Future Internet Perspectives on an Operational Transport Planning ICT Tool

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***Abstract*—In this paper, the design of a transport planning module utilizing Future Internet capabilities is described. It is reported on a use case study where functionality from the module will be used to improve the planning of containerized fish transport from Norway to Brazil. Future Internet capabilities are used to integrate services from several actors along the transport chain through the FInest collaboration platform. This improves collaboration between transport actors by automatically utilizing real time information about transport demands, transport services, transport contracts and transport related events during planning and replanning. In the proposed solution, actual capacities are checked automatically and bookings are done based on the transport demand and the selected services. Through interaction with event handling and execution functionalities, replanning is supported in the transport planning tool, and effects of the events on the transport plan are shown directly. The paper concludes that Future Internet capabilities used for transport planning and replanning will increase information visibility and availability throughout the transport chain, and that the solutions can be easily adapted by different actors to fit their specific needs. The fish use case study showed that services offered through Future Internet are promising for increasing capacity utilization for the carriers.**

***Index Terms*—operational transport planning, short sea shipping, future internet, ICT tools**

I. Introduction

Efficient and effective transport planning and replanning is about making sure that relevant and correct information is available at an early time in the process. This increases the possibility to select optimal transport solutions and gives the transport user better decision support. Visibility and availability of information throughout all phases (marketing, planning, execution, and completion) in the transport chain and between all actors are important to meet the increased requirements and competition [1]. Planning consists of handling the booking process from both the Logistics Service Provider's (LSP's) and Logistics Service Client's (LSC's) side, but it is also about handling resource utilization and information requirements. Thus, it is tightly coupled to resource status, availability, configurability and the possibility to negotiate more efficient use of equipment.

The requirements towards near real-time planning support increase as the logistics business processes get more and more dynamic. Most current transport planning tools only have access to information from a restricted number of logistics service providers and logistics service users. Especially, information about contracts, business processes, overview of logistics service availability, and information about various events appearing during the value chain, are only visible to a restricted number of actors and only collected from a restricted number of sources [2].

Increased amount of transportation leads to new requirements on transport, increased needs for information exchange and a need for improved collaboration between all stakeholders during the transportation process. For instance, the possibility to effectively select the transport providers is important for the profitability for companies heavily dependent on transportation [3]. The possibilities given by Future Internet are foreseen to help out with this, especially regarding the information exchange, and the collaboration between stakeholders.

Future Internet is a general term for research activities on new architectures for the Internet [4]. One initiative is the FI-PPP program hosted by EU to accelerate the development and adoption of Future Internet technologies in Europe, advance the European market for smart infrastructures, and increase the effectiveness of business processes through the Internet [5]. According to the 'Future Internet Architecture (FIArch) Group', the most important properties for a Future Internet Architecture are the need for the service components be accessible on the application level by using meaningful abstractions ensuring modularity and loose coupling of modules, the need to look at data and processes as self-managed, local entities, and having a more "open" system with better distribution of information between stakeholders.

Future Internet technologies and also the related cloud computing concept offer a unique opportunity to improve collaboration in the supply chain by removing barriers to system deployment, increasing transparency, encouraging new on-demand software applications, integrating Internet of Things with users in real time and encouraging novel business models that capture value in new and innovative ways [2]. This is done by providing availability of operations and data at anytime, anywhere, according to the goal of Future Internet.

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In this work we strive to utilize the advantages of Future Internet to increase the competitiveness of short sea shipping by increasing the service level of maritime transport. This is done by improving the capabilities of transport planning, ease the information exchange throughout the value chain, handle events at an earlier stage, make it easier for the service providers to send out offers, and make it easier for the transport users to get an overview of existing transport services.

We describe a transport planning module design and prototype that strives to meet the shortcomings of information exchange by providing real-time, online data for contracts, events, demand descriptions and service descriptions by utilizing capabilities from Future Internet [2], [6]. The module uses concepts from Future Internet as being developed under EU's Future Internet Public Private Partnership program [7] to implement domain-specific, configurable and extensible services to improve and ease transport planning. The work was done in the context of the FInest and FIspace projects [8], [9], where the transport planning module was part of the application layer as shown in Fig. 1.

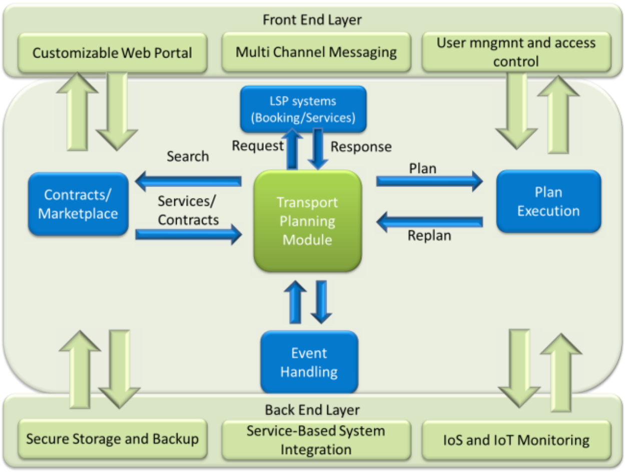

Figure 1. Transport planning module in the high-level architecture of the finest collaboration platform

II. The FInest Transport and Logistics Platform

The aim of the finest project was to develop a Future Internet enabled ICT platform for better supporting and optimizing the collaboration and integration within international transport and logistics business networks.

The FInest platform is structured into three layers, each of them using service-oriented and cloud technology, facilitating interoperability, openness and extensibility through standard interfaces. The front end layer of the finest platform provides users with role specific and secure access from different devices to information concerning the operation of the transport and logistics network, Fig. 1. The domain specific functionality for transport and logistics are available to the users through customizable web interfaces in the front end. Each user can configure the portal by selecting dedicated applications depending on the capabilities needed by this specific user. In addition, the front-end will be integrated with messaging systems to notify users and trigger actions. Also, access control to sensitive data and user management is important to ensure that propagation of information is done in a controlled way.

The back end layer of the FInest platform provides access to, and integration with, legacy systems, third-party services (Internet of Services) and Internet of Things (IoT) devices (sensors). Future Internet technology, and especially the Internet of Things, will make information about the transport processes, the goods, and the transport available at near real time, thus allowing systems and users of the FInest platform to quickly respond to planned and unplanned events. Legacy system integration is facilitated by service-oriented technology, for instance by exposing features of legacy systems as services, or by offering access to legacy systems via the "Software as a Service" delivery model [3].

The Contracts/Marketplace- module provides computer support for logistics service provider selection, contract management and the provision of contract related service requirements. The Plan/Execution module supports the inter-organizational, business-to-business collaboration between transport and logistics network partners by tracking and tracing shipments on the level of business processes and notifying the involved stakeholders in case of deviations or need for action. The Event Handling module provides event-processing facilities to determine relevant situations occurring within and in the context of the transport process. Such events include, for instance, delays of transport and critical weather conditions.

The Transport Planning Module provides support for dynamic transport planning and re-planning activities, exploiting real-time event data and with respect to contracts between business partners. Re-planning of shipments occurs when real-time signals from the event handling indicate that a current transport plan cannot be achieved because of some event that has arisen in the shipment process.

III. Transport Planning Module Description

A. *Overview of Transport Planning Module*

This section describes the main ideas of the design of a transport planning module (TPM) using Future Internet concepts to achieve visibility and sharing of information and by giving feedback on the execution directly during the planning process. The module supports the generation and maintenance of door-to-door transport plans by using the description of the demand, real time information of logistics services, real time contract information, execution statuses, and details of relevant events.

As stated by van Stijn *et al*. [10] and Overbeek et al. [11], visibility of information throughout the transport chain is of crucial importance for the efficiency of the whole transport process. Also, the ability to have an online overview of available services and capacities are important [12].

The motivation for the TPM is to describe a design with functionalities both for the Logistics Service Client (LSC) and for the Logistics Service Provider (LSP) where near real-time information is available during the planning process, and where status information from the transport execution is used to show how the plan is affected, Fig. 2. For the LSC, the TPM must support the building of a door-to-door transport plan based on the client's demand and online available services, using the latest available information for service descriptions. For the LSP, the most important functionality is that it enables the providers to present their services to a large number of LSCs, and that information about these services is readily available. If the TPM is connected to a marketplace, this marketplace can be used by both the LSP to publish their services and find demands that they can fulfill, and for the LSC to find services and to enter their demand to try to get a good transport offer. In case that the execution of the transportation fails, the TPM must show the effects of the delays and problems on the actual transport plan, and also allow the user to do replanning.

A planning process in the TPM starts with a description of the demand for transport, and it ends up with a door-to-door transport plan. When the demand is described, the system must find services that fulfill the demand. Contracts must be checked to find out whether there exists some agreements between this LSC and some LSP(s). For parts of the demand that are not covered by contracts, the TPM must look for services at various LSP sites and transport marketplaces to try to find services that wholly or partially matches the demand.

After a set of services are selected and configured they have to be booked. The booking can be done through simple interactions with LSP's systems, or through marketplaces or logistics information hubs with booking facilities.

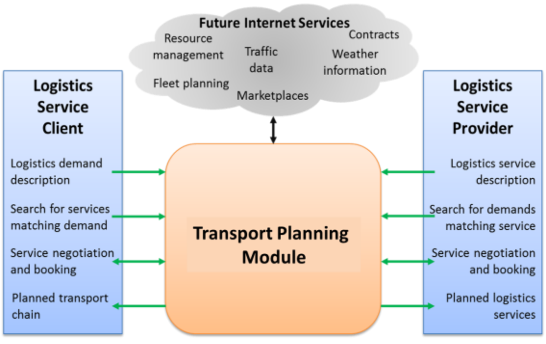

Figure 2. TPM functionalities (Source: [10])

B. Planning and Replanning in the Context of Future Internet Capabilities

This section lists how Future Internet capabilities as for instance the possibility of having available, up-to-date information on transport services (time tables and actual capacities), having available statuses on transport plans, cargo, and positions, and having available and up-to-date execution plans may impact transport planning and replanning.

- *More reliable output of the booking and planning process:* When the actual transport capacity data is available during planning time, it may allow better utilization of the transport resources. Also, the most suitable transport can be more easily selected.
- *Improved matching between transport service and transport demand:* The negotiation between the LSP and the LSC during the planning and booking processes may be improved since match making of transport offers (LSP's services) and demands (from the LSC), can be done for instance in a marketplace. Future electronic marketplaces may work as a meeting place for LSCs and LSPs where both sides may achieve advantages: More service offers are available to the LSCs, and more transport demands are available to the LSPs during the operational planning.
- *Improved replanning:* Improved information availability means the quality of replanning can be improved. Real-time information on the availability of services may also lead to better service utilization. Notifications of events relevant for replanning can be reported at an earlier stage or even be predicted before they occur. Also, there will be more time available for replanning.
- *More flexibility in long term planning:* Increased availability of transport demand information may help LSPs to plan their services better. They may be able to handle more demands, thus increasing utilization of transport means and other resources and improve the forecast on capacity needs. At the LSC's side, they may receive service offers from a larger set of LSPs and receiving offers more fine-tuned to their needs. An assumption is that marketplaces support increased transparency.
- *Simple and efficient booking systems:* The possibility to invoke functions in several, often diverse, booking systems through a single interface will simplify booking routines, for instance by reducing the need to retype the transport demand and thus be less exposed to human errors.

C. Online, Up-to-Date Information

An important contribution from the Future Internet technologies to the domain of operational planning is the possibility to utilize online, up-to-date service provider information together with online transport demand requests from the logistics service client. This creates new possibilities both for planning with long time horizons (e.g. planning a transport that will be executed weeks or months after the planning starts) and for planning with very short time horizons (e.g. replanning with tight deadlines). This is made possible through the advent of adaptive service-oriented systems through the use of Future Internet [13].

The increased information overview can be especially important for replanning of existing transport plans. For replanning, the deadlines can be short and the task of making quick decisions are made easier by improved information exchange among actors.

Future Internet concepts are suitable to support collaboration between different actors (the various providers and clients of different logistics services) during set up and changing of a transport plan. Most important is that Future Internet is used to make information available to all actors participating in the planning task.

D. Using Internet of Services for Transport Service Descriptions and Booking

A main point for the TPM is to show how online service descriptions for transport services and online booking facilities for services may ease the booking process.

The basic idea is already well-known for passenger air travel, where search for and booking of transport is made simple through internet solutions. The concept is extended to freight transport and to all modes, and the planner shall be able to use transport services from different providers through automatic booking.

Freight transport is a more complex situation than the air passenger case; the transport demand is more complex, as e.g. the type of cargo and possibilities for consolidations and splitting of cargo may affect the transport. The transport services may also be more complex, for instance there are both prescheduled "line" transports and "tramp" transports where the schedule is based on the demand, and there are also complex services consisting of sub-services from several providers. Also, as the transport user is usually not following the transport in person, information exchange and processing for cargo handling, document and customs handling and handling of deviations become more complex.

If the LSPs publish updated online description of services and service schedules, this can be used to create a better overview of the transport possibilities; it is envisioned that service description publishing will be common in the future, and a Future Internet transport planning module should utilize this potential.

It is envisioned that booking of transport will be possible through online services, e.g. through the provider's own services or services at a transport marketplace or a logistics information hub. Future booking services may have advanced functionality like tentative booking (e.g. in case of dependencies between different service providers) and negotiation facilities (for negotiation of the terms of the booking).

E. Configuration of Transport Services and Online Collaboration

It may be useful for the actors to be able to change or configure the transport services with respect to time, resource utilization etc. when this is possible. As such changes affect both LSCs and LSPs, collaboration between the actors on configuring the service should be a possibility. A Future Internet platform may provide facilities for such collaboration, where the plans including possibilities and consequences of changes may be shared between the actors in addition to typical conference services (i.e. teleconferencing, screen sharing, chat functions etc.). Related to this is the match making capabilities provided through a marketplace where both LSPs and LSCs can have an active role in creating a transport plan.

A transport plan module may also add the functionality to predict (e.g. through simulation) consequences of different configurations for the actors in the transport service (or entire chain), e.g. with respect to resource availability, utilization, and timing.

F. Deviations and Replanning

There is always a possibility for deviations in the execution of a plan, and replanning is an important part of the planning. While replanning basically is "planning again" and the same facilities can be used as when the original plan was made, there are often constraints that the new plan must take care of that could be ignored while making the original plan. For instance, a much shorter time window between planning and execution may mean that detailed knowledge about the availability of local transport resources (e.g. trucks that can bring the cargo from the current terminal to the neighboring terminal within the next 12 hours) may be of importance.

This means that information on resource availability and early warnings about deviations about to occur may improve the replanning process. Future Internet may increase the accessibility of the information on transport resource availability, and a Future Internet planning module could use this information to facilitate replanning. For deviation-triggered replanning, early information about the deviation will give more time between starting the replanning process and the execution of the new plan.

It may be preferred that the new plan "connects" with the original plan at some point, reducing the need to plan whole chains anew and cancel already booked services. A good planning tool shall have the possibility to use parts of the original plan when this is feasible.

It should be noted that not all replanning is initiated because of deviations in the execution of the original plan. The planner should be able to change and update the plans (for instance cancellation of bookings) for other reasons; for the transport planning module this means that replanning may be performed at any time. The transport planning module must allow replanning to happen, and the effects of replanning can be handled in the LSPs systems for instance by introducing penalties for late cancellations. Note that the effects of late cancellations can be reduced since the changes in capacity immediately will be available for some other LSCs. Replanning will be done according to existing contracts in the same way as planning.

G. Distributed Transport Planning

The well-known way to organize a logistic chain with several operators is to have a centralized database containing information about all possible transport providers and their capabilities, timetables etc. A system with a centralized database has all information available in its database and LSPs have to update their profiles, schedules and other relevant information to reflect their current capabilities. A lot of this information is necessarily duplicated at both the centralized database and the local systems of the LSPs. Cargo tracking is usually also done in a centralized way. Information about where a cargo is located is updated at some critical waypoints, and this information is then transmitted to a central database, which might be queried by customers.

Another type of management would be a decentralized way of both planning and executing the transportation and tracking of cargo. LSPs could hook up their local systems to for instance a Logistics Information Hub or online marketplaces. Such hubs and marketplaces could in turn be connected to other hubs and marketplaces, thus creating a network of transport information from a wide selection of providers. The Future Internet may provide advanced possibilities for this kind of specialized networks of information sources and markets.

IV. Case Study: Short Sea Container Transport of Dried Fish

A. *Introduction*

In this section, we describe the work done on a use case dealing with short sea container transport of dried fish from west coast of Norway to continental Europe. The case was elaborated in the context of the FInest project [8], [14], and it will be further developed and tested in the FIspace project [9].

In this use case, we envision that the usage of TPM functionality will improve the handling of late booking cancellations since the container line will get easier access to alternative cargo to fill up the vessel. Also, the terminal planning and resource coordination will be improved since the TPM can show the effects of events happening during the transport execution directly on the transport plan.

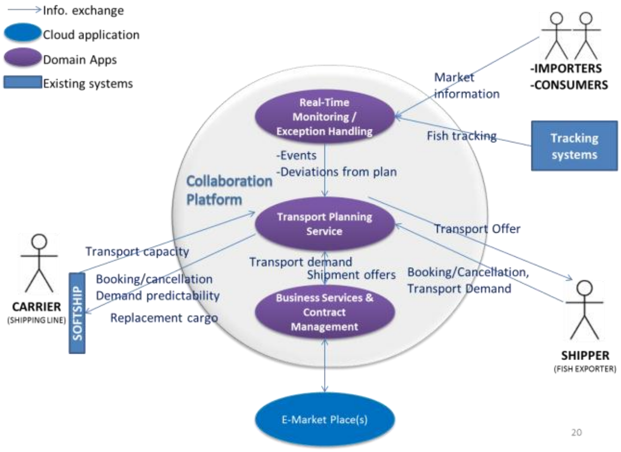

Figure 3. Overview of fish distribution and (Re-)planning use case (Source: [14])

The fish trial is concerned with the planning of logistics and transport activity in the fish industry, a crucial process for ensuring performance across the whole supply chain. The main challenges addressed are low predictability of transport demand and late shipment booking cancellations, mostly due to lack of collaboration or access to information, affecting directly the resource and asset utilization of service suppliers (carrier, terminal). Furthermore, data quality in the planning phase is essential for enabling effective monitoring of transport execution, Fig. 3.

The trial describes a case where dried fish is exported from Norway to Brazil: Fish exporters produce fish products (dry and frozen) continuously, sell it to retailers/wholesalers overseas, then contact a cargo agent for carrying out the logistics operations, including planning, booking/contracting of transport services, customs declarations, follow up, and tracking and tracing of cargo. The carriers are responsible for shipping the fish cargo from west coast of Norway to continental Europe, then overseas. Carriers receive bookings continuously as well as cancellations, which they need to handle in the best possible way in order to maintain an acceptable level of capacity utilization.

The following was seen as the three main challenges in the fish use case [15]:

- Late booking cancellations
- Terminal planning
- Resource coordination

B. *Late Booking Cancellations*

Late booking cancellations relate to two problems, namely "no shows" and "dummy booking". In both cases, the result for the feeder operator is loss of income due to missing cargo and due to short time to find replacement cargo.

"No Shows" means that the booked cargo does not appear in time at the terminal to be loaded. This is mainly caused by delayed booking information flow due to late information, short planning window, and more explicitly due to manual transfer of information. "Dummy booking" or "Booking Cancellation" means that bookings are cancelled very close to voyage departure (24-48 hours). From the exporter's point of view, these problems are related to unpredictable variations in fish production, difficulties in getting import or export license for food transport and varying time to get other clarification documents.

An important problem which could be avoided thanks to better planning upstream in the supply chain is the reservation of capacity by customer for securing place onboard a ship for the desired voyage. Regardless of how this reservation of capacity is done, whether customers book several ships for the same shipment, or whether they book without knowing really the amount of cargo that will in fact be available, the problem is still the one of bookings being unreliable and the feeder operator not being able to do anything to avoid it.

The identification of the challenge's root causes highlight the need for solutions for both reducing the number of late cancellations of bookings and overcoming the consequences of these cancellations. While the former is more dependent on changes in business models regarding cancellation policy and pricing models, the latter is believed to represent an interesting opportunity for Future Internet technology. Indeed, these late cancellations can be dealt with through more active search for customers in need of transport, i.e. finding cargo that can cover for these late cancellations more effectively and in a short period before vessel departure. This is definitely a case where the use of principles described in the TPM can be very useful since it offers up-to-date information about transport services during the planning process.

C. Terminal Planning

Late changes in the bookings also appear to be a problem for the terminal planning. The terminal's loading activity is dependent of several factors: loading list ready, containers available, fish cargo available at terminal, fish cargo cleared for export, vessel at port and ready for loading, cargo handling equipment and workers available. Late changes in booking create a need for replanning, rush work, waste of resources and reduced time for cargo handling.

The main problems related to the Terminal Planning challenge and their root causes are as follows:

- High resource use, in terms of time, man-hours, and physical activity related to the treatment of bookings.
- Delay in ship departure or incomplete loading of ship, both due to the reduced time for loading (due to delay in ship arrival, delay of cargo, or delay in loading list).

The identification of the challenge's root causes highlight the need for improvement in planning upstream in the transport chain, all the way from the shipper (fish exporter), to the carrier, to the port. Using the ideas similar to that described in the TPM will notify the planner about changes that have occurred to the plan at an earlier stage, and will make the available time to do replanning longer.

D. Resource Coordination

Another challenge that was discovered in the use case was lack of visibility of resource availability and resource needs at the port/terminal. This resulted in inefficiency in the coordination of service bookings and (re)planning of resources. This was mainly due to lack of information availability or easy access, multiple communication channels, and lack of automatic transfer of data.

Suboptimal resource coordination is a problem for both the port and terminal's service users (ship, shipping line, ship agent) and the port and terminal service providers. On the one hand, announcing port calls and booking of services require a lot of interaction and manual information transfer between the carrier, ship agent, and captain. On the other hand, the efficiency in planning and replanning at the port could be greatly improved with more synchronization among resources.

Three main problems were identified as the root causes:

- Difficulty in finding information about logistics services at, from and to the port. This problem is a general information centralization and availability challenge, and concerns all roles in the transport and logistics domain. Direct view of logistics services in the TPM will help out with this.
- Inefficient process for booking port and terminal resources and services. Today each port call includes a high number of interactions and messages. Besides, the ship seldom has access to real-time information when preparing a port call.
- Resource availability conflict. The most direct problem related to coordination of resources is that there are very often problems of resource unavailability, and coordination among the carrier (the ship), the port and terminal service providers is inefficient. Direct booking of resources through the TPM will help out with this.

V. Conclusion

The transport planning module presented in this paper gives an example on how recent and future improvements in internet technology may be used to increase the effectiveness of operational transport planning processes, by utilizing available information on transport services and contracts, and matching these with the transport needs. As the technology also may make information from different sources available faster, a more up-to-date, sometimes even real-time, view of the transport resource situation may be achieved, giving better possibilities for planning with short timing horizons, which will be useful for deviation handling. This will also make it easier for the transport users to set up multimodal transport chains.

The paper also exemplifies the use of the TPM in a short sea shipping setting. These examples were among the use cases generating requirements for the modules developed the FInest project, and will also be among the trials used to test functionality and business value for the solutions developed in the follow-up FIspace project.

We believe that the nature of Future Internet technology, with higher availability of relevant information, new possibilities for business-to-business collaboration, and possibilities to integrate information and services from widely heterogeneous systems, may contribute to higher visibility and ease of use of transport and logistics solutions. Future Internet solutions may also contribute to leveling the fields between large actors and SMEs, both for the transport providers, transport customers, and software providers.

As a result of a larger Future Internet research program, the design of the transport planning module has never been intended as a stand-alone system, but as a part of a larger environment of cooperating modules and applications. As a result from the FInest project, it is designed with dependencies to services offered by other FInest modules or similar systems to fulfill some of the functionalities. The TPM is also intended to be used as one building block when a business analyst configures the platform to a certain user.

The module design also builds on the assumption that a marketplace or information hub for transport information, demands and services exists, and that this can be used to publish and find both transport service offers and transport demands. More work must be done to achieve such an information hub, especially regarding integration with legacy systems and the issue of privacy of data.

Further, contract information is not readily available as it is now, and this also has to be investigated more. Regarding collaboration and information exchange, much work remains on the collaboration platform, as currently being further developed in the FIspace project. Also, it is important to get a critical mass of users of the platform, including both transport and logistics actors and app developers.

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REFERENCES

[1] F. Arendt, N. Meyer–Larsen, R. Müller, and A. W. Veenstra, "Practical approaches towards enhanced security and visibility in international intermodal container supply chains," *International Journal of Shipping and Transport Logistics*, vol. 4, no. 2, pp. 182-196, 2012,

[2] R. Franklin, Y. Engel, M. Hagaseth, Å. Tjora, F Fournier, R. Fleischhauer, *et al.*, "Cloud based collaboration platform for transport & logistics business networks," in *Proc. 6th International Scientific Symposium on Logistics. Bundesvereinigung Logistik,* 2012.

[3] B. Heaney. (August 2013). Priorities under Globalization. Cross-Border Transportation Strategies. [Online]. Available: http://www.aberdeen.com

[4] J. Domingue, A. Galis, A. Gavras, T. Zahariadis, D. Lambert, F. Cleary,P. Daras, *et al*., Eds., *The Future Internet -- Future Internet Assembly 2011: Achievements and Technological Promises,* Series: Lecture Notes in Computer Science, vol. 6656, Subseries: Computer Communication Networks and Telecommunications, 1st Edition., 2011.

[5] EC FIArch Group (January 2012). Future Internet Design Principles. [Online]. Available: http://www.future-internet.eu/uploads/media/FIArch_Design_Principles_V1.0.pdf

[6] R. Franklin, A. Metzger, M. Stollberg, Y. Engel, *et al.*, "Future Internet technology for the future of transport and logistics (invited)," *Service Wave,* 2011.

[7] FI-WARE. (2013). [Online]. Available: http://www.fi-ware.eu

[8] Finest. (2013). [Online]. Available: http://www.finest-ppp.eu

[9] FIspace. (2013). [Online]. Available: http://www.fispace.eu/Pages/FIspace.aspx

[10] E. van Stijn, D. Hesketh, Y-H. Tan, B. Klievink, S. Overbeek, F. Heijmann, M. Pikart and T. Butterly. (2013). Single windows and supply chains in the next decade: The data pipeline. [Online]. Available:http://www.unece.org/fileadmin/DAM/trade/Trade_Facilitation_Forum/BkgrdDocs/UNPaper_DataPipeline.pdf

[11] S. Overbeek, B. Klievink, D. Hesketh, F. Heijmann, and Y-H. Tan. (2011). A Web-Based Data Pipeline for Compliance in International Trade. [Online]. Available: http://ceur-ws.org/Vol-769/paper7.pdf

[12] Dinalog. (2013). Synchromodal Transport. [Online]. Available: http://www.dinalog.nl/en/themes/synchromodal_transport/

[13] A. Metzger and C. C. Marquezan, "Future internet apps: The next wave of adaptive service-oriented systems?" in *Towards a Service-Based Internet*, W. Abramowicz, I. M. Llorente, M. Surridge, A. Zisman, and J. Vayssière: Springer Berlin Heidelberg, 2011, pp. 230-241.

[14] A. Rialland, Å. Tjora, H. Koc, E. van Harten, Ø. Olsen, *et al.*, *FInest D2.5 Final Use Case Specification and Phase 2 Experimentation Plan*, 2013.

[15] A. Rialland, L. Ramstad, H. Koc, and E-J. van Harten, *FInest D2.3 Detailed Specification of Use Case Scenarios*, 2012.

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