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CHALLENGES OF CLOUD TECHNOLOGY IN MANUFACTURING ENVIRONMENT

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ABSTRACT

The rapid growth Information systems and advanced network technologies have significant impact on enterprises around the world. Enterprises are trying to gain competitive advantage in open global markets by using the latest technologies, along with advanced networks, to create collaboration, reduce costs, and maximize productivity. The combination of latest technologies and advanced manufacturing networks technologies lead to growth of new manufacturing model named Cloud Manufacturing which can shift the manufacturing industry from product-oriented manufacturing to services-oriented manufacturing. This paper explores the literature about the current Manufacturing problems, understands the concept of Cloud Computing Technology, introduces Cloud Manufacturing and its role in the enterprise, and investigates the obstacles and challenges of adopting Cloud Manufacturing in enterprises.

Keywords: Cloud Technology, Cloud Manufacturing, and Cloud Computing.

1 INTRODUCTION

The use of new technologies and networks are becoming critical success factors in any enterprise. Enterprises are trying to gain competitive advantage in global markets by using the latest technologies, along with advanced networks, to create collaboration. Manufacturing companies currently rely on many advanced network technologies, such as Agile Manufacturing, Network Manufacturing, and Manufacturing Grid to operate a single manufacturing task from the integration of distributed sources. These manufacturing networks enable collaboration and sharing of manufacturing resources between manufacturing units (Xu 2012).

Although manufacturers benefit from the implementation of state-of-the-art technologies in gaining advantage over competitors, there are problems in these existing network technologies that affect production within the manufacturing industry. These issues include the sharing of manufacturing resources, where the manufacturing resources cannot be distributed into the manufacturing network due to lack of manufacturing services management in the manufacturing network. Inability accesses the manufacturing hard resources (i.e. equipments) in the manufacturing network (Gao *et. al* 2013). Absence of knowledge sharing and distribution between manufacturing units, suppliers, customers, and partners to development strategies in how to enhance competitive advantage and in how to understand manufacturing practices within the industry (Xu 2012).

To address the issues affecting the industry, a new manufacturing model, called Cloud Manufacturing, is emerging. This model can provide and share manufacturing resources and

manufacturing capabilities as services to the users in enterprise. Cloud Manufacturing model is complex and involves many advanced technologies and networks that need to be integrated efficiently, and it affords the ability to exchange data and share knowledge among the different users (customer, suppliers, and partners), which can be an important factor to reduce costs, maximize productivity, increase in the utilization rate of resources, and create collaboration (Wang and Xu 2013). Also, it has the potential to exceed expectations with the right implementation; and it can change and restructure manufacturing systems in the manufacturing industry, and move it from production-oriented manufacturing to service-oriented manufacturing (Xu 2012).

2 AN OVERVIEW OF CLOUD COMPUTING TECHNOLOGY

The Cloud Computing Technology concept is changing the way of invented, developed, deployed, scaled, updated, maintained, and paid for information technology services (Marston *et. al* 2011).
There are variety definitions for Cloud Computing Technology, but one of the best and generic definition has been defined in 2011 by the National Institute of Standards and Technology (NIST). NIST define Cloud Computing Technology as "Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics**,** three service models, and four deployment models".

The relationship between traditional computing device and Cloud Technology can provide a better understanding of this new technology. Figure 1 demonstrates this relationship.

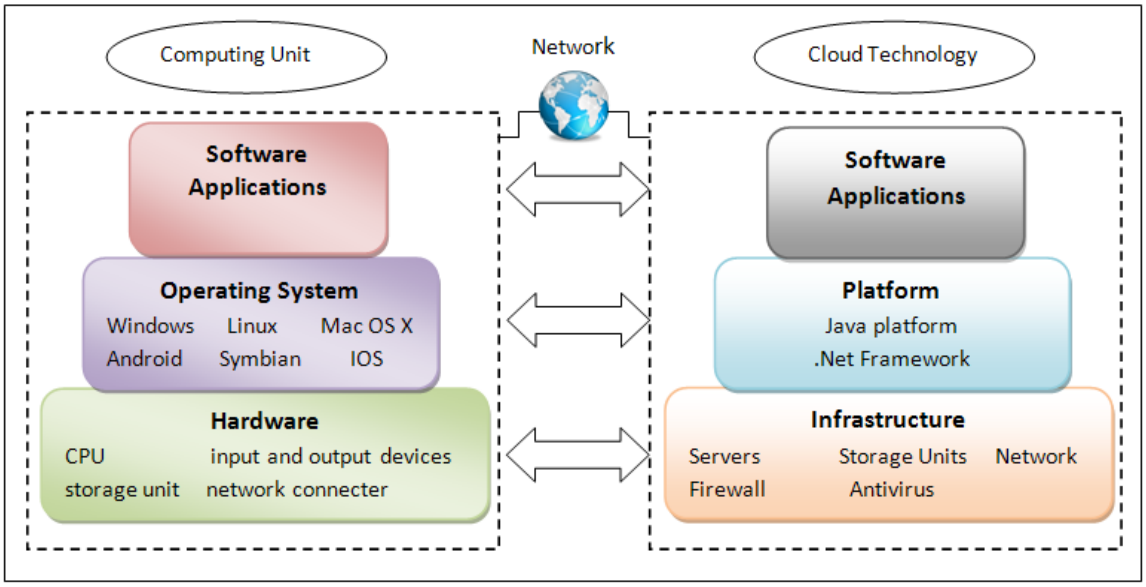

Figure 1: Relationship between traditional computing device and Cloud Technology

There are three main elements in traditional computing device, hardware, operating system, and software applications. Each element has a specific role in the computing device. The hardware consists of central processing unit (CPU), input and output devices, storage unit, and network capability. The CPU is responsible for all operations in the computing device, and network capability is connecting the computing device to the network for joining other computing device on the network. The operating system is a set of software programs to manage the application, and to control hardware devices in the computing device. The third element is software applications that exist in the computing device to perform tasks for the users.

Similarly, Cloud Computing Technology has same elements with different terminology, the Cloud Technology elements are infrastructure, platform, and software. The infrastructure consists of all the necessary services and facilities to provide computing resources for the users. The platform provides a development environment for developers to develop their own application, where a

developer user can write, run, upgrade, fix, and change his application. The final element provides software applications based on the needs of the user.

3 CLOUD MANUFACTURING

The role of technology in the manufacturing industry has become critical factor and it is fundamental in supporting technical and business processes. Today, the emergence of new technologies such as Cloud Computing, Internet of Things, Virtualization, and Web Services, with the help of existing advanced manufacturing networks, can shift the manufacturing industry from product-oriented manufacturing to services-oriented manufacturing. The combination of innovative technologies and existing manufacturing networks has created a new concept, called "Cloud Manufacturing".

Cloud Manufacturing can define as a manufacturing model that depends on new technologies and advanced manufacturing networks to share the manufacturing resources and capabilities as services, and create collaboration with other users. Manufacturing resources refers to soft resources(workforce, software, knowledge) and hard resources(manufacturing equipments, monitor control devices, materials, transportations, storages), whereas manufacturing capabilities refer to ability to transform manufacturing resource into another form (design, production, management, communications, etc). The goal of Cloud Manufacturing is share the manufacturing resources and manufacturing capabilities to create collaborative work between customer, suppliers, and partners locally, nationally, and internationally.

3.1 Cloud Manufacturing Architecture

Lv (2012) proposed a architecture for Cloud Manufacturing consists of five layers:

Physical resource layer:

Includes all the manufacturing resources and manufacturing capabilities, and links those resources and capabilities to the global network by using technologies such as Internet of Things.

Virtual resource layer:

Prepare the manufacturing resources and manufacturing capabilities for the cloud environment by virtually encapsulating physical resources, and publishing them into the core service layer.

Core service layer:

Manages the cloud services of the encapsulation of manufacturing resources and manufacturing capabilities for the users (provider, operator, and consumer), hence: cloud services include registration, service booking, charge, and search.

Application interface layer:

Provide integration between the existing manufacturing application system and the cloud service in order to deliver a manufacturing application system according to user demands.

Application layer:

Provides access for users to request a Cloud Manufacturing service from any device (PC, laptop, smart phone), from anyware (company, home, aboard).

3.2 Cloud Manufacturing Deployment Models

There are four types of deployment models in cloud environment, public cloud, private cloud, community cloud, and hybrid cloud. Each type is designed for specific situation that suitable for the enterprise (Marston *et. al* 2011).

Public Cloud:

A public cloud is offered services and infrastructure from off-site, third party service provider via the Internet. The advantage of this kind of cloud is reducing the cost of (IT) solutions in the enterprise. An example of public cloud that is used by many enterprises is the E-mail providers such as Hotmail.

Private Cloud:

A private cloud provides same services and infrastructure of the public cloud for the enterprise but within the enterprise. The access for the private cloud is limited to enterprises only. The key advantage for this cloud is ability of control the cloud infrastructure. Enterprises often prefer using private cloud for critical information.

Community Cloud:
A community cloud is shared and used by several enterprises that have the same mutual interests and concerns. For example, in United Kingdom all Government agencies may share computing infrastructure on the cloud to manage data related to citizens residing in United Kingdom.

Hybrid Cloud:
A hybrid cloud consists of two types of clouds, public cloud and private cloud. This cloud used by enterprises to determine how to distribute and share critical information, services and infrastructure within or outside the enterprise.

4 CLOUD MANUFACTURING CHALLENGES

Many enterprises, which implemented or trying to use Cloud Computing Technology, have major consideration about this technology. Today, most of enterprises that used Cloud Computing Technology have fears of putting their critical data and application in the Cloud due to trust issue (Chow *et al.* 2009), while Greenwood *et al.* (2010) state that the host of all data and applications in the Cloud environment will be impossible for any enterprise. They assume a combination of Cloud Technology and existing servers within the enterprise. Understating the challenges in Cloud Manufacturing can be a significant factor for adopting Cloud Manufacturing into enterprises. A few studies indicates key challenges in Cloud Manufacturing as shown in Figure 2 (Wyld and Maurin, 2009; Shade O *et. al*, 2010; Marston *et. al*, 2011; Ogunde and Mehnen, 2013)

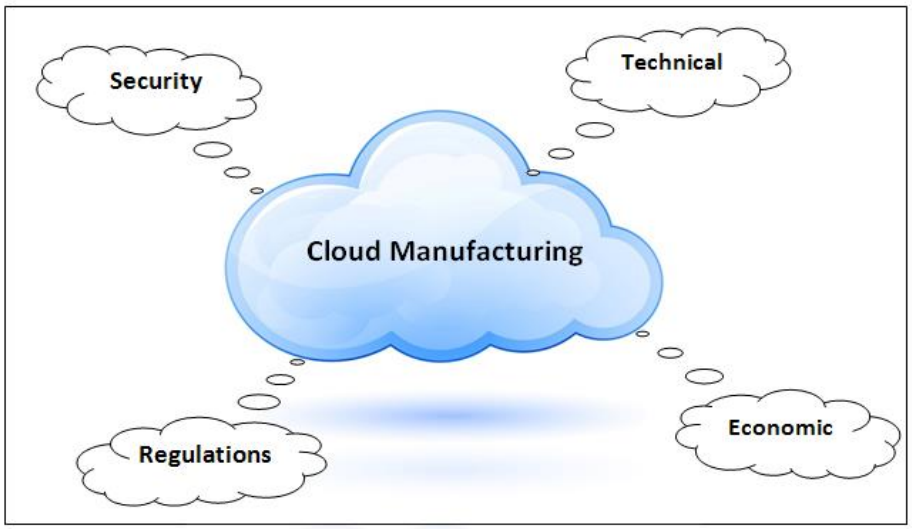

Figure 2: Cloud Manufacturing challenges

Most important challenge in Cloud Manufacturing is security, where many issues such as privacy, data deliver, data control, and hackers are the major issues of security in the Cloud environment, and many enterprises do not want adopt this technology for previously mentioned issues. A survey conducted in 2010 by Harris Interactive for Novell company shows that 91 percent are concerned about security issues in the public cloud, 76 percent believe data is more secure internally in IT departments in the enterprise premises. Also, the complexity of Cloud Manufacturing can create suitable environment for security breaches and losing control of data and applications that are critical for the enterprise.

Because of the complexly of Cloud Manufacturing system and involves many advanced technologies and networks that need to be integrated efficiently, many technical challenges exist in the cloud. Among these challenges, transform manufacturing resources and capabilities into cloud, network outage and system failures (availability), the ability to work together with different information systems, more than one cloud, and different software applications (interoperability), and easily grow of information system due to increase demand for cloud services (scalability).

Both of manufacturing resources and manufacturing capabilities are core of Cloud Manufacturing system, and it need many technologies such as Internet of Things and wireless sensors to coordinate

between Cloud Manufacturing system and manufacturing process. But the amount of data collected from different equipments and tools lead to overload in network and make it very slow for exchange data in Manufacturing Cloud system. Also, need more storage space into the cloud due to data collection of real-time manufacturing resources, and need more process resource from cloud to handle this data. All those issues can result in Cloud Manufacturing system failure.

Although, cloud providers invests a lot in their systems to grantee availability of the cloud systems, but there are many incidents, such as Gmail outage for 100 minutes in 2009, can create doubts about the cloud capabilities for delivering critical data and application for enterprises. The cloud providers guarantee deliver cloud services to customers under any circumstances, but sometimes enterprises can not access their data and cloud resources due to network outage and system failures. The outage may be permanent as provider company gone out of business or temporary as failure in provider company systems. Either way, fail to provide data and cloud resources can be disaster on enterprise, where the enterprise can not function without their data and cloud resources.

The aim of Cloud Manufacturing is to manufacturing resources and capabilities between different parties (manufacturing units, supplies, other enterprises, and customers), but to manage different information systems and different manufacturing systems under Cloud Manufacturing umbrella can be difficult task for both enterprises and cloud providers. For example, legacy systems are substantial irreplaceable in many enterprises, and it is costly and time consumer to put it into cloud. Moreover, many cloud systems architecture designed as closed systems, which prohibit to interactive with other cloud systems. Also, different cloud providers can create a vendor lock-in situation, where each cloud provider has its own way to run the cloud different from other providers. This limits the choices for enterprises to choose between other cloud providers in the market.

Availability, performance, and quality are the major concerns when enterprises using cloud services. The relationship between cloud provides and their customers need to be more efficient and effective by using standards, agreements, and regulations to know the responsibilities and duties of each party in Cloud Manufacturing system. Lacking control of the data and it location in the cloud may creates conflict with regulations laws in enterprise's country, an example for this dilemma, European Union and American countries have laws prohibits moving certain data types outside the enterprise's country.

The cloud provides need to ensure their customers about their services by using Service Level Agreement(SLA). Until this day, there is no official standard for Cloud Computing Technology, but there ongoing work from International Organization for Standardization (ISO) for standardization of Cloud Computing Technology. The standard is expected to be a guideline or code of practice for Cloud Computing Technology.

From the economic perspective, the purpose of using Cloud Manufacturing is to reduce the cost of investment in IT. Cloud Technology allows enterprises, especially SMEs, to use computing resources and capabilities at low cost. A research indicates that the implementation of cloud technology in enterprise has financial benefits reach to nearly 37%. However, the implementation of Cloud Manufacturing can raise the cost of using network communication (bandwidth) to send and receive data from the cloud. Moreover, Using Cloud Manufacturing for large enterprises can be costly due to need of more Cloud resources for their large projects. Also, possibility of switching Cloud providers because of dissatisfaction of Cloud provider services could be costly and time consumer for the enterprise due to difficulty extract the data existing in the cloud.

5 CONCLUSIONS

Cloud Manufacturing is one of the emerging technologies in the field of Information system, and has a significant impact in manufacturing industry by sharing the manufacturing resources and capabilities as services, and creating collaboration. However, there are many challenges that can be obstacle of Cloud Manufacturing implementation in manufacturing industry. Enterprises have their suspicions and fears about Cloud Manufacturing capabilities. This paper focused on some important challenges regarding security, technical, organization, and economic. It is very important to understand and provide solutions to these challenges before jumping into Cloud Manufacturing.

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