Virtual Logistic Networks in Dutch Horticulture [1]

C.N. Verdouw (cor.verdouw@wur.nl)
LEI, part of Wageningen UR, PO Box 29703, 2502 LS The Hague, The Netherlands

A.J.M. Beulens
Wageningen University, Logistics, Decision and Information Sciences group, Hollandseweg 1, 6706 KN Wageningen, The Netherlands

J.G.A.J. van der Vorst
Wageningen University, Logistics, Decision and Information Sciences group, Hollandseweg 1, 6706 KN Wageningen, The Netherlands

Abstract
Virtual logistic networks are often advocated as an agile alternative to static pipelines that efficiently push products to the marketplace. These networks are dynamic organizational structures that temporally bring together resources of different organizations based on the virtualization of physical logistic objects. The paper assesses the emergence of virtual logistic networks by means of the highly instructive example of the Dutch horticulture. More specifically, it presents the current situation concerning the enabling role of information and communication technologies and it defines remaining future challenges.

Keywords: Virtualization, Logistic networks, Horticulture

Introduction
Static pipelines that efficiently push products to the marketplace are not sufficient to meet the demands of current volatile markets on logistics. Virtual networks are often advocated as an alternative approach that enable agility and responsiveness. Virtual networks are dynamic organizational structures that temporally bring together resources of different organizations to meet worthwhile opportunities (Davidsow and Malone, 1992; Goldman et al., 1995; Venkatraman and Henderson, 1998). A key driver of virtual logistics networks is the virtualization of physical objects enabled by new information and communication technologies. Planning, orchestration and coordination are based on virtual representations of physical products and logistic resources. This implies that the actors performing these tasks are not necessarily the ones handling and/or observing these physical objects and they can be at total different locations. As a consequence, virtualized networks enable the decentralization or decoupling of physical flows from (centralized)

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planning, orchestration, and the coordination taking place in other locations and by other partners.

The emergence of virtualization is currently reshaping supply chain management in the Dutch horticulture. The horticultural sector in the Netherlands is of world-class quality, and serves as main trading hub for Europe (CBI, 2008). The sector has a huge impact on the Dutch economy. It is the largest exporter of fresh-products in Europe. It belongs to the top-3 largest exporter in the world and has significant opportunities for further growth. Despite the current leading position, the sector needs to look forward and innovate to stay in the lead. Today, most horticultural products, i.e. flowers and plants, physically pass through the auction houses on their fixed routes from (inter)national growers to (inter)national customers to allow for physical inspection and quality control. However, it is now widely accepted in the sector that virtualized networks are an important answer to challenges posed by the markets and the opportunities offered by nowadays affordable new technologies, in particular ICT.

This paper assesses the emergence of virtual logistic networks by means of the highly instructive example of the Dutch horticulture. More specifically, it aims to analyze the current situation concerning virtualization in this sector and to define remaining future challenges.

Methodology

The present research is carried out as part of the Da Vinc3i project (www.dinalog.nl) in close interaction with the involved business partners, which represent the majority of the Dutch horticulture (including auction, traders, growers and industry associations). The research started with a literature review to define virtual logistic networks. Based on the literature review a framework for analysis was developed, focusing on the enabling role of information and communication technologies (ICT). The framework defined seven key themes, which were used to investigate the current situation in the Dutch horticulture sector. This investigation was based on desk research and explorative interviews with key industry experts. Last, the framework for analysis was used to define future challenges that were evaluated by industry experts of the Da Vinc3i project.

Virtualization of Logistic Networks

The concept of virtualization has been used as a compelling catchphrase to describe to the revolutionary impact of information and communication technologies (ICT) on business processes, organizations and society (Crowston et al., 2007). Basically, the word “virtual” contrasts with “real” or “physical”, which implies having the essence or effect without a real-life appearance or form (World English Dictionary). Virtualization is used in reference to digital representations of real or imaginary real-life equivalents. As such, virtualization removes fundamental constraints concerning:

- *Place*: virtual representations do not require geographic presence, i.e. physical proximity, to be observed, controlled or processed;
- *Time*: besides the representation of actual objects, virtualization can reproduce historical states, simulate future states or imagine a non-existing world;
- *Human observation*: virtual representations can visualize information about object properties that cannot be observed by the human senses.

Although dealing with the same basic concept, virtuality has been applied to different domains and the concept has been used in different meanings and with different focuses. The main perspectives as apparent in literature are:

- *Organizational perspective:* virtual enterprises and virtual supply chain networks;
- *Team perspective:* virtual collaborative working environments;
- *Information technology perspective:* virtual machines and (technological) networks;
- *Virtual reality perspective:* digital environments that are experienced by human users as reality;
- *Virtual things perspective:* digital representations of physical objects that link all relevant object information, usually in the internet (Internet of Things).

Virtual logistic networks combine the first and last perspective: virtual organizations and virtual things.

Virtual Organization Perspective

The term 'virtual organization' or 'virtual enterprise' became popular in the 1990s to characterize the development towards dynamic organizational structures that temporally bring together resources of different organizations to better respond to business opportunities (Davidsow and Malone, 1992; Goldman et al., 1995; Venkatraman and Henderson, 1998). It can be seen as a consequence of the focus of companies on core competences (Prahalad and Hamel, 1990). End customers can only be served by the collaboration between the independent companies that forming a network of complementary resources, i.e. a virtual organization.

More recently the network perspective of virtual organizations is stressed. Virtual networks are formed on-the-fly during business operations based on a selection of capabilities and enabled by flexible inter-organizational information systems (Grefen et al., 2009; Vervest et al., 2004). Basically, the underlying concepts are the same as at virtual enterprises or virtual organizations. However, the focus slightly differs since the emphasis is in particular on the rapid (re)construction of supply chain configurations that plan, coordinate and control the business processes required to achieve a specific value proposition at a specific moment in time. Consequently, in virtual networks a dynamic variety of chain processes, connecting network partners in horizontal and vertical relations, takes place in order to satisfy demand (Verdouw et al., 2011).

Virtual Things Perspective

The virtual things perspective is related to the Internet of Things, which provides a vision of a world where the power of combining ubiquitous networking with embedded systems, RFID, sensors and actuators makes the physical world itself a relevant part of any information system (FI-WARE, 2012). The interaction between real/physical and digital/virtual objects is an essential concept behind this vision. In the Internet of Things, physical entities have digital counterparts and virtual representations; things become context aware and they can sense, communicate, interact, exchange data, information and knowledge (Guillemin & Friess, 2009). In other words, each physical object is accompanied by a rich, globally accessible virtual object that contains both current and historical information on that object's physical properties, origin, ownership, and sensory context (Welbourne et al., 2009). The Internet acts as a storage and communication infrastructure that holds a virtual representation of things linking relevant information with the object (Uckelman et al. 2011). As such, virtual objects serve as central hubs of object information that combine and continuously update data from a wide range of sources (see Figure 1).

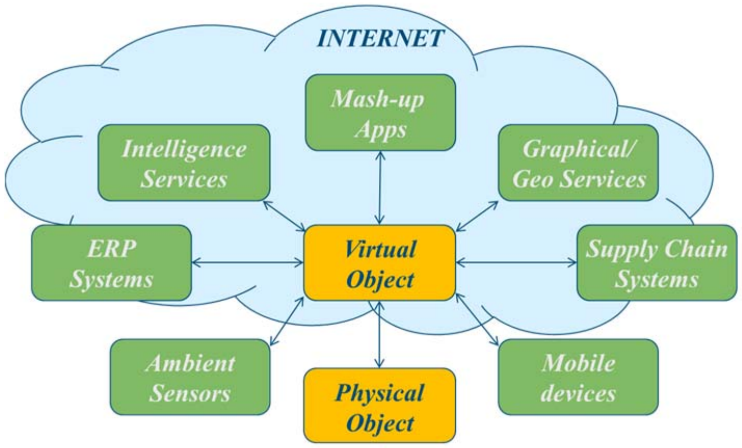

Figure 1 – Virtual objects in the Internet of Things

The virtualization of physical objects allows for the decoupling of the physical and information aspects of logistics operations (Clarke, 1998). The actors responsible for planning, orchestration and coordination are not necessarily also the ones handling and observing these physical objects and they can be at total different locations. As a consequence, virtualization enables the decentralization or decoupling of physical flows from (centralized) planning, orchestration, and coordination taking place in other locations and by other partners.

In summary, virtual logistic networks combine the perspectives of virtual organizations and virtual things. They are dynamic organizational structures that temporally bring together resources of different organizations based on the virtualization of the physical logistic objects such as containers, shipments, products, trucks and vessels.

State of the Art in Dutch Horticulture

This section describes the current situation concerning virtual logistic networks in Dutch horticulture, including bottlenecks and relevant best practices. The investigation focuses on the enabling role of ICT, which is classified into seven key themes.

Automatic Identification and Data Capture

Automatic Identification (AutoID) or Automatic Identification and Data Capture (AIDC) refers to methods of automatically identifying objects, collecting data about them, and entering that data directly into computer systems (Wikipedia, 2012).

One-dimensional barcode scanning is the most widely used AutoID technology in Dutch horticulture. This technique is used on different levels of aggregation, including individual products, crates, trolleys and locations. Also multi-dimensional barcodes (GS1 Databar, QR code) are increasingly being applied, in particular in the provision of product information to consumers.

The sector is also for a long time active with RFID. In the 1990s this technique was applied on an experimental basis to optimize internal logistics. Since 2011 there is a breakthrough because the complete pool of CC containers is equipped with RFID (3.9 million trolleys). CC trolleys are the most-widely used logistic containers in the sector. This was the world's largest RFID implementation up to then (Wessel, 2010). Furthermore, recently all auction trolleys are tagged with high frequency (UHF) transponders (around 270.000 trolleys), next to an already available LF tag used from 1999 (den Bakker, 2009).

Several projects utilise this technology base for tracking and tracing, logistic planning and scheduling and RFID-based Quality Controlled Logistics (combination with different types of sensors). For example, the Plant-to-Customer project analyses and demonstrates the benefits of RFID in plant supply chains based on a pilot implementation including growers, traders and logistic service providers (Swedberg, 2010). The GO! project implements a RFID Supply Chain Platform (based on the tagged CC containers) for inbound and logistics of a plants trader (Wessel, 2012).

However, RFID is not yet applied on the individual item level. There are technological constraints like limited reading quality of tags due to damp, dust and metal, but the decisive factors are organisational conditions, in particular: a proper business case for all involved participants, agreement on the distribution of benefits, trust in the privacy of data and the use of RFID for business process improvements.

Quality Monitoring

The monitoring of quality parameters is an essential issue in horticultural supply chains that deal with fresh products. Important enabling technologies are fixed sensors, advanced barcodes, data loggers, Time Temperature Indicators, RFID-enabled sensors and wireless sensor networks.

In the Dutch horticulture, currently mainly fixed sensors and data loggers are used. The most important bottleneck is the timeliness of quality condition information. The monitoring information is mostly used in a defensive way, i.e. in order to determine the causes of quality problems afterwards (Scheer et al., 2011). However, there are some examples that go beyond this static approach, including:

- Cold Chain Score Card: development and implementation of a quality monitoring system for the sea transportation of flowers (ten Hoope, and van der Hulst, 2010);
- Greenrail: project to stimulate rail transportation of flowers and plants, including the development of a dedicated container with a built-in GPRS system for remote temperature control (www.greenrail.nl);
- Smart Agri-Food pilot Quality Controlled Logistics: pilot in a plants supply chain that combines RFID and sensor technologies for quality controlled logistics and retail store replenishment (www.smartagrifood.eu).

eBusiness Messages

The Dutch horticultural sector is very active in eBusiness for a long time. In the early 1990s, an industry association was started for the development, maintenance, application and promotion of eBusiness standards, i.e. Florecom (www.florecom.nl). As a consequence, much progress has been made in the development of EDI and XML standards. Furthermore, generic standards (like orders, invoices, despatch advices, etc.) are well integrated with international standards, in particular because of cooperation with GS1. However, the international embedding of horticulture-specific standards is still an important point of attention. The horticultural sector collaborates on this issue in Tuinbouw Digitaal (Verloop et al., 2009a).

Last but not least, the adoption of standards is still too low. Several initiatives are running to increase the usage of standards by the horticultural business and ICT vendors, for example Plantcenter Europe. This is a consortium of traders, growers, auction and logistic service providers that collaborates in the application of eBusiness standards to improve supply chain logistics (www.tuinbouw.nl).

Product and Logistic Coding

Product coding is a difficult issue in horticulture (Verloop et al., 2009a). The product variety is high, horticultural products are living products with dynamic characteristics and the need for the level of the required level of detail differs for different purposes of usage. For example: the product ‘green indoor plant’ might be sufficient for the Point of Sales, but the specific variety must be known for tracking and tracing purposes. This complexity has resulted in the availability of several conflicting standards for the coding of horticultural products. The VBN coding system is the dominant upstream product code (used by growers, traders, auction). The Linnaeus project has recently renewed this standard (www.vbn.nl). Coding Living Green (CLG) is a coding system based on EAN13/GTIN for Point of Sales scanning (www.levendgroen.com). Furthermore, many retailers, traders and producers issue own codes, based on the generic GTIN standard or otherwise. Florecom is currently working on harmonising these different standards and on integrating them with relevant international standards (in particular those of GS1).

Florecom is also the central industry platform for logistic coding standards. For this purpose usually international cross-industry standards like the Global Location Number (GLN) are used. For example, in previous years all relevant Dutch locations for logistics in the flowers and plants sector (about 20.000 in total) are coded with GLN.

Enterprise Information Systems

Enterprise Information Systems support the processing of information at different levels ranging from operational to strategic, including mechanized cultivation and logistic systems, enterprise management systems and business intelligence applications. In the horticultural industry impressive achievements are made concerning the mechanisation of production, harvesting, sorting, packaging and warehouse management. However, many companies in the sector struggle with their enterprise management systems among others due to a lack of solid and seamless integrated enterprise management systems that are at the same time flexible and include dynamic planning (Robbemond and Verdouw, 2012). This was the reason for around 30 plants growers to start Plantform (www.plantform.nl), an association for horizontal cooperation in the development and implementation of integrated enterprise management systems (Verloop et al., 2009b).

Supply Chain Information Systems

Supply Chain Information Systems are software systems that support the rapid, error-free, efficient and safe information exchange between supply chain participants, including systems for Tracking & Tracing and Supply Chain Planning. There are several central information hubs in horticultural supply chains, in particular for logistic tracking and tracing. The most important operational examples are:

- KissIT: central logistics data hub that combines dynamic Tracking & Tracing information with orders and shipping documents (www.kissit.nl);
- RSLM: central system of transporters to manage the pool of auction trolleys (www.rslm.nl);
- LIPSS: collaborative system for logistics planning and monitoring of a group of traders (www.tuinbouw.nl).

However, the adoption of these systems advances only with difficulty. Important limiting factors are a lack of intra-enterprise interoperability and organisational factors such as unclear business models and a lack of trust in the privacy of data. The project Hubways addresses this issue on the level of the logistics between market places in The Netherlands (www.hubways.nu). It aims to deliver a sector-wide adopted digital platform that supports the exchange of cargo, capacity and information.

Market Information Systems

Market information systems support the processing of transactions via a market mechanism. They include functionality to provide information about available products, to compare products on buying criteria, to agree on price, and to process the transaction administratively (including payment). Market information systems can be subdivided into Business to Business (B2B) and Business to Consumer (B2C) systems.

Business to Business (B2B)

The usage of B2B market information systems in the Dutch horticulture has expanded a lot in the previous years. The most important developments are the emergence of on-line trade platforms and the digitalisation of the auctioning process.

In on-line trade platforms growers publish available product supply, including visual information (picture), quality information and other relevant parameters. Traders can transfer this supply information directly to their own web shops. Traders can combine, split and pass on orders to growers and orchestrate delivery. Important trade platforms are Plantconnect (plants; plantconnect.nl) and eTrade (flowers; www.florahollandetrade.nl), both deployed by the auction FloraHolland. Many traders and growers also have their own B2B web shops.

Traditionally, auctions are dominant market places in the flowers and plants industry. The largest flower and plant auction in the world is FloraHolland in the Netherlands. In previous years FloraHolland has implemented a virtual auctioning system called KOA (Remote Auctioning). Customers can buy, anywhere in the world, real-time via internet on all the FloraHolland auction clocks. The products needs not to be physically present at the auction clock, which implies that they can directly be transported from producers to customers. In Q4 2011 almost 70% of the flowers of the two main auction locations were traded via virtual auctioning (www.floraholland.com).

A crucial precondition for both on-line trade platforms and virtual auctioning is the quality of product information and images in two dimensions. First, a buyer must be able to form a good judgment of the product according his specific frame of reference and purposes of usage (fit-for-use). Secondly, the reliability of information must be unquestionable (trustworthiness). Therefore, the quality attributes are standardised in the flowers and plants sector and there are strict procedures for supply and verification of product information and pictures. Furthermore, there are databases with high-quality product reference information. The most important example is the VKC image base (Plantscope), which is a central database of standardised product information and pictures of all varieties of flowers and plants that are on the market (www.vkc.nl, www.plantscope.nl). Another example is Wikiplant: a website with extensive product information about indoor and outdoor plants (www.wikiplant.nl).

Business to Consumer (B2C)

Also for consumers many web shops are introduced, mainly for flowers. Important European web shops for flowers include fleurop.de, interflora.fr, interflora.co.uk, inteuroflorist.nl in the Netherlands (van Dijk and van der Salm, 2010). A recent development is the emergence of web shops in which local consumers can buy directly from local growers (local for local), for example Fresh from the Grower (www.versvandekweker.nl).

The communication with consumers via smartphone apps is in its infancy. There are several examples of QR codes on plant labels that are linked to consumer information such as optimal treatment, including www.ficusforever.nl, www.flowercouncil.org and the PlantScanner App of plantconnect.nl. Also some web shops have a mobile application that is available as smartphone app, e.g. the Android app of the web shop Flowerservice.nl. Furthermore, recently the first flower shop on Facebook was introduced (www.facebook.com/bloemen.nl).

However, the volume of B2C internet trade is still very low in comparison with traditional market channels like flower shops and super markets. The most important reason is that most consumers still want to see flowers and plants before buying.

Future Challenges

Based on the previous State of the Art analysis, main future challenges concerning the virtualization of logistic networks in Dutch horticulture have been defined. They are classified into: i) Dynamic Virtual Representation, ii) Connectivity, iii) Intelligence and iv) Implementation and Configuration.

Dynamic Virtual Representation

Geographically dispersed physical objects have to be tied to and continuously update a virtual representation of the object, i.e. (lots of) horticultural products and logistic resources. The virtual objects must ‘adequately’ represent the identity, place and (dynamic) properties of the (physical) objects of interest, they must be ‘reliable’ for different purposes of usage, they must be timely available and the security and privacy must be unquestionable. Furthermore, virtual objects may provide multiple views for different users, having distinct purposes of usage. In the horticultural sector, much progress has been made in the last years to virtualize transactions in particular for B2B trade. However, the virtualization of the logistics from grower to the market is in its infancy. Important future challenges include the virtual representation of dynamic product and quality parameters during transportation, uniform product coding and real-time projection of future states. A complicating factor behind these challenges is that the properties of horticultural products are highly dynamic because they are living products.

Connectivity

Information about relevant physical objects must be available, accessible and shared timely and secure with other organizations in order to enable adequate response within allotted timeframes. This in particular requires i) solid infrastructures to communicate information of objects while safeguarding property, access and usage rights and ii) standards for a seamless identification and exchange of product/logistics data. There is a good basis available for logistics connectivity in the Dutch horticulture. There is an active association for eBusiness (Florecom) that develops, maintains, applies and promotes connectivity standards in the sector. Furthermore there are central data hubs for logistics and several internet market places. An important remaining challenge is to find solutions that combine the advantages of local and centralised supply chain information systems (distributed software applications based on web services, without central data storage). These applications should support rapid, reliable, secure and flexible data communication.

Intelligence

The shared information needs to be appropriate for planning, coordination, orchestration and control of the logistics network. Therefore, information systems must support the intelligent analysis and reporting of exchanged data. These functionalities enable early warning in case of disruptions or unexpected deviations (e.g. in lead time, temperature, etc.) and advanced forecasting about consequences of detected changes by the time the product reaches destination. So far, the Dutch horticultural sector has focussed on technology and standardisation issues. The usage of dynamic virtualization data for intelligent decision support is an important future challenge. Using such application requires big changes of business processes and supply chain cooperation.

Implementation and Configuration

In temporal virtual networks, it must be possible to easily set-up, connect and disconnect information systems needed to achieve a specific value proposition. However, many difficulties emerge when implementing virtualization in horticulture. It is a major challenge to accelerate implementations by combining flexible customisation with efficient standardization approaches. Last but not least, besides the technical implementation challenges discussed above, organisational implementation is a major issue. Virtualization of logistic networks has a big impact on supply chain organisation and is expected to result in new business models such as specialised virtual orchestrators and local-for-global trade by SMEs without traders as offline intermediaries.

Conclusion

This paper has assessed the emergence of virtual logistic networks by means of the highly instructive example of the Dutch horticulture. It has presented the current situation concerning the enabling role of ICT and defined remaining future challenges. The paper shows that the Dutch horticultural sector is making major progress in the virtualization of transactions, including remote auctioning and on-line trade platforms. However, the virtualization of the logistics lags behind this development. Several persistent underlying issues are identified, including the quality of product information and images, harmonization of product coding, availability of well-integrated backend systems and organizational issues such as trust in data privacy and a proper division of benefits.

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