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Towards a Mobility Data Space: Data sharing via linked semantic data, an example for eFTI

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Abstract

The objective of the European Commission responsible for mobility (EC DG Move) is to create a Mobility Data Space for persons and freight. We will focus on freight movements in, into, and out of the European Union. Such a data space should address all modalities, air, sea, road, rail, and inland waterways. This contribution will focus on road transport. The proposed solution is based on an open world assumption, where different stakeholders can share access to their data and contribute to functionality supported by the environment. This solution has been adopted by the Digital Transport and Logistics Forum (DTLF), an expert group raised and chaired by EC DG Move. The focus will be on creating what is called a 'protocol' for interaction between systems and heterogeneous applications of all stakeholders involved. An example of the implementation of the protocol by a combination of a triple store, supported peer-to-peer data sharing technology supported by blockchain is provided. A specific focus is given to the deployment of the proposed solution for the electronic Freight Transport Information (eFTI) Regulation. The proposed solution is not adopted by EC DG Move as eFTI Implementing Act and is solely the proposal of the authors, based on concepts, principles, and architecture developed by the Connecting European Facility (CEF) FEDeRATED Action and adopted by the DTLF.

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1. Introduction

The Digital Transport and Logistics Forum (DTLF), an expert group raised and chaired by the European Commission, Directorate for movement of persons and freight (EC DG Move), is developing a federated network of platforms, implying that existing platforms and solutions are interoperable and enable a logistics enterprise or authority to connect to only one solution of choice and be able to support business digital. The latter feature is called ‘plug and play’ (Digital Transport and Logistics Forum, 2022). The DTLF is supported by two Connecting European Facilities (CEF) funded actions, namely FEDeRATED (www.federatedplatforms.eu) and FENIX (www.fenix-network.eu). Where the FENIX Action has a focus on creating connectivity between different platforms, FEDeRATED has its focus on business interoperability with a solution of choice. Thus, FEDeRATED and DTLF have the objective to create an open and neutral data sharing infrastructure to support digitized business collaboration compliant with regulations, based on existing solutions that are available to all logistics stakeholders (level playing field).

A logistics data sharing protocol is under development by DTLF and being validated in FEDeRATED Living Labs based on a data pull. Data remains at the source, so a source controls the access to its data. This is called data sovereignty (FEDeRATED, 2021). In this context, the roles of data holder and – user are distinguished (European Commission, 2020). Whenever a data user wants to access data of a data holder, a data user requires a link to that data. So, a data holder distributes links to only those data users that are allowed access to data. This is called ‘Linked Data’ (Heath & Bizer, 2011). To provide meaning to these links, they reflect the actual or future state of logistics activities. These are shared by ‘event’ (see the semantic model as explained by (Digital Transport and Logistics Forum, 2022)).

The DTLF also addressed paperless road transport based on the eCMR Convention (UN / CEFACT, 2022). This convention adds the ability of digitization to the original CMR convention. This CMR convention covers liabilities and responsibilities for freight transport by road, supported by a document. This document is defacto used by authorities for governing regulations. Thus, replacing the CMR document with a data set required authorities to be able to accept data sets. This resulted in the electronic Freight Transport Information (eFTI) Regulation (Council, 2022). The eFTI Regulation must be implemented by 2025, meaning that all relevant EU Member State (MS) authorities need to be able to digitally receive data sets from business. Subgroup 1 and 3 of DTLF (www.dtlf.eu) prepare eFTI implementation options in various teams. This contribution explores the application of concepts and semantics developed by DTLF SG 2 (Digital Transport and Logistics Forum, 2022) to eFTI by analyzing the variety of implementations options for eCMR by private sector enterprises. The principle is to utilize business data for compliance to regulations like eFTI according to the data pipeline concept (van Stijn, et al., 2011).

Our research approach is based on Design Science (Hevner, March, Park, & Ram, 2004) and their process steps (Peffers, Tuunanen, Rothenberger, & Chatterjee, 2007). These steps are problem identification and motivation (1), solution objective (2), design and development (3), demonstration (4), evaluation (5), and communication (6). The current version is in the design and development phase, is already shown to relevant stakeholders, and as a next step will be applied in practice this year (2022). We don’t detail the problem identification and motivation; this is driven by the eFTI Regulation. We will first discuss the solution objective in terms of the variety of implementation options and present the design.

2. Solution objective

In our analysis, the stakeholder roles, the transport services, authority processes, and asset ownership and-exploitation are the basis for the requirements. These will be described in this section and a summary will be given. The solution objective relates to the development in the context of the eFTI regulation. Any future scenarios can be included at a later stage, for instance a gradual integration of autonomous vehicles and sustainability improvements by reducing vehicle movements.

2.1. Analysis

The roles are formulated as transport service buyer and – provider (UN / CEFACT, 2022). In this context, a transport service provider is a road carrier. Any party in a logistic chain outsourcing transport can be a transport service buyer, for instance a consigner, a consignee, a forwarder, and another carrier, where this carrier can have another modality (e.g. sea, rail, and air). A transport service can for instance be ordered by a consignor, in which case the delivery conditions are ‘free delivered’ and transport charges are paid by the consignor, or by the consignee, in which case the delivery conditions are ‘ex works’ and transport charges are paid by the consignee. Additional roles are those of truck driver, i.e. the person operating a (combination of trailers and) truck, competent authority (a governmental organization, agency, or delegated representative implementing (relevant parts of) the eFTI Regulation for a particular area of responsibility), road infrastructure manager, and emergency service for accident handling. In this context, it is relevant to assume that a truck driver will have a trip with one or more loading – (dispatch) and discharge (delivery) locations, where a commercial relation between a transport service buyer and a carrier is represented by the cargo that needs to be loaded at one location and discharged at another. These locations are named a ‘call’. Such a trip, or more general an itinerary which is also the basis for data pipelines (van Stijn, et al., 2011), can be represented by a state transition diagram specifying that a truck arrives at a location of call, can load and/or discharge cargo, and depart. During the itinerary, relevant locations like border crossing can be provided. These locations between calls might not yet be available in trip data of a carrier; they need to be provided for entering and leaving the EU. In the context of the eFTI Regulation, the party providing access to eFTI data is called the economic operator. This can thus be a transport service buyer or -provider.

Road transport services distinguish amongst others full truck load (FTL) and less than truck load (LTL) shipment. FTL is also called direct transport: goods are transported from one dispatch – to one delivery place. The dispatch – or delivery place are not necessarily owned or controlled by a transport service buyer, e.g. a consignor can be a transport service buyer and owns/controls the dispatch place but not the delivery place. FTL is applicable to any type of cargo, e.g. pallets, bulk, and containers. Container transport could be hinterland transport for a port, in which case a forwarder (merchant haulage, where a forwarder acts as representative for a consignor (pre-carriage to a port) or consignee (on-carriage to the delivery place)) or shipping line (carrier haulage) could order transport. Although one container is for one delivery place or from one dispatch place, a truck can transport multiple containers at one time, each container destined for or from different places. In case of FTL transport, currently an CMR document can be issued by either a transport service buyer or – provider. For instance, transport service providers can be small enterprises with no or limited IT (Information Technology) capabilities and utilize a portal provided by their customer.

LTL is based on a distribution network provided by the transport service provider or a transport service provider bundles shipment of goods. A typical distribution network consists of several distribution centers. One country can have one or more distribution centers. Transport between these distribution centers is on a regular basis, for instance overnight. Each shipment between two distribution centers consists of multiple consignments. In a distribution network goods are pickup by a carrier at different locations, enter a distribution network with its internal routing, and are delivered at the proper delivery locations. Picking up and dropping of goods can be done as what is called a milk run: a truck driver has a route for picking up or dropping off goods. In case of a milk run for pickup, data of a transport order might not yet be provided by a consignor. A consignor may have framework contract with a carrier and have several unique consignment identifications with associated labels that are stickered on the goods and registered by the truck driver when picking them up. Dropping of goods is also known as ‘last mile delivery’ or ‘city distribution’, which may be outsourced to local carriers. The carrier produces the CMRs for each consignment on behalf of its customers, and thus most likely the eCMRs. These types of applications are mostly fully digitized and don’t use a CMR. They apply proprietary solutions.

In practice, there are more variations. For instance, a consignor or eCommerce platform provider may also have its own distribution network for providing eCommerce shipments to buyers of these goods. They act as transport service provider to eCommerce websites using their retail platform. Another example is a consignee like a large retailer that organizes its pickup of goods of several providers to one distribution center and applies cross-docking for distribution of goods to its retail stores.

There are basically two types of authority processes, namely roadside inspection (halting) and remote inspection. The eFTI Regulation does not make a distinction between these processes, but they are expected to be specified within the eFTI Implementing – (IA) and Delegating Act (DA). These provide specifications for the eFTI common data set, procedures, policies to share data between economic operators and competent authorities, and the criteria for the certification of eFTI platforms and services (European Commission, 2020). eFTI seems to have a primary focus on roadside inspection where a truck driver must provide all relevant data either digitally or on paper. However, since eFTI also covers the transport of dangerous cargo (by road), this needs to be accessible due to safety procedures and restrictions.

Remote inspection can be supported by sensors, like camera's with ANPR (Automated Number Plate Recognition) or Vehicle Identification Numbers (VIN) via appropriate protocols, and risk targeting algorithms (data analytics). Remote inspection can be on a regular – (constant monitoring of for instance a city center to detect offences) or ad hoc basis, e.g. in case of road accidents with trucks involved (this example is probably not known as remote inspection. Remote inspection can result in halting.

In case of ANPR, a license plate refers to a truck or its trailer. Each asset like a truck and a trailer is registered by its owner with a license plate at a national registration authority. It seems obvious to retrieve data of the cargo carried by a truck via this registration authority. However, there are different compositions of a truck (see next figure) and ownership/user relationships. Each asset (truck or trailer) has its unique identification (might be a VIN) and someone managing and/or registering that identification: a producer, an OEM (Original Equipment Manufacturer), an owner, and a user. An OEM can act as owner and lease a truck or trailer to a carrier. An OEM may also provide fleet management services by remotely monitor the an asset, based on for instance a unique identification of its asset. The owner can also be identical to a user, i.e. a carrier owns its assets, or differ. In the latter case, an asset can be leased for a longer period or hired for an individual logistics activity. Commercial relationships between an owner and user of an asset are private transactions, which means they are not known by an authority. In this context, a user is a transport service provider. This means that utilizing a license plate registration authority (or extending it) will not necessarily provide information where (eCMR) cargo data can be retrieved for remote monitoring, for instance to handle emergencies. In case of roadside inspection, an identification for retrieving data can be given by a truck driver to an inspection officer.

Fig. 1. options for truck compositions

We did not yet address the data representing the cargo carried by a truck and its trailers. This data (the 'business data set' instead of 'eCMR, since there is not always an eCMR data set) is stored in an IT (Information Technology) system, which is known as eFTI platform in the regulation (European Commission, 2020). Such platform can be any type of system, like an Enterprise Resource Planning (ERP) system, a (cloud) Transport Management System (TMS), a trip planning system, a eCMR platform, and an On–Board Unit platform (OBU). An IT system storing the business data set should support the following functionality: non-repudiation of handover of goods to a truck driver at dispatch and at delivery. Currently, (electronic) signatures are used for this purpose. A dispatch party, a truck driver, and a delivery party all provide an (electronic) signature to an (e)CMR. It means that whenever cargo is handed over to a next activity in a logistics operation, data integrity and non-repudiation at handover should be assured by both parties involved in handover.

2.2. Requirements overview

The previous analysis results in the following requirements

- The business data set representing the commercial relationship and carriage conditions between a transport service buyer and – provider (known as ‘eCMR’ data set) can be stored by a transport service buyer or – provider.
- In framework contracts of distribution networks, proprietary solutions are applied for the ‘business data set’ and its integrity and non-repudiation.
- Integrity and non-repudiation of business data sets needs to be assured at handover.
- A truck consists of one or more assets, each asset with its own license plate, registration, owner, and user (operator) that are not necessarily the same.
- Transport of all cargo types (goods, bulk cargo, containers, and other equipment) for one or more consignments (FTL or LTL) must be supported.
- The function for which a truck is used, i.e. the transport service it offers in terms of the cargo type that can be transported, is determined by its user at any given time. It will also depend on capabilities of a driver, e.g. certificates for dangerous goods handling.
- The registration of an asset can be in different Member State as where the administrative operation takes place, i.e. where the data is stored. This is because owners and users can differ and the fact that the business data set can be managed by a transport service buyer or – provider.
- There is a variety of IT solutions that can serve as eFTI platform and act as data holder. These IT solutions can be owned by an enterprise with a logistics role or can be provided as a service to such an enterprise.
- Service providers that can act as eFTI platform operate across (Member State) boundaries.
- An authority can perform roadside – (halting) and remote inspections. Road accidents with trucks involved are considered as remote inspections. Remote inspections are supported by ANPR, or when applicable, VIN sensors in trucks (assets like trailers do not have a VIN).
- An authority can perform administrative inspections requesting detailed CMR information details (post-carriage) from a transport service provider.
- Roadside cameras can detect the license plate of a truck or a trailer.
- An authority is not able to distinguish the function of a truck (see before) and whether its user is already fully digitized with proprietary functionality.

This leads to the main conclusion that a consignment data set cannot be associated with the owner of an asset. However, an IT system supporting a truck driver in executing its trip will all data relevant to eFTI.

3. Design and development

The design and development is the application of the architecture developed by the FEDeRATED Action and adopted by the DTLF, subgroup 2 (Digital Transport and Logistics Forum, 2022). The relevant components of this architecture will be given first and, secondly, their application to eFTI is given.

3.1. Architectural elements of the DTLF

The DTLF architecture is a based on a pull approach, where data is kept at the source. Links to data are shared by a data holder to a data user. A data user stores these links in what is called an ‘index’ and can search this index for relevant data. Finding relevant data, a link provides access to this data stored by a data holder.

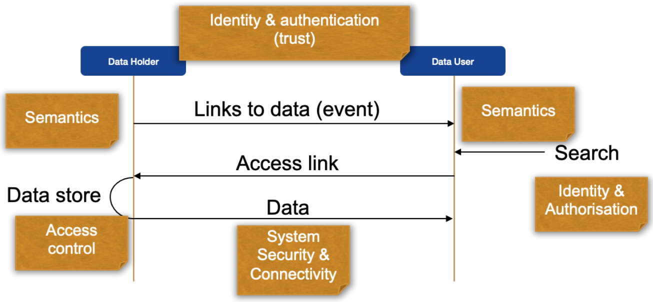

Fig. 2. Sequence diagram of a data pull based on sharing linked (event) data

Of course, a data user must have the authorization to access this data and a data holder must be able to authenticate the identification of a data user and must trust the authorization of a person acting on behalf of a data user to access the data. Both data user and – holder must implement the same semantics and syntax for sharing the data. Logistics events that are part of the semantic model (Digital Transport and Logistics Forum, 2022) represent the 'linked data'. Whenever a data user accesses data, a data holder must implement access control to its local data store. These aspects are visualized in the previous figure.

The following figure shows the relevant architectural elements. The 'language' component, or more particular the semantic model, (Digital Transport and Logistics Forum, 2022) is accessible via the federatedplatforms.eu – developer portal.

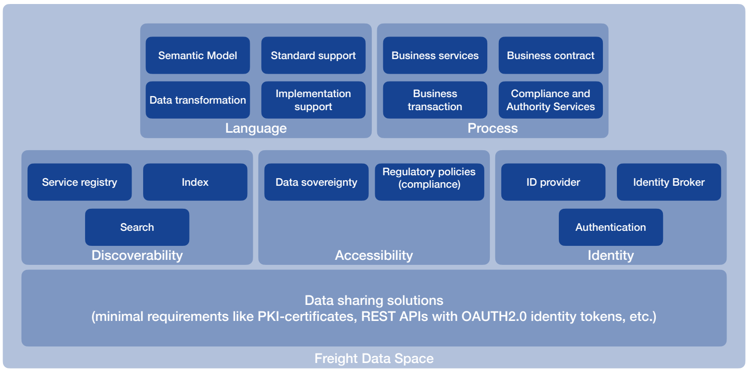

Fig. 3. Architectural elements of the DTLF (Digital Transport and Logistics Forum, 2022)

The main assumption is that there are many data sharing solutions, if they support agreed connectivity protocol(s) and certain functionality, for instance to support non-repudiation by means of a log and audit trail of what has been shared between two indexes. The service registry of the architecture specifies the events that can be provided by a data holder, including the data sets that are accessible via links shared in those events. These data sets can represent business (document) data sets like a transport order or an electronic document (eCMR) or data of an asset (e.g. a dangerous goods classification of the cargo).

3.2. Applying the architecture to eFTI

The requirements formulated in the previous section and the conclusion that a trip (or more general 'itinerary') is the basis for implementing eFTI is the basis for implementing eFTI. A truck driver will have the relevant itinerary data and a link to the business data set. This is shown by the following sequence diagram.

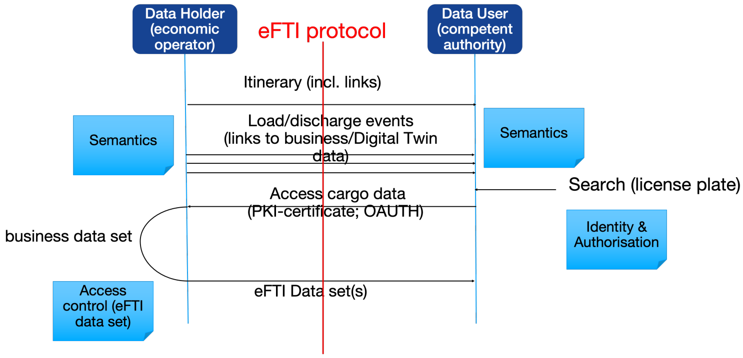

Fig. 4. Basic sequence diagram for eFTI

The data that is shared between an economic operator and competent authority is called the 'eFTI protocol'. It specifies the expected behavior of both roles with respect to eFTI. The figure shows that itinerary data is shared to the relevant authorities. These authorities only need to receive that part of the itinerary that describes the cargo that is moved within or in/out their domain. They don't have access to any cargo data in the domain where they have no competency. This is the goal binding principle (FEDeRATED, 2021). The figure also show search by authorities on 'license plate'. This can be a license plate of a truck or a trailer. In case of roadside inspection, a link is provided by a truck driver, there is no search on the index required. This search is only for remote inspections where license plates are the search criterium.

The itinerary contains all places of call, where data will be loaded and/or discharged. Each actual load and discharge is included separately, with a link to where data is stored. There can also be links on cargo level, providing access to for instance dangerous goods classifications. It allows a competent authority to access all data of a consignment or data of individual pieces of cargo. Sharing the itinerary and load/discharge events enables a competent authority to also validate aspects like cabotage, where a truck is allowed to transport limited number of consignments on its return trip. This implies that a decoupling between transport operation and its monitoring by competent authorities based on regulations is achieved.

Complexity is introduced in case the business data set is stored in a (cloud) IT system of a transport service buyer. A carrier can provide the link to this data, but a competent authority can only have access via a carrier. A carrier is also the one known to a transport service buyer; the latter may also not know the license plate of a truck transporting its cargo. Although a carrier acts as data holder towards a competent authority, the provenance of the data is with the transport service buyer. A carrier must forward the query of a competent authority to a transport service buyer.

3.3. Deployment by nodes

The proposed deployment is by providing all relevant stakeholders with a so-called node that implements the eFTI protocol. The following figure decomposes the previous sequence diagram by introducing such a node. These nodes are called 'Basic Data Infrastructure' (BDI) nodes, in line with the Dutch Digital Transport Strategy (Dutch Minstry of Infrastructure and Water , 2022).

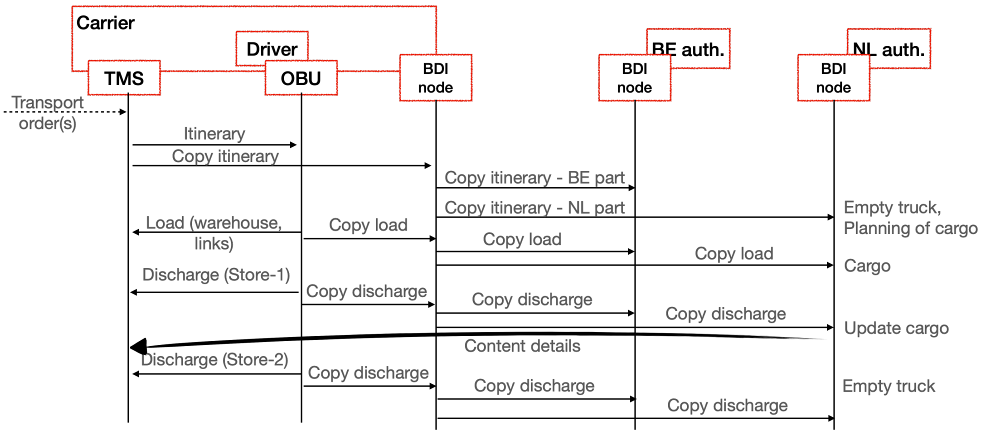

Fig. 5. sequence diagram including BDI nodes

The previous sequence diagram is an example where an itinerary crosses the Belgium and Dutch border. A carrier has a single BDI node which distributes the relevant parts of the itinerary and load and discharge operations to a competent Belgium and Dutch authority.

A BDI node consists of two components, namely one that is the index and the other that provides peer-to-peer data sharing as a data sharing solution identified by the DTLF architecture. The index is implemented by a triple store, namely GraphDB. The triple store implements the complete semantic model, which is an ontology represented as a turtle file. The access to cargo details provided by a BDI node to a competent authority, i.e. the eFTI data that is required by a competent authority, is represented as a subset (a 'view') of the semantic model. The connectivity is implemented by Corda (www.r3.com). Corda is peer-to-peer data sharing solution implementing Transport Layer Security (TLS) and the Corda protocol. It uses a notary network for non-repudiation, providing a blockchain. Corda has a network management facility that allows registration management of a Corda node to the network. Each registered node can be used for peer-to-peer data sharing. It enables rapid on-boarding of new stakeholders to the network. Both GraphDB and Corda are freeware, meaning that everyone can apply them. When constructing a robust infrastructure, most likely the commercial version of these software components are required.

4. Conclusions and further work

We have developed an artefact, the BDI node, and its interfaces, the eFTI protocol, to support the eFTI Regulation. The proposed solution optimally uses data that is already shared by enterprises like itinerary data and load/discharge events. Thus, implementation of the eFTI Regulation should have minimal impact for business. The BDI node and the eFTI protocol are an implementation of the DTLF Architecture. Although not provided in this paper, details of the eFTI protocol can be made available. Next steps are to validate the artefact in a practical setting with multiple carriers and competent authorities and to align the artefact with the eFTI Regulation Implementing – and Delegating Act.

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