Smart logistics: An enterprise architecture perspective

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Abstract. Logistic enterprises are increasingly becoming smarter and more efficient by using real-time contextual data. A currently unsolved problem for small to medium sized logistic service providers (SMLSPs) is, how to use real time data in **existing** business processes & IT systems. Enterprise architecture can be used as a tool to solve this problem and aid in adapting existing processes & IT. This would lead to improved operational planning and disruption handling; thereby bringing them closer to becoming smart, context aware logistic enterprises.

Keywords: smart logistics, enterprise architecture, context awareness, smart planning, disruption handling, operational planning

1 Introduction

In this era of interconnected businesses and systems, enterprises have access to a large amount of potentially useful contextual data. Using this data, enterprises can provide smart products/services, leading to more profits. As observed in the case of DHL [1][2] data from diverse sources is analyzed to turn disruption in the supply chain into competitive advantage. Nevertheless, SMLSPs find it challenging to incorporate contextual data in existing processes. In existing logistics research, this aspect has not yet been adequately investigated[3]. Examples of frequent challenges faced by SMLSPs are (a) what activities must be performed for smarter services? (b) what will be the changes to existing process? (c) does the enterprise have required IT capability? (d) how can different data source be integrated? Furthermore, SMLSPs are frequently unaware of the latest technological trends and state-of-the-art technologies available for smart services and business process improvements. For example, big data analytics can improve demand prediction and negotiations with partners LSPs (logistic service providers), but, very few SMLSPs are doing it[2][4]. We choose to focus on SMEs because:

- they have limited resources but have to compete with big players in the market. In order to compete, they must move towards smart logistics.
- they often don't have an enterprise architecture (EA) which makes it difficult to achieve business-IT alignment.

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- existing literature rarely derives smart logistic requirements from the perspective of SMLSPs.

Activities for smart logistics are motivated by industry requirements which we gathered via interviews with representative SMLSPs [1,2]. EA (enterprise architecture) modeling is used to illustrate how these activities would fit in the current business/IT landscape of a SMLSP. It is well known that logistic companies can improve transport planning, track & trace services and order closure by using contextual real time data[5][6][7][8][9][10].

The main contribution of the paper is to motivate and present a generic EA for smart logistics scenarios. The primary target audience are SMLSPs which can use this EA to adapt their processes and IT systems. This will facilitate their transition to smart enterprises.

Our research consortium consists of logistic companies including Seacon[1], CTT[2], CAPEGroep[3] and OVSoftware[4]. This research is part of the Synchromodal-IT project supported by Dinalog[5].

2 Background

The term *smart logistics* is frequently used in logistics literature, yet, there is not a widely agreed definition[11]. Although, this may not necessarily hinder the use of latest technologies by SMLSPs, it does create hindrance for researchers to build upon and combine similar existing works. Moreover, as observed in [3], most literature on smart logistics focuses on RFID technology but the use of other state-of-the-art technologies is usually ignored. In this paper we choose to motivate smart logistics processes from the industry point of view. We conducted interviews with SMLSPs to inquire *what*, according to them are smart logistics processes?

GS1 Logistics Interoperability Model (LIM)[12] and One Common Framework for Information and Communication Systems in Transport and Logistics (OCFTL)[13][14] provide an overview of the top level business processes in any logistics company. On one hand, LIM is a representative reference model for logistic companies, while on the other hand, OCFTL incorporates the results from 8 European projects over logistics. A mapping between LIM and OCFTL can be found in [14]. As mentioned in [12], these top level business processes are 1) Inter operation Agreement 2) Master Data alignment 3) Logistic services conditions 4) Long term planning 5) Operational Planning 6) Execution and 7) Completion. In this paper we focus on Operational Planning and Execution, because these are the core processes for SMLSPs. The sub-processes for Operational Planning and Execution are shown in Fig. 1.

[1] www.seaconlogistic.com
[2] www.ctt-twente.nl
[3] www.capegroep.nl
[4] www.ovsoftware.nl
[5] www.dinalog.nl

For smart logistic, enterprises have to use data from diverse sources. This data can be static (e.g. order data), near-real time (e.g. data from hubs, terminals) or real time (e.g. AIS data)[9]. Furthermore, data can also be in different formats i.e. unstructured (e.g. emails), semi-structured (e.g. XML) or structured (e.g. from databases). The integration of all this data into existing processes presents a big challenge for companies and is frequently ignored by existing researches [15]. Furthermore, a road map towards smart logistic services is not found in literature. This paper tries to fill this research gap by using EA to show the use of contextual data and state-of-the-art technologies in operational planning and execution.

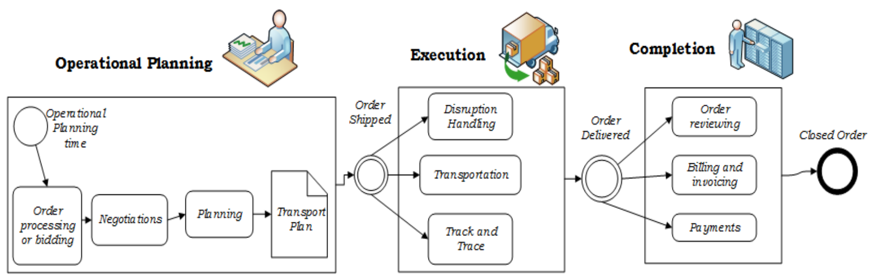

Fig. 1: Main business processes in logistics

3 Methodology

We followed design science research methodology [16] for this research. Following are the steps of our method.

1. **Problem Investigation.** Six interviews were conducted with six SMLSPs to identify desired improvements in operational planning and disruption handling. As additional information the interviews also provided insights about the current business and IT infrastructure of the companies. Using this information, an *as-is EA* of a generic SMLSP was made. [17]. Due to space constraints this is not included in this paper.
2. **Treatment Design.** Based on interview results, a *to-be EA* of a generic smart SMLSP (Fig. 3) was made. This EA includes desired process improvements and relevant state-of-the art technologies. It give a holistic view (business level, application level, infrastructure level) of a smart SMLSP's planning and execution process.
3. **Treatment Validation.** As a preliminary validation of the to-be EA, a web application is being developed using Mendix[18]. Once developed, LSPs would be able to use the web application in conjunction with their existing applications to achieve smarter planning and execution. To validate the usefulness and utility of the web app. another series of interviews will be the conducted. We have devised a 3-step validation experiment, which is explained in Section 5.

4 Enterprise Architecture in a smart logistic context

For designing the *to-be EA* there can be two possible approaches:

1. Top-down. Start with the desired improvements/requirements as indicated by SMLSPs, during interviews and then choose applications and data that are necessary for these improvements.
2. Bottom-up. Start with available (or new) data sources, state-of-the art technologies (applications) and use then to implement the desired improvements.

We chose to adopt a top-down approach owing to its relative ease w.r.t treatment validation. We have chosen ArchiMate as the EA modeling language to model the *to-be EA* because of its wide spread acceptance in the EA modeling domain and it being an OMG standard[19]. The following subsections discusses the desired process improvements by SMLSPs.

4.1 Operational planning

1. **Use of constraints**. Based on the order characteristics, the planner should be able to choose which data sources to taken into account while planning a transport route. E.g. exclude weather information (alerts) but include live traffic (or traffic predictions) while planning an order route. Moreover, different routes should be prioritized such as, least CO_2 emitting route, fastest route, shortest route and cheapest route.
2. **A Dashboard**. Interviews with LSPs indicated that a dashboard [20] increases the efficiency of planners. Among the main requirements, for such a dashboard, was the possibility to see events that can cause future disruptions, live trace & trace of shipments and expected future orders. Such a dashboard enables a good overview and control over operations.
3. **Smart planning module**. SMLSPs often do manual operational planning. Smart planning implies a lot of different functions[10]. The recurring features of a smart planning module during the interviews were: (a) demand aggregation, (b) optimization of load for every transport trip (c) optimum route selection (d) use of demand patterns while planning (e) use of real time contextual information and (f) re-planning in case of disruptions.
4. **Integration of new data sources**. SMLSPs want to get data from new data sources which provide real time contextual information. By combining data from these sources they can make a well informed prediction of the current (and future) situations and plan accordingly. E.g. AIS data from ship routes to predict ETA (estimated time of arrival) of deep sea vessels [7].
5. **Use of a common data model** Data from diverse sources raises syntactic and semantic interoperability challenges. The use of a common data model [9] helps in combining data from different sources.
6. **Big data analytics**. The use of big data analytics in improving logistic service is already done by big players in logistic [1]. Yet its is quite difficult for logistic SMEs to use those technologies due to the investments it requires. Another reason is it difficult for them to gauge the ROI on big data ana-

lytics. Big data analytics can help in predicting demand patterns, expected disruptions etc. thereby improving the enterprise's agility.

4.2 Execution

1. **Track and Trace**. The most important activity during (transport) execution is locating a shipment, in logistic terms, ETA determination. Monitoring of shipment and determining ETA is a cumbersome task [9]. Currently, planners have to collect data from different websites for this. Techniques like web-scrapping should be integrated should be included in a dashboard for easy monitoring ETA estimation.
2. **Disruption Handling**. In most SMLSPs, disruption handling is an adhoc process. The planner has to continuously monitor various websites and inquire infrastructure providers for any current (e.g. accidents) or future disruptions (e.g planned maintenance of rail roads). Furthermore, in case of disruptions re-routing of shipments is seldom done (Fig. 2). In [21] a detailed study on disruption handling options for a SMLSP was done. The *to-be EA*

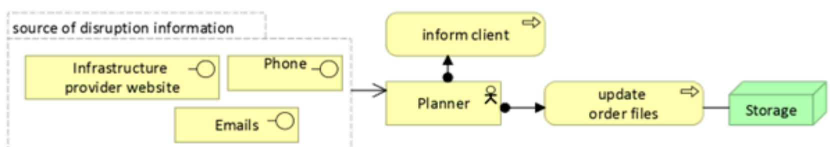

Fig. 2: Current disruption handling process

has a disruption handling module, whose main functions are (a) to collect data from pre-defined sources (e.g. websites/APIs/sensors etc.) (b) check which shipments are (or can be) disrupted (3) inform the planner as an alert (on the planner's dashboard) in case an action is required and (4) allow re-planning of a shipment. This way, the planner doesn't have to manually check for disruption, instead web-service and APIs are used to collect this information.

5 Discussion

This paper highlights the use of state-of-the-art technologies and contextual data to achieve smarter operational planning and execution by SMLSPs. A definition of *smart logistics* is purposely not provided, rather the concept is motivated via interviews with LSPs. Thus, this paper aims to extract smart logistics requirements from SMLSPs and propose an architectural approach to address these requirements based on state-of-the-art technologies. Big logistic companies like DHL, already have a robust IT infrastructure in place and use state-of-the-art technologies. SMLSPs usually face a challenge in this respect.

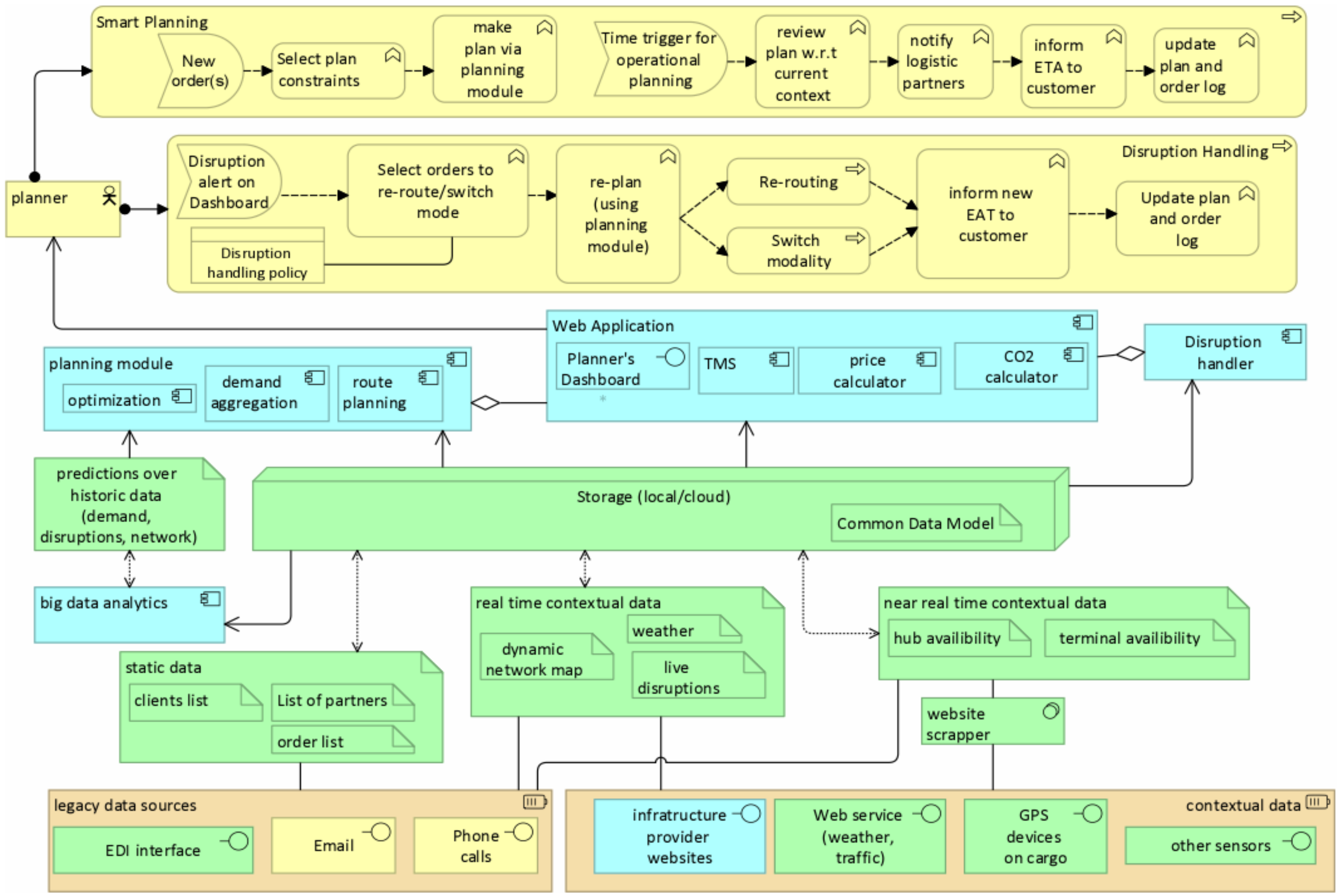

Fig. 3: Representative To-be enterprise architecture for a smart LSP

Their resources are limited. Therefore, they should identify their goals, prioritize them, and relate them to relevant business processes. This will ensure maximum ROI on new technological investments. The *to-be EA* (Fig 3.) can act as a tool for SMLSPs to compare and contrast their own EA (or to create one). Using it they can devise a step-by-step road map towards smarter operational planning and execution. A major challenge for SMLSPs, which is not discussed in this paper, is, access to logistics physical infrastructure (hubs, inter-modal terminals, etc.). The lack of infrastructure hampers activities like re-routing and modality switch when a shipment is en-route. Therefore, either SMLSPs should make agreements with infrastructure service providers or develop their own to fully implement smart execution.

Validation of the proposed *to-be EA* is in process and consists of the following 3 steps. These steps are conditional and sequential:

1. The components of EA are developed, e.g., a common data model [9], a smart planning algorithm [5][6] and a planner's dashboard [22].
2. These components will then be integrated (as shown in *to-be EA*) in the current processes of a set of selected SMLSPs, who are prepared to participate in a validation research experiment.
3. Step 3 is interviews with selected SMLSPs. The aim of these interviews will be to gain answers to the questions, *(a)* do the proposed new components play an instrumental role in achieving smart logistic goals? *(b)* what additions and improvements are required in the proposed EA.

6 Conclusion

Enterprises must adapt to changing business environment and market demands, to stay in business. In this paper we have shown how SMLSPs can solve basic challenges towards implementing smart service. We can conclude that (a) smart logistics consists of a number of activities that contribute towards desired goals (b) these activities can be mapped to an EA that in turn facilitates a gap analysis. (c) an EA allows enterprise to devise a step-wise plan towards smarter logistic services. The authors do not claim that the list of requirements obtained via interviews, is an all-inclusive list of features of smart logistics. Such as exercise must be repeated with other stakeholders to develop a consolidated and well grounded list of requirements. Also, to avoid tunnel vision and localization of results further validation of the *to-be EA* model for smart logistics is required.

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