BIG DATA ANALYTICAL FRAMEWORK IN MANAGING MAINTENANCE MANAGEMENT FOR GOVERNMENT OFFICE BUILDINGS IN MALAYSIA

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DEDICATION

Specially dedicated to Abah and Mak

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"In the name of Allah, the most Gracious and the Most Merciful"

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ABSTRACT

The government sector in Malaysia faces major challenges in managing maintenance data. The development of technology and software for industry 4.0 has produced a vast volume of data, and the increase is very high. The sudden rise of Big Data has left real estate players unprepared to use it effectively. Furthermore, the Computerized Maintenance Management System (CMMS) and Sistem Pengurusan Fasiliti Berpusat (eSPFB) used in the government, especially in Putrajaya, are not working well. Based on the research and monitoring conducted, the data in the CMMS are still incomplete for analysis and projection to assist or support strategic decisions in managing facilities. Although it can produce dynamic dashboarding for decision-making, it does not involve Business Intelligence (BI) in providing real-time analysis or an interactive dashboard to the user, making it easier for newcomers to understand the system. Scattered, insufficiency and inaccuracy of maintenance data have become challenges for the maintenance department, making modelling the process or the management of maintenance activities enormously hard and complex. To mitigate this situation, the government must have a framework that can assist in managing the maintenance data management of public facilities, which encompasses an improvement tool through the dashboard simulation model for enhancing current conventional maintenance practices containing the necessary information to satisfy the stakeholder. Due to problems arising in the management of government building maintenance, especially during the decision-making stage, this research attempts to develop a new approach in managing dispersed and complex domain structures using Business Intelligence. Three objectives drove the study, firstly to identify data management challenges in maintenance management; secondly to determine the existing big data and business intelligence in federal government buildings, and thirdly to develop the big data analytical framework in maintenance management for federal government buildings. The Federal Territory of Putrajaya was chosen as the case study for this research. Three research methodologies were employed to achieve the research objectives, a literature review, a questionnaire survey and expert opinion. Firstly, the literature review identified four barriers to CMMS and eSPFB implementation and eight elements of data management challenges in government buildings. The respondents were asked to choose their level of agreement with the barriers and data management challenges. The respondent involved experts from the maintenance and asset management field, making them reliable and relevant for validating the barriers and data management challenges in maintenance management. Six experts were selected based on purposive sampling. Next, questionnaires were distributed to the target group of 35 supervisors who were selected through random sampling at the Jabatan Kerja Raya, Putrajaya. Data were analysed using IBM SPSS 23. The result showed that 73% of the respondents had difficulties collecting maintenance management data. Lastly, the big data analytical framework was developed, grounded by a dashboard simulation model and validated through expert opinions. The developed framework and dashboard simulation model was recommended as a new approach to replace the existing conventional method. In conclusion, this approach is an added value for the government in making structured knowledge in conveying maintenance data to the users for decision-making and better performance of public facilities by Jabatan Kerja Raya.

ABSTRAK

Sektor kerajaan di Malaysia menghadapi cabaran besar dalam mengurus data penyelenggaraan. Perkembangan teknologi dan perisian untuk industri 4.0 telah menghasilkan jumlah data yang besar, dan kenaikannya sangat tinggi. Peningkatan mendadak Data Raya (Big Data) menyebabkan pemain harta tanah tidak bersedia untuk menggunakannya dengan berkesan. Tambahan pula, Sistem Pengurusan Penyelenggaraan Berkomputer (CMMS) dan Sistem Pengurusan Fasiliti Berpusat (eSPFB) yang digunakan dalam kerajaan khususnya di Putrajaya tidak berfungsi dengan baik. Berdasarkan kajian dan pemantauan yang dijalankan, data dalam CMMS masih tidak lengkap untuk dianalisis dan unjuran bagi membantu atau menyokong keputusan strategik dalam pengurusan fasiliti. Walaupun ia mampu menghasilkan papan pemuka dinamik untuk membuat keputusan, ia tidak melibatkan Kepintaran Perniagaan (BI) dalam menyediakan analisis masa nyata atau papan pemuka interaktif kepada pengguna, menjadikannya lebih mudah bagi pendatang baharu untuk memahami sistem. Data penyelenggaraan yang bertaburan, ketidakcukupan dan ketidaktepatan telah menjadi cabaran bagi jabatan penyelenggaraan, menjadikan pemodelan proses atau pengurusan aktiviti penyelenggaraan menjadi sangat sukar dan kompleks. Untuk mengurangkan keadaan ini, kerajaan mesti mempunyai rangka kerja yang boleh membantu dalam menguruskan pengurusan data penyelenggaraan kemudahan awam, yang merangkumi alat penambahbaikan melalui model simulasi papan pemuka untuk meningkatkan amalan penyelenggaraan konvensional semasa yang mengandungi maklumat yang diperlukan untuk memuaskan pihak berkepentingan. Disebabkan masalah yang timbul dalam pengurusan penyelenggaraan bangunan kerajaan, terutamanya semasa peringkat membuat keputusan, penyelidikan ini cuba membangunkan pendekatan baharu dalam menguruskan struktur domain yang tersebar dan kompleks menggunakan Kepintaran Perniagaan. Tiga objektif telah mendorong penyelidikan iaitu pertama untuk mengenal pasti cabaran pengurusan data dalam pengurusan penyelenggaraan; keduanya untuk menentukan konsep data raya dan kepintaran perniagaan sedia ada dalam bangunan kerajaan persekutuan, dan yang ketiga untuk membangunkan rangka kerja analisis data raya dalam pengurusan penyelenggaraan bagi bangunan kerajaan persekutuan. Wilayah Persekutuan Putrajaya telah dipilih sebagai kajian kes dalam penyelidikan ini. Tiga metodologi kajian telah digunakan untuk mencapai objektif kajian iaitu tinjauan literatur, tinjauan soal selidik dan pendapat pakar. Pertama, kajian literatur mengenal pasti empat halangan pelaksanaan CMMS dan eSPFB, dan lapan elemen cabaran pengurusan data dalam bangunan kerajaan. Responden diminta memilih tahap persetujuan mereka terhadap halangan dan cabaran pengurusan data. Responden melibatkan pakar dari bidang penyelenggaraan dan pengurusan aset, menjadikan mereka boleh dipercayai dan relevan untuk pengesahan halangan dan cabaran pengurusan data dalam pengurusan penyelenggaraan. Enam pakar telah dipilih berdasarkan pensampelan bertujuan. Seterusnya, borang soal selidik telah diedarkan kepada kumpulan sasaran seramai 35 orang penyelia yang dipilih melalui persampelan rawak di Jabatan Kerja Raya, Putrajaya. Data dianalisis menggunakan IBM SPSS 23. Hasil kajian menunjukkan 73% daripada responden menghadapi masalah dalam mengumpul data pengurusan penyelenggaraan. Akhir sekali, rangka kerja analisis data raya telah dibangunkan,

berasaskan model simulasi papan pemuka dan disahkan melalui pendapat pakar. Rangka kerja yang dibangunkan dan model simulasi papan pemuka disyorkan sebagai pendekatan baharu untuk menggantikan kaedah konvensional sedia ada. Kesimpulannya, pendekatan ini merupakan nilai tambah kepada kerajaan dalam membuat pengetahuan berstruktur dalam menyampaikan data penyelenggaraan kepada pengguna untuk membuat keputusan dan prestasi kemudahan awam yang lebih baik oleh Jabatan Kerja Raya.

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LIST OF ABBREVIATIONS

BD	-	Big Data
BDA	-	Big Data Analytics
BI	-	Business Intelligence
CMMS	-	Computerized Maintenance Management System
DW	-	Data Warehouse
ETL	-	Extract, Transform, Load
MM	-	Maintenance Management
JKRWPP	-	Jabatan Kerja Raya Wilayah Persekutuan Putrajaya
OLAP	-	Online Analytical Processing
JKR	-	Jabatan Kerja Raya
eSPFB	-	Sistem Pengurusan Fasiliti Berpusat
SPSS	-	Statistical Package for Social Science

LIST OF SYMBOLS

n	-	The sample size
N	-	The population size
e	-	The acceptable sampling error
AI	-	Average Index
i	-	0,1,2,3,4,5

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CHAPTER 1

INTRODUCTION

1.1 Overview

Nowadays Maintenance Management (MM) is covering a primary role for competitiveness in manufacturing. The industry of MM is experiencing the same trend as other industries regarding its data generation, storage, and management. Over time, MM expands from manual reports towards Computerised Maintenance Management Systems (CMMS) and knowledge-based management. According to John Walker (2014), CMMS's essential features include data analysis, reporting, and information exchange. In short, CMMS software is used worldwide and takes the place of manual maintenance activities (paper and pen tracking, as well as excel spreadsheets).

Figure 1.1 explains how the maintenance industry has evolved throughout technology's successive waves (White, 2004).

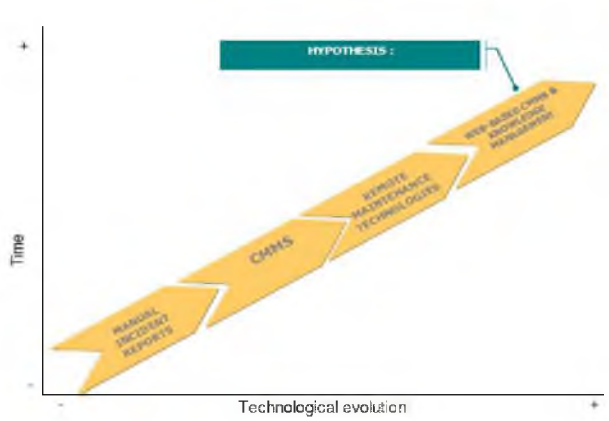

Figure 1.1 Predicted Evolution of Maintenance Management (White, 2004)

Figure 1.1 shows that the MM industry has evolved from manual reporting to electronic reporting. Manual maintenance methods mainly consist of random phone calls, emails, and sticky notes. While some corporations have made incredible advances in using technical tools like CMMS. A CMMS is software that centralizes maintenance data and streamlines maintenance process. It helps maximize the use of transportation, machines, communications, plant infrastructures, and other assets. The maintenance system is also growing more complex, allowing remote access to equipment. Those in control can use the Internet to monitor equipment and gather maintenance data. While web-based knowledge management offers online integration and access to vast amounts of data resources, which pushes the growth of web-based knowledge management (Masoni *et al.*, 2017).

Effective maintenance requires proper data management – collecting, analyzing, and using models for decision making. Besides, digitalization has brought a vast amount of information and data sources that MM may exploit to improve its processes and asset-related decision-making. This evolution of MM has brough a lot of opportunities but also various criticalities about information and data management. However, it is seldom that the maintenance data are properly recorded and utilized in a systematic way especially government. The number of data sources on which a government could count on is remarkably

increased in the last years due to the digitalization process. We can witness growing amounts and complexity of asset data; therefore one of the main challenge lies in the area of data management and Information Technology (IT) (Gavrikova *et al.,* 2021). Without streamlined data management processes, decision-making is frequently biased and not data-driven, which can lead to lower efficiency of decisions, higher costs and increased risks of asset failure (Gavrikova *et al.,* 2021).

As the data-driven economy evolves, businesses have started utilized Big Data (BD) and Business Intelligence (BI) techniques to support the data management process. BD and BI are playing a pivotal role for processing large amounts of production in real time (Desouza and Jacob, 2017). These technological changes are essential to keep the Malaysian government up to date and in line with developed countries. As we all know, government mainly involves with vast amount of data, thus government have no choice but to embrace BD management. Without the right tools and architectures, government won't be able to effectively use the information it has collected (Biddick, 2012).

1.2 Problem Statement

Since the early 2000s, the MM industry has been undergoing e-maintenance, a developing concept in which assets are monitored and managed over the Internet (Tretten and Karim, 2014). MM evolves from manual reports to Computerised Maintenance Management Systems (CMMS) throughout time. Today's CMMSs are well-designed and contain all of the information essential to complete the task at hand, but there is always space for improvement. MM is a term that refers to the collection of all technical and administrative actions, as well as managerial and supervisory actions, taken during the life of an item in order to maintain or restore it to a state in which it can perform a needed function. Due to the high risk of failure, it is critical to continuously improve maintenance functions. Furthermore, the maintenance process

is aided by a diverse range of resources, including paperwork, staff, support equipment, materials, spare parts, facilities, information, and information systems.

For several years, public sector organizations have seen several changes, not only in their governance structures and management practices, but also in their MM. In this respect, the Putrajaya's Jabatan Kerja Raya (JKR) serves as the regulating agency for the operation and maintenance of the Federal Government Office Building in Putrajaya. JKR's specialized responsibilities include ensuring that the office and all of its equipment, including outdoor office space and common areas, operate and are adequately maintained. Lighting systems, fire protection devices, air conditioning, elevators, telephones, as well as cleaning and landscaping work, are all maintained (Yah and Rahimi, 2000). A CMMS is a common interface in maintenance practice and is the primary user of maintenance data in JKR. A CMMS provides support for the entire maintenance process, including maintenance support planning, maintenance planning, maintenance execution, maintenance assessment, and maintenance improvement (Tretten and Karim, 2014) as well as assisting maintenance personnel in creating work orders, registering ongoing tasks, obtaining instructions for maintenance tasks, registering completed tasks, and reporting deviations/problems.

The evolution of MM has brought a lot of opportunities but also various criticalities about information and data management. Due to this, the JKR has also use CMMS to manage maintenance work on government facilities. A study was undertaken on the JKR's use of CMMS and it was discovered that there are inconsistencies and several key shortcomings that the department must fix. Among the challenges associated with the usage of CMMS include unclear ownership of data and applications, CMMS server infrastructure that is dispersed across multiple sites, as well as security concerns and unreliable analysis of government data. Additionally, many suppliers are uninformed of the strategic value of their asset data and hence do not collect data in a systematic manner (Ismail, 2021). A CMMS is believed to aid in data management by managing maintenance alarms, work orders, actions, data storage, completed activities, and status reporting, among other things. However, it frequently lacks the power to facilitate the user in performing the activity, which results in human

error, mistakes, poor data quality, and other criticism (Tretten and Karim, 2014). According to Tretten and Karim (2014), a badly designed system can actively encourage user mistake. In this situation, a CMMS with an inadequately designed user interface (UI) can exacerbate the risk of user error and inaccuracy (Murthy *et al.*, 2015a). As supported by Labib (2014), many CMMS lack of basic user-friendly design as a result of the systems being created for accounting and IT users rather than for the unique needs of maintenance employees. Although the role of a CMMS as a critical tool to support MM, Nabilah *et al.* (2021) report that the successful implementation rate of these systems is surprisingly low, between 25 to 40% and only 6 to 15% of all users get the most of its full capability. Samad *et al.* (2013) argue that a maintenance platform such as a CMMS should be able to track information history and handle vast amounts of data. However, as per the study, the system is quite complicated due to the fact that it performs a significant number of activities and collects data from the entire manufacturing process. Additionally, Ismail (2021) argues that JKR's current CMMS system was not intuitive, making it difficult to search for and locate key information. He notes that achieving centralized, dynamic visibility and automated management was problematic due to the fact that maintenance data was initially buried in paper files and then dispersed across spreadsheets (Abd and Bin, 2017).

Adequate data management techniques, structures, and capabilities can result in significant asset efficiency and effectiveness (Dahanayake and Sumanarathna, 2021). Thus, adopting sufficient techniques for maintenance data management appears to be vital for any organization, but particularly for government. Maintenance documentation often gave challenge for government as it require the process to collect, store and record information (Marquez and Iung, 2008). According to Marquez and Iung (2008), the success of maintenance documentation depends on having a multi-tasking and a fast and easy-to-manage database. While many authors recognize the value of a comprehensive approach to MM and data management (Gavrikova *et al.*, 2021), that available material appears to be restricted and fragmented. Previous studies on MM mainly focused on maintenance optimization model, maintenance techniques, maintenance scheduling, maintenance performance measurement and maintenance policies (Garg and Deshmukh, 2006; Chang, 2014; Vieira and Cardoso, 2014; Duffuaa and Raouf, 2015). There was not much emphasis on identifying the need for advanced

technology in MM, particularly in terms of maintenance documentation. Furthermore, the report does not focus on the government sector, which necessitated the investigation. As mentioned by Labib (2014), documentation has long been prominent on the list of recommended practices to improve development and help maintenance. However, this field often lack of up-to-date documentation. For years, the importance of documentation has been stressed by educators, processes, quality models and despite of this we are still discussing why it is not generally created and maintained. Documentation in government practice typically suffers from the following problems: nonexistent or of poor quality; outdated; over abundant; difficult to access (for example when the documents are scattered on various computers or in different formats: text, diagrams); and, lack of interest from the programmers (Ahmed *et al.,* 2017). In addition, several investigations on software maintenance problems have given high priority to the problems of lacking or inadequate maintenance documentation, and a high turnover rate among maintainers (Samad *et al.,* 2013).

Proper data management in maintenance suited well with maintenance software which can easily record and track data. However, the maintenance software was not widely used in the Malaysian government and private sectors. Previous studies reported that some organisations still use conventional data recording methods through Microsoft Excel and Microsoft Word (Maslesa *et al.,* 2018). Nevertheless, this approach is outdated and time-consuming, as data may be misplaced or mishandled during the recording stage. According to Ismail (2020), Microsoft Excel and Microsoft Word databases are not conveniently used that should be altered into more security and using sophisticated technology with Information and Communication Technology (ICT). The conventional method affects the quality and efficiency of MM process in government sector (Razmi-Farooji *et al.,* 2019). In addition, using conventional method of MM at government sector creates many problems (Razmi-Farooji *et al.,* 2019), among which is the file information is in mistaken handling, recorded in the unsystematic database and difficult to edit yet to update because the data is made in the non-collaboration database. Besides, vast and complex data leads to the limited and slow operation or data processing (Illankoon and Lu, 2019). Naimi and Westreic (2014) agreed that iterative data gathering and service delivery using the conventional method could be time-consuming.

The government opted to build a new system that would be more robust, user-friendly, effective, and capable of assisting with data management in JKR to address these CMMS and maintenance documentation difficulties. eSPFB, or Sistem Pengurusan Fasiliti Berpusat, is the name of the new system (Abd and Bin, 2017). The JKR has taken the effort to design their own CMMS system and has given the contractor some flexibility in terms of which CMMS software they can use instead of eSPFB. However, following its implementation in late 2016, only twenty-four facility management contractors among hundreds of government facilities maintained and inspected by the JKRs have been recognized as using eSPFB in Malaysia. Only twelve contractors in Putrajaya use the eSPFB technology (Abd and Bin, 2017). JKR Putrajaya is a department that is responsible for the management of federally owned facilities located at the national administrative centre, making them a distinct government division with one of the world's largest asset portfolios under management. As a result of these factors, MM data is frequently scattered across a fragmented environment that is frequently maintained in organizational silos. As a result, data are unavailable when they are needed, progress toward digital governance is stymied, and there is little openness on what data is stored or how it is used (Abd and Bin, 2017). As suggested by Ioannis (2021), there is an increasing need for complete maintenance data and information to be available and in real-time for decision-making. Currently, the main problem encountered in eSPFB is that the way of reporting is static and unable to provide real-time dashboard thus stunting government growth and productivity. According to Raza *et al.,* (2016), real-time **reports are necessary as it is visible and available at a moment's notice to assist in** making important decisions. According to Nabilah *et al.*, (2021), eSPFB lack of training about how to operate the system makes the user difficult to use it. Besides that, the use of this system is still in its early stages and many plans will be implemented to improve this system.

Managing data related to maintenance is a crucial challenge for all businesses (Lin *et al.,* 2007; Brous *et al.,* 2015), since the majority of enterprises lack the necessary competencies to understand available data effectively and convert it to valuable management information. Additionally, businesses generate an enormous amount of asset data; yet, not all of this data is meaningful, and it is also insufficient

for management decision-making (Chongwatpol, 2016). Additionally, we observed that the emergence of the internet of things (IoT), BD and BI (D. Jin, 2018) has evolved into one of the more complex and current data management platforms. Several articles discuss the challenges of implementing information systems that enable maintenance reporting and visualization (Raza *et al.,* 2016) or data management in e-maintenance (Loukopoulos *et al.,* 2017; Razmi-Farooji *et al.,* 2019) as well as the challenge of using Building Information Modelling (BIM) and data management concurrently (Halmetoja, 2019). Often, government produce large datasets leaving them with no choice to embrace BD management. Despite with the current situation in JKR makes data management become critical in this study specifically in maintenance. The current field of research is primarily concerned with asset optimization, operational decision-making at the operational level (Gavrikova *et al.,* 2021), and data quality in maintenance management, including the inadequacy of management structures and procedures. Campos (2014) take a similar approach, proposing a framework for data governance that includes information systems, data sources, data analysis, and data visualization. The framework should make it easier to comprehend asset data and convert it to relevant management information. While, Campos (2014) focus on supporting maintenance data management through developing data infrastructures that comprise such elements as data, people, technology, standards, policy, processes and data governance.

With the expanding volume of data in JKR, the government requires innovative methods of data collection in order to conduct analysis and make data-driven choices. It is critical for JKR to employ innovative data analytics tools and platforms in order to stay current with recent issues. The current eSPFB is semi-automated and relies heavily on Microsoft Excel spreadsheets for data analysis. This approach of showing data provides only a limited amount of analytical visualization. Microsoft Excel is quite limited when it comes to managing large data sets especially those with structured and unstructured data thus make this complicated the data analysis and reporting process (Vecherkov *et al.,* 2017). To smoothly transform complex data into knowledge, one such rapidly emerging technology is Business Intelligence (BI). The concept of BI has grown in importance as a result of the promise of value creation through BD. BI streamlines data collection, automatically analyses complex data sets,

provides visuals of the maintenance performance, and give actionable insights. According to Negash (2015), BI may be effectively used in business development to disseminate solutions to complicated problems. The combination of BD and BI has the potential to extract more inventive thoughts and solutions from the cloud of dust. BI necessitates BD as a disruptive technology that relies on data analytics to get actionable knowledge. This occurs because the nature of BI permits the storage of vast amounts of data; thus, BI is well-suited for BD (Campos, 2014). Significantly, BI allows the government to access real-time data and react quickly to make better decisions. Furthermore, data management is a subset of BI that encompasses a wide range of applications used across the complete BI system. Similarly, Ioannis (2021) stated that good data management techniques are a critical component of any BI system's performance. Interestingly, BI is no longer an added utility, rather, it became a requirement for government or any organisation looking to stay competitive, and even to remain afloat, in an entirely new, data-driven environment (Chongwatpol, 2016)

BD and BI benefits maintenance industry in various way especially in maintenance data management. BI works well with BD in making it easy for maintenance department to comprehend and analyse the data. When it comes to industrial maintenance, BD makes predictive analytics faster and easier from a more diagnostic (or preventative) maintenance approach to a proactive one. With the help of BI, it able to translate the maintenance data into meaningful and actionable information (I. Lopes *et al.,* 2016). Reporting in maintenance department is essential to know the current state of maintenance data in JKR, therefore BI able to help in turning the data into decision making. BI help JKR make better decisions by showing present and historical data within the maintenance context. Over the past few years, BI has evolved to include more processes and activities to help improve business performance. These processes include data mining, reporting, descriptive analytics, data visualisation, visual analysis and data preparation (Kans and Galar, 2017). There are many BI platforms available for reporting, data visualisation and creating customized dashboard for multiple level of user which differs greatly from the conventional method such CMMS and eSPFB utilize in JKR. The conventional method affects the quality and efficiency of maintenance performance and processes.

To date, little empirical research has been found in BD and BI literature on maintenance management especially in JKR. According to Sun *et al.* (2018), most firms include government sector are still stumbling around in the dark they seek to fully understand the function and capabilities of BD and BI. As per literature review, the majority of BD and BI adoption studies focus on the telecommunications, insurance, retail and wholesale, tourism, manufacturing, advertising, healthcare, and financial services industries (Sun *et al.,* 2018; Raza *et al.,* 2016; Biddick, 2012; John Walker, 2014). While many authors recognize the value of a holistic approach to maintenance and data management (Komljenovic *et al.,* 2016; Munir *et al.,* 2019b), extant work focusing exclusively on BD and BI deployment appears to be limited. The **"maintenance" BI literature focuses on** examination of competitive intelligence practices in the maintenance sector, frameworks for managing and analysing data, and mainly in the areas of computer science, transportation, marketing management and geography (Mariani *et al.,* 2018). It's fascinating to consider how BD and BI may turn government maintenance data into insight. Sun *et al.* (2018) state that it is necessary to keep software systems up-to-date and useful: Any software system reflects the world within which it operates, when this world changes, the software needs to change accordingly. Thus, additional study should be conducted on the integration of BD and BI, as well as on the specific treatment of maintenance data management processes. With BD and BI, it helps maintenance management in JKR move from traditional descriptive analytics (what happened?) to advanced diagnostic analytics (why did it happen?), predictive analytics (what will happen?), and prescriptive analytics (how can we make it happen?) (Chongwatpol, 2016).

Based on the aforementioned issue, it was motivated to conduct the study of data management particularly in maintenance for government sector in Putrajaya. Due to issues occurring in the administration of government building maintenance, particularly during the decision-making stage, the research to be conducted is critical. Maintenance data that is scattered, insufficient, and inaccurate has become a burden for the maintenance department, making modelling the process or managing maintenance activities extremely difficult and complex. The evaluation of the literature revealed a need for more research aimed at boosting the use of maintenance data management in government in a more innovative and intuitive manner. Hence,

the study developed the maintenance management dashboard simulation model in improving maintenance management for federal government office buildings in Malaysia particularly Putrajaya. We address this research gap and present a novel approach for handling scattered and complicated domain structure maintenance data using business BD and BI tools. More importantly, this research gives an overview of the difficulties and requirements for maintenance with a particular emphasis on BD and BI integration that aid in the management of maintenance through informed decision-making and can be applied horizontally in government sector.

In a summary, through the problem identification related to the study has revealed several major gaps that leads to the conducting of the research which were:

- Lack of consideration or paying little attention to BD and BI integration in handling data management with specific to maintenance job function in government office building;
- Discussion on data management in maintenance for government office building is fragmented and limited;
- JKR's lack of an advanced database management system has made it difficult for the government to make educated decisions, making data management crucial.

1.3 Research Gap

Since the existing government sector in Putrajaya has yet included proper methods in handling government buildings particularly in terms of data management, this study aims to fill the gap since not much of study focus on providing proper system in maintaining maintenance data in JKR and aims to provides knowledge regard to the areas. With the BD buzzword is paving its way within the local real estate industry, it further adds to the burden for the government to handle the existing database management system such as CMMS/eSPFB through conventional methods. The proposed BD and BI analytical framework are expected to improve the conventional

methods in maintenance related problems. And the development of dashboard simulation model is an example of the application of BD and BI integration in maintenance data management especially government office buildings in the Federal Territory of Putrajaya. The integration of BD and BI is expected to change the work process to be more proactive maintenance rather than preventative maintenance.

1.4 Research Question

Several research questions have been generated in facilitating the course of the research for this study. The research questions are as followed:

i. What is the data management challenge among federal government office buildings in maintenance management?
ii. Is there any existing BD and BI adoption in federal government office buildings, particularly in Putrajaya?
iii. How are BD and BI proposed for federal **government office building's** maintenance activities, particularly in Putrajaya?

1.5 Research Aim

The aim of this research is to develop a new approach of managing scattered and complex domain of maintenance data through BD and BI adoption. The new approach of managing maintenance data could improve the current conventional method and performance of government sector in Putrajaya especially JKR in handling maintenance management and better facilities performance.

1.6 Research Objectives

Several objectives have been assigned to accomplish the aim of study which are:

i. To identify data management challenges within the concept of Big Data and Business Intelligence concept for maintenance management in federal government office buildings.

ii. To determine the existing Big Data and Business Intelligence concept of federal government buildings in Putrajaya.

iii. To develop the big data analytical framework in maintenance management for federal **government office building's maintenance activities,** particularly in Putrajaya.

1.7 Research Scope

In light of the research question and objectives, the extent of the research work is limited to;

i. Existing BD and BI adoption in federal government office buildings, particularly in Putrajaya.

ii. The usage of data management by Putrajaya Jabatan Kerja Raya (JKR) in handling maintenance data management of federal government office buildings in Putrajaya.

iii. Maintenance management data from the team that supervised Facility **Management contractors in Putrajaya's government building.**

iv. Simulation of the maintenance management under the concept of big data and business intelligence

1.8 Research Significance

This research could provide support to the maintenance management practices such as:

The maintenance management sections.

i. BD and BI adoption able to streamlined data management process in maintenance practices thus allow governments to enhance staff competency and quality of life.
ii. BD and BI should facilitate the process of interpreting maintenance data to meaningful management information and improve decision making based on underlying data.
iii. BD and BI tools allow JKR in government sector direct access to the data they need to track maintenance more efficiently. It is ideal for a government that wants to provide a centralized and interactive data analysis for industrial revolution 4.0.
iv. BD and BI increase the possibilities for; utilizing data from multiple origins; processing large volume of data and making more advanced reasoning and decision making.
v. Contribute significantly on intelligent system that lets the government make an integral part of decision-making and can be applied horizontally to solve the problems in maintenance practice through business intelligence.
vi. The develop maintenance management simulation model can be implemented for benchmarking the similar units of business.

The federal, state and local authorities.

i. The study may provide comprehensive and practical approaches towards effective maintenance data management

ii. Each of the government tier-level may recognize any critical issues on the maintenance management and optimize the resources allocated through the understanding of the best practice maintenance management dashboard.

Other beneficiaries.

i. Every related maintenance management from other public and private sectors may implement and integrate the developed management dashboard towards effective and sustainable maintenance management

1.9 Research Methodology

A mixed method was adopted in this study consisting the quantitative and qualitative approach to accomplish the stipulated objective of the research. The mixture of the research methods consisting of few methodologies which were:

i. Literature review
ii. Questionnaire survey
iii. Case studies
iv. **Experts' opinion**

These activities were steered in sequence. Data collection was adopting different methods to achieve each objective of the study. The comprehensive literature review was conducted to obtain the theoretical foundation concerning the research topic. Content a**nalysis and expert's validation was adopted** to answer the first objective which was to identify data management challenge among government office buildings in maintenance management. The second objective was to investigate any existing BD and BI adoption in government office buildings, particularly in Putrajaya. The case studies and questionnaire survey were employed to answer this section. Lastly, the developed maintenance management dashboard simulation model based on

the results from the second objective, the dashboard was validated utilizing the experts' opinion. Further details and discussion for each research methods were specified in Chapter 3.

1.9.1 Literature Review

The purpose of the literature review was to identify research gaps in maintenance data management in the government sector. Following then, several studies and research have been examined in order to achieve the notion of big data and business intelligence in improving government maintenance data management. Through a thorough literature review, eight data management challenges in maintenance practises were discovered that should be considered for effective maintenance management in the government sector. Adoption of big data and business intelligence was investigated in determining the most effective tool to include in the study to improve on present maintenance methods.

1.9.2 Questionnaire Survey

A questionnaire survey was constructed to find the answer of "Is there any existing BD and BI adoption in government office buildings, particularly in Putrajaya?" The questionnaire survey was developed based on a comprehensive literature review on BD and BI integration in maintenance management practices. A total of 35 sets of updated questionnaires were distributed to individuals who work directly with the database management system in the Putrajaya government office building. Descriptive and frequency analysis were employed to analyse the data.

1.9.3 Case Studies

The case studies were conducted on government office building in Putrajaya. The aim of conducting the case studies was to answer the second and third objective of the study. JKR is the regulatory agency in implementing the maintenance of the federal government office building located in Putrajaya. Therefore, it is necessary to collect data and respondent from this building to ensure the result is reliable. The detail explanation related to case studies can be seen in Chapter 3.

1.9.4 Expert's Opinion for Validation

The experts' opinions were pursued to validate the developed maintenance management dashboard simulation model. The dashboard was developed based on the established conceptual framework and big data analytical framework in the literature review chapter and the findings from the data collection. The experts' opinion is concerning the features, content and design of the framework. Thus, the details for the research methodology can be seen by referring to Chapter 3. It provides the flowchart for this study and justification based on the research objectives.

1.10 Thesis Structure

This study consists of seven chapters that are organized to demonstrate the systematic method of research.

Chapter 1: Introduction

This chapter explains the fundamental principle of the study through the background of study and problem statement. Besides, the chapter outlined the research questions, and to answer the questions, the aim and objectives of the research were justified. Furthermore, the scope of the research and a brief explanation of the research methodology were covered. The chapter is concluded with the contribution of the

research to knowledge were primarily emphasized to show the significance of the study.

Chapter 2: **Literature Reviews**

This chapter will discuss a review of previous studies related to overall big data and business intelligence, particularly in maintenance management of government office buildings in Malaysia. Also, this chapter detailed out building maintenance management context in Malaysia and the challenge faced by maintenance management on handling big data of maintenance management. The conceptual framework was established as the basis for data collection and developing the proposed maintenance management dashboard simulation model.

Chapter 3: **Research Methodology**

This chapter describes the methodology, the research stage, instruments for data collection and data analysis techniques used for the study. It outlines the research design and research approaches that specifically chosen to achieve the research objectives. The mixed method is carried out in this study. The questionnaire survey, case studies and experts' opinions were considered suitable for answering the research questions. Furthermore, every designated way helps to guide the data collection techniques and analysis to execute the research process.

Chapter 4: Data Collection and Analysis

In this chapter, the data acquired through the questionnaire survey was analysed empirically by employing the descriptive analysis through SPSS. As for the experts' opinions, the Likert Scale was employed to analyse the level of agreement by the experts. While, the Frequency Analysis were employed to analyse the data collected in questionnaire survey.

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Chapter 5: Development of Big Data Analytical Framework in Maintenance Management

This chapter aims to explain the process of developing big data analytical framework and maintenance management dashboard simulation model using Microsoft Power Business Intelligence, which can use big data concepts for maintenance management in Putrajaya government office building.

Chapter 6: **Results and Discussion**

In this chapter, the results from the analysis were discussed and highlighted. The discussion of the analysis from the questionnaire survey regarding the data management challenge and current maintenance management practices. Also, the last part of the chapter deliberated the development of the maintenance management dashboard **and the validation conducted utilizing the expert's opinion**.

Chapter 7: Conclusion and Recommendations

This chapter represents the conclusion of the study and the assessments of the accomplishments for each research objective. This study may be used and become a platform for future research which looking for improvement and enhancement in terms of methodology and outcomes.

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