A new approach to use Virtualisation as a basis for Information Management: We regard Virtualisation and Smart Objects (IOT) as a basis for Innovation in Supply Chain Networks using IOT.

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Information management is concerned with managing the Information and Information Technology Resources of an organisation. We progress now rapidly into an era where IT and other technologies (in particular IOT, Smart Objects and all kinds Services) are used to innovate, automate and support the collaboration in Business Processes both on the level of the individual company (cooperating with others and their resources) to execute their own business processes or on the level of the supply chains they are involved in. This change of the scope(multi actor, new technologies and shared platforms) and nature of the IT domain also has its consequences for Information Management. In this paper we will briefly describe some current developments and thereafter describe some consequences for Information Management.

Current developments.
The use of ERP, production and logistic systems is required and rapidly growing in response to societal requirements and available and affordable technologies. Traceability systems are currently widely used in (food) supply chain networks to track whereabouts of identified business objects over time and to track and trace the history of properties, whereabouts, property rights and provenance of these objects. In addition, important innovations in food supply chains are taking place and are to take place that are based on these systems and on utilising a broad range of new technologies, in particular technologies such as Internet of Things (IOT) and Smart objects combined with sensor, actuator and robot technologies.

In particular these innovations encompass increased virtualisations(multiple) of objects in shared IT platforms (like FIspace/FIware), also called Digital Twins (Verdouw et.al. 2017). Based on these virtualisations remote and decoupled management and control and (partly) automated designated execution of processes takes place. The latter is in part provided by automated controllers and machines that have been developed and implemented. These mentioned developments and innovations have various implications, as described earlier by us and reiterated here:

- The whereabouts over time of uniquely identified objects and relationships between objects can be represented by virtualisations of mentioned objects. Virtualisations of objects then being globally uniquely identified digital representations of the identification of objects and of evolving (dynamic) properties of objects of interest (including conceptual ones)). As a consequence objects and their virtualisations can be tracked and traced if access to these virtualisations is possible and granted.
- That means that not only the whereabouts over time of objects can be tracked and traced, but also recorded dynamic properties and even expected properties over time. In particular for instance, as changing quality properties and conditions of fresh products while traveling through a supply chain are of the utmost importance for logistics management, these properties can be observed, captured and stored in virtualisations using IOT technologies next to projections for comparisons. In brief we make observations, process observed data and store these data into virtualisations of objects of interest in or accessible via the internet.
- In turn adequate virtualisations (available, accessible, integrity, fit for use) allow one to use these virtualisations both for (automated) management and control activities and for the automatic execution of operational activities.
- As a consequence, using virtualisations, we can decouple operational and observational activities from planning, management, execution and control (PMC) activities. That means that remote decoupled PMC activities executed by man and/or machine is possible if necessary virtualisations are timely available and accessible. A prerequisite is then that there is no ambiguity about usability and meaning of the virtualisations being captured and used.

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- Further, decoupling operational and PMC activities provides us with the possibility to organize logistic or supply chain networks differently by separating organizations involved in the orchestration of logistics from organizations actually performing operations.
- This mentioned phenomenon of decoupling operational and PMC activities also takes place on the level of individual organisations that collaborate with other organisations in the execution and PMC of their own primary processes. For example a farmer works together for precision farming with service providers (for sensory data) and with (a variety of) contractors that have specific machines and resources available.
- As a consequence of previous points, in brief, we have to do with supporting and partly automating and PMC of collaboration processes. Both on the level of an individual company and on the level of Supply Chain Network Processes. Collaborations with various organizations and service providers where decoupling of designated tasks from the place of execution using virtualisations takes place.
- Finally we need IT infrastructures with particular architectures, with components residing in and or connected to the Internet to bring about systems, services and communications that will allow us to define, share and use virtualisations. Infrastructures like FIware.

In innovations using technologies and virtualisations, virtual and virtualisation are thus important concepts. The concept of virtual is used in several meanings. Virtual supply chains combine amongst others the perspectives of virtual organizations and virtual things (Verdouw et al. 2012). Virtual organisations are dynamic organizational structures that temporally bring together resources of different organizations to better respond to business opportunities (Davidson and Malone, 1992; Goldman et al., 1995; Venkatraman and Henderson, 1998). The virtual things perspective is related to the Internet of Things (IOT), which provides a vision of a world where physical and conceptual objects are connected real-time to their globally uniquely identified internet representations. Further technologies like smart objects with associated IOT virtualisations play an important role. Smart objects then being combinations of technologies such as computers, software, network technology, sensors and actuators capable to execute operational activities as governed by their software system, communicate and interact with their virtualisations and other objects. In virtual supply chain networks (VSCN) we combine these different perspectives. VSCN can be defined as dynamic organizational structures that temporally bring together organizations and resources of different organizations based on the virtualisation of physical and conceptual logistic objects such as containers, smart objects, orders, shipments, products, bill of lading, trucks and vessels (just to name a few). The virtualisation of physical (smart) objects allows for the decoupling of the physical and information aspects of logistics operations (Clarke 1998). Actors responsible for PMC, (partly) automated execution, orchestration and coordination are then not necessarily also the ones handling and observing these physical objects and they can be at totally different locations (as described before). As a consequence, virtualisation enables the decentralization or decoupling of physical flows from (centralized) PMC, orchestration, and coordination taking place in other locations and by other partners.

Consequences for Information Systems and Infrastructures.

Information Infrastructures and Information Systems that are meant to support, enable or partly automate mentioned collaboration processes in VSCN thus necessarily do have a much greater scope than Infrastructures for an individual company. The same holds for Information systems as many are supposed to support or automate (parts of) collaboration processes and interact with systems of participants in collaborations. Information systems and data repositories (IS) of businesses, connected to or (having components) part of shared IT platforms comprising virtualisations or giving access to them, can and must thus enable these VSCN with flexible chain-encompassing tracking and tracing systems and decision support based on available information.
Main functionalities of these IS or services encompass (a) first of all effectively capturing and maintaining information about (smart) objects in a VSCN, (b) secondly the transformation of that captured information into the creation and storage of virtualisations of the (smart) objects of interest, (c) give access to and process information from these virtualisations upon request, (d) safeguard property rights using access and usage rights. As an example, such systems may therefore provide for a virtualised view on logistics flows from farm to fork by supporting a timely and error-free exchange of logistics information and providing functionality for intelligent analysis and reporting of exchanged data to enable early warning and advanced forecasting. Support for intelligent DSS that is. Three critical features of

these systems are therefore distinguished (Verdouw et al. 2013): real-time virtualisation, logistics connectivity and logistics intelligence.

Virtualisation in VSCN based on virtual things is still in its infancy, although enabling technologies are currently maturing fast (Chui et al., 2010) and prices for technology, storage, services and communication are going down. Future challenges are not only concerned with technology (integration) issues (like most IOT challenges as addressed in literature), but especially also with functional and organisational issues (see Verdouw et al., 2013). These challenges can be classified into:

i) *Dynamic virtual representation*: geographically dispersed physical and conceptual objects have to be observed with known observation methods and means, data must be captured and then tied to and continuously update a virtual representation of relevant objects. These representations must adequately represent the identity, place and (dynamic) properties of the (physical) objects of interest, they must be 'reliable' and 'fit for use'for different purposes of usage, they must be timely available and the data integrity, security and privacy must be unquestionable;
ii) *Connectivity*: information about relevant objects must be available, accessible and shared timely and secure with other organizations in order to enable adequate managerial or operational response within allotted timeframes;
iii) *Intelligence*: the usage of dynamic virtualisation data for intelligent decision support for planning, coordination, orchestration and control of the supply chain network;
iv) *Implementation and configuration*: virtualisation has a big impact on supply chain organisation and is expected to result in new business models and into the need of shared IT infrastructures throughout VSCN.

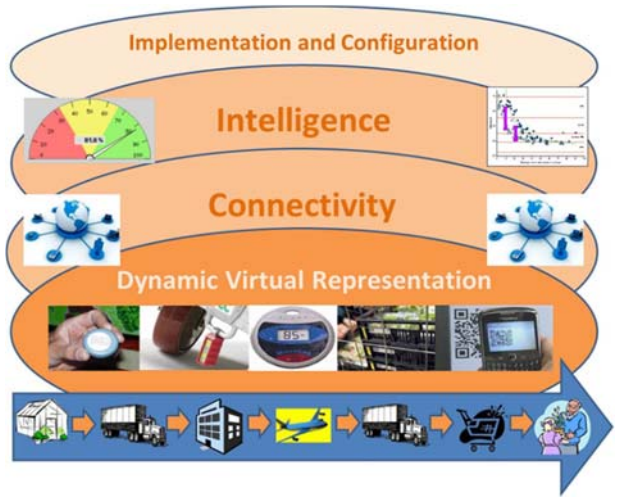

Figure 1 Main challenges for virtualisation of agri-food supply chains (Verdouw et al., 2013).

Information Management:

Given the brief description of the expected and scope of developments with respect to innovations and the expected use of IT, IT services, other technologies and infrastructures to bring these innovations about, we can easily see that the information management function has (to) change quite drastically in response to these described developments. Some features emerge:

1. The scope of the function has drastically increased. We have to support both horizontal cooperating and vertical (VSCN) processes. The actual execution and support of these processes, the (smart) objects with their virtualisations and management and control of these processes are then an important starting point for deriving requirements for Information Management. This rather than an analysis of information requirements of administrative processes.

2. The scope of the function has (to) increase(d) drastically on the organisation level. As the main focus of systems support is moving towards collaboration processes. We have to do with a network of participants, service providers and standardisation bodies. Each participant having their own IT- infrastructure and possible participation in Software Eco systems (Kruize 2017).
3. The scope has drastically increased with respect to technologies. We have to do with IOT, Virtualisations, IT-services, APPS and Future Internet, with sensors, actuators etc. and automated operational systems. In fact in the past the worlds of ERP/DSS on the one hand and factory automation (ISA-95) on the other hand were well separated. In the support of collaboration processes in the agro-food domain (in particular precision agriculture) these worlds are necessarily united.
4. Therefore these technologies, IOT, Platforms and virtualisations are part of the mentioned starting point for deriving Information Management Requirements. Basically, on the level of VSCN (in particular agro-food with many small companies) we thus connect and integrate the worlds of ERP and ISA-95.
5. Also this emerging expanded scope also has many consequences for developing systems and infrastructures (in cooperation with parties concerned). Participating in and adhering to standards of standardization bodies is important to ensure interoperability and shared understanding of messages exchanged. Participating in Software Ecosystems may amongst others help to foster the development of reusable and sharable services, to find services with well-defined functionality, help to give access to deployed services, may provide for tools to configure specific information systems form services, etc.. The main question is then how do you have knowledge about available infrastructure (components) (Find function). And in what areas do you have to participate in exchanging information or even joint decision making between participants in (sub) networks of importance. This since together these constitute the Infrastructure that an organisation is to embed in.
6. Finally, for the time being, given the scope and developments, it is easily clear that an organisation has to develop and maintain an architecture for the development of their IT infrastructure, with the links to other (shared) infrastructures.

In our presentation we will pay attention to these developments and sketch the consequences for (the) information management (function).

Structuur: Ontwikkelingen Intro implicaties: control coordinatie en infrastructuur uit elkaar halen. Eventueel architectuur/infrastructuur meenemen.

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