Review

Legacy Systems Modernisation for Citizen-Centric Digital Government: A Conceptual Model

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Abstract: Information technology and communication (ICT) plays an important role as a catalyst for organisational development and innovation. However, old information systems that are known as legacy systems often expose organisations to the risk of business failure. These systems are not only impeding the advancement in technology strategy but also hindering the organisations' business competitiveness. Nevertheless, legacy systems are essential in supporting critical functions in organisations including the public sector and could not be scrapped easily. These systems need to be given a new strength through modernisation to continue providing the best service in line with global trends. Modernisation is a complex task that involves several related aspects. In the context of the public sector, legacy systems involve a complicated information relationship, environment, and culture, while ensuring the citizens are of high priority. The implementation of a digital government represents the transformation of the public service delivery to the citizens that emphasises a citizen-centric design. This study, therefore, aims to address this concern by reviewing the factors involved and suggesting a guideline in the form of a conceptual model to assist in the modernisation of legacy systems for a citizen-centric digital government. Data from the theoretical study were analysed using content analysis. The results show that the legacy systems' modernisation comprised four main aspects, namely human, process, product, and organisation aspects, with related factors and elements. This model contributes as a reference for the public sector and provides overall guidance in performing legacy systems modernisation.

Keywords: legacy system; legacy system modernisation; legacy system migration; digital government; citizen centric

1. Introduction

The implementation of Information and Communication Technologies (ICT) services involves substantial expenditure for an organisation. Therefore, to achieve the return of the investment made, the ICT hardware and software are used for a long period until they are classified as legacy systems. This long usage period makes legacy systems increasingly important to the organisation [1,2]. They maintain important business logic and data needed in the daily business operations [3].

Hence, legacy systems continue to play an important role in the implementation of ICT today. Large organisations still use these systems in operating their businesses including in the delivery of critical services [1,2]. However, legacy systems that are associated with the use of obsolete technologies pose difficulties to organisations in implementing daily operations. The maintenance process is difficult due to the lack of experts that understand the systems, high maintenance costs, and lack of documentation [4–6]. These systems are also difficult to expand and integrate with the new information systems due to the old technology's limitations [3,5].

Legacy systems are also used in supporting government service delivery to the citizens. The systems that have changed from time to time are still used as they bring high business

values to the public sector [7]. They retain important public administration functions and years of data indispensable in daily operations. However, rapid technological development has made the use of these systems more challenging in the public sector [8]. Legacy systems cannot meet the demand for information access in the public sector that is now taking place across organisations and national boundaries [9]. These systems have been identified as obstacles to the innovation efforts needed by the public sector to keep pace with the technological global change [10,11]. Therefore, these systems need to be enhanced to ensure they can continue supporting the service delivery to the public sector.

Looking at the importance of these systems to the public sector, they cannot be stopped easily [10,12]. Additionally, the new development of legacy systems is high risk because it involves greater cost and a longer time to rebuild the systems [13]. The new system will also not necessarily be similar in terms of its ability compared to the legacy systems that have been operating stably for many years [6]. These factors led many organisations to choose modernisation to ensure that legacy systems remain relevant in delivering the best services [14,15]. The modernisation of legacy systems is important when the maintenance of the old systems has been inappropriate due to the technical constraints and unable to meet the increasingly challenging new demands [16]. Modernisation involves greater changes compared to what can be achieved during the maintenance phase. The main goal of modernisation is to reduce maintenance costs and increase the flexibility of the systems through the transition to a new technology environment [2].

However, modernisation is not an easy task as it involves several aspects including technical, business, organisational, and environmental aspects [17]. Legacy systems in the public sector involve complicated information relationships among other agencies, the culture in the organisation, and the norm environment [10]. Additionally, the needs of the citizens as the main customers of government services should be given high priority [18]. Initiatives towards a citizen-centric digital government show the efforts taken by the government to enhance the use of technologies in providing the best service to the citizens [19]. Thus, service delivery systems that will be developed to support the digital government services need to adopt a more interactive, citizen-centric design and engage the citizens [19,20].

This study addresses the above concerns by identifying relevant factors in implementing the modernisation of legacy systems for a digital government. The conceptual model provides a generic guideline for the public sector that includes technical and non-technical aspects. This study contributes to the enhancement of knowledge specifically in the modernisation of legacy systems along with digital transformation globally. It will be a guideline for the public sector in implementing the task of legacy systems modernisation in the new era.

2. Literature Review

This section elaborates the digital transformation of public sector, citizen-centric digital government, and legacy systems modernisation for a citizen-centric digital government.

2.1. The Importance and Challenges of Legacy Systems

Legacy systems are still being used to deliver critical services in many large organisations including the public sector. Information systems that are old but non-critical to the organisations will not reach the status of legacy [6]. Legacy systems are reliable systems that have been operating well in the production environment to support daily operations. The old systems are handled by experienced users that make the business operations run smoothly [6]. The systems are key assets for the continuity delivery of services in organisations [5]. Legacy systems hold many pieces of important business information since their implementation [3,12]. These systems are the primary contributor of information consolidation across agencies including in the public sector [8].

Technological rapid advancement makes the usage of legacy systems in organisations increasingly demanding. The technology used to develop the systems has become obsolete

and led to technical issues for the organisation. The issues that are often associated with these systems include the difficulties in maintaining the old systems and the time-consuming and expensive nature of these processes [5,6,21]. Additionally, legacy systems often lack documentation and experts in the old technology that has been used [16]. Legacy systems hinder the improvement needed by organisations to be aligned with global changes. The systems are unable to meet the current requirements of the stakeholders. As a result, innovation efforts are often impeded because of these systems [10,11].

2.2. Legacy Systems in the Public Sector

The public sector strives to provide the greatest service to citizens through efficient and reliable technologies. The implementation of the electronic government (e-Government) is an effort to enhance the efficiency and effectiveness of public sector services [22]. The coverage of e-Government has also expanded to a larger domain that requires collaboration with partners, suppliers, and customers for excellent service delivery. Along with that, the need for data sharing and integration among public sector information systems has become increasingly important for efficient delivery of services. The integration of internal and external information systems is required to enable productive data management [9].

However, behind the scenes, there are still public sectors using legacy systems to support the delivery of services to the citizens [11]. Most of the systems are core systems that are used to support critical functions of the public sector [10]. They rely heavily on these systems that have been in operation for a long time in their production environment and are proven to be reliable to support the business operations. These systems that have undergone changes over time are still being used as they bring high value to the public sector. They store important public administration functions and data needed by the public sector and have become an important contributor to the consolidation of information about the public sector business [8].

Although legacy systems are very important in supporting daily operations, e-Government innovation efforts are often hindered by these systems [11]. They lead to technical problems for the public sector that prevent the success of the e-Government. The systems were developed using software and hardware that were compatible at the time they were developed. As time goes on, the technology used had become obsolete and brought technical problems to the public sector. The maintenance of the systems has become difficult due to the lack of experts who understand the systems, the increasing cost of maintenance, and the lack of documentation [5]. These systems are also difficult to expand and integrate with new information systems [9]. Legacy systems are unable to meet the requirement of information access that has now taken place across organisational and national boundaries [22]. Sharing information through the integration process poses significant challenges to the public sector agencies that are still using legacy systems [3,9].

However, since these old systems are crucial to the organisations, they cannot be stopped easily [12]. The public sector needs to think of the ability of the systems and plan their direction to enable them to stay relevant and continue supporting the service delivery to the citizens.

2.3. The Digital Transformation of Public Sector

The world is now moving to the next industrial revolution, which features high and sophisticated technology. The fourth industrial revolution, also known as Industry 4.0, was introduced in 2011 and has begun to attract researchers' attention in recent literature [23–25]. The revolution impacts not only the manufacturing industry but also ICT, medical, business, education, and labour supply [24,26–29]. It is closely related to smart features, the globalisation of data usage, and information integration to achieve expected future advantages. The transition to this new revolution provides several benefits to organisations including enhancing organisational competitiveness and increasing flexibility and productivity through the use of robust technology [23,26]. Organisations that

move from traditional business practices to the use of recent technologies have a higher chance of staying relevant and successful in the long run [30].

Along with global technology development, the government continues to look for new ways to serve citizens through the support of the latest technology. Governments worldwide are aiming for the transformation of the public sector in line with the global changes. They aim to enhance service delivery to the citizens with the support of technology in increasing the value received by the public [31]. Public value refers to various benefits gained by citizens from different perspectives. This includes products or services that meet citizens' expectations, service efficiency, and provide services from authorised sources and innovative and flexible ways to respond to the citizens [32]. The government is now facing greater demands and expectations from the citizens for quality service that is more innovative and responsive [33]. In this regard, the implementation of a digital government is targeted to be more concerned with the use of cutting-edge technology in improving the service delivered to the citizens [31]. This new era provides the opportunity to strengthen citizens' collaboration with government services delivery.

2.3.1. Digital Government

Digital government represents the transformation of the public sector into the next phase of public management and delivery of Information and Communication Technology (ICT)-based services [32]. The implementation of a digital government is planned to offer more integrated and innovative services to the citizens [34,35]. Digital government initiatives focus not only on the transformation internally but also on the government and citizens relationship, including communication channels in the interaction with the government [36].

In terms of definition, various interpretations were found regarding digital government. It is a synonym of electronic government (e-government), explaining the ICT role in the public sector [37]. However, most researchers agreed that digital government and e-government are different. According to [38], an electronic government is a one-way relationship where the citizens only receive services through the website. This is known as a government-centric service. On the other hand, a digital government is described as a citizen-centric era that allows government and citizens to collaborate through different channels [39]. A digital government generally refers to the use of technologies in the public sector to give better services and improve relationships among the government, citizens, and the private sector [36].

Another interpretation of e-government and digital government is that a digital government uses integrated digital technology to implement government modernisation strategies, particularly to generate public value [32]. Meanwhile, an e-government uses ICT to improve the government administration. In addition, digital government, government 3.0, and smart government are synonymous with depicting the use of the latest technology initiatives in government agencies, sharing open data with citizens, government agencies, and other organisations that can be accessed anytime based on need [40].

2.3.2. Citizen-Centric Digital Government

In the transformation of the public sector along with the current global needs, the implementation of the services should emphasise citizens' involvement. This is essential in order to build the relationship between the government and citizens and to ensure they receive the best services as needed [39]. Traditional government-centric services have passed, and a new approach is needed to modernise the service delivery systems with the integration of digital technology [33,41].

A citizen-centric digital government pays special attention to the needs of the citizens. The involvement of the citizens throughout the life cycle of the service is essential to ensure that their needs are taken into consideration [42]. The citizens' involvement is the main criterion to illustrate the citizen-centric service. The design of the information systems has new themes including participation design, usability, and interaction [20]. This design is

needed to encourage the citizens' engagement in improving the government services as there will be a better alignment between the government system and the work practices of the citizens [20].

2.4. The Modernisation of Legacy Systems for Citizen-Centric Digital Government

The public sector agencies that are still using legacy systems will face difficult situations. Although these systems bring technical problems, they cannot be scrapped easily because they have contained important business information since they started operation [3,6,42]. However, if they continue using legacy systems, they will have to bear the technical difficulties along with the high cost and the barriers to innovation efforts planned for a digital government implementation [11,13]. At the same time, if the legacy systems are replaced, it is feared that the new system will not be able to support business as effectively as legacy systems. The redevelopment of legacy systems is also at risk because it involves higher cost and a longer time frame for having to redesign the system from scratch [13]. System requirements have to be determined from the beginning, and the risk of losing essential functions is high. As such, legacy systems' modernisation should be an option for public sectors that can no longer maintain the systems.

Modernisation is a process of improving legacy systems using appropriate methods beyond what can be achieved during the maintenance period. Modernisation updates the old systems to enable them to communicate with the latest technologies by emphasising agility features to ensure the systems can respond rapidly to business changes [16,43].

In implementing legacy systems' modernisation, several aspects should be taken into account. In addition to the technical aspect, modernisation also involves business, organisational, and environment aspects [10,15]. In realising the government's directions, the delivery system also needs to incorporate a citizen-centric design that is more interactive, easy to use, and involves the participation of citizens [18,20]. Therefore, all these aspects need to be considered to ensure the modernisation is according to the government's direction and supports the goal of transforming service delivery to the citizens.

2.4.1. Implementation of Legacy Systems Modernisation

There are many methods to implement modernisation that have been explained by researchers [13,15,17]. Basically, it involves several activities in different phases that need to be completed. In the early phase, pre-implementation activities that involve project planning need to be performed. Proper planning is important for a modernisation project [21]. In general, the planning of modernisation includes costing, human resources, a timeline, a scope, selection of the modernisation technique, and the action plan of the entire project [6,17].

Determination of system requirements is an important task in software engineering to define requirements based on the organisation's direction. The system requirements' definition for the modernisation of legacy systems includes the gathering of old and new requirements. The old requirements were obtained from the business logics in the form of codes in the legacy systems [44,45]. Since legacy systems usually lack documents to be referred to, reverse engineering was mentioned as a method to extract old requirements from legacy systems [17,44–46]. The overall system architecture that is required to be understood includes the functions, limitations, and data. Next, the requirements can be extracted in terms of the business logics, rules, and data. Then, the requirements should be documented for future reference [13,44]. New requirements need to be acquired from the current users using suitable procedures [44]. These combinations of old and new requirements were then analysed before being validated by users [44]. The requirements specification should only consider the latest relevant requirements [10].

Based on the system requirements, the new modernised system is designed and developed [17,46]. The development is performed based on the method that has been decided earlier [17]. The modernisation testing is challenging and requires more efforts [13]. Different types of testing using test scripts should be carried out as planned. The old

functions through the use cases of legacy systems need to be tested to make sure they provide the required result in the new environment. Only tested new applications should be installed in the production environment [17,45,46]. The installation includes the hardware, software, and data migration. The system should be monitored for a certain period for any errors [17]. Users and technical staff can be trained parallelly [46].

The modernisation of legacy systems needs the participation of different stakeholders from the management, business, and technical sectors. The top management needs to give their support to the implementation of the project [47]. The representatives from the business and technical sectors include the project manager, domain expert, software engineer, system developer, auditor, requirement engineer, and tester [13,45]. A project manager needs to have leadership skills to be able to manage the project successfully in line with the digital government demand [47,48]. The team needs to be knowledgeable and experienced to make sure the process runs smoothly [45,49]. Additionally, good relationships and good communication skills in the team are important success factors [48,50,51]. The attitude of the team, such as being hardworking and focused, is also one of the important criteria for a successful project [48]. In addition, a separate testing team is also required to ensure quality testing [13,50].

Besides the participation of the stakeholders as the implementer of the public services delivery, citizens' participation as the users of the services need to be taken into account. The citizens need to have ICT knowledge to enable them to be involved and use the government's information systems [47,52].

Although challenges in implementing legacy modernisation were discussed more from a technical perspective, organisational factors are also significant, especially in the public sector [10]. Modernisation depends on the resources of the organisation and should be aligned with the organisation's direction, business strategy, law, and policy [10,17,46].

The above studies have provided factors that are significant in implementing the modernisation of legacy systems. However, studies on legacy systems' modernisation have generally focused on the technical aspects and proposed various techniques in handling the modernisation task [13,16,46]. There are still few studies on the overall process of implementing legacy systems modernisation.

2.4.2. Citizen-Centric Digital Government Characteristics

For most governments around the world, citizen-centric digital government is still a new subject, and there is still a lack of models or frameworks that can extensively explain them [53]. However, there are guidelines and methods developed in the related fields for different contexts [53–56]. The fundamental citizen-centred approach that is the Citizen-Centric Demand Model has been introduced [53]. This model listed the basic elements of citizen-centric to assist the government, namely transparency and openness of data, the involvement of citizens, and responsiveness.

In a digital government, the involvement of citizens has become an important criteria in measuring whether the services offered are citizen-centric. Therefore, citizens' involvement was always highlighted in order to strengthen the collaboration of government and citizens [42,56]. A We-Collaborate application that provides a collaborative environment with the citizens has been proposed [56]. It emphasised the methods that can be used to increase the citizens' engagement. A framework to measure the engagement of the citizens in the government services was developed [42]. It suggested the involvement of the citizens in the modernisation phases including design, development, testing, and implementation. Additionally, a collaborative design approach was introduced with methods and tools to increase the involvement of the citizens in the government service delivery system development [57]. Citizens' involvement throughout the service life cycle is important to ensure their needs are taken into account. In the context of citizen-centric digital government that emphasises citizens' engagement, responsive interaction service features are a priority [53,58]. It is important to ensure that a two-way citizen and government interaction is easy regardless of place and time. Communication channels were also highlighted for

a smooth interaction [42,57,59]. The role of social media as a communication channel to facilitate the citizens is gaining popularity in the citizen-centric research [57–60].

Additionally, easy-to-use features need to be taken into account to ensure that citizens can access and use the system smoothly [42,54,58]. In addition, a framework that provides a systematic approach in establishing robust information sharing in a safe and private environment has been introduced [55]. It shows the importance of a safe government digital infrastructure in enhancing the trust of the citizens. While the government is a complex entity in terms of the number of agencies that provide services, for the citizens, it is still from a single source of service that is the government. For that purpose, a single sign-on approach should be considered in the government service [55].

In general, most of the studies on citizen-centric government have been on the basic principle, citizen involvement, the channel of communications, and the success factors of the implementation. Citizen-centric features were specifically highlighted in accordance to the purpose of the study. Overall citizen-centric features especially related to the legacy systems modernisation were not emphasised.

2.4.3. Overall Features of Citizen-Centric Digital Government

A quality information system is essential to ensuring the citizens receive the highest value from the services offered by the government. Therefore, to ensure the delivery systems meet the expectations of the citizens, the overall quality criteria must be considered. This study has selected four models that provide a comprehensive measurement of product and service quality. This is to ensure the modernisation of legacy systems takes into account the overall criteria of product in providing high-value services to the citizens.

Two of the models are from the International Organisation for Standardisation 25010, namely Systems and Software Quality Model (ISO/IEC 25010:2011) and Data Quality Model (ISO/IEC 25012:2008) [61,62]. The other two models are the Renaissance Method [63] and SERVQUAL Model [64]. The related ISO models provide established international standards for quality rating of information systems and data by accredited bodies. These ISO models are more complete and overcome the weaknesses of other system quality models [65]. Since legacy systems are also information systems, the models would be appropriate to use to obtain comprehensive product features in implementing modernisation. The Renaissance Method is a structured guideline for legacy systems evolution that provides related characteristics for system assessment. In addition, the SERVQUAL Model was selected since the public sector is a service-based industry and this model can be used to assess the services provided to the citizens.

- Systems and Software Quality Model (ISO/IEC 25010:2011)

This international standard is the revision of the ISO 9126 model with some amendments. The ISO 25010 model can be used to support software evaluation from different perspectives, including those that are related to procurement, development, maintenance, software audit, and quality assurance [66]. This model consists of quality in use and product quality categories. The quality in use of this model is related to the product interaction and usage results in a particular context. It covers standards regarding human interaction with computer systems including the software that is used. The related features are satisfaction scale, freedom from risk, context coverage, effectiveness, and efficiency. Product quality outlines the standards for the static and dynamic nature of computer systems. It can be used for both computer software and hardware systems. The features are functional suitability, performance efficiency, compatibility, usability, reliability, security, maintainability, and portability.

- Data Quality Model (ISO/IEC 25012:2008)

The data quality model ISO 25012 is complementary to the ISO 25010 model. It outlines 15 features of data quality, which are divided into two categories: the inherent data quality and the system-dependent data quality [67]. The inherent data quality refers to the quality of data that has its own potential when it is used according to the specified conditions in

fulfilling the actual and implied requirement. The features of inherent data quality include precision, consistency, currentness, completeness, and credibility. The system-dependent data quality is the quality of data that is obtained and protected according to certain conditions based on the use of computer systems. The quality of this category depends on the technology domain where the data is used and achieved through the capabilities of computer system components. The highlighted features are availability, portability, and recoverability. In addition, there are some features of the data quality that are identified in both categories. The features are compliance, accessibility, efficiency, confidentiality, accuracy, ability to be understood, and traceability.

- Renaissance Method

The Renaissance Method was introduced primarily to assess the needs of profit-based systems. The method provides quality characteristics to assess legacy systems, which refers to the technical conditions, business values, and organisation aspects [63]. The related attributes include the rating of vendor, cost of maintaining and licensing, rate of failure, personnel, performance, functionality, data, documentation, external dependencies, law, security, testing infrastructure, and acceptance of change.

- SERVQUAL Model

This model is used as a general method in measuring the quality of services in various organisations including public and private sectors [64,68]. From all the proposed service quality assessment methods, the SERVQUAL model has become an important and popular tool for assessing service quality [69,70]. This model is classified into five (5) main dimensions, namely tangibles, reliability, responsiveness, assurance, and empathy [64].

3. Research Methodology

This study aims to answer the following research questions:

R1: What are the factors involved in legacy systems' modernisation for a citizen-centric digital government?

R2: How do these factors combine to form a conceptual model?

In order to answer the above research questions, this study adopted the qualitative method of study. The approach allows the researchers to obtain a deeper understanding of and information about the study [71]. The specific qualitative technique used in this theoretical study was a review. By using this technique, information about the research problem can be gathered from multiple sources including books, journals, proceedings, and reports. Additionally, a review is also the right way to avoid the same study to be replicated [72].

The initial stage of this theoretical study involved the determination of the research background, research problems, research questions, research objectives, and research scope. This is important to help in identifying research gaps, what needs to be achieved, and identify areas to be studied. The review was then conducted to determine in detail the models, methods, and factors involved in the modernisation of legacy systems for citizen-centric digital government.

3.1. Search Method

The review for this study was conducted through multiple databases. The databases that were accessed for the searching include Web of Science, Scopus, Elsevier, Springer, IEEE Xplore, and Science Direct. The search for the research material involved several key related keywords. From preliminary observations, it showed that the search results for modernisation of legacy systems were limited when the search scope was set for the public sector or digital government only. Therefore, broader search keywords were first established, which were more likely to capture all relevant articles from the database [73]. The keywords used were "legacy system modernisation", "legacy system migration", "citizen centric", "user centric", and "digital government". Then, several conditions have been

included as acceptance or rejection criteria of the articles being searched. The acceptance criteria include:

- Articles related to the modernisation and evolution of legacy systems.
- Citizen-centric related articles for the public sector.
- Journal articles, proceedings, research books, and theses.
- Articles produced in English.

The rejection criteria for the references of this study were:

- Articles that did not match the acceptance criteria.
- Articles where the title, abstract, and keywords were clearly not relevant to the research questions.
- Articles whose full text could not be retrieved from the database.
- Articles that have duplicates.

This study reviewed the related methods and techniques proposed by previous researchers in the modernisation of legacy systems and the implementation of citizen-centric digital government. This is to understand how the guidelines proposed by the researchers can support the legacy systems modernisation for citizen-centric digital government.

3.2. Content Analysis

The selected references were analysed using content analysis [74]. Content analysis is a technique used in categorising and grouping the data besides studying the category occurrences frequency. Content analysis methods are systematic and iterative methods for categorising text in specific concepts and codes [75]. Figure 1 shows the steps of implementing the content analysis adopted in this study [75,76].
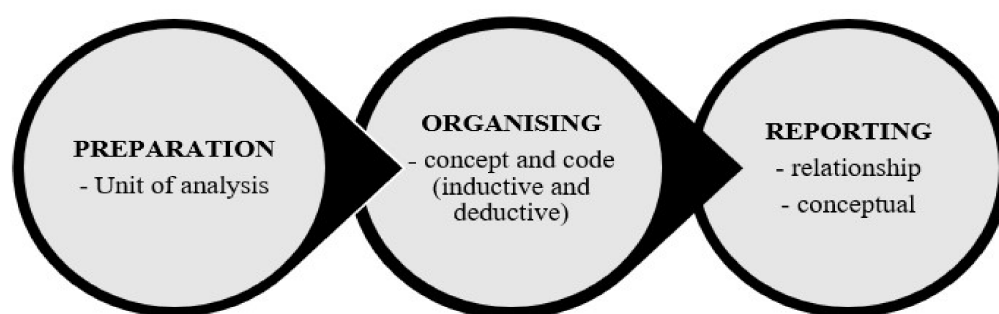

Figure 1. The content analysis process.

- Preparation

This phase began with the determination of the data involved in the analysis process. The data involved were from the theoretical study including journal articles, proceedings, and related books. The analysis of the selected references extracts and categorises the elements on legacy systems modernisation and citizen-centric digital government based on predefined dimensions. Additionally, the snowball technique was also used on the obtained materials in order to expand the search.

- Organising

The data were analysed deductively and inductively. Deductive analysis was performed on the text by identifying and validating existing concepts that were derived from the literature. On the other hand, inductive analysis identified new concepts from the literature text. These concepts were then categorised into related groups and codes according to hierarchical levels, namely, aspects, factors, and elements.

- Reporting

In this final phase, the data obtained were compiled and parsed in a conceptual model with the relationships between aspects, factors, and elements.

4. Results and Discussion

In line with the initiative towards the citizen-centric digital government, the service delivery needs to adopt a new interactive citizen-centric design and involve the citizens. Thus, the implementation of legacy systems' modernisation must include all relevant factors from different aspects including the citizen-centric requirements to provide unified guidance to the organisations.

Figure 2 shows the conceptual model of legacy systems modernisation for a citizen-centric digital government. This model is comprised of four main aspects, namely human, process, product, and organisation. Each aspect has several factors and elements that are relevant to its grouping.
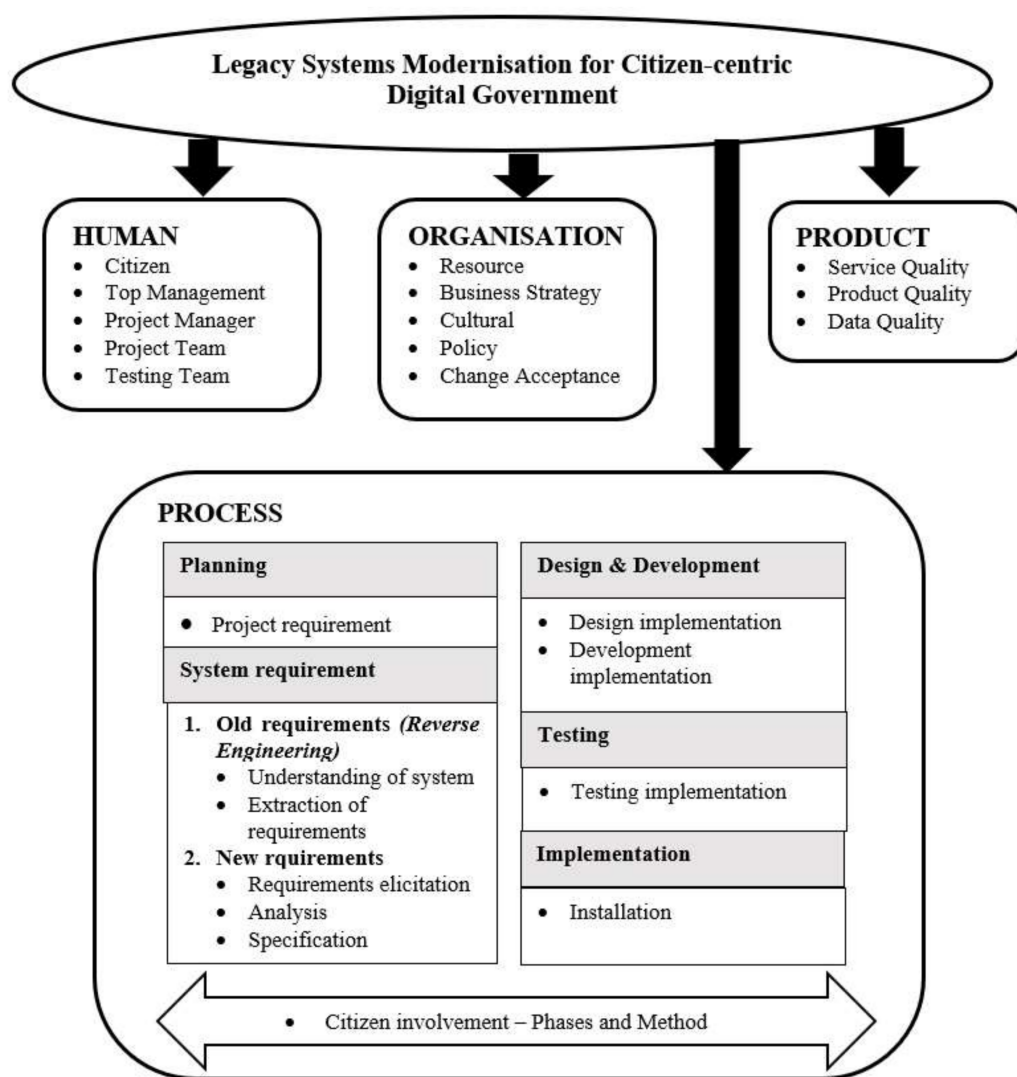

Figure 2. The conceptual model of legacy systems' modernisation for citizen-centric digital government.

The human aspect covers roles that involve implementing the legacy systems modernisation for a citizen-centric digital government. These roles are the citizens, top management, project manager, project team, and testing team. Each role has its own characteristics to ensure the success of the project.

The process aspect includes all the activities that need to be carried out. The activities were divided according to five development phases. The earliest phase is the planning, which mainly involves the project requirements' planning, including the scope, time, cost, human resources, technique, and action plan of the entire project. The system requirements'

determination phase involves old and new requirements gathering. In the old requirements task, the systems need to be understood before the extraction of requirements can be performed. The legacy requirements extracted should be documented for future reference. The requirements' elicitation, analysis, and specification preparation are important activities during the gathering of new requirements. The finalised old and new requirements will be used during the design and development phase. A new system is designed for its interface, database, and integration. It is then developed involving coding using a programming language that has been decided. In the testing phase, the testing process is performed according to the procedure which includes the testing types, script, and use cases. The final phase is the implementation phase that involves the installation of the new modernised system. In addition, the modernising legacy systems activities for citizen-centric digital government require citizens' involvement throughout the process. The involvement activities are performed based on the modernisation phase and the appropriate method as required.

Citizen-centric product features are divided into three main factors, namely service quality, product quality, and data quality. Each factor consists of related elements that need to be considered in modernising legacy systems.

For the organisational aspect, four factors were acquired from the previous studies that will influence the modernisation task. The factors are the project resources, business strategy, culture, policy, and change acceptance. Table 1 lists the factors and elements with a short description of the related elements.

Table 1. Lists of factors and elements.

Aspect	Factor	Element	Description
Human	Citizen	ICT skill	ICT skills of the citizens.
	Top Management	Support	Support from the top management in making the project successful, e.g., financial allocation.
	Project manager	Experience	Experience in the relevant areas of the project.
		Knowledge	Knowledge about project, especially related to project management.
		Leadership	Leadership skill in managing modernisation projects.
	Project Team/Testing Team	Technical skill	Knowledge and skill in the system, including the legacy systems and new system.
		Domain knowledge	Knowledge in the relevant area and domain.
		Communication skill	Skill in communicating with the team, management, and user of the system.
		Relationship	Practise good relationship and teamwork.
		Attitude	The attitude of the team members, such as being hardworking and focused.
Process	**Phase 1: Planning**		
	Project requirement	Scope	The scope of the modernisation project.
		Time	Timeline to complete the project.
		Cost	Costing of the modernisation project.
		Human resource	All the personnel that are involved in all phases of the project.
		Technique	Selection of the best modernisation techniques to be used.
		Action plan	All related activities in all the phases.

Table 1. *Cont.*

Aspect	Factor	Element	Description
		Phase 2: System Requirements Determination	
		Old Requirements	
	Understanding of system	Function	Task and process flow of system.
		Data structure	The structure of the legacy data.
		Architecture	Architecture of the system containing the hardware, software, and network.
		Constraints	Restriction or limitation set in the system.
	Extraction of requirements	Business rules	Rules of the business from the legacy codes.
		Business logic	The logic of business extracted from the legacy codes.
		Data	Legacy system data.
		Legacy systems' specification	Documentation from the understanding and the requirements that were extracted.
		New requirements	
	Requirements elicitation	Method	Approach used in gathering the requirements.
	Analysis	Old and new	Analyse the old and new requirements and selection of the significant requirements to be considered in the new system.
	Specification	Old and new	Specification that combines both old and new requirements.
		Validation	Validation by the relevant customer or user.
		Phase 3: Design and Development	
	Design implementation	Interface	Design the interface of the new system.
		Database	Design the database of the new system.
		Integration	Design the integration involved.
		System architecture	New architecture design.
	Development implementation	Coding	Development of the legacy systems to the new interface, function, or platform.
		Phase 4: Testing	
	Testing implementation	Procedure	Testing implementation based on different type, test case, and use case.
		Phase 5: Implementation	
	Installation	Hardware and software	Installation of hardware and software.
		Migration	Migration of legacy data.
		Monitoring	Monitoring the implementation for any errors or failure.
		Training	Training for the technical and non-technical users.
		Citizen involvement	
	Implementation of involvement	Phase	Related phases of modernisation.
		Method	Appropriate method.

Table 1. *Cont.*

Aspect	Factor	Element	Description
Product	Service quality	Effectiveness	The effectiveness of the system.
		Efficiency	System performance efficiency.
		Satisfaction	System that meets the requirements and the benefits needed.
		Responsive	Responsive interaction between government and the citizens.
		Transparency	Trusted service to the citizens.
	Product quality	Functionality	System functionalities that meet the requirements of the users.
		Performance efficiency	Performance of the system based on the time and resource utilization when performing its functions.
		Usability	System that can be easily used by users in receiving services.
		Compatibility	System that can exchange information with other systems or components.
		Reliability	High system availability.
		Security	Security requirements and characteristics.
		Maintainability	The ability and the easiness of the system to be maintained.
		Portability	Flexibility of the system to be installed or used in different environment.
	Data quality	Accuracy	Correct and accurate data.
		Completeness	The completeness of data.
		Currentness	Latest and updated data.
		Compliance	Comply to the data standard.
		Openness	Data are always open and available for anyone to access and use at any time needed.
Organisation	Resource		Resources required in implementing the project.
	Business strategy		Business requirements and direction of the organisation.
	Cultural		Organisational culture.
	Policy		Law or policy related to the modernisation.
	Change acceptance		The acceptance of the changes introduced.

5. Conclusions

Along with the global changes, the legacy system modernisation becomes an important task to be implemented by the public sector. They need guidance to avoid any failure during the implementation of legacy systems' modernisation and to make sure it fulfils the latest direction of the government, including the citizen-centric digital government. This paper has come out with a conceptual model to provide overall guidance in implementing the modernisation of legacy systems in line with the citizen-centric digital government requirements.

This study used a qualitative method and specifically conducted a review technique. References about the topic were gathered from multiple reliable databases. The source of references included books, journals, proceedings, and reports. Data were analysed using content analysis.

The conceptual model shows that there are four aspects that need to be involved in implementing legacy systems' modernisation for citizen-centric digital government, namely human, process, product, and organisational aspects. Each aspect consists of its important factors and related elements that influence the modernisation. These factors and elements were derived from previous studies that have successfully developed guidelines in supporting the legacy systems modernisation. They were complemented by the citizen-centric requirements in line with the current initiative of the government. Few studies have showed their practical applicability and were implemented and validated empirically [6,45,58]. Nevertheless, the factors obtained from this research will also be confirmed by an empirical study in the related government agencies to verify the accuracy and feasibility.

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