Smart Units in Distributed Manufacturing (DM) -Key Properties and Upcoming Abilities

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Abstract
Rapid developments in ICT totally reshape manufacturing as machines, objects and equipment on the shopfloors will be smart and online. Interactions with virtualisations and models of a manufacturing unit will appear exactly as interactions with the unit itself. These virtualisations may be driven by providers with novel ICT services on demand that might jeopardise even well established business models. Context aware equipment, autonomous orders, scalable machine capacity or networkable manufacturing unit will be the terminology to get familiar with in manufacturing and manufacturing management. Such newly appearing smart abilities with impact on network behaviour, collaboration procedures and human resource development will make distributed manufacturing a preferred model to produce.

Keywords: virtualisation, networkability, autonomous unit, smart manufacturing

1. Introduction

The convergence of intelligent devices, intelligent networks and intelligent decisions will enable information integration to support agile networks, real-time monitoring and controlling of manufacturing plants and assets and rapid customization and realization of products. Smart processes, further enabled by advanced software support and digital technologies, will continue to alter the productivity and quality of production processes for many decades to come (Deloitte, 2012). In DM[1], smart processes are driven by networks of smart manufacturing units. These units are expected to be context-aware and predictive with the ability to make decisions for diagnosis, for prognosis and for optimal performance.
Ubiquitous Computing (UC) denotes another vision of a future world of smart objects, i.e. physical items whose physical shape and function is being extended by digital components (Langheinrich et al., 2000). This increasing miniaturization of computer technology results in processors and tiny sensors being integrated into more and more everyday objects, replacing traditional computer input and output media. Instead, people will communicate directly with their clothes, watches, pens, or furniture – and they communicate with each other and with other people's objects (Ferguson, 2002). It is neither a single technology nor a specific functionality, which is behind UC but rather a bundle of functions which together create a new quality of computing (Satyanarayanan, 2002).
Cloud computing is a novel model for enabling ubiquitous computing, a 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 multiplied and released with minimal management effort by service provider interaction (NIST, 2011). A cloud is a type of parallel and distributed system consisting of a collection of interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements and established through negotiation between the service provider and consumers (Buyya et al. 2008). Virtualisations of resources and fast interconnections open up companies in general and manufacturing areas in particular to new services and services' architecture i.e., cloud hardware-as-a-service (HaaS), cloud software-as-a service (SaaS), cloud platform-as-a-service (PaaS), cloud infrastructure-as-a-service

[1] Distributed manufacturing is a manufacturing network whose functionality and performance is independent of the physical distance between the involved units and elements.
This includes logical and spatial dispersed units which cooperate and communicate over processes and networks in order to achieve manufacturing functions (Kuehnle, 2010).

(IaaS). Virtualized computing resources allow big data storage, cloud ERPs and Cloud Manufacturing is already propagated, specifying a new mode of intelligent manufacturing which may become a networked mode with quickest responses to market demand, enhanced competitiveness and facilitated collaborative manufacturing (Zhang et al., 2010). Furthermore Resource Cloud Encapsulation (RCE) of soft and hard manufacturing resources and resource sharing are services resource virtualization in CM (Ming & Chunyang, 2013). RCE is supposed to largely reduce the coupling between physical resource and manufacturing application by the transferring physical resources into logical resources and virtual CM services. In addition, resource pooling and virtualization enable even more sophisticated solutions under Cloud-Based Design and Manufacturing (CBDM). It is a type of parallel and distributed system consisting of a collection of inter-connected physical and virtualized service pools of design and manufacturing resources (Wu et al., 2012).

All cloud solutions enable to dynamically adapt in order to satisfy unpredictable or unexpected demand. The manufacturing cloud service can offer rapid scalability at all levels, e.g. manufacturing cells, general purpose machine tools, and standardized machine components (Wu et al., 2013)[2].

Public clouds are handled by third parties, and the work of many different clients may be mixed in the factories (virtual), servers, storage systems and other infrastructure in the cloud. End users do not know what other clients works may be carried out in the same factories, even on the same machines. Private clouds are a good choice for companies that need high data protection. Hybrid clouds that combine the models of public and private clouds may be the key to achieving an external supply in scale form and under demand, but these clouds add the complexity of determining how to allocate tasks and processes across these different environments (Macia-Perez et al., 2012).

Computer scientists had come up with the Internet of Things (IoT) in the context of ERA (EU). IoT technologies are already used to access and to connect manufacturing resources. The IoT can be defined as a dynamic global network infrastructure with self-configuring capabilities, where physical and virtual “things” have identities, physical attributes, virtual personalities, use intelligent interfaces and are seamlessly integrated into the information network [3]. In industry, the “thing” may typically be the product itself, the equipment, the transportation means, etc. Adding more data to objects, we are witnessing the upcoming of a huge IoT, where every physical object has a unique identity (RFID, RFIT), (Eguchi & Thompson, 2011, Kortuem u.a., 2010). For general use, a Smart Object (SO) is an autonomous physical/digital object augmented with sensing, processing, and network capabilities[4]. In contrast to RFID tags, SOs carry chunks of application logic that let them make sense of their local situation and interact with human users. Coupled with software agent technology however, RFID can transform everyday objects into smart objects as well (Chan et al., 2012).

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[2] Web Services Resource Framework - WSRF - seems to be another closely related work that has been brought forward by the Organization for the Advancement of Structured Information Standards (OASIS). Manufacturing resource description is done via the encapsulation of manufacturing resources. In order to realise the resource sharing and collaboration among the heterogeneous and distributed manufacturing resources, web service resource framework based on resource management and manufacturing resource encapsulation are needed.

[3] Technologies for realizing IoT devices have already been around for years, and have been standardized by the IETF, starting from the lower layers of the stack and moving up. Today, we have IPv6 as a foundation running over links such as those found in mobile networks (2G, 3G and LTE) as well as low power local area sensor networks such as IEEE 802.15.4/6LoWPAN and EPICS. The implementation can be based on multiple agent languages and platforms (JADE, JADEX, LEAP, MAPS) on heterogeneous computing systems (computers, smartphones, sensor nodes).

[4] In 2008, an open group of companies launched the IPSO Alliance to promote the use of Internet Protocol (IP) in networks of "smart objects" http://www.ipv6forum.com/index.php. As different definitions of IoT do currently exist, for manufacturing purposes it is useful to refer to IoT as a loosely coupled, decentralized system of smart objects (SOs), which are autonomous physical/digital objects augmented with sensing/actuating, positioning, processing, and networking capabilities.

Additionally pervasive computing has migrated from desktops to micro devices, and embedded computing is increasingly integrated into various kinds of objects. Significant progress has been made in many domains, such as machine-to-machine (M2M) communications, using wireless sensor networks (WSNs), ZigBee[5] and wireless body area networks (WBAN) (Chen et al., 2011).Achievements refer to the communications among computers, embedded processors, smart sensors, smart actuators, and mobile terminal devices without or with limited human intervention (Wan et al., 2012). The rationale behind M2M communications is to generate more autonomous and intelligent applications by networking and interconnecting machines.

For manufacturing the Industrial Internet is a term coined by GE (GE, 2012) and refers to the convergence of intelligent devices, intelligent networks, and intelligent decisions., the Industrial Internet is creating the very foundation needed to make smart manufacturing possible by bringing together brilliant machines, analytics, and scalable software platforms to enable nearly instant person-to-person (P2P), person-to-machine (P2M resp HMI), and machine-to-machine (M2M) communication (Wan et al., 2013).

Some years ago, an object virtualization method has emerged, known as Cyber-Physical System (CPS), also DCPS if distributed), (Lee, 2008), meaning the integration of computing systems with physical processes and physical environments[6], (Ptolemy, 2013). Components are networked at every scale and computing is deeply embedded into every physical component, possibly even into materials (Sztipanovits et al., 2012; Derler et al., 2012). A When using CPS, components may adapt themselves automatically to the other components, which inevitably changes the way in which these CPPS-enabled components are designed and manufactured (VDI/VDE, 2013). CPS and IoT cannot be clearly differentiated since both concepts have been driven forward in parallel, although they have always been closely related (CERP-IoT, 2009).

According to European Telecommunications Standards Institute (ETSI), standardization plays an indispensable role in long term development of the M2M technology[7], too. The five elements' structure proposed by ETSI results in three interlinked domains, formed by an M2M area network and M2M gateway, communication network domain and 3G, (Lu et al., 2011). Fig 1 shows M2M architecture domains in health and home applications, the cutting edge of the developments.

As advanced control techniques, cloud computing, emerging network technologies, embedded systems, and WSNs are further upgraded, CPS may be seen as an evolution of M2M. Moreover, all other developments, be it IOT, SO or pervasive or UC seem to converge to CPS as the most comprehensive ability to bridge cyber manufacturing worlds to the physical world. For DM applications, these smart developments are anticipated by the more specific Cyber Physical Production Systems (CPPS), e.g. strongly propagated in the national funding scheme Industry 4.0 in Germany.

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[5] ZigBee Home Automation is the industry leading global standard helping to create smarter homes that enhance comfort, convenience, security and energy management for the consumer. It appears to be the technology of choice for world-leading service providers, installers and retailers, http://www.zigbee.org/.

[6] Cyber-Physical System (CPS) is a system of collaborating computational elements controlling physical entities.

[7] The applications of M2M communications extraordinarily depend on many technologies across multiple industries. The technical standardizations for M2M are proceeding in 3GPP, IEEE, TIA, and ETSI. The ETSI drafting standards for information and communications technologies considers an M2M network as a five-part structure http://www.etsi.org/website/homepage.aspx.

(1)Devices, usually are embedded in a smart device and reply to requests or sends data.

(2) Gateway, acts as an entrance to another network. It provides device inter-working and inter-connection.

(3) M2M area network, furnishes connection between all kinds of intelligent devices and gateways.

(4) Communication networks, achieve connections between gateways and applications.

(5) Applications and services pass data through various application services and are used by the specific business-processing engines. Software agents analyze data, take action and report data.

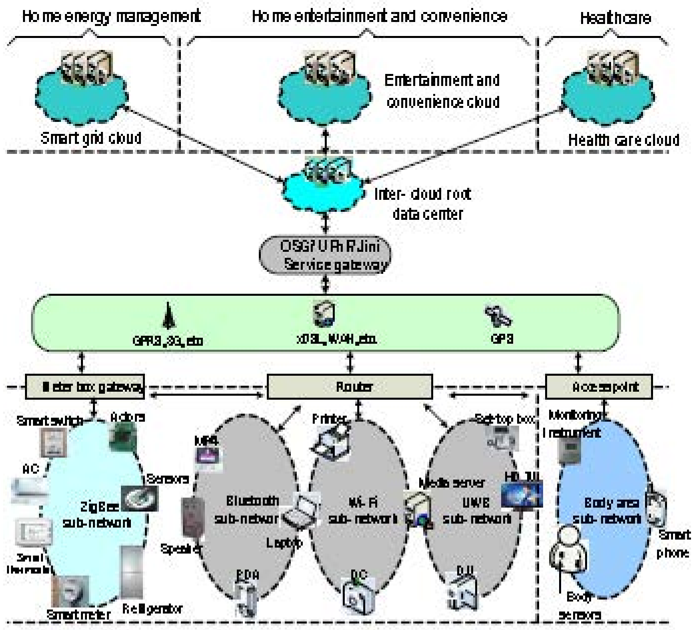

Figure 1: M2M Smart Grids advances in Healthcare according to Wan et al. 2013, as a blueprint for upcoming Smart Manufacturing networks

Cyber units may easily capture all functions a manufacturing unit may expose, as verified by the author for the control (MES) level (PABADIS'PROMISE), later for the factory and the field levels by atomising the automation pyramid levels (Fig. 2). Machines and devices including their controls are represented (emulation) by resource agents able to communicate and to negotiate (Peschke *et al.*, 2005). Standards as IEC 61804-3 specify the Electronic Device Description Language (EDDL) technology; AutomationML (Automation Markup Language), promoted by the author and his team has been approved as International Standard in June 2014 (IEC 62714-1), provides an open standard for suitable data formats in plant engineering information, based on XML.

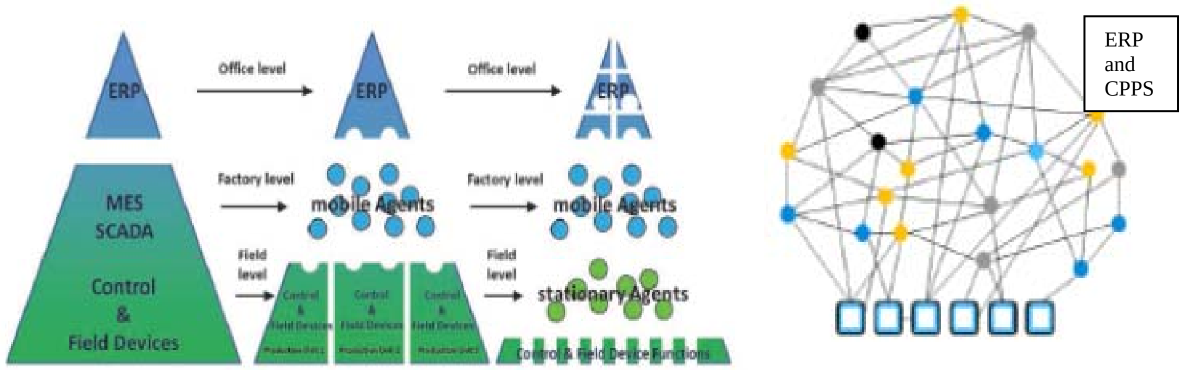

Figure 2: Progressing dissolution of level structures in Distributed Automation towards CPPS (according Peschke et al. 2006 and VDI/VDE 2013)

From the DM viewpoint, we rather see promising actions in choosing and selecting adequate devices for combining with manufacturing equipment or for upgrading manufacturing units. Moreover, progresses in WBAN have been extremely rapid, so many chapters even in most recent research concerning person-to-machine, P2M (respectively HMI) are obsolete already.

In manufacturing, disruptive innovations, as this next generation of ICT, meet strong resistance, as the protagonists are caught in path dependencies and strongly insist on pursuing the habitual innovation lines. However, it would be more successful to accept that innovations come from outside and to try to implement the most suitable ones instead of launching own initiatives for developing own specific smart manufacturing units.

All critical technologies for Smart DM are mature. Sensor and actuator networks, intelligent controls, planning models, plant performance optimization software, cyber-physical systems, security and other related devices are fully available on the market. Synthesized with model based engineering, systems integration technologies, open data analytics platforms, engineering information systems, and decision support methodologies at all levels, these devices are ready for use in DM.

2. Smart Manufacturing Units' Properties

As all smart units (Kawsar & Nakajima) manufacturing units, too, may be seen as specifications of the IoT and CPS. Manufacturing will increasingly appear as equipped by physical or/and digital objects, upgraded with sensing, processing, actuating and networking capabilities. Additional abilities, as environment-awareness or self-logging and self-reporting features further augment these objects and allow carrying many data about themselves as well as their activity domains. Moreover, smart units may make emerge network structures e.g. as results from their collaborative processes executed by manufacturing units striving for incentives (attractors). DM networks are being composed of self-optimising, self-orienting entities, managed as well as formed by defined rules. Network management establishes proper and genuine processes or initiates interactions, where units float within network configurations or collaborate and communicate on all levels of detail. Some configurations seem more favourable than others in some respect, so continuous monitoring has to evaluate for gradual and stepwise decisions or configuration alternatives; main issues are linking or detaching. In DM, business opportunities represent such governing "attractors", giving inputs to drive, to operate and restructure manufacturing networks to build up and to optimize versatile collaborative process nets.

3. Networkability

Smart units in DM have to exhibit strongest abilities to network. Networkability[8] may be seen as both, the internal and external ability of units to collaborate, simultaneously considering all manufacturing process relevant aspects (Oesterle et al., 2000). Networkability is defined at the DM network level by giving out the rules for alignments of network configuration at all levels of detail of units and subnets. Networkability may be supported by implementing coordination mechanisms that evolve interrelations between units towards networked organizations.

Networkability of smart units is enhanced by sensing and actuating technologies, which capture the global and the local contexts of products, objects, other units, and communication infrastructures, even IT models. In manufacturing, especially process and decision parameters are concerned with the aim of generating efficient processes, thus smart manufacturing units may even carry factory models, equipment geometries, process and task as well as interaction and decision models (Kuehnle, 2013).

In order to harmonise the networks on all LoDs, the models, attached to the network entities, should demonstrate fold and unfold properties that originate e.g. from encapsulated generics.

For networks in manufacturing, aspect wise decompositions have already been successfully introduced as generic set up, distinguishing between aspects as information, organisation and processes similar to e.g. the specification of the CIM/ OSA framework and consecutive standards (Kosanke, 2006). Equivalent layer wise resource co-ordination schemes for networked manufacturing have also been successfully applied for enterprise units' networks

[8] Networkability of units may be measured both quantitatively and qualitatively for each of the above aspects. Quantitatively, networkability may be assessed by considering both time and costs, whilst qualitative analysis of networkability addresses the quality of change.

elsewhere [9][10] (Alt &Smits, 2007). Smart DM proposes the layer wise decomposition for fold and unfold generic to support networkability on all levels by keeping the aspects separate and tied together network wide at the same time, Fig. 3.

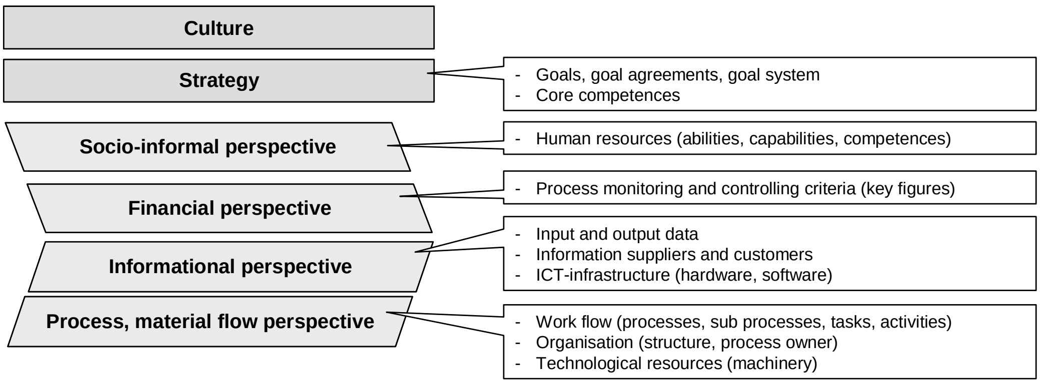

Figure 3: Process and manufacturing unit modelled by 6 layer descriptions

I. The culture layer envisions the network as a social system and captures the value and thinking pattern within the network. Consistent values are prerequisite for the networks' success.
II. The strategy layer describes the way, the network deals with the market and the resources. To quantify strategies, networks use objective systems, describing the actions of a network towards markets, economical pressure, and technological changes.
III. The social-informal layer models the HR and organisation contexts of the network. It includes all kinds of social and informal factors that determine and influence relationships within the network. Given that the network relies on autonomous units, teaming and communication skills' elements prove to be important.
IV. The financial layer deals with the evaluation of performance and the allocation of value addition across the network.
V. The information layer primarily addresses the design and handling of the flow of information. The major challenge is, to back up interconnections and re-configurability of devices or IT infrastructure. Smart units are equipped with computing units. Control systems are emulated using different networkable operating systems.
VI. The layer of process and material flow addresses the technical and physical side of the transformation steps. Technical function descriptions as well as logistics and materials handling are covered.

The layers culture and strategy may be considered as the 'umbrella' for all 4 resource layers. Dependent on the case and the level of detail to be addressed, fold and unfold properties are embedded to meet the corresponding levels of detail for communication between different

[9] *Products and services. Networkability of products and services signifies their ability to be customized, and aggregated swiftly and with low barriers so that they are aligned to requirements in the network.
*Processes. Processes are critical building blocks of organizations. Networkability of processes implies that they may be synthesized quickly and with low costs to produce agile products and services.
*Information systems. Networked information systems are required to be easily to be reconfigured to meet new and changing network requirements.
*Employees. Employees are the linking pin in the networked organizations, gluing enterprises at the personal level.
*Organizational structure. To be networkable, organizational structure needs to be able to morph dynamically to accommodate evolving, interconnected business processes.
*Culture. Networkable culture refers to the culture-related ability of organizations to allow highly dynamic and trusted collaborations between partners in the network.
[10] 1. physical goods, 2. information, 3. people, and 4. Finances (Bartlett & Goshal, 2002)

entities. The layers also support the syntheses of network frameworks with specific priorities of aspects e.g. human centred team concepts or purely ICT driven units by layer-wise descriptions of interconnections of units, maintaining the complete aspect views throughout the entire networks on all levels of detail (Fig. 4).

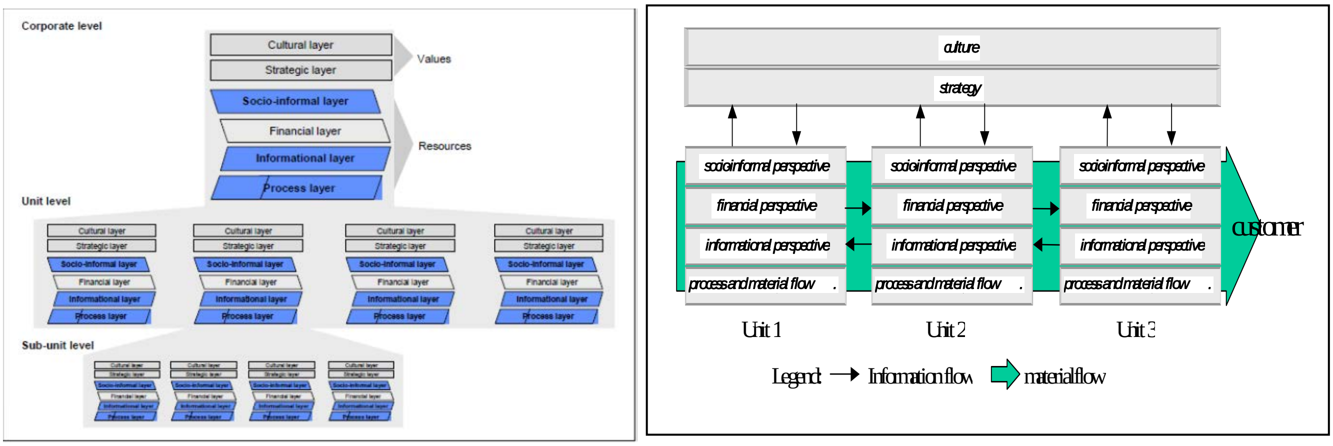

Figure 4: Generic Units' Layer model applied to Levels of Detail (Self-Similarity) and Networking (Layerwise Harmonisation)

In DM networkability of units has to promote the configuration of inter-unit collaborative processes on all layers. This includes the decision abilities, providing all procedures involved in governing and executing the necessary activities for (re)designing and setting up new or restructured processes. Processes in DM may be defined as an inter-related set of functions, ordered by precedence relationships, triggered by event(s) and producing observable results (Piedade et al. 2012).

Networkable decisions to be taken result in processes' configurations used as:

- descriptive mapping illustrating performed or running processes for analysing and extracting process parameters;
- prescriptive mapping, supplying anticipated process options for further evaluation and networks evolution and
- prospective instrument, displaying anticipated eventual configurations for simulation (which configurations should be preferred or avoided).

Activities and functions of the units may easily be structured according to the levels of detail, well differentiated according to the relevant network aspects. These generic models may as well be considered for process descriptions as they include the key constituents. They may be implemented according to the units' levels of detail and the units are assumed to organise tasks and activities respectively, Fig. 5. Orders, process segments and tasks may e.g. be executed via software agents[11].

[11] Groundbreaking work on this field has been done in international projects and by multinational consortia for establishing standards and for proposing theory that support distributed communication and decision making structures. Closest to the problem areas outlined here are the set ups of PABADIS and (GRACE, 2013). These approaches for Multi-Agent Systems (MAS) e.g. establish four types of agents, defined taking into consideration the process execution and as well as control the process segment specializations.

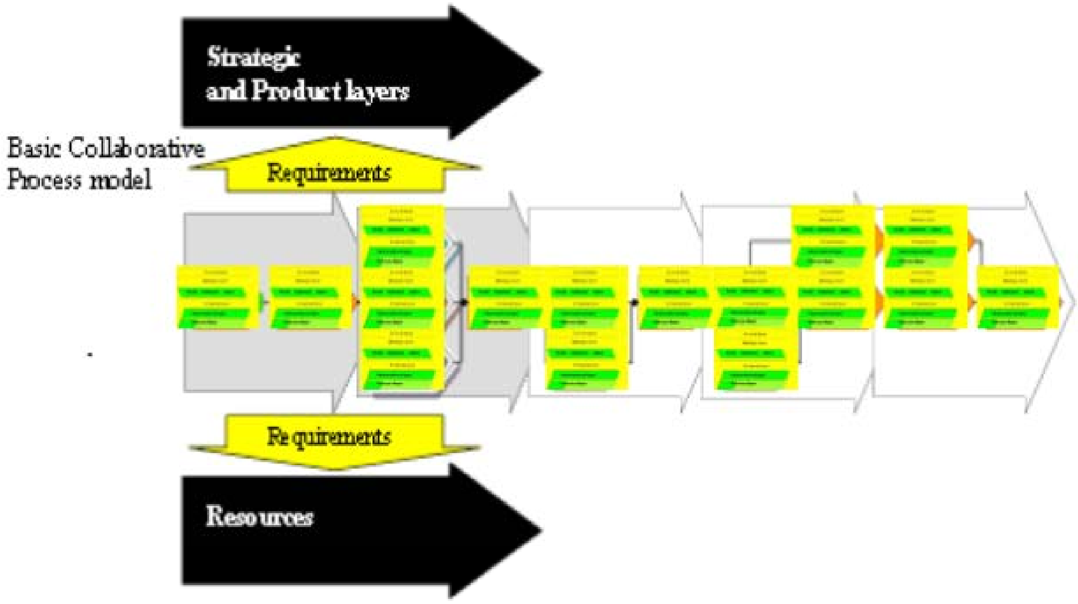

Figure 5: Basic Collaborative Process composed of Layer described Units

Based on the basic concept for the model the thematic approaches, i.e. product and resource, represented by agents, may be composed more detailed as a configured process network as results of agents interactions.
The introduced aspect layers of network ability do not only allow describing the units and prepare setups for interrelations. The layers also allow narrowing down a number of properties and smart manufacturing units are expected to exhibit in DM. These properties will not have to be newly engineered; it suffices to select and specify from the already existing devices.

4. Acceptance of existing Boundaries and Network Participation

Each smart manufacturing unit has to carry its digital presence, uniquely identified in the digital world, which includes ID and network interface address or other application-specific high level naming. Existing boundaries of the DM network must be accepted. This also affects the hierarchies of the (traditional) manufacturing systems in ERP, MES and shopfloor terms with clear responsibilities for factory equipment such as machines or factory sections. Smart manufacturing units should always retain its original functionalities and appearances, and maintenance should extend their physical usages so it is mandatory to decouple the augmented features from the original unit features. Smart units must support its original functions and properties, even if the augmented electronic cyber part is out of order.
Moreover, the requiring interactions with smart units should be identical to the interactions with the original object. Mental models, cast into emulation that keep the instrumentation implicit (without additional interactions), will make humans commonly experience that they are dealing with the physical real objects rather than their digital abstract objects.

5. Context awareness

A smart unit is augmented with various technologies, thus it is expected that a smart unit is able of knowing its operational and situational states and should be able to describe itself. This awareness might be also be provided by a secondary infrastructure e.g. cloud.
Awareness is generally defined as the ability to provide services with full awareness of the current execution environment. A definition is given by (Dey & Abowd, 2000) as any information that can be used to characterize the situation of entities (i.e. a person, place or object) that are considered relevant to the interaction, including the user and the applications themselves.

Aware units offer functionalities for gathering context data and adapting behaviour accordingly, aware systems, as cyber-physical systems, are by nature concurrent, as establishing and running processes are intrinsically concurrent and the coupling with computing shows concurrent composition of computing processes with the physical ones[12] by definition.
Using sensors and actuators, once recognised gaps and deviations may be stated and reconfigurations and adaptations may be initiated for determining current states of the models and vice versa, displayed effects may induce actions in the real world. Manufacturing information, which has been handed out as specs, work sheets, drawings, or schedule information, are now instantly and very precisely available enabling prompt identification, processing and communication of between actual and planned states and parameters.
To represent the current network states in a model system as well as to bring in modifications (e.g. for optimisation) from the model world into the real world, the different "network worlds" may be stored as models and gradually harmonized, so each action in the real manufacturing world may have an effect on the models and vice versa result in reactions towards the environment. Adequate set ups may be characterised as:

(1) A set of models that allow us to properly represent the context information at conceptual level. These models are capable to describe information related to objective fulfilment, position within the environment, location aspects and behaviour policies, as well as to the users that can interact with the system.
(2) Strategies and the decision procedures to allow the units to take adequate measures or to anticipate failures and to adapt the models according to new context data (Serral et al., 2008).

The set ups must as well depict a number of alternatives of possible states or configurations that might be chosen for further optimisation. However, history and time might keep from taking decisions in these directions and may therefore configurations be kept as future options. This notion of model thresholds is also called Dual Reality, (Schwartz et al., 2013) (possibly extended to multiple realities)); the "gradual iterative" decision mechanisms behind are outlined in (Kuehnle, 2013).

6. Heterogeneity

Heterogeneity of units is referred to as the properties of units being composed of diverse elements and using dissimilar constituents. In DM, heterogeneous manufacturing units and their constituents configure a networked and have to closely collaborate. Overcoming heterogeneity is a central issue in DM, as, due to the variety of devices and units involved, DM is intrinsically heterogeneous. The units or their constituents are to be connected and to configure networks comprising different types of computing units, potentially with vastly differing memory sizes, processing power, or basic software architecture. In DM, heterogeneity may therefore be assumed omnipresent, it occurs on all levels and for a number of reasons. On the informational side, heterogeneity may additionally come with different hardware platforms, operating systems, or programming languages. On the conceptual level, heterogeneity originates from different understandings and modelling principles for the same real-world phenomena.
Basically, two ways of coping with heterogeneous systems can be differentiated:
1. Establishing a comprehensive unified theory and

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[12] Accordingly, each of the aware manufacturing objects may carry a number of respective attributes classified into (Dey & Abowd, 2001):
identity (unique identifier),
location (geographic position, proximity etc.),
status (or activity) (intrinsic attributes of units, e.g., tool use, processes running etc.)
time (local time, timely priorities, ordering steps etc.).

2. Providing abstract data models and semantics.

In smart DM both directions are recognized. Inherent heterogeneity- and integration issues of different components as well as all challenges around are treated with novel unifying network and control theory (Kuehnle, 2013). The generic layer aspects of the introduced model definitely allow separating heterogeneous connectivity and collaboration issues as well as keep their break downs and fold ups. Therefore enabling interactions between sets of heterogeneous ICT devices of different brands and marks, i.e. interoperability, is conditio sine qua non in any DM scenario.
Moreover, heterogeneous networks require permanent revision of network components with emphasis on real-time operations requirements, so communication and sensing, actuating and processing in meshed control loops are supported.

7. Interoperability

The property of diverse systems and subsystems to work together (inter-operate) is referred to as interoperability. Interoperability is defined, as soon as operable units are available. Operability itself refers to the ability to safely and reliably run a system, in line with general and unit specific requirements. IEEE defines interoperability as the ability of two or more systems or components to exchange information and to use the information that has been exchanged. Interoperability can be understood as the capability of ICT systems as well as all supporting processes to exchange data as well as to allow sharing of information and knowledge.
Issues in collaboration and co-operation of units appear in larger contexts as communication between people, communication between people and ICTs and also between different ICTs. Consequently several levels of interoperability are differentiated. Furthermore, IEC TC 65/290/DC identifies levels of compatibility depending on the quality of communication and application features in a cumulative scale (Fig. 5).

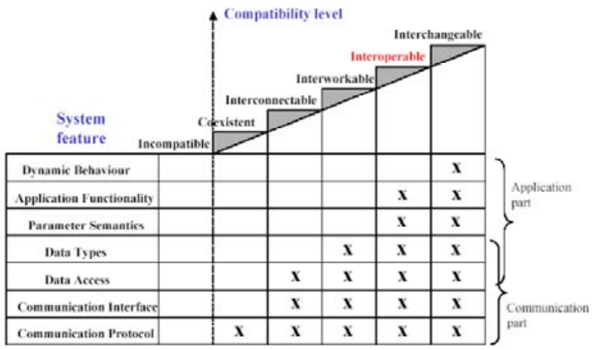

Figure 5: Compatibility levels based on IEC TC 65/290/DC

Especially the term of Interchangeablity is used as intermediate level of communication and expresses an ultimate interoperation. TCP/IP includes mechanisms that address automatically; the most important implementations are SLP, zero config, universal plug and play and UPnP[13]. Combinations of services and processes, as desired in DM, are e.g. supported by service oriented architecture (SOA). Functions are not addressed directly; instead services are requested via defined interfaces[14]. The service program acts as an intermittent between the client and the provider. SOA is therefore an important vehicle for pay services and a significant step towards new concepts of smart DM for addressing services via networks

[13] The procedure for discovery is another important part, though the most common are universal description discovery and integration UDDI and WS discovery protocol, generally based on XML, Web service descriptions annotated in WS DL and messages encapsulated in the Simple Object Access Protocol SOAP.
[14] The following features are important: index, representing a collection of services, able for restoration and finding, client for the take up a service and provider, eventually offering service that has been registered.

according to usage, as e.g. offered by cloud providers. The major achievement of SOA is the principle of encapsulation for implementing functionalities on its generic level supporting fold unfold principles by hiding or forgetting functionalities in certain situations. Encapsulation also supports mappings between functionalities on different levels of detail of the equipment and various stages of granularity.

8. Autonomy

Units demonstrate autonomy or are called autonomous, if these units are able to perform their actions without the intervention of other entities (Hasselbring, 2000). Autonomy includes the ability to interact or to self-organise in response to external stimuli, establishing a positive self-fed loop with the environment. Innovations and developments have rapidly contributed to higher intelligence of a number of manufacturing units allowing self-organisation, self control and eventually full autonomy of factory objects and units (Cloud). Autonomous units may now do their communication independently and may decide how to handle interactions with the outside world, by use of de-centralised decision making and by the formations of autonomous hub organisations with own rules and procedures within a collaborative process or supply network. For differentiation of actions and decision mechanisms in context aware manufacturing equipment, a differentiation of context dimensions may be introduced (Prekop & Burnett, 2003):

- -External (physical) refers to context that or captured by units' interactions or can be measured by hardware sensors, i.e. location, movement, alignment parameters, strategic input
- -Internal (logical) is unit specific, i.e., goals, tasks, objectives fulfilments, KPIs, improvement effects, operations or processes.

Dependent on captured and monitored data, events or stimuli, a manufacturing object may have to become active. Most important are models for decision procedures, so the manufacturing objects can adequately respond to monitoring results, if actions are required. Models to support units on the decision making also regard possible strategies to activate, guaranteeing adequate alignment and the preconditions and cases in which these strategies could be activated. The objective in the model is to maximise the performance obtained through the strategies activation, considering that an active strategy positively or negatively influences the KPIs defined to measure an objective.

Smart units may have capabilities to take certain actions as simple as switching from state to state or as complex as adapting the behaviour by other decision-making, action plans for self-healing, self organising and self sustaining. Depending of the smartness of the unit, the degree of autonomy may vary.

The starting point for a definition of a unit's autonomy is the ability of units to independently define and negotiate own objectives and pursuing strategies to achieve or to approach objectives. Within DM processes, autonomies are always restricted by the mode how other network units activate their strategies and how they define their objectives. Alignment of strategies and the harmonization of objectives include decisions concerning partners' selection, contract agreements, objectives' re-definition and performances as well. The network units have to keep own objectives and network objectives aligned with other units objectives in the network or check modified structures for collaboration by adapting or renegotiating links, restructuring network solutions and confirm or revise missions. Reciprocally, any misalignments will result in possible conflicts between the implemented strategies and the defined objectives, jeopardizing the benefits of collaboration or even breaking up processes. Misalignments and overstretching of the resource base certainly reduce or eliminate a unit's autonomy.

Standard Objective Bundle, decision space and negotiation of objectives is outlined in Kuehnle, 2013. A respective commercialised method for assisting in designing and identifying the goals has come up as Goal Directed Task Analysis (GDTA) process, Fig. 7. Actionable sub-goals ultimately achieve the original goal. For each sub-goal it must be considered how the operator will attain Level 1 projection, Level 2 comprehension, and ultimately Level 3 perception. Once, the business goals of a unit are clearly understood the configuration can be designed.

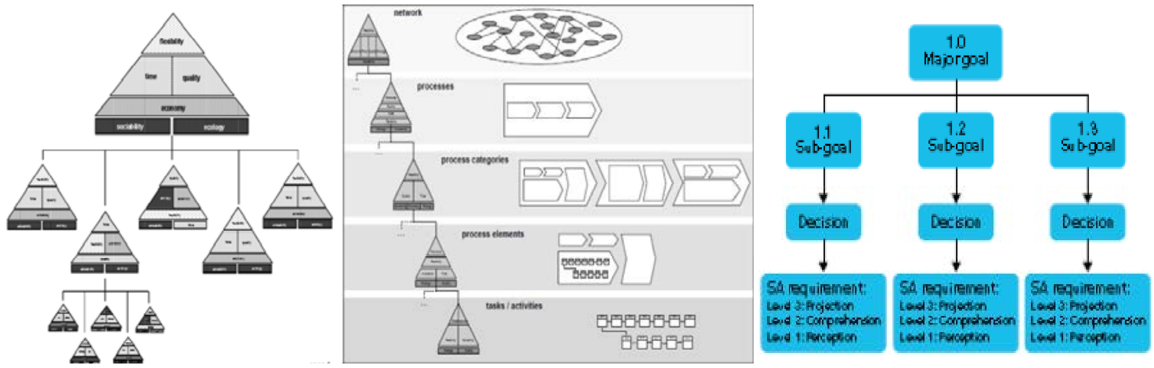

Figure 7: Break - down of network standard objective systems according to self-similarity principles (Kuehnle, 2013), implemented as GTDA software design (Krajewski, 2014)

9. Modularity

Units are considered modular, if they can be decomposed into components that may be interchanged and matched in various configurations. The respective components are able to interact, to connect, to exchange resources, using standardized interfaces. Different from monolithic systems, modular units are loosely coupled. Modularization entails the ability of processes, information systems and products to be packaged as reusable modules that can be (re-) combined with other modules, collectively making up new, value-adding artefacts. Modularity relates to the degree of dependency of elements of the module and is realized by allowing loose coupling between modules, implying that modules should have as little interdependencies as possible. In this manner, modular designed objects behave like autonomous network constituents, which can be networked in a relatively straightforward way. Standardization is the coordination mechanism of preference allowing modular networked objects to be synthesized in a standard manner, decreasing the need for mutual agreements on interoperability. As modularity in manufacturing is not a new concept, there are already examples of modules in DM systems, especially in the areas of control systems, equipment design, and human resource development and in enterprise management[15].

The intrinsically heterogeneous nature of modular systems enables to cope with various technologies and tools. In manufacturing successful use of modularity is mostly based on the ability to align process steps involving different units in order to form viable and efficient value chains by transmitting and exchanging data in a seamless way. Abilities to combine modules, abilities to understand systems of systems and its components and variably combining these, are crucial.

Naturally associated with modularity is the property of compositionality, which means that higher level systems' properties can be derived from the local properties of individual components. Compositionality is frequently impacted by strong interdependencies of software and systems adequately designed with embedded higher level properties.

15 Prominent examples are distributed controls for operations engaging one or more components, equipment in flexible equipment for discrete manufacturing, shop floor autonomy and empowerment of self managed teams, fractals as well as modular interpretations of enterprises in the concepts of virtual factory, virtual enterprise or extended enterprises, primarily aiming at increased agility and flexibility.

Major challenges for modularity are especially the alignments of human resource practices and information systems, so fragmented operations can be adequately supported by human capabilities. More intelligent units, e.g. smart objects, will enclose control and decision processing. It is decisive, in which way the units or activities are interconnected. Modularity also implies that, aside local feedback and local decision-making, capabilities are offered for prioritizing task allocation and capabilities are available for the execution of partial process chains.

10. Scalability

The capability to extend/reduce resources in a way, that no major changes in structure or application of technology are necessary, is generally referred to as scalability[16].

Due to stronger links between cyber objects and real manufacturing units, the term of scalability evidently becomes highly relevant for DM and manufacturing networks. Of course, a main concern is the capacities' scalability, i.e. the facility to increase or decrease necessary resources to efficiently accommodate broadly varying capacity loads. For example, cloud manufacturing gives the cloud consumers options to quickly search for, request and fully utilize resources procedures, e.g. search for idle and/or redundant machines and hard tools also in other organizations, in order to scale up manufacturing capacity.

Scalability can be seen as one important requirement to realize self organization in DM as it enables adapting processes rapidly in highly dynamic environments. Moreover, in DM, such adaptation processes are gaining importance in plug & work applications. Scalability may refer to the commodity background as discussed in the remote manufacturing cloud, e.g. more machines of the same type in different sites or different companies to fulfil large order quantities in shorter time.

Another field of scalability discussions is the area of control and computing power in the area of cloud computing.

11. Conclusions and Outlook

Additional machine capabilities will completely and rapidly change manufacturing all over the globe. Wireless communication, powerful online identification and localization devices have been successfully integrated in manufacturing already; now novel upgrading functionalities are introduced to the shopfloor. There is certainly much more to come, especially if we imagine implanted or embedded processors in practically any object and any piece of equipment. Mechanisms can be implemented for virtually composing products or for intelligent components finding each other on the path to value creation. Powerful and efficient applications, available as cyber physical systems, as Internet of things, pervasive computing or machine to machine communication will make Distributed Manufacturing a preferred model to produce.

Wireless technologies will further strengthen telecommunications' involvement in manufacturing. This tendency has just started to gain ground by the introduction of efficient tracking systems in synthesis with cloud computing solutions. Manufacturers of computer hardware as well as software vendors will have to take into account this virtualisation of resources. After some reluctance of leading software providers to offer these upcoming services e.g. cloud, impressing solutions have quickly changed attitudes. Software as a service, infrastructure as a service etc. are fully integrated in important software service programs. Anything as a Service (AaaS) could be the wording anticipating more upcoming options.

Additional equipment features, such as awareness, autonomy, modularity, scalability and networkability will step into the manufacturing thinking, which might be called smart

[16] It is measured in dimensions such as administrative scalability, functional scalability and capacities' scalability. Scalability in Manufacturing refers to the ability of a manufacturing system to handle growing or shrinking amounts of loads or usage in a smooth manner by its ability to be enlarged or reduced to fully accommodate the growth or the shrinks.

distributed manufacturing. Management should be aware of upgraded machines and manufacturing equipment, orders and products, parts and pieces.
Networkability will gain utmost importance on all levels, be it for all KPI's on all levels, additionally introduced network ability parameters or network rules. Management could get prepared for situations where network ability and alignment parameters have higher priority in comparison to traditional KPIs.

Observing the players from telecommunication, hardware makers, software designers and systems integraters and the innovation power behind, it is obvious that there will be more intriguing innovations ahead. All controls of machines, robots and other equipment may be upgraded to emulate all capabilities and functions in order to ensure IP interoperability. Multi-agent systems navigate units by polling and negotiating functionalities to build up optimum process sequences. Both, product design and equipment design will have to be revised completely. Increasing portions of manufacturing will become information, further optimising resources' consumption and instigating the reuse of material as well as the after-use of products. Companies should prioritize to upgrade their equipment and to take "smart" investment decisions on new machines. The melting of key information technologies is only at the beginning of an era; the first humanoid robot, able to replace humans on the shop floor, is expected to appear latest by 2025.

Management should be aware of alternative network configurations at any time and have evaluations ready. Time and history will, in most cases, inhibit to switch to the optimum network configurations. It will only be possible with some delay. Nevertheless all alternatives should be prepared as plans, ready to be activated, as soon as the implementation situations occur. Companies should continuously question their strategies. Business models are jeopardised and constantly flowing, key competencies keep repositioning. Pressure will come from companies, taking higher risks in outsourcing ICT, as the advantages are amazing. Inside and outside of companies, there will be three top priorities for information, data, and procedures: 1. security, 2. security, 3. security!!
Important studies from renowned institutions indicate rationalisation effects that could cut the workforce in industry down to 50% within the next 10 years. The remaining half will have skills that differ from today's qualification schemes (Davis & Edgar, 2011). The shopfloor will be the domain for digital experts, placing emphasis on developing IT skills and new-media literacy. Man machine interfaces and employee involvement have always been hot research spots and will continue to provide a plethora of problems for intensive actions. However, progresses in body area networks will simplify many discussions. The tendency shows a clear development towards a strong involvement of digital natives on all levels and in all sectors of industry.

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