Computerized Maintenance Management System in IR4.0 Adaptation - A State of Implementation Review and Perspective

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Abstract. Computerized Maintenance Management System (CMMS) is a software package that stores computer databases of information about maintenance operations, evolving in the 1960s as the era of computational and mathematical systems began. Since then, the evolution of CMMS has continued to evolve with the ready availability of technology and requirements. While industry 4.0, refers to a new phase in the transformation of the industrial revolution (IR) focusing on digitization, automation, machine learning and real-time data. Therefore, the aim of this paper is to review the implementation of CMMS in revolution adjustment by investigating the functions of the IR4.0 in automation process and analysing the maintenance operations. The paper solely focused on the functionality of this system's implementation attributes to the ability of the system integration to logically concept of IR4.0. This paper is also examined issues related to organizational and supplier readiness in integrating the IR4.0 concept into CMMS. In addition, by implementing CMMS based on IR4.0 enablement, it can have a significant impact on work processes, forward analysis, operations and maintenance costs.

1. Introduction

Maintenance management in large industrial operations is complex and has a significant impact on the profitability of business income. Thus, it seems that maintenance management is almost impossible without the support of a computer base [1]. Therefore, in the near future, CMMS will be able to assist in the management of relevant maintenance activities in an efficient and effective manner [2, 3]. In order to achieve efficient maintenance management, technical, economic and historical information about the device and the company's facilities are required, thus through the use of the computerized maintenance management system (CMMS) this is achieved [4].

Maintenance management can be characterized as a lot of exercises to characterize upkeep goals, techniques, and obligations and to execute them in manners, for example, maintenance arranging or planning, control and maintenance support oversight, as well as improving organizational structure including economic aspects [5]. While CMMS is a software package that stores information in a
computer database, it contains information about the organization's maintenance operations. This software helps maintenance managers optimize their activities and make informed decisions [6]. According to Bagadia [7] and Kullolli [8] both agree that the current version of CMMS is primarily used to drive scheduled preventive maintenance actions, as well as to manage data related to asset conditions [9]. It refers to a book written by Bagadia [7], entitled “Computerized Maintenance Management Systems Made Easy”. The CMMS revolution began in the late 1980s and early 1990s, where most organizations began to move from pencil and paper, to computer usage [10]. Beginning in the 90s, the use and programming of “Access” began to evolve, here again the maintenance of the technology based on current technology, where information stored in databases made it easier for users to record, search, analyze and report [11]. The diagram below illustrates the chronology of CMMS transformation changes from the 1980s to the present.

Figure 1. The chronology of CMMS transformation and connecting to the industrial revolution [10, 11, 15, 16]

The need and increased expertise in the field of technology bring about a new change, referring to a book published by Schwab [12], entitled "The Fourth Industrial Revolution" clarifying that the Fourth Industrial Revolution was set apart by the rise of supercomputers, shrewd robots, driverless vehicles, genetic altering and the advancement of "neurotechnology" that empower people to better optimizing brain function [13]. With the concept of “Big data” the information gathered can be analyzed more precisely and faster, it is enhanced by the technology of telecommunications (IoT) network technology that enables information and communication to be streamed anywhere in a fast time [14]. It is to be seen that during the initial three modern transformations mechanical, electrical and data advancements have been created, planned for expanding profitability and checking of business methodology [15]. At first early industrial advancement revolution it aimed to increase productivity through the use of hydro power, the improvement of steam power utilization and the improvement of machine apparatuses, while in the second modern upheaval presented power and mass creation and in the third mechanical unrest expanded the utilization of robotization with the utilization of hardware and data innovation. Right now, the fourth modern upset is underpinned by the Cybersecurity System (CPS) approach that combines physical engineering with the information age (ICT) for a more efficient and competitive future industry [15, 16]. The latest digital technology is widely used in the manufacturing industry, but by adapting the Industry 4.0 concept, it will change the concept of production based on the latest technology. This will lead to greater efficiency and will transform traditional relationships among suppliers, manufacturers, and customers, as well as between humans and machines, as well as decision making using the AI concept [17]. The table below shows the nine technological trends shaping the Industry 4.0 industry block.
Therefore, this paper will discuss the benefits of CMMS by adopting the concept IR4.0 in its implementation, along with the issues they are facing and a significant impact on work processes, forward analysis, operations and maintenance costs.

2. CMMS requirements in IR4.0 adaptation

Next-generation maintenance solutions should lead to industrial digital transformation and should have more user-friendly operations with the latest technology. Based on the requirements of 4.0 and the latest technology, it can be concluded that CMMS is a prerequisite to achieve this goal. This is seen from the point where CMMS is a system based on information gathering and operating relationships. Currently, CMMS able to meet almost all IR4.0 requirements [18]. Therefore, understanding the requirements and functions for CMMS preparation in implementing the IR4.0 concept is important. The combination of physical engineering, electronic engineering and ICT expertise will impact the success of the CMMS in preparing this new revolution.

Technological change has changed the world, this makes the need to change as well. In which, the technological requirements of ICT are seen as a catalyst for this change and this leads to changes in the socio-economic and organizational operations. In the 21st century, digital skills are crucial to the well-being of modern living. Humans are seen to depend on the existence of this technology, in coordinating the needs of daily life [17]. Now many organizations are beginning to see and implement a system of information and communication technology (ICT) to improve their business processes and operations, in the provision of products and better service with minimum operating costs [18]. Maintenance management is very important in all sectors of the industry. In achieving more effective maintenance management it requires a change from traditional management to ICT technology-based management. Therefore, it should be in line with the passage of time and in line with the latest technological evolution [1, 3]. In maintenance management, CMMS acts as a repository of information or data related to maintenance concepts, asset counts, spare parts, personnel information and planning methods. This information is important in helping management analyze and plan maintenance operations [1]. CMMS is reactive, as it can provide unlimited feedback based on predefined parameters, where as more data is entered into the database the more trend analysis is possible.

The current operating data obtained is entered manually and its accuracy can be disputed, through the transformation of the latest technology, every information can be sent to the system immediately without the need for manual input into the system. This process is called the integration process.
Through this integration process, information is sent quickly and accurately to every system connection, without the need for human presence as an intermediary. This helps increase productivity and makes the repair process easier and faster [19]. With the adaptation of the latest technology, maintenance managers can monitor many operations or facilities at one time, this is because the system assists in the collection of information online and the analysis of the information is communicated to humans for the purpose of final decision [20]. This is the impetus for global trends for the transformation of the modern industry and operating systems, where humans and machines together with technology form partnerships to enable operations to become smarter.

CMMS offers a variety of core maintenance functions. It is not limited to manufacturing but expands to facilities, utilities, vehicle management, hospitals, sports arenas and more where every type of equipment or asset is subject to repair and maintenance needs. With the current improved technology and increased competitiveness along with operating cost control, more and more companies are turning to CMMS over the use of manual methods to track and organize information [9]. Different CMMS components include but are not limited to:

- Equipment data management
- Preventive maintenance
- Predictive Maintenance
- Manpower Monitoring
- Work order and Complaint system
- Maintenance Scheduling and Planning
- Inventory control
- Buying assets and Inventories
- Maintenance Budget
- Asset tracking and searching

CMMS's ability to handle large amounts of data and quickly has opened up new opportunities for maintenance, this provides a better methodology in dealing with an association's benefits. CMMS is presently a key segment of huge numbers of the company's maintenance departments, and offers support at various levels in the following organizational hierarchy [11]:

- It can support the monitoring of conditions (CBMs) of machines and equipment, to offer a sense of mileage damage and fatigue.
- It can follow the development of extra parts and request substitution if vital.
- It permits operation to report error function more rapidly, along these lines permitting support staff to react to issues all the more rapidly.
- It encourages improved correspondence among activities and upkeep work force, and is urgent in improving the consistency of the data went between these two departments.
- It furnishes upkeep organizers with verifiable data expected to create Preventive Maintenance plan.
- It gives upkeep supervisors data through empowering progressively compelling control in the exercises of their specialization.
- It offers bookkeeping data about machines to empower capital use choices. furthermore,
- Providing the top management with important information on the state of health care of assets in their organization.

2.1. Integration between system operations

According to Nine Trends in Industrial Technology 4.0, there are many systems in one process and this requires integration with each other. Two out of nine of these trends, the IOT and BigData require integration in the delivery and the state of shared information.
The Internet of things (IoT) is a worldwide innovation foundation that empowers advanced data and devices to speak with each other truly or for all intents and purposes [21].

Figure 3. Internet of things [21]

It is a concept of communication that is extended through the Internet to all the equipment and communication around us. It is likewise considerably more than machine-to-machine correspondence, remote sensor organize, sensor arrange, GPRS, RFID, WI-FI, GPS, chip, etc. This allows communication of each application through this IoT technology [14,17,21].

According to Vermesan [22], for the activation of IoT technology should be considered three categories namely, (1) technology that allows the "thing" of information to be obtained contextually, (2) technologies that enable the "thing" of information to be acquired contextually and (3) technology in improving security and privacy [21]. Looking at categories (1) and (2) above, it refers to the sophistication of things and things through the concept of IoT communication, while the third category addresses the need for functional and security enhancements to categories (1) and (2).

Therefore IoT isn't an innovation, however it is a mix of various equipment and programming advancements, known as integration process.

While "Big Data" is the process of collecting data in each relationship for analysis and sharing purposes [23]. It is a "mass digitization" of each data and stored in a database for analysis purposes. The CMMS system is a system that applies this concept to the maintenance management sector, whereby all the information gathered can be used for future analysis.

3. Its implementation

As discussed in the introductory topic, CMMS is a software package that stores the organization’s entire maintenance operations database. It is a key process in business activities. Referring to the writings of Márquez [24] in the book entitled "The Maintenance Management Framework" there are three levels in business activities, namely (1) The strategic level, (2) The Technical level and (3) The operation Level [20] and it's refer as following:

- The strategic level
  It sets maintenance management goals to coincide with business goals. Planning in setting critical targets to current operations. At this stage establishing relationships with other systems such as electronics, devices or other systems like ERP is very important.

- The tactical level
  It determines the assignment of a predetermined maintenance resource. The requirements of detailed maintenance, planning and scheduling resources are set in this stage. CMMS as
a maintenance management system will store every planning information in the system database. It will implement scheduling, planning and allocation of resources in terms of manpower and maintenance spare parts.

- **The operation level**

  To ensure that maintenance tasks are performed according to the planning that has been set based on the task category, schedule, procedures and tools that have been set. At this stage the assigned work will be distributed to the staff involved. While maintenance data should be included and updated in the CMMS database upon completion of the task.

  However, there are additions to the above three frameworks that are a complement to this process cycle in meeting the requirements of IR4.0. It is “The analysis level”. In this stage all the information collected will enter the phase of "Big Data" in the analysis according to the specified parameters. This analysis is needed in response to maintenance operations, it is intended for further correction and planning tasks [23]. In this process mathematical and statistical calculation methods are used and the results of the analysis will be shown in the form of graphical tables or percentages. For example OEE analysis, process benchmarking, frequency and so on.

![Image](image_url)

**Figure 4.** Levels and IT systems in the MDSS process

### 4. Discussion

As has been explained in the introduction section that CMMS has existed since the 1.0 revolution and it is no stranger to the maintenance management sector. However with the advent of revolution 4.0 it is changing the perceptions and needs of today, involving automation technology that presents new challenges to all sectors for change in line with the digital transformation to remain competitive. Readiness for IR 4.0 can be defined as the ability to take advantage of future production opportunities, reduce risk and be competitive in responding to unforeseen future shocks [25].

#### 4.1. Impact and advantages

The need to use the IR 4.0 approach has begun to permeate within the maintenance community. It began to be mention and discussed in each session and blog entries. By leveraging the CMMS functionality by integrating IR4.0 requirements, it will greatly benefit the organization's operations in enhancing the maintenance of operational maintenance processes and redirecting its direction to digitization.

CMMS functionality will be better if connected to equipment and machines, where CMMS can obtain preliminary information and analyze the data based on the control parameters that have been planned [9]. Through the results of the analysis, CMMS is able to make better maintenance planning forecasts. It can take over human functioning in planning maintenance. Human task can be focused on decision-making and implementation tasks, therefore it becomes an effective practical solution [9].
In addition, integration with machine-made smart sensors can detect changes in the way machines operate, such as if the parts vibrate at a higher speed than usual [21]. The function of work instructions or job notifications can be improved, this through the integration of CMMS to a smart device or smart phone. The software will notify technicians of newly scheduled tasks on their mobile device [21]. With the capabilities and combination of IoT and Big Data technologies, AI analysis can be better enabled [23]. Analyzes such as Overall equipment effectiveness (OEE), brake down trending, cost effectiveness and so on can be issued accurately, without the need for calculation time. This improves operational productivity and facilitates future decisions.

4.2. Industrial readiness

However, it is seen that the readiness of the industry is still not ready to reach the level of IR4.0 [21]. There is still a long way to go, this is because it involves time, knowledge, skills and high costs in its implementation.

This is contributed by the level of awareness and knowledge related to technology, good infrastructure availability and the impact of high technological transition costs, making this implementation less popular.

In addition, according to the judgment [26] skills and the acquisition of skills of workers in IR 4.0 among Malaysian SMEs are at level 1, which is in the beginning stage. This refers to the analysis conducted by Bank Negara Malaysia in 2019, in the study stated that Malaysia as the leader of IR 4.0 in the region in terms of digital transformation, however the Malaysian economy is still lagging behind Japan and Singapore [26].

5. Conclusion

This paper explores and review the transformation of CMMS functionality in adapting IR4.0 technology, with the functions of a CMMS can be developed to achieve more efficient management of maintenance.

In conclusion, adapting the 4.0 technology in CMMS functionality is capable to be realizing it. This is because this technology is already available and only requires the integration or sharing of information with one another. It will provide more unexpected functionality within CMMS and make CMMS centralized in database and maintenance operations.

CMMS will become a reactive system, where without the need for human presence between processes. The machine via smart device or sensor will always send information to CMMS, therefore CMMS is able to monitor the operating behavior of the machine according to the process specifications that have been set. Any errors that occur in the operation will be detected and corrective instructions sent to the maintenance engineer for further action. With this time stopping and finding the cause of failure can be eliminated.

For the long term integration of this technology can have a huge impact on operating costs, quality and productivity of work, employment and business profits. However, seen to adapt to the incorporation of this technology, start-up costs are a major constraint. Management needs to spend a lot of money to upgrade each tool and do integration in each system. Apart from that, the readiness of local workforce knowledge in the operation of this technology also has an impact on the successful implementation of this technology integration.

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