Kotusev et al., 2017). EA consists of different building blocks managing the system evolution (Sajid & Ahsan, 2016). Halawi et al. (2019) highlighted different EAFs that many other researchers and practitioners have suggested, like The Open Group Architecture Framework (TOGAF) and Zachman IS framework. Fadlil et al. (2021) and Halawi et al. (2019) stated that EA frameworks have distinct guidelines and principles, but some have shortcomings.

Depending on the needs and challenges that IT and other areas of the business raise, an organization can use EA approaches for several purposes. Hinkelmann et al.

(2016) think that Zachman IS framework represents an enterprise's holistic view to present insights and understanding. Widjajarto et al. (2019), on the other hand, think that TOGAF has been the most popular EA framework globally due to its flexibility and focus on information technology. TOGAF provides complete methods and guidelines to assist in the lifecycle of the enterprise architecture (Holilah et al., 2019). The TOGAF Architecture Development Method (ADM) is the heart of the TOGAF framework and its logic as it helps architects manage the life cycle of EA (Fahana & Azhari, 2018). Kotusev (2018) asserts that ADM forms an iterative cycle for the complete process. The decision-making determines the extent of the enterprise scope, detail, the time target to achieve, and architectural assets to be the focus. ADM covers the preliminary phase, architecture vision, business architecture, information systems architecture, technology architecture, opportunities and solutions, migration planning, implementation governance, and architecture change management (Gormantara & Emanuel, 2020). Figure 3 depicts the TOGAF® architecture development method cycle.

Figure 3

TOGAF® Architecture Development Method Cycle.



Note. The TOGAF® ADM is iterative, over the entire process, between phases A to H, and within phases. B to D are architecture development phases that realize Business, Software, and Infrastructure architectures. E and F focus on planning, G focuses on governance, and H represents the architecture change management. Adapted from "*The TOGAF® Standard, Version 9.2*," by ® The Open Group, 2018, (https://pubs.opengroup.org/architecture/togaf9-doc/arch/). Copyright 2018 by ® The Open Group. Reprinted with permission (see Appendix D)

EA helps manage the complexity of the IT environment. Mayer et al. (2018) stated that many consider enterprise architecture management (EAM) an effective technique to manage a substantial degree of complexity, corporate information systems (IS) environments. Gong and Janssen (2019) noted that EA is a broad concept, and half of their reviewed articles provide empirical evidence that supports EA improving the value of IT. There is very little academic research that addresses the modernization of legacy systems from the enterprise architecture perspective. On the other hand, many whitepapers, proceedings, and conference papers address the issue from an EA perspective. Most scholarly academic work focuses on IT development, Infrastructure management, and other IT areas.

IT Architects Roles in Enterprise Systems Modernization

IT professionals perform the function of enterprise architecture under different job titles. Abunadi (2019) and Gellweiler (2020) highlighted that IT architects perform the enterprise architecture's job functions and pursue similar goals. Gellweiler (2019) stated that various types of IT architects contribute differently to IT projects. Rahimi et al. (2017) added that IT architects suggest initiatives to modernize the IT landscape based on emerging IT trends and IT architecture complexity. They are two parts to the role of the IT architect. One part is the role of a subject matter expert (SME) for business transformation, and the other is a quality assurance agent, ensuring persistence through continuous operational efficiency. Girsang and Abimanyu (2021) added that an architect performs different tasks, such as creating architectural roadmaps, delivering an integration strategy, providing architectural governance.

Architects of all types put in considerable effort to understand the complexity of legacy systems. Bontinck et al. (2016) stated that architects acknowledge the complexity of legacy systems, and they have the role in coaching the business and raising the concern of complexity, interdependencies, and interconnectedness.

Enterprise Architects/Enterprise Architecture

Enterprise architecture plays a central role in modernizing IT to align with business goals. Gong and Janssen (2019) and Menchini et al. (2021) asserted that many organizations embraced EA to improve their IT value and attain asymmetry between business transformation and continuous operational efficiency. Organizations often adopt enterprise architecture for various reasons. Dang and Pekkola (2019) noted that organizations adopt EA when developing their IT or businesses to manage modernization initiatives. Enterprise architects play a crucial role in project delivery. Gellweiler (2019) asserted that enterprise architects commonly govern solution developments and are responsible for designing and handing over projects for implementation. Legacy Systems complexity is a challenge for enterprise architecture. Baškarada et al. (2020) added that enterprise architects aim to optimize and modernize the entire IT landscape of an organization. Manwani and Bossert (2016) emphasized that enterprise architects must ensure that organizations can manage legacy systems' complexity while starting innovation and modernization projects to remain competitive.

Applications/Software Architects

An applications architect or software architect is the individual who operates within the scope of an application/software. They identify the architectural requirements

of modern applications and help to map existing applications to the new structure. Hohpe et al. (2016) asserted that application architects must have a broader and deeper knowledge of different types, including software areas other than design and architecture, hardware, and domain-related knowledge. Erder and Pureur (2017) suggested that software architects must focus on the entire application delivery life cycle, understand the application code, and operate in a more decentralized fashion. Erder and Pureur (2017) also added that software architects must hone non-IT skills such as communication; also, operating in ambiguous contexts are increasingly critical. Bass (2018) suggested that software architects must work hand in hand with the development team to ensure there is personnel to support tools and that the team is familiar with the tools that support production applications. Arquilla and Bugayenko (2018) added that software architects are the guiding rails for an IT project; they keep their team of developers on vision while accepting the responsibilities for the team's actions as a whole.

Data Architects

The focus of architecture is to plan the design, layout, and construction of business-critical data infrastructures. Data architects provide knowledge in handling disparate data sources from varied data sources. Farrell and Bengtson (2019) state that data architects oversee data architecture that comprises standards that guide which data to collect and transform. Data architects help design and provide the blueprint for data management (Farrell & Bengtson, 2019). Large enterprises could have different complex data architecture, and most of their data are held in legacy systems, for which the data structure details may be unknown. Jha et al. (2020) stated that legacy systems and data

are critical to the organization from the data architecture perspective, but also, the retrieval of the data is inefficient and expensive. Many organizations balance between social and technical factors. Brous et al. (2016) consider data infrastructures as socio-technical systems. Guinan et al. (2019) believe data architects play a crucial role in modernization and digital transformation projects. Guinan et al. (2019) also added that organizations include them in small teams that consist of resources who work solely in these projects and not be active on other projects simultaneously.

Solution Architects

Solution architects address business needs and issues through the development of applications and products. Gellweiler (2020) believes that solution architects focus more on products, systems, and technologies for a subject matter. In contrast, Baškarada et al. (2020) indicated that solution architects specialize in specialized products and technology stacks such as Big Data analytics. Solution architects translate the vision for the project to the development team through collaboration. Krishnamurthy (2017) thinks that solution architects can communicate with stakeholders, build consensus, and work toward success. Gellweiler (2020) thinks that the words solution and systems describe the enterprise architecture's technical segments, and organizations can use them interchangeably. Gellweiler (2019) stated that sometimes industries consider systems architects as solution architects who focus more on the functional sections within the overall enterprise architecture. Rahimi et al. (2017) added that solution architect uses the EA function to design project solution architecture.

Systems and Infrastructure Architects

Systems architects are technology and business experts. McDermott and Salado (2019) stated that system architects develop their skills broadly across the technical and business domains. Organizations leverage systems architects' skills to understand the current architecture, to-be architecture, standards, and recommendations for emerging software and hardware systems trends. Guenov et al. (2020) insert that systems architects project the vision and the future of the infrastructure and communicate it to the stakeholder. According to Guenov et al. (2020), systems architects decide how to integrate technologies into systems architecture. Like enterprise architects, systems architects can create and review IT strategies and produce a technology roadmap to build IT infrastructure that meets the business need. However, Gellweiler (2020) thinks that systems architects perform their tasks at the implementation and operation level, unlike enterprise architects who are more strategic at the departmental level.

Transition and Summary

Section 1 introduced the IT problem within large enterprises. The IT issue comprised the challenges large enterprises face when maintaining a complex IT landscape. This section also included the background, significance of the study, the introduction of the chosen framework, the questions that guide the research, and a literature review. The literature review offered more insights into the selected STS theory conceptual framework, its evolution, and principles. STS theory captures two subsystems, a technological subsystem, and a social subsystem. The STS theory review was essential to establishing individual, teams, and organizational perspectives and technical views

when modernizing legacy systems. The STS theory provided opportunities to identify an enterprise's strategies, business processes, and associated resources such as information systems and humans to modernize legacy systems.

The literature also introduced legacy systems, challenges with legacy systems, existing approaches to migrating legacy systems, and enterprise architecture's role in capturing current and to-be organization requirements that address the IT landscape's architectural design. This section also described the role of the IT architects.

Section 2 provides the project's detail, including the researcher, participants, qualitative method justification, population and sampling methods, ethical study conduct, data collection and analysis techniques, and study reliability and validity issues. Section 3 consists of detailed findings and describe applications to professional practice, implications for social change, recommendations for action, and future research.

Section 2: The Project

Purpose Statement

The purpose of this qualitative multiple case study is to explore the strategies IT architects in large enterprises use to modernize legacy systems. The population comprises IT architects in two large enterprises involved in legacy systems modernization projects, one in healthcare and one in the financial services industry in the San Antonio-New Braunfels, Texas metropolitan area in the United States. Large enterprises might use the study's findings to understand the benefits of having strategies to modernize legacy systems. This study's outcome may contribute to positive social change by being a factor in economic growth that arises from increased efficiency gained from the modernization of legacy systems.

Role of the Researcher

A researcher has many critical roles in qualitative research, including selecting participants, gathering data from participants, and analyzing data to develop different themes (Vindrola-Padros et al., 2020). In qualitative studies, researchers are ultimately the instrument by which information is gathered (Roller, 2019). As a researcher, my role in this case study was to engage participants in collecting data from them using in-depth interviews, analyze the data, and present the findings while minimizing any potential bias. I have assumed many IT roles during my professional career, including web developer, IT helpdesk analyst, database administrator, network administrator, Enterprise Relation Planning (ERP) technical analyst, and now enterprise architect. I became familiar with many systems, infrastructures, applications, and associated IT challenges

during this time. I was not involved in modernizing those systems but only supporting them. I have observed technology evolution and how IT organizations struggle to maintain legacy applications and supporting systems. As such, the enthusiasm toward modernizing IT systems and becoming familiar with IT systems helped provide a foundation for this research. I moved from Germany to the region around San Antonio, Texas, in 2006, and I have lived there since. I did not consider organizations I worked for in this study nor any nearby organizations. I had no current or past personal or professional relationships with individuals who work for the organizations in my study.

The Belmont Report outlines ethical principles and guidelines that researchers should adhere to while conducting studies involving human participants (U.S. Department of Health & Human Services, 1979). Belmont Report established basic ethical principles that include respect for persons, beneficence that maximizes benefits, and justice, fairness in distribution for each participant (Strauss et al., 2021). As critical components of ethical research, a researcher must provide excellent communication of the study risks and benefits to the participants and balance between the two to ensure that the participants have the absolute right to decline to participate and withdraw from the research (Nusbaum et al., 2017). I conducted this research to ensure the participants were fully aware of the interview process and treated them equally. I reviewed the participants' informed consent to express their wiliness to participate in the interviews and explained the risks and benefits before the interviews, as detailed in the ethical research section.

An explorative and qualitative study can be prone to bias. I set aside my knowledge and biases and ensured transparency. A researcher can minimize bias by using

multiple data sources, interviewing multiple participants, using an interview protocol, and implementing member checking (Birt et al., 2016; Ebneyamini & Sadeghi Moghadam, 2018; Thomas, 2017a). Yeong et al. (2018) suggested that interview protocol increases the interview process's effectiveness, keeps the researcher focused, and minimizes the risk of deviation and interpretation bias. To avoid bias in qualitative research, the researcher should be transparent about who they are and the research process and disclose their personal bias (Bradley et al., 2020; Ebneyamini & Sadeghi Moghadam, 2018; Galdas, 2017). Bradley et al. (2020) and Galdas (2017) suggest that researchers recognize bias to understand the findings' utility and implement intended actions to reduce bias. I made sure that the interview questions' wording did not reflect personal bias. I was transparent with the participants regardless of my IT skills. I used the interview protocol (see Appendix A). Following the interview protocol ensured that I remained neutral while all participants answered the same core questions. Castillo-Montoya (2016) considers developing a well-refined interview protocol an excellent instrument to engage in an interview, build the order, clarity, and quality of questions, and enhance the overall interview process. I followed the protocol not to induce bias. Sometimes, it was tempting to change the wording of a question or introduce inflections in questions that could have impacted the interviewee’s understanding and potentially result in bias in their replies. I consciously did not do this. Furthermore, I used the protocol in Appendix B to document observations during the interviews and field notes.

Participants

Research requires qualified participants who have a solid understanding of the subject. Researchers must consider participants who have experience and knowledge with the researched topic and best answer the research questions (Castillo-Montoya, 2016; Mueller, 2019). Reischer and Cowan (2020) stated that selecting participants in qualitative methods is essential to the research process, thus warranting those knowledgeable and have experience in the research subject would likely have much to offer to the research. Korstjens and Moser (2017) also emphasized the importance of selecting knowledgeable participants who can articulate and discuss the topic in-depth. The application of eligibility criteria in the study increases the generalizability and the validity of the findings (Averitt et al., 2020). Hanson et al. (2016) added that the eligibility criteria minimize the heterogeneity of the study. I employed the eligibility criteria that align with the topic of the study and the research question. For this study, the eligible participants must be (a) individuals that are full-time employees at two large enterprises located in the San Antonio-New Braunfels, Texas metropolitan area, (b) individuals who assume the job function of IT architects, (c) individuals that had been in architecture roles for a minimum of 5 years either in the current organization or previous organizations (d) individuals that worked on legacy systems modernization projects and (e) individuals with whom I did not have a recurring work relationship.

Professional social networking sites allow researchers to connect with IT professionals sharing the same interests. Researchers often choose social network platforms to gain access to potential participants (Gelinas et al., 2017; Peticca-Harris et

al., 2016). I used the professional media platform LinkedIn to search for potential participants for this study. I also used the platform to identify the IT leaders within the organizations. I initiated contact with the IT leaders via email, including the Organizational Agreement to Participate to review, explain the research topic, seek approval to conduct interviews within their IT organization, and ask if they can allow me to reach out to potential participants meeting the selection criteria. Two IT leaders provided a list of potential participants who met the selection criteria.

Researchers should address how to contact the participants and the meetings' locations and conduct the data collection process (Lawrence, 2020). I sent the participants the initial email explaining all aspects of the study, the research question, the scope, and how they would fit into the research. Informed consent is one of the critical elements in research when involving human participants (Biros, 2018; Dickert et al., 2017; Xu et al., 2020). Researchers must present an informed consent form to engage participants in a study (Cilliers & Viljoen, 2021; Xu et al., 2020). Nusbaum et al. (2017) suggest providing the potential participants with the consent form either in-person, via email, or regular mail. I attached the informed consent form to review and a signed copy of the Organization Agreement to Participate in the email. The informed consent form outlined what we discussed during the interview. I worked with the participants through email to agree on a time to conduct Zoom interviews.

Having a pleasant and respectful conversation, listening to participants, and having friendly interaction during the interview help build a rapport with participants (Bell et al., 2016; Prior, 2018). DeJonckheere and Vaughn (2019) suggested that the

researcher listen attentively and respectfully to the participant's information to build rapport. DeJonckheere and Vaughn (2019) further suggested avoiding jargon during the interview. I met the participants, greeted them with a smile, treated them equally with respect, and followed the interview protocol (Appendix A). I listened attentively and respectfully to the interviewees and avoided slang or jargon when speaking to the participants. I confirmed that each participant understood the nature and the scope of this study, the need for participation and anonymity, the moral obligation, and the benefit of participation. I then asked each individual if there were any further questions before continuing. It is essential for the participants to be comfortable with the researcher, know the researcher, and trust him by establishing a rapport (Alase, 2017). I asked each participant if they were comfortable before starting.

Research Method and Design

This section addresses the selected research method and design and justifies why the selected method and design were appropriate for addressing the problem statement. I selected the research method and design based on the research question and data availability.

Method

For this study, I chose the qualitative research method. The qualitative method provides a comprehensive understanding of complex problems (Alefesha & Al-Jamal, 2019; Chauvette et al., 2019; Li et al., 2018). Researchers use qualitative research to gain an in-depth knowledge of specific research questions that quantitative research can never answer (Arseven, 2018; Bradshaw et al., 2017; Chauvette et al., 2019; Hall & Harvey,

2018). The qualitative approach uses theory as a lens that shapes the research design, often uses inductive logic, and pays specific attention to particular individuals (Fan et al., 2020; Feng & Behar-Horenstein, 2019; Levitt et al., 2018; Wright et al., 2016). Aspers and Corte (2019), Chauvette et al. (2019), Collins and Stockton (2018), and Maher et al. (2018) stated that the qualitative method helps researchers engage participants in generating rich and contextual data. A qualitative method helped generate rich and detailed data from IT architects' experiences and knowledge.

Everyone has unique experiences and perceptions that shape what he believes about the world (Kesberg & Keller, 2018). Ontological (what can we know?) and epistemological (how can we know?) beliefs affect the research approach (Wright et al., 2016). Two of the significant philosophical paradigms and worldviews that researchers bring to the study and influence research endeavors are positivism and constructivism (Bhatta, 2018). According to Bonache and Festing (2020), researchers define the positivist paradigm as a paradigm that explains a phenomenon by searching for regularities and relationships between constituent elements. The role of the researchers following the positivist paradigm is to provide deductive explanations through generalizable quantitative approaches that they can measure empirically (Adom et al., 2016; Baur, 2019; Bonache & Festing, 2020; Park et al., 2020). According to Park et al. (2020), positivism aligns with the hypothetico-deductive model of science that starts with a theory to test hypotheses, design an experiment through operationalizing variables, and conduct an empirical study based on experimentation. Wright et al. (2016) and Park et al. (2020) indicated that positivist researchers produce knowledge through objective

measurements and quantitative relationships between variables. Nyein et al. (2020) stated that the positivist paradigm and quantitative methodology go together.

In contrast, the constructivist paradigm seeks to comprehend the phenomenon under study from the participants' experiences using different data sources (Adom et al., 2016; Alzaanin, 2020). According to Adom et al. (2016) and Bogna et al. (2020), researchers who adopt the constructivist paradigm tend to employ qualitative research methods to investigate the phenomenon. According to the constructivist view, Wright et al. (2016) indicated that the researcher creates knowledge by exploring beliefs, perceptions, and experiences of the world, often capturing and interpreting through observation, interviews, and focus groups. As a constructivist, I did not construct knowledge through objective measurements and quantitative relationships between variables. I employed the qualitative method to build knowledge through the experience of IT architects and represented the information I gathered rather than passively taking in that information. The qualitative method is more suitable for this study because it aims to understand IT architects' experiences. I am interested in detailed accounts about the reality that IT architects construct.

Åsebø et al. (2020) stated that the quantitative method aspires to quantify behaviors, opinions, and other variables and generalize statistical results. However, it misses the contextual details and provides less detailed accounts of human perceptions. Bradshaw et al. (2017) and Hall and Harvey (2018) agreed that quantitative research does not help researchers gain an in-depth knowledge of the phenomenon of interest. This study aims to gain an in-depth understanding of IT architects' strategies to modernize

legacy systems. The quantitative research method was an unfitting choice because of this study's exploratory nature and the absence of dependent and independent variables and hypotheses.

I also considered mixed methods. Mixed methods research uses qualitative and quantitative methods within a single study (Berman, 2017; Fàbregues et al., 2020; Timans et al., 2019; Venkatesh et al., 2016). Mixed methods researchers combine two distinct methods with added resources, expertise, time, and knowledge of quantitative and qualitative methodologies (McKim, 2017). Regnault et al. (2018) also indicated that the mixed methods approach draws inferences using quantitative and qualitative methods and researchers require qualitative and quantitative research experience. Guetterman (2017) stated that conducting mixed methods requires the researcher to be skillful and familiar with qualitative and quantitative methods. Pragmatism is the third paradigm that embraces both qualitative and quantitative approaches. Some researchers believe that integrating quantitative and qualitative research strategies does not fall comfortably within positivism and constructivism paradigms. According to Kaushik and Walsh (2019), pragmatism allows the researcher to move back and forth between induction and deduction while creating data and theories.

Given that I eliminated the quantitative approach as an option and lacked the expertise to integrate both methods, the mixed methods research approach was not appropriate for this study. Many researchers in academia have suggested that the mixed methods approach is time-consuming and labor-intensive (Almalki, 2016; Bracio & Szarucki, 2020; Sindhuri & Dongre, 2021). That was another reason for not selecting

mixed methods. Moreover, given the absence of measurable correlation, and the study relies on an in-depth investigation and examination of the problem statement, a mixed methods approach was not appropriate for this research.

Research Design

I selected multiple case study design over ethnography and phenomenology to address the research question. A case study can provide a vivid inquiry into a specific phenomenon through a case or multiple case. A case study helps elucidate or explore phenomena (Alpi & Evans, 2019; Arghode et al., 2017; Rashid et al., 2019). Harrison et al. (2017), Paparini et al. (2020), and Thomas (2017b) mentioned that a case study is an in-depth description and analysis of a bounded system that helps to study the complexity within real situations. This research is explorative and seeks to understand the cases and inquire in-depth about the modernization of legacy systems. Investigating similarities and differences among the cases' characteristics helps better understand a specific subject. Brink (2018) and Burrows et al. (2020) asserted that multiple case studies enable the researcher to understand similarities and differences between various cases. Ridder (2017) believes that replication logic is a characteristic of a multiple-case study and helps with a cross-case analysis that reveals similarities. Finding similarities and differences in IT architects' strategies to modernize legacy systems helped understand this topic. Therefore, the multiple-case study design is appropriate to explore strategies IT architects use to modernize legacy systems in their organization.

Another qualitative study design I considered is the ethnography study. Researchers use ethnography to study a cultural group of an environment or settings over

prolonged fieldwork and time (Kapofu, 2021; Morgan-Trimmer & Wood, 2016; Webster & Rice, 2019). Badu et al. (2019) also added that ethnographic design describes the daily meaning of the study's phenomenon within a societal and cultural context. This study aims not to study a cultural group of an environment or settings over a prolonged time. In the ethnographic design, participant observation is the core method by which the researcher becomes part of the phenomenon under study and shares the participants' daily lives (Harwati, 2019). Reigada et al. (2020) and Sagoo and Grytnes (2020) chose the ethnographic design to observe participants' daily interactions. Given the nature of the research topic and the research question, I did not share the participants' daily lives or observe them. Therefore, I decided not to choose the ethnographic design.

I considered phenomenological design as a qualitative design of choice. Daher et al. (2017), Van Manen (2017), and Willgens et al. (2016) assert that the phenomenological design focuses mainly on the study of an individual's lived experiences through a phenomenon. Kalu (2019) and Neubauer et al. (2019) assert that phenomenological design aims to provide a detailed examination of a phenomenon's lived experience through participants' perception of events. Tomaszewski et al. (2020) presented a similar description of the nature of phenomenology. According to Paul (2017), phenomenological design has two approaches descriptive and interpretative. I examined strategies IT architects use to modernize legacy systems, not their experience or perception. Examining strategies is explorative and not descriptive nor interpretative. As such, phenomenology was not appropriate to conduct this study.

The research design of this study is a multiple case research design. A multiple case study allows the examination and the exploration of processes, as Brink (2018) mentioned. Saunders et al. (2018) stated that achieving data saturation requires using the interview process to the point where the new themes do not contribute to the overall story. Fusch et al. (2018) asserted that using triangulation of multiple data sources enhances reaching data saturation. I leveraged the interview process to obtain rich information until no new information might contribute to the research. I also used the organizational documents protocol to get organizational documents and artifacts from IT management to reach data saturation. Dalglish et al. (2021) asserted that corporate materials such as documents and artifacts provide rich veins of insight into the phenomenon under study. MacLure and Stewart (2018) and Saunders et al. (2018) stated that the researcher keeps data collection until nothing new is apparent to achieve data saturation. Saunders et al. (2018) further explain that a researcher achieves data saturation if the interviewees begin to provide the same comments repeatedly. I interviewed all participants and scheduled follow-up sessions until no new information or new themes arose. Investigators go through cycles of collection and analysis. Researchers recommended reevaluating and reexamining interview data to confirm saturation (Vasileiou et al., 2018). Upon finishing data collection, I iteratively re-analyzed interview data. I collected data using open-ended questions in semistructured interviews with IT architects. I asked participants to bring any organizational documents and artifacts to augment and support the interview data. Fusch et al. (2018) asserted that integrating multiple data sources enhances achieving data saturation.

Population and Sampling

The study population is two teams of IT architects employed in two large enterprises, one in healthcare and one in financial services industries in the San Antonio, Texas, metropolitan area, who used strategies to modernize legacy systems. The IT management of the two organizations estimated the population of 16 architects at the financial organization and eight at the healthcare organization and eight potential participants.

The term population is all people or items potentially relevant to answering the research question, while sampling selects a segment of the population for investigation (Bhardwaj, 2019; Rahi, 2017; van Rijnsoever, 2017). Njogu and Muraba (2018) recommended using census sampling because the population size is very small and shares a distinctive characteristic(s). The distinct characteristics of the population of this study are the employees in large enterprise IT architects, and Census sampling involves all population members to become the research sample (Aropah et al., 2020; Sangadji et al., 2020). I used census sampling to get participation from all population members. Beverly et al. (2018) stated that selecting census sampling is best when the sampled population has a set of facets and qualities. I used census sampling to include the entire population based on the predefined selection criteria. I considered the non-probabilistic Snowball sampling, but Valerio et al. (2016) indicated that referral contact might not effectively identify different individuals and fear privacy or confidentiality. I chose not to use Snowball sampling. I did not consider probability or random sampling. Random sampling often applies to quantitative research and involves some probabilistic process to select

participants (Mbuagbaw et al., 2020). I do not seek to choose participants randomly, and this qualitative study's goal is not statistical.

Reaching data saturation is critical for this research to establish a good quality study and deliver information-rich findings (Tran et al., 2017). Lowe et al. (2018) indicated that achieving data saturation is by continuing data collection and not stopping until there are no new or relevant themes or supporting information. Hennink et al. (2019) also indicated that the depth in data is as significant as the number of interviews to achieve data saturation. According to Moser and Korstjens (2018), researchers carry more interviews to reach saturation in many cases. Nelson (2017) and Saunders et al. (2018) also asserted that further data collection is necessary until the information becomes redundant. Reaching saturation is when observing more data will not lead to discovering more information related to the research questions (Lowe et al., 2018). I kept conducting interviews, reviewing documentation, scheduling follow-up meetings, and performing member checking until additional data did not lead to new information related to the research question. Earnest (2020) addresses the follow-up interview as prolonged engagement, ensuring data saturation and testing for misinformation.

The health and safety of the participants are a top priority when conducting an interview. Due to Coronavirus disease 2019 (COVID-19) pandemic circumstances, many organizations have their workforce work remotely and commit to health officials' social-distancing practices. Dodds and Hess (2020) indicated that researchers should consider moving face-to-face interviews to online interviews due to the enforced social distancing. Internet-based communication methods allow researchers to conduct interviews with

participants using audio and videoconferencing across the internet via synchronous connectivity (Lo Iacono et al., 2016). Archibald et al. (2019) found that many participants prefer video conferencing for interviews due to convenience, privacy, and fewer possible distractions. I plan to conduct interviews through audio and video conference services with audio recording only unless participants prefer face-to-face meetings. Researchers perceive face-to-face interviews as the best approach as they represent a natural encounter where the interviewer interacts with participants while observing their body language and the environment (Irani, 2019). A good interview setting allows the researcher and participants to circumvent interruptions and get an acceptable clear audio recording (DeJonckheere & Vaughn, 2019). I worked with the participants to identify a quiet private meeting location that makes them comfortable and ensures their privacy to avoid any malaise and discomfort. I informed the participants of the time to allocate toward each interview session. Researchers inform participants how long the interview will last, and they can change interview times and dates at any time (Irani, 2019).

Ethical Research

While carrying out a qualitative study, the researcher's role is to ethically gather, analyze, and organize research data (Mozersky et al., 2020). Involving human participants in scientific research implicates various ethical concerns that researchers must address throughout a study (Salhia & Olaiya, 2020). To address those ethical concerns and ensure the participants' protection, I used informed consent allowing the participant to decline to participate at any point during the process. It is necessary to

obtain informed consent from each human subject before participation (Manti & Licari, 2018).

The informed consent process started with (a) an introduction to the study, (b) an invitation to participate, (c) a quick screen for eligibility, (d) discuss scope further, (e) assess the understanding, (f) participants will decide whether to participate or not and then (g) document the decision. The informed consent form outlined the study's introduction, description, the nature of the participation, potential risks and benefits, privacy and confidentiality, and their agreement to audio record the interview sessions. I informed all participants that their participation was voluntary. Informed consent should include a statement that participation in research is voluntary, probable risks and benefits, information about procedures to ensure data protection and privacy, including duration of storage of personal data (Manti & Licari, 2018). I asked the participants to reply to the initial email to acknowledge if they agreed to participate.

The adequate application of the three core principles in the Belmont which emphasize on: respect for persons, beneficence, and justice (Campbell, 2017; Kaye, 2020; Sng et al., 2016). The requirement to obtain participants' informed consent before conducting data collection is a conduct-constraining rule that has its foundation in the principle of respect for persons (Reis-Dennis, 2020). Andrews et al. (2018) added that the researcher should inform participants through the informed consent process and choose participation in research. Ploug (2020) stated that the informed consent process is necessary to protect individual participants against harm. In qualitative interviews, researchers should be communicating the benefits and the risks of research to participants

properly (Nusbaum et al., 2017). I provided an informed consent form to clarify that their participation is entirely voluntary to address these principles. They can request to withdraw from the interview at any time. Also, I addressed all the terms in the form. I explained that I protected their privacy by assigning labels such as Participant X rather than their name during the data collection and in the final study. I stored the two organizations and the participants' names in a separate password-protected file. I listed the benefits and risks of participating in this research. The interview questions did not cause any psychological risks; they are not embarrassing, nor offensive, or sensitive in any way. DeJonckheere and Vaughn (2019) indicated that an ethical attitude should include respect, thoughtfulness, and decorum towards participants during the research process.

The consent form includes details of the researcher's role, purpose, and benefits, the right to withdraw from the study at any time, incentives for participation, data retention and protection policies, and identity protection. I asked the participants to contact the researcher via email if there was a desire to withdraw from the study. The form also explains the voluntary aspect of their participation without compensation or any other incentives. I reduced the exposure to distress and discomfort by outlining the study's risks and benefits in the consent form.

Sometimes participants are hesitant and concerned about disclosing certain information and identity (Sim & Waterfield, 2019). In research, participant confidentiality means not to disclose what participants revealed during their involvement in the study without their consent while also protecting their identities (Surmiak, 2018).

The organizational agreement to participate and the informed consent form addressed the interviews' confidentiality and any documents and artifacts. I asked the participants to reply to the email if they accepted. I did not offer any incentive or compensation for the participants for conducting the interviews. The use of incentives remains a contentious ethical problem that might lead to a potential risk for undue inducement and coercion (Gagnon et al., 2020; Largent & Fernandez Lynch, 2017; Sansom et al., 2020).

I stored the collected data in digital and print form based on the data's nature in a fireproof safe lock. I will keep the data for 5 years from the date of final research approval to protect participants' privacy. I am the only person who has access to the safe lock. I stored the participants' names, organization names, and associated IDs in a separate password-protected excel spreadsheet. I stored all files in a password-protected and encrypted drive.

Data Collection

Instruments

In a qualitative study, researchers are the primary instruments, and they focus on constructing the interview questions that answer the research question (Majid et al., 2017; Ravindran, 2019). In this study, I acted as the primary instrument of data collection. Researchers can conduct semistructured interviews, meeting observations, and document collection (Alpi & Evans, 2019; Harrison et al., 2017; Rashid et al., 2019). Phillippi and Lauderdale (2018) added that taking field notes in a qualitative study enhances data and provides a rich context for analysis. Reflexive journaling serves as a way for researchers to document the methodological decisions throughout their research, insights, and

emergent issues they might face throughout the research (Bashan & Holsblat, 2017; Nowell et al., 2017; Orange, 2016). The sources of evidence for case studies comprise participants' interviews, supporting documents, archival records, and artifacts (Alpi & Evans, 2019; Awor et al., 2020).

I collected data through semistructured interviews with open-ended questions following the interview protocol presented in Appendix A. I asked the participants to bring any supporting documents and artifacts and collaborate with IT management to get any other documents about the legacy systems modernization. I also used a document collection checklist (Appendix C) to index any copies of any pertinent organizational documents and artifacts that explain the architects' strategies and procedures to modernize legacy systems. I took field notes through the interview observation protocol in Appendix B and kept records of the process throughout the research, relevant information regarding the schedules with each participant, insights, and key decisions using a reflexive journal. The checklist contained the participant ID, the receipt date, the document type, and the rationale. The capture of open-ended responses became straightforward with digital recording devices (Singer & Couper, 2017). I scheduled a Zoom video conference with audio recording only through an audio recording program. Archibald et al. (2019) consider Zoom another data collection tool, and the ability to record the interview is an advantage for researchers in terms of data management and security. The Zoom platform supports real-time audio and video and allows researchers to communicate with their participants, and it does not require an account to join a zoom meeting (Lobe et al., 2020). Recording the audio can eliminate the distraction of taking

notes by hand and concentrate on the interview more (Quiroz et al., 2019). A face-to-face interview was not possible due to COVID-19 restrictions by the two organizations. The face-to-face interview helps establish trust between the researcher and the participants (Kirchherr & Charles, 2018). Researchers consider trust relationships between researchers and participants paramount to successful research (Guillemin et al., 2018).

Researchers consider the interview protocol an instrument to ask questions about the studied topic and guide the interview (Castillo-Montoya, 2016). I used the interview protocol (see Appendix A) for semistructured interviews to help track the participants' activities, stay on topic, and guide their interaction during each interview. A consistent interview protocol minimizes the risk of interpretation bias and increases reliability (Forero et al., 2018). Yeong et al. (2018) added that the Interview protocol assists researchers in obtaining quality data. I used interview protocol and asked the participants the same questions in the same order to compare the answers more straightforwardly and improve the data quality. Butler et al. (2021) define member checking as a technique in which a researcher returns preliminary results to the study participants to confirm that the findings resonate with their experiences and provide further reassurance that those study findings accurately capture their perspectives. I conducted member checking follow-up interviews as another strategy to confirm the responses' understanding and improve the data's reliability and validity. Follow-ups sessions with participants are essential to ensure data quality (Sherif, 2018; Thomas, 2017a). To ensure the participants' willingness to engage in member checking interviews, I asked them during the consent process.

Data Collection Technique

There are different techniques of data collection in qualitative research (O.Nyumba et al., 2018). Researchers believe that primarily the phenomenon under study directs the way towards the appropriate research approach on the basis of research questions and the study's goal (Saxena, 2017). Through this study, I intend to explore in-depth the strategies IT architects use to modernize legacy systems. Hence, I employed semistructured interviews as the primary data source and collected organizational documents and artifacts pertinent to modernization strategies' legacy systems. Before starting an interview with a participant, the researcher must explain all study aspects (Levitt et al., 2018). After obtaining IRB approval number 10-05-21-0760766 and organization agreement to participate, I reached out to the IT management to provide a list of potential participants who meet the selection criteria. After contacting the potential participants, if they showed interest, I confirmed consent. I explained the purpose of semistructured interviews through the interview protocol form (Appendix A). I answered some questions the participants had and set times for data collection. I scheduled 60-minute interviews with each participant and ensured that the scheduled date and time were mutually optimal. I followed the interview protocol (Appendix A) with each participant. I took notes whenever there was a need to follow up on a specific question, or the participants used nonverbal signs while answering a question. At the end of the interview, I asked the interviewees if they had any further information.

IT organizations produce documents and artifacts, such as processes and information models and architecture sketches (Göran, 2019; Sajid & Ahsan, 2016). I

collaborated with IT leadership to provide supporting documents and artifacts through email. I indexed each document in a documents and artifacts collection checklist (Appendix C).

Member checking helps the researcher capture the participants' voices and ensure that the researcher is correct from the participants' perspectives (Candela, 2019). Caretta (2016) emphasized that member checking can help sort out any misunderstanding in data collection that triangulation might not address. Member checking is a widely used way of demonstrating rigor in qualitative research (Johnson et al., 2020; Smith & McGannon, 2017). I used member checking to validate the collected data during the interview by returning a transcribed interview to the participants to check for accuracy and ensure the data represents the participants' words and meaning. I scheduled a follow-up interview within two to three days of the first interview allowing the participants to review and discuss the data they provided during the interview and rectify or add any information I did not capture. I sought verification of the participant's approval verbally or through email. The member checking process allowed enhancing the rigor of the study and its reliability.

Data Organization Techniques

During the data collection process, I collected different information from interviews. A proper organization of the data can make the coding and analysis much more manageable. The collected data organization is one of the principles of quality research that adds credibility to the study and establishes content validity in qualitative research (Roller, 2019; Stenfors et al., 2020). Røddesnes et al. (2019) stated that NVivo

helps organize and arrange the data. I cataloged all collected data in a computer-aided qualitative analysis software tool (CAQDAS) NVivo and Excel The benefit of Nvivo is the ability to load data from different sources to use for coding and helps streamline data organization and analysis (Brower et al., 2019; Dalkin et al., 2021; Laranjo et al., 2020). Besides, I used external encrypted storage to organize the different files captured during the interviews. I digitized and destroyed any physical form, including field notes and reflexive journals. Then, I protected and encrypted all digital files with a password and stored them for 5 years. After 5 years of the study's completion, I will delete them permanently to comply with the requirements of Walden University.

Data Analysis Technique

In this multiple case study, the data collection methods are semistructured interviews and supporting documents and artifacts from participants and participating organizations' IT management. Triangulation means combining different perspectives on the studied issues (Flick, 2016; Vogl et al., 2019). There are different types of triangulations. Da Silva Santos et al. (2020) and Johnson et al. (2017) addressed different triangulation types: investigator, theory, data, methodological, and environmental. Researchers use triangulation when collecting data from various sources (Abdalla et al., 2018; Goffin et al., 2019; Orth et al., 2020; Renz et al., 2018). The different data sources help researchers study the same phenomenon using different times, populations, and places with the same method (Da Silva Santos et al., 2020; Vogl et al., 2019). Triangulation helps to ensure validity by comparing the collected data to reduce the chances of reaching false conclusions (Da Silva Santos et al., 2020; Vogl et al., 2019).

The triangulation facilitates the validation of data through the cross-verification of multiple sources. Celestino and Bucher-Maluschke (2018) considered triangulation a knowledge generation tool by searching, selecting, evaluating, and summarizing data from different sources by predefined criteria. Fusch et al. (2018) stated that triangulation adds depth to the collected data, and through it, researchers can mitigate bias and enhance achieving data saturation. Data triangulation happens when researchers use different collected data from different places, times, and populations (Natow, 2019). I used data triangulation to analyze the collected data from the semistructured interviews and copies of any pertinent organizational documents, artifacts, and reports that explain strategies or procedures architects use to modernize legacy systems.

Investigator triangulation is when various researchers do the analysis process together to enhance the depth of the findings (Archibald, 2016; Lemon & Hayes, 2020). This triangulation type is not appropriate for this study since I am the only researcher conducting this study. Theory triangulation is when researchers obtain the same results using different theoretical approaches (Da Silva Santos et al., 2020; Villarreal Larrinaga, 2017). This study did not use multiple theoretical approaches; therefore, theory triangulation is inappropriate. Researchers use methodological triangulation when using various methods simultaneously and doubt any given method's reliability (Da Silva Santos et al., 2020; Heesen et al., 2016). I used methodological triangulation since I gathered interview data and documents supporting the modernization strategies. Environmental triangulation is when researchers use multiple locations and various settings to determine which environmental factors may influence the research findings

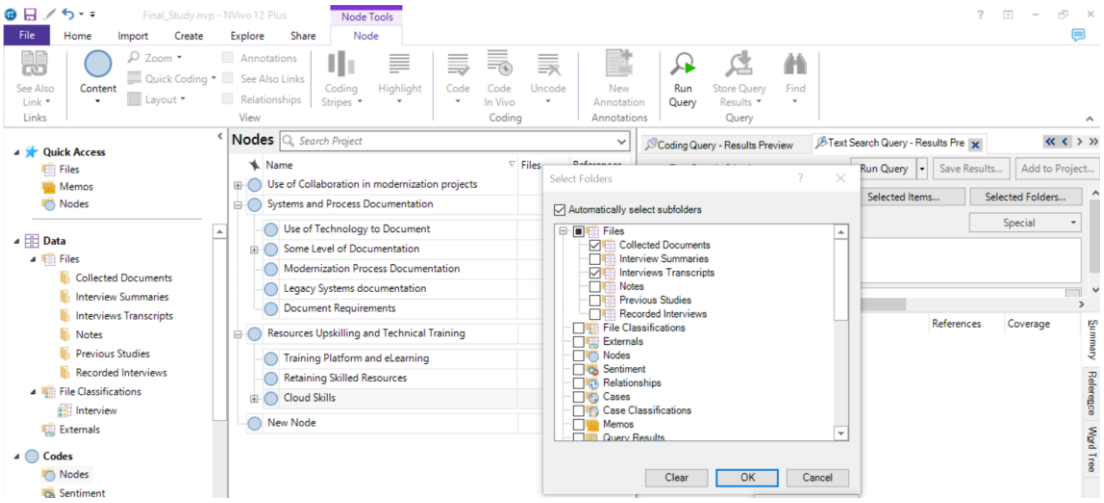
(Da Silva Santos et al., 2020; Fusch et al., 2018; Horton et al., 2018). The environmental triangulation is not appropriate for this study as it does not check whether the environment could affect the interview findings. I used data triangulation as a data analysis technique to compare and contrast data elements and help offer depth and reliability to the study. I used the interview protocol to ensure I asked the same questions to use data triangulation, methodological triangulation, member checking, and literature reviews to ensure data saturation.

I asked each participant to provide releasable documents and artifacts supporting the modernization strategies of legacy systems. I reviewed all supporting documents and artifacts to extract relevant information and audio-recorded all interviews. I used Microsoft Word to transcribe the recordings and validate them with Express Scribe Software. Some researchers use CAQDAS, such as NVivo, to organize, handle, and code data in qualitative studies (Brower et al., 2019; Dalkin et al., 2021; Laranjo et al., 2020). CAQDAS packages such as NVivo support an in-depth analysis of the large amount of data the researcher collected and assist researchers in reading and analyzing large numbers of texts allowing them to generate links and visualize relationships (O'Neill et al., 2018). I used NVivo 12 to analyze data and help identify and organize themes.

Figure 4 represents a screenshot of NVivo 12 Plus depicting the list of nodes and the search function.

Figure 4

Qualitative Data Analysis Computer Software NVivo 12 Plus



Note. From NVivo 12 Plus software illustrating the hierarchical themes and code structure, and text search query Nvivo 12 Plus features.

I performed thematic analysis. The thematic analysis goes through familiarization with the collected data, coding, identifying themes, reviewing themes, and generating thematic networks to create an interpretation (Bonello & Meehan, 2019; Young et al., 2020). The thematic analysis process involves familiarizing the data, developing initial codes, searching for themes, reviewing, designing, and naming themes, and producing the report (de Leeuw et al., 2019; Nowell et al., 2017). I used this thematic analysis process suggested by de Leeuw et al. (2019) and Nowell et al. (2017). I analyzed the data I collected through the lens of STS theory. As I went through thematic analysis, I developed associations within concepts and themes that align with the STS theory conceptual framework. I organized the literature review into different subthemes related to the STS theory technical subsystems such as collaboration tools, documentation tools,

and technical training resources, and the social subsystems such as the architects, the enterprise architecture team, project members, collaboration, and resources training.

I shared with the participants a concise and understandable summary of the interpretation of their input to verify the accuracy of their responses. In qualitative research, researchers conduct data analysis through four processes: data logging, anecdotes, data coding, and thematic network (Akinyode & Khan, 2018). Data coding or the development and use of codebooks are essential to demonstrate the research rigor (Roberts et al., 2019).

During the data collection and analysis journey, I monitored member checking results and any new information from interviews. I also reviewed the current literature for potential opportunities to correlate themes with recent findings from peer-reviewed publications.

Reliability and Validity

Reliability and validity are two critical considerations to meet with any type of data collection. The research approach's reliability and validity are essential to ensure evidence of the research's quality (Anufriyeva et al., 2021; Earnest, 2020; Hayashi et al., 2019). Using different data collection methods would boost triangulation's potential, increasing the research's validity and reliability (Da Silva Santos et al., 2020; Natow, 2019; VanLeeuwen & Torondel, 2018). In qualitative studies, total transparency and honesty of scientific findings to avoid bias are critical parts of the complete effort of trust in science and an ethical expectation (Kretser et al., 2019; Resnik & Elliott, 2016). It is beneficial to incorporate an audit trail and reflexive journal that provides transparency to

reduce research bias (Mackieson et al., 2018). I created an audit trail and recorded a reflexive journal accordingly. Johnson et al. (2020) asserted that identifying convergence of data. Being aware of personal beliefs and experiences also helps to mitigate bias. I used the same interview protocol (Appendix A) to moderate bias. A consistent interview protocol minimizes the risk of interpretation bias and increases reliability (Danese et al., 2021; Forero et al., 2018). Asking the same questions in the same order increases the interview's consistency, reliability, and validity. Qualitative data involves interviews, observed actions, artifacts, documents, and drawings (da Santos et al., 2021; Lê & Schmid, 2020; McDonald et al., 2019). I gathered data from different sources, including interview data, copies of pertinent organizational documents, and artifacts explaining strategies or procedures architects use to modernize legacy systems. Member checking helps expand the knowledge by giving the participants the chance to add to the interview and the interpreted data after their initial semistructured interview (Birt et al., 2016; DeCino & Waalkes, 2019; Thomas, 2017a). With that in mind, I used member checking by confirming the data's interpretation with the participants to establish the tenet of accuracy, credibility, and validity of the answers.

Qualitative researchers consider that trustworthiness is essential to evaluate the study's worth (Amin et al., 2020; Connelly, 2016; Galdas, 2017). Guba and Lincoln (1994) consider trustworthiness and authenticity the proper quality criteria of qualitative research from the constructivism perspective. Trustworthiness requires demonstrating credibility, dependability, transferability, and confirmability (Amankwaa, 2016; Connelly, 2016; Korstjens & Moser, 2017; Moon et al., 2016).

Dependability

In qualitative research, dependability ensures the findings' consistency and repeatability (Amankwaa, 2016; Forero et al., 2018; Nyirenda et al., 2020). To establish the study's dependability, researchers must clearly describe the decisions taken during the research process (Langtree et al., 2019). As I go through the research process, I write down notes during data collection and data analysis to keep relevant information regarding the schedules with each participant, insights, and methodological decisions. Amin et al. (2020) and Johnson et al. (2020) stated that strategies such as member checking, reflexive journaling, prolonged engagement, peer debriefing, and enabling an audit trail helps researchers increase dependability. Johnson et al. (2020) stated that researchers could improve dependability by reporting a detailed research method to inform the reader that the researcher used proper research practices. Forero et al. (2018) and Tsou et al. (2021) asserted that leaving an audit trail and reflexive journal increases the research's dependability. To help ensure dependability and consistency, I used member checking, lengthy interviews, audit trail, reflexive journal recording, and detailed research method reports such that future researchers can repeat the research.

Credibility

Credibility is confidence in the findings' truth (Amankwaa, 2016; Amin et al., 2020; Moon et al., 2016). Techniques that establish credibility include tenacious observation if suitable to the study, peer-debriefing, prolonged engagement with participants, triangulation, and member checking (Johnson et al., 2020; Kwak, 2019; Nowell et al., 2017). In rigorous qualitative research, the participants should provide

evidence to support findings (Maher et al., 2018). In interview-based studies that often convey key features of participants' experiences, researchers consider member-checking a proper validation technique (Amin et al., 2020; Thomas, 2017a). Triangulation can increase the study's credibility and validity (Amin et al., 2020; Renz et al., 2018). I consider using prolonged participant engagement, member-checking, and data triangulation to establish credibility.

Transferability

Transferability is the ability to provide others with the context which supports the research validity and influences the reliability (Hayashi et al., 2019; Korstjens & Moser, 2018). Transferability is critical to applying research findings (Forero et al., 2018; Moon et al., 2016). Nowell et al. (2017) suggested that researchers are responsible for providing in-depth and rich accounts of participants' interpretation to allow other researchers to decide whether the research findings are transferable or not. I documented in-depth and rich accounts of the participant's interpretation of the topic under study in field notes and the final study report. I also provided a detailed description of the research, and reaching data saturation might help establish transferability. Data saturation eases the transferability of the research findings (Forero et al., 2018).

Confirmability

Confirmability proves that interpretations of the findings are not figments of the researcher's imagination but from collected data (Korstjens & Moser, 2017). Confirmability extends the confidence that other researchers can confirm the findings (Forero et al., 2018). Audit trails refer to preserving all collected data related to the record

of procedures used to collect them and any data collection and analysis notes. I would use an audit trail that would consist of raw data, process notes, and all the research steps. Nowell et al. (2017) suggested keeping track of the development of themes in a codebook, including an audit trail, to help establish confirmability. Keeping a track record of the data collection process and considering the triangulation processes help assess the findings' confirmability (Forero et al., 2018). Data triangulation and maintaining a reflexive journal to establish an audit trail are the strategies I used in this study to ensure confirmability.

Data Saturation

Researchers choose participants with experience of relevance to the research question to ensure data saturation (Johnson et al., 2020; Moore et al., 2017; Moser & Korstjens, 2018). To achieve data saturation, the researcher continues recruiting participants and collecting data until no new codes and themes emerge (Sebele-Mpofu, 2020; Shabany et al., 2020). An appropriate sample for this study comprised IT architects with at least 5 years of IT architecture experience who worked on modernization projects. I interviewed qualified participants until saturation, whereby collecting more data would not achieve further insight. Fusch et al. (2018) and Johnson et al. (2020) asserted that integrating multiple data sources enhances reaching data saturation. I used various data sources such as interviews, organizational documents, and artifacts to improve data saturation. I used triangulation to compare and contrast the key findings across the data sources.

Transition and Summary

In this section, I outlined the purpose of this study to explore strategies that might apply to large enterprises trying to cope with legacy systems challenges and the cost of maintaining them. I chose a multiple case study design as a research methodology to gather pertinent information for this study. After collecting data from semistructured interviews, I used thematic analysis to generate, organize, and track themes with the computer-assisted qualitative software program, NVivo. I used triangulation, reflexive journaling, keeping, audit trail, and member checking procedures to ensure validity and reliability. I have also detailed the actions to warrant the participants' well-being, privacy, and protection. These actions align with the Belmont Report, the Walden University IRB procedures to comply with the ethical standards. In Section 3, I discuss the themes I analyzed and discovered after interviewing the research participants. I associate the findings with the current state of the research and the themes I identified during the academic literature review. I evaluate the research findings and describe their application to professional practice and implications for social change. I then present my recommendations for future research.

Section 3: Application to Professional Practice and Implications for Change

In this study, I focused on exploring strategies IT Architects used to modernize legacy. This section presents an overview of the study, research findings, their application to professional practice to affect social change positively, recommendations for action, suggestions for further research, a reflection on the research process, and a conclusion.

Overview of Study

The purpose of this qualitative multiple case study was to explore the strategies IT architects in large enterprises use to modernize legacy systems. I gathered data from semistructured interviews I conducted with eight IT architects from two teams within two large enterprises in finance and healthcare operating in the San Antonio-New Braunfels metropolitan area and from document analysis. I used member checking to validate the study findings. The findings reveal three themes pertaining to the IT architect's strategies to modernize legacy systems: collaboration in modernization projects, systems and process documentation, and resources upskilling and technical training.

Presentation of the Findings

The main research question for this study was: What strategies do IT architects in large enterprises use to modernize legacy systems?

The approach for addressing this question comprised conducting semistructured interviews to generate in-depth information from IT architects with an architecture team from a financial and two healthcare organizations located in San-Antonio-New Braunfels

metropolitan area. The semistructured interview helped to understand the different strategies IT architects used to modernize the legacy systems in their organizations.

The population comprised 16 architects at the financial organization and eight at the healthcare organization. Four from each organization qualified because they had a minimum of 5 years of architecture experience, had worked on previous modernization projects, and assumed the roles of systems/infrastructure architect, data/database architect, application architect, and solution architect. I initially excluded the other domain architects, namely security, information, network, and technical architects. The two teams are part of enterprise architecture practice, but none had architects with enterprise architect roles. Surmiak (2018) indicated assigning each interview participant a unique identification number/code to track progress and maintain privacy. I labeled each participant and company with a number. I assigned Participant 2, Participant 3, Participant 4, and Participant 5 to Company 1 and Participant 6, Participant 7, and Participant 8 to Company 2. I analyzed documents from each organization, including vendor best practices, communication examples, screenshots of presentations, and wiki content. I triangulated the semistructured interviews transcripts as well as organizational document reviews. Before the interview, I obtained consent from all the study participants via email expressing their willingness to participate. Each interview session lasted between 20 to 40 minutes.

I analyzed data and arranged them into themes using NVivo. I compared themes with the literature reviewed to establish relevance and consistency. STS theory was the conceptual framework I used in this study. Using Microsoft Word, I transcribed interview

data and uploaded transcriptions, research observations, and notes from interviews and documents, and interview audio recordings into NVivo. I kept notes as well to contribute to the research journal. Using NVivo, I stored the data based on data type to simplify the analysis, highlighted the themes, and conducted in-depth data analysis. Out of my analysis, the three main themes that emerged included: (a) use of collaboration in modernization projects, (b) systems and process documentation, and (c) resources upskilling and technical training. These major themes comprised codes that I used to contextualize the central themes.

Theme 1: Use of Collaboration in Modernization Projects

The use of collaboration with the project team and stakeholders was the first theme I identified during data analysis. The use of collaboration with project teams and stakeholders means building trust and goodwill and providing a solid foundation for modernization projects with stakeholders to work and collaborate towards mutual goals and objectives using collaboration tools such as teams, online meetings, and wikis. All participants indicated that collaborating and communicating with project team members stakeholders are part of the modernization projects strategies. The illustration in Table 2 highlights one of the major and minor themes attributed to data analysis: the use of collaboration in modernization projects.

Table 2

Minor Themes of Use of Collaboration Modernization Projects

	Participants		Documents	
Major / Minor	Count	References	Count	References
Use of Collaboration for Modernization Projects	8	38	3	9
Communicate and Engage with Project teams Regularly	8	14	1	1
Establish Review Board	4	8	3	6
Use online tools to collaborate	8	10	1	1

Overall, most participants agreed that regular communication and engagement of stakeholders and team members is critical to the team's collaboration in modernization projects. The responses from the participants indicated that they engage team members and stakeholders to make them aware of the state of the IT ecosystem. Their views were consistent with the findings of Gregory et al. (2020). Recent literature confirms that project teams and stakeholders must recognize the importance of collaboration (Department of Defense, 2019). Lin et al. (2021) highlighted that collaboration and communication are critical factors influencing enterprise system implementation. From an enterprise architecture perspective, architects produce artifacts reflecting certain planning decisions collaboratively with stakeholders, never by themselves alone (Kotusev & Kurnia, 2020). The modernization project type dictates the level of collaboration. Sovacool et al. (2020) defined the level of collaboration as the extent of significant

cooperation between the involved parties. Earning stakeholder trust requires collaboration through various formal and informal communication channels (Bond-Barnard et al., 2018). For example, Participant 3 emphasized the importance of stakeholders' good relationship and stated, "Modernization of legacy systems if not done in a vacuum, it is probably driven by good relationships with stakeholders upfront." Similarly, Participant 8 highlighted the importance of communication and maintaining a good relationship with stakeholders:

> My stakeholders, for example, in host platform services. I am in contact with those on a daily basis. …. It is vital and essential to have the stakeholders involved because, number one, they have the money. Architects do not have any money. All we had was the influence, you know, we are spending their money. So yes, it is beyond vital that you have a very good relationship with your stakeholders… They have been walking with you along through it, you sat down, until you get their approval, and move forward, you know, you have had to develop that relationship with the stakeholders.

Participant 4, as a solution architect who worked closely with the business and started to embark on a multi-year modernization journey, proposed the need to collaborate with and engage the stakeholders in modernization projects from day one. Participant 3 suggested having dedicated architecture teams who focus on research and proof of concept (POC) efforts collaboratively and communicate every step with the stakeholders before deciding which direction they need to take. Participant 8 suggested helping stakeholders and

decision-makers through collaborative education understand where the legacy system impedes their business from a risk perspective or the competitive advantage position.

Participant 1 stated that they engage stakeholders as early as possible, and often those stakeholders drive the modernization efforts. Collaboration with stakeholders is a must to understand better requirements and how to meet expectations:

> Their engagement is not optional… So, their engagement would be extremely early. We are having discussions about what we are intending to scope, what direction was intended on going, understanding requirements, document and understand how we are going to satisfy a set of requirements. (Participant 1)

Participant 5 mentioned the need for collaboration with the product owners, primary support team, development team, and business stakeholders to identify deficiencies and business future needs and goals. Participant 5 highlighted to focus on transparency, collaboration, and making fact-based and group-based decisions as he stated:

> It is very easy to look at the elephant in the room and think I am not only bringing people with me because it is just going to be someone to make decisions, but the reality is tackling the elephant in the room. It does take a village. It takes the entire team.

According to Nugroho (2018), the more interactions occur, the greater the likelihood of knowledge sharing. Participant 6 highlighted the importance of collaboration among a larger audience, stating:

> Say there is strength in numbers, the more people you can get to have and share your vision and to drive forward that work for you, share the load, the burden, and

> start converting that culture, the easier your job will be and the more it will be successful... You will start to see changes.

Participant 7 collaborates with a centralized architecture group and has to go through the organizational structure to regularly seek feedback from other stakeholders. From the end-user feedback perspective, Participant 7 brings in a technical analyst to relate technical information and brings in a business analyst to bridge gaps.

The COVID-19 pandemic caused a rapid shift to full-time remote work for many IT workers and resulted in online meetings for collaboration and communication (Yang et al., 2021). From the collaboration tools perspective in Company 1, all participants use mostly emails and online meetings to communicate and collaborate. They also use an internal online wiki to share knowledge between the architecture teams and the stakeholders. Eliche-Quesada et al. (2021) consider Wiki a computer-supported collaborative learning tool to support online collaboration. Most participants suggested that wiki positively supports knowledge sharing and collaboration by making critical information more accessible during modernization projects. Company 2 uses Microsoft Teams, Emails, Quickface, and other online meeting tools to collaborate. Participants 1 and 8 indicated that before the pandemic, they often had informal conversations and collaboration in the hallways with stakeholders by which architects received feedback from them.

Some participants touched on the role of a collaboration with a review board as they are part of a review board that their organization had recently created, comprised of architects, subject matter experts, and stakeholders that collaborate with the business and

the technical teams on any technological or process change and provide guidance. A recent study by Bui (2017) confirmed the need for collaboration with the review board that consists of critical functions to approve standards and provide guiding principles. Most participants believe it is crucial to collaborate with project stakeholders, balance stakeholders' needs and interests, and ensure that all parties pull together and support the modernization efforts. This aligns with Gellweiler (2020), who described the role of IT architects who perform tasks such as building relationships with team members and business stakeholders and taking the leadership role in robust business-IT relationships. Pańkowska (2021) noted that organizations use EA model framework guidelines to analyze collaboration views that reveal information and exchanges among the different team members and between the enterprise and its partners. Some researchers refer to collaboration as a key process between shared attitudes and productivity (García-Buades et al., 2019).

Most participants agreed to choose the right tool to collaborate. Besides Email and online meetings, Wiki was one of the main practical collaboration tools, and Microsoft teams were second. Wiki technology provides opportunities to foster collaborative writing and enhance confidence in technological ability (Luo & Chea, 2020). Testing technology is also done collaboratively between the project team members and stakeholders. The findings of Otaduy and Diaz (2017) showed that a Wiki platform could facilitate project team members to perform testing and collaborate.

Participants 3 and 8 reported good relationships with stakeholders to drive legacy systems modernization projects, and it is beyond vital to have such a good relationship.

Participant 8 stated, "I spend a lot of time, and sometimes it is sort of education, bring the stakeholders along to see the point where you are." Participant 4 added, "We have got to have all those stakeholders and users be part of the process from day one." Likewise, Musodza et al. (2021) reported that besides building buy-in, stakeholder involvement from day one could positively impact the project by incorporating different ideas and knowledge. I found that participants think that great relationships are built through one-to-one conversations to get feedback and find out more about what makes each person tick.

The STS theory, which guided this study, supported the findings from participants and this theme. Based on the sociotechnical framework, the activities of the modernization projects enhanced the relationship between participants and stakeholders, such as regular collaboration to align IT direction and resources and organizational impact of new technologies. This aligns with Jin et al. (2021), who considered stakeholders and technologies mutually constitute a socio-technical system. Also, it aligns with Hole (2021), who explained that in the context of STS theory of software and stakeholders, there is a fundamental proposition for stakeholders to help deploy software based on stakeholders' requirements and specifications. García-Buades et al. (2019) linked sociotechnical theories to other attributes that contributed to human aspects, such as positive attitudes that trigger productivity-related behaviors, which lead to organizational performance.

Researchers agreed that modern technologies such as collaboration tools affect IT modernization project success factors in recent literature. There are not many research

studies that address this theme in a similar setting. Some researchers recognized collaboration tools as technologies that support team members' cooperation (Zorić et al., 2021). In IT practice, Muthucumaru (2021) found that collaborative technology can preserve the values of organizational culture, like procedures, hierarchies, and accountability. Muthucumaru (2021) also added that collaboration tools allow every member of the IT project team to contribute to the development of the project and address problems.

Theme 2: Systems and Process Documentation

The theme of the importance of systems and process documentation in Modernization Projects was the second theme to emerge during the data analysis phase of the study. The coding categories that make up this theme included documentation of systems, documentation of modernization process, and documentation tools. Documentation of systems and processes means that in order engage in modernization projects, and architects use documentation tools to capture all the technical components of the new and legacy systems, the current architecture, and how the modernization process would look. The documentation can be in digital media, an online presence such as wiki, or a document management system like Microsoft SharePoint. van Laar et al. (2017) suggested effectively communicating knowledge to different audiences using digital media and online formats. The foundation of any future architecture initiative must be adequate documentation of the legacy architecture (Gong & Janssen, 2019). According to Gong and Janssen (2019), the as-is IT architecture serves as an input to build the to-be IT architecture. The process of architecture documentation can contribute

to an improved understanding of the organization and its components (Niemi & Pekkola, 2020). Some organizations adopt a centralized library and repository of documents of the current architectures and the applications and systems subject to modernization to locate and process the information about the application in the future.

Table 3

Minor Themes of Documentation in Modernization Projects

	Participants		Documents	
Major / Minor	Count	References	Count	References
Documentation in Modernization Projects	8	25	4	4
Modernization Process Documentation	7	5	3	2
Legacy Systems Documentation	8	10	3	2
Use of Technology to Document (Wiki, SharePoint)	8	9	2	2

The concept of adequate documentation was prevalent throughout the data. All eight participants commented on the importance of good documentation. When I asked, "to what extent have the IT architects and the IT organization documented the process of legacy systems modernization?", participant 2 noted that the last three years, the IT organization had done a lot more documentation, and they had very minimal documentation for legacy systems. Participant 2 stated that the older architectures, both from architecture and infrastructure management perspectives or operations perspectives,

are not documented very well, but the newer architecture are very well defined and documented. Participant 2 also mentioned that when it comes to legacy systems documentation, there is a lot of tribal knowledge. Participant 2 added that moving to newer architecture is no longer reliant on that knowledge. Participant 3 stated that the documentation of legacy systems was more specific to know individual teams supported those environments. It was left up to their interpretation, documentation, and how the individual units supported those legacy systems.

Participant 4 stated that before beginning a modernization journey, they go through internal processes and document the application or system to modernize and work with partner professional services partners such as KPMG, Price Waterhouse Coopers, and Deloitte and produce documentation of the initial engagement. Professional services firms such as PwC are knowledge-intensive firms (Harvey et al., 2021). Large enterprises create roadmaps for systems modernizations and digital transformation, and the implementation of modern technologies (Cotrino et al., 2020). Participant 2, Participant 7, and Participant 8 noted that they create roadmap documentation to keep track of various improvements.

Interestingly, in Company 1, Participant 3 and 2 noted that regulatory compliance requirements recently drove the documentation. Standard compliance in information systems means respecting standards, laws, and regulations that apply to services from different sources and various levels (Bicaku et al., 2021). According to Participant 2, Participant 3, Participant 4, and Participant 8, documentation was probably always a requirement and is precise and consistent. Participant 3 added there had been great strides

to adopt standard documentation requirements, and the information relevant to the legacy systems is well understood, from a compliance adherence perspective, that is standardized across all the organization. Participant 3 added that they focused on ensuring that across different units within the organization that there is consistency that they can go to any legacy system, regardless of whether it is Mainframe or if it is at the application layer or any of our other legacy environments that documentation and processing procedures are consistent. Participant 6 noted that documentation is more feature and specific technology-centric and cannot be reusable. Participant 6 added that they recently standardized forms and documents with the same look and feel as the organization grows. Participant 5 noted that documentation is hard to maintain; it is easy to say that they should document everything due to leadership and resource change or onboarding new resources. Participant 5 further suggested integrating documentation in the change process, having a firm and well-defined documentation step, and maintaining the documentation. Participant 6 suggested incorporating documentation into the software development lifecycle during each phase.

Documentation is paramount as it facilitates the software development process (Cummaudo et al., 2020). All company 2 participants referenced using best practices of Azure cloud adoption plan. Participant 5 shared Document 1, the Microsoft cloud adoption plan template used to document a cloud migration project. Participant 5 also shared Document 2, “cloud adoption framework for Azure,” emphasizing that documenting and establishing the cloud strategy will help stakeholders and IT understand the benefits of migrating to a cloud solution.

Participant 5 noted that in most IT projects, documentation gets cut off due to the delivery timeline. A study by Kasauli et al. (2021) confirmed another study by Rahy and Bass (2020) that documentation slows down development in IT projects, and organizations try to cut on documentation to speed up the delivery. Participant 7 consumes 40% of his time on documentation. The level of detail in architecture, systems, and process documentation depends on the audience. Participant 7 explained that he uses two different levels of documentation, one high level for C-level audience that provides the high-level picture about a solution and the second one the next layer down for Vice Presidents and Directors audience that might cover logical systems configurations, software versions, systems requirements, data transportation models and authentication models.

All participants noted the need for a documentation repository or library. Participant 3 indicated a centralized repository from a technology portfolio perspective to reference where IT architects and staff find documentation. All participants from company 1 mentioned the use of architecture artifacts. The author in document 9 explains how to document the different artifacts and why and when to create these artifacts. According to document 9, the artifacts comprise an Architecture overview that includes an ecosystem of tech capabilities and tools, system context (systems and people), architectural views, diagrams and models, non-functional capabilities such as critical system qualities, technical viability assessment that covers risks and mitigations, and then architecture decisions. Participants 2 and 4 explained it as a wiki document that covers the functional requirements, risks, overall architecture, and how it will look in the future.

It also lists some of the technology decisions to deal with specific technology. Participant 4 shared how the architect can create and export the artifact document during the interview. He could not share a real example due to third-party non-disclosure restrictions.

Company 2 uses the Prosci ADKAR model to document the modernization process. The ADKAR model outlines five building blocks that an individual must address to change successfully: Awareness of the need for change, Desire to support the change, Knowledge of how to change, Ability to demonstrate new skills and behaviors needed for the change, and Reinforcement to sustain the change (Wong et al., 2019). According to Document 4, Awareness makes the employees aware of the coming change; Desire builds upon awareness and explains the "WHY" driving the change. The third is Knowledge, building upon desire and explaining the WHEN, WHO, and WHERE. The fourth building block is Ability, which builds upon knowledge and explains the HOW behind the change. The last building block is Reinforcement which is a crucial step that builds upon all prior framework components and reinforces the need for change. In this stage, architects can assess what worked and what did not and learn the positive outcomes of the change through success stories and testimonials.

STS theory concerns the interaction of people with technology, and interaction of architects with systems, architecture, and processes documentation is one of the primary concerns during legacy systems modernization projects. Legacy systems documentation provides an overview of the system and helps project teams and stakeholders understand the underlying technology.

The findings of this study demonstrated that documentation in modernization projects is in alignment with existing literature. Santos et al. (2018) agreed that documentation generation is critical in software refactoring for system modernization. Dunn et al. (2021) mentioned that documentation assesses the extent and accessibility of information using a particular data or product. With legacy systems, documentation is often missing or outdated, and source code is the only reliable source of information about a system (Vijaya & Venkataraman, 2018). Kaur et al. (2017), Liang et al. (2017), Satish and Mahendran (2019), and Sneed and Verhoef (2019) all agreed that having appropriate documentation of legacy systems helps understand the complexity of these systems and decide which modernization route to take.

Some of the participants acknowledged the lack of documentation of most legacy systems. They praised the idea of developing a set of standards and processes for the future to require documentation of processes, systems, and architecture. Hollmann et al. (2020) believed in well-crafted documentation such as standard operating procedures necessary for reproducibility and traceability. Participants from Company 1 all mentioned that their organization developed a set of standards and processes that help document systems, architectures, and procedures. Most of the time, the documentation is a compliance and regulatory requirement.

There is some alignment between the findings in this research and STS theory. Systems and process documentation involves IT architects and other project team members as people, organizational guidelines and requirements as organization subsystem, and legacy systems and documentation tools as the technical subsystem. An

ideal tool for documentation, most participants, suggest using an online wiki. They are moving away from static documentation tools, such as Microsoft Word documents, and uploading them to SharePoint. According to most participants, the wiki is a powerful documentation tool, and they can set up automation to generate documentation within the wiki. This aligns with other researchers' findings. Theunissen et al. (2022) noted that some researchers prefer wikis due to their simplicity, flexibility, and open collaboration. Company 2 uses a wiki to generate architectural artifacts, as discussed above, dynamically. There is always the human factor that plays a role in creating the documentation. According to some participants from effective IT practice, that time for documentation and prioritization is a challenge in IT projects.

Theme 3: Resources Upskilling and Technical Training

The next theme to emerge during data analysis was the need for resources upskilling and continuous training to engage in modernization initiatives (see Table 4). Wahab et al. (2021) define resource upskilling as the procedure of training resources a new skill. There is a need to bridge the skills gap during modernization projects in this context.

Table 4

Minor Themes of Upskilling and Technical Training

	Participants		Documents	
Major / Minor	Count	References	Count	References
Resources Upskilling and Technical Training	8	104	3	13
Cloud Skills	6	10	3	2

Training Platform and eLearning	8	20	2	2

Architects, engineers, developers, and project team members must be trained on new technologies to ensure they engage in a modernization effort. Mitropoulos and Douligeris (2021) strongly recommend training for the capacity building of enterprise staff. Technical staff who will implement new technology should receive adequate training during the designing, creating, and testing of the system (Gitelman et al., 2018). Most participants discussed the need to align the architecture core team's skillsets. All 8 participants from the two participating organizations agreed that upskilling and training are essential to start a modernization journey. Document 2 shows that Company 2 just started a training platform for their IT staff as proof of concept of an internal training platform. Analyzing the link cited in Document 2, the platform provides different classes and training materials by product brands like Amazon (AWS), Salesforce, VMware, RedHat, etc. IT functions such as IT management and leadership, security, networking, etc. cloud, and project management. Company 2 offers external and internal training, as Participant 4 described it, to keep the IT resources fresh on their skills on technology and added that top performers take advantage of this.

Participants 2, 3, 7, and 8 mentioned that they do a lot of research and education on new technologies. Participant 8 stated, "From an architectural perspective, we have continuous training and then of course, within our domains, we are open to continuing to be in training especially on what is next type of things with technology. We spend most

of our lives in training." Participant 3 responded. "There will be a series of training for the technology. There is, you know, every effort is taken to ensure that, you know, that these teams have the proper education, the proper tools…". Document 7 is a snapshot of an internal wiki that provides links to training, and each training has a hands-on labs activity to learn. Participants 2, 3, and 7 learned new technologies through proofs-of-concept and labs.

Participant 7 is a hands-on type of architect who stated in terms of learning new technologies, "These types of processes are not always easy because they are often modern, and they are not in your environment. It could be hosted in other areas, or it could be very limited in scope. So, I go into that type of approach, getting my hands on it knowing that I may or may not succeed, or my level of quality that I expect to get out of there will be low-medium. And I go into that type of learning and increase my skillsets inside of there and take as many wins as I can and do not worry about the things I cannot change or modify." Participant 2, however, does proof of concepts but with engineers' help and gets involved in the details. Participant 2 stated, "I am not going to be in the weeds, you know like I need to know enough, but there is going to be an engineer and subject matter experts." Participant 2 continued by saying, "As an architect, I can learn these things, but also the engineers have to know these things right. So, while we are doing research, we involve the engineers as well. But in the end, they will be the ones that are managing these things." The training involves various technologies, including legacy, when architects recommend refactoring as a modernization approach.

All participants of Company 1 noted that one of the challenges for mainframe environments comes with the shrinking talent pool of those well-versed in supporting them. Company 1 provides extensive internal technical training of the mainframe systems for technical talent. Interestingly Participant 5 stated that skilled resources are not readily available, and the expertise in-house gets locked into just a particular product or technology. It is costly to train and maintain their certifications. Participant 5 suggested providing training right before the modernization project or initiative starts to benefit from the training; otherwise, learned knowledge might get diluted and a retrain is necessary.

Vendor training, in-house training, and peer-to-peer learning could lead to enhanced IT and non-IT skills (Alsabahi et al., 2021). Participant 6 states, "I always prefer vendor training over non-vendor training. If I am working with a vendor, they will take the time, and they will be knowledgeable and know what their product should be doing and should not be doing. But otherwise, if it is like homegrown stuff**,** if you are moving to a cloud provider or whatnot, you know, again, I do not try to be a master of all cloud providers." Participant 2 stated, "we have a lot of relationships with vendors and lot of times I am learning about these technologies that are maybe three or four years out. But, you know, I am kind of hearing of them when they are getting built… If I am intrigued by something, then I start asking the vendor for more information." Participant 4 stated, "We partner with external organizations and contractors and to be that solution help us partner with that modernization solution, so they bring their own good skill sets into play when we select our firm that will help us with that." This aligns with

Fahrenbach and Luomi-Messerer (2021), who stated that acquiring learning outcomes can be through different learning settings (formal, non-formal, and informal). It also aligns with Document 7 on sharing existing documentation by the vendor where it makes sense. Some participants lean toward formal technology learning to hone their technical skills and prepare for modernization projects through vendors and partners, some through community forums, online materials, and some through proof of concepts and experimenting with technology in a lab environment.

Based on sociotechnical systems theory, learning to address the human and technical elements during modernization projects simultaneously is the purpose of training (Pasmore et al., 2019). The two organizations in the case study set up labs and learning spaces for the architects and other IT staff to interact with systems and technologies to learn and assess. If workers within the organization are given the appropriate means and utilize them, they can reach the expected outcome of technology modernization.

Applications to Professional Practice

IT architects should consider different strategies to modernize legacy systems. This study identified strategies IT architects could use to modernize legacy systems. These strategies include collaboration and establishing a collaborative environment, systems and processes documentation, upskilling resources, and training. The IT architect should highlight the importance of collaboration and align collaboration with the team's goals. IT architects need to ensure the architecture team, engineering team, and various

stakeholders understand the usefulness and relevance of documentation of the current architecture and its components.

Modernizations projects should rely on collaboration between architects, multiple departments, and business units inside and outside IT. Regular communication could help address any issues around getting critical stakeholders on the same page. IT architects should check the preparedness of the IT organization to take on a modernization initiative. The architecture team should constantly get stakeholders' feedback, involve them early, and keep them informed.

IT architects document the as-is architecture and to-be architecture and a process before beginning a modernization initiative to deal with unanticipated scenarios. Implementing new technologies is just one part of IT modernization; it is equally mandatory to ensure that support staff and end-users know how to use the latest technology to their full advantage. Even the engineers, architects who are innovation-minded individuals will feel uncomfortable adopting new solutions without adequate preparation and training. Appropriate training supports technological innovation, but technological innovation also facilitates new approaches to training. In 2020, traditional in-person learning was limited due to the COVID-19 pandemic. While this abrupt change was often challenging, it also led organizations to refine many emergent approaches to training, including online learning. As a result, training programs are more versatile, engaging, and audience-centric than ever before, increasing the likelihood that learners will internalize the information presented throughout the training experience.

Implications for Social Change

This study aimed to provide an understanding of the strategies IT architects teams used to modernize legacy systems. Organizations can benefit from effective collaborations, good relationships with projects stakeholders, systems and processes documentation, and adequate training and resource upskilling. Socially responsible large enterprises will provide better service to the community and more support. This research might positively impact IT and the business, resulting in positive social change for the people and communities. The collaborative mindset allows addressing issues by bringing together individuals with diverse backgrounds and different perspectives and skills.

Communicating with stakeholders early and often, so they fully understand the benefits of your project helps build that trust. Engaging stakeholders has many advantages. Having stakeholders on board with the modernization efforts makes a big difference in political and moral influence. In large modernization projects, architects involve many key stakeholders, which helps establish the organization as transparent and ethical. The collaboration allows people to develop trust, build positive relationships, and put more ideas on the table.

Recommendations for Action

I explored IT architects' strategies to modernize legacy systems in two large enterprises. The study findings showed that an IT team that focuses on architecture and legacy systems documentation promotes collaboration and relationship management. It also helps their resources learn new skills and take training to engage in a modernization journey. IT architects should collaborate with their teammates, stakeholders, vendors, and

business SMEs from day one of the modernization journeys. Collaboration always brings new ideas to the table and facilitates a greater understanding for the project stakeholders. Each IT architect team can assess the strategies and use them if they have legacy systems to modernize.

In general, this study might be beneficial to IT architects, enterprise architecture practices, key stakeholders, and the enterprise architecture community. The findings from this study will be available through different means. First, I will communicate a high-level summary of the results of this study to the research participants via email. Second, ProQuest will publish the study in its database. The publication will be available to other academic scholars to download and review. Wherever possible, I intend to share the research results using effective and appropriate platforms such as my workplace, conferences, trade journals, and training seminars. While this study did identify strategies to modernize legacy systems in large enterprises, more research is needed.

Recommendations for Further Study

Several limitations of this study suggest further research. The research method of this study has imposed limits on the results due to the chosen design, participants, organization, data collection, and other aspects of the study. The first limitation was that the data collection was limited to interview questions and fewer organizational documents. Financial and healthcare organizations have intensified security scrutiny. Data loss prevention controls prohibited participants and management from sharing all pertinent documents. I recommend additional qualitative studies with expanded data collection, including focus groups, standards documents, and observations.

The study findings were limited to infrastructure, application, data, and solution architects due to the restricted participant criteria of the study population. Additionally, this study was limited to two small IT architecture teams within two large enterprises in San Antonio-New Braunfels metropolitan area. I recommend further qualitative research studies that include more than one team per organization, other industries, and locations. I recommend additional qualitative studies exploring the perceptions of enterprise architects, technical architects, business architects, and other domain architects involved in system modernization projects. Finally, this study was limited to two small IT architecture groups restricting the generalizability of the results outside of the two case organizations. I recommend quantitative research to determine if the results of this study are generalizable outside of the two small teams from two case organizations from two different industries.

The study findings also indicated areas that warrant additional research. The study findings highlighted the significance of collaboration in modernization projects but did not explore the processes and observe a live example of collaboration during modernization project phases. Additionally, the training was also significant, but the study did not examine the contents of training material and observe the skill development process. I recommend further research to explore the skill development techniques. During one of the interviews, A participant noted that in-house training material is not available, pushing experts to get content from other locations. I recommend further research to explore ways for large enterprises to provide adequate training to identify the gaps.

Reflections

I entered this doctoral study avid for research but with a bit of hands-on comprehension of the necessities of such a program. I experienced different challenges as I went through the various milestones. The doctoral study process was a journey filled with obstacles but also enlightenment. However, to be able to manage this program and avoid repetitive mistakes are crucial to success. Each time I make a mistake, I learn from it and go to the next task. I carried on and enriched my knowledge in the process. During this program, I acquired skills in conducting ethical academic research, analyzing research, and how research exert influence on others.

This doctoral study helped create the opportunity to become a researcher. I enjoyed the journey, and it will hopefully mean that I spring up again better prepared to walk out into the world and explore new opportunities.

I spent more than 15 years in IT. I understand the role of documentation, continuous training, and collaboration in IT projects and the benefits of modernizing deprecated systems. The ethical research training helped a lot in understanding the pitfalls. I avoided any personal bias at all costs, and I did my best as it is easy to unintentionally bias the research. I remained neutral during my interaction with the participants to not impact the results. I acknowledged potential biases during the interview recording, the interpretation and analysis of the data, and throughout the whole process when possible.

Summary and Study Conclusions

Legacy systems modernization projects are typically one of an organization's most essential investments today, yet they are also most likely to fail. Legacy systems modernization projects require consistent engagement with stakeholders and collaboration with the project team members, detailed documentation of systems, architecture, and processes, and most of all, a skilled team of architects and professionals to manage every facet of the modernization effort.

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Appendix A: Interview Protocol Form

Research Basis: Explore strategies to modernize legacy systems.

Date and Time:

Organization ID:

Interviewee ID:

Step 1	The consent form, privacy document signature	Pre-interview step to perform. Provide consent form to the participant and ensure obtaining a signature from the participant before conducting the interview
Step 2	Introductory protocol	My name is Rabie Khabouze. I am a doctor of IT candidate at Walden University. I have been working in IT for more than 15 years, from end-support to strategic planning. Thank you for agreeing to participate in this study and for taking the time to meet.
Step 3	Convey the purpose of the study	This study aims to explore the strategies IT architects in large enterprises use to modernize legacy systems.
Step 4	Explain the need for participation in the study	Gathering information and data from this interview will help address the research question of this study as well as partial fulfillment of the degree of Doctor of IT from Walden University
Step 5	Discuss moral obligation and the benefit of participation	I will share any knowledge and information gathered in this study with you and the academic and professional community. This information might help develop a more understanding of strategies to use to modernize legacy systems. I want to make sure that your participation does not involve any compensation and is entirely elective.

Step 6	Address ethical, confidentiality and privacy concerns	I would like to get first your permission to audio record you. After recording the interview, I will address you with participant ID# instead of your name. Please, no need to mention the name of the company. We will label it as company ID# to protect your privacy and the privacy of your organization. Please refrain from using the name of the organization. All collected information will be stored in a password-protected and encrypted drive. The recording of this interview will remain strictly confidential. You have the right to stop at any time or refuse to answer any questions, and I remind you that the information you provide during this interview will remain confidential and will not be disclosed to anyone. All information provided during the interview will be handled as strictly confidential and will not be disclosed to anyone, including your management. I will keep this research records in an encrypted and password-protected device and lock in a safe for 5 years and then destroy them. I will be the only one accessing these records during the 5 years. Do you have any questions before we proceed? If not, do I have permission to start recording and write down notes?
Step 7	Start recording the interview	My name is Rabie Khabouze. I am with participant ID#. Today is <Today's date> and it is <Time>. Thank you for permitting me to record this interview. I would like you to please confirm that I

		have explained the purpose and the background of this study. I addressed the motivation of your participation and its benefits to the academic and professional community.
Step 8	Ask interview questions	• How would you describe the operational challenges that IT has faced in the past, maintaining legacy applications and supporting infrastructure? Please explain. • Describe the challenges caused by legacy systems, and how have you handled them? Please elaborate. • What is your understanding of the impact of maintaining legacy enterprise systems on the overall IT landscape? Please elaborate. • How would you characterize the organization's overall preparedness for integrating new modern applications into the existing infrastructure? Please explain. • To what extent have you documented the process of legacy systems modernization? Please elaborate? • How do you align your skill sets before taking on a modernization project? Please elaborate • To what extent have you involved the stakeholders and end-users in the process of

		legacy systems modernization? Please elaborate? • What strategies do you use to improve the success rate of modernizing your legacy systems applications to the current IT environment? Please elaborate. • What strategies contributed the most to the success rate of legacy systems modernization? Please elaborate.
Step 9	Ask Possible Follow-up questions	• Describe what you just mentioned? If you could please elaborate more? • Could you please expand on the tools at your organization? • On the last question, could you explain it more? • What modernization approach worked best? • Do you have any additional information you think might help the study that you do not mind sharing?
Step 10	End Interview questions	Thank you for answering all the questions. Would you like to add any additional information related to this topic?
Step 11	Address member checking and follow-up.	Is it possible to schedule a follow-up interview to make sure I interpreted your responses correctly? You will receive a summary of my interpretation of this to verify the accuracy.

Step 12	Thank the participant	Thank you again for allowing me to interview you. I appreciate your contribution to the study and will talk to you soon.

Appendix B: Observation Protocol

Topic: strategies used by IT architects to modernize legacy systems

Date and Time	
Location	
Participant ID	

Notes:

Descriptive: Description of participants, activities, interactions, and events
Reflective: Questions to self, observations of nonverbal behavior, interpretations.

Appendix C: Documents and Artifacts Collection Checklist

Topic: strategies used by IT architects to modernize legacy systems

Date and Time	
Location	
Participant ID	

Evidence:

Evidence Type (Text, Artifact)	Format Digital/Printed	File Name	Source (public organization website, participant, management)	Reference Question

Appendix D: Copyright Permission From The Open Group

Re: Request to receive permission to use ADM cycle figure 4-1 from https://pubs.opengroup.org/architecture/togaf9-doc/arch/chap04.html

JB Joyce Brown <j.brown@opengroup.org>
To Rabie Khabouze

Reply | Reply All | Forward

Tue 6/29/2021 11:38 AM

Hi Rabie,

We are happy for you to reference the requested image in your doctoral dissertation at Walden University.

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Kind regards,

Joyce Brown | Legal Assistant
The Open Group
548 Market Street #54820
San Francisco, CA 94104 USA
SKYPE: j.brown2018_1

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On Jun 28, 2021, at 7:51 PM, Rabie Khabouze via legal at The Open Group <legal@opengroup.org> wrote:

Dear The open group legal team,

I'm completing on my doctoral dissertation at Walden University entitles "Modernization of Legacy Information Technology Systems". I would like your permission to reuse the TOGAF ADM cycle figure in my dissertation.

The article in reference: The Open Group (2018). Introduction to the ADM The TOGAF® Standard, Version 9.2.https://pubs.opengroup.org/architecture/togaf9-doc/arch/chap04.html

The figure to be reproduced is: Figure 4-1. TOGAF ADM cycle
<image002.png>