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THE IMPACT OF INTERNET OF THINGS (IoT) IN A MANUFACTURING SECTOR

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ABSTRACT

Manufacturing of goods involves a lot of work and requires machinery for connectivity and efficiency. This is achievable through the use of well-connected and designed Machinery communicating together to achieve a predefined goal. Internet of things within the manufacturing sector is the key to achieving the entire manufacturing goal. Recent studies revealed the applicability of internet of things in many areas of human endeavours by allowing and providing method of intelligently connecting devices for resource sharing. The objective of this paper is to outline the impact of internet of things within the manufacturing sector. The objective is attainable through discussing and identifying what is required to enhance a positive functionality of internet of things with the support of an analysis of required architecture, resources and capabilities. Also the evolution and application of manufacturing system structure is discussed to help identify recent advances in Information technology and the requirements of decision support systems in advanced manufacturing. Exploration of all the above helped in identifying the technological gaps in relation to adopting Internet of things as an infrastructure of a manufacturing system. Finally the related advantages, possible future works and associated challenges are discussed.

Keywords: Advanced Manufacturing Systems (AMSs), Internet of things (IoT), Cloud Computing (CC), Cloud Manufacturing (CMfg), Enterprise Systems (ESs)

INTRODUCTION

Information Technology helps greatly in solving problems with ease within many sectors currently. It is through the development of technology that theories are being applied and developed to meet the requirements of the growing competition and customer demands. Also, the need to have green manufacturing and the socialization of manufacturing led to the ever increasing need to develop and fill the gap and environmental demands. Demands within the manufacturing sector triggered the proposal of advanced manufacturing systems so as to meet requirements which includes producing products of highest quality at the lowest possible cost, within the cleanest environment using the greatest flexibility with the help of improved knowledge. There are several ways of achieving the above which include flexible manufacturing, Herrero-Perez (2010) Manufacturing grid Zhao (2008), Dynamic alliance Sanchez (2001), green manufacturing Rusinko (2007), and also global manufacturing Jovane (2008) to name just a few.

Fig. 1 below shows how the socialisation of the resource sharing, creation of value, participation of users working together to match the supply and demand and on demand use including personalization within the manufacturing sector working well together to enable a much faster and clearer running of the system Hu (2013), Tao (2011). To avoid the hindrance of application management services (AMS) performance, there is should be adequate knowledge of how best to

connect the underlying physical manufacturing resources to the internet using the common specifications, standards and an open architecture.

The low knowledge of the advanced servitization of manufacturing resources complicates the flow, causing a lot of limitations to number of services which will be provided to the users and the emergence of the internet of things is the answer to these problems. The IoT technology made virtual manufacturing possible thereby paving way for parallel computing to solve complex problems by hiding much of the physical characteristics of the manufacturing resources within advanced manufacturing from the users. Internet of Things allows the realization of an effective connection, communication and control between physical and information worlds. There is a wide study and application of IoT and CC not only in manufacturing but also different fields as it allows for ever-changing and new methods of connection and intelligent perceptions which in turn allows for connection of anything, sharing of resources and on-demand use. This is important in this modern world as it offers real time solutions and connectivity when required which is a big positive.

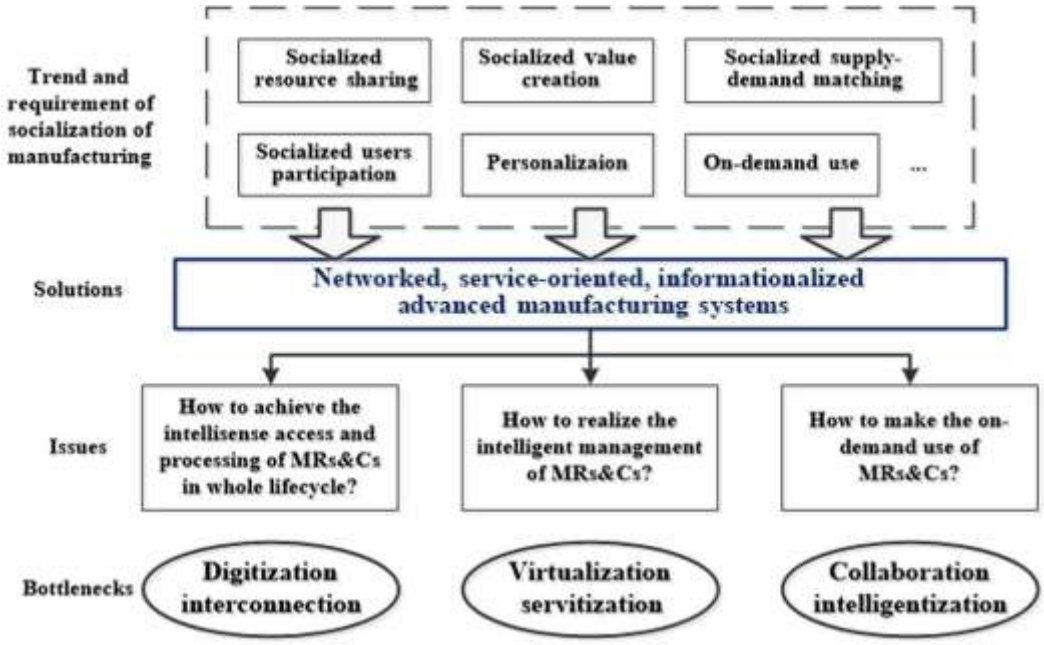

Figure 1: Bottlenecks of AMSs and possible solutions. Source: Transactions if Industrial Informatics, volume 10 (2014)

Evolution of Manufacturing Systems

Manufacturing systems are designed to produce goods through the use of different various resources which includes machines, tools. The design of such a system involves different types of decision making at all levels involved within the activities of manufacturing. The decision making process involves activities such as defining the what really needs to be done through the scope and boundaries of a given problem and its primary objective, finding out input and output relational models and the required system parameters.

Decision making also includes gathering and management of data to know how the current system is performing and make correct decisions according to that given situation. An enterprise system is normally used to help make decisions as it allows the collection and maintenance of data and also serving as a decision making system within an enterprise.

Description of Advanced Manufacturing System

The advancement and complexity of a manufacturing system is defined normally by the number and nature of inputs, required outputs and all the interrelated components as discussed by so many researchers. This system of manufacturing also measures the differences of the scope and boundaries of manufacturing as its main focus. It allows for the examination of system parameters, inputs and outputs. The system parameters are used to represent the components of the system and the relations, which then are classified as a representation of structural parameters and all the variables used to design. The design variables are then used as the factors of change against time. Examples of such variables are typically the inputs and outputs, the variables then represent how the system interacts with its environment.

Fig 2 below shows the evolution of inputs, outputs and the components of the system. It also shows how the manufacturing system evolution is then divided into different phases Cusumano (1991), and Sustainable manufacturing Bi (2011). The diagram gives also a clear representation of how within the manufacturing evolution the inputs, outputs and parameters change with time. This change is a clear reason why information systems for the future needs to have space for changes of IT infrastructure as well as the uncertain changes within the system environments.

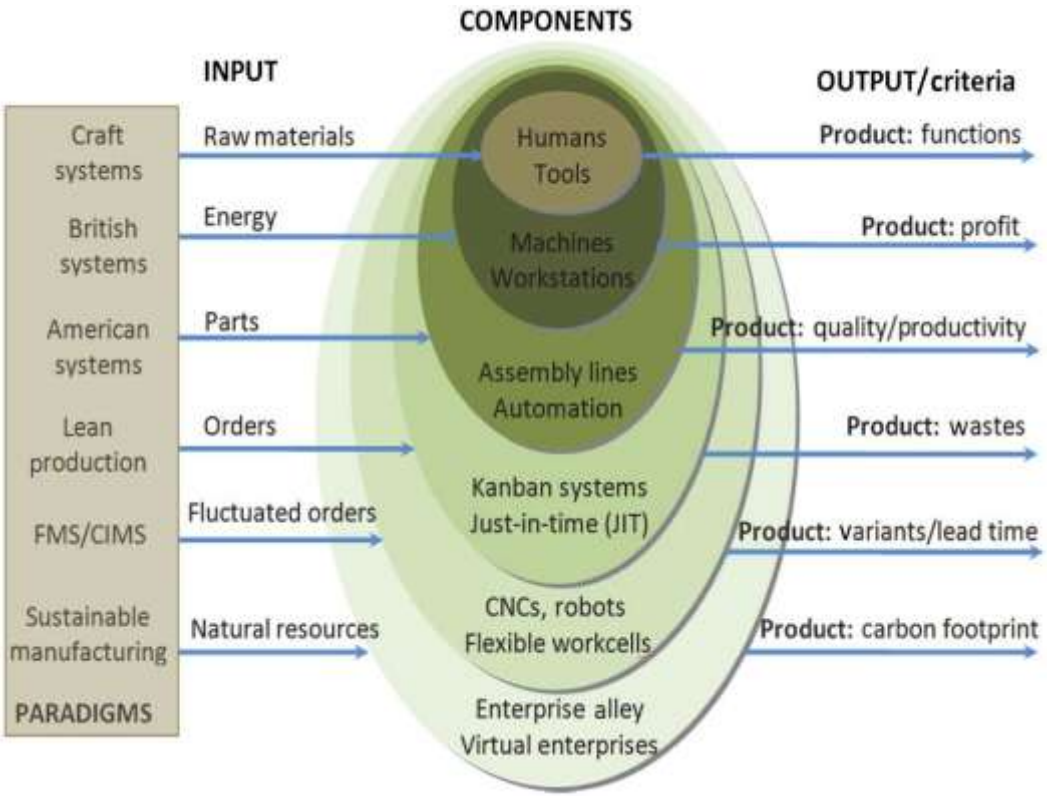

Figure 2: Evolution of Inputs, outputs and system components. Source: Industrial Informatics Vol 10. (2014)

Application of IoT in Manufacturing Systems

According to researchers, the origin of IoT is from the radio frequency identification devices (RFIDs) which are a system proposed in 1999 by MIT Auto-ID Labs. Internet of things is the network of physical devices, vehicles, home appliances and other items embedded with electronics, software, sensors or actuators and network connectivity which enable these objects to connect and exchange data. The internet of things can simply be defined as an intelligent connectivity that allows accessing anything at anytime and anywhere Artzori (2010)

IoT allows accessibility of required data, light, mechanics, heat and even location to name but a few. The accessibility is made possible in real time through the use of RFID technique, global positioning system

(GPS), sensors, laser scanners etc. Research and development have also allowed for IoT advancement as it enables the connection of item to item to the information space and the physical world. The technological advancement focused on how to access any terminal device connected to the internet and managing its applications in different sectors through related websites.

Even though, there is still the need to have a clear and uniform definition and even architecture about IoT but many different applications like smart everything which includes homes, buildings, cities, business, Inventory and many more have already used it Miorandi (2012).

Internet of things did and is still ringing many changes especially within the practical production of a manufacturing setting through intelligent manufacturing. The generalization of IoT in the manufacturing setting allows for the use of 4c's (Connection, Communication, Computing and Control)

Fig 3. Shows the different Manufacturing applications which include;

i) Workshop Applications Gusmeroli (2013):

These are applications that mainly help to achieve terminal connections and the required information for the enterprise management used for automation in the control of IoT enabling manufacturing execution in workshops. The three functions of an IoT enabled are then the access, control and identification. Control helps in the process of the physical manufacturing where during the execution the correct material is used to process the semi-finished product to the required final one. Identified and retrieved data from this IoT enabled setting is related only to the input of the information system. IoT in

workshops enables the automation in control within manufacturing and all the related execution activities.

ii) Enterprise Applications Bardaki (2012), Li (2012):

This application allows for the information integration between the product, production and other business management information. The integration of the IoT workshop is and other internal and external systems is enabled by this application. Example being that of generating own service manufacture which will then participate in the external supply chain on top of being part of the management of supply chain internally.

iii) Application between Enterprises Artzori (2012):

This application is responsible for information handling. It is useful in the storage, analysis, securing, usage, and integration of the enterprise information. It also addresses any issues arising from the processing of such information

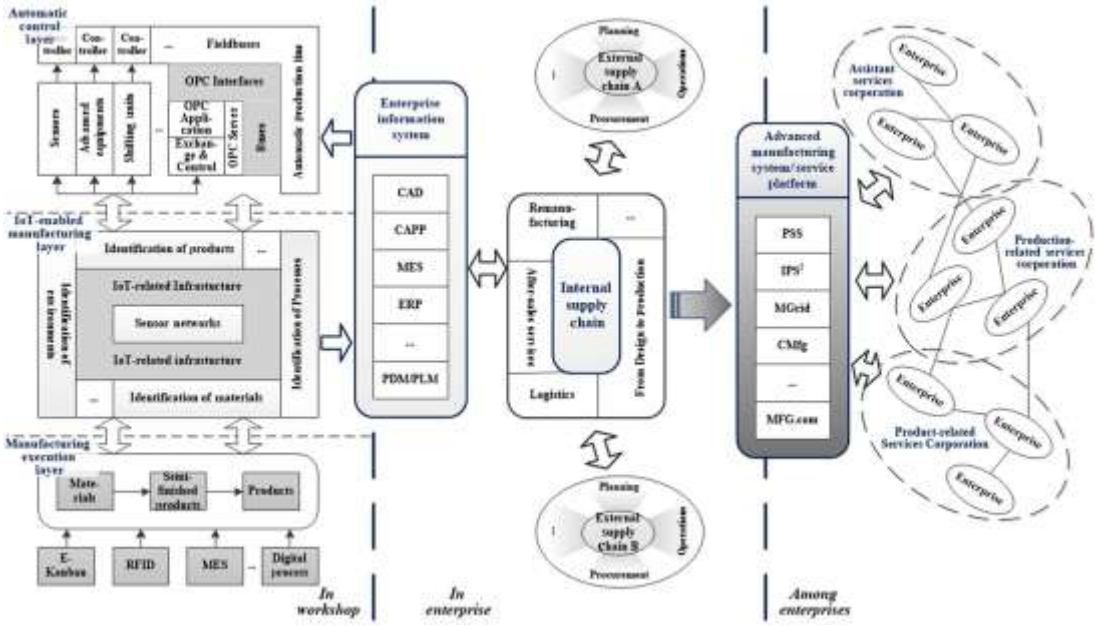

Figure 3: Application of IoT in Manufacturing. Source: Tao et al (2014)

There was a review by Xu et al (2014) on the advances made within the IoT industries. Application of the internet of things within the modern settings was done by, Bi et al (2014). Presently the RFID is playing the most important part when it comes to the development of IoT technology. Sensors, Nanotechnology and Smart technology are playing a part together with RFID towards the expectation of interconnection of anything. IoT is fast becoming the solution to the construction of a platform that allows sharing and interconnection of resources within the manufacturing sector. Most recent development is helping with the provision of high performing Computing technologies that help contained many problems within the Manufacturing sector.
IoT also plays a part in the information gathering within the manufacturing sector for use and decision making; through a process of data acquisition and management. Data acquisition is made possible by the use of sensors that are used to collect data manually and then application of recording methods which involves a visual inspection of the product or even a measuring object Kristoff (2010). According to Pinto (2007) sensors play a pivotal role in the manufacturing and success of a new product through collection, processing and sharing of data between objects. The shared required data is then used to improve the product wherever and whenever the need arises.

The application of IoT in manufacturing is not always smooth as the process comes with critical requirements for adaptation. Its completeness comes with the need for connection of components to allow communication, data management, decision making and acquisition of the data. The connection of the devices is not easy and has to meet the manufacturing requirements and its functions. The set up challenges includes

Complexity: there are factors which always increase the difficulties such as i) the versatility of the modern products which requires parts to meet and satisfy certain standards for them to function. ii) production of complex products involves different activities at different stages and this may lead to impossibilities when it comes to performing all the required activities within the factory. Uncertainties: there is a level of dynamism which has to be maintained within manufacturing environments. This means complex decisions have to be made in a short period of time making it highly demanding for one to know the changes in real time as well as uncertainties and also share the data over the whole system within the specified real time. Risk assessment and uncertainties assessment was done by Zeng and Skibniewski (2013) which involved a fault free approach. Other uncertainties are also navigational, according to Corrales *et al* (2014) as certain products require a robot to navigate in a certain way which can be impossible due to factory layout.

Unused resources: decision making departments need Computers and data has to be stored for a local complex decision making. This makes it very expensive to set up as high performing Computers are required to make decisions on distributed complex issues. Distributed resources are always associated with synchronization problems.

Limitations of existing work: Manufacturing patterns continually deal with ever changing new challenges to meet the requirements of the environment within which it operates. Example of such a limitation is that of Software and Hardware flexibility failing to balance as there is need for a higher degree of flexibility when it comes to the

manufacturing system as there are uncertain changes involved Bi (2011-14)- Bui (2011).

First time correct: The competition within the manufacturing sector leaves no room for nonvalue activities which includes buffering and even machine repair as the downtime means the enterprise is left behind. As a way of remaining in the game and on top of competitors, the organisation has to make the required product correctly for the first time and also try by all means to minimise excessive inventory. Each and every workstation needs to avoid making errors as a single error on one station affects the whole production line. This also calls for strict quality control measures as any defected parts causes a rise in the cost of the end product.

Advantages of IoT in a Manufacturing Sector

Internet of things also comes with its advantages to the manufacturing sector through the use of 4Cs which are part of the intelligent perception and connection, control, computing and most importantly communication. The advantages includes that the hardware parts of the manufacturing set up that is the manufacturing equipment and the software part of the set up are connected to wide ranging networks due to the advent of IoT technologies such as intelligent sensors which can be the optical fibre and also RFID embedded system. This kind of connection allowed by IoT even within the manufacturing sector avails important information when needed, such as the information on capabilities, productivity and other functional parameters. IoT does not only avail the information but it also enables the intelligent collection, proper communication, enhanced processing and the use of the whole-life cycle of manufacturing enterprise.

Another advantage is that IoT enhances the communication of data in-between M2M (this includes transmission of data between machines, between man and machine and between machine and man) via IoT technicalities such as the 2G/3G/4G, LAN and WSN and the resultant factor is that there will be a bridge between the physical world, the Manufacturing and the virtual world. The availability of user requirement specifics also leads to realising another advantage of IoT in the manufacturing sector as there will be control available an example is that of intelligently assigning equipment for a specific task after which another different service can be arranged such as maintenance after task IoT also paves way for the empowerment of customers through e-commerce. This can be an added advantage to the enterprise as besides comparing prices, customers can personalise their products and can change orders or even do a real time order placing. The satisfaction level of customers is assured from their own perspective as the IoT will be merged in the Enterprise system.

Challenges of IoT

There are so many challenges to be addressed within the operation, upgrading and development of internet of things. This involves the need for designing and production of specialist high frequency antennas, sensors and also to properly deploy required technologies such as sensors made out of optical fibres. These are required for online monitoring as well as real time monitoring especially when dealing with equipment involving high speed rotations and high temperatures. Most of the IoT work within manufacturing involves data collection from the manufacturing processes and equipment, what remains lacking is the study on how to intelligently realize the mining of that data and its processing to output important information

meant to serve production requirement. The available study still remains insufficient to offer the required information in one click Tao et al (2014). Also attention needs to be paid towards the safety, reliability and management standards in relation to the application of IoT and CC in the manufacturing process. Privacy protection is also another issue and contradictions arising between the resources of manufacturing and the sharing of information. Cost of running and setting up of IoT in a manufacturing sector still remains a challenge as it involves huge capital, the main reason for getting into business is to make profit, owners invest in minimal expenditure on the IoT project, the results are positive as interconnectivity eliminates loads of idle time which is uncalled for.

Another challenge is that IoT currently is offering information visibility and not for timely decision making. There is need to enable an automation of decision making in IoT to offer a higher level of system strength and a quicker understanding (agility). Easier integration of IoT and its adaptation needs to be made easy by making sure that there is a service orientation of the IT infrastructure Spiess *et al* (2009). According to Jeffery (2009), Cooper and James (2009) data management within IoT still has so many challenges. Atzori *et al* (2012) revealed that there are Challenges involved in the adapting and automating for smartness as well as making sure there is security and privacy. The authors pointed out the need for a completely new infrastructure that addresses the challenges.

Li *et al* (2013) proposed the elimination of all the redundant data during its acquisition and sharing within the IoT and WSN applications. Also, Jiang *et al* (2012, 2013, and 2014) stressed the need

to standardize system integration while Jakobs *et al* (2014) discussed the best way of adapting IoT standards for meeting up the customers' requirements.

Conclusion and Future works

Industrial internet of things is playing a role which contributes positively to the timely production of required products. This article focused on the evolution of IoT, advantages and challenges within the manufacturing sector especially the Manufacturing systems and Cloud based Manufacturing.

Working as a robot operator in a manufacturing industry can make one to draw interest in finding out the best way of making IoT more effective and timely problems solving set up. Since there are still bottleneck associated with the current state of IoT in manufacturing sectors which has to be transformed from being just production-oriented to being flexible enough to even being service oriented. The study identified and suggested further research into information analysis during production since the analytics needs attention as for example, there is no end to end traceability of data at some production companies. Even though with internet of things information is made available but will be incomplete as it will not provide proper stage by stage analysis of the process when required for decision making. It's one of the areas that need focusing with the aim of improving information required at each and every stage for analysis.

REFERENCE

Alam S, Chowdhury M.M.R, and Noll J (2011), "Interoperability of Security-enabled Internet of things," *Wireless Pers. Communication*, Volume 61, pp 576-586

Atzori L, Lera A, and Morabito (2010), "The Internet of things: A Survey," *Computer Networking*,volume 54 pp. 2787-2805

Atzori L,Lera A, and Morabito and Nitti M (2012), "The Social Internet of Things (SIOT)-When social networks meet internet of Things: Concept, architecture and network characterization," *Computer Networking*, volume 56, no.16, pp3594-3608

Bardaki C, Kourouthanasis P and Pramatari K (2012), "Deploying RFID-enabled services in the retail supply chain: Lessons learned towards the Internet of Things," *Information Systems Management*, pp 233-245.

Bi Z.M (2011), "*Revisit System Architecture for Sustainable Manufacturing*," volume 3, no.9 pp1323-1340.

Bi Z.M and Kang B (2014), "Sensing and Responding to the changes of geometric surfaces in reconfigurable manufacturing assembly," *Enterprise Information Systems*, volume 8 no.2 pp225-245

Bi Z.M and Lang S.Y.T (2007), "A framework for CAD and Sensor Based Robotic Coating Automation," *IEEE Trans. Industrial Information*, volume 3, no.1 pp84-91

Bi Z, Xu L and Wang C (2014), "Internet of Things for enterprise systems of modern manufacturing," IEEE Trans Industrial Information, volume 10, no.2 , pp1587-1595.

Bui N (2011), Internet of things architecture (IoT-A) ..., [Online]. Available: http/www.iot-a.eu/public-documents/documets-1/1/1/dl.1/at_download/file, accessed on 29/11/2017.

Chandrashekar H and Bhasker B (2011), "Quickly locating efficient, equitable, deals in automated negotiations under two-sided information uncertainty," *Decision Support Systems*, volume 52 pp 157-168.

Cooper J and James A (2009), "Challenges for database management in the internet of things,"*IETE Tech. Revision,* Volume 26 no.5 pp 320-329

Corrales A, Malfax M and Salichs M A (2014), "Signage system for the navigation of autonomous robots in indoor environments", *IEEE Transactional Industrial Informatics*, Volume 10, no.1, pp 680-688.

Cusumano M A (1991), Shifting Economics: From Craft Production to Flexible Systems and Software Factories. MIT Work paper #332-91/BPS [Online] Available: http:/dspace.mit.edu/bitstream/handle/1721.1/2367/SWP-3325-24663534.pdf? sequence=1, accessed 23/11/2017.

Gusmeroli S, Piccione S, and Rotondi D (2013), "A capability-based security approach to manage access control in the Internet of Things," Math. Computer Modelling, volume 58, no.5-6, pp. 1189-1205.

Heer T, Moorchon-Garcia O, Hummen R, Keoh Loong S, Kumar S and Wehrle K (2011), "Security Challenges in the IP-based Internet of Things", *Wireless Pers. Communication*, Volume 61, pp 527-542.

Herrero-Perez D and Martinez-Barbera H (2010), Modelling distributed transportation systems composed of flexible automated guided vehicles in flexible manufacturing systems," *IEEE Trans. Industrial Information* vol.6, no.2 pp 166-180.

Jack Hu S (2013), "Evolving paradigms of Manufacturing. From Mass production to mass customization and personalization," *Procedia CIRP*, Volume 7, pp3-8.

Jakobs K, Wagner T, and Reimers K (2001), Standardising the Internet of Things- based. Final report of IMP Project [Online]. Available: http:// www.wi.rwth-aachen.de/Forschung/Final-reportpathfinder-project.pdf, accessed on 29/11/2017.

Jeffery K G, "The Internet of Things: The death of a traditional database?" *IETE Technology Revision*, volume 26, no.5, pp313-319.

Jiang H, Zhao S, Qiu S and Chen Y (2012), "The cooperative effect between technology standardization and industrial technology innovation based on Newtonian mechanics", *Information Technology Management,* volume 13 no.4, pp.251-262.

Jiang H, Zhao S, Qiu S and Chen Y (2012), "Strategy for technology standardization based on the theory of entropy," *Information Technology Management*, Volume 13, no. 4 pp 311-320.

Jiang H, Zhao S, Wang X and Bi Z (2013), "Applying electromagnetic field theory to study the synergistic relationships between technology standardization and technology development," System residual Behavioural Science, volume 30, no.3 pp272-286.

Jovane F,Yoshikawa H, Alting L, Boer C.R, Westkamper E, Williams D et al (2008), "The incoming global technological and industrial revolution towards competitive sustainable manufacturing," *CIRP Ann.-Manufacturing Technology*, volume 57, no. 2 pp641-659.

Kristoff S (2010), *Sensors and Data Acquisition* [Online]. Available: http:// suite101.com/article/introduction-to-data-acquisition-a64903, accessed on 15/11/2017.

Li Q, Wang Z.Y, Li W.H, Li J, Li C, Wang C and Du R.Y (2013), "Application integration in a hybrid cloud computing environment: Modelling and platform," *Enterprise Information Systems*, Volume 7, no.3 pp 237-271.

Li S, Xu L, Wang X and Wang J (2012), "Integration of hybrid wireless networks in cloud services oriented enterprise information systems," *Enterprise Information Systems*, volume 6, no.2 pp165-187.

Pinto J (2007), *A Short History of Automation Growth*, [Online]. Available: http://www.automation.com/resources-tools/articles-white-papers/articles-by-jim-pinto/a-short-history-of-automation -growth, accessed 13/11/2017.

Rusinko C.A (2007), "Green Manufacturing: An evaluation of environmentally sustainable manufacturing practices and their impact competitive outcomes," *IEEE trans. Engineering Management*, volume 54, no.3 pp.445-454.

Sanchez L.M and Nagi R (2001), "A review of agile manufacturing systems," International journal Prod. Res.., volume 39, no.16, pp 3561-3600.

Spiess P, Karnouskous S, Guinard D, Savio D, Baecker O, and De Souza L.M.S et al (2009), "SOA- based Internet of Things in enterprise services," *in Pro. IEEE International Conference Web Service,* Los Angeles, CA, USA pp.968-975

Welbourne E, Battle L, Cole G, Gould K, Rector K, Reymar S et al (2009), "Building the internet of things using RFID: The RFID ecosystem experience," *IEEE Internet Computing*, volume 13, no 3 pp48-55.

Tao F, Zuo Y, Xu L, Zhang L (2014), "IoT-based intelligent perception and access o manufacturing resource toward cloud manufacturing," *IEEE Trans. Ind. Information*, Volume 10, no.2 pp 1547-1557

Tao F, Zuo Y, Xu L, Lv L and Zhang L (2014), "Internet of things and BOM based life cycle assessment of energy-saving and emission-reduction of products," IEEE Trans. Ind. Information, volume 10, no.2

Xu L, He W and Li S, "Internet of Things in Industries: A Survey," *IEEE trans. Ind. Information*, to be published

Zeng Y and Skibniewski M J (2013), "Risk assessment for enterprise resource planning (ERP) system implementations: A fault tree analysis approach," *Enterprise Information System*, Volume 7, no.3 pp 332-353.

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