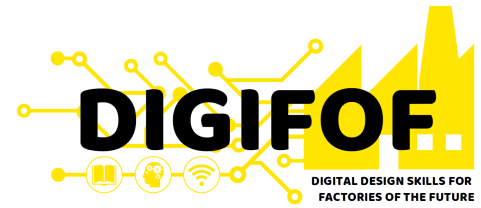


Cloud Manufacturing for modeling virtualised resources

Julia Siderska, PhD

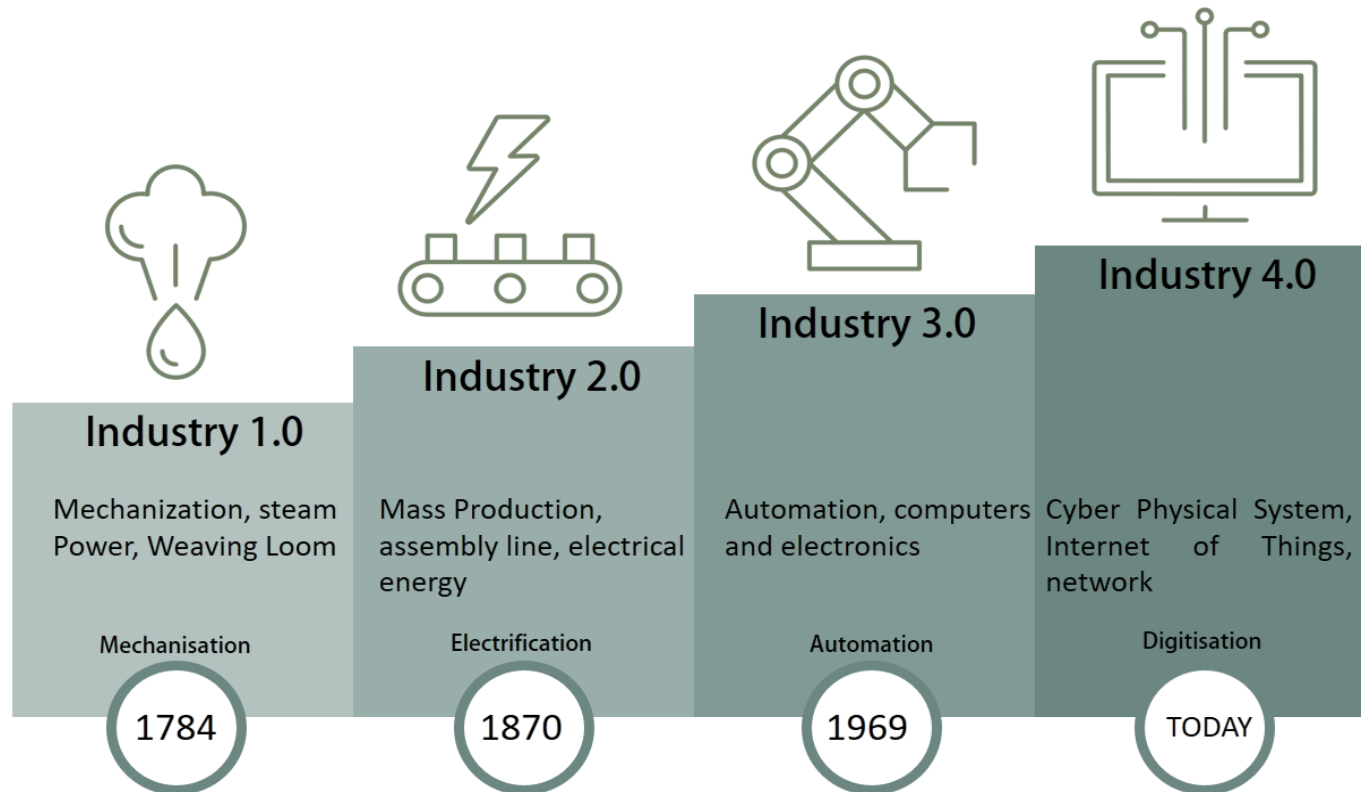
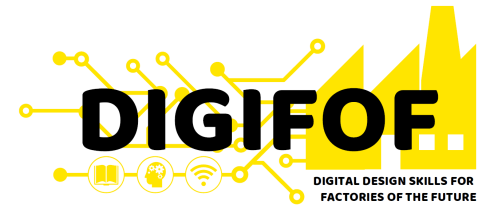


Agenda



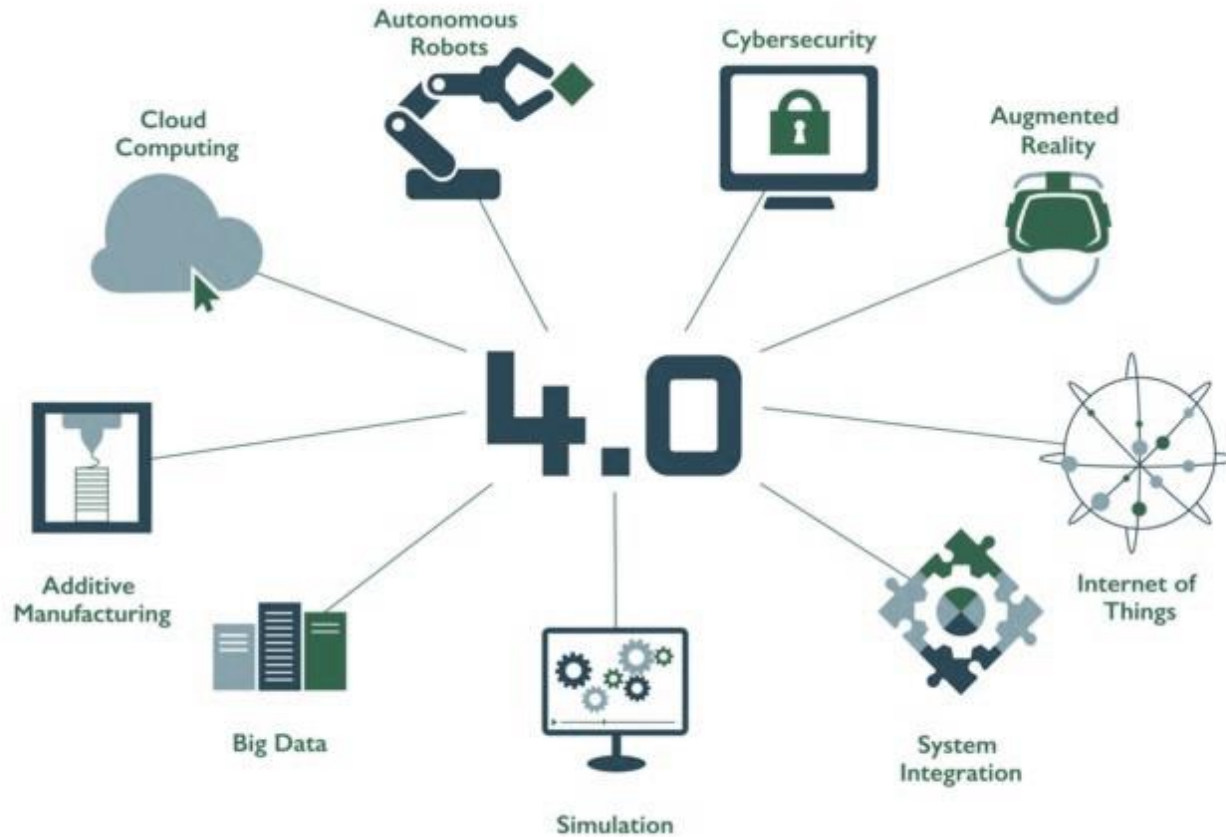
- ✓ Evolution towards Industry 4.0 and digital technologies
- ✓ Concept of CMfg – fundamentals and definitions
- ✓ Relationships between cloud computing and CMfg
- ✓ Key enabling technologies
- ✓ Participants of CMfg system
- ✓ Virtualization of resources
- ✓ Architecture of CMfg system
- ✓ Exercises for participants

Evolution towards Industry 4.0



Source: <https://medium.com/@winix/industry-4-0-the-digital-technology-transformation-b23ba02a7dd2>

Industry 4.0 framework – digital technologies



Source: <https://www.foodmanufacture.co.uk/Article/2017/06/15/Smart-food-factories-move-even-closer>

Cloud Manufacturing - fundamentals



- ✓ an emerging paradigm of servitisation in which dynamically scalable and virtualised manufacturing resources, know-hows, abilities and capabilities involved in the whole lifecycle are inserted into cloud and provided to the users in the form of services over the Internet in a pay-as-you-go manner
- ✓ assume the change of a physical product (software or hardware) into a service
- ✓ integrates innovative technologies (IoT, cloud computing, service-oriented technologies, virtualisation, semantic web, advanced high-performance computing technologies) with advanced manufacturing
- ✓ enables and supports cooperation, sharing and management of manufacturing resources

Cloud Manufacturing - definitions

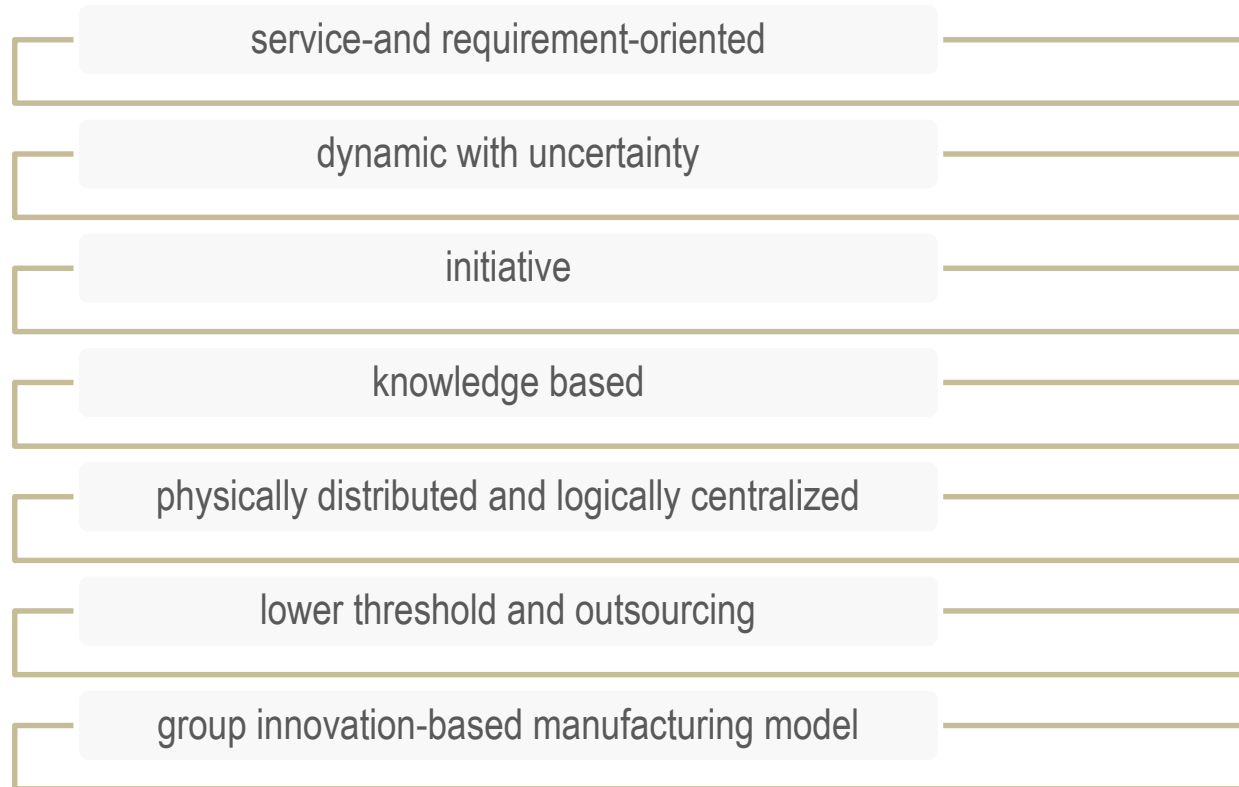


- ✓ **Manufacturing resource** - an entity that can support an activity or a function involved in the life cycle of a product (hard resources and soft resources)
- ✓ **Manufacturing capability** - professional competitiveness, e.g. manufacturing resources, intellectual advantages and credits, for undertaking a job in a product life cycle
- ✓ **Cloud Manufacturing platform** - an entity that manages a shared pool of manufacturing resources and capabilities over a network, offering integrated IT-based infrastructure and tools for both suppliers and demanders
- ✓ **Resource virtualisation** - a mapping process from a real manufacturing resource to a logical one
- ✓ **Capability servitisation** - an encapsulation process from an abstract description of a manufacturing capability to a standard cloud service according to a specification
- ✓ **Cloud Manufacturing system** - system consisting of cloud users, cloud platform, manufacturing resources and capabilities, supporting specific applications in a manufacturing domain

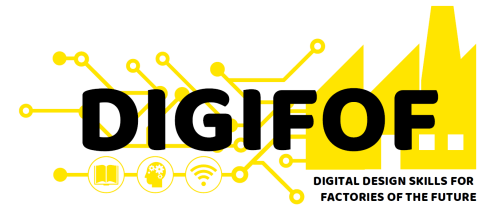
Cloud Manufacturing – typical characteristics



An integrated cyber-physical system that can provide on-demand manufacturing services, digitally and physically, at the best utilisation of manufacturing resources



The classification of manufacturing resources and capability



CMfg Resources

Manufacturing Capability

Design
Capability

Simulation
Capability

Product
Capability

Testing
Capability

Maintenance
Capability

Management
Capability

Manufacturing Resources

Hard Resources

Soft Resources

Equipment

Computing

Materials

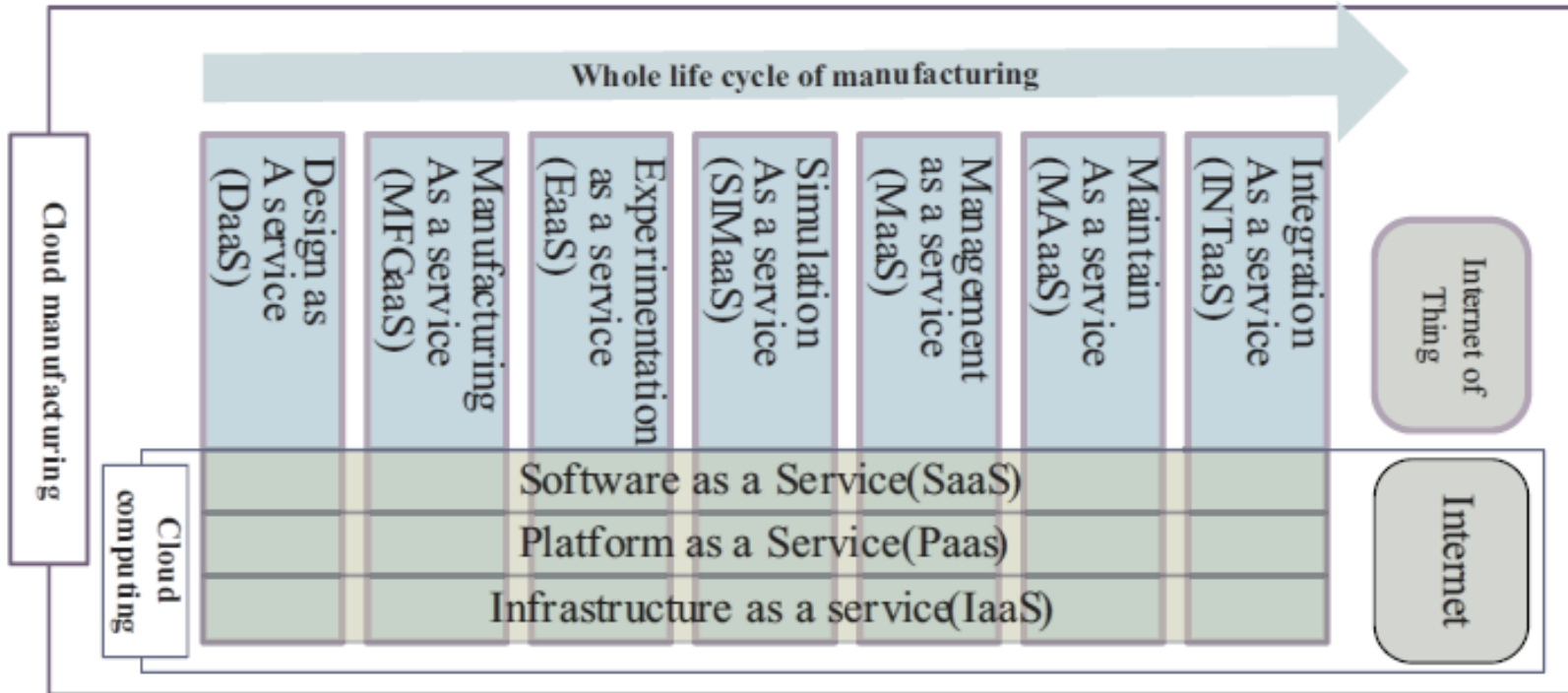
Software

Knowledge

Human

Source: own elaboration on the basis of: L. Zhang et. al., *Cloud manufacturing: a new manufacturing paradigm*, Enterprise Information Systems, 2014, Vol. 8, No. 2, 1–1

Relationships between cloud computing and CMfg



Source: F. Tao, *Cloud manufacturing: A computing and service-oriented manufacturing model*, Proc. IMechE Vol. 225 Part B: J. Engineering Manufacture

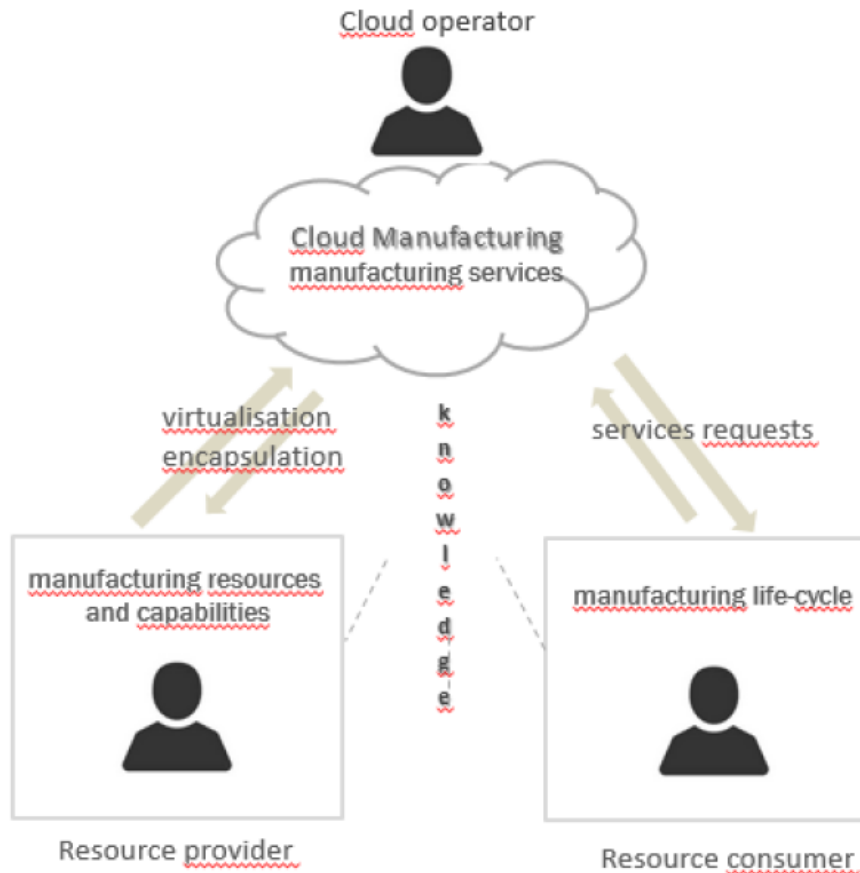
Key enabling technologies of CMfg



Key enabling technologies for cloud manufacturing	Components or characteristics	References
Existing manufacturing systems and technologies	CAD (computer aided design), MIS (manufacturing information system), etc.	Tao, Zhang, and Nee (2011) and Xu (2011)
Cloud computing	Software as a Service (SaaS), Platform as a Service (PaaS), Infrastructure as a Service (IaaS); public cloud, private cloud, hybrid cloud, community cloud, etc.	Armbrust et al. (2010), Zhang et al. (2010) and Li et al. (2012)
Internet of Things (IoT)	Radio frequency identification (RFID), wired and wireless sensor network, embedded system, intelligence in smart objects	Atzori, Iera, and Morabito (2010)
Virtualisation	Virtual services, Virtual machine, data and information virtualisation; virtual description specification	Xu (2012), Goth (2007), Liu, Li, and Wang (2011), Li, Hu, and Wang (2011), N. Liu and X. Li (2012) and Chen et al. (2011)
Service-oriented technologies	Service-oriented architecture (SOA), web service, enterprise service bus, semantic web, ontology	Izza (2009), Xu (2011), Valilai and Houshmand (2013) and Jammes and Smit (2005)
High-performance computing (HPC)	Parallel processing, multiple tasks	Younge et al. (2011) and Vecchiola, Pandey, and Buyya (2009)

Source: W. He, L. Xu; *A state-of-the-art survey of cloud manufacturing*, International Journal of Computer Integrated Manufacturing, 2015, Vol. 28, No. 3, 239–250.

Participants of CMfg system



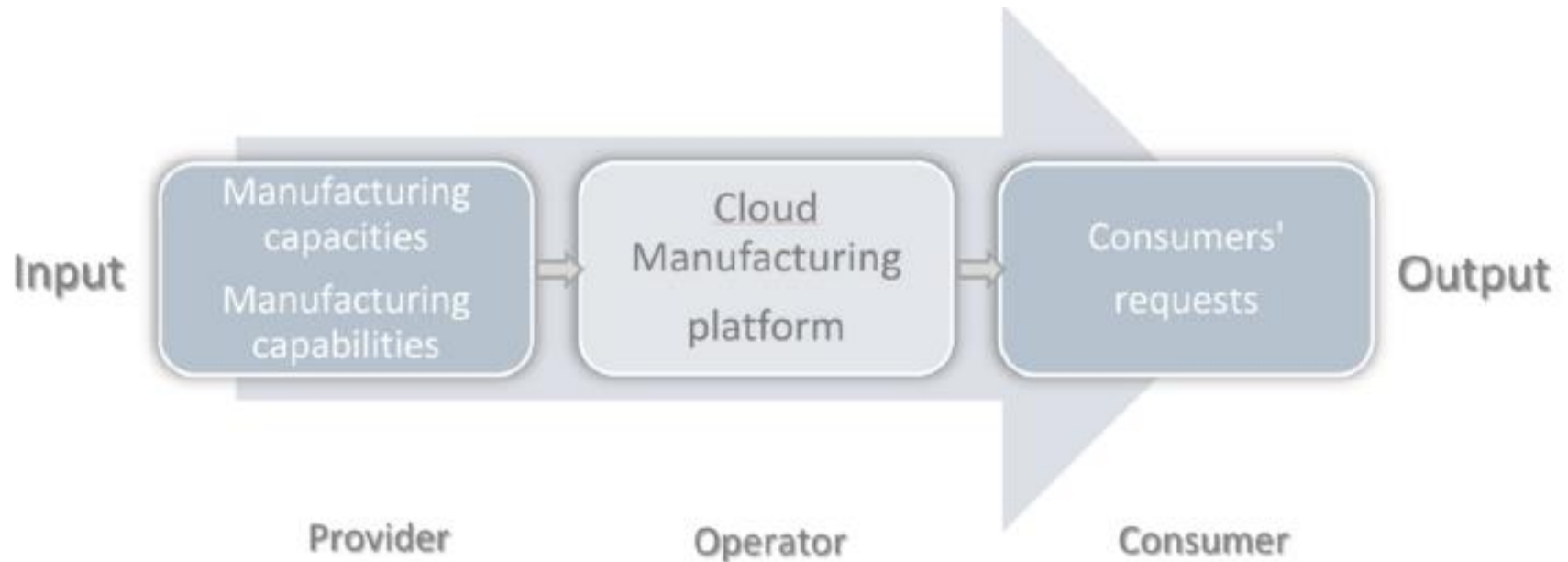
Cloud provider is an entity that provides manufacturing resources and capabilities as cloud services via a cloud platform

Cloud consumer (resource consumer) is an entity that utilises cloud services via a cloud platform to fulfil demands

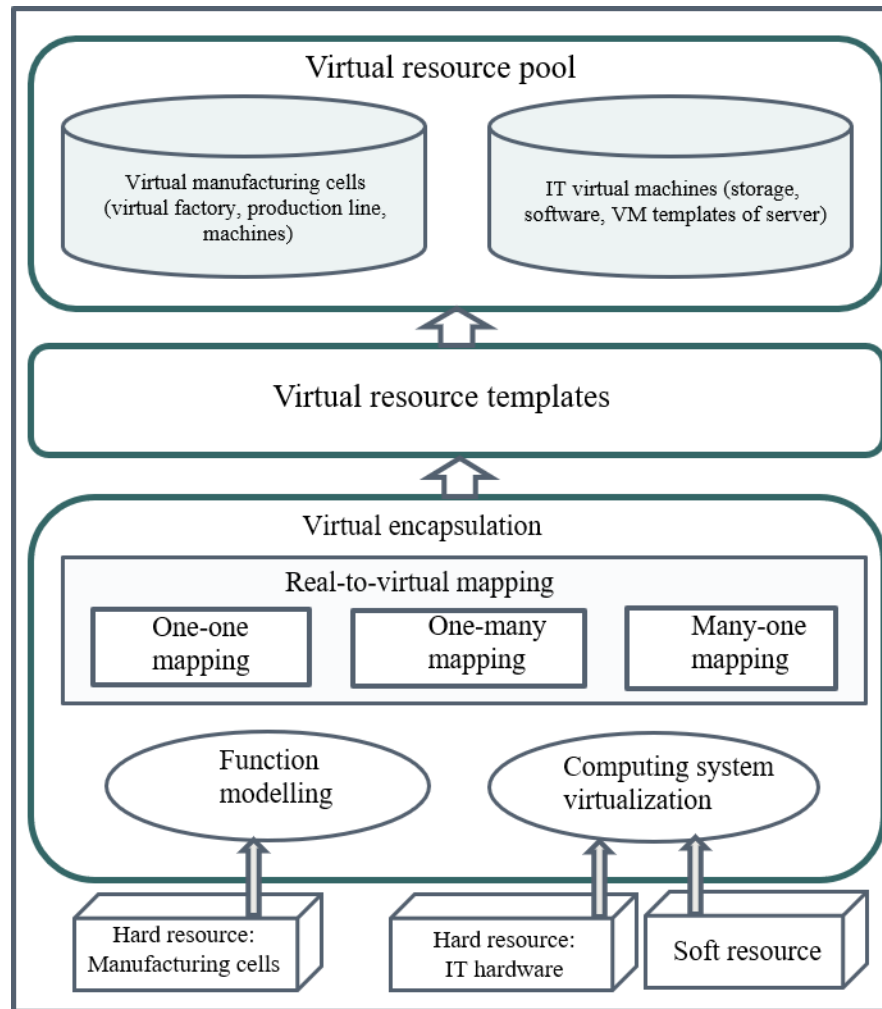
Cloud operator (cloud broker) is an entity that operates and manages a cloud platform

Source: J. Siderska, K. Mubarok, *Cloud Manufacturing platform and architecture design*, Multidisciplinary Aspects of Production Engineering – MAPE vol. 1, 2018

Cloud Manufacturing operating principle

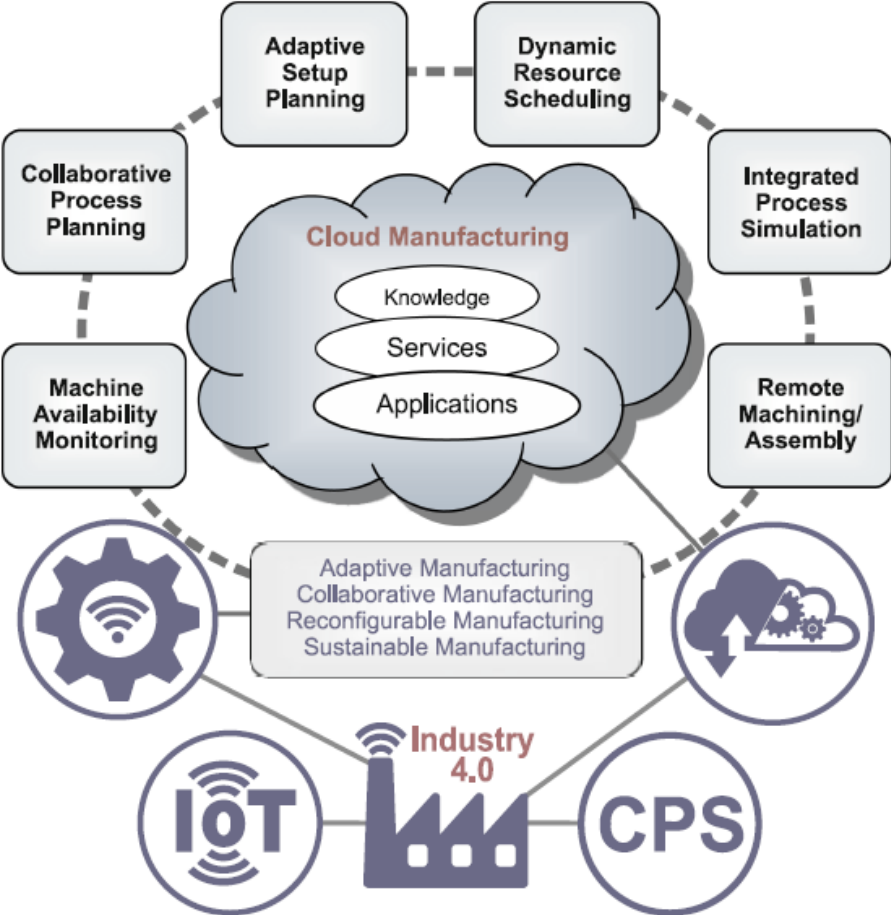


Virtualization of resources



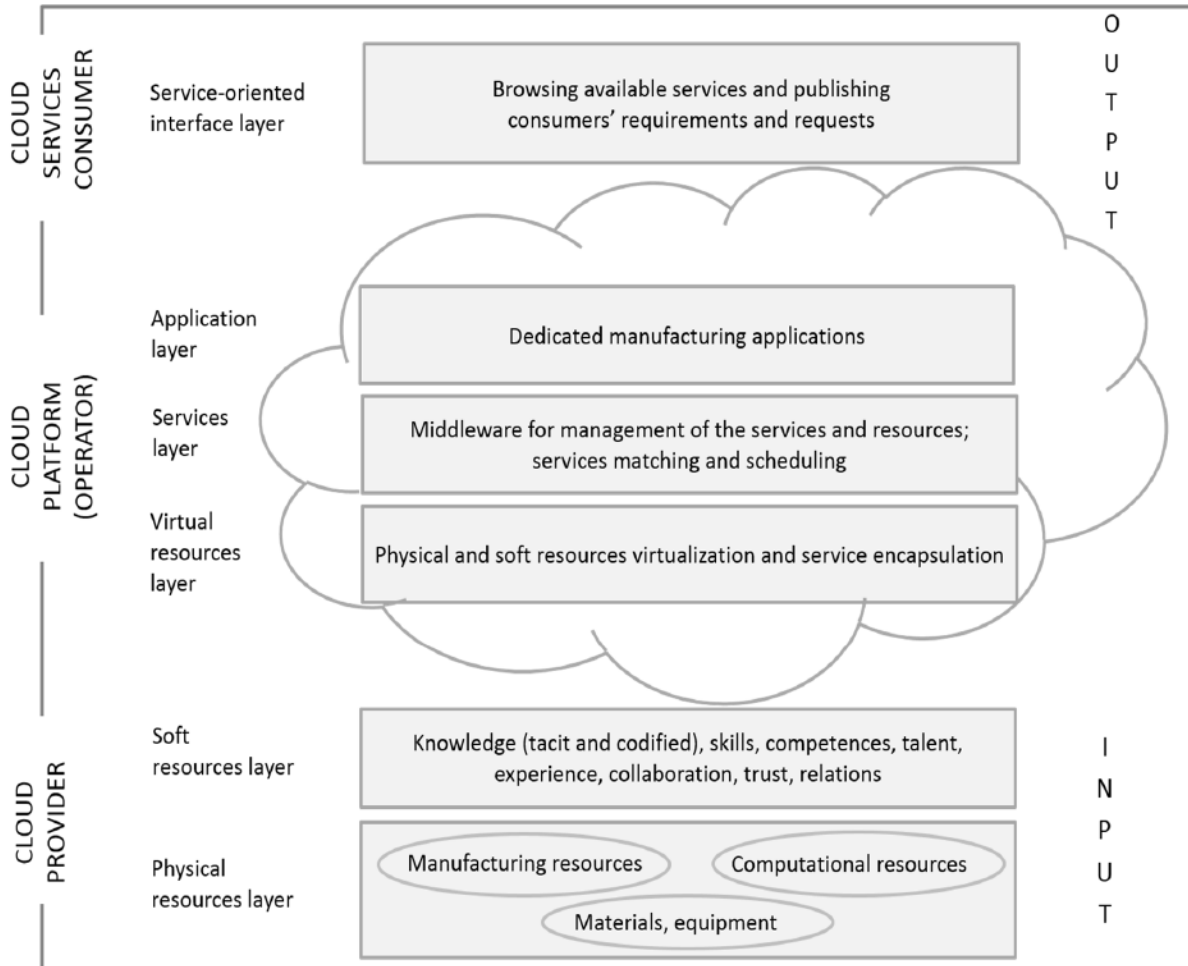
Source: own elaboration on the basis of: L. Ren et. al., *Cloud manufacturing: from concept to practice*, Enterprise Information Systems, 2015, Vol. 9, No. 2, 186–209

A Cloud Manufacturing platform in Industry 4.0 framework



Source: Milosevic et al., *A Cloud-Based Process Planning System in Industry 4.0 Framework*, Proceedings of the 4th International Conference on the Industry 4.0 Model for Advanced Manufacturing, Springer, 2019

Architecture of Cloud Manufacturing system



Source: J. Siderska, K. Mubarak, *Cloud Manufacturing platform and architecture design*, Multidisciplinary Aspects of Production Engineering – MAPE vol. 1, 2018

Exercises, tasks for participants

1. Identification of data sources in participant's companies
2. Data acquisition – knowledge base, data base
3. Identification of virtualizable soft and hard resources and capabilities in participant's companies
4. Examples of resources to be inserted into manufacturing cloud and made accessible to fulfil demands and requests of presumptive consumers

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