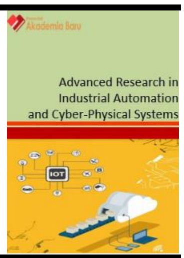
Journal of Advanced Research in Industrial Automation and Cyber-Physical System

Journal homepage: www.akademiabaru.com/aria.html
ISSN: 2637-0263



IoT Optimize The Product Lifecycle Management

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ARTICLE INFO

Article history:
Received 9 January 2019
Received in revised form 1 March 2019
Accepted 9 March 2019
Available online 22 April 2019

ABSTRACT

The evolvement of Internet of thing (IoT) is undeniable by making the management process become more ease at lowest cost as possible. Product lifecycle management (PLM) is a best approach to be embedded the IoT for the entire manufacturing processes. Real cases reported for weak PLM implemented like late market entry that faced by A380 while Toyota faced cost loses in repair, deals and market share from massive called that effect on company reputations. The embedded IoT with its potential may optimize the manufacturing management, make more efficient and offer the traceability on product/project status beside improve the flexibility, maintainability, reusability as well as extensibility. In this paper, the framework for the embedded IoT into PLM is proposed by emphasizing the usage of multi-agent system (MAS) as data carrier to dispatch the data for authorize user. The term traceability is measured based on respond time in real time system in order to track the information in just in time. The real time test (RTT) is done through different operating systems that commonly used in industry and also support the data acquisition, control and robotics in distributed environment.

Keywords:
Internet of Things, Product Lifecycle Management, New Product Development

1. Introduction

The evolvement of information technology opens wide door for other fields like business, manufacturing, management and etc. to be moved for high efficiency and performance. Two difference definitions of PLM that bring to same goal of manufacturing process. The perfect combination between people, process and data is an integration concept of PLM [1] was a first definition as shown in Figure 1. According to Kevin [2] PLM is a process that possess the ability to leverage investment in product development process by delivering more innovative and impactful products where it is extend from idea generation until product retirement. The initial idea of PLM is to emphasize the customer relationship management where delivering the customer service well is a main factor that most business to compete each other.

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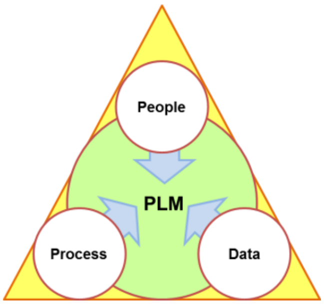

Fig. 1. The PLM concept. The perfect combination between people, process and data is an integration concept of PLM [1]. The initial idea of PLM is to emphasize the customer relationship management where delivering the customer service well is a main factor that most business to compete each other.

1.1 Manufacturing in the Future

Online customization and purchasing is a new disruptive purchasing model that affected the manufacturing system and chain. This model required an evolution management while the operational levels become a huge challenge [3]. Terms of Big Data cannot be denied in Industry 4.0 where the only effective solution to manage and control the complexity and disturbances is by adapting the manufacturing networks [4]. Behind the manufacturing networks, IoT, data exchange, product life cycle management (PLM), business web, social web, computer hardware and software become the pillars. It is view by Mourtzis *et al.*, [4] in Figure 2 that incorporates the recent trends in internet technologies that able to give better support to the Industry 4.0.

Any manufacturing field that engaged with network involved its organization in manufacturing and assembly to form raw material into finished product [5]. The complexity in the system is contributed by the variety that exists in an industry. Complexity is a re-emerged activity that done repeatedly and inspired the methodology of big-data management in computer network to take on complex system. Furthermore, it's also energized many research fields with sufficiently fast ability to tackle any problem in many industries [6]. In PLM perfective, a PLM network engaged with entire entities in manufacturing in order to make sure the product produce meet the demand and target. Furthermore, the PLM network is aim to ease the manufacturing management by providing the data on-board as well as can be accessed anywhere at any time.

The applications of IoT have compelling the enterprise operations to keep up and meet the market demand. The force of global market makes many industries to rethink their productivity, quality strategies techniques and approach of overall operations management. Industry 4.0 as future manufacturing is targeting to compel the principles and strategies of just in time (JIT), total quality management (TQM), computer integrated manufacturing (CIM), agile manufacturing, lean production, quick respond manufacturing (QRM) as well as supply chain management (SCM) [7].

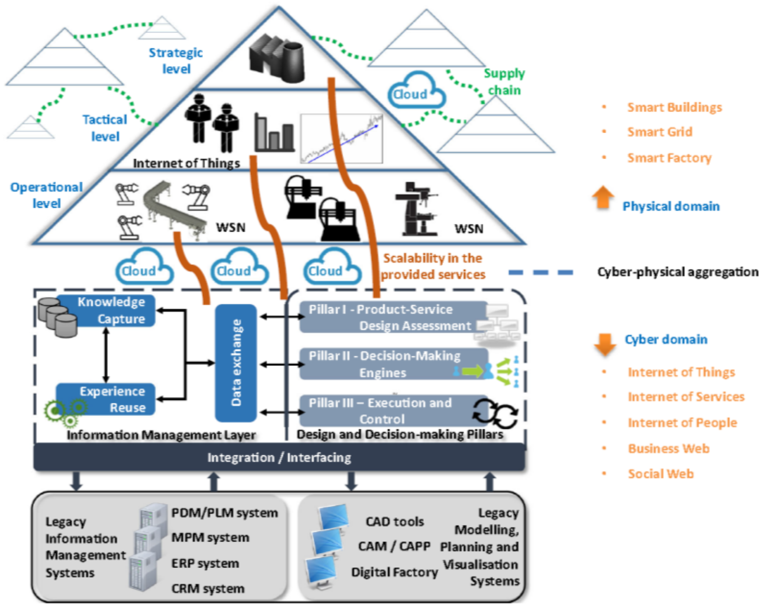

Fig. 2. Manufacturing view in the [4]. As an emerging manufacturing, the automation is not only automating the physical processes but data also include. The automated of physical processes and information processing able to achieve a long-term sustainable production. The automation processes become a goal in deterministic manufacturing and one of the criteria for Industry 4.0.

The challenge and manufacturing issues in Industry 4.0 is summarized in Figure 3 below where it's divided into three main factors which are man, machine and management. To handle the complexity in manufacturing network, the future focused leadership and mind set is required. Furthermore, the more intelligent equipment or machines occupied, the higher skill worker required to operate that. Traceability become a main focused in this study where the usage of IoT is manipulating to track the product information and material used during manufacturing process. The traceability makes the whole manufacturing processes become visible and easy to manage.

PREC-IN monitoring system provides the most effective adjustment in process parameter and its lead to reduce the final product performance. Furthermore, the corrective action is achieved in just-in-time [8]. Smart technologies for manufacturing bring a bundle of complexity in order to manage and control the information either giver or share and improve the communications in near-real-time. The expanding accessibility of 'huge information' has raised the desire that we could make the world more unsurprising and controllable. Indeed, the real time respond (RTT) in communication and management able to overwhelm the instabilities get from delayed response or worst information handling [9]. Industry 4.0 possess the smart technology equipment such as communication devices and information tools in order to inform the customer/client about product status by loading the data in near-real-time or just in time. Beside that the operator's accountability and line performance can be evaluated can be informed in near-real-time [10]. However, does the devices and tools able to respond in near-real-time? In this study, RTT is study by using two different operating system where the signal parsing through socket connection.

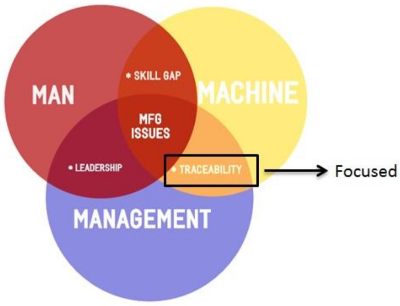

Fig. 3. Current manufacturing issues faced. The challenge and manufacturing issues in Industry 4.0 is divided into three main factors which are man, machine and management. To handle the complexity in manufacturing network, the future focused leadership and mind set is required.

2. Product Lifecycle Management

2.1 Issues in Product Lifecycle Management

PLM emphasized the combination of people, process and data to be successfully implemented. However, the implementation of PLM also contributes to several losses based on real case scenarios occurred around the world when it's neglected several factors. Figure 4 shows the six issues that been identified from the current study and the factors affected in sustainable PLM.

Green focused should provide an important competitive advantage instead of minimizing the environmental harm only. In to integrate environmental issues into new product development (NPD), the environmental factors must be considered in all stages of the manufacturing process [11]. The emerging of green technology involve two sides in manufacturing perspective, customers demand and supply from manufacturers which pressuring and responding to it. This point of view enforced the pre-production stage to consider the environmental issues in the design process [12]. Polonsky and Ottman [11] believes that the successful of green NPD involve a wide set of stakeholders while Lee and Kim [13] agreed that the suppliers plays a major role for NPD where it's begun from the design concept stage to the prototype development stage. Collaboration and communication are two main factors for green NPD. Collaboration is defined as coordination and alignment with project teams since the green NPD having a broad demand and various inputs and multifunctional product development, to meet market and environmental regulatory requirements become a main reason why the team needs to be coordinated. Effective communication between stakeholders is needed in order to provide information to produce green NPD. The information become extremely valuable in preproduction stage where it involves design and testing in order to ensure the NPD is meet the environmental regulations.

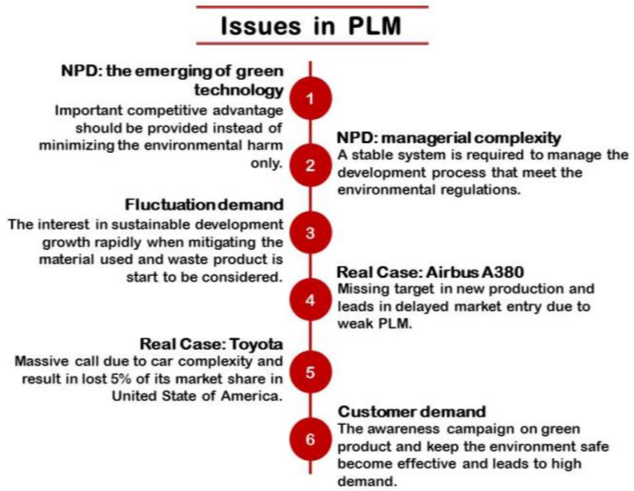

Fig. 4. Issues in PLM. In PLM, there are three important factors that make it complete and works efficiently. People, process and data required good collaboration and by intervening the technology into PLM make it become more successful to merge the business globally.

Complexity in NPD required a stable system to manage the development process. To manage the entire PLM is not an easy activity in order to meet the target such as customer demand, early market entry, new invention product and etc. The transforming of virtual production (designing, testing and simulation) into physical production is difficult to control during phase of life. The managerial complexity of PLM becomes cross-enterprise issues and even more challenging. Late market entry and exceed the targeted cost are the serious consequences faced if the company loses control in PLM. It is proven by real cases reported when weak PLM was implemented.

i) Case 1: Airbus Company: A380 was reported on missing target in new production and leads to delayed market entry due to their weak product life cycle management (PLM) [14].
ii) Case 2: Toyota Company: Until year 2009, Toyota made a massive vehicles call due to car complexity of 11 major models and over 9 million vehicles. The recalls cost at least $2 billion in cost of repair and lost deals. The recall result in lost 5% of its market share in United State of America and further drops foreseen [15].

The fluctuation demand occurred when the awareness campaign on green product and keep the environment safe become effective. This point enforced company to create new product that comply with environment regulation. The interest in sustainable development growth rapidly when company start to consider mitigating the material used and waste product and any future weakness as well as inefficiencies can be avoided [16]. Organizing and managing the sustainable development and NPD become more complex and it's dependent on organized process and technology as a critical success factors [1, 17]. PLM required technology as an integrative approach in order to manage the data and process for NPD towards sustainable and efficiently possible in new product process but not in development/design phase only [1].

Current practise of PLM is reviewed in Table 1 where the most application is neglected the technology invention in order to manage the data and process. The successful collaboration process can be achieved when PLM able to interact with coordination, information exchange, negotiation and solving conflicts [18]. In PLM, there are three important factors that make it complete and works efficiently. People, process and data required good collaboration and by intervening the technology into PLM make it become more successful to merge the business globally. To reduce the communication barrier cause by geographically factor and the used of web-based management seem the only way to make it successfully manage.

Gaps analysis as shown in Figure 5 has been concluded from the reviews on current PLM implementation and agent web-based application. Too focused on NPD is noticed as the first gap where current implementation or research put a lot of focused in pre-production stage in order to make sure the product development comply with the environment rules and regulations. Second gap reveal the poor information interaction and lack of data exploitation for the entire PLM and Gmeling and Seruing [1] noticed that the sustainable NPD is only feasible to be done in pre-production only and hard to be implemented in the entire of PLM. It is because the company lack of communication by ignoring the information exchange between supplier, customer and retailer become the third gap in current PLM practise. This point of view proved the idea proposed by Polonsky and Ottman [11] where the sustainable NPD should be involved with wide stakeholders. In order to achieve the sustainable PLM, the information exchange and trading is required in entire PLM. By emphasizing the MAS in PLM, it’s able to make the idea of sustainable PLM happen with its ability to solve the complexity and expedite the process and secure communication network in management and production process.

Table 1
Studies reviewed on PLM. In PLM, there are three important factors that make it complete and works efficiently. People, process and data required good collaboration and by intervening the technology into PLM make it become more successful to merge the business globally

Author	**Issues Focused**	**Industrial Focused**	**Idea Proposed**
Tao *et al.* [19]	Product Life Cycle Energy Management (PLEM): Energy consumption	Manufacturing Firms Area: design, production and serve process	IoT in PLEM
Wiesner *et al.* [18].	The interactions between SLM (Service Life Cycle Management) and PLM (Product Life Cycle Management)	Manufacturing Firms	Combining the PLM with SLM by using the IT technology. .
Gmelin and Seuring [1]	New Product Development (NPD)	Automotive companies	Sustainability in NPD
Främling *et al.* [20]	Communication in Sustainable PLM (Green Information System)	Manufacturing Firms	Intelligent Product Model for Sustainable PLM Applications
Kiritsis [21]	Closed-loop PLM	Production Management	Physical device i.e: sensor, timer etc. is required to achieve the level of intelligent system/process
Schuh *et al.* [22]	Non-effective application of lifecycle management concepts	Manufacturing and Business	Process oriented framework to support effective PLM implementation

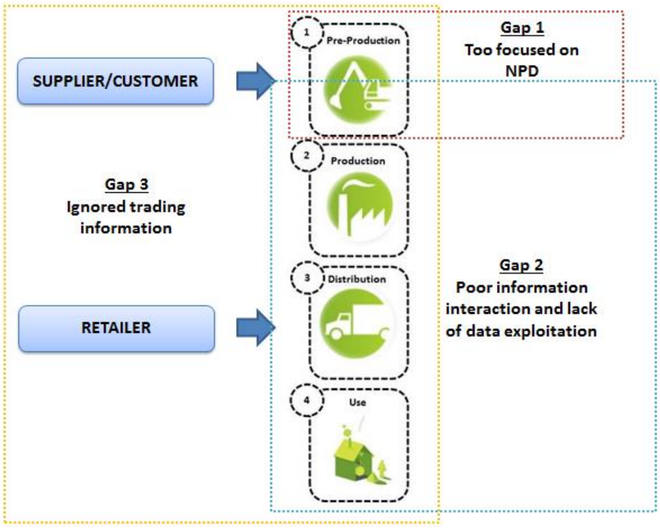

Fig. 5. Gaps in current PLM practise. Current practise of PLM neglected the technology invention in order to manage the data and process. The successful collaboration process can be achieved when PLM able to interact with coordination, information exchange, negotiation and solving conflicts.

2.2 Multi Agent System in Product Lifecycle Management

The collaboration in communications views between PLM with high-tech components (internet technology) will improve time to deliver product to market that meet customers' requirements. The collaboration will help the companies to increase revenues and reduce costs [23]. From the analysis done by Accenture, the large communication, media and high-tech companies require huge investment of capital in order to achieve the effectiveness and efficiency in PLM process.

PLM was evolved parallel with computer world and internet technology. Siemens company can be assumed as a pioneer in PLM software where it's recognized as an information strategy, an enterprise strategy and, ultimately, a transformational business strategy [24]. For global information traceability and visibility to maximize the impact of PLM process, new approach with internet environment is required. The integration of PLM with internet is able to accelerate time on the data sharing between two different locations. Oracle company who is one of the inventors of PLM in cloud-based has introduce the PLM as a Service with capability to export the product information in common file formats (excel, csv, xml) and help the organizations to share easily the product information across the enterprise without compromising speed or reliability with granular APIs and Web Service [25]. Table 2 show the pattern of evolvement in PLM.

The review on agent web-based in manufacturing is show in Table 3 where the agent web-based is starting to be implemented in year 2013 through XMLAYMOD in machining platform (CAx Interface) for production stage [26]. Nyanga *et al.*, [27] proposed the used of multi-agent system (MAS) in production stage for machine selection. The others research does not apply the used of agent in order to manage the data and process in different places through web-based. Furthermore, the manufacturing web-based only focus in early PLM stage which are pre-production and production only by neglecting the information trading between supplier, customer and retailer.

Table 2
The pattern of evolvement in PLM. The PLM evolvement for global information in traceability and visibility to maximize the impact of the PLM process. Time acceleration on data sharing between two different location become undeniable

	PLC	PLC Software	PLC as a Service
Definitions	A systematic approach to managing the series of changes a product goes through, from its design and development to its ultimate retirement [28].	A software solution to automate the management of product-related data and integrate the data with other business processes [28].	A set of diverse business strategies, processes and applications by identifying the right projects, processes and problems that can be solved [29].
Capability	Enables to manage all aspects of their product development process, from the initial idea through to retirement [30].	Strategically manage the complete life cycle of a product: from the ideation phase through to recycling and retirement [31].	Provides on-board product and catalogue data from various internal and external systems [25].
Focuses	The mechanical aspects of product design, including bill of materials management and release to manufacturing [30].	Process efficiency, rapid innovation, cross-functional collaboration, closed-loop quality control, risk mitigation, and cost-effectiveness [32].	Build a healthy innovation pipeline fuelled by a steady stream of high-value ideas and product concepts [32].
Information strategy	It builds a coherent data structure by consolidating systems [24].	Align the value chain, and provide a single source of truth for product data [32].	Manage and synchronize product development data and processes to accelerate time to market [32].
Enterprise strategy	It lets global organizations work as a single team to design, produce, support and retire products, while capturing best practices and lessons learned along the way [24].	A comprehensive approach to innovation built on enterprise-wide access to a common repository of product information and processes [24].	Share completely, standardized and consistent product information with internal systems and trading partners [25].

Table 3
Review on agent web-based applications. In year 2013, the agent web-based is started to be implemented in manufacturing fields through XMLAYMOD in machining platform for production stage. However, in 2015 the MAS was applied in production stage also for machine selection. Since then the evolvement of MAS is very minimum to be used in manufacturing.

Author	Focus	Agent Collaboration	Manufacturing area focused
Nyanga *et al.*, [27]	Machine Selection	Yes (MAS)	Production
Colledani *et al.*, [33]	Product Quality	No	Production and maintenance
Tao *et al.*, [19]	The intelligent perception and access of manufacturing resources	No	Pre-production and Manufacturing Resources
Dutra *et al.*, [34]	SoftDiss (Service Oriented Framework to the Design of Information System Service)	No	Pre-production

Valilai and Houshmand [26]	XMLAYMOD for machining platform (CAx Interface)	Yes	Production
Wang [35]	Job-shop machining	No	Production
Masud and Huang [36]	E-learning	No	Non-manufacturing application
Lan *et al*. [37]	Networked manufacturing service system for rapid product development	No	Pre-production

2.3 Components of Multi Agent System in Product Lifecycle Management

There are multi-agents involve in the design of the monitoring application, mostly regarding software agents. All the information/manufacturing data gain from the section, need to save in the database in order to make the user ease to monitoring the data through the web. However, if the users feel that the data is not enough or goes incorrectly, the user able to request the data from the provider/assigned people from the section. In every section, at least one people/employee is assigned as authorized people for data provider. The components of MAS in PLM are as follow:

i) Pre-production Agent: The agent needs to ensure the manufacturing data is enough and ready to be shared in the web-based. Beside that the agent needs to ensure that the products/materials is ready to be manufactured.
ii) Production Agent: The agent needs to collect all the manufacturing data such as product quantity, quality, production status (employees' attendance, machine breakdown, WIP and etc.). Besides that, the agent needs to ensure that the product is ready for shipment.
iii) Distribution Agent: The agent is assign to ensure that the product is successfully delivered to the customers. However, if there any issues related on delivery, the agent needs to update the information into the database.
iv) Use Agent: In this section, the agent represents as voice of customer where agent search the customer complaint on the product related and updated into the database.
v) Disposal/Recycle Agent: In certain manufacturing process, the scrap/reject items can be recycled as a new product for the other production line and some of them cannot be used at all. At this point, agent needs to search and identify the quantity of recycle and disposal items. All the information gain is required to be updated/save in the database.

2.4 Type of Manufacturing Data

Table 4 shows the type of manufacturing data that agents will be searched. The agents searched the data in the section assigned. Those data are saved in the database where the user will surf the web for monitoring application. Those data are allowed to be reviewed and extracted from the system by the authorized users. Those data categories listed is critical to be monitored in order to make sure the product order meet the demand. Furthermore, the data also can be used to ensure the production meet the target.

Table 4
The type of manufacturing data for searching agents. Those data are allowed to be reviewed and extracted from the system by the authorized users. Those data categories listed is critical to be monitored in order to make sure the product order meet the demand. Furthermore, the data also can be used to ensure the production meet the target

PLM Agent	Manufacturing Data
Pre-production	Engineering Note, Engineering Change Note, Material Note, Material Change Note
Production	Material Input, Qty. output, WIP, Reject, Rework, Quality status
Distribution	Ordered, Received, Released Type of Shipment, ETD, ETA
Used	Customer claim/complaint
Disposal or Recycle	Disposal and recycle quantity

2.5 Multi-agent Architecture in Product Lifecycle Management Network

Based on review work conducted, the specific multi-agent framework for PLM-Network is proposed as shown in Figure 6. The approach is extending from the previous work done by Lu & Wang [38] where the agents is comprises into four categories: customer-centric, manufacturing-centric, retailer-centric, and distribution-centric in framework proposed. Dealing with customer information management becomes a responsible for customer-centric agents. Utilization of customer information in production is managed by manufacturing-centric agents in order to produce the customer demands in the right time. The critical information regarding on the product quality and recycle or reuse product is obtained by retailer. The retailer agent is appointed to share the data gained with manufacturer in order to decide the collected reuse or recycle product is entitled for repair or refurbish. The distribution-centric agents are responsible for delivering information of materials and products to the manufacturer and retailer.

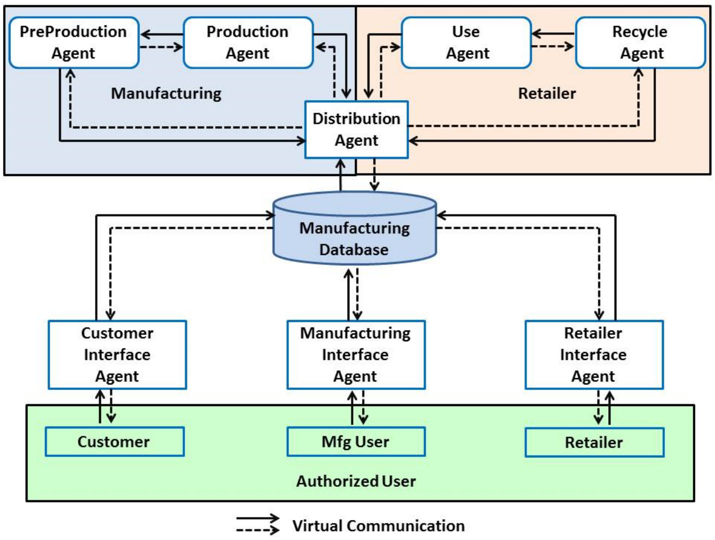

Fig. 6. Multi-agent framework for PLM-Network

3. Round Trip Time

Most of the manufacturing target emphasized the time period for every activity including communication. The purpose of the experiments in this section is to verify the optimal cost through RTT. RTT is measure by using socket communication between two or more computer involve client and server environment. The PC or workstation is referring to client which provides with friendly interface such as Windows. While a group of users is provided by server to client for sharing the server program [39].

There are two type of operating system used that running over the network where the details of machines (computers) used is shown in Table 5. Windows and Linux as an operating system provide the communication link between users and the devices [40]. The communication between two programs running through socket that constitutes a client-server application. The connection process started with client send a request to the server on specific port. The server is on ready mode for listening and accepts the request from the client. Once the connection is accepted, the client able to use the socket to communicate with the server and begin with read/write from their sockets. The process cycle is shown in Figure 7 below where the activities is keep on happening until the server is disconnected.

Table 5
Machine Details. Windows and Linux as an operating system provide the communication link between users and the devices [40]. The communication between two programs running through socket that constitutes a client-server application

Machines name	Operating System	RAM	IP Address
V_1	Window 7	4.00 GB	120.17.42
V_2	Window 10	4.00 GB	120.17.92
V_3	Window 8	4.00 GB	120.17.45
V_4	Linux Ubuntu	972.6 MB	120.17.194

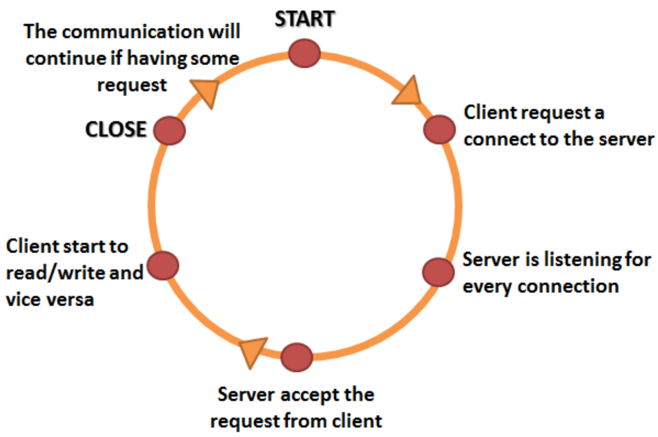

Fig. 7. The general process cycle for one-way communication through sockets and server. The activities are kept on happening until the server is disconnected. The connection process started with client send a request to the server on specific port. The server is on ready mode for listening and accepts the request from the client. Once the connection is accepted, the client able to use the socket to communicate with the server and begin with read/write from their sockets.

From the test conducted, the time is estimated based on the formula below where the T_0 is a time for server to accept the connection while T_1 is an ended time for the communication process. The client started to read and write or vice versa during the communication process.

$$RTT_n = T_1 - T_0 \tag{1}$$

For the RTT, seven attempts or task been implemented, and the mean time is calculated by using the equation below:

$$Raw\ Mean\ RTT = \left[\sum_{i=1}^{i=n} RTT\right]^{-n} \tag{2}$$

3.1 Intra-Platform

Intra-platform communication occurred as internal signal respond in one machine as shown in Figure 8. Huge difference of respond obtained by V_3 compare to V_1, V_2 and V_4. The different probably cause by the machine itself where V_3 is frequently used for programming development compare to others. Furthermore, the other machine is rarely used. However, the speed of network also contributes to the long period taken for every machine to respond. Table 6 show the result obtained for intra-platform that involves four different machines and two different operating systems.

Table 6
Intra-platforms' round-trip time results. The testing is done for internal operating system communication. The V_3 obtained the fastest result compare to others due to high frequency of used for programming

No. of Attempt	Machines Name			
	V_1	V_2	V_3	V_4
1	749	847	11	613
2	655	842	6	617
3	717	874	7	648
4	702	893	7	625
5	765	825	7	657
6	717	1092	6	638
7	733	825	6	655
Mean of RTT (ms)	719.71	885.43	7.143	636.143
Raw Mean of RTT	102.816	126.490	1.020	90.878

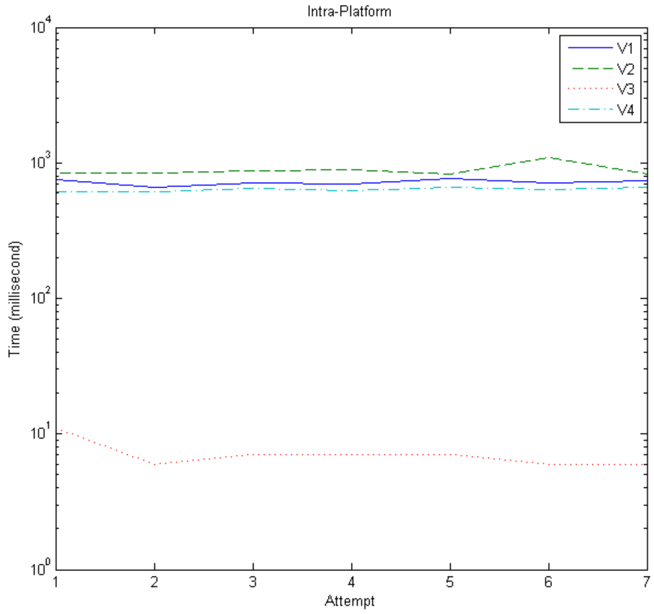

Fig. 8. Intra-Platform signal respond in time (millisecond). Intra-Platform signal respond in time (millisecond). Machine V_3 obtained rapid respond compared to other machines. This frequency of used for programming may become a contribution factor.

3.2 Inter-Platform

For the inter-platform signal responds involved difference server for every testing. Overall performance showed that the server V_3 in Figure 6 gives the fastest signal respond in 14ms compared to others. However, the V_4 in Figure 7 shown the overall signal respond in 588ms where the Linux is an operating system for that machine. Linux give a lot of benefit for computer and network development but it less to be used for manufacturing purpose. For server V_1 in Figure 4 and server V_2 in Figure 5 shown the instability occurred with overall signal respond is 644ms and 645ms respectively.

Table7
Inter-platforms' round-trip time results. The result obtained when the V_1, V_2, V_3, and V_4 become a server and communicate with others machine. The respond time is calculated and still showing the V_3 is fastest than others

No. of Attempt	**Machines Name**											
	V_1			**V_2**			**V_3**			**V_4**		
	V_2	**V_3**	**V_4**	**V_1**	**V_3**	**V_4**	**V_1**	**V_2**	**V_4**	**V_1**	**V_2**	**V_3**
1	624	702	656	640	719	641	16	15	13	587	592	597
2	655	639	624	656	641	640	16	13	6	588	588	586
3	640	639	655	625	656	1438	14	15	5	589	586	587
4	671	639	640	641	641	641	16	19	15	588	586	587
5	640	640	640	641	640	656	20	15	15	590	586	587
6	639	655	624	672	625	641	19	15	12	586	590	592
7	640	639	639	640	640	641	14	6	16	592	586	587

Mean of RTT (ms)	644	650	640	645	651	756	16	14	11	589	587	589
Raw Mean of RTT	92	92.86	91.43	92.14	93	108	2.29	2	1.57	84.17	83.86	84.14

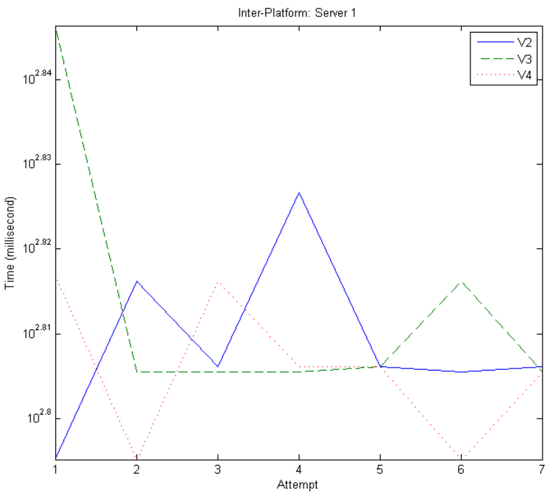

Fig. 9. Inter-Platform signal respond in time (millisecond) for Server V_1. Instability of connection show in server V_1, however machine V_3 shows stability in one-way communication

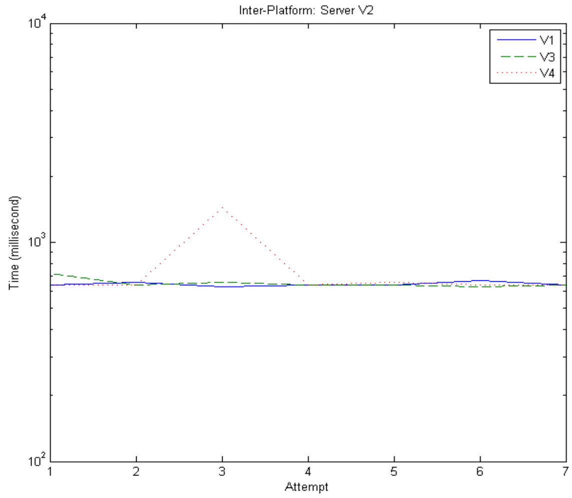

Fig. 10. Inter-Platform signal respond in time (millisecond) for Server V_2. Stable communication shown by most of the machine but the respond not so rapid compare to server V_3 and V_4

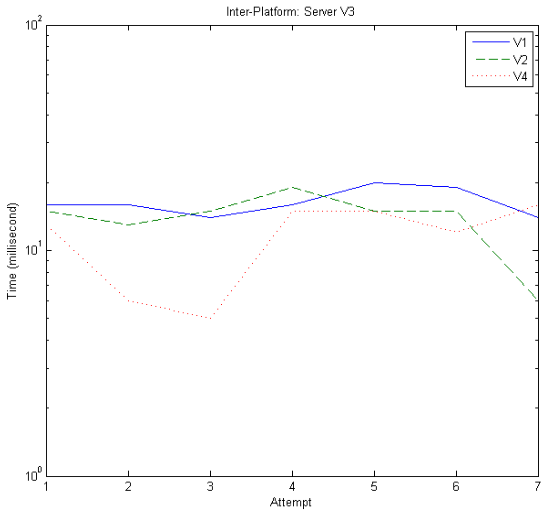

Fig. 11. Inter-Platform signal respond in time (millisecond) for Server V_3. The fastest respond is obtained by V_3 compared to V_1 and V_2 that used same operating system which is Window. If all manufacturing process could have this time respond it may give benefit to the manufacturing management in delay traceability and expedite the contingency plan in order to meet the market demand

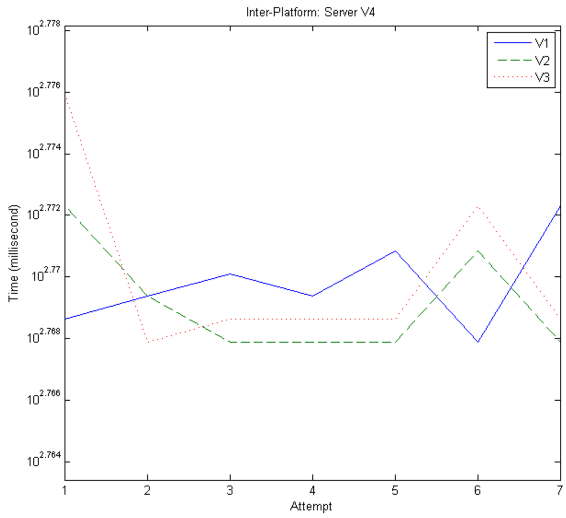

Fig. 12. Inter-Platform signal respond in time (millisecond) for Server V_4. Linux as an operating system for V_4 also give better respond even the machine does not frequently used for programming development. Linux as an operating system offered the stability in system security compared to others operating system

4. Conclusions

The application of MAS integration is more important for efficient PLM which involves the data transportation and transformation between one or more business application. Multi-agent supply chain has offered the ability to reach the bigger market, perform build-to-order product, deliver excellent service to meet the customers' demands and create new products and provide services that adapt to the competitive and environmental needs.

The evolvement of agent based in PLM make the system more autonomous, dynamics and reconfigurable. The interoperability of agent-based in PLM will expedite the manufacturing process by rapid information on the availability of production resources to be used in order to provide the production requirements. The using of multi-agent system (MAS) in manufacturing is widely evolved. All the implementation makes the manufacturing process more flexible and agile. Agents gain the information on the state of the manufacturing system, the commitment between man and machine can be achieved easily. Agents also optimizing the manufacturing system.

Stable communication showed by most of the machine but the respond not so rapid compare to server V3 and V4 however, instability of connections show in server V1 in one-way communication. The fastest respond is obtained by V3 compared to V1 and V2 that used same operating system which is Window. Linux as an operating system for V4 also give better respond even the machine does not frequently used for programming development. Linux as an operating system offered the stability in system security compared to others operating system but because of the complexity of system to be used as well as operated become an occupied barrier.

Industry 4.0 required rapid respond for every issue to be measured by help from IoT. The fastest respond gained, the more efficient of manufacturing processes is achieve. However, in current practise of PLM and manufacturing management, it's difficult to obtain. The fastest time respond may give benefit to the manufacturing management in delay traceability and expedite the contingency plan to be implemented in order to meet the market demand. The IoT also give benefit to cost reduction in paperless management and sustainable development when market demand changed rapidly nowadays.

Acknowledgement
The author would like to acknowledge the High Education Ministry of Malaysia for the study sponsored and Universiti Teknikal Malaysia Melaka (UTeM) for the facilities support.

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