Data sharing in supply and logistics networks – development and implementation of extendable, standardized platform services for the Physical Internet in an open dynamic ecosystem of organizations

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Abstract: *data sharing is the core of the Physical Internet. Data availability is expected to improve decision making, thus reducing costs and improving sustainability by better capacity utilization. Willingness of stakeholders to actual share data is not addressed by this paper; this paper focusses on capabilities of stakeholders to actually share the data. These capabilities are decomposed into technology, data sharing models agreed bilaterally by two stakeholders or in supply and logistics chains, and standard interaction patterns with supporting semantics. This paper present three basic innovations, namely a decoupling of supply and logistics use cases by constructing standardized platform services, introducing business services for identifying data requirements, and extendibility based on distributed development by re-use and extension of common models.*

Keywords: *data sharing, ecosystem, blockchain, International Data Space, platforms, business services, choreography, hyperconnected*

1 Introduction

One of the features of the Physical Internet is hyperconnectivity of organizations and physical assets to improve decision making (Endsley, 1995), thus contributing to the societal challenge of zero-emission. Literature shows that the COx footprint of synchromodal planning can be upto 60% less than only using road transport, where synchromodality is on synchronization of transport legs with dynamic planning (Behdani, Fan, Wiegmans, & Zuidwijk, 2014). Several experiments with autonomous transport means like trucks, trains, and barges, take place, including truck platooning to reduce fuel consumption and contribute to sustainability. These logistics devices have computational capabilities and become more and more programmable.

Data sharing and interoperability are a prerequisite for decision support by individual actors that are hyperconnected. These actors, organizations and autonomous assets, currently require to make agreements on data sharing to reach process interoperability (layer 4 in the interoperability model of (Wang, Tolk, & Wang, 2009)). Coming to these agreements and implementing them takes time, which prevents implementation of innovative supply chain concepts like visibility, synchromodality, dynamic planning, agility, and resilience (Wieland & Wallenburg). It also prevents large scale adoption of innovations developed in closed ecosystems.

From a technology perspective, different solutions interoperate with their specific technical protocols, providing services to share data between different entities. On the one hand, these solutions function independent of their application, they can be extended by a functional entity providing functional services to users. On the other hand, these solutions provide particular functional services on top of their technology services, for instance functional services to their users in a port community. Functional – and technical services of different solutions are not always interoperable. Different choices have been made, for instance regarding data syntax, data standards, and technical protocols. These lead to closed solutions, that are not scalable.

The functional services, which are called platform services (figure 1), require standardization. Figure 1 shows the relation between the various elements of a data sharing infrastructure for supply and logistics, expressed in terms of services, protocols, interfaces, and entities supporting the protocols whilst providing services (Tanenbaum, 1996). Standards can be made generic, but their implementation to a user will be specific, since that user will not utilize the full functionality. A user will require that functionality of a standard, that supports its business services. These business services formulate data requirements, that can be mapped to standardized platform services using ontology alignment (Euzenat & Shvaiko, 2010). Guidelines and tooling are required to support users to integrate with platform services.

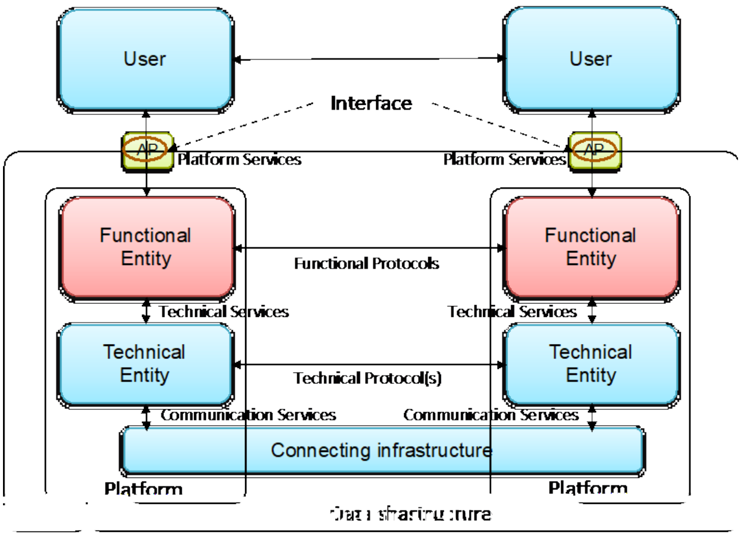

Figure 1: services, protocols, and interfaces of a data sharing infrastructure

Supply and logistics is complex in the sense that different modalities, different product types, and various trade and compliance regulations are applicable. Thus, we don't consider it feasible to construct one semantic model covering all data that can be shared amongst all stakeholders. At meta level, a modeling technique has to be applied that allows re-use of semantics. In the same way, the interaction sequencing needs to be specified. Thus, a choice for modeling techniques that caters for distributed development and implementation needs to be made.

This paper discusses four interoperability aspects for developing and implementing platform services, supporting business services: technical interoperability solutions, interoperability modeling techniques, conceptual interoperability, and guidelines. Achieving conceptual interoperability results in open data sharing solutions for supply and logistics, which is required to construct the Physical Internet and realize hyperconnectivity.

2 Technical interoperability solutions

This section briefly introduces some technical protocols, potential implementations of these protocols for data sharing, and a discussion with respect to these implementations to create an open data sharing infrastructure for supply and logistics.

There are a lot of technology and protocols available for data sharing between organizations, implemented with various business – and governance models. The most commonly known technology is that of Enterprise Service Bus, ESB (Erl, 2005) requiring a central solution with a governance model. Alternative solutions have been developed based on peer-to-peer technical protocols like ebMS (electronic business Messaging Services (Wenzel, 2007)). The latter supports an asynchronous reliable and secure peer-to-peer exchange of data that can be based on Collaboration Protocol Profiles and Agreements (Kotok & Webber, 2002). Yet other technical protocols are based on asynchronous queuing mechanisms like AMQP (Advanced Message Queuing Protocol), MQTT (Banks, Briggs, Borgendale, & Gupta, 2019), or Industrial Data Space Communication Protocol (IDSCP). Where queueing protocols are connectionless, IDSCP is a connection-oriented protocol. Most recently BlockChain – (BCT) or Distributed Ledger Technology (DLT) is introduced to construct immutable, distributed databases for data sharing in supply and logistics (Badzar, 2016), interconnected via the Tendermint protocol (see for instance (BigchainDB GmbH, 2018).

These different technological components can be combined to operate an infrastructure for data sharing. The current types are available:

- Peer-to-Peer network – the architecture of International Data Spaces (IDS) supports such a network based on connectors integrating with IDSCP. A broker provides a type of registry and a clearing house can be used for logging and audit purposes (Otto, et al., 2016). A connector has a local interface to for instance a sensor based on MQTT. There can be many brokers and clearing houses; a user, having a connector, should register with a particular broker and is able to share data. When registering with a broker, data sharing policies can be registered.
  Of course, peer-to-peer networks can be implemented by other technical protocols like ebMS or other protocols. A (distributed) registry will required for finding and sharing data with users.
- (Commercial) platforms – these platforms support the many-to-many data sharing, most often based on ESB technology. Each platform requires a particular configuration, so the configuration tools need to be integrated with each platform. The main advantage of these platforms is decoupling of technical protocols of their users; they provide all types of protocol conversions.
  Some of these platforms focus on specific communities, like enabling data sharing between all relevant stakeholders in a port community, support specific functionality like supply chain visibility, or support all types of data transformations. Each of these solutions has its particular governance – and business model, like community based with the relevant community stakeholders governing the solution or commercial.
- Distributed Ledger (Franklin & Hofman, 2018) – the data shared between any two stakeholders is stored in an immutable, distributed database. There are open standards to create a distributed database, e.g. Tendermint. Interoperability between distributed ledgers seems yet difficult, since in not only addresses technical – and functional interoperability, but also for instance the notary scheme used by the different ledgers

(Koensa & Polla, 2018). Complexity of interoperability increases by implementation of so-called smart contracts, self-executing software code that automatically performs operations on the data, and combining data structures and process logic. Separation of data and process logic can be achieved by for instance storing data validation rules as SHACL (Shape Constraint Language, (World Wide Web Consortium, 2017)) on a ledger, where these SHACL files relate to a common ontology. Additionally, the same technology can also be used for transaction confidentiality, addressing the issue of economic and private sensitivity of data.
Basically, a distributed ledger thus is able to share and store all type of data. One can distinguish three types of functionality for distributed ledgers: record integrity by immutable storage of a hash on the ledger, records by storing all relevant shared data on a ledger, or proof of ownership by storing tokens on the ledger (Lemieux, 2017). Tokens can serve as access control rights thus functioning as Linked Data (Heath & Bizer, 2011). These tokens can be combined with record integrity.

Each of these technical infrastructures has pros and cons, which will not be discussed in this paper. One could argue that a peer-to-peer network architecture like IDS can support all functional protocols, but it will require some type of centralized functionality. The centralized functionality, a broker and clearing house, can have many instances, where one instance acts on behalf of a community or a provider of the infrastructure. Although a broker and clearing house seem to operate at technical entity level (figure 1), they will only operate by storing data shared by the technical services of the technical level. Thus, a broker and clearing house combine functionality of technical - and functional entities. DLT seems promising, but current technology and their implementation still lead to closed solutions due to complexity of interoperability (Koensa & Polla, 2018).

Most probably, these solutions will all exist in parallel, constructing a distributed network or system-of-system (The Digital Transport and Logistics Forum (DTLF), 2017). These solutions should be interoperable at two levels, namely technical and functional, where functional interoperability considers the functional protocols (figure 1). Technically, they need to agree on protocols like IDSCP, ebMS, or other protocols like Tendermint used by BigChainDB. Functional interoperability can be split into vertical – horizontal interoperability:

- Vertical interoperability – two platforms or solutions providing similar services should be able to share data.
- Horizontal interoperability – two platforms or solutions providing complementary services should be able to share data.

Functional interoperability is not only required for the platform services, but also at registration level. Users of different solutions should be able to find each other and share data. At this moment, these peer-to-peer - like IDS and immutable distributed database infrastructures are data agnostic, implying they can be used to store or share any type of data. Community platforms are constructed to share specific data sets, e.g. load lists and manifests in a port, each with their specific registration functionality. To achieve functional interoperability, the platforms services need to be specified, which will be presented in the next sections.

3 Interoperability modelling

There are different ways to model interoperability between organizations, i.e. platform services providing business protocols (figure 1). For instance, authorities derive data sets and interaction sequencing from legal text, resulting in models like those of the World Customs Organization (WCO) data model (World Customs Organization, 2010). These interaction models support for instance global customs declarations, where each customs authority can construct its specific implementation guides (Hofman, 2018). These guides are available as unstructured (text) documents, XML Schema Definitions (XSDs), or in a proprietary data structure. Interaction models can be documented as sequence diagrams (Object Management Group (OMG), 2015).

Modeling supply and logistics chains is more complex. It requires specification of all stakeholders involved, their roles in the chain, the relation between these roles, and the data shared amongst, resulting in implementation guides of standards. Sequence – and activity diagrams can be applied as modeling techniques can be used to model the processes. For practical reasons, most probably data of business documents shared amongst stakeholders will be modelled as a basis for the implementation guides. These implementation guides will be documented as in the previous example.

There are three issues in the aforementioned approach that will increase interoperability costs. First of all, supply and logistics chains will change over time, stakeholders need to implement innovative logistics concepts like supply chain visibility, agility, resilience and synchromodal planning (Wieland & Wallenburg). These changes will affect the sequence – and activity diagrams that have been developed, they will have to be revised. The second issue is sharing semantics of implementation guides by XSDs or unstructured documents. XSDs have implicit semantics, based on element names. Semantics of these elements will be given in documents, which may lead to interpretation issues and thus implementation errors perceived as low data quality. For instance, data of a participating stakeholder is mapped to a wrong XSD element, which leads to processing errors at the recipient of that data. The final issue is that of data mapping of internal databases to the implementation guides. The complexity of this issue is inherent to the number of implementation guides to be supported, where these guides are part of data sharing agreements. Each implementation guide needs to be mapped to an internal data structure. Since one stakeholder may have many implementation guides with the same functionality (Hofman, 2018), for instance implementation guides of orders with their customers, such a stakeholder can develop one internal file for each interaction type (like one for ‘orders’). Transformations can be developed by mapping internal files to implementation guides, resulting in XSLT files (XML Style Language Transformation). This may still lead to many transformations.

To overcome these issues, many stakeholders develop data sharing agreements in the context of framework contracts or legislation (Williamson, 1975). The following techniques are proposed to develop an open infrastructure; they will be applied to supply and logistics in the next section:

- <u>Interaction choreography of two stakeholders</u> – the interaction sequencing of any two stakeholders is modelled as choreography (Object Management Group, 2011). Internal processing rules based on outsourcing strategies of individual stakeholders participating in supply and logistics chains is outside scope. This provides an optimal way to construct models of supply and logistics chains by means of so-called transaction trees (Dietz, 2006). It also supports basic functionality like stuffing shipments of different shippers into one so-called Less then Container Load (LCL) container.

- Data semantics represented as ontologies - there are different solutions to modeling data semantics, e.g. One object models or entity diagrams. These models can however not always be shared amongst different tools. Data semantics can be represented as ontologies with the Ontology Web Language (OWL). OWL is an open standard that can be shared amongst different tools and can be re-used to construct ones own models. SHACL can be applied to formulate data requirements of individual interaction types based on these ontologies, thus supporting data validation and contributing to data quality. Data itself can be shared using any syntax, e.g. XML, JSON-LD, and RDF (Resource Description Framework), applying messaging, Application Programming Interfaces (APIs), or Linked Data (Heath & Bizer, 2011). The use of these technologies will require functionality of platforms and solutions.
  Semantic models can be applied in various context, e.g. modeling bilateral -, community – and supply and logistics chain data sharing. Semantic models can also be used as a canonical data model (Hohpe & Woolf, 2004) for integration in organizational networks like those of supply and logistics.
- Ontology alignment for data transformations – database structures of individual stakeholders are aligned with a semantic model for data sharing (Euzenat & Shvaiko, 2010). It requires these database structures to be expressed as ontology and applying ontology alignment algorithms (Shvaiko, Euzenat, Jiménez-Ruis, Cheatham, & Hassanzadeh, 2018). Most of these algorithms detect synonyms in different ontologies; more complex transformations like combining instances of two concepts into one instance of another concept or implementing calculation rules is still too complex for these algorithms. These algorithms require human supervision to validate the proposed alignments. The alignments can be represented in a specific language, called EDOAL, Expressive and Declarative Alignment Language (David, Euzenat, Scharffe, & Trojahn dos Santos, 2011), but this is not supported by platforms. Thus, transformation of alignments to XSLT may have to be developed.
  Ontology alignment can also be applied to support existing (implementation guides of) standards. XSDs should be represented as ontologies that can be aligned with other ontologies resulting in data transformations. Experiments with these types of algorithms for supply and logistics are reported in the IPIC2019 conference.

A semantic model can be applied as canonical data model of a data sharing infrastructure constituting various platforms and solutions (see before). Using OWL to represent a semantic model, allows for extendibility and distributed development of semantic models. Ontology alignment will enable individual organizations to plug their IT back office systems (semi-automatically) in such an infrastructure. To be able to support this functionality, a conceptual model needs to be specified specifying semantics of data shared in supply and logistics networks supported by various technical data sharing paradigms like messaging, APIs, Linked Data.

4 Supply and logistics business services supported by platform services

Like stated, platforms and interoperability modeling technologies still require functional protocols, for instance data sharing semantics and platform services have to be known. Also, data sharing agreements have not yet been addressed, they still would be required. This section introduces a conceptual model for interoperability in supply and logistics.

From an IT perspective, supply and logistics is simple. It is all about moving particular physical objects like containers or pallets with some means of transport, e.g. trucks, vessels, trains, and barges, from one location to another according timing requirements. Complexity is in construction of supply chains, the type of goods to be transported, dealing with exceptions (resilience and agility), and compliance with international and national regulations. This complexity is reduced by modeling bilateral interoperability (see the previous section) and by introducing the concept of business services, rooted in services science (Spohrer, May 2009). The application of this concept needs to relate to a semantic model expressed as ontology (see before).

Therefore, the following aspects will be addressed by a conceptual model for interoperability in supply and logistics:

- An upper ontology with the basic concepts and properties for data sharing in logistics, namely (figure 2):
    - Physical objects – all physical objects that can be observed in the real world, including their associations. Examples are containers that can be loaded and transported by vessels. These physical objects are represented as 'digital twin' (Boschert & Rosen, 2016). SHACL can be applied to specify technical details of concepts and properties of a digital twin, like an identifier for a container (a container number) needs to have a certain structure.
    - Locations – all locations that are relevant to supply and logistics operations, including their physical capabilities like 'storage', 'transshipment', and 'cross-docking'. These locations, or 'places', are known as terminals, warehouses, or railway yards. Locations can also be grouped into for instance ports, regions, and countries.
    - Actors – data properties of actors that can participate in supply and logistics. Besides organizations, also digital twins can participate as actor, i.e. they can receive, store, process, and share data with others depending on their IT capabilities.
    - Time – time is the most important for supply and logistics. It associates digital twins with a location, e.g. a container has arrived at a terminal, and constructs associations between digital twins, e.g. a container is loaded on a vessel at a time.

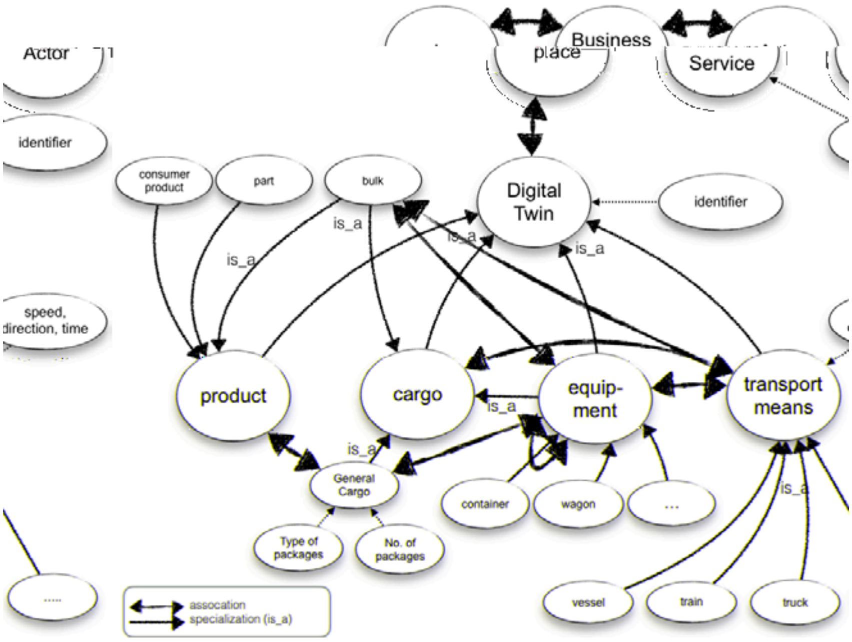

Figure 2: high level semantic model (upper ontology)

- Views and extensions – the upper ontology is a basis for creating particular views and constructing extensions. Views can be mode – and/or commodity specific. One can for instance construct a view for air transport and, at the same time, include extensions in this view that are only relevant to air. A commodity specific view would focus on interoperability of for instance container transport or commodity trading (Hofman, 2019). Finally, views and extensions can also be constructed from a legal perspective, for instance safety rules for transport means. Such a legal perspective may require additional data to be shared, that is not part of the upper ontology or another specific one, although data like dangerous goods details may also be shared amongst enterprises and thus be part of another view. If so, a rule could be to include extensions that are part of two views in the upper ontology to make them identical.
- Business services – these are the capabilities of service providers that need to be matched with goals of customers. Examples are 'transport', 'transshipment', and 'storage', but also handling legalities can be offered as business services. Business services comprise data of digital twins that can be handled, location(s), transport modalities, and time schedules. They can be expressed by time tables, voyage schemes, and flight schedules. In some occasions, business services can be composed like picking up returns when delivering goods.
  Specification of business services is the basis for actual business transactions. Furthermore, business services also formulate data requirements. For instance, if a service provider is able to transport containers by sea, container details need to be given and locations are known as port of loading and – discharge.
- Business transaction interaction patterns (Dietz, 2006) that specify data flows between a customer and service provider in the context of a business transaction. These patterns are specified as choreographies. Each interaction type of the choreography will have minimal data requirements like a transport order always requires data providing details of at least one type of Digital Twin, e.g. a container. where each interaction expresses minimal data requirements based on a semantic model, e.g. an order for a container transport service should at least contain details of one container. SHACL can for instance express data requirements of interactions.

These interaction patterns add complexity to 'time'. A customer can have a request for a time when cargo is ready to be accepted and needs to be delivered ('expected times'), a service provider provides a planned time, during execution an estimated time of completion of a business transaction, and finally the actual time. Expected and planned times can be given as time windows (periods).

Interaction patterns can be decomposed in functionality like 'publish and find business services', i.e. a logistics marketplace, 'booking', 'ordering', and 'supply chain visibility'. This decomposition, which specifies the platform services (figure 1), can result in separate platforms or solutions, that have to be horizontal and vertical interoperable (see before). Horizontal interoperability of for instance a booking and ordering platform with a supply chain visibility platform will be based on order data (Hofman, Dalmolen, & Spek, 2019). Vertical interoperability between supply chain visibility platforms is based on interoperability of the supply chain visibility services provided by each platform.

The conceptual model, which can already contain technical details that can be validated by open source software, needs to be transformed in a technical model specifying for instance APIs. The technical model may include additional data not present in the conceptual model and/or can simplify data. An example of a technical model for Supply Chain Visibility is given by (Supply chain visibility paper).

5 Guidelines for data sharing in supply chains

And yet, there are many different supply and logistics chains, characterized by:

- Geography – global, regional, national, or city oriented supply chains. These supply chains are subject to different (inter)national and/or local (municipality) regulations. Statements like Certificates of Origin or Long Term Supplier Details are required for VAT purposes in relation to trade agreements.
- Number of stakeholders – the most simple supply chain involves a shipper, carrier, and a consignee, but more complex one have different transport legs with transshipment and/or bundling of cargo flows.
- Type of cargo – basically, three types of cargo are identified, namely bulk -, general – and containerized cargo (figure 2). These types of cargo require different assets for transportation, whereas the size, weight, and volume are also relevant. eCommerce shipments are for instance general cargo, but will require bundling of many small shipments into a bigger one.
- Cargo details – size, volume, and weight are already mentioned, but also the fact that cargo can be dangerous (e.g. chemicals) and requires temperature control for quality purposes (e.g. flowers and fruit) leads to different actions, including for instance quality surveillance.
- Delivery terms – these will define responsibilities and payment of transport charges.
- Framework contracts – many customers and service providers have framework contracts, thus do not require booking. These framework contracts may also exist between a large shipper and a globally operating carrier, thus providing details to a forwarder to use that particular carrier.
- Sensoring and autonomous assets – assets may have different types of sensors, interoperable via sensor platforms of these sensor providers, whereas the same assets will also have computational power, thus being able to act (semi-)autonomous.

The perspective of each actor in these chains will be different, a global forwarder perspective will for instance differ from a (global) carrier or shipper perspective. SMEs will yet have another perspective, they will require ready to use solutions provided by the platform services.

There are two approaches that can be followed, namely on-boarding with a platform that provides the standardized platform services or model and match one's supply and logistics chain(s) with the platform services of the conceptual model. On-boarding is feasible when the platform services are standardized, fit requirements of an individual user, are adopted by a critical number of users, and are provided by interoperable infrastructures. Supply chain visibility services provided by various (vertical) interoperable platforms could be an example for on-boarding. On-boarding requires alignment of internal databases with the platform services to implement the local interfaces (see figure 1).

Modelling one's supply and logistics chain(s) can be more complex. A globally operating shipper will for instance a global supply network meeting customer demands with various stakeholders involved. All the aforementioned variations will exist. A proposed approach is:

1. Use case(s) – identify one or more use cases, i.e. one or more relevant parts of a supply network that requires attention and can be improved.
2. Business case – develop a multi-stakeholder business case for the use cases based on standardized platform - and business services. Simulation can be applied as a means to develop a business case and identify improvements. Business cases are for instance driven by the introduction of new or changes to existing legislation, introduction of new technology providing opportunities, etc. or a requirement for cost reduction and improved efficiency.
3. As-is – model a use case with stakeholders involved, time sequence diagrams for data sharing and data semantics of the various interactions. The as-is situation will include compliance to regulations.
4. To-be – match the use case to the conceptual model by identifying the functionality of interaction patterns at interfaces between the various stakeholders and the data semantics modelled by the semantic model. This may lead to extensions of the conceptual model, for instance to be able to represent particular data by the semantic model or to identify new interaction types as part of the interaction patterns.
5. Implementation – implementation not only considers adaptation of business processes and thus human actions, but also the support of the to-be situation with platform services. Different stakeholders may use platforms of different providers, with differences in platform services. These platforms will have to be interoperable and harmonize their services to match with the to-be situation. Furthermore, each stakeholder will have to align its internal IT systems with the platform services, both at data – and at interaction level. A generic Access Point (AP) can be used for this purpose, providing the matching between internal IT systems and the platform services provided at the local interface of a platform provider (figure 1).

On-boarding and modeling and matching supply chains can be supported with templates and tools like multi-stakeholder business case tools, value modeling tools, and ontology development tools. However, there is not yet an integrated toolset able to support organizations in modeling and on-boarding their supply chains.

6 Conclusions and further work

This paper proposes the construction of extendable, standardized platform services for business services that can support all types of supply and logistics chains. Decoupling of these platform services from a user's perspective enables the development of a global open infrastructure building upon various technological solutions and hide complexity of such an infrastructure from users. The introduction of business services further creates a decoupling of users; they will be able to share data based on requirements of their business services.

Data sharing technology is expected to evolve. DLT and IDS for instance will evolve and platform service providers will improve their service offering to stay competitive. Like discussed in section 2, DLT and IDS implementations and platform service providers combine technical – and functional interoperability (figure 1). A separation of concerns of functional – and technical protocols is required using particular interoperability modeling techniques (section 3). By modeling data requirements of business services supported by a business process choreography and a semantic model, conceptual interoperability can be achieved. Like argued, supply and logistics chains come in many flavors, requiring a need for guidelines to use and extend the proposed conceptual models and integrate back office systems with standardized platform services (figure 1).

A governance structure is required that is platform overarching. It has to focus on platform services and their extendibility, business services, functionality required for ontology alignment, and underlying technical protocols, with the objective to create an open data sharing infrastructure with many technical solutions. Such a governance structure may be similar to that of the Internet, consisting of a Governance Board, an Architectural Board, an Engineering Task Force, and a Platform Service Provider Group. Users, i.e. enterprises and authorities, will be part of the Governance Board. The Architectural Board and the Engineering Task Force will provide input for standardization and requires participation of independent experts.

The development of such an open data sharing infrastructure should be driven by use cases, based on the basic concepts specified in this paper. Use cases will provide adoption. By creating guidelines, individual stakeholders will be able to adopt the solution, but this will take time. With respect to adoption, we identify three stakeholder groups: platform service providers, enterprises, and authorities. Platform service providers may fear to lose market share based on platform interoperability, but having harmonized platform services may also lead to an increase of market share by adoption of these services by enterprises through on-boarding. Enterprises require guidelines for using an open data sharing infrastructure, since each of them will not be able to create the solution on its own. They require collaboration with competitors and authorities to construct an open data sharing infrastructure, which is only acceptable if they set up the aforementioned governance structure before actually developing a solution.

Authorities have two roles, namely the one of legislator and governance of compliance to legislation. In the latter role, authorities have similar approach as enterprises, they will require optimal data quality for their function. They can enforce solutions based on legislation. In their role as legislator, authorities will have to focus on a level playing field, i.e. inclusion of SMEs. In the same way, data quality at the business-to-government (B2G) interface will improve if business-to-business (B2B) data sharing is facilitated. Thus, authorities can initiate the development of a data sharing infrastructure primarily supporting B2G, but at the same time also supporting B2B. Use cases with enterprises are required, for instance supporting new legislation like the electronic Freight Transport Information Regulation. One must note that authorities don't have good reputations in developing these types of IT based infrastructures.

Thus, there is still a lot of work to be done. Details are already researched (see the references of this paper). Next steps are also to investigate autonomous agents utilizing the proposed platform services, thus creating the Physical Internet.

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