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A Guidance to Legacy Systems Modernization

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***Abstract*— Rapid development of information technology and communication (ICT) has increased the use of information systems in organizations since a decade ago. At the same time, many organizations are still using old information systems to support their business, known as legacy systems. Even though these systems cause technical problems, but they are still used to support service delivery to the customer. These systems are also essential to organizations as they have been operated for many years and possess high business value. The operation of legacy systems cannot be stopped quickly, as it will affect daily business tasks. However, organizations with legacy systems need to think about the ability of the systems to support their future direction. Modernization of legacy systems needs to be implemented to ensure the systems are aligned with global changes as well as improving the competitiveness of the organizations. This study, therefore, reviewed the phases and factors involved in legacy systems modernization to identify gaps and their insufficiencies. There are many studies on legacy systems, but only a few have focused on the overall process of legacy systems modernization. Most studies on legacy systems are technical in nature and refer to specific aspects and phases of modernization. This study aims to provide overall guidance to the organizations in performing legacy systems modernization.**

***Keywords*— legacy system modernization; legacy system; legacy system migration.**

I. INTRODUCTION

Information and communications technology (ICT) play a vital role in the operational of organizations' daily business. ICT is widely used for management and execution of organization operational tasks. It makes day-to-day business to function smoothly and productively in accomplishing the organization's goal. ICT engages as a catalyst to the organizations growth and creativity. Nonetheless, the capability of the information systems that are being used affects the advantages that will be gained from the ICT implementation. Old information systems that frequently expose organizations to the possibility of operation failures are not likely to give the required benefits. In addition, rapid advancement of technology makes these information systems outdated and inconsistent with the latest demands. The related information systems are considered legacy systems. They don't just limit the organizational competitiveness but also become hurdles to the improvement of technology strategies of organizations. Business improvements and the new modifications needed by the organizations are resisted with the use of these systems [1],[2],[3].

Even though legacy systems cause technical problems, these systems are important assets of organizations. They cannot easily eliminate or avoid the use of legacy systems because the systems contain essential business information and data since implemented [4],[5],[6]. Any failure caused by the systems will have serious consequences in running daily business tasks. Organizations that are using legacy systems will find themselves in a tough position. These systems are important in running their organizational activites but they have to bear with unnecessary expenditure and technical issues [2],[7].

The world, on the other side, is now moving towards the next phase of the revolution of industry. The fourth industrial revolution is a complete transformation that encompasses all parts of economy and industry, including life aspects. It was launched in 2011 in German and has started drawing attention of researchers in the current studies [8],[9],[10],[11],[12],[13]. The term "smart" is used to illustrate the intelligence in the new generation including smart governance, smart product, smart facility, smart city, and smart manufacturing [10]. This revolution is known for the latest technologies such as internet of things, big data, cloud-based platform, and radio frequency identification (RFID).

The move to the new era offers organizations several benefits, including strengthening their profitability, enhancing efficiency, and productivity by using state-of-the-art technology [9]. To reap the advantages of this transition, the leaders of organizations need to put the fourth industrial digital transformation at the top of their managerial agenda.

Organizations which still run their business using legacy systems need to contemplate the systems' ability in supporting their future path. Organizations need to implement the modernization of legacy systems to improve their competitivess in the new challenging era [14].

However, legacy systems modernization is not a simple task. Legacy systems involve complicated relationships of information, organizations' normative environments, and organization culture [15],[16]. Consequently, organizations require a holistic guideline to assist them in the modernization of legacy systems that include technical and business aspects [17].

The above concerns are addressed in this paper by defining the phases and factors influencing the legacy systems modernization. The phases and factors provided the organizations a systematic guideline that consists of technical and non-technical aspects. The study leads to technological development along with information enhancement in legacy systems and digital transformation globally. The paper is arranged in parts where Section 2 explains about the modernization of legacy systems from the literature review and the methodology used in the study, Section 3 discusses the result of the research, and Section 4 summarize the study and states the future work.

II. Material and Methods

For the Materials section, this paper discusses the previous studies in two perspectives that are legacy systems and legacy systems modernization. Later part of this section explained on the methodology used.

A. Overview of Legacy Systems

Legacy systems have become one of the interesting subjects studied. Several issues, methods, approaches, and guidelines on legacy systems have been discussed and developed [17],[18],[19],[20],[21]. Similarly, studies that are focusing in legacy systems modernization are rapidly attracting researchers [4],[16],[17],[22] to make sure the systems are aligned to the latest technology development.

Different researchers have different definitions of legacy systems. Legacy systems were defined as old, critical, and core information systems that have been executed in a live environment for quite some time [5]. Legacy systems have also been described as running information systems that are still capable of meeting some business needs but not aligned with the evolving architectural standard [19].

Legacy systems are information systems whose technologies, programming codings, and standards are from the prior generation or era of innovation [23]. Along with this definition, all related solutions will ultimately become legacy and will be given important concentration by the researchers in the area of information systems.

Legacy systems are comprise of six elements that are software of application, supporting software, system hardware, data of application, business process, rules or policies [24]. The elements are interconnected to form absolute and complete information systems. The adjustments or enhancements made to one element would therefore have a strong probability of affecting other element of the systems.

1) The importance of legacy systems : Many large organizations including public sector, are still using legacy systems in providing mission-critical services. Old and obsolete information systems but not critical to the organizations will not gain the status of legacy [5]. Legacy systems are proven as reliable systems in supporting daily operations and operate well in the production environment. Legacy systems are important foundation for continuous service delivery of the organization [6]. Business operations run smoothly because users are familiar using the old systems [5]. Legacy systems play an important role in organizational operation and the failure caused by these systems will have a high impact on the organization. Legacy systems have remarkably served the organizations by delivering the intended result and therefore they bring greater business value [2]. These extremely valuable assets to the organizations represent many years of business rules, codings, data, users, experience, modifications, and enhancements needed in operating daily operations [4], [25]. These systems have become the main part of an organization's information flow and become important contributors to the consolidation of information across agencies especially in public sector [15],[26],[27]. Legacy systems are the key assets to the organizations as they act as important sources for the business administration. The business logics in the form of source codes and data in the systems are valuable to the organizations [4],[28]. Through this source codes, business rules and requirements can be extracted out for any purpose including system enhancement [29].

2) The challenges of legacy systems: The use of legacy systems in the organizations is becoming increasingly demanding due to the rapid technological advance. The technology used in developing the systems has become outdated for the recent generation and resulted to technical issues to the organization. Legacy systems maintenance had become expensive, hard, and taking too much time [5],[6],[26],[30],[31]. The maintenance increases the organizational cost due to the obsolescence and technical support issues [6],[32]. The maintenance process of the systems becomes tough and slow [6],[2],[16],[26]. There are also difficulties due to the insufficiency of experts in the old technologies used and the documents to be referred [6],[31],[33]. Furthermore, the systems can't meet existing needs of stakeholders. Legacy systems restrict enhancement needed by organizations to be aligned with the global change. For example in public sector, although legacy systems are very important in supporting the service delivery, but innovation efforts were often hindered by these systems [15],[34]. In spite of that, legacy systems cannot be thrown away easily because they are essential to the organizations [4],[5]. Furthermore, it is considered costly and high-risk to rebuild legacy systems from the scratch [16]. Taking these factors into consideration, many organization opted to modernize the systems.

B. Legacy Systems Modernization

Based on the life cycle of software, the evolution of software are divided into main activities that are maintaining, modernizing, and replacing the information systems [35]. Discontinuation will be carried out if the information systems have not made any contribution to the organization. The activities of maintenance occurred upon the deployment

of an information system to keep it running. During the maintenance, only a small enhancement is done without involving major system structure changes. The systems will become outdated over the years. The maintenance could be challenging and expensive at this time. This circumstances urge the organization to modernize the legacy systems for substantial enhancements on the particular information systems instead of continuing maintaining them [16],[22],[33]. However, replacement will be the right choice if the old information systems cannot be modified or expanded anymore [36].

Modernization is the legacy systems advancement process by employing suitable methods. It is important when present maintenance operations cannot meet the new demanding needs because of system limitations [36]. Legacy systems modernization enhances the aging application systems with the latest technology to enable them to continue supporting the organizations' operations. It often highlighted on agility of system application to ensure legacy systems are able to respond quickly to business-related changes [4],[18].

However, the modernization of legacy systems is not an easy job. It covers many aspects related including business, organizational, and environmental [16],[17]. Legacy systems are also related to complicated relationship of information, normative behavior and environment [15]. The legacy model of work often continued and caused changing resistance although the technology is replaced. This will prevent the organization from transforming the service delivery to the customer. Organization therefore requires a detailed guidelines that incorporates business and technical aspects to allow legacy systems to be systematically modernized [16],[17].

1) Significance of Modernization: The number of legacy systems that need modernization is overgrowing, and more studies in this area will be needed [16]. Modernization of legacy systems become significant to the organizations when system maintenance is no longer applicable primarily because they are unable to meet new requirements. Therefore, to ensure the systems remain important to deliver the best services, organizations need to plan for legacy systems modernization. With the latest innovations in the current digital age, like cloud and mobile computing, legacy systems modernization in academia and industry has become increasingly important [36].

Cost reduction and increasing the flexibility of the systems are the most essential reasons for modernization [5]. Modernization is the best way to move from the obsolescence to a new environment by incorporating the current technologies or architecture to achieve the highest level of information systems usage. Additionally, demands for more interactive, easy-to-use, and secure systems have put pressure on organizations to opt for modernization [25]. For example, state-of-the-art solution like web service interface can automate and provide secured access to the user. Organizations are prepared to pay out a large amount of money in execution of ICT services as they bring great significance in the day-to-day business operations. Accordingly, to preserve the investment made for legacy systems which were generally built at high expenses, the systems should be given a new life through modernization [37].

The daily business operation will be interrupted if the usage of the systems are stopped immediately. Rebuilding the systems from scratch would have higher risk and its key failure is losing of existing essential and vital information on organization business [16]. Therefore, modernizing the old systems from a diverse range of approaches will be the best choice for the organizations [16],[30],[37].

2) Comparison of models and methods : Modernization can involve minor or major changes depending on the techniques used. Modernization which includes only changes to the user interface and does not affects the system's overall function is called black box technique or wrapping [35]. Wrapping has become the favoured user interface technique since it is an easy solution for modernization, fast, cheaper, and less risky [35],[36]. User interface modernization upgrades the system's usability and is mostly recognized by final users [37]. On the other hand, white box technique of modernization or also known as reengineering requires extensive study to understand the systems before implementing the legacy systems with new functionalities [4],[16],[38]. Besides that, migration is also one of the modernization techniques [39]. Migration is a strategy for transferring legacy systems to a versatile environment without disrupting the actual data and regulation of the systems [25].

Several researchers have concentrated on different methods in executing modernization. Wrapping is the popular technique used in legacy systems modernization. Guidelines for the modernization of legacy systems utilizing wrapping method in service-oriented architecture (SOA) platform have been introduced by [37],[40]. A strategy to migrate legacy systems to SOA using wrapping technique was discussed mainly on a technical perspective [40]. It involves recovery of the legacy systems architecture up to the new platform transformation. In implementing legacy systems modernization, many researchers mentioned the importance of understanding the legacy systems before the requirements were extracted [17],[37],[40],[41].

Some researchers concentrated on spesific phase of systems modernization. The requirements gathering stage during modernization has received attention by [29],[42]. The important factors that influenced the requirement phase of the modernization were adressed [29] and the game-based tool has been implemented to guide in the analysis process [42]. Reverse engineering approach has become significant during requirement phase of the legacy systems migration process [22],[29],[41],[43]. This approach is widely used for the architecture recovery, analysis of codes and the rules extraction from the legacy systems. In the modernization project, particular concentration must be given during the requirements phase to avoid missing significant business information from the old systems [15].

Interests in migrating and integrating legacy systems into latest platform or solution are also increasing due to the technological limitation on the systems. The migration of the systems to the cloud environment was discussed by [17],[22],[38]. Smile2Cloud famework was developed to provide a guideline on the modernization of legacy systems to the cloud platform using migration technique[22]. It

includes activities to extract security requirements using reverse engineering from legacy systems, analysis of new security requirements, design, and installation in the new platform.

System Migration Life Cycle (SMLC) provides systematic steps on the migration strategy of legacy systems to the cloud environment. This guideline covers activities from before, during, and after migration [17]. Before the migration process, the activities namely legacy systems understanding and evaluation, task of planning and reverse engineering to extract the requirements were carried out. Activities during migration stage include designing, developing, and testing the system to ensure that the migration is feasible before being deployed in the cloud environment. Post-migration is the stage for assessing the migration.

Besides cloud environment, web modernization process and modernization by integrating legacy system to big data were described by [1],[20]. The process explained was mainly on the technical implementation.

MARMI-RE methodology has been developed in supporting the modernization of legacy systems which emphasize on migrating the traditional business logics, the most reusable component of modernization strategies [41]. This method comprises of many important activities including the analysis of the legacy systems and its environment, extracting the old requirements using reverse engineering, designing and developing the new system, testing, and installing the system. In addition to this, the Butterfly methodology was introduced that gives special focus on migrating the legacy data that resides in a mission-critical domain [44]. This methodology includes related activities on the determination of old systems requirements by utilizing reverse engineering, gathering latest requirements, designing, developing, testing, and deployment.

3) Legacy Systems Modernization Process : Before the technical implementation of legacy systems modernization, pre-implementation activities such as planning need to be carried out. Every modernization project needs proper and detailed planning [30]. Generally, it involve planning on the project cost, timeline, human resources, selection of technique, change management, and action plan [5],[17]. System requirements determination is an important phase in software engineering that involves defining requirements based on the organization's goal. This has been proven by [45], that shows a clear requirement is one of the major reasons for a success project. The incomplete requirement will cause the project to be challenged. In legacy systems modernization, old and new requirements need to be gathered to produce a complete and latest set of required items.

Old requirements were extracted from the legacy systems codes [17],[22],[37],[40]. Reverse engineering was mentioned as a significant approach by previous researchers in extracting old requirements from legacy systems [17],[22],[29],[41],[44]. The systems need to be well understood generally on the architecture, function, data, and constraint before extracting the codes that contain business rules. Requirements from the legacy systems should be documented for future reference [16],[29]. In order to include latest needs from the users, new requirements were gathered from the users using appropriate method [29]. These requirements were analyzed and mapped with the old requirements before validated by users [40],[29]. Only relevant requirements were documented in the specification [15].

The new application system has to be designed based on the system requirements for a new targeted design [41],[44]. It can then be developed using the development method that has been decided [17],[44]. In order to ensure the modernized system runs smoothly, it needs to be tested using test cases and different type of testing that has been planned [16]. For example, regression testing was recommended if the use cases from the legacy systems can be obtained [16]. However, the extraction of use cases is difficult and requires more work as it has to be compared between the legacy systems functionalities to the new application [5]. This resulted in the modernization testing to be challenging and therefore required more effort.

Tested application can be installed in the real environment in which it will be operated [41]. Most researchers recommended that the installation is performed incrementally to mitigate any possible failures [17],[44],[16]. Training for users and technical staffs can be done parallel [41]. Modernization of legacy systems needs the involvement of stakeholders from business and technical sector. They include project manager, domain expert, software engineer, system developer, requirement engineer, and tester [21],[28],[16]. The team needs to be knowledgeable and experienced to make sure the process run smoothly [18], [22]. Besides, good relationships and good communication skills in the team are important success factors [12],[15],[44],[47].

Although challenges in implementing legacy modernization were more focused on a technical perspective, cultural and business processes are more significant, especially in public sector [15]. Modernization is also dependent on the financial aspect of the organization and should be aligned with the organization's direction, business strategy, law, and policy [15], [17], [41]

In general, the previous studies indicate phases and factors that are essential in implementing the modernization of legacy systems. However, studies on the modernization of legacy systems is mainly focused on technical perspective, proposing different approaches and methods to handle the modernization [4],[16],[41],[44],[40]. Studies that concentrate on the general perspective of legacy systems modernization are still limited. Therefore, this research analyzed the phases and factors involved in the modernization of legacy systems in providing a holistic guideline to the organization.

C. Research Methodology

This research focused on answering the questions listed below:

- R1 : What are the related phases in the modernization of legacy systems?
- R2 : What are the factors identified for each phase?

The method used in this study is a qualitative method. This method was chosen because it is appropriate in addressing the above research questions. By employing this method, a researcher can obtain detailed understanding on the research topic [48] .

The qualitative technique employed in this study was review. It is a practical approach that prevents repetation of similar study several times. Information regarding the research problems were collected from various references such as journal articles, proceeding papers, scientific books, and reports. The references search for the review was performed through multiple databases including Scopus, Elsevier, IEEE Xplore, Springer, and Science Direct. The keywords search used were “legacy system”, “legacy system modernization” and “legacy system migration”.

This study reviewed related legacy systems modernization guidelines and methods proposed by researchers and studied how they support legacy systems modernization. Content analysis technique was utilized in analyzing the chosen references [49]. It involves coding, categorization of data, and the study of elements occurrences frequency. The procedure has been continuously executed during the whole analysis process. The reason for the content analysis was to list out and categorize the related data of legacy systems modernization from the aspects that were defined on the collected references. The snowball method has been used to extend the searching scope from the materials already acquired.

III. Results And Discussion

The review shows that there are many studies related to the modernization of legacy systems. The related studies are compared to enable to identify the gaps that can be further investigated in later research. Apart from that, the previous studies are analyzed in identifying the related phases and factors to implement legacy systems modernization.

A. Legacy Systems Modernization Phases from Different Purpose of Studies

Table 1 shows the comparison of studies according to their focus, domain, scope, and phases that are involved in implementing the task.

TABLE I
LEGACY SYSTEMS MODERNIZATION PHASES FROM DIFFERENT PURPOSE OF STUDIES

Author	[22]	[17]	[40]	[16]	[29]	[15]	[41]	[44]
Focus	Migration to modern environment				Requirement phase		Code migration	Data migration
	Cloud	Cloud	SOA	Web application	Requirements determination	Modernization challenges		
Domain	Technical-related	Technical and Business-related	Technical-related	Technical-related	Technical-related	Business-related	Technical and Business-related	Technical-related
Scope	Not specific to public sector					Public Sector	Not specific to public sector	
Phase								
P1 – Plan for modernization	X	√	X	X	X	√	√	X
P2A – Old Requirements	√	√	√	√	√	√	√	√
P2B – New Requirements	√	X	√	√	√	√	X	√
P3 - Design & Development	√	√	√	√	X	X	√	√
P4 - Testing	X	√	X	√	X	X	√	√
P5 - Execution	√	√	X	√	X	X	√	√

The latest researches in the modernization of legacy systems are mainly concentrated on the migration of legacy systems to the latest platform such as Cloud, SOA and web environment. The legacy systems modernization studies are also focused on the data migration and legacy codes that contain the business logic of the organizations. Besides, researchers are keened in studying the spesific phase in modernization and normally the requirement phase is favoured.

In term of the domain, studies in the modernization of legacy systems are mostly concentrated on a technical related domain. The researchers proposed techniques and methods on the operation of modernization from a technical perspective. Still not many researchers that have given attention on the general aspects of legacy systems modernization including management aspects.

In term of scope, most studies focused for all sectors in general. Guidelines that were proposed by the researchers were not spesific to the public sector, although few studies have shown that legacy systems in public sector agencies include complex knowledge relationships, culture, and environment of the organization.

In general, there are five phases in implementing legacy systems modernization derived from the studies. The phases

involved are planning, determining old and new requirements, designing and developing, testing, and implement the system. Previous researchers concentrated less on the planning stage. However, the phase for old requirements extraction from the legacy systems was frequently emphasized due to the important business information in the systems. Reverse engineering has been highlighted as an important approach to be used when implementing the old requirements extraction.

B. Legacy Systems Modernization Factors

The review indicates that many factors need to be considered in implementing legacy systems modernization. Table II shows the relevant factors and elements involve in legacy systems modernization. The factors cover the process, human, and organization aspects to provide overall guideline to the organizations. The factors in the process aspect are described through modernization phases to provide a clear view of the entire activities in implementing legacy systems modernization.

TABLE II
LEGACY SYSTEMS MODERNIZATION FACTORS

Factor	Element	Explanation
A. Process Aspect		
Phase 1 – Planning		
Project requirements	Cost	Overall cost involved in the modernization.
	Time	Time needed to complete the project.
	Human Resource	Human resource involve for all phases.
	Technique	Modernization technique selection.
	Action Plan	Action plan and timeline for all relevant activities.
	Change Management	Change management involves organization and project including change request and quality control.
Phase 2 – System Requirements Gathering		
a) Old Requirements From Legacy Systems (Reverse Engineering)		
System understanding	Architecture	System architecture including hardware, software, and network.
	Function	Function and process flow of system.
	Data	System data.
	Constraints	Constraints or restriction in the system.
Requirements extraction	Business rules	Business prosess from the codes.
	Legacy systems specification	Documentation from the understanding and rules extracted.
b) New requirements		
Requirements elicitation	Method	Method used to gather requirement.
Analysis	Selection	Analysis of old and new requirements and selection of the important requirements to be considered.
Specification	Combination	Specification that combined both old and new requirements.
Validation	Customer	Validation by the customer or user.
Phase 3 - Design & Development		
Design implementation	New design	New design including architecture, function, data model or interface design
Development implementation	Development method	Development technique and approach used.
Phase 4 - Testing		
Testing implementation	Type	Different kind of testing.
	Test case	Test cases in implementing the testing including use case from the legacy systems.
Phase 5 - Implementation		
Installation	Installation method	Installation implemented based on method planned such as *Incremental*
	Verification	Installation validation by user.
	Monitoring	Examine and monitor the implementation for any errors or failure.
	Training	User and technical training
B. Human Aspect		
Project manager	Experience	Experience in the relevant area.
	Knowledge	Knowledge in organization management.
Project Team and Testing team	Technical skill	Technical knowledge and skill including in legacy systems and new system.
	Domain knowledge	Knowledge in the relevant area and domain.
	Communication skill	Communication skill among team, management and user.
	Relationship	Good relationship and team work.

C. Organization Aspect	
Business Strategy	Strategy and business model of the organization.
Financial allocation	Financial source in implementing modernization.
Culture	Organization cultural and practice.
Law	Law including relevant policy and act.

1) Phase 1 – Plan for modernization : Planning is the initial phase to prepare for modernization. The important factor in this phase is the determination of project requirements. The requirements of the project should be planned accordingly to ensure the process runs smoothly. The determination of project requirements include elements of cost, time, human resource, selection of modernization technique, action plan for the whole phases of modernization, and the change management.

2) Phase 2 – System Requirements Gathering : The next phase for the legacy systems modernization is the system requirements gathering. This phase involves combination of old and new requirements gathering. The old requirements are derived from legacy systems that contain important logics and business rules since the systems were implemented. The new requirements are gathered from the users or stakeholders.

- Old Requirements : The process to gather requirements from legacy systems should be implemented using reverse engineering approach. The main factors involved at this stage are the system understanding and requirements extraction. System understanding includes studying the elements of architecture, function, data, and constraint of the systems before the extraction of the requirements from the legacy codes. Requirements extraction from the systems will produce the business rules and should be documented as the legacy systems specification.
- New requirements : The new requirements gathering process is based on the requirement engineering process [29]. Requirements engineering is an important task for any development of information system including legacy systems. Factors that should be considered during this phase are requirements elicitation, analysis, specification, and validation. Requirements elicitation collects requirements from different stakeholders and users using appropriate methods. The analysis of the requirements involve the selection of the important requirements from the old and new requirements. Specification that contains the combination of selected old and new requirements should be prepared. The requirements should then be validated by the customer.

3) Phase 3 - Design & Development : The important factors in this phase are the design implementation and the development implementation. Based on the requirements, the new system is designed to produce the new design of the modernized system. The new system is then developed using the new design that has been produced. The development process should be carried out using a method that was planned in the planning phase.

4) Phase 4 – Testing : The important factor at this stage is the testing implementation. Testing of the developed system should involve elements of testing type and test case. Different types of testing that have been planned during planning need to be carried out. The testing include relevant test cases to test the old and the requirements. Use cases from the legacy systems should be obtained to ensure the functions from the legacy systems are also be tested in the new environment.

5) Phase 5 – Execution : After completing the testing, the new system is ready for deployment into the new platform. The important factor in this phase is the installation of the systems in the new platform. Installation should be done using agreed installation method, such as incremental method that was highlighted by previous researchers. Verification of the installed system should be done with the users. The system should be monitored to make sure it works properly and immediate action can be taken in the event of any failure.

In executing the modernization of legacy systems, factors from human aspects that need to be considered throughout the phases include the Project Manager, Project and Testing Team.

- Project Manager : Project manager is the person that is in charge of the overall process and execution of the project. The project manager need to have experience in the relevant area. The person should also be knowledgeable about the project in order to manage it successfully.
- Project and Testing Team *:* The project and testing team consists of business and technical representatives, including the domain expert, software engineer, system developer, and requirement engineer. The teams should have technical skills, domain knowledge, communication skills, and good relationships among the team to ensure the success of the project.

Legacy systems modernization should also consider the factors from organization aspect. The factors include a business strategy of the organization, financial allocation to implement the project, organization culture and law or policy of the organizations.

IV. CONCLUSIONS

The digital transformation agenda needs to be placed at the top priority of the organizations. This is consistent with the worldwide change in the fourth revolution of industry. The revolution refers to the current and sophisticated technology with highly automated solution. Organizations that still use legacy systems in executing their daily activities should examine the capability of the systems to support their upcoming path.

Modernizing the legacy sistems is an essential task by related organizations to ensure the systems can meet the expectation needed in the new era. To implement the

modernization of legacy systems successfully, organizations need overall guideline that cover all related aspects. This paper has reviewed the phases and factors involved in implementing the modernization. The proposed guideline will be able to support the organization in improving their competitiveness through a holistic guideline in implementing legacy systems modernization that cover the process, human, and organization aspects.

This is a qualitative study that employed a review technique. The references related to the research topic have been gathered from several online databases. The references include journals, proceedings, articles, books, and organization's reports. The results from the study reveal that there are five phases need to be implemented in legacy systems modernization. There are many factors involved in each phase of the implementation. Besides, there are also human and organization factors that need to be considered in implementing the task. However, the factors obtained from earlier studies were redundant and isolated. The factors have to be reviewed to the modernization of legacy systems.

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