Enterprise Architecture in a Synchromodal Logistic Environment

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ABSTRACT

Synchromodal transportation is an innovative development for logistic companies to keep up with the increasing demands while becoming more sustainable. In synchromodal logistic, IT applications and its infrastructure play a vital role. For example they help a logistic service provider with planning, monitoring and execution of transport. In the current situation logistic companies have not the IT capabilities to fulfill the requirements of synchromodal transport. The goal of this research is to analyze how the IT landscape of logistic company needs to change to perform synchromodal transport. To do this, an enterprise architecture model is built based on information from the literature study and on information from qualitative interviews with practitioners in the field of logistics. The focus of the enterprise architecture is mainly on the application layer. The new enterprise architecture shows strong comparisons with the initial enterprise architecture, no applications are removed, only a few applications are added. Each individual and existing applications needs to be extended with an API (application programming interface). One dedicated application can integrate all these internal APIs to one API for external usage. The main purpose of the added applications is to enable data exchange between LSPs (logistic service providers). With the results of this research LSPs are given a general overview to see how they need to change their application layer of the enterprise architecture to be able to perform synchromodal.

Keywords

Synchromodal, transportation, logistics, applications, logistic service providers, IT architecture, enterprise architecture

1. INTRODUCTION

Increasing demands in the transport sector leads to more pressure on the infrastructure and environment. The European Commission states that the transport sector in Europe needs to be more structured, efficient and flexible in order to reduce the pressure on the infrastructure and environment.

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[5]. The Commission wants at least a 60 percent reduction of Green House Gasses emissions from transport by 2050 in respect with 1990, and a more competitive transport sector.

The introduction of synchromodal transportation seems to be promising development in the logistics sector [6]. It is a more efficient and more flexible transport type than traditional transportation types. Carriers choose the best mode of transportation, not only during the planning but also during the transport itself, it enables a carrier to react on changing circumstances [26]. Other transport types in the transport sector are: multimodal transportation, intermodal transportation, co-modal transportation [23]. The difference between synchromodal transportation and, for example, multimodal transportation is that with synchromodal transportation the decision for the next route is taken during the transport, and as late as possible. The route and modalities thus can change during the transport. Synchromodal transportation can be seen as the next step after co-modal, multimodal and intermodal transport [23]. This way of transportation does not only reduces the pressure of logistics on the environment, it also decreases the possible delays.

Logistic service providers (LSPs) are facing numerous challenges to be able to perform synchromodal transport. One challenge is that it is hard for LSPs and carriers to change modalities, it would require much changes, for example in contracting [4]. However, even a bigger challenge seems that LSPs do not seem to know what new process they need to do and what new IT capabilities they need. Since IT is vital in the business processes of LSPs and carriers, this means they are not able to perform synchromodal.

2. PROBLEM STATEMENT

As a LSP that offers only one or two modes of transport, it is very hard to perform synchromodal since you only have the option to transport one way or the other. These often smaller LSPs therefore need to be a part of a consortium of LSPs. Together they are able to perform synchromodal. However, this requires open information sharing between the LSPs and it requires LSPs to take real-time planning actions. Incoming information about the current situation should be processed in real-time to transport in the most efficient way. All transports should also be actively being monitored, what not always happens, to determine if the transport will arrive in time or whether it is delayed. To do all this, LSPs need to know what the optimal way is to organize their processes and IT portfolio. The goal of this research is to analyze how the
IT portfolio of a LSP needs to change to make it possible for a LSP to perform synchromodal. It will help LSPs to become more sustainable, to reduce the pressure on the environment, and to increase their efficiency. Not only LSPs will profit from this research, though the whole transportation chain will become more sustainable. The research will provide, especially smaller, LSPs with an enterprise architecture that will help them to be able to take place in a consortium of LSPs. By enabling more LSPs to perform synchromodal transportation, the next step to the 60 percent reduction of Green House Gasses is made.

2.1 Research question
The following research question is derived from the previous problem statement.

RQ: How should the IT architecture of a logistic service provider change to perform synchromodal transport?

To answer the main research question, two sub-questions have been specified:

1. What is the current IT portfolio of a LSP?
2. What additions to process and IT portfolio will happen because of synchromodal transport?

2.2 Scope
The current IT landscape will change in order to enable LSPs to transport synchromodal. The changes of synchromodal transportation on the IT landscape can be described in many ways. In this paper the changes will be presented in enterprise architectures. Not the enterprise architectures of LSPs are studied in this research, they are only used to present the changes.

The effect of synchromodal transportation on business processes can be described very detailed. However, for describing the changes in IT landscape it is not needed to go into detail on the business processes. The main changes in processes will be described in such way that it can be used to determine the changes in enterprise architecture.

There are a lot of LSPs and carriers in the world, and they all differ in size, available modalities and amount of employees etc. This means that there are also different IT systems and applications available. An universal answer to the research question depends on the company. In this paper we choose a generic approach for a small to medium sized LSP. As a result of this, and to make this research feasible, this research will focus on mid-sized LSPs. To do this, a generic LSP will presented to which all results will be related.

3. METHODOLOGY
In order to reach the end goal, the methodology of this research is divided into multiple parts based on the main- and sub-questions. Answering these questions involves not only a literature review, but also at least two interviews with logistic consultants in order to present a model which can be used in business. The literature review is the basis of the research, it will describe the current situation. The interviews may, or may not, then support the results of the literature research. Thereafter, enterprise architecture will be modeled. This section provides more information on these steps.

The structure of the paper is equal to the research methodology, which is as follows: first the literature research will be described, thereafter the effects of synchromodal transport on business process. The sections that follow will describe the current state of art including an enterprise architecture, and new enterprise architecture for synchromodal transport. The last two sections will consist of a discussion and a conclusion.

3.1 Literature study
A literature study will be done for answering the research questions. It involves two main subjects, on one hand the study will look into IT characteristics of LSPs in the current situation, and on the other hand the effects of synchromodal transport on business processes. For this literature study multiple databases will be used, including Web of Science, Scopus and Google Scholar. Using predefined search criteria, all literature will be gathered. Thereafter the identical articles will be filtered out. The remaining papers will be judged based on their title, abstract and conclusion. The last part of the literature research is to fully read all the articles that are left over. For the first subject information about the current IT landscape is derived. Information regarding activities and effects of synchromodal transport on business processes is derived for the second subject.

3.2 Interviews
After the literature research the next step is to gather information via interviews. For this research two logistic consultants will be interviewed. Although two interviews is not much, logistic consultants have a good overview on the sector in general. The selected logistic consultants should have a strong affinity with IT. LSPs will be chosen based on their size and their kind of services. A LSP that has just a few people will probably not have a complex enterprise architecture to support their business processes. However, this research focuses on enterprise architecture so most small companies do not meet the requirements for this research. The kind of services that a LSP offers is also taken into account.

The interviews will be semi-structured. The structure of the interview and a few questions are determined on forehand. For exploration interviews, such as these interviews, it is helpful to be able to ask questions based on the answers of interviewees. The outcome of the interview will give extra insight and validate the outcome of the previous literature research.

3.3 Effects of synchromodal transport
The effects of the synchromodal transport on the business processes, that is, how will business processes change to be able to perform synchromodal transport, will be described by means of two business process models. The first model will describe the current situation, when synchromodal transport is not used. The second business process model will describe how the processes should be going when using synchromodal transport. The main input of information for these models will be the conducted interviews, however, information from the performed literature research will also be taken into account.
3.4 Enterprise architecture
After gathering information via interviews and literature research, the focus will be on modeling the enterprise architecture in the current situation. Not all enterprise architectures of LSPs will be the same, to overcome this issue the model will focus on the general characteristics of a LSP, a generic LSP will be drawn to support this process. The model that will be developed will be the input of the last step of this research. As mentioned in 2.2 logistic businesses can differ a lot from each other. This will also make it challenging to make a generic model. To make the modeling a more accessible a generic LSP will be drawn.

3.5 Enterprise architecture changes
The last main step of this research is to model how the enterprise infrastructure of a LSP should change by means of a model. The enterprise architecture model of the current situation will be changed in such way that the new enterprise architecture model will support the changed business processes. The new model should not be a model that can be implemented in the organizations without any changes, it should give an interpretation which can help organizations to change. This step will answer the main research question of this research.

As earlier mentioned, IT characteristics and enterprise architecture are very general subject. For this research, the focus will be on the kinds of applications, the flow of data, and data sharing. Based on the findings of the literature research, qualitative interviews and the developed enterprise architecture for LSPs to perform synchromodal logistic, the paper will be finalized by a conclusion and a discussion.

4. ENTERPRISE ARCHITECTURE CURRENT SITUATION
To determine the current enterprise architecture from literature the search query: "((enterprise* AND architecture*) OR (information* AND landscape*)) AND (transport* OR logistic*)" was used initially. Results from this search query differed a lot from the expected results. For example "transport" is often used in other academic fields. To reduce the amount false positives the search query was changed to one with more restrictions: "Logistic* AND architecture AND IT", the search query was only used on the title field.

No case studies were found, the most results were designs for logistics management systems that could be used for future applications. Multiple papers describe a similar application, although it is not explicitly written. All described systems, sometimes referred to as Logistics Information System, contain applications that show analogy with ERP systems. A generic system was described by [27]. This system contains three levels (components). The first level, Logistics Park Information Service Center, processes all logistic information. Logistics Center Information Sub-center, the second level, is responsible for all the operations: information transportation, freight wagon operations managements, scheduling, freight flow, flow direction statistics, and financial settlement. The last level, Logistics Service Network Receiving, connects the logistic service network to logistics center.

Another research focused on implementing a intermodal transport corridor in an existing system. Macario R. and Reis V. [12] developed an information system for a Portuguese logistic operator that wants to start intermodal transport. Interesting aspect of this research is that the information system is designed for a logistic company that already has an Enterprise Resource Planning (ERP) system that supports all business processes. However, the information system for the intermodal transport process will be a dedicated unit. There is one connection between this system and the ERP, and that is that new orders that can be transported intermodal, are send from the ERP to the dedicated unit.

An interesting research, especially if the goal of this research is taken into account, is a research about the information service architecture for international multimodal logistic corridor by [10]. Leviakangas, Haajanen and Alaruikka identified all the required information services and a service distribution map that are needed for an information system for the transport corridor from the Nordic countries (Finland, Sweden and Norway) through Poland, Czech Republic and Austria, and ends in the Southeast European countries.

More valuable information about enterprise architecture of LSPs was provided by means of an interview with a software developer/logistic consultant which mainly develops software for logistic companies. The main activity of this software developer is creating a data integration layer for logistic companies to easily exchange data within the company. To develop such data layer, business processes were linked to all running systems. For a medium sized LSP, which does the transport partially itself and partially subcontracted, 16 systems in total were identified. In general the following six systems can be found in a logistic company. This information was later confirmed by a second interview, also with a logistics consultant.

1. ERP
2. Fleet management systems
3. Transport management systems
4. Warehouse management systems
5. Finance
6. Salaries

Finance, customs and salaries can for some companies be placed under the ERP.

5. SYNCHROMODAL TRANSPORT
Synchromodal transport will have an on influence multiple business processes, the influence on each business process is however not equal. In a previous literature research by Singh et al [21] four different categories of business operations were distinguished: Smart Planning, Dynamic Handling, Dynamic switching and Demand Aggregation. These operations are the operations that will change or are new in order to perform synchromodal. In this section the changes of these four operations are described in detail.
5.1 Activities

5.1.1 Planning

In the planning process all the details for the transport are planned in such a way that they met the service level agreement/goals. Van Riessen has a clear vision on how the planning process should be to be able to perform synchronomodal [24]. Planning in synchronomodal transport is complicated, instead of planning a fixed route with A-B connections, planning should be integrated within the network. In order to consolidate transport flow, a service network between all network locations needs to exist. The integrated network plan should incorporate self-operated and subcontracted transport. Van Riessen identified multiple planning models in his research [25], most of them are used in an offline situation ([2], [3], [8], [1]). Four online planning models were identified by Van Riessen as online method, however, two models can only be used for planning in single corridors ([28],[9]), the other two can be used in networks ([11],[13]).

How an integrated network planning changes the planning process will be different for each LSP. It is nonetheless clear that this process depends heavily on IT due its complexity.

5.1.2 Dynamic handling

Unexpected situations during transport should be handled dynamically. In other words, if a disturbance is detected, the impact should be analyzed to see how it influences the transport. Another common term in literature for a disturbance or unexpected situation is disruption. Every disruption should be placed in a category [20]: Permanent Disruption, Temporary Disruption and Other Disruption. In the current situation disturbances are not handled all the time.

This quote clearly shows how the current situation is:

An employee in a LSP was asked, what happens when you know that there is high probability of delay in the shipment arriving at the port?

He replied, “We just send the truck, and ask the truck to wait. May take a few minutes or even a full day.” [19]

If a disturbance was detected, the system should handle all influenced orders to make sure they still meet the service level agreements. This process is described in the next subsection.

5.1.3 Dynamic switching

Dynamic switching, sometimes referred as Real time switching, is a new process which reschedules a transport operation [16]. This is an essential process within synchronomodal transport, it allows the transport to switch from modality to make sure the optimal route and modality are used [17]. In current logistics this process will often not be found. Dynamic switching shows strong similarities with planning. However, instead of planning a new transport, you need to reschedule an existing transport order. The key difference with the planning process is that the LSPs and carriers of the initial transport planning are informed. Either a transport order for those LSPs or carriers is canceled, or the order is updated with new details. It is critical that those LSPs and carriers are informed and aware of the new planning, otherwise these changes will lead to delays, and other negative effects.

5.1.4 Demand aggregation

Demand aggregation, or consolidation, is a process before and during the transport. Transport often becomes more efficient by bundling loads, that it also what synchronomodal transport is trying to achieve [15]. Initially this should be taken into account during the planning of transport. However, also after a unexpected situation demand should be aggregated.

5.2 Control tower

Synchronomodal transport operations heavily relies on IT and the use of data. It requires data from all concerned parties and different kinds of sources. To optimize the distribution of data between multiple organizations control towers, or cross chain control centers, can be used [7]. These kind of applications try to enable the synergetic potential in the supply chain [18]. The advantage of control towers may be that they can provide a standardized way for organizations to exchange transport data. Since these applications are not common to be found in organizations, there is no (not yet) a standard. With the introduction of synchronomodal transport standards should be set.

6. ENTERPRISE ARCHITECTURE

6.1 Description generic LSP

To model the enterprise architecture a generic LSP will be described. The models as presented in the following sections are based on a generic LSP with the business processes and IT applications as described below. The generic LSP is a third party LSP. Orders are partialy transported by the company itself, some orders, or a part of an order, are outsourced. Each transport order consists of four phases, table 1 contains an overview of these phases with a brief description. Orders are partially outsourced since the company for example does not own an airplane or a train, but is has international activities. The generic LSP transports using different modalities such as train, truck, airplane, barge and deep see. Orders can be placed via telephone or email, there is not online environment for customers to place an order. When an order is received an employee ensures that the order is administrated in an Enterprise Resource Planning (ERP) application, and makes sure that a Planner will make a planning for the transport order. The ERP system contains multiple components such as sales, contracting, accounting and customer relationship management. On operational level some processes are done completely manual,

<table>
<thead>
<tr>
<th>Processes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary</td>
<td>Exchange of documents and agreement on contract.</td>
</tr>
<tr>
<td>Planning</td>
<td>Plan the transport order, includes communication with other LSPs.</td>
</tr>
<tr>
<td>Transport</td>
<td>The execution of all transport steps, including the external steps.</td>
</tr>
<tr>
<td>Finalizing</td>
<td>Complete order in administration.</td>
</tr>
</tbody>
</table>
planning is an example of such process. All transport orders are placed in a special application, Transport Management System. This systems triggers that a transport is executed at the right time. This LSP does not monitors the transport and has therefore also not an monitoring application. Furthermore the generic LSP uses a Fleet Management System to manage there fleet. To manage their warehouse a Warehouse Management Application is used.

6.2 Current state of the art
The enterprise architecture, as can be found in figure 1 is a high level generic enterprise architecture, which is derived from detailed version, for the generic LSP as described in 6.1. The model is developed with ArchiMate, which is a tool to model an enterprise architecture. In this model, the generic transport process was modeled. A detailed model requires an extensive case study. For this language there is no clear vision of how to model an external party. For this model a special color scheme was used to model external parties, external parties are colored dark gray. Additionally the external parties are put outside the groups of the three different layers.

The business process layer is divided into four different groups, each group contains a series of process which can be put in a specific group by nature. For this model, only the transport process in general was modeled. As the exact details of each process are unknown, and since the model should be generic, an abstract overview is given. However, it gives an good overview of when and where which applications are used within the business.

The application layer presents all the applications that are used within a typical 3PL (third party logistics) which is a LSP that offers integrated operation, warehousing and transportation services. From the interviews and literature can be derived that LSPs in general all make use of an ERP system. All applications that are related to an ERP are modeled within a single group. It can have a major influence on future IT project implementations while some ERP systems have API available and some not. Furthermore the application layers contains the applications which are used for operational activities such as the transport management system and the warehouse management system. In an international LSP an extra application, specifically for customs, can be added to the application layer.

The third layer, the technology layer, consists of four different devices assuming that the ERP is running on one server and that the other applications have its own server. A real implementation can allow to have multiple applications running on one single server by creating virtual machines.

The overview of current situation strongly shows that IT is not well developed within the generic LSP. Applications are not integrated which each other which makes it more difficult to exchange data. This will be a massive challenge while synchromodal transport heavily depends on data. Although this enterprise architecture is developed for a fictive LSP and may therefore not be an exact interpretation of reality; in general it shows strong closeness with reality.

6.3 Changes of current state
Multiple aspects of the business and application layer need to change to enable synchromodal transport. In the following section a initial solution is described which enables the generic LSP to perform synchromodal

6.3.1 New enterprise architecture
An enterprise architecture which enables a LSP to perform synchromodal can be found in figure 2. This model is a modified version of the enterprise architecture from the previous section.

Business processes layer.
There is no need to completely change the business processes compared with the current situation as described in 6.2. To transport synchromodal there are some small changes in existing processes needed, also a new processes will be added. Due to the advanced way of planning within a network, the planning process will mainly be done automated. No processes will be removed as a result of this.

Furthermore, one of the activities within synchromodal transport, dynamic handling as mentioned in 5.1.3, requires a new business processes. This process will only be triggered in case there is an unexpected situation. The trigger to start this process will come from a specific application which monitors the situation, this is described in the next part (6.3.1). Note that in order to make the detailed model more clear some processes such as ”Notify partners” in the Planning phase, which is suitable to completely be handled by IT, are still modeled as a process in the business layer.

Application layer.
On the level of applications the first aspect would be to easily exchange data between businesses using APIs (Application Programming Interface). APIs can be described by a set of functions and protocols which enables other applications to easy communicate with it. One could for example use an API for every single application. This would enable to exchange data, however it is not efficient. If another LSP needs information which is stored by two different applications, it would need to call two different APIs. Although it is a straightforward solution, on organizational level it will cause extra work and problems. For every API you need to manage user access and permissions since not all users need to have access to the same data [22]. A more advanced solution would be to create one API for external usage, which is actually one interface for the different internal APIs. Such implementation would be easier to maintain on organizational level. User access and permission only need to be handled for one API, the API for external usage.

A second application that needs to be added to the application layer is needed for the disruption handling. Within the company there should be an application that is responsible for receiving the disruption messages. Together with the API for external usage this application can be seen as the control tower as mentioned in 5.2.

The current state of the art describes the process of transport planning as a mainly manual process. To use the planning models as mentioned in 5.1.1 a separate planning application should be developed. This planning application
Figure 1: Enterprise Architecture Synchronodal Transport
Figure 2: Enterprise Architecture Synchromodal Transport
should reduce the workload of a planner by automatically plan a transport. It can not only plan a route within the network, it is also able to fast calculate which is best route by looking at different aspects including demand aggregation.

**Infrastructure layer.**
The least changes in the enterprise architecture model are made in the infrastructure layer. The current devices will still be in place. Only a few devices will be added to this layer. These will be devices for the external API, the planning application and one for the situation monitoring application.

**6.3.2 Implications**
The proposed initial solution in 6.3.1 for changes in enterprise architecture for the generic LSP contains some great advantages in comparison with the current situation. First, this approach can be implemented in phases within in a organization. In the first phase a LSP needs to start with the API for external LSPs (the control tower application), and with one or more internal connected APIs. In the next phases it can start developing and implementing APIs for other applications. The second advantage of the approach is that this architecture is backwards compatible with the current business process. No applications are removed or modified, only a few applications will be added to the IT landscape and some applications will be extended with an API. An advantage of this implementation is that if a LSP decides to switch back to the previous way of working it does not have to apply changes to its IT landscape. Although the IT landscape/application layer is backwards compatible, it will be very challenging for a LSP to switch back from synchromodal transport to the previous way since there are multiple changes on business process level and the mindset of employees is changed. The changes and additions are inspired by service oriented architecture (SOA), they are loosely coupled and have the benefits of SOA [14].

Next to the advantages of the solution, the approach also has a downside. For an update of each application you should investigate if the API still works, and if it still works in the same way. Each update can in potentially break your external API. This would occur more rare if the external API is hard coded integrated with an application, in such case it is possible that the integration takes places on the level of the database. This technical downside should not be an issue if software testing takes place for each update.

**6.3.3 Validation**
Validation of the new enterprise architecture is challenging since the architecture is developed for a generic LSP. In this research no validation is applied on the model. A possible method to validate the outcome of this research is to discuss it with LSPs and transport consultants. Although this is not an exact method of validation, it still provides valuable information about missing applications, incorrect business process or bad relations. In the future LSPs will become more advanced and adopting changes in their IT to transport synchromodal. In this scenario a methodology to validate this research is to compare it with those business that already transport synchromodal. A requirement for this methodology would be that the LSP that will be compared shows strong similarities with the generic LSP.

7. DISCUSSION
The upgraded enterprise architecture for LSPs to enable synchromodal transport as presented in this paper is one way of implementation, there may be other ways. Although some decisions are considered well and can be seen as alternatives, a critical reader could argue that creating APIs for each different application, the proposed enterprise architecture, is not needed if there is one application who orchestrates the whole transport network. In that case that one application could extract data from all different sources. Such solution is more in place when you can develop all applications from the beginning. Since the main research question was related to how the current situation could be changed, such approach was not within the scope of this research. The enterprise architectures in this paper are modeled in ArchiMate. ArchiMate is a widely used tool and is used by practitioners and academics. Other tools were shortly taken into consideration, ArchiMate seemed to be the most useful.

As the results of this paper indicate, synchromodal transport requires a far more advanced IT landscape within a LSP. Nonetheless, it is not impossible for LSP to change their landscape. The approach of the enterprise architecture presented in this papers shows that a LSP can start implementing IT applications for synchromodal logistics without influencing the use of the current applications. There are only a few applications added the landscape, these applications enable a LSP to exchange their data in a secure way. The enterprise architectures described in this paper are purely developed for the generic LSP. Although interviews and literature were the basis of the generic LSP, it may not be the best generic LSP which represent a logistic company. Next to that, the enterprise architectures are modeled using the ArchiMate language, due to the complexity and amount of unknown information about how the applications itself work, it was not possible to use the ArchiMate specification properly.

Although this research answers the main question, new lights have been shed on the problem statement. It is indeed true that LSPs do not know how to change their IT applications and enterprise architecture to be able to transport synchromodal, the interviews revealed actually a much bigger and more concerning problem in the logistics industry. Although it was not explicitly said during the interviews, the logistics sector show strong signs that they do not see the added value of using IT in your applications, or that their current state of the art of IT as far behind compared with other sectors.

Three interesting topics for future research arise from this research. The methodology of this paper focused on a generic LSP, a future research could bring this research into practice such that a more specific insights can be gotten by focusing on a single organization. This case study should be used to do an extensive validation and testing of the outcome of this research. A second future research should focus on technical implementation of the control tower application and how it can be connected with the other applications. In this research the communication goes via APIs, it is however not sure if this is the best method since you are dealing with old and outdated applications. The technical implementation was not within the scope of this project. The third topic for future research concerns the IT awareness within
the transport sector. Acknowledging the added value of using IT within your business can have massive influence for success rate IT projects. Researching what the current state of IT awareness within the transport sector is, and how it can be improved, seems to be a good starting point to get LSPs to change their enterprise architecture.

8. CONCLUSION
Although synchronomodal transportation is a promising development in the transportation sector, there are still some major challenges to overcome. As this paper shows, the current IT landscape and enterprise architecture are not sufficient to be able to perform synchronomodal. To determine the current state of the art a small literature research was done and two interviews were held. Thereafter the changes which are needed to be able to transport synchronomodal were identified by a literature research. These changes are related to four different activities: planning, dynamic handling, dynamic switching and demand aggregation. This paper presents an initial solution of how the enterprise architecture could change to enable a LSP to perform synchronomodal. The first step is to create a special control tower application with an API for external parties to use, this enables the data exchange between LSPs. Thereafter, the control tower should be integrated with the internal used applications such as transportation management systems and fleet management system. These integrations can be realized by creating a dedicated API for each application. Generic enterprise architectures are presented in this paper to give a quick overview of the current state of the art, and the wanted situation.

LSPs can use the results of this research to get a grip on the changes to IT that are needed for synchronomodal transport. Unfortunately they can not use the exact same enterprise architecture since LSPs and the generic LSP probably differ on some aspects, but it is a good starting point. This paper focused on a initial design specifically for a generic LSP. Extensive validation and testing of the proposed enterprise architecture is therefore not possible and thus could be a topic for future research.

9. REFERENCES
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10. APPENDIX

10.1 Appendix A - interviews

10.1.1 Interview consultant/software developer

The interviewee started by giving a small description of the company he works for. The company develops software, in Mendix, for different kind of companies. Most companies they develop software for can be placed in the logistic sector. Example of such a company is a 3pl in Twente, the Netherlands. The main solution they develop is a software package that connect the back end application with the visibility in the supply chain (order status, jobs to the on board screen etc.). The function of the interviewee can mainly be placed in the category of consultant.

In order to provide more information the decision was made to take a look at case of a 3pl. For this company they developed a data integration layer that provides an integration between back-office systems, B2B and Employee/receiver systems. This company has in total 16 systems running, some of those system have an overlap between their functionality. The cause of this problem can be found in the origin of the company. The company is the result of multiple mergers, during those mergers, they did not integrate their applications. They use for example two different kinds of ERP software. In total 97 integration’s were made in order to make a data integration layer that can be connected to all systems. Another case that was discussed during the interview was Spring Global Mail. This company does the transport operations of a very large multinational information technology company and one of Netherlands biggest delivery services. This company has 6 systems supporting their daily operations. One of those systems was developed in-house.

The IT situation of logistic companies is old. A company that does international transport at Schiphol still uses spreadsheet software, just as an example. Another LSP recently upgraded their software from 2008 version to the 2012 version. Outdated software causes not only security vulnerabilities, but also a lot of missing functions and features. The classic MS-DOS screens, which are particular outdated computers, can also still be found at LSPs. One of the clients of the software developer migrated from a 20 year old legacy system to a new system just last year.

The first step for the logistic service providers should be the data integration layer. This layer can then provide an API with which other companies can connect. A major challenge if we look at synchromodal transport is aggregation of the load.

10.1.2 Interview logistic consultant

The interview started with a small explanation of this research. Thereafter the interview give did a small introduction of his current and previous jobs. Currently the interviewee is connected with Dutch institute for advanced logistics in a function as program manager Cross Chain Collaboration Center. In his previous functions he was concerned with multiple logistic projects.

After the brief introduction the interview started by general questions related to IT of LSPs. The IT landscapes and enterprise architectures of transport companies are very different. Some companies still use spreadsheet software to do their transport management. Other companies, the more advanced ones, use specialized software for example to make the planning of a transport. In the most medium sized LSPs a few general applications can be found: transport management, warehouse management, and fleet management software. For finance processes such as quotation, salaries etc. businesses almost always use ERP software. Currently software specifically for planning of transport (automatic planning) can only be found in more advanced LSPs, the greater part of LSPs still plan by hand. The used software packages are most of the time not implemented in each other with exception of the ERP software.

Next to software to support the business processes LSPs also use IT to for supply and demand of transport orders on specific marketplace website. This website allows LSPs to find a carrier, or to offer their own services.