Shipping Information Pipeline: Initial Design Principles

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Abstract. This paper presents a design science approach to solving persistent problems in the international shipping eco system by creating the missing common information infrastructures. Specifically, this paper reports on an on-going dialogue between stakeholders in the shipping industry and information systems researchers engaged in the design and development of a prototype for an innovative IT-artifact called Shipping Information Pipeline which is a kind of "an internet" for shipping information. The instrumental aim is to enable information seamlessly to cross the organizational boundaries and national borders within international shipping which is a rather complex domain. The intellectual objective is to generate and evaluate the efficacy and effectiveness of design principles for inter-organizational information infrastructures in the international shipping domain that can have positive impacts on global trade and local economies.

1 Introduction

This research in progress paper seeks to contribute to Design Science Research (DSR) by identifying and evaluating initial design principles for IT-artifacts that help resolve existing problems, create operational efficiencies and increase competiveness in the supply chain of international trade. The paper reports on a research project that seeks to design and develop an innovative IT artifact named Shipping Information Pipeline. The domain of international trade has evolved over centuries. The utilization of standardized containers has enabled very efficient inter modal shift, for example between truck transport and sea transport. The international physical infrastructures have evolved technologically to become very efficient supply chains. Even so, the business eco system is rather complex and there are quite a few barriers in the supply chain for international trade, mainly administrative barriers which is a significant challenge for international trade. The actors in the supply chain are missing an efficient information infrastructure to facilitate the physical infrastructure [12]. The aim of the shipping information pipeline is to provide such an information infrastructure utilizing the internet as a foundation for the communication. It's estimated by World Economic Forum that lowering barriers for international trade by increasing collaboration will have a positive impact on economy. Some stakeholders have already realized that modern IT could be the means towards efficiencies but also that they can't be suc-

cessful doing it on their own. Existing research shows that the domain for the shipping information pipeline is complex with more than twenty organizations involved in any given individual shipment and each of the organizations utilize their proprietary IT solutions. From an industry perspective, the problems and issues in the domain of international trade are around the barriers since the physical infrastructure is already quite efficient. But the organizations can't lower the barriers by themselves since the solution has to involve multiple organizations along the supply chain of the international trade lane. None of the organizations involved are the obvious driver of such an IT solution. Therefore a key stakeholder has reached out to researchers for help to investigate and design a possible solution a shipping information pipeline. From an academic perspective, there is a research gap in the extant DSR knowledge regarding the design of a shipping information pipeline. To address this knowledge gap, we propose to employ the theory about inter-organizational systems and design theory for information infrastructures. Towards this end, we formulate the following research question: *What design principles can help inform the design, development and evaluation of a shipping information pipeline for international trade?*

2 Research design

This research-in-progress paper reports on approximately one year of research and development effort. The research reported here is drawn from a large four year research project which involves many different types of organizations in the European business eco system for international trade. The primary research field is Information Systems (IS) with other domains such as operations management, international trade economics and law informing the project. Given that the aim is to design an IT artefact that has both academic rigor and industry relevance, the method of Design Science is an obvious choice. Design science research is a particular perspective within IS research [4, 19] which focuses on the development of artifacts related to information and communications technology. Design science research includes an evaluation of the designed artifacts. Design science research places IS research in between the industry environment or practice and the academic realm of knowledge base. In the case of the shipping information pipeline, our criteria for relevance and rigor are guided by a set of "seven guidelines for Design Science in Information Systems" [10]. More than twenty five interventions are part of an ongoing dialogue between stakeholders in industry and researchers related to the large research project CORE (www.coreproject.eu). The interventions have involved both researchers and practitioners and range from dedicated workshops, meetings and conference calls to conferences arranged by others. The initiator and facilitator of the interventions vary: sometime it's the practitioner and at other times it's the researchers. Data collected from these interventions consists of audio-recordings and written material. The interventions have been documented by written material in the form of minutes of meetings and presentations which in the subsequent interventions have been taken up for discussion and comments.

3 Theory

The dominant IT artifact utilized for efficiency gains in the supply chain for international trade is Inter-Organizational Systems which are also characterized as one type of information infrastructure. Inter-Organizational systems are defined as “information systems to span boundaries between countries, organizations and the relatively separate components of large, geographically dispersed corporations” [5]. IOS can bring “significant competitive advantages” [13] and serve an essential role to facilitate integration and develop unique processes across the supply chain [24]. Extant literature on the utilization of IT for collaboration across organizational boundaries and borders is primarily focused on IOS [14]. Further, current literature on IOS employs more than 25 theories [18] and no single theory stands out as predominant. The majority of research regarding IOS is focused on EDI [21], and a majority of the described IOS are successfully utilizing EDI [22]. For international trade, the benefits of facilitating IOS based on EDI is well documented [15, 16, 17] and it has also been pointed out that the cost of change are relatively high [9]. The EDI based IOS are utilized between some fragmented parts of the supply chain for international trade, for example communication between the shipping lines, terminal operators, port authorities. The aim with the shipping information pipeline is to provide a less costly solution than EDI message based IOS and the shipping information has to cover the end-to-end supply chain for international trade. IS design theory [6, 23] includes: a) requirements b) a set of system features c) kernel theory, and d) design principles. The proposed design principles for information infrastructures are a kernel theory ("theory-in-use" by practitioners) informed by the insights of “How Do Infrastructures Evolve” [7]. They consist of a set of refined properties for information infrastructure with *emergent properties*: Shared, Open, Heterogeneous, and Evolving; and *structural properties*: Organizing principle, and Control. Formulated theoretically, information infrastructures 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.” [8]. Based on the kernel theory, a set of five design principles and nineteen design rules for II has been suggested as design strategy addressing two generic problems for IIs: bootstrap and adaptability. Based on the design theory for II several examples of failure and success have been given to validate the theory[2]. Both the EDI message based IOS and the shipping information pipeline is a business / industry sector information infrastructure and accordingly the design theory for information infrastructures should be applicable.

4 Design

In the following we report the early conceptual design phase, the prototype design phase and the instantiation phase of the prototype. Early in the design phase the practitioners recognized that the administration barriers for the supply chain for international trade can be best described as a “black box” and that no one can provide an overview of all the actors. Accordingly, recording all the essential and desired re-

quirements is nearly impossible. Further, only very few of them have IT capabilities which enable them to propose futuristic requirements. The traditional IS design theories where the starting point is the requirements seemed not to be applicable since the user requirements are unknown. Detailed requirements cannot be determined prior to the design but have to evolve. Therefore, the researchers undertook the task to analyze the current situation for a specific trade lane which could form a basis for deep understanding of the domain [11, 12]. Additionally, a search for alternative design approach was initiated by adopting a more evolutionary approach that involved presentations and discussions within the business eco system. Several of the involved organizations reported engagement in standardization work with the purpose of harmonizing the data used for international trade and to be able to exchange data. Given the multiple organizations and the number of nationalities involved, the progress and results are rather limited especially regarding actual implementations. Accordingly, the design of the shipping information pipeline should depend a little as possible on standards. The central design objective was to enable collaboration among all the actors in the supply chain for international trade and thereby lower the barriers for international trade. Many of the organizations involved already have IS solutions for optimizing their part(s) of the activities (e.g. most authorities have implemented single windows system) and accordingly the potential gains are to focus outside the organization (e.g. by enabling collaboration with other organizations). Our analysis showed that this collaboration already takes place utilizing a range of communication channels based on peer to peer communication which means that very few actors holds updated information [12]. As such, a core design principle was to offer one shared information infrastructure. The authorities would like to improve the data quality by getting access to source data[1] which typically are located in another nation outside the authorities' area of control. The authorities are crucial for the collaboration since it's them that's blamed to be the cause of the barriers and are best positioned to enable a lowering of the barriers not by lowering their demands but by mandating collaboration regarding the information they need and by provisioning additional information (e.g. green lane for trade lane for shipments). Given that authorities are crucial then the design and development efforts need to include and engage the authorities. One of the major logistic service providers has attempted to facilitate to provide the source data for the authorities but their customers became reluctant to share more the information. One of the large terminal operators have attempted to create a collaboration platform but the leading stakeholders could not agree on the set up because they feared lock-in situations. It seems that a single organization in the eco system will not be successful at developing solutions for the end-to-end supply chain. As such, we proposed to form a collaboration of stakeholders behind the shipping information pipeline. Note that to a large extent the organizations' IT is outsourced to IT vendors and the IT capabilities within the organizations are limited. One way forward is to design and build a prototype to demonstrate the solution and engage actors from the various organizations utilizing the IT artifact for real shipments for one specific trade lane as a demonstration case. Towards this end, we decided to start with one trade lane crossing three

[1] EU Annex 30A specify the data of interest for the European authorities

continents instead of starting with one organization or one geographical location because our design focus is on opening the "black box". Future implementations and demonstrations will include an increasing number of trade lanes and geographical locations. The design of the prototype actively involved many stakeholders in various settings and focused on a set of design properties (Jensen et al 2015 forth coming). The design properties comply with the design properties proposed for information infrastructures [8]: open, shared, heterogeneous, and evolving whereas the structural properties regarding organization and control have been postponed. Additionally, the design has also focused on what the shipping information pipeline is not going to encompass. For example to avoid 'big brother' perception (1), the shipping information pipeline will not service commercial arrangements, not have a central database with all trade information, will not exchange detailed shipping data in a standardized format and will not be an EDI broker. In this way the shipping information pipeline differentiates itself from other existing IOS solutions. Note that the installed base for collaboration solutions within international trade mainly are IOS based on EDI messages where the control is centralized. None of the stakeholders behind the installed base have taken the initiative in this regard. Additionally the SIP shall be inexpensive to use or even free (2) and allow partners to develop applications and service on top of the SIP and charge for this (3).

The design theory for information infrastructure' design principles and rules addressing problems of bootstrapping evolution have been reviewed but haven't been used. One reason could be that there is no installed base that provides a critical mass. Neither researchers nor practitioners have been able to formulate the kernel theory for the shipping information pipeline. Instead, the theoretical formulation keeps being adjusted (e.g. to the audience for the design evaluation). Another reason could be that the shipping information pipeline has not been bootstrapped yet since it's only in the very first initial phase of design. To be able to reference the same shipment, the focus on id's (4) early became one of the key design principles of the prototype. Inspiration to rethink came from IS literature on the topic [3], a presentation of a case on id [2] and various standards (e.g. GS1 and WCO data model). Another key design principle is to focus on event types (5) which was inspired by a European information infrastructure case presentation for traffic information and the issues experienced (Lyytinen 2015 forth coming). This led to the proposed trade lane specific taxonomy[2] (6). Another key design principle for the shipping information pipeline is that it should be service based (7). To explore and inspire the possible services to be offered by the shipping information pipeline, the concept of affordances (8) used in modern IT solutions e.g. "like" on Facebook have been used to simulate the future solution (Jensen and Vatrapu 2015 forth coming) which provided adjustment in the services with regard to the design scope. Trust is critical for organizations utilizing the shipping information pipeline and accordingly the information stored and shared is kept to the essential minimum and for more details the actors need to follow an URL (9). The design principles for authentication (10) are planned to be based on already available standard services/components [20] . The shipping information pipeline need to work

[2] Cassandra Living Lab White Paper May 2014 DASC methodology: Data Analysis for SCs

similar as the internet with free access to information (11) and simple to use (12) for the actors that do not have to care about the technicalities. The instantiation of the first prototype has now been completed based on the above discussed design principles and continually being refined. For the first prototype the authentication has been left out and replaced by a log on window. The next step is to try and evaluate the use of the prototype of the shipping information pipeline on real shipments.

5 Evaluation

The evaluation of the shipping information pipeline is an ongoing process where various potential stakeholders evaluate typically at different abstraction levels. The abstraction levels include actor or user level, organizational level, country / society level as described below. The evaluations are rather positive even so no single organization seems to be tempted to front up the costs for the shipping information pipeline. The public authorities do not see the implementation of a shipping information pipeline as their task and each of the private organizations have other projects with higher priority and/or potential. The individual actor using the shipping information pipeline will be able to get more insight into events in the supply chain for international trade for the shipments in which he or she is potentially interested. Today none of the actors have transparency. Accordingly, when asked they find that the service provided by the SIP very 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 shipping information pipeline can improve the possibilities for more efficient logistical coordination and lower the risk which will impact the international trade cost. The administrative border related part of international trade cost addressed by the SIP is significant-approximately 20% of the retail cost [1]. The service providers (e.g. a major shipping line) are the main driver behind the shipping information pipeline and obviously they are interested in mainly foreseeing that lower international trade cost will increase trade volume resulting in more business especially when being a first mover. The authorities derive value from the shipping information pipeline with the possibility to get data directly from the source which results in data quality increases compared to today which enable the authorities to improve their risk assessments and the accuracy for the calculation of tariffs etc. Several IT vendors are offering products and have an installed base that facilitate information interexchange for international trade and they have been positively engaged in communication about the shipping information pipeline but none of them have seen a business opportunity which they pursue yet. At country level the impact of reducing the administrative barriers are estimated to have 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 have resulting in increased Gross Domestic Product (GDP) by 3% and 5% [25]. The success of the SIP depend on the capability to secure benefits as described above to the actors and organizations involved to a degree that they will use the SIP.

6. Discussion

Since there are multiple actors and organizations potential utilizing the shipping information pipeline and evolutionary design approach was chosen. Further, since the requirements specification for the domain is rather difficult, we developed and evolved the design principles for the shipping information pipeline in one specific trade lane as a demonstration case. The design principles were informed by extant literature as well as empirical work. That said, our research addresses a knowledge gap in DSR with regard to design principles for IT artifacts with multiple stakeholders across organizational boundaries and national borders. The design properties have guided the coding of an early prototype which has been presented and evaluated, and currently is tested on shipments from Kenya to Europe, which will inform the future the evolution of the prototype. Next step is to expand the design implementation and evaluation to more shipping trade lanes.

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