Innovative Data sharing in logistics, migrating from UN/EDIFACT to the OpenTripModel

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ABSTRACT

System interoperability is an aspect of IT systems, it describes the ability of two or more IT systems or components to exchange information and use the information that has been exchanged. Within the logistics sector system interoperability is not well established between companies due to the way data is stored and communicated. Electronic Data Interchange (EDI) has been the main practice of sharing data between companies in the logistics sector. This paper focuses on the interoperability challenges observed with the UN/EDIFACT data standard and dives into the feasibility and applicability of the OpenTripModel as an alternative. The aim of this paper is to be a contribution to the body of knowledge regarding the decision-making process of migrating from an EDI-based data standard such as UN/EDIFACT standard to an API-based data standard such as the OpenTripModel.

Keywords

Logistics, Interoperability, EDI, EDIFACT, OpenTripModel, OTM, Innovation, API, Data sharing

1. INTRODUCTION

The logistics sector is a network where multiple parties work together like a chain. Shippers share information about cargo conditions and loading/discharging windows, Transporters have information about the actual location of trucks, origins, and destinations. Governments have information about environmental zones, time windows, and load/discharge locations. For a successful transfer of goods and services, these parties need to work and communicate with each other. The sharing of this kind of information is either done by IT systems, spreadsheets, emails, PDF's or telephone. This is a time-consuming process where the shared information is not always on time, correct or complete.

The demand for standardization in data interchange is more present than ever. Data collection more than just storing data, it is becoming important for the decision-making processes of companies, but can also be used for real-time tracking. In 2016 the International Data Corporation estimated that data-driven companies with real-

time visibility and predictive analytics would be $430 billion more productive than their competitors[20]. To be able to profit from these new technologies it is of key importance for transporters, loaders, and software suppliers to innovate such that they will not miss out on these new technologies and lose potential revenue.

Historically, within the logistics sector is there have been two data standards dominating the market. For the European market, this is the United Nations rules for Electronic Data Interchange for Administration, Commerce and Transport abbreviated as UN/EDIFACT, whereas for the American market this is the Accredited Standards Committee X12I chartered by the American National Standards Institute abbreviated as ANSI ASC X12I. Both standards are very similar regarding the structure and when they were invented, but use different terminologies. This paper has its main focus on the UN/EDIFACT protocol, but due to the similarities will be applicable to ANSI ASC X12I as well [3]. Both are Electronic Data Interchange (EDI) standards, which implies that the data is written in files which are then shared through E-mail or (S)FTP.

By now it is safe to assume that UN/EDIFACT is outdated. One of the main problems is that within UN/EDIFACT there are multiple ways to portray the same data. This depends on the design choices made by every organization individually in the implementation process of the standard. There are no clear conventions on how to write the data elements of a message written in UN/EDIFACT syntax, and occasionally different message types can be used to describe the same logistical event without deviating from the standard. This leads to different interpretations of the standard leading to custom implementations making it challenging for different organizations to integrate their IT systems with each other. To achieve system interoperability, incoming messages need to be fully understood by the receiving system. As every organization can have their own custom implementation of UN/EDIFACT, custom data-parsers need to be written before the receiving system can understand the incoming message.

Currently, there are alternative solutions to EDIFACT such as the OpenTripModel (OTM). The OTM is an open-source data model where unlike EDIFACT data is always portrayed in the same format. The model is designed to be easy to integrate and it supports functionalities like real-time collection and insights of logistics data by using REST full web services instead of E-mail and (S)FTP. The OTM model is maintained by the Stichting Uniforme Code Transport (SUTC) a non-profit organization for the logistics sector with the aim of supporting interoperability between actors in the industry by setting data standards. This paper will focus on the OTM model as an alterna-

tive to UN/EDIFACT, but can also be applied to similar models alike.

The first part of this paper consists of the background in which EDI and UN/EDIFACT are laid out together with the interoperability challenges observed with it. In the middle part the OTM model is analyzed, where it is shown how it can be used for real-time data sharing and how the model is structured. At the last part the potential of data sharing in logistics is laid out together.

2. BACKGROUND

2.1 Logistics Software Systems

A typical software solution for managing an organization active in the logistics industry is an Enterprise Resource Planning System (ERP) which consists of a Warehouse Management System(WMS) and a Transportation Management System(TMS). Multiple ERP systems are connected to each other through a Supply Chain Management system (SCM). The differences between an SCM and ERP are becoming less and less visible as more and more ERP systems support multi-site capabilities, cross-site planning, and processing functions enabling ERP systems to manage a supply chain without an SCM[13].
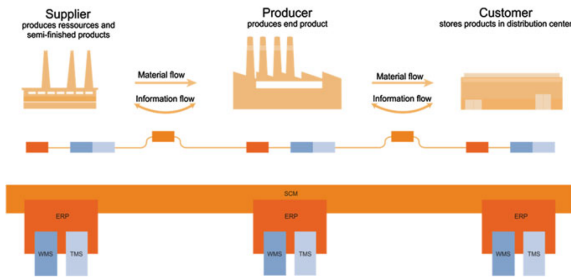

Figure 1. A. Nettsträter et al [13]

2.2 EDI and UN/EDIFACT

Electronic Data Interchange (EDI) is a practice used for non-human data interchange with relation to business transactions between collaborating organizations. Within logistics EDI is used between TMS and ERP systems to send transport orders an communicate status updates of a pack of goods during the transportation process. The first step of implementing a successful EDI is choosing a standardized data format. These formats are generally defined and maintained by Standard Development Organizations (SDOs) directed at a specific domain or industry. Within logistics, the most predominantly used data standard is UN/EDIFACT maintained by the United Nations Centre for Trade Facilitation and Electonic Business (UN/CEFACT). UN/EDIFACT was developed by the united nations and approved by the International Organisation for Standardization (ISO) in 1987 as the ISO9735 standard [16]. After its release it soon became famous and the UN/CEFACT extended the standardized format to other industries such as healthcare, insurance, law, construction, production, and the tourism branch. Every EDI data format is built on the four pillars depicted in figure 2. The syntax refers to the structure, a data element is the smallest unit within an EDI file, whereas a segment is a group of similar data elements. Finally, a message is a sequence of structured data segments.

2.2.1 EDI B2B integration
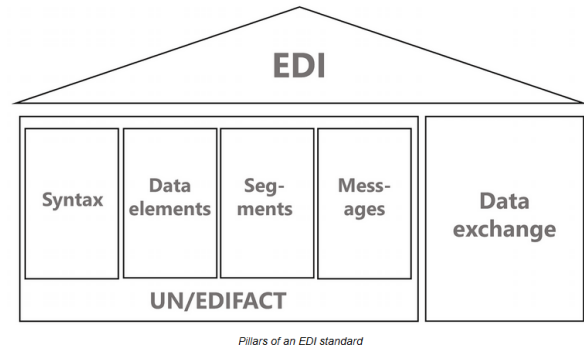

Pillars of an EDI standard

Figure 2. Edifact Pillars [7]

The contents of EDI messages are written and stored in files where the extension used is irrelevant, this can be JSON, PDF, EDI, or even TXT. EDI messages are shared through flat file communication, typically through E-mail or (S)FTP. Incoming EDI messages are first sent to the parsing module, which dissects the incoming message such that it can be understood by the system. The difficulty of writing this parsing module depends on the standardized data format and design choices made when the standard was implemented.

```
1  UNH+3536+IFTMIN:D:95B:UN'
2  BGM+340+MEDUDN469074+9'
3  MOA+7:84.00:EUR'
4  FTX+DIN+++pu 25/5 - dgd'
5  RFF+BN:MEDUDN469074'
6  RFF+TON:3602195 5351572'
7  RFF+BM:MEDUDN469074'
8  RFF+CAO:WDP010T0120521001'
9  GOR+2'
10 TDT+20+NZ118A+1+++++3FWL4:::MSC JULIE'
11 DTM+62:202105171400:203'
12 LOC+9+ZADUR+:::DURBAN,SOUTH AFRICA'
13 TDT+30++2'
14 NAD+IV+MSC BELGIUM'
15 NAD+CA+MSC'
16 NAD+MS+MEDLOG TRANSPORT'
17 CTA+IC+Yasmine De Bruyn'
18 COM+yasmine.debruyn@medlog.be:EM'
19 NAD+SF+BEANRTH++MPET DEURGANCKDOK+SINT
   → ANTONIUSWEG+ANTWERP+BELGIUM+9130'
20 NAD+ST+NLWDPAB++WESTDORPE 3MCT+AUTRICHEHAVENWEG
   → 10+WESTDORPE+NETHERLANDS (THE)+4554 MB'
21 GID+1+960::::BAG'
22 PIA+5+310250::169'
23 FTX+AAA+++SODIUM NITRATE'
24 NAD+DP+++SQM HOLLAND BV+AUTRICHEHAVENWEG
   → 10,:-+Westdorpe+NETHERLANDS (THE)+4554 MB'
25 DTM+2:202105260000:203'
26 MEA+AAE+G+KGM:24660.0000'
27 DGS+ADR5.1+1498++3+++++5.1'
28 FTX+AAD+++SODIUM NITRATE - -'
29 MEA+AAE+G+KGM:24660.0000'
30 EQD+CN+MSDU1025750+2210:::20' DRY VAN 8'6'+++5'
31 MEA+AAE+AAL+KGM:24660'
32 SEL+FX13558917+SH'
33 FTX+SIN+++.'
34 FTX+CUS+++Transit:T1 uitgesteld door klant'
35 NAD+CM++SQM HOLLAND BV;AUTRICHEH AVENWEG 10:,;4554 MB,
   → Westdorpe'
36 NAD+DP+++SQM HOLLAND BV+AUTRICHEHAVENWEG
   → 10,:-+Westdorpe+NETHERLANDS (THE)+4554 MB'
37 DTM+2:202105260000:203'
38 UNT+38+3536'
```

This message represents a delivery instruction to pick something up at the 25'th(4) of March from the port of Antwerpen(19) in Belgium and transport it to Westdorpe(20), a village in the Netherlands. The package is 24660 KG(29) of Sodium Nitrate, a type of salt. The salt was shipped

overseas by the Mediterranean Shipping Company Belgium(14), the issuer of the instruction is Medlog Transport(16), a logistics company specializing in container inland shipping.

All of this information is written in the data elements of the message at the last part of every line. Data elements transmitted in EDIFACT messages do not always have equal semantics. Medlog Transport could alternatively have used the UN/LOCODE instead of the address of the port on line 19, for Antwerp this would be BEANR. Line 12 could be changed to South Africa, Durban instead of the other way around, or they could have used GPS coordinates for all the addresses mentioned in the message. Instead of Sodium Nitrate, they could also have used NaNO. 3; the chemical formula depicting sodium nitrate, or Peru saltpeter, Soda niter, or cubic niter which are some of the other names for sodium nitrate. These differences address the problems observed with **semantic interoperability** in the logistics domain.

The semantics of a singular data element can be depended on the semantics of another data element[5], if KGM was not specified on line 26 we would not have known that the weight was depicted in kilograms, but we would still have known that the product shipped is salt, so it would still be possible to make the right guess identifying SODIUM NITRATE as salt and knowing the substance. Data elements on which other data elements' semantics are dependent are called qualifiers. In this case, the Salt is a qualifier, its semantics tell us something about the unit of measurement used in the data element of line 26. As the data elements are undefined and therefore custom-built, they are impossible for a system to read without a custom parsing module. The most difficult data element of this EDIFACT message can be read at line 4: "pu 25/5 - dgd". Using the documentation of EDIFACT we can know that IFTMIN is a delivery instruction, using logical reasoning we can assume that pu is an abbreviation for pick up, but without more context, it is hard to understand what 'dgd' abbreviates.

Even the message type could have been different whilst still correctly following the UN/EDIFACT standard. Instead of an IFTMIN message, they could also have chosen to send an arrival notice (IFTMAN) or a container announcement (COPARN) message. None of these options would have been false, the message would still describe the same logistical event, but in a different way. Within UN/EDIFACT for transport, the IFTMIN messages are the hardest to read, as an instruction message could be anything.

2.2.2 EDI data sharing

The different possibilities of denoting the same logistical event whilst still following the standard addresses the challenges opposed with the standard regarding **semantic interoperability**. Semantic interoperability denotes the ability of different IT systems or applications to understand exchanged data in a similar way. As the data elements are undefined within the UN/EDIFACT standard and therefore custom-built, they are impossible for a system to read without a custom parsing module. When two organizations using UN/EDIFACT want to achieve interoperability, the parsing module will need to be hard-coded to understand the semantics and the choice of message types for different events. This needs to be done for every singular collaborator an organization wants to integrate their IT systems with.

EDI messages are sent through flat-file communication,

the messages are written in files that are shared through FTP or E-mail to the integration component. The integration component will then parse the message, such that the ERP system of the receiving party is able to read the message. The integration component awaits EDI messages to be parsed by a polling interval, which in most cases is 15 minutes. Every 15 minutes the integration component will send an information request to the connected parties, asking if they have EDI files ready to be parsed. Every time an information request is processed, a new connection is established using the right (S)FTP credentials. After the information request is finished the integration module will disconnect from the (S)FTP server. The polling interval causes a delay in data sharing which can not be worked around with using this technology. Reducing the polling interval to a lower number could potentially overload an FTP server, as authentication and retrieving the available files take a load on the FTP server. Keeping the FTP connection open is not an option either, once a connection has established the directories of the connected party are read as-is, to check if new files uploaded to the directory you would have to refresh the connection and there is a limit of 500 concurrent connection per FTP server. Therefore, there will always be a delay when using (S)FTP, making real-time data sharing impossible.

2.2.3 The Extinction of Edifact

EDI revolutionized how organizations exchanged information which each other, its impact was enormous on a global level. Information shared by paper or telephone before could now be communicated automatically without any human interaction necessary. EDI enabled companies to automate high-volume communications allowing their staff more time to focus on more profitable tasks and provide better customer service due to the better supply chain visibility. Another byproduct of EDI was a reduction in data entry mistakes as humans tend to make mistakes from time to time. But now we have arrived at a time of Big Data, Internet of Things, REST-full web services, Block-Chain and the industry is still stuck with a standard which was first released in 1988 and uses technology invented in 1971 (E-mail and FTP). To this day EDI is the default way of how logistical businesses communicate freight information with each other. In 2015, 200 executives from supply chain and logistics were surveyed on EDI and what they think would be the future of data interchange. 85% polled to still be using EDI of which 43% responded that they are frustrated with EDI. Of the 57% who were not frustrated, there was however still a strong sense between them that the days of EDI are numbered. Furthermore, 55% polled to be considering web services APIs as an alternative to EDI[18].

One of the reasons for the frustration experienced by the supply chain and logistics executives originates from the complexity and high maintenance costs of using legacy EDI systems identified in the previous paragraph. There have been numerous attempts to create successor systems to UN/EDIFACT, the first attempts of changing towards another way of modeling data enabling the use of newer technologies were after the internet boom in the early 2000s with the introduction of XML-based EDI standards. How to model UN/EDIFACT in XML was officially defined by ISO TS/20262 in 2002 and was introduced as XML/EDIFACT. XML/EDIFACT is a combination of the vocabulary of UN/EDIFACT and the syntax of XML. It is a far more superior format for electronic business transactions than the clunky flat-file formats used by UN/EDIFACT[9], but has never really taken off. Examples of other XML-

based EDI projects conducted before 2005 are ebXML in 1999 [14], Universal Business Language (UBL) in 2004, Context Inspired Component Architecture (CICA) in 2002 [3], the Open-EDI reference model in 1997, Unified Modeling Language (UML) for EDI XML , the eCo Interoperability Framework Specification of 1999, Commerce XML (eXML) and the Common Business Library (xCBL) in 2003[19]. This is quite an extensive list of flopped XML-based EDI attempts. Because of XML, all of these attempts are designed with a syntax-based approach in which semantics are rarely addressed causing the same interoperability problems to prevail as seen with UN/EDIFACT[6]. The main reason why these successors have all flopped was that the urgency of switching to a new data standard was not high enough and the solution too complex. But where this was the case more than a decade ago, now is the moment to accelerate the agenda of data sharing in logistics in the context of digital transformation and sustainability[8].

One of the main benefits of having higher interoperability is to be prepared for integrating new applications, which is ultimately about enterprise evolution. We are at the start of the fourth industrial revolution (industry 4.0) powered by the Internet Of Things opening up business opportunities in automation, big data analysis, and real-time supply chain visibility. UN/EDIFACT is defined for interoperability on a syntax level with respect to transport orders, such as costs, estimated time of arrival, and customs approvals. The technology necessary for real-time data sharing is incompatible with UN/EDIFACT, and the messages for this kind of data is non-existent within the standard. UN/EDIFACT is defined for industry 3.0, powered by the birth of the internet and the rise of computer networks such as WAN/LAN. Switching to a new data standard is not only about easier b2b communication anymore, but rather about preparing your organization for the future (industry 4.0). Because UN/EDIFACT and the technology behind EDI has no future prospects, it is not the question of whether UN/EDIFACT will be discarded as a data standard, but rather the question of when.

3. OPENTRIPMODEL

A proposed API-based alternative for EDI data sharing is the OpenTripModel(OTM). The OTM model was initially developed for data sharing with control towers[10], the central point within a supply chain which has the overview of all logistics flows. The first versions of the model were developed by Simacan, a dutch company offering software solutions to some of the largest players in the logistics branch of the Netherlands, such as PostNL or Ahold Delhaize. In 2017 the model was handed over to the Stichting Unifrome Transport Code (SUTC), a Dutch non-profit organization with the aim of supporting safe and efficient data sharing within the logistics industry by setting data standards[1]. With help of subsidies of the dutch ministry of infrastructure, it was developed further and made available as an open-source data model with OpenAPI specification. The OTM model is the first one of its kind which is directed towards data sharing between not only companies, but also government bodies. The idea behind including government bodies in the data model will make it possible to whilst planning routes directly see all restrictions regarding road narrowness, height limits, environmental zones, road maintenance and real-time traffic jams. This paper covers OTM 5.0 which was released on November 2020, but is also applicable for OTM 5.1 which is a minor update on the model released during the writing of this paper in June 2021.

Figure 3. :
OTM 5.0 data model

3.1 The structure of OTM

The fundamental idea behind the OTM is splitting data into static and dynamic data where the interaction between them is decoupled. Static data is data that rarely changes, this could be the location of a building or the characteristics of a vehicle, such as max capacity, width, and length. Dynamic data is the data that does change all the time, such as the real-time location of a vehicle.

The OTM model is built upon the concepts of life cycles, entities, events, and actions. Life-cycles, depicted in green in the outer circle of figure 3 refers to at which point in time certain data was modeled with respect to a logistical process. Distinguishing these life cycles enables companies to look at their operations from different perspectives [15] The model has multiple entities of which the base-entities are portrayed in yellow in Figure 3, besides these base-entities, there is the transport order, consignment, and an entity used to model documents. A consignment entity describes the goods to be transported between consignor and consignee, whereas a transport order describes multiple consignments grouped together.

The model is specified for JSON language, every entity has their own specific id or UUID and can be treated as objects and referenced back to. All static entities can live in multiple life cycles by keeping the same ID. This allows the user of the model to watch their logistic processes from different perspectives. Entities modeled within the realized life cycle can be used for Billing whereas data modelled in the planned life-cycle can be used for the decision-making process of accepting transport orders.

Events and actions can only live in one life cycle. They are the centerpieces of the model and enable real-time data sharing of sensor data and logistical processes. Events are used to give updates on earlier provided data and are used for real-time data sharing of the status of a **singular** entity. In total there are ten events defined of which seven relate to the vehicle entity (i.e. *locationUpdateEvent, startMovingEvent, stopMovingEvent, startWaitingEvent, startEngineEvent, stopEngineEvent and sensorUpdateEvent*). Then there is the *updateEvent* to update the static data of an earlier provided entity, this is for example used when

an adjustment is made to the route entity due to a traffic jam whilst a vehicle is driving.

In contrast to events that focus on real-time data sharing with respect to one entity, actions are used for real-time data sharing with relation to multiple static entities coupled together (i.e *Stop, Load, Unload, handOver, Move, attachTransportEquipment and detachTransportEquipment action*). The *load* action is used to couple multiple consignments to the vehicle transporting them, a handover action couples the transfer of consignments between actors, and a move action multiple couples multiple locations to a vehicle. When a move action is modeled during or after a logistical operation (i.e. during the actual/realized part of the life cycle), then the information can be retrieved from real-time sensors, which are shared as events. All though events are conceptually different from entities, they are modeled just like any other entity in the model and can therefore be seen as an entity. An action is the coupling of multiple entities together, thus the move action is an ordered list of event entities.

3.2 OTM profiles and Hierarchy

Whereas UN/EDIFACT is structured as a tree with a strong hierarchy of dependencies and an over-extensive-catalog, the OpenTripModel is structured as a graph with multi-directional interaction between the different entities. At first this can be overwhelming, but this makes it easier to model the different use cases. Depending on the use case, the viewpoint might change and another entity can become top-level in which the other entities are nested. As every organization's supply chain is organized differently it is impossible to model all fixed workflows without losing flexibility. This amount of flexibility is perfect when developing complex IT systems with a specific workflow, but can be a pitfall regarding **ontological interoperability**. The ontological aspect of interoperability tell us something about how objects defined in the model relate to the other objects.

Although all data is modeled the same way within the model, the relationships between the different pieces can differ. Without clear conventions on how to model specific use cases, this could lead to companies modeling the same data, but with a different ontology which would eventually result in them still not being able to communicate with each other. To combat this problem various profiles are constructed designed for specific use-cases. These OTM profiles are a stricter set of rules on top of the model to ensure that specific messages have a clear intent and are unambiguous. These rules define the hierarchy of entities and have more specific rules for addressing required fields which are optional in the official specification. Each profile describes which entities are involved and what data fields are required within each entity. Before two companies can communicate using the OTM, they have to agree upon which profile they are going to abide by.

By following a profile for specific use cases the OTM model can be used for b2b communication. Right now there are three OTM profiles defined, but it can be expected that more will released in the future as the concept of an OTM profile was first released in OTM 5.0 which was released in November 2020. Current profiles exist for the interchange of transport orders between a carrier and shipper, trip monitoring, and VESDI for data sharing between IT systems used in the logistics industry and institutions for statistics.

A transport order is generally the first communication between a carrier responsible for transporting the goods and a shipper consisting of a request for a consignment of goods. The Transport Order profile is structured in such a way that the top-level element is the TransportOrder entity, whereas the goods transported are at the bottom of the hierarchy. In the profile, a consignment must have at least one goods entity, one load, and unload action which both must have a location. This is initially the type of message of which all revenue is made for companies offering logistical services. Transport orders are defined in UN/EDIFACT as an ORDERS message, but when using the model, custom integration would not be necessary anymore lowering the threshold for organizations to establish new partnerships.

After implementation of the Transport Order profile, it can be used as input for the planning of trips in the Trip Monitoring profile. The top-level entity of the profile is the trip entity, the profile is used to model trips of vehicles visiting multiple locations where it does multiple actions. Implementing the Trip monitoring profile in an IT system is the innovation enabler for better supply chain visibility using GPS data. If the GPS system is compatible with the model or has resources available to support the model ensuring compatibility, connecting the GPS system to a vehicle entity will be an easy process. This can be done by modeling the vehicle and sensor entities after which they can be coupled by sending an associationCreated event to the OTM server. After this is done, the GPS system needs to be configured with the right credentials and the UUID of the vehicle, and the interval of sharing data.

```
1    {
2    "id": "e3260867-f47c-4f5a-9d0d-a8d5b81cfe6b",
3    "lifecycle": "actual",
4    "vehicle": {
5      "uuid": "34ace8e4-925b-47c2-a3e6-2d18d406a5a5",
6      "entityType": "vehicle",
7      "associationType": "reference"
8    },
9    "geoReference": {
10     "lat": 2,
11     "lon": 3,
12     "type": "latLonPointGeoReference"
13   }
14 }
```

After the configuration is done, the GPS system can continuously send GPS updates by sending PUT requests to the OTM server

The last profile is the VESDI profile, VESDI is an abbreviation for Vehicle, Emission, Shipment, Data, Interface. The profile defines a hierarchy for modeling realized trips with the OTM model including the vehicle, goods transported, and fuel consumption. The profile is designed for interoperability between IT systems used in the logistics industry and institutions for statistics such as the CBS in the Netherlands. This can be interesting for Dutch companies as CBS has a mandatory survey that has to be filled in by logistical companies on a yearly basis. Right now these surveys are filled in by hand through a web-from, but the VESDI profiles can automate this process. For bigger companies, this could be an incentive to implement to model as the size and amount of work necessary to answer these surveys depend on the number of vehicles an organization has.

3.3 Implementation of the OTM

The OpenTripModel can be used to model both the enti-

ties in the TMS and WMS of an organizations' ERP system [11]. The complexity of implementing the model will heavily depend on the piece of software and organization it needs to be implemented within and the motivation behind implementing the model. The complete model does not have to be implemented within a system, just the objects and use cases that are relevant to the organization. Then there is the choice of implementing the model within existing TMS, WMS ERP systems replacing their current data structure or using a middleware solution that acts as a bridge between the model and structure of the IT systems.

When the motivation of implementing the model within a company is to only be able to receive and send transport orders to and from collaborating organizations who have already implemented the model, then just this part has to be implemented. Integrating this OTM profile means by means of using middleware is relatively cheap. The mandatory elements necessary is a consignment entity which must have at least on goods item, and one load and unload actions which must both have a location. Sending transport orders, containing the same information already exists in most IT systems for the industry, as transport orders is in the scope of UN/EDIFACT and is the first line of communication when ordering logistical services. Once a middleware component is developed with respect to an OTM profile targeted at a specific TMS system, then other companies using the same TMS system can use the same piece of middleware, as data is always modeled the same way and the hierarchy of entities are defined by the profile. Therefore implementing this use can be rather cheap, as there is no extensive amount of custom integration necessary.

When the motivation of implementing the model within an organization is to prepare themselves for the future by enabling the use of real-time visibility through sensors powered by the Internet of Things, then the implementation process will be more extensive. The OTM model is open-source and specified in Swagger, an open specification for defining REST APIs. The specification lists all resources and operations which can be called upon them, furthermore all parameters and whether they are optional or required are specified as well. The Swagger Codegen project can generate a Software Development Kit (SDK) in various languages including Objective-C, Python, and Java from a Swagger specification [17]. This enables auto-generation of stub code for the whole model, saving a tremendous amount of time in the implementation process. Again, the complexity will depend upon the complexity and hierarchy of the IT system it is implemented within, but the auto-generation will ease the implementation process. The Swagger UI enables developers to test their implementation of the model by sending GET and PUT requests as of where the specification is hosted, offering a testing platform to confirm whether the model was understood correctly.

3.4 Interoperability with the OpenTripModel

The OpenTripModel acts as a dictionary, wherein EDIFACT the data elements in a message are undefined, within OTM all relevant data within the model are defined, addressing the semantic interoperability challenges observed with UN/EDIFACT. Referring back to the EDI message in section 3.1, the location and unit of measurement would be relevant data and therefore defined by the OTM model. When a location is shared between a TMS, WMS or other systems, it is of importance that the systems have the ability to understand exactly the input of these fields, they are relevant for route planning and knowing which vehicle has enough capacity to transport them. On the other hand, again referring back to the example, the way of how to denote Sodium Nitrate is not defined by the model. Modelling all these things would make the model way too extensive and the implementation process way to to complicated. The height, weight, length, quantity for goods are defined by the model, together with potential extra information regarding the transportation of dangerous goods. When all these properties are known, then it is not of importance if a company used Soidum Nitrate or Peru saltpeter has been used as the description of the good. By doing this, the model tackles the problem of semantic interoperability, without being fully semantic interoperable to keep flexibility and simplicity. The semantic interoperability of relevant data saves a tremendous amount of time and money regarding the integration process necessary for two companies to achieve interoperability, when implemented right, integration of two companies can be as simple as creating API keys and exchanging them. Authentication itself is outside of the scope of the OTM model, the documentation does recommend the use of Bearer authentication, also known as token authentication.

Establishing a secure connection takes time and money, agreements between both parties have to be made on how to recognize users on machines(authentication) and which data should be made available. This is where the iSHARE scheme comes into play, the iSHARE scheme is a set of data sharing agreements that enables organizations to allow access to their data using the OTM model. All parties using the iSHARE scheme in combination with the OTM model do not have to set new agreements with each other regarding authentication and authorization and have control over which data they share and to whom. By using the agreements scheme, the process of negotiation on how and what to share is eliminated, saving money in the integration process. Transfollow can be used to facilitate the legal exchange of consignment notes, transport orders, and invoices, also known as e-CMR between logistics partners using the OTM model.

The model can be used to integrate the TMS with the Fleet Management Systems of commercial vehicles. Every transporting vehicle has an FMS system, the FMS is a standardized interface for data of commercial vehicles, it keeps track of all system properties of the vehicle such as engine properties, speed, acceleration, and GPS location. The first to have developed this integration was a collaboration of the TMS supplier Filogic together with the FMS supplier Data2Track. Besides real-time data sharing this implementation involves status updates supplemented with answers from the driver as well, introducing an interactive aspect between the driver and the TMS.[10].

Government bodies in the Netherlands have made real-time data available on municipality and road authority information as a pilot in 2018. This is information such as road diversions, traffic jams, or environmental zones. When planning a trip, information is directly available on what vehicle to use and what to expect. As this information is available in real-time, the TMS and FMS systems have real-time access to this data. The TMS can use this for planning the trip, but if new information comes up during the trip, then the TMS can communicate this to the FMS and change reroute the navigation in order to prevent delays.

When an organization decides to switch over to the Open-TripModel, that does not imply that the other parties it collaborates with would do the same. The other parties are still used to EDI communication and expect the same from the organization that switched over to the new model. This is not a problem, as the OTM is a data-sharing model that can be disconnected from the internal Enterprise Resource Planning of a company as a middleware solution, it can still and receive and send EDI messages just as it did before. An organization can choose to run the OTM parallel to its old data model. The OTM could be used for its internal business communication, effectively enabling real-time tracking of events such as loading/unloading or GPS location, and then construct an EDI message and use existing channels whenever there is an update in the OTM lifecycle.

During the development phase of the OpenTripModel, the developers took several other existing standards into account. The developers wanted to make the model as simple as possible and choose to re-use some aspects of other models or refer back to them. This prevents unnecessary translation between other standards. Datex II codes can be used to identify traffic warning types in events. The dynamic traffic management aspect of the OTM model was inspired by the DVM-Exchange standard, TransFollow can be used for the exchange of consignment notes and can be referred back from the Shipment entities and several IDs used in the GS1 standard refer back to the different entities in the model. his prevents unnecessary translation between other standards and has the advantage of familiarity.

The question of whether the OTM model will be the new default is something only time can tell. Maybe there will be a segmentation of different models designed specifically for different types of Transport, such as overseas, freight, aviation, or train transport. As long as the other potential models would be similar in the sense of having defined the relevant semantics addressing the problem observed with UN/EDIFACT. No semantic customization implies that an universal data parser could be used instead of a custom built one. Ontological Interoperability can be achieved with other data standards on condition that they have a defined hierarchy or use profiles like the OpenTripModel. If two different data models both use a different hierarchy, but one which is defined, then the universal data parser can be developed in a way such that it can translate between the different hierarchies and still achieve perfect interoperability.

4. THE POTENTIAL OF DATA SHARING IN LOGISTICS

Data sharing within logistics has been a topic since the beginning of this century. Whilst 10 years ago the solution regarding data sharing was too complex and the need not high enough, now would be the moment to accelerate data sharing within logistics [8]. The world is changing towards a networked society enabled by the Internet of Things. There is huge potential in real-time sensor-data-sharing throughout the whole logistical supply chain, which companies are starting to pick up on. For this section, we are approaching the benefits of a Utopian situation where the logistics sector has switched over to a truly integrated transport system described by the Alliance for Logistics Innovation through Collaboration in Europe [2]. A truly integrated system is a system where all parties

involved in every logistics chain are integrated with each other through one main hub or other technologies. All organizations speak the same language, the integration will work seamlessly and full interoperability is achieved between all organizations in the sector.

Based upon our own general observations during this research we have categorized the potential of having an agreed-upon-market-wide model from a singular companies perspective in four categories:

- Integration costs
- Efficiency
- Big data Opportunities
- Sustainability

EDI comes with high integration and maintenance costs, whenever two companies active in a supply chain want to connect their TMS systems together, this needs to be done by a third-party integration specialist. In a truly integrated system, there will be a huge cut on these costs. Hard-coded b2b integration would not be necessary anymore, once implemented achieving interoperability can be as easy as exchanging two API keys. Achieving flawless interoperability using EDI b2b communication is a complex process that takes time and money, resulting in a certain threshold for new partnerships. Removing these limitations to integrate with new companies will have a positive impact on the flexibility of the market, leading to an increase in competitiveness, from which loaders, consumers, and new companies entering the market will profit.

Due to the lack of overview within the logistics sector, the system is inefficient. In 2009 research was conducted on the role of logistics and transport for reducing carbon emissions by the World Economic Forum [4]. Optimized networks were identified to be a category with high potential regarding both sustainability and efficiency. For long-distance transport, Euro stat surveys estimated that 24% of all vehicles transporting goods in the EU are running empty. When the vehicles are non-empty they are on average only loaded 57% of their maximum capacity, ending up at an overall efficiency of 43%. It is estimated by the ALICE that a 10%-30% improvement would potentially equal €100 - €300 billion economic relief in Europe. Flow in balances can only explain half of the loss in efficiency ending up with an opportunity estimated at €160 billion for Europe [2].

The networked society powered by the Internet of Things opens up valuable opportunities for companies. When a company capitalizes on these opportunities, it will have a strategic advantage over its competitors. Companies will be able to distinguish themselves from companies that still use EDI as being an innovative company. By implementing the OTM model companies will be able to give better and more extensive information to their customers distinguishing themselves as a company that offers better service. On the other hand, this data is also to value of for the company itself or the supply chain it is active in. Logistics providers maintain an enormous flow of goods, when monitored in real-time this will create huge data sets which can give logistics organizations insights they would not have before. Big data analysis opportunities

can aid companies to give new insights in supply chain risk management, service improvement, customer loyalty management, last-mile optimization, and strategical and operational resource capacity planning [12]. A conceptual mapping study has been conducted on Process Mining possibilities with the OpenTripModel showing how the basic requirements for process mining are met by the model [15].

5. DISCUSSION

EDI communication has established itself as the default for b2b communication since its introduction in 1987. From the industry, it is clear that there is a desire to innovate away from old standards such as UN/EDIFACT towards a better alternative such as the OTM model to be able to capitalize on real-time data sharing and quicker integration with other companies. There is a psychological aspect that should be taken into account on why it will be a slow process for the market to switch over to a new way of organizing and sharing their data. There is a certain distrust observed between companies making them reluctant to start sharing more data with each other. As described in section 3.3, attempts to make successors of UN/EDIFACT before 2005 have all failed. Back then the real benefits of implementing the model would only come if other companies would do the same. Why would a company invest and take the economical risk of implementing the model into their ERP system if other companies would not do the same?, why not wait and see first if others around you will do it, and only then decide to follow? In economics, this problem is described using game theory with as-symmetric information.

But now a data standard is not only about b2b integration anymore, it is about enterprise evolution, industry 4.0, the Internet of Things, about being prepared for the future. This is the point where companies can distinguish themselves in the sector as innovative and ready for the future. The OTM model could be seen as a prerequisite for companies when they want to implement real-time monitoring of their logistical processes. All though a long-term advantage of the model is that it will ease the complexity of b2b integration and the high maintenance costs associated with it, the short-term advantage is way bigger. In the short term, transporters have better visibility over their fleet enabling them to deliver better and more comprehensive customer service. Rising customer demands regarding sustainability and supply chain visibility together with the increase of solutions available will lead to a shift towards a new data-sharing infrastructure for the sector. As written in subsection 2.2.3, it is not the question of if, but rather when this will happen. Maybe it would need even more innovation such as wide availability of drones to handle the inventories of warehouses or robots which can automatically load a vehicle or maybe even self-driving vehicles. One could predict that the incentive to abandon EDI and switch to REST-full web services will be approaching exponential growth in the short future. The growth of a data model such as the OTM, will most likely be initiated by the bigger companies in the industry. These big companies have the resources available to innovate, and when they do, the other smaller companies which they work together who are dependent on the big company will have to follow suit.

The question of whether the OTM model will be the new default is something only time can tell. In section 3.4 it is written that the OTM model can inter-operate with other models as long the semantic and ontology are in the scope of the model. All though this is given as a condition, it is one which will most likely always be met with the newer models. The semantic interoparbilty challenges have lead to frustrations in the market, it is not likely that if the market will switch over to a new default that this mistake would be made twice. On the other hand, a model without a hierarchy as it will cause interoperability problems not only with other models, but also within the model itself. This has already happened with the OTM 4.0 version, this caused the flexibility to be too high and gave them the motivation to roll out a big update (OTM 5.0) where the hierarchy is defined by means of profiles.

With the latest developments around Blockchain, there have been a lot of scientific research done one the applicability's of using this technology for data sharing in logistics. Switching from flat-file communication to data sharing over block chain might be a leap too far. As of now there have been no heterogeneous data sharing systems targeted at b2b communication successfully implemented using this technology and there is a certain distrust between companies regarding the sharing of their data. As the OTM model is a dictionary, it could be used in combination with this technology[11], but future research has do be done whether this is feasible.

In the introduction of section 5 an agreed-upon-market-wide data model is described as an Utopian situation. A requirement of achieving full interoperability on a global level is having a world-wide consensus, which is unrealistic. On the other hand, full interoperability would mean that a standard should all be implemented the same way with the same hierarchies. Besides, no data model can cover all logistical companies, there will always be companies active in niche industries needing to model certain types of data not supported by a standard. If everything would be included, this would make a data standard too complex to ever by widely adapted on such a big scale. There is a balance between simplicity, flexibility and scalability which should always be taken into account.

6. CONCLUSION

This paper gives an insight in the interoperability issues observed in Electronic Data Interchange between logistical companies using data formats such as UN/EDIFACT. We can conclude that UN/EDIFACT has no long term prospects, it is not fit for industry 4.0 due to its technological limitations and semantic interoperability issues. Real-time data sharing is becoming more and more important for companies to track their internal supply chain and for transporters to give better customer service. We analyzed the OpenTripModel, showing how it could be a viable alternative to the UN/EDIFACT data standard, and how it is structured and used. A distinction was made between the long and short-term advantages of implementing a model like the OpenTripModel. The short-term advantage is that it enables real-time data sharing between an FMS and TMS and the collection of this information, enabling the use of big data analysis and better customer service. The long-term advantage is that it will ease the process of integrating with other companies, lowering the cost and the faster communication between different organizations. The lesson learned from this paper is why UN/EDIFACT is at its end and how/why the OTM model can be a suitable successor. Future work on the OTM model could point out how AI decision making can be integrated into a system using the OTM model and how it could be used for the communication of self-driving cars between the TMS and FMS.

7. ACKNOWLEDGEMENTS

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