Piggy backing on supply chain visibility to improve risk analysis – progress report of two data pipelines

Abstract: Interoperability in logistics is a prerequisite for realizing data pipelines and the Physical Internet. Actual positions and movements of shipments, containers, vessels, and other transport means have to be shared via standardized events, thus creating visibility. Supply chain visibility is expected to improve all types of processes, support synchronmodality, and improve risk analysis from a compliance and resilience perspective. Technically, organizations implement their solutions, which are being and have been validated in so-called Living Labs or demonstrators in various European funded projects. This paper presents two cases that are currently being validated in practice.

Keywords: supply chain visibility, data pipeline, piggy backing, Enterprise Service Bus, Event Driven Architecture

1 Introduction
Supply chain visibility is said to improve business process efficiency [1]. Improved knowledge of estimated arrival times of goods at certain locations can improve handling of these goods and thus reduce costs, e.g. by scheduling personnel at arrival or reducing transshipment and thus transport movements. Data captured for visibility can also be used by authorities from a compliance and security perspective. Customs authorities require this additional data to their current declaration for risk analysis improvement and introduced the concept of data pipeline for seamless data sharing as a solution [2]; authorities ‘piggy-back’ on supply chain data [3].

A data pipeline is a representation of a tradelane of a particular buyer, seller, or producer constituting of stakeholders involved, the underlying physical processes, data these stakeholders share, and IT solutions applied for sharing the data. Thus, a separate data pipeline represents each tradelane, where underlying IT solutions will support one or more stakeholders participating in such a pipeline. The actual implementation of a data pipeline is by interconnecting legacy systems of the stakeholders and/or support by commercial – and community solutions [4]. It is not to be expected that one global system will implement the data pipeline, but interoperability between existing systems and solutions needs to be constructed [4].

As of currently, many interoperability implementations in trade and logistics are based on the message paradigm, but also other mechanisms are explored to address instance real-time data sharing for dynamic planning or resilience [5], Service Oriented Architecture (SOA) supported by Enterprise Services Busses (ESBs) [6] or Linked Data [7]. For real-time data sharing, the current generation of platforms supports an Application Programming Interface (API) registry [8], a particular SOA implementation based on the REST protocol. APIs are still technical specifications that require interpretation to derive semantics.
This paper presents two cases of implementing the data pipeline for visibility that also provides data to Dutch Customs Administration (DCA). First of all, the problem is introduced, and secondly, the cases are presented. Results of these two implementations are expected in the first half-year of 2016; this paper reports on the set up of the cases. The paper will end with a discussion on further research.

2 Towards supply chain visibility
By implementing supply chain visibility [1] buyers, sellers, and manufacturers improve their business processes allowing administrations to piggyback on visibility data [3]. Having this additional data, administrations can improve risk analysis for supply chain security [2], without increasing the administrative burden and within the scope of (global and EU) customs laws and their national implementation. Improved risk analysis will increase supply chain predictability and reduce requests by administrations to traders for providing additional data. First of all the processes and their data are briefly described and secondly some issues with respect to visibility are introduced.

2.1 International trade
International trade, which is goods movement from one continent to another by sea, air, or over land, can be triggered in different ways, for instance a retailer buying goods from a foreign producer, a company placing a production order with its foreign production plant, a (large) foreign eCommerce company shipping goods to end-consumers, a Logistics Service Provider (LSP) with a Vendor Managed Inventory (VMI) service on behalf of its customer replenishing stocks in distribution centers, and foreign producers that ship their goods to a market place and remain owner till these goods are sold at the market place. An LSP replenishing stocks can act as exporter or importer. At the same time, a manufacturer can also replenish its stocks in its local distribution centers in other countries. Different types of goods can be involved, e.g. consumer electronics, automotive spare parts, product components, and agricultural goods. The goods can even change ownership during transport, e.g. oil and grain. These differences in trade all lead to transport orders for consignments, where these consignments are based on packing lists of production orders or picking lists. Goods don’t always change ownership in international trade, but ownership can also change more than once during transport.

Figure 1 visualizes the combination of these different trade flows, where they all lead to transport orders (TO) of consignments. One, part of one, or two or more purchase – or replenishment orders result in a consignment. These consignments can be split into separate shipments or can be combined with other consignments of different sellers, manufacturers or LSPs into one shipment, for instance by stuffing packages of different consignments into one container. The figure shows an example of physical processes of transporting goods from one country to another via sea with containers. The bottom of the figure shows the physical processes from a plant to a final destination, also known as Place of Acceptance and Place of Delivery respectively. There are different variants of these physical processes, e.g. stuffing can be performed at the Place of Acceptance and stripping in the port of discharge. Also modalities can differ, e.g. containers can be transported by barge from a port of discharge to an inland terminal and from thereon with a truck to a warehouse, a
The goods, represented by a packing list and also known as a consignment, are stuffed into containers, transported from a port of loading to a port of discharge, stripped, and transported to the Place of Delivery. The figure shows that various parties have particular trade data, e.g., a manufacturer, seller, or LSP has a production order or picking list and a forwarder a stuffing list. At the same time, they share data, e.g., a buyer/importer/LSP and a seller/manufacturer/exporter/LSP exchange a purchase – or replenishment order, dispatch advice, and invoice, and a forwarder exchanges a TO and Bill of Lading (B/L) with a carrier. In sea transport, a B/L represents ownership of goods: the actor having the original B/L is the owner of the goods. In case ownership is transferred, the last known owner is written on the back of the B/L form. A waybill, or house airway bill in case of air transport, is used for goods with non-transferrable ownership. A forwarder at exit probably shares a (copy) B/L with a forwarder or recipient at entry. Customs is visualized with three types of data: export, import, and entry of incoming goods into a country. Export and import movements have identical data structures and represent a customs view on consignments. A carrier produces an Entry Summary Declaration (ENS) 24 hours prior to loading shipments at the country of exit to the customs at entry in the first port of call of a vessel for a particular country or the European Union (EU). At exit, excise goods also need to be declared, which the figure does not visualize.

A data pipeline [2] comprises all data shared between stakeholders for a particular
tradelane, including all events generated by the physical processes, and supported by IT systems used by different stakeholders. Since international trade can be triggered in different ways and has different constellations of physical processes (see before), there are many data pipelines. These data pipelines can utilize identical IT systems used by stakeholders, but the data and its semantics is different.

Figure 1 visualizes an example of links between trade data of different stakeholders like a relation between a stuffing- and a packing list. Although not visualized, a dispatch advice contains the packing list of one, part of one, or more purchase- or replenishment orders. Documents representing trade data of stakeholders are shared between various stakeholders in supply and logistics, e.g. a purchase order is shared between a buyer and seller and an LSP can generate a replenishment order for a manufacturer. Production data and packing lists for consignments are the basis of export- and import declarations produced by an exporter and importer respectively. A forwarder can act on behalf of a buyer or seller as importer or exporter. Import and export declarations can have references to container numbers, but only if those are known by an importer or exporter.

Each stakeholder has particular view of the physical processes with their internal identification schemes and those used in shared (electronic) business documents, e.g. products, packages, containers, and vessels. Customs declarations have a unique identification, a so-called Movement Reference Number (MRN), and identifications to goods from a customs perspective (Harmonized Systems code (HS-code) on the goods to be able to classify identical products of different manufacturers from a VAT and security perspective.

The arrows from production order to load list/manifest and to a goods receipt could be a representation of the so-called data pipeline [2]. Additionally, figure 1 also visualizes the generation of status events by physical processes with dotted lines, e.g. an event that containers have arrived in a port generated at the gate of a terminal or containers loaded on a vessel generated by a crane.

The concepts ‘consignment’ and ‘shipment’ are basic to trade flows. A consignment represents all goods that are picked up at the same time at a place of acceptance and have to be delivered together at the same time at a place of delivery. A shipment is the view taken by a carrier to move particular goods together between two locations, e.g. between a port of loading and – discharge. A shipment can contain (parts of) one or more consignments.

2.2 Lack of visibility
All these differences in trade flows and organization of data pipelines lead to lack of visibility, e.g. a consignee might not know when actual shipments will arrive and his consignments will be available. As [2] argued, one of the main issues is the so-called Consignment Completion Point (CCP): the stuffing list is not available. One of the other issues is that a container is transshipped from one vessel to another between the port of exit and the port of entry. Although a stakeholder thought a particular container would arrive with a known vessel, the container in fact arrives with another vessel. Although visibility is recognized as one of the basic supply chain innovations [1] and there are examples of business cases for visibility, its implementation is still complex because of the many stakeholders involved and differences of implementation of data standards [9].

The objective of customs has been visibility of goods coming into a country,
assessing risks before actual loading takes place based on an ENS, and informing a carrier in the country of exit of rejection of goods. Customs has three issues that are similar to those of a goods recipient, namely they don’t know the contents of a container, they don’t know which containers have actually been loaded on a vessel, and they are not informed of any transshipments between a port of exit and port of entry.

2.3 Implementing visibility
This section analyses visibility. Firstly, a conceptual approach is given. Secondly, the relation with existing solutions and business documents is discussed and finally, a proposal for implementing visibility with events is presented.

Conceptual approach to visibility

Conceptually, visibility concerns the location and potentially direction and speed of movement of trucks, vessels, containers, packages, etc., which we will call ‘physical objects’, (nearly) real time, with the objective to predict the time of arrival of objects at a particular location, e.g. a port or a place of delivery (figure 1). If a stakeholder has no visibility, it does not know where the physical goods are. If a stakeholder has real time visibility, it always exactly knows where the objects are.

Figure 2 shows a data representation of visibility by illustrating that physical objects can contain other objects, e.g. several packages with products on a pallet constitute cargo. Figure 2 also shows some specializations of products and transport means; ‘container’ can also be further specialized in for instance Uniform Load Device for air transport and Danish containers for flowers. Figure 2 also shows that a transport means has as data properties speed and direction at a time. The data structure shown in figure 2 can be the basis for a visibility dashboard. By showing locations on a map, the physical goods flow and movement of transport means can be visualized over time.
Each association between two object types can have two timestamps: the start at which the association is physically created, e.g. the actual loading time of a container on a vessel, and the end time. The association between a physical object and a location has six timestamps: the expected, estimated, and actual start at which the association is physically created, e.g. the Estimated Time of Arrival (ETA) of a vessel in a port provided by a carrier, and the expected, estimated, and actual end time. The expected times are given by a customer, e.g. a shipper or consignee, providing the time at which the goods (ultimately) need to be present at the place of delivery (figure 1), the estimated times represent a planning of a service provider, e.g. a carrier, and the actual time can be generated by a device attached to a physical object. The actual timestamps and the speed and direction of transport means are the basis for calculating ETAs.

Some associations have extra data properties, e.g. the one between ‘product’ and ‘cargo’ and ‘cargo’ and ‘container’ have a property ‘number’ expressing the total number of products per packaging unit and the number of cargo items per container. The association between ‘product’ and ‘transport means’ represents bulk cargo with data properties ‘volume’ and/or ‘weight’ expressed in a unit (tons, kilograms, litres, etc.).

A physical association between any two objects is also created and omitted at a particular location; both objects have to be at that location at the same time. An association between any two objects can only be created between their time of entry and exit at a location. A rule would also be that the time of exit at a location of an object is identical to that of the object that contains or carries it. For instance, the departure time of a container from a port is identical to that of a vessel carrying that container.

Relation with existing solutions

Business documents, internal IT systems of stakeholders, and events generated by sensors or actuators attached these physical objects (IoT – Internet of Things) contain data of these physical objects and their associations with timestamps, e.g. a purchase order contains products that are bought and have to be delivered at a certain location and time, a dispatch advice contains the cargo, and a load list the containers loaded on a vessel in a port. To increase visibility, links between various these physical objects and shared business documents have to be constructed and (real time) events containing the location of physical objects have to be shared amongst stakeholders for authorized access to source data. These two aspects and required software components will be briefly discussed in this section.

Uniform Resource Identifiers or URIs can create linked data of various data objects, both internal data and data shared by business documents [7]. The approach of linking various documents or objects by business is identified in implementing EPCIS (Electronic Product Code Information System; [10]), where identifications of business documents, product codes, and container numbers are applied to construct these links. Creating linked data requires harmonization or alignment of data structures and standardization of links. Whereas URIs can be constructed in a flexible way and are globally unique, EPCIS is based on a harmonized identifier scheme. Figure 1 already shows examples of links between business documents and data stored in IT systems of stakeholders, e.g. purchase order number, production order
number, transport order number, and B/L number; figure 2 shows the more conceptual approach.

**Event Driven Architecture**

The event-based approach is proposed to share access to on the one hand data of physical objects represented by business documents, and on the other hand provide real time location, speed, and direction of transport means like vessels and trucks, including the creation of associations between the various physical object types like the loading of a container on a vessel. These events can also be shared with administrations. This latter approach, in which several supply chain stakeholders can provide events with a URL to relevant data to an administrations, is called ‘optional multiple filing’. The objective of a customs administration is to retrieve any data to additional an ENS on a voluntarily basis (‘optional’) by any stakeholder of a trade lane (‘multiple’). All data can be made available to customs that is also relevant for visibility in supply chains, e.g. dispatch advices, stuffing lists, and Bills of Lading. Since optional multiple filing is voluntarily, the data actually remains in the private domain and is made accessible to customs in any available structure with semantics (e.g. PDF, XML, GS1, EDI, and UBL).

Basically, three functions are distinguished, namely a Trader End Point (TEP) where data of a particular stakeholder is stored and made accessible to others by sharing events (basically a Uniform Resource Locator (URL) of a web server), an ‘Enterprise Service Bus’ for distributing events based on subscriptions [6], and a ‘visibility dashboard’. A dashboard receives all events, makes them retrievable by a key, and provides access to the data stored by a TEP. To be able to process all available data, both its structure and data type (i.e. business document like purchase order) need to be known by the dashboard. For this purpose, a ‘profile’ is shared containing the business document type and its data structure, and the URL of a TEP. An event refers to a profile, contains identification for searching the data in the dashboard (e.g. a Movement Reference Number (MRN) or B/L number) and a URI (Uniform Resource Identifier) that extends the URL for a REST Application Programming Interface (API) to access the data (see figure 3). The figure shows that more than one TEP can provide information to a visibility dashboard, where each TEP has its specific profile. Any stakeholder, requiring visibility at its particular level of a tradelane, can operate the visibility dashboard. For instance, a forwarder can operate a visibility dashboard for carriage to a port and loading containers on a vessel if that forwarder arranges transport to a port and an administration will be interested in all goods entering its domain from a foreign domain [2].

![Event-based approach](image)

**Fig. 3.** Event-based approach
Conceptually, three roles are identified with respect to visibility, where each of these roles can have its particular functionality: ‘trader’ like a shipper, buyer, forwarder, or carrier providing visibility data and/or requiring visibility, ‘Value Added Service Provider’ (VAS Provider) and ‘administration’ like customs administration (table 1). The table shows that both a trader and a VAS provider can implement all functionality.

Table 1. Implementation options of the event-based living lab.

<table>
<thead>
<tr>
<th>Functionality</th>
<th>Trader</th>
<th>VAS provider</th>
<th>Customs</th>
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</thead>
<tbody>
<tr>
<td>TEP</td>
<td>x</td>
<td>x</td>
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<tr>
<td>Enterprise Service Bus (ESB)</td>
<td>x</td>
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<td></td>
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<tr>
<td>Visibility dashboard</td>
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Whereas a trader can have a visibility dashboard, customs also can implement such a dashboard for optional multiple filing. In this particular case, an ESB needs to generate an additional event to indicate that additional data available via a customs dashboard. DCA has identified three search criteria to which the additional data has to be related, namely an MRN, a B/L number or a container number. It means for instance that a stuffing list can be given per container. Furthermore, the assumption taken by DCA is that a B/L contains additional data to the ENS like the actual shipper and consignee and a more precise goods description of a container. In case more than one container is used to ship a purchase order, a container number for a purchase order is insufficient. Via ‘cargo’ an association with ‘product’ needs to be created (see figure 2).

3 Two cases
Two cases with different stakeholders are currently implemented and validated to improve visibility and allow customs to piggyback on these visibility solutions, namely the one of a forwarder arranging goods flows for its customers and the second of a consignee receiving goods. Customs will operate a visibility dashboard searching on events and accessing data stored at a TEP with an API. Since customs officers normally utilize their declaration system that stores ENS data, this latter system needs to contain an indication that additional data is available at the visibility dashboard. Therefore, the ESB needs to generate two events, one to the declaration system and the other to the dashboard.

3.1 A forwarder case
In this case, a forwarder acts as trader. The forwarder is fully responsible of the complete goods flows from exit to entry on behalf of a shipper or consignee. As such, the forwarder’s objective is to create full visibility to its customer and to efficiently utilize existing transport means. For this latter purpose, the forwarder develops a so-called Control Tower [11] to support synchromodality [12].

The Control Tower of the forwarder contains a complete file of all business documents (e.g. purchase order, invoice, and stuffing list) shared between
Fig. 4. The forwarder case.

Currently, the forwarder is able to generate events to DCA, whereas the latter one is able to access the data via the API. Since the forwarder provides visibility to its customers, these customers have to agree that DCA will also be able to subscribe to events for particular trade lanes. The latter is yet to be solved and data will be shared between a forwarder and DCA in the first quarter of 2016.

3.2 A consignee case

In this particular case, a consignee acts as recipient of goods of a producer. The producer still owns the goods when they receive at the place of delivery (see figure 1). The objective of the consignee is to create visibility of goods flows for efficient planning of personnel handling these goods. Goods can be transported by air and sea to the Netherlands. Since it concerns agricultural products, a phytosanitary certificate needs to be present indicating that the goods can be shipped to the Netherlands. The Dutch food and drug authority (NVWA) and customs administration perform a risk assessment of the products from their perspective, which is currently sequentially: first NVWA assesses risks and secondly customs administration. In case of air transport, this might lead to delays in handling goods at the airport. The proposed situation is to share the phytosanitary certificate of the producer as soon as possible via the consignee to NVWA and Dutch customs.

For air transport, a VAS provider supports the functionality of both the TEP and the ESB on behalf of the consignee. The consignee stores all relevant data in the domain of the VAS provider, where the latter provides authorized access on behalf of the consignee to other stakeholders (figure 5). For sea transport, another VAS provider implements an ESB, called the Shipping Information Pipeline (SIP), whereas the data is still stored at the TEP of the first VAS provider. In this latter case, the carrier for sea transport triggers the event that is generated to DCA by the SIP. The phytosanitary certificate is still stored at the TEP of the consignee.
Fig. 5. The consignee case.

Other tradelane stakeholders are for instance the airport, forwarders at exit and entry, and the shipper. An airport system like that of Schiphol airport can for instance generate an event with the Estimated Arrival Time (ETA) of an airplane; a port authority can do the same for a vessel. Extra complexity is added to this case by the fact that sea transport enters Europe in Antwerp, implying that DCA will not receive an ENS. Belgium Customs and DCA have agreed to share the ENS.

A large sea carrier is developing SIP, which thus will also apply SIP to provide visibility. The governance model of SIP is still under development at this stage. Since the VAS provider is developing visibility services via a dashboard to the consignee, the ESB of the VAS provider must also be able to retrieve events of the SIP. The VAS provider must provide subscription functionality to its customer, where the VAS provider will be able to forward these subscription requests to the proper stakeholders and their ESB solutions. Figure 5 shows an example where a subscription request is forwarded to SIP. These types of visibility services are still under development.

4 Conclusion and discussion

This paper explains international trade, lack of visibility and a way to implement visibility, and presents two cases. Technically, data can be made available to a visibility dashboard of customs with an Event Driven Architecture [6]. Data will be viewed as it is, namely as PDF or with a user interface generated by the XSD (XML Schema Definition) of a particular electronic business document (e.g. GS1, UBL or a Message Implementation Guide of existing XSDs). In the first half-year of 2016, experiments will be conducted to investigate the conditions for piggy backing and its added value to customs. Next steps will be (1) to further develop the visibility dashboard based on a generic data structure (figure 2) that integrates data of different
sources (i.e. sensor data and business documents) and construct complete visibility, covering also aspects like parties involved and historic data [2] and (2) integrate additional supply chain stakeholders to the dashboard and provide additional data. Furthermore, various aspects like the governance of SIP and development of visibility of the consignee (section 3.2) need further elaboration. The latter shows that a federated approach is required of linking different solutions [13], thus constructing global data pipelines. In this respect, IT security is of great importance in terms of Identity, Authentication, and Authorization [14], but also cyber security to prevent active attacks on IT systems of tradelane stakeholders.

Although the objective of administrations perform risk assessment with tradelane data required for supply chain visibility (piggy backing), there are different solutions to provide data to an administration. Whereas the approach presented in this paper is based on EDA, other cases are taking a message-based approach where data is collected and pushed to a customs administration. These cases, performed Her Majesty’s Revenue and Customs administration (HMRC), need to be compared with the approach taken in this paper. Further research is required in additional transformation services between both approaches, which makes support of trade flows to both the UK and the Netherlands possible with one solution for traders.

A final issue is alignment with the Import Control System 2.0 (ICS 2.0) where a data set required by customs administration is under development and has to be implemented before 2020. Although the data set is already specified, mechanisms to retrieve or push the data to an administration or the roles of particular stakeholders in providing data are not yet specified. In the United States (US), the roles are clearly specified in the Import Security Filing (ISF): the importer is responsible to provide a complete data set. Identical solutions would be required by trade to reduce administrative costs and improve trade facilitation.

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References


