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Key Design Properties for Shipping Information Pipeline

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Abstract. This paper reports on the use of key design properties for development of a new approach towards a solution for sharing shipping information in the supply chain for international trade. Information exchange in international supply chain is extremely inefficient, rather uncoordinated, based largely on paper, e-mail, phone and text message, and far too costly. This paper explores the design properties for a shared information infrastructure to exchange information between all parties in the supply chain, commercial parties as well as authorities, which is called a Shipping Information Pipeline. The contribution of the paper is to expand previous research with complementary key design properties. The paper starts with a review of existing literature on previous proposed solutions for increased collaboration in the supply chain for international trade, Inter-Organization Systems and Information Infrastructures. The paper argues why the previous attempts are inadequate to address the issues in the domain of international supply chains. Instead, a different set of key design properties are proposed for the Shipping Information Pipeline. The solution has been developed in collaboration with a network of representatives for major stakeholders in international trade, whom evaluate it positively and are willing to invest, develop and test the prototype of the Shipping Information Pipeline.

Keywords: International Trade, Inter-Organizational Systems, Information Infrastructure

1 Introduction

Research regarding international trade estimates that 40% of the delays in the lead-time of supply chains for international trade in the large ports are caused by administrative burdens imposed by authorities. Typically data inaccuracy is 50% for the information reported by businesses to authorities; since these data are used for the risk assessment, this is rather critical. The annual world-wide extra costs due to administrative burdens of crossing borders are estimated in the range 100-500 Billion US$[1].
The organizations in international trade are characterized by utilizing a wide range of communication channels including phone, e-mail, SMS and paper based media for information and documentation related to the shipments. This creates issues for the actors involved including lack of knowledge about status, information and documentation of shipments. Information exchange in international supply chain is considered

[1] Cassandra Research Project presentation, 2014

adfa, p. 1, 2011.
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extremely inefficient, uncoordinated and far too costly [1]. To address these challenges it's in line with previous research e.g. [2] propose to use a shared information infrastructure (II) for communication of the related shipping information whereby the information can be shared among multiple organizations[2]. The II for shipping information is named the *Shipping Information Pipeline* (SIP). It's the long term ambition to design, build, and test (ultimo 2015) plus evaluate a prototype of the SIP and this paper only covers the initial design of a prototype.

International trade plays an important role in the global economy and is a complex eco-system. The domain of international trade involves up to 40 actors/organizations in a single shipment including both private businesses and public organizations in a complex eco-system [3]. Furthermore, a serious complication in this eco-system is that the information exchange is extremely inefficient and rather uncoordinated. Complete different IT systems and message standards are used on different sides of the oceans. This has led to a practice, where information exchange is based primarily on paper and e-mail with many re-typing and copy-paste operations, phones calls and text messages. Consequently, it's relatively costly and error prone for the commercial parties as well as authorities e.g. inspection agencies in supply chain. Finally, the number of independent organizations and the huge variety of different IT systems make changes extremely difficulty even if the changes seem beneficial for the overall eco-system.

Usage of modern IT to improve the situation in international trade has been researched and attempted previously but none of the solutions have become used at an international scale. The design of an II as the SIP is different from solutions proposed in previous research which built on more traditionally centralized information systems; because the SIP has no central database, organization or control. For the previous solutions almost all communication is based on bilateral information exchanges between two organizations; whereas an II as the SIP enables sharing of information simultaneously among multiple organizations or even sharing the information by publishing it public. The SIP is comparable to the Internet and designed to be on top of the Internet and its standards. The SIP is an internet for shipping information.

In order to design the SIP one of the major players in international shipping decided to engage in research regarding the design properties for the SIP. The major player foresee that it's impossible for a single player to become successful with the SIP and search for ways to establish a collaboration with other partners including authorities in the international trade. To engage other partners the designing and testing of prototypes of the SIP are important. The research involves design theory for information infrastructure and follows the design science method to guide the research.

Accordingly the research question guiding this paper is:

What would be the key design properties of a Shipping Information Pipeline?

[2] Organizations can be public or private e.g. a company, a cooperation, an association, an institution, etc.- an entity on its own; an actor belongs to an organization and can be user of IS solutions. A stakeholder will have a stake e.g. in owning the SIP.

The scope of this research is limited to the containerized international trade bound for the European Union by deep sea, but this is not a severe limitation since the majority (seventy to ninety percentages) of imported goods to the European Union is carried by container ships. Accordingly the other means of transport are not considered here.
The largest volume to Europe passes through the port of Rotterdam. Accordingly the research has focused on trade lanes governed by Dutch authorities.
The rest of the paper is structured as follows: First theories behind previous proposed solutions, Inter-Organizational Systems [4] and design of Information Infrastructures (II) are presented. Secondly the research method is described. Thirdly are the proposed key design properties for a domain specific II for shipping information within the supply chain for international trade for containerized trade bound for European Union. Finally, an evaluation is provided and followed by a discussion.

2 Literature review

The roots of the idea to share data via an electronic pipeline for international trade and subsequently attempts to develop IOS for international trade are presented below. Followed by a presentation of theories regarding IOS solutions currently used for information exchange and the Design Theory and design properties of II.

2.1 The roots of the idea of an electronic pipeline for international trade

The idea of a sharing data via an electronic pipeline roots back to two official EU representatives from Dutch and United Kingdom customs. They came up with the idea of an electronic pipeline when visiting China, and they proposed that the European authorities should get the data about each and every shipment from the source e.g. the Chinese company packing the container. This kind of solution would dramatically reduce import authorities' serious problems with poor data quality; which is seriously affecting the customs / inspection authorities, when they are performing risk assessment of inbound cargo.. Several studies have identified that the quality of the data provided to authorities is poor, misleading and in some cases even fraudulent. An illustrative example is that when a container vessel stranded, there was a comparison of the filed information on the contents of the containers and the actual contents when the containers were opened and the authorities found that the data quality was only around 60 percentages [5]. Accordingly, there is a clear advantage to the EU authorities, if they via an electronic data pipeline could get the data directly from the source.
This idea caught on in the EU, and research funds were made available to fund a range of research projects addressing some of the technological challenges and demonstrating the possible solutions. Important projects addressing the issues and analyzing the potential benefits for organizations involved in international trade: ITAIDE[3], Contain[4], Integrity[5], Cassandra[6], and iCargo[7]. In the ITAIDE project (2006-

[3] www.itaide.org
[4] www.containproject.eu

2010) an "I3" framework was developed for accelerated trade through networks of trusted traders utilizing an II built on IT innovations which enables four critical capabilities[8]: Real-time monitoring, Information sharing, Process control, and Partner collaboration [2]. They identified that the technology "enables designing new ways of working, i.e., new business models. The ITAIDE technologies .. facilitate a redesign of the interaction pattern between government and businesses, and second, by facilitating piggybacking as a process optimization." (ibid. p. 179). The idea of piggybacking enable actors involved to reuse electronic information instead of retyping whereby work effort is reduced and the data quality is improved. Several living labs were developed and successfully evaluated with a range of leading IT vendors illustrating the fact that by following the ITAIDE approach, it's possible to make a significant improvement in trade facilitation. In a subsequence research project Cassandra (2010 – 2014) the electronic data pipeline concept was elaborated for enhancing visibility in international supply chains by an event driven architecture providing more up to date / real time data to improve the logistic efficiency. [6, 7]. Based on stakeholder analysis more solutions for business-to-government information have been developed e.g. a customs dashboard [8]. The above mentioned projects have successfully developed local IOS solutions primarily based on EDI (and standards) for demonstration purposes which subsequently not have been adapted by the organizations involved; one of the major reasons given is that the organizations are reluctant to share their information / documents. In summary the idea of an electronic pipeline dates years back and the solutions tend to focus on harmonizing / standardize information. This research contribution is to provide complementary design properties which affect the architecture of the SIP.

2.2 Inter-Organizational system for international trade

In more general terms, IOS are defined as "information systems to span boundaries between countries, organizations and the relatively separate components of large, geographically dispersed corporations" [9]. Extant literature about using IT for collaboration across organizational boundaries and borders is typically studied under the umbrella of IOS [4]. A closer look on the IOS literature reveals that there are more than 25 theories [10] and no single theory stands out as predominant. The majority of research regarding IOS is focused on EDI[9] [11], and a majority of the described IOS

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[5] www.integrity-supplychain.eu/

[6] www.cassandra-project.eu

[7] www.i-cargo.eu

[8] "Real-time monitoring is the capability to monitor and log real time – where a shipment is and how it is handled. Process control is the capability to document and evaluate that business processes meet control standards. Information sharing means the ability to electronically exchange information regarding shipments with trading partners and authorities. Partner collaboration refers to the joint capability of trading partners and IT providers to develop end-to-end control and transparency."

[9] Based on the international EDI standard: United Nations/Electronic Data Interchange For Administration, Commerce and Transport (UN/EDIFACT) developed under United Nations.

are successfully utilizing EDI [12]. For international trade, the benefits of facilitating IOS based on EDI are well documented [13] but the cost of change is relatively high [14]. The proposed SIP can be categorized as an IOS according the IS theory on IOS [9] since the SIP is an information systems with the purpose to span boundaries between organizations with separate components / systems and borders of countries which are geographically dispersed. The examples of IOS includes "electronic data interchange .. supply chain management, electronic funds transfer, electronic forms, electronic messaging, and shared databases" [15]. Note that, though it's widely used for the collaboration, e-mails are not considered as IOS because the IOS focuses on system-to-system connection and not system-to-human. Similar the SIP focuses primarily on systems and leaves the actor / user centric element to the individual organizations. The majority of the IOS researched are based on standardized EDI messages and in this regard the design of the SIP is different since the standardization is limited to the identifiers and the few additional data (needed for the subscribe service). So, with respect to standardization, the key focus of the SIP is on standardization of IS systems interfaces, and not on standardization of data and or messages that are exchanged between the systems.

Even IOS based on EDI is relatively successful; it's primarily used by large organizations and only covers a small part of the communication of information and documentation involved in international trade [16]. The widespread use of EDI based IOS [4] are mainly automation islands (mainly due to the standardization required primarily is successful locally), which are not properly integrated especially not internationally, accordingly there is a huge need for some type of inter-organizational reengineering to reduce mistakes, increase efficiencies and reduce time lag. The SIP can reengineer the IOS by offering communication across multiple organizations and borders complementing the existing traditional EDI based IOS. By designing the SIP to a lower cost and entrance investment than the existing IOS the SIP is expected to be used by more organizations and cover more information / documentation.

2.3 Design theory for information infrastructure

The components of an IS design theory includes: a) Requirements b) Set of system features c) Kernel theory and d) Design principles / properties [17]. Hanseth and Lyytinen [18] propose a design theory for IIs based on IS design theory with a kernel theory and a set of refined properties for II. The emergent properties are: Shared, Open, Heterogeneous, and Evolving. Formulated theoretically, IIs is defined "as a shared, open (and unbounded), heterogeneous and evolving socio-technical system consisting of a set of IT capabilities and their user, operations and design communities." [19]. Additionally are identified two structural properties: Organizing principle and Control. Based on the kernel theory, a set of design properties and nineteen design rules for II has been suggested as design strategy addressing the two generic problems for IIs: bootstrapping and adaptability, bootstrapping being the initial start up and adaptability being the spreading of use.

The proposed SIP can be characterized as an II according to the IS definition of IIs since the SIP complies with both the emergent properties: Shared, Open, Heterogene-

ous, and Evolving; and structural properties: Organizing principle, and Control. Additionally the SIP is intended to have a global reach, being open to any organization, to be one virtual pipeline build on many pipelines, and to be realized through evolution; accordingly the SIP is regarded as an II. The IS theory to guide the design and development of a successful SIP would then be the design theory for IIs [19], which includes a set of design properties and design rules for successful bootstrapping and evolution. The organizing principle for the SIP is not settled yet but it's intended to facilitate the emergent properties where the control is distributed to the involved organizations.

Note that Hanseth and Lyytinen [19] do not distinguish between the different types of communication in the II since they have both industry specific EDI based IOS platform and the Internet as examples of II. The concept of communication makes a crucial design property difference between the EDI based IOS and the "Internet" for shipping information. Furthermore the governance of trust and protection of information is found to be a key design property where the SIP differentiates between published shared and trusted information shared only bilaterally after authentication. In above has been discussed to which extent the SIP can be categorized as IOS, a platform and / or an II according to the IS theory. The proposed SIP can be characterized as an II and an IOS, even it's development is very different from the development of standard EDI message based IOS. Accordingly the IS theory is providing guidelines for successful design and development of the SIP.

3 Research method

The research method applied for the research reported is following an IS design science paradigm, and the interventions are described in the following. The initial focal case for the design of the SIP has been the trade lane transporting fresh cut roses from Kenya to Europe. Design science research is a particular perspective within IS research [20] which focuses on the development of artifacts related to information and communications technology. Design science research includes an evaluation of the designed artifacts. For the initial design the evaluation is artificial and not naturalistic based on real use of the SIP which follows in a later when the prototype is tested on actual shipments. Design science research places IS research between the environment (practitioners) and the knowledge base (researchers), the knowledge justifies the proposed solution to the problem in the environment. In the case of the SIP, the exchange is between a network of organizations within international shipping and the IS research field's knowledge, and the research focuses on relevance and rigor guided by a set of seven "guidelines for Design Science in Information Systems" [21]. This research has been inspired by those guidelines e.g. for the design and evaluation phases.

One of the key features of a design science project is iterations of interventions between practitioners and researchers. The interventions with both researchers and practitioners range from dedicated workshops, meetings and conference calls to workshops over 1-1½ year from spring 2014.The interventions have been documented by

written material in the form of minutes of meetings and presentations, which in the subsequence interventions has been commented upon in order to validate the correctness of the documentation.

4 Design properties for the Shipping Information Pipeline

In this section is presented the key design properties for a domain specific II for international containerized trade bound for European Union. The idea was first conceived in the IT department of one of the stakeholders (a large international container shipping line), which initiated an initial design named the SIP. Several activities have taken place towards prototyping of the SIP, which involved identifying: the conceptual idea, the business benefits and the associated business model, the major stakeholders, the issues addressed by the potential use, the potential barriers / obstacles, etc. In the following is only the design properties described.

The conceptual idea has been communicated between participants from of the potential stakeholders, who defined the SIP in the following way: "The SIP is a service based facility to allow partners in the supply chain to share accurate original data from it's source. It can connect any number of trading partners .." (minutes of meeting from a workshop 3rd September 2014 between potential stakeholders). They identified two main issues: Lacking full end-to-end supply chain visibility and lacking the ability to efficiently share common data/documents.

Another set of stakeholders focused on other but related main issues: I) the potential for reducing the relatively high cost of the administrative barriers for international trade; II) the security challenge for the authorities; III) lack of visibility in the supply chain for international trade. Different stakeholders focus on different issues to be addressed by the SIP. The potential users have been identified by a mapping actors among the more than thirty organizations involved in one selected trade lane for international trade and encountered actors from both private and public organizations in more than five countries. Additionally the information primarily in the form of documents to be shared were listed and characterized. The businesses benefits for the potential organizations utilizing the SIP have been exemplified in order to identify possible business models for all relevant actors potentially affected by the new SIP. There seems to be a challenge identifying a feasible business model for using the SIP.

The potential stakeholders for the SIP have been analyzed and include e.g. IT vendors and start ups. No stakeholder stands out as being the obvious 'key-stakeholder', who is able to set the standards and enforced it. Every stakeholder holding an installed based have been positive to the idea of communicating using the SIP, but none of them have taken the lead. Instead each and every stakeholder has established collaboration with all the other relevant stakeholders, and consequently more or less everyone is in principle prepared to take part in an overall initiative, but nobody is prepared to make a commitment to lead. It seems to be a paradox that nearly all of the involved organizations are expected to benefit from the SIP but none of them sees SIP as their core business. One of the major stakeholders in the supply chain took initiative to design a first version of the SIP and the key design properties are described in the

following. The design of the SIP is kept very clean and with one clear focus: sharing of information about events for shipments relevant for the actors in the supply chain for international trade. For the communication to potential stakeholder the conceptual idea behind the SIP has been formulated in design properties / criteria:

- **"No big brother**
  In order to avoid big brother issues where a central entity has access to central database with detailed information on global trade, no trade document are stored in or transferred via the Shipping Information Pipeline. (partly relates to the structural design properties of II: organization and control)
- **Integrate once – Connect to everyone**
  When an actor has built the required standardized integrations, the actor will be able to exchange information seamlessly with all other actors integrated with the Shipping Information Pipeline. (relates to the design property of II: shared)
- **One virtual Pipeline build by many physical Pipelines**
  For the users the Shipping Information Pipeline will look like one pipeline, but the actual physical infrastructure can be handled by several individual organizations. Standards will ensure the Shipping Information Pipelines integrates seamlessly in a way similar to how the Internet works today. (relates to the design property of II: heterogeneous)
- **No facilitation of commercial agreements**
  The Shipping Information Pipeline will not facilitate commercial agreements between two actors." (is not addressed by any of the design properties of II)

The above design properties / criteria from presentation at a workshop 16th October 2014 reflect the focus on creating trust for the organizations using the SIP, ease of use and global coverage. The trust is addressed by not publishing, sharing or storing detailed data about shipments in the SIP but leaving that to a direct bilateral connection among the ones wanting to share. Additionally excluding commercial agreements increase the trust since no commercial data are in the SIP to prevent any use of the SIP to gain commercial benefits on behalf of competitors are not facilitated by the SIP. When an organization has integrated to the SIP then the exchange of event information will be seamlessly and easy to use e.g. from inside the organizations' IT systems. The global coverage of the SIP is ensured behind the scene even regional set of SIPs are foreseen demanded by practicalities and by authorities.
The above description of the design considerations, including the design properties communicated by the stakeholder taking the initiative, illustrates that the design of the SIP involves many dimensions without an overall consent about the actual properties. The design of the SIP complies with all the design properties from design theory for II and is in line with the ideas from previous research: information from the source via an electronic pipeline, piggy bagging, and up to date / real time information; but to focus only the key design properties were communicated. Further the key design properties communicated changed depending on the actual utility of the particular organization and the extent to which it's possible to address their concerns. The key

design properties communicated for the SIP could be characterized as not being a fixed set of properties but rather to be flexible, evolving and adapting to the audience.

5 Evaluation of the Shipping Information Pipeline

The evaluation of the SIP is an ongoing process where various potential stakeholders evaluate the SIP typically at different abstraction levels. The levels include actor level, organizational level, country/region level and society level.

The individual actor in the many organizations using the SIP will be able to get more insight into events in the supply chain for international trade for the shipments in which the individual actor is potentially interested since today none of the actors have transparency. Additionally the SIP will provide higher quality and up to date information compared to today where information often is missing, out of date and of poor quality information and out of date information which is a major headache for the actors. Accordingly, when asked they find the service provided by the SIP useful especially when things do not go as planned.

The private organizations involved are the traders and the service providers. The traders foresee that the SIP can improve the possibilities for more efficient logistical coordination and lower the risk which will impact the international trade cost and willingness to trade. The international trade cost can be split in a physical transportation cost and an administrative cost of respectively 8% and 20% of retail cost [22]. The SIP addresses primarily the administrative border related part of international trade cost which is significant and amounts to approximately 20% of the retail cost. The service providers e.g. a major shipping line (the main drivers behind the SIP is obviously interested) foresee the main benefit being that lower international trade cost will increase trade volume resulting in more business especially when being a first mover.

The public organizations are active in supporting the prototype to realize the idea (including the two officers from customs in NL and UK, who first came up with the idea of utilizing an electronic data pipeline for international trade). Further the public organizations taking part in the piloted trade lane express their willingness to collaborate regarding the pilot project accordingly they foresee potential improvements for their area of responsibility. Through the SIP the authorities will have the opportunity of getting data directly from the source whereby the quality of the information will increase compared to today, which enable the authorities to improve their risk assessments and the accuracy for the calculation of tariffs etc. but it also imply a change for the authorities' way of working since they need to follow a link to get detailed information instead of receiving it (when requested).

Another set of private organizations involved are IT vendors offering solutions that facilitates information exchange for international trade. They have been positively engaged in collaborating regarding the SIP but none of them have seen a business opportunity, which they want to pursue. Anyhow a major IT vendor has been involved in a series of workshops detailing the architectural design of the SIP and has agreed to invest and build a prototype. But the vendor is still struggling to find an attractive business model, hence it is unclear, who is prepared to fund the further de-

velopment and operations of the SIP. Governing of the SIP is also a challenge for such a hugely diversified group of organizations involved in the SIP.
At country level the impact of reducing the administrative barriers are estimated to have a significant impact on trade volume which affects the economic positively. The World Economic Forum (WEF) estimates that an improvement to half-way of regional best practice and of global best practice will result in increased Gross Domestic Product (GDP) by respectively 3% and 5% [23]. Such improvements are important especially for developing countries e.g. in East Africa (Sub Sahara), where the similar estimate is an increase in GDP by 12% if applying halfway global best practice. For the first piloted trade lane between East Africa and Europe several association expressed positive expectations about the SIP and committed to be actively involved in the first pilot project lead by TradeMark East Africa[10].
European Union has a clear an interest in the SIP, since EU is actively involved and is funding the research program in which the testing of the SIP prototype is a part. The EU sponsors especially aim to improve the security for containers imported to the EU and to ease trade between US and EU.
At society level WEF estimates that by lowering barriers for international trade volume will increase and thereby fuel economical growth. "Estimates suggest that an ambitious improvement in two key components of supply chain barriers, border administration and transport and communications infrastructure, with all countries raising their performance halfway to global best practice, would lead to an increase of approximately US$ 2.6 trillion (4.7%) in global GDP and US$ 1.6 trillion (14.5%) in global exports. By contrast, the gains available from complete worldwide tariff elimination amount to no more than US$ 400 billion (0.7%) in global GDP and US$ 1.1 trillion (10.1%) in global exports." [23]. On basis of the above the SIP can potentially contribute significantly to the growth in the global economy.
In summary: 1) a venture fund of a major IT vendor has decided to fund to built a prototype of the SIP based on the design properties 2) a regional pilot implementation is planned for East Africa 3) EU sponsors the research 4) several organizations involved in international trade have committed to participate in testing with real shipments. The willingness to engage and invest in prototyping and testing of the SIP is taken as a positive evaluation of the design properties for the SIP.

6 Discussion

The overall vision of the SIP has guided the development of the key design properties. The design of previous attempted solutions for collaboration in the supply chain for international trade has been EDI based IOS; the design of the SIP is based and in line with the design properties for II plus additional ones but still in line with the initial ideas: information directly from the source, piggy bagging and real time information. One of the advantages is that an IOS based on II as the SIP is built on top of the internet and it's standards requires less standardization efforts compared to the EDI based

[10] Trade and Markets East Africa is an East African not-for profit Company Limited by Guarantee established in 2010 to support the growth of trade in East Africa.

IOS. Compared to previously attempted solutions the design knowledge is not the EDI based IOS but Design Theory for II.
Only a set of the design properties namely the key design principles have been communicated (in writing) among the stakeholders. Further focusing on the key design properties contribute to make the design clean and simple. The key design properties have evolved and have been adjusted over time primarily depending on the audience, the above described key design properties express the consensus among organizations involved in the prototype even so minor adjustment of the design properties are to be expected. As described above the key design properties for the SIP add design properties to the ones provided by previous research regarding IOS for international trade. The contribution of this paper is to expand previous research with complementary key design properties.

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