Identification of Enablers for Effective Implementation of Cloud Manufacturing

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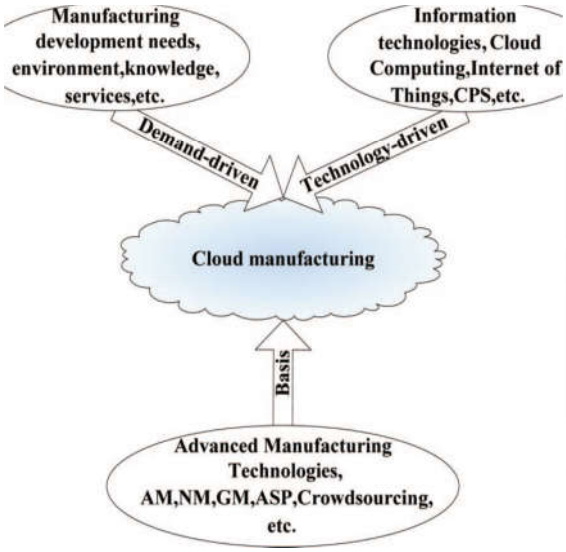
Abstract: The emerging cloud paradigm has a prominent effect on manufacturing. The move from hardware bound systems to requirements based service provision is enabling the transition to cloud manufacturing. A networked manufacturing service provision system requires vast amounts of information to be exchanged in a non-ambiguous and timely manner to meet production requirements. In this paper, interoperability is identified as a key enabler for cloud manufacturing and a framework for realisation of interoperability across heterogeneous computer aided manufacturing systems is proposed. Using this framework, manufacturing resources can be shared by a large number of clients based on requirements and priorities. Cloud manufacturing is a new technological paradigm that may revolutionize how organizations use IT by facilitating delivery of all technology as a service.
Keywords: Cloud computing, cloud mfg, enablers to adoption, Manufacturing as a service,

1. Introduction

Cloud Manufacturing, has been introduced as the emerging manufacturing service-oriented paradigm. This paradigm utilises cloud computing technology along with Internet-of things and state-of-the-art manufacturing technologies to integrate manufacturing resources and capabilities to offer on demand, reliable and affordable manufacturing services for the entire manufacturing product life cycle [1]. Through the intelligent integration of manufacturing resources and capabilities, a shared pool of resources is created in the cloud manufacturing platform, promoting cloud users to acquire manufacturing tasks as a service [2]. The integration of the deployed manufacturing resources and capabilities is achieved through virtualisation, as resources are enabled for access as cloud services [3]. Manufacturing resources (i.e. equipment, materials, software, knowledge, and skills) and manufacturing capabilities (i.e. design, production, management, and communication) are advertised and shared on a large unified network using the internet. Interoperability is therefore one of the essential requirements for enabling cloud manufacturing application [4], providing a framework of open standards and application protocols to enable easy migration and integration of manufacturing applications and data between different cloud service providers [5]. In this paper, the current architectures for forming cloud manufacturing systems are discussed together with their enabling technologies. Cloud manufacturing resource sharing system is then defined, aiming to execute various part designs with different features, through the intergeneration of heterogeneous manufacturing resources.

1.1 Concept of cloud manufacturing: Cloud manufacturing is a new manufacturing paradigm based on networks. It uses the network, cloud computing, service computing and manufacturing enabling technologies to transform manufacturing resources and manufacturing capabilities into manufacturing services, which can be managed and operated in an intelligent and unified way to enable the full sharing and circulating of manufacturing resources and manufacturing capabilities. Cloud manufacturing can provide safe, reliable, high-quality, cheap and on-demand manufacturing services for the whole life cycle of manufacturing [6].



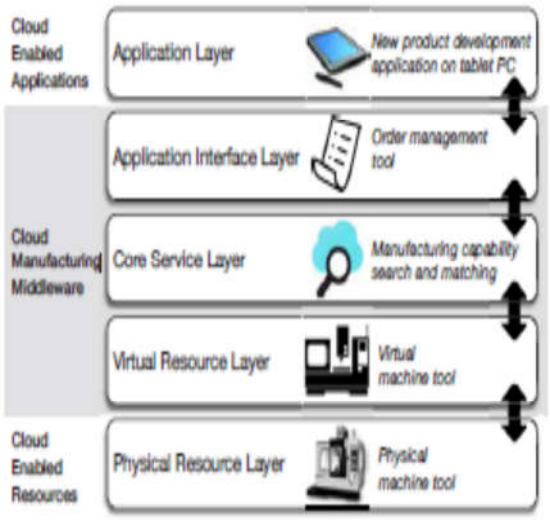


Figure 1. The proposition of CMfg.[6] Figure 2. The architecture of CMfg. [6]

1.3 Typical characteristics of Cloud manufacturing: Providing on-demand services for the whole life cycle of manufacturing, supporting agile virtual organisation/community, intelligent perception of manufacturing resources, Knowledge based intelligent manufacturing, Wikipedia style and group innovation based manufacturing

1.4 Key technologies for implementing cloud manufacturing platform: General technologies, CMfg resource perception and access technologies, Virtualisation and servitisation technologies of CMfg resource and capability, Construction and management technologies of CMfg service environment, CMfg service environment running technologies,
CMfg service environment comprehensive evaluation technologies, CMfg safety and security technologies, CMfg pervasive human–computer interaction technologies, Informationised manufacturing technology and Application implementation technology.

1.5 Functional View:

The cloud manufacturing resource sharing system model as shown in figur

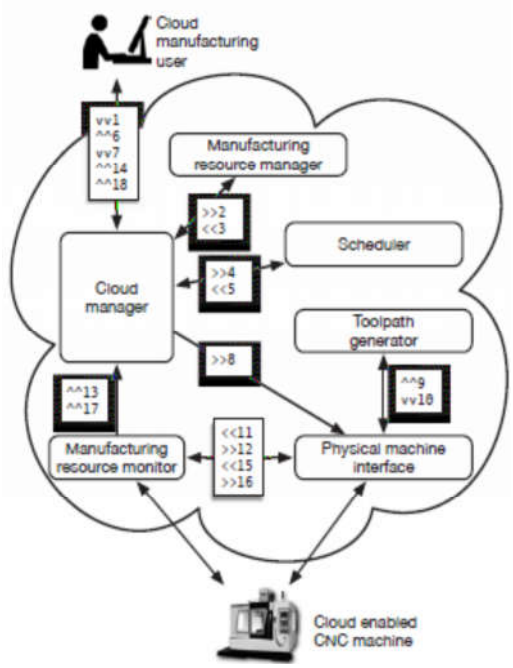


Fig. 3. Functional view

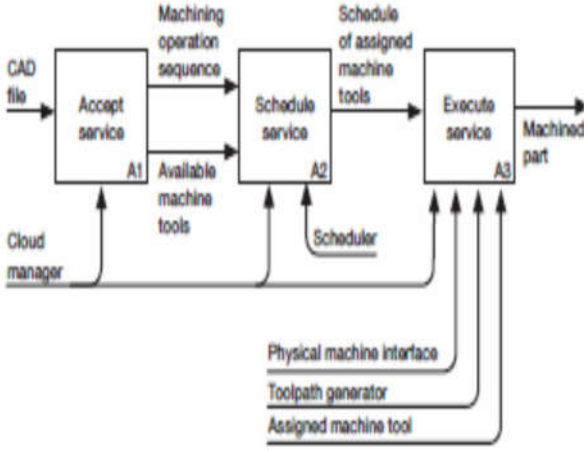


Fig. 4. Cloud mfg resources sharing

CMfg service platform and manufacturing cloud: CMfg service platform, CMfg resources in CMfg service platform, MCS in a CMfg service platform, manufacturing cloud in CMfg service platform, Construction of manufacturing cloud for CMfg service platform.

Prototype of CMfg platform: Virtualisation-supported subsystem, cloud service management subsystem, knowledge data base management subsystem and cloud services-oriented complex product design subsystem

2. Literature Review

The move from hardware bound systems to requirements based service provision was enabling the transition to cloud manufacturing. A networked manufacturing service provision system requires vast amounts of information to be exchanged in a non-ambiguous and timely manner to meet production requirements. The paper, interoperability was identified as a key enabler for cloud manufacturing and a framework for realisation of interoperability across heterogeneous computer aided manufacturing systems was proposed. Using this framework, manufacturing resources can be shared by a large number of clients based on requirements and priorities [7].

Cloud computing has been the potential to speed up IT adoption among SMEs in developing economies. The research aimed to identify the key enablers and other factors that influence cloud adoption among SMEs in Tamil Nadu. The author highlight cost benefits of using cloud infrastructure, scalability and agility of cloud services as the key enablers of cloud adoption [8].

The work proposed a cloud-based information portal as an enabling technology used as a single point of reference by supply chain stakeholders; the latter will use that portal to feed it with

real-time information from existing platforms so that a better visibility for all parties was enabled. That portal will implement accessible interfaces with parties of each step of the transport process (e.g. interface with the customer, warehouse, next-leg carrier) using standardized formats as far as possible. It will allow for a flexible parameterization per customer and for a straightforward incorporation of regional special requirements, as is the constraint of single customer per container applicable in some countries. The portal will permit a better visibility level for end customers, promote standardization of logistics processes, offer an increased profitability for cloud services providers, improve their activities expansion, as well as accelerate customs process handling [9].

The main objective of the paper was to understand the mutual interaction of the enablers and identify the 'driving enablers' (i.e. which influence the other enablers) and the 'dependent enablers' (i.e. which are influenced by others). The enablers have been identified through the literature; their ranking was done by a questionnaire-based survey. An ISM model has been prepared to identify some key enablers and their managerial implications in the implementation of TPM [10].

Combining the cloud computing, 'internet of thing', virtualization, and service-oriented technologies, advanced computing technologies with existing manufacturing models and enterprise 'informationization' technologies, a new computing- and service-oriented manufacturing model, called cloud manufacturing , was proposed. The concept, architecture, core enabling technologies, and typical characteristics of cloud manufacturing were discussed and investigated, as well as the differences and relationship between cloud computing and cloud manufacturing. Four typical clouds manufacturing service platforms, i.e. public, private, community, and hybrid cloud manufacturing service platforms, are introduced. The key advantages and challenges for implementing cloud manufacturing were analysed [11].

The paper shows the Cost Modelling & its effectiveness by demonstrating how practitioners can use it to examine the costs of deploying their IT systems on the cloud. The Cost Modelling tool was evaluated using a case study of an organization that was considering the migration of some of its IT systems to the cloud. The case study shows that running systems on the cloud using a traditional 'always on' approach can be less cost effective, and the elastic nature of the cloud has to be used to reduce costs [12].

3. Concluding Remarks

The following enabler of the cloud mfg collected through the literature review for the further analysis and a useful interpretation for getting benefits as shown in Table No. 1.

S. No.	Enabler	S. No	Sub Enabler	References/Source
1	Operational	1	Operational and control technique	Tsertou et al-2016
		2	Automated production with AGVs	Wilson et al 2015, Tsertou et al-2016
		3	Expert System	Tsertou et al-2016, Wilson et al 2015
		4	Automated production with Robots	Wilson et al 2015, Tsertou et al-2016
		5	Advance sensor technology	10, Tsertou et al-2016
2	Manufacturing Systems requirement	6	Green type Manufacturing	Nagar and Raj (2012)
		7	Sustainable type	Nagar and Raj (2012)
		8	Digital type	Tsertou et al-2016
3	Methodology	9	Effective use of IT standards	FTao et al 2011

	followed	10	Computer simulation	FTao et al 2011
4	Work culture of the organization	11	Ability to make decision/solve problems	Nagar and Raj (2012)
		12	Ability /disposition for continuous learning	Nagar and Raj (2012)
		13	Work culture in the Organisation	Nagar and Raj (2012)
5	Internet of Things	14	Semantic web	FTao et al 2011
		15	Embedded systems technology	FTao et al 2011
6	Current Legislation	16	Pollution control	Nagar and Raj (2013), Nagar and Raj (2012)
		17	Landfill taxes	Nagar and Raj (2013), Nagar and Raj (2012)
		18	Emissions trading	Nagar and Raj (2013), Nagar and Raj (2012)
		19	Eco-label	Nagar and Raj (2013), Nagar and Raj (2012)
7	Energy Star	20	Sets standards for external and internal power supplies	FTao et al 2011
		21	Sleep modes on computers	FTao et al 2011
		22	Idle modes on computers	FTao et al 2011
		23	Standby modes on computers	FTao et al 2011
8	Cloud Computing	24	Existing mfg IT	FTao et al 2011
		25	Service-oriented technologies	FTao et al 2011
		26	Advanced computing technologies	FTao et al 2011

The dynamic changes of global market environment have not only brought new challenges for manufacturing industry, but also the higher requirement is put forward for the networking development of manufacturing industry. The realization of flexible management of resource service composition in cloud manufacturing will finally enhance the information and intelligence of manufacturing industry to a new level. In this paper, the enabler of cloud manufacturing was studied as well as the involved key enablers and their support. In the future, the specific solutions for the key issues in the manufacturing can be removed by cloud manufacturing.

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