IPIC 2016
3rd International Physical Internet Conference
June 29-July 1, 2016 | Atlanta, GA USA

Evaluating five typologies on costs and requirements for hyperconnected logistics networks

Abstract: *Today, individuals are used being connected with the Internet everywhere at any time, collaborate with each other, share experiences, and use eCommerce facilities. They are said to be hyperconnected. Whereas individuals have a human-machine interface with a platform storing their data, organizations will have their own heterogeneous IT systems. These IT systems will have communication capabilities like Internet protocols, but they require additional functionality to share data. Data is shared with a syntax and is information via agreed semantics. Organizational behavior should be standardized linked to business processes creating value. This paper identifies five typologies for implementing hyperconnectivity and evaluates these typologies based on indicative figures of implementation costs and efforts for individual actors and policy makers.*

Keywords: *hyperconnected, logistics services, data policies, Internet of Things*

1 Introduction

Hyperconnected encompasses 'super-fast connectivity, always-on, on the move, roaming seamless from network to network, where we go – anywhere, anytime, with any device' (Biggs, Johnson, Lozanova, & Sundberg, 2012). A hyperconnected world not only comprises individuals with embedded sensors in their smart devices, but considers all types of devices (e.g. vessels, trucks, containers, and boxes), where these devices are enterprise resources used to deliver value. Different sensors and supporting communication technology is applied for different devices; Automatic Identification System (AIS) with Global Positioning System (GPS) is for instance applied for vessels and barges; trucks have on-board units and CANbus acting as sensors. These so-called actors are able to share (B2B – Business-to-Business; M2M – Machine-to-Machine communication; M2H – Machine-to-Human) and generate large amounts of data, with a challenge to extract meaning from this data. The introduction of LoRa technology (www.lora-alliance.org) extends battery life of sensors for bi-directional communication that can be applied for M2M of for instance intelligent cargo or – π-boxes (Montreuil, Meller, & Ballot, 2013).

Due to for instance liability and commercial sensitivity, actors are hesitant to share data with others (Eckartz, Hofman, & Veenstra, 2014). We have introduced the concept of a semantically rich infrastructure of federated platforms (Hofman, 2015) to create a virtual logistics data space for controlled data sharing amongst actors. By registering and connecting, each actor will be able to participate in this data space and collaborate with all other registered and connected actors. Registration considers both capabilities in terms of value or business/logistics services and data policies of an actor. Registration allows an actor to join a community and configure its community of smart devices. Since each actor will have its particular internal data structure, connection to the infrastructure considers the matching of heterogeneous data structures via a common model, similar to enterprise integration (Erl, 2005). This contribution evaluates different ways of implementing interoperability and proposes an approach reflecting logistics goals and - capabilities or – services of a resource. Whereas in the past electronic messaging based on bilateral or community agreements of open standards implicitly supported this approach, this contribution proposes to make such an approach explicit. The main advantage is to connect once after registration and participate, thus lowering Total Cost of Ownership (TCO) of interoperability and constructing a hyperconnected logistics network. The main research question of this paper is: what would be the optimal interoperability TCO for each individual stakeholder and for a total organizational network.

This paper analyzes 'hyperconnected' and introduces five typologies for its implementation. Each individual actor will adopt or be forced to adopt a typology for different reasons. This paper considers analyzes the size of an organizational network for adopting a particular typology based on implementation costs. In fact, it identifies the optimal network size to switch from one typology to another. By also considering requirements imposed by hyperconnectivity, a preferred typology is presented, whereas this is still in its early stages of development. The analysis is both useful to individual actors that consider adopting a typology and to policy makers that are required to make decisions on particular measures stimulating interoperability in supply and logistics nationally, European Union, and globally and reduce administrative burdens imposed on business.

First of all, hyperconnectivity is analyzed, secondly typologies are introduced, and thirdly, a decision model for selecting a typology by an actor and policy makers is provided based on indicative estimates of effort and costs. Finally, conclusions will be drawn and recommendations to proceed are given.

2 Implementing hyperconnectivity

This section analyses hyperconnectivity and its requirements for implementation. The next sections introduce implementation typologies from literature (section 3), enterprise integration, and value modelling (section 4).

2.1 Hyperconnectivity requirements

Hyperconnectivity is specified as 'super-fast connectivity, always-on, on the move, roaming seamless from network to network, where we go – anywhere, anytime, with any device'. On the one hand, it requires what one could call 'seamless interoperability' (Chituc, Azevedo, & Toscano, 2009), whereas on the other hand it can be expressed in terms of interoperability layers. Seamless interoperability is the capability of an organization to collaborate instantaneously with any other organization. It implies that no additional agreements are required to be able to share data electronically in a bilateral collaboration of two organizations on a transaction basis (Williamson, 1975). Most bilateral collaborations in supply and logistics are based on long term contracts, although supply chain innovations like agility and resilience require other transactional collaboration (Wieland & Wallenburg).

Agreements amongst business partners can be expressed according interoperability layers that combine a reference model for Open Systems Interconnection (Tanenbaum, 1996) with a layered model for interoperability (Wang, Tolk, & Wang, 2009), and includes technology paradigms (Erl, 2005). The layers are (Figure 1):

- Business processes interoperability (pragmatics): expressing the behaviour of an actor supported by an IT application. Pragmatics can be modelled for binary - or multi-actor collaboration (Schonberger, Wilms, & Wirtz, 2009). Whereas modelling binary collaborations, only behaviour of any two actors involved is modelled, multi-actor collaboration modelling constructs what one could call reference models for value chains (Heuvel & Papazoglou, 2010). Each value chain represents logistics – or supply chain based on a framework contract amongst stakeholders. Reference models for value chains are probably always implemented differently. United Nations Modelling Method (UMM) is an example of a method supporting development of both bilateral – and multilateral collaboration, although UMM is generally considered too complex (Huemer, Liegl, Motal, Schuster, & Zapletal, 2008).

- IT application interoperability. Many open standards for business-to-business (B2B) interoperability exist with semantics implicitly contained within a syntax. A separation into three layers may improve interoperability between IT applications:
    - Semantics: the meaning of the data. Semantics can be expressed in various ways, e.g. implicit as XML tag names, textual, unstructured documents comprising Implementation Agreements (IA) of Electronic Data Interchange (EDI), potentially generated by a tool, or by a structured syntax like Ontology Web Language (OWL). There are several examples of semantic models represented as Unified Modeling Language (UML) class diagrams (see for instance (World Customs Organization, 2010)) based on common data types like addresses, weights, and monetary amounts (United Nations Center for Trade Facilitation and Electronic Business, 2009).
    - Technology paradigm: the underlying architectural patterns to actually share data, e.g. messaging, Service Oriented Architecture (SOA) supported by for instance Application Programming Interfaces (APIs) or Event Driven Architecture (EDA), see (Erl, 2005), or data crawling and link evaluation technologies for Linked Data (Heath & Bizer, 2011). A choice between any of the paradigms is based on requirements stemming from pragmatics, e.g. a combination of EDA with APIs can be applied for processing real time data providing high volatility (Batini & Scannapieco, 2006).
    - Syntax: the structure of data exchanged between any two IT systems, e.g. eXtensible Markup Language (XML) or EDI. A barcode can be considered as a type of syntax, representing most often identifications (Kuerschner, Condea, Kasten, & F, 2008).
- Connectivity between computer systems (hardware). This type of interconnection is decomposed in two layers:
    - Communication protocols: the ability to actually exchange data between two computer systems over the Internet. Internet protocols, either with security features, can be applied, where any computer system connects via a link to a node of the Internet and total network with links between nodes provide particular quality of service.
    - Data link/physical network: the ability to connect a computer system to a node of the Internet, where the data link provides particular capacity for data sharing. The data link can have particular physical topologies, like a star or meshed network, using its own specific protocols like broadband or 3/4/5G.

An Internet Providers utilize one or more Physical Network Providers. Internet Providers offer capabilities for data sharing between two computer systems with a particular Quality of Service comprising capacity, speed, availability, and reliability, syntax. Supply – and logistics stakeholders require a global coverage of an Internet Provider with reasonable costs and preferably no additional roaming costs induced by a Physical Network Provider. On top of connectivity of an Internet Provider, additional functionality might be required like reliable and secure data transfer in case for instance reliability of an Internet Provider is insufficient and data accessibility outside business partners is not required (Hofman, 2015). The following paragraph presents choices for implementing interoperability for business processes and IT applications.

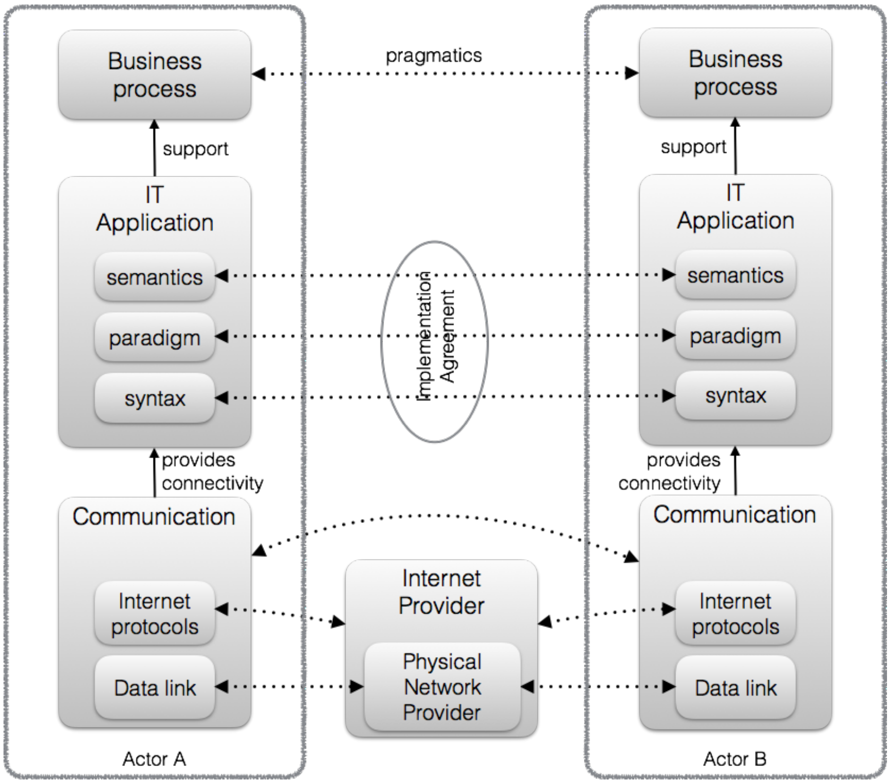

Figure 1: Interoperability layers

2.2 Implementing interoperability – current practice

Each of the identified layers requires choices to be made by organisations. This paragraph briefly introduces these choices and their implementation.

Choices for IT interoperability require an understanding of the requirements of business processes, thus further detailing 'pragmatics'. Whereas in the past, sharing business documents electronically has been and still is one of the main focuses, the Internet of Things (IoT; (Uckelmann, Harrison, & Michahelles, 2011)) at container level (Montreuil, Meller, & Ballot, 2013) enables visibility, resilience, and agility requiring transactional relations amongst stakeholders (Wieland & Wallenburg). In case of IoT, each device will have a particular process specifying its capabilities.

These different applications all relate to each other, e.g. visibility will provide awareness of location and movement of a container and related to a transport order the ability to detect late or expected arrival at its location. These latter requirements refer to improved decision-making by increased situational awareness (Endsley, 1995).

An Implementation Agreement (Figure 1) thus addresses the following aspects:

1. Business process interoperability. A particular application for electronic data sharing provides requirements for selecting a particular technical paradigm. One can distinguish between coupled and decoupled business processes: in coupled processes, a sender of data halts its process until a reaction is returned; in decoupled processes, sender and recipient run their processes independently and act on the latest available data they have shared. Visibility

can for instance be considered as a decoupled process: whenever an IoT device generates a status event, any visibility application can process the event at a later stage.

2. Data semantics. There are two options for representing data semantics, namely (1) development of a semantic model or (2) documenting in a syntax, e.g. have meaningful XML tags. Open standards based on EDI or XML for supply and logistics have implicit semantics, although there are semantic models for interoperability (World Customs Organization, 2010) and (Janssens & Delcourt, 2016), which are however restricted to the use of a particular tool and thus not open. Semantics will be made specific to any two collaborating actors, although other solutions are feasible (see further).
3. Technical paradigm and syntax. There are two choices to be made based on coupled - or decoupled business processes. The choices are:
    a. Technology paradigm: messaging, EDA combined with SOA, or Linked Data can support decoupled business processes. SOA best supports coupled business processes.
    b. Syntax: selection of a syntax depends on the selected technology paradigm: XML, EDI, or JSON can be used for messaging, SOA and EDA; RDF (Resource Description Framework) supported by SPARQL (Simple Protocol And RDF Query Language) can additionally be used to implement Linked Data.

From an implementation perspective, any IT application will have its internal database structure that has to be transformed into semantics and technology of an Implementation Agreement. The implementation of each IAs requires an integration function with data transformation functionality. Basically, all stakeholders have to implement such a function, i.e. a Peer-to-Peer (P2P) implementation, but a commercial – or community platform like a Port Community System can also provide the functionality as part of the infrastructure (Hofman, 2015).

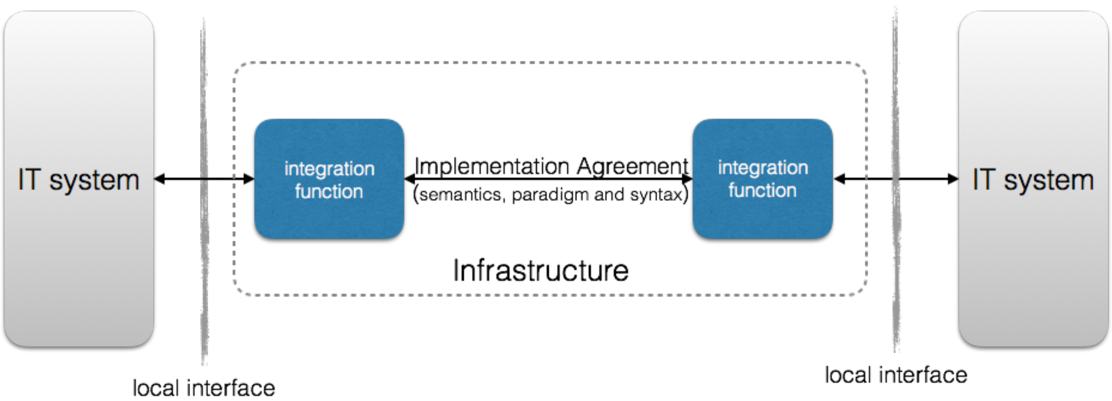

Figure 2: P2P implementation of data transformation

Based on the previous, a distinction between Implementation Agreements (IA) and configurations of an integration function is made. Any IA specifies pragmatics of one or more interfaces, i.e. one message is considered equal to one interface that needs its particular configuration.

3 Implementation typologies from literature

Actors adopt a particular typology for implementing interoperability. Literature (Choudry, 1997) identifies three typologies for implementing IAs and their configurations (Figure 3). Figure 3 shows the total number of IAs for a network of dominant players, with the number of configurations required by the network. The typologies are:

1. Bilateral Agreements: two actors develop bilateral IAs (IA_B) based on for instance open standards like EDI. This is called the 'Meshed Model' typology or electronic dyads (Choudry, 1997).

   An example. Say an IA covers for instance three interactions, e.g. a message like a product or service catalogue, a purchase order, and a despatch advice, and the network consists of 200 interacting actors. Each actor will have 199 IAs with a total of 995 configurations. In total, there will be 39.800 IAs and 119.400 configurations (Figure 3).

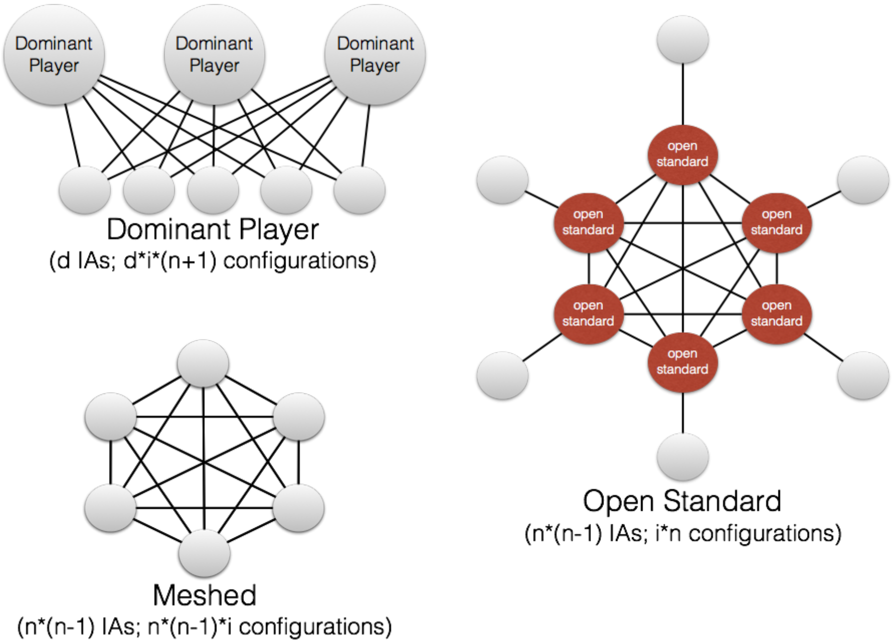

Figure 3: Three typologies for implementing interoperability (n: number of actors; i: number of interfaces; d: number of dominant stakeholders)

2. Dominant Player: particular (large) stakeholders have developed mandatory Implementation Agreements (IA_{DP}). Authorities, large retailers, or carriers are examples of organisations with their specific IA_{DP}'s, where these IA_{DP}'s might be based on open standards. An IA_{DP} covers all interfaces of a Dominant Player with its peers. We will call this the 'Dominant Player' typology or electronic monopoly (Choudry, 1997). The assumption is that in this typology the smaller actors do not share data electronically, which is not always the case, e.g. customs declarations are based on a network of chains with collaborating logistic stakeholders.

   In case the network consists of for instance 25 EU customs authorities with five interfaces per IA that might be based on the same semantic model, each trader has to implement 125 configurations (25*5). In case the total network consists of a fictive number of 5000 traders, the total number of configurations is 651.340.

3. Community Agreements: communities have developed Implementation Agreements (IA_{CO}). Communities are for instance all actors operating a particular transport modality, e.g. sea, rail, or air, or operating in a hub like a port or airport. These IA_{CO}'s are based on open standards or other IA_{CO}'s. We will call this the 'Open Standard' typology or multilateral Inter Organizational Information System (Choudry, 1997). This typology implies having

bilateral implementation agreements, with one configuration of the integration function for an interface of an IA. Take for instance the same number of actors as the example of meshed typology. The total number of IAs is identical (i.e. 199 per actor and 39.800 in total), but the number of configurations reduces to 3 per actor and 600 in total. The underlying assumption is that configuration of a bilateral IA defines a constraint to an open standard.

In the meshed – and open standard typology, hyperconnectivity is not achieved for all collaborating actors, in the sense that additional IAs are always required. In the Dominant Player typology, only the dominant player does not require additional IAs and thus will be hyperconnected to those others that implement these IAs. Dominant players can also join forces and adopt the Open Standard typology, which reduces the number of configurations for other actors. This approach can for instance be taken by EU customs authorities by adopting open standards for messaging and utilize a common semantic model (Janssens & Delcourt, 2016) for developing IAs.

This analysis of the different typologies leads to two interesting research questions, namely (1) is there a solution providing hyperconnectivity to all actors and (2) when would it be profitable to adopt or switch to another typology. The first question will be answered section 4.1; the second will be addressed in section **Error! Reference source not found.**.

4 Typologies for hyperconnectivity

The previous sections have shown that hyperconnectivity with existing typologies is not feasible. This section introduces two alternative typologies, namely the Integration Service Provider typology and the Value Modelling typology. Figure 4 shows the two alternative typologies that will be explained hereafter.

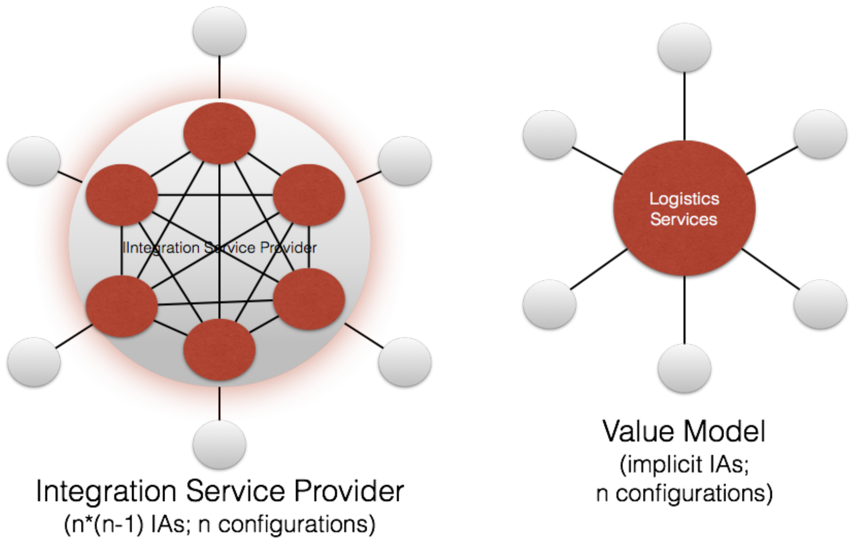

Figure 4: Common Information Model and Value Model typology

4.1 Integration Service Provider typology

The Integration Service Provider (ISP) typology is a technical solution stemming from Enterprise integration (Erl, 2005) by implementing an Enterprise Service Bus (ESB) for interoperability amongst different actors. It requires a central organization managing the ESB and its configurations. An ESB basically supports a meshed typology, since there will not be open standards nor a dominant IT application. To reduce the number of configuration, a Common Information Model (CIM) for sharing data amongst all internal IT applications can be developed. The database scheme of each IT application can be made to this CIM for that data that can be shared with other IT applications, thus giving 1 configuration for each IT application. Still, Implementation Agreements between different IT applications will have to be developed to meet data requirements of these IT applications.

The ISP typology can be applied to interoperability amongst different actors, leading to n*(n-1) IAs and n configurations (Figure 4). Take the figures of the meshed typology, the total number of IAs is identical (i.e. 199 per actor and 39.800 in total), but the number of configurations reduces to 1 per actor and 200 in total. Like in the Open Standard typology, the implementation of each IA and its interfaces re-uses the configurations.

The ISP typology requires development, maintenance, and implementation support of a semantic model, which can be costly (see further). From a business perspective, the ISP typology can have two governance structures, namely it can be a community system owned by its users or a commercial system. Actors can decide to develop a community system, e.g. a Port Community System. Such a community system requires a business model for covering all TCO that is either financed by major stakeholders and/or based on usage. Both a community – and a commercial system might develop a CIM to reduce their TCO and thus increase their competitiveness. In this respect, various additional research questions from a governance perspective can be formulated like would it be feasible to separate governance of a CIM from its implementation by either a commercial - or a community system, and would a commercial system be cheaper for its users? These questions require additional analysis that is outside scope of this paper.

4.2 Value Model typology

Thus, the ISP typology already reduces the number of configurations, it still requires IAs and thus does not fully meet requirements of hyperconnectivity in the sense of seamless interoperability. Where all previous typologies do not address business process interoperability (section 2.1) explicitly, this section introduces the concept of '<u>value</u>'. The Value Model typology assumes that each actor provides value to or requires capabilities of other actors in a network. Formally, a distinction between goals of a service consumer and capabilities of a service provider can be distinguished (Fensel, Kerrigan, & Zaremba, 2008). From a business perspective, a value modelling or value analysis is taken, see for instance (Spohrer, May 2009), (Gordijn & Akkermans, 2003), or (Hofman, 2013). The underlying assumption is that each type of business - or logistics service implicitly specifies information requirements, e.g. in case of transport always two locations, the goods, and times need to be given. Thus, there is one IA for each logistic service type and each actor can express its capabilities or goals in terms of that logistic service type. A distinction is thus made between 'logistic service' as the generic concept with particular properties, and its instances of actors. Transport, transhipment, and storage are for instance logistics services with properties. Properties of for instance 'transport service' are:

- <u>Duration and (geo-)location</u>: transport between areas or cities will take a time. To provide a transport service, the place of acceptance and time of availability of cargo, and the place of delivery and the expected time of delivery have to be given. Places can be stations for rail, inland terminals for barges, or ports for vessels. A reference to a particular TEN-T corridor can be made.
- <u>Cargo</u>: the type of cargo that can be handled, e.g. (dry) bulk, parcels, or containers. Additional characteristics of the cargo are required, like weights, dimensions, and an indication of reefer and/or dangerous cargo. Cargo details, including for instance identifications, have to be known to select a proper service. Handling instructions require an indication of the content of the cargo.

- Additional services: these include particular services like attaching a reefer unit and configuring the proper temperature, producing required documentation, particular handling capabilities, etc. Additional services can be selected; a list will have to be provided. A provider can offer additional services upon (implicit) request of a service consumer.

Modality and priorities might be additional properties of 'transport service' that can be selected. Additionally, rates and tariffs at different levels might be given, also considering the additional services. An additional aspect is the negotiation between a customer and service provider on times, prices, and other conditions according an interaction choreography between consumer and provider (Hofman W. , 2012). For instance, a booking request has to provide sufficient data for producing an offer, e.g. totals of the cargo to be transported in terms of weights, dimensions and number of units with an indication of dangerous and/or reefer, locations, and an indication of times need to be given. Details have to be given in an order, e.g. the container numbers and their weights. However, these details may also be mentioned in a booking request.

In the Value Model typology, each participating actor selects its 'logistics services' and publishes its instances of these services in its role as service provider. Each logistic service has its IA and interaction choreography, where a business process will support the interaction choreography. Each logistic service will lead to a configuration for the integration function.

In case of service consumer, selection of a logistic service provides an IA for that service, where a service consumer can only provide relevant or known data. For instance, in case a service consumer always has Full Container Load (FCL), without requiring temperature control or being dangerous, that service consumer can never provide data for these properties.

The main advantage is that each stakeholder can publish its IA_{BS} and configure its integration function, independent of all others. Semantics between all IA_{BS} needs to be common, which requires the existence of a semantic model. The Value Model typology is yet in an early stage of development and far from mature.

5 Network size for adopting or switching a typology

The previous sections have five implementation typologies for hyperconnectivity. The Value Model typology best fits all requirements for hyperconnectivity, but still has various research questions that are yet to be answered. This section will address the research questions posed in the introduction, namely the adoption of a particular typology by an individual actor and for the total network based on TCO approach. As stated in the introduction, the latter part of the research question is relevant to policy makers. The first part of the question is answered by identifying the intersection point of different typologies. The second part needs to consider the individual cost components. To answer this question, firstly cost components are identified and secondly these questions are answered.

5.1 Costs components and cost calculation model for interoperability

For all typologies, the following costs are considered identical and are thus not used for calculating the intersection points of each typology:

- Labour costs (€750/day). Annual maintenance costs are not considered, since these are similar for each typology.
- Initial investment costs (IC) for interoperability per individual actor that include development of human skills, organisation, and hard- and software costs are estimated 500 kEuro.

Table 1 lists the specific cost components expressed in person days for each of the topologies. These figures are relative to each other, for instance it is expected that configuration of and IT application with open standards, a CIM, or for a particular logistics service requires twice the effort than those of a meshed model. Development of a CIM is considered some three person years, which is only indicative. It might be less or more, depending on the scope of the CIM. The TCO of a a commercial - or community system depends on the size (number of employees) and the functionality of the ESB applied. Consider an organisation of 25 employees (some 2 million Euros) and hosting, etc. of 3 million Euros will give an estimate of a TCO of 5 million Euro. Depending on its business model, a commercial system most probably has higher TCO.

This paper considers operating facilities to support the Value Model typology similar to the ISP typology requiring a community system, although these are probably far less. Some registries and advanced open standards are required to support the Value Model typology, e.g. the choreography and search, find, and match logistics service.

Table 1: Effort specific to each typology (expressed in person days with the exception of Community System)

Cost component	Meshed	Dominant player	Open Standards	ISP	Value Model
IA Development	20	200	20	20	-
Configuration	10	10/100	20	20	-
CIM development	-	-	-	700	700
Community System	-	-	-	5 mio Euro	-
Service registr.	-	-	-	-	10
Service connection	-	-	-	-	20
Facilities	-	-	-	-	5 mio Euro

A reduction of effort can be made by semi-automatic generation of configuration files by means of an ontology that serves as a CIM (Euzenat & Shvaiko, 2010), which is in fact similar to the Open Standards typology for re-using configurations.

Based on experience of the authors, the estimates of effort are the minimal ones that can be achieved in a well-organized, knowledgeable environment. Efforts are probably higher whilst initial investments are either already made partially based on internal application integration and can be re-used for organizational interoperability.

5.2 Adopting or switching typologies

Each actor can make individual decisions for adopting a typology, but they can also join forces to adopt another typology like an ISP typology instead of an Open Standards typology. Firstly, the decisions for an individual actor will be considered, secondly those of a community, and thirdly the policy perspective will be taken.

The basic assumption is that an actor starts innovation (Tan, Hofman, Gordijn, & Hulstijn, 2011) resulting in a Meshed typology. An actor has two choices: either become a Dominant Player or adopt the Open Standards typology. The latter assumes Open Standards are available. Even if an actor has adopted the Open Standards typology, it can still select the Dominant Player model, either with or without internal ISP typology. The choice is based on the number of business partners ‘t’

(Figure 5). The figure, based on the equations given below and estimates given in table 1, show that whenever there is an open standard, it is always useful to adopt one instead of developing ones own.

Mostly, large actors will take an adopt ISP typology internally and provide an IA to their stakeholders. In this particular equation, costs will need to be compared instead of effort and the TCO for an internal 'community system' needs to be considered. The calculation shows that adoption of open standards and a large number of business partners make it attractive to implement such an internal solution.

Transition to a Value Model typology will not be feasible in case an actor has already chosen the Dominant Player typology. In both cases, costs and effort are independent of the number of business partners.

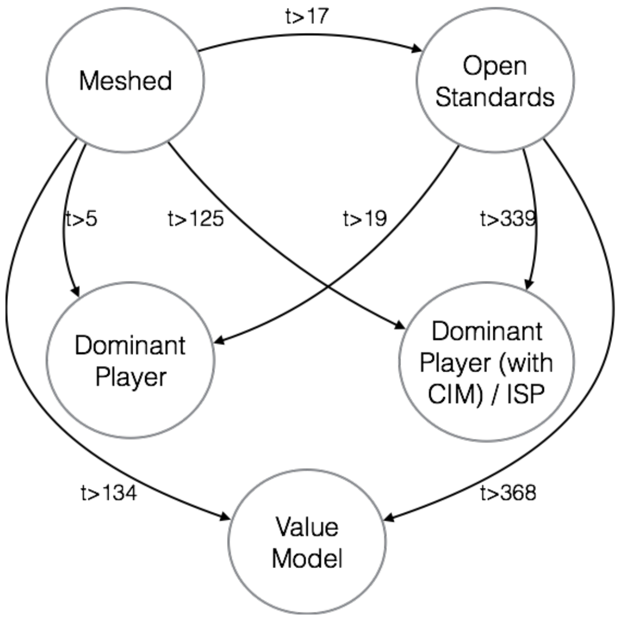

Figure 5: Transitions from meshed to other typologies based on the number of business partners (t)

The equations are based on estimates of efforts given in table 1 (adoption of the Open Standards – and the Value Model typology encompasses initial costs of 500 kEuro):

- Meshed to Dominant Player: t*20+t*4*10 = 300 → t>5;
- Meshed to Open Standards: (t*20+t*4*10)*750 = (t*20+20)*750 + 500.000 → t >17;
- Open Standards to Dominant Player: (t*20+20)*750 + 500.000 =300 *750 → t>19;
- Meshed to Dominant Player (with CIM) or ISP: (t*20+t*4*10)*750 = (700 + 100)*750 +5 (mio Euro) → t>125;
- Open standards to Dominant Player (with CIM) or ISP: (t*20+20)*750 + 500.000 = (700 + 100)*750 +5 (mio Euro) → t>339;
- Meshed to Value Model: (t*20+t*4*10)*750 = (700 + 10 + 20)*750 + 500.000 + 5 mio Euro→ t>134
- Open Standards to Value Model: (t*20+20)*750 + 500.000 = (700 + 10 + 20)*750 +500.000 + 5 mio Euro → t>368

Secondly, actors might decide to develop to jointly adopt a ISP typology with an underlying community system. The equation is identical to the ones in the transition of a Meshed – or Open Standards typology to a Dominant Player typology developing a CIM (Figure 5). Open environments like ports with many stakeholders are examples to adopt the ISP typology by implementing a community system.

The final question, relevant to policy makers, is where the intersections are for selecting a particular typology. The Dominant Player typology will probably not be considered by a policy maker, since it provides no equal playing field for all stakeholders. Migration of the ISP typology to the Value Model typology requires development of facilities replacing a community – or commercial system, whereas such a system might probably already partly have these facilities (Hofman, 2015).

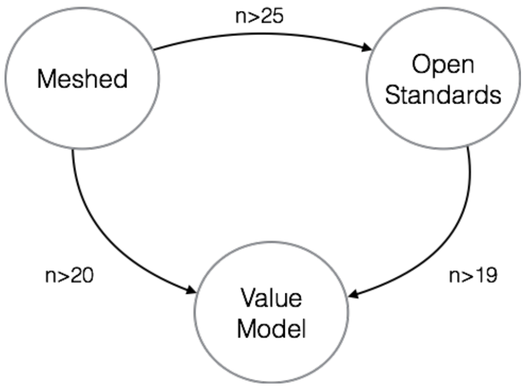

Figure 6: Transitions from meshed to other typologies based on the size of an organizational network (n)

The equations are already provided in the previous sections presenting the typologies (initial investment for both the Open Standard – and the Value Model typology is considered for each actor):

- From Meshed to Value Model: n*(n-1)*(20 + 3*10)*750 = n*30*750 + (700 + 10 + 20)*750 + n*500.000 + 5 mio Euro n>20
- From Meshed to Open Standards: n*(n-1)*(20 + 3*10)*750 = (n*(n-1)*20+n*3*20)*750 + n*500.000 → n>25
- From Open Standards to Value Model: (n*(n-1)*20+n*3*20)*750 + n*500.000 = n*30*750 + (700 + 10 + 20)*750 + n*500.000 + 5 mio Euro → n>19

6 Discussion, conclusions, and recommendations

This paper has identified five interoperability typologies, namely the Meshed -, the Dominant Player -, the Open Standards -, the ISP- , and the Value Model typology. These typologies all consider constructing Implementation Agreements and configuration of integration functionality.

Figure 5 illustrates that it might be cheaper for an actor to adopt the Value Model typology instead of adopting the Dominant Player typology with an internal ISP typology. The same figure shows that a Value Model typology can be preferable to a ISP typology with a community system, where the Value Model typology still requires implementation support. Unless an actor has a large network of for instance more than different 340 suppliers, it is always preferable to that actor to adopt a Dominant Player typology. In that case, transaction costs in transactional relations are less than those of framework contracts (Williamson, 1975).

Of course, there are barriers that prevent or instruments that stimulate adoption of the Dominant Player typology (Choudry, 1997). In case an actor has insufficient 'buying power' and is a provider, it will be difficult to impose IAs to its consumers. In case these consumers are individuals, a service provider might be able to adopt this typology. Laws are instruments that stimulate the adoption of the Dominant Player typology by authorities (and of course the large number of business partners).

Policy makers are recommended to develop policies for implementing the Value Model typology over any other typology (Figure 6). Whenever the number of actors remains less than 20, no (inter)national policy is required. Whilst from a cost perspective, the Value Model typology is the preferred solution; it is yet in its early stages of development and far from mature (see before).

All figures in this paper are indicative. Estimates of efforts are based on experience and can be further refined by research to interoperability implementation costs. However, since supply and logistics consists of many millions actors (e.g. the Netherlands has over 12.000 trucking companies), and this number will increase with introduction of the Physical Internet, it is safe to assume the Value Model typology will be the best cheapest solution to construct the Physical Internet. Since the Value Model typology also provides optimal support for hyperconnectivity, it is the recommended way forward. It is recommended to develop a Proof of Concept or demonstrator for the feasibility of the Value Model typology with a focus on registration of logistics services, connection to a (federated) infrastructure, and search, find, and match logistics services meeting required capabilities.

Further research is also required for migrating existing typologies to the preferred one. As stated in section 5.2, a dominant player will probable not migrate to a Value Model typology since it will not decrease costs. In case a community like EU Member State authorities operates as a dominant player, they will probably only migrate if their costs of adoption of the Value Model typology is less than the benefits that can be gained by business interfacing with those authorities. The indicative figures in this paper illustrate due to the large number of business stakeholders with Business-to-Government (B2G) data sharing, the total costs of the Value Model typology will be less than that of authorities acting as dominant players. Adoption of the Value Model typology will decrease the administrative costs for business, which is a political issue.

References

Batini, C., & Scannapieco, M. (2006). *Data quality: concepts, methodologies, and techniques.* Heidelberg: Springer-Verlag.

Biggs, P., Johnson, T., Lozanova, Y., & Sundberg, N. (2012). Emerging Issues for a Hyperconnected World. *The global information technology report* , pp. 47-56.

Chituc, C.-M., Azevedo, A., & Toscano, C. (2009). A framework proposal for seamless interoperability in a collaborative networked environment. *Computers in industry , 60*, 317-338.

Choudry, V. (1997). Strategic Choices in the Development of Interorganizational Information Systems. *Information Systems Research , 8* (1).

Eckartz, S., Hofman, W., & Veenstra, A. F. (2014). A decision model for data sharing. *eGov2014.* Dublin, Ireland: Springer.

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors: the journal of the human factors and ergonomics society , 37* (1), 32-64.

Erl, T. (2005). *Service Oriented Architecture - concepts, technology and design.* Prentice-Hall.

Euzenat, J., & Shvaiko, P. (2010). *Ontology Matching.* Springer.

Fensel, D., Kerrigan, M., & Zaremba, M. (. (2008). *Implementing Web Services - The SESA Framework.* Springer-Verlag.

Gordijn, J., & Akkermans, H. (2003). Value based requirements engineering: exploring innovative e-commerce ideas. *Requirements Engineering Journal, 8(2)* , 114-134.

Heath, T., & Bizer, C. (2011). *Linked Data - evolving the Web into a Global Data Space, Synthesis lectures on the Semantic Web: Theory and Technology.* Morgan & Claypool Publishers.

Heuvel, W.-J. v., & Papazoglou, M. P. (2010). Towards Business Transaction Management in Smart Networks. *IEEE Computing Society* .

Hofman, W. (2015). Federated platforms for seamless interoperability in the Physical Internet. *Second International Physical Internet Conference.* Paris.
Hofman, W. (2012). Runtime logistic process orchestration based on business transaction choreography. *Business Process Management - Process Aware Logistic Systems workshop.* Talinn.
Hofman, W. (2013). Service-oriented enterprise interoperabilty in logistics. *IWEI.* Enschede.
Huemer, C., Liegl, P., Motal, T., Schuster, R., & Zapletal, M. (2008). The development process of the UN/Cefact Modeling Methodology. *10th Int. Conf. on Electronic Commerce (IEC).* Innsbruck, Austria: ACM.
Janssens, F., & Delcourt, J.-L. (2016). EU launches new Customs Data model based on WCO standards. *Panorama* , pp. 60-62.
Kuerschner, C., Condea, C., Kasten, O., & F, T. (2008). Discovery Service Design in EPC global Network: towards full supply chain visibility. *International Conference, IOT2008.*
Montreuil, B., Meller, R. D., & Ballot, E. (2013). Physical Internet Foundations. In T. Borangiu, A. Thomas, & D. Trentesaus, *Service Orientation in Holonic and Multi Agent Manufacturing Robots* (pp. 151-166). Heidelberg: Springer-Verlag.
Schonberger, A., Wilms, C., & Wirtz, G. (2009). *A requirements analysis of Business-to-Business integration.* Bamberg: Fakultat Wirschaftsinformatik und angewandte Informatik Otto-Friedrich-Universitat.
Spohrer, J. K. (May 2009). Service Science, Management, Engineering, and Design (SSMED) - An emerging discipline - Outline and References. *International Journal on Information Systems in the Service Sector* .
Tan, Y.-H., Hofman, W., Gordijn, J., & Hulstijn, J. (2011). A framework for the design of service systems. In J. Spohrer, *Implementing Service Science.* Springer-Verlag.
Tanenbaum, A. S. (1996). *Computer Networks (Third Edition).* Prentice Hall.
Uckelmann, D., Harrison, M., & Michahelles, F. (. (2011). *Architecting the Internet of Things.* Heidelberg: Springer.
United Nations Center for Trade Facilitation and Electronic Business. (2009). *UN/Cefact Core Components Data Type Catalogue version 3.0.* Geneva: UN/Cefact.
Wang, W., Tolk, A., & Wang, W. (2009). The levels of conceptual interoperability model: applying systems engineering principles to M&S. *Spring Simulation Multiconference.* Society for Computer Simulation International.
Wieland, A., & Wallenburg, C. M. (n.d.). The influence of relational competencies on supply chain resilience: A relational view. *International Journal of Physical Distribution & Logistics Management* , 300-320.
Williamson, O. (1975). *Markets and Hierarchies: analysis and antitrust implications.* New York: Free Press.
World Customs Organization. (2010). *WCO Data model - cross border transactions on the fast track.* World Customs Organization.