Federated ICT for Global Supply Chains

IT Service Management in Cross-Border Trade

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***Abstract*—Cross-border trade inherently involves coordination of a highly complex community of actors belonging to groups with different priorities. This management complexity is further increased with the addition of ICT, which brings in obvious benefits but also hidden risks and challenges,. Federated ICT management is a new discipline that has emerged to tackle such complexity, and therefore it may be wondered whether its implementation in cross-border trade instances may mitigate the risks and overcome the challenges.**

By means of case studies and secondary data sources we suggest that techniques and approaches from federated ICT management – such as community modelling, maturity assessment and incremental improvement – may help the cross-border trade community manage their ICT systems better. Through adapting intervention strategies and providing conceptual models and best practice guidance, we can support more reliable and efficient supply chain operations and more efficient cross-border trade.

Keywords— cross-border trade; supply chain management; federated ICT, ITSM, federated management; cloud computing; Grid computing; ITIL; ISO/IEC 20000; FedSM; CASSANDRA

I. INTRODUCTION

A. Federation as the Standard Mode or Operation

ICT has played a major role in enabling the emergence of more and more complex value networks in all sectors of society. The ability to identify the optimal supplier and submit an electronic order immediately (and sometimes even automatically) has created a complex marketplace with new specialist roles. For example, an actor may focus solely on orchestrating and further subcontracting or outsourcing the product or delivery of a service for commercial or public sector customers – essentially providing a service that is similar to the Business Process as a Service (BPaaS) that is gaining momentum in the Cloud domain.

A new marketplace has resulted from breaking down traditional monolithic business models, where most of the activities were performed "in-house" into several layers of "orchestrators" coordinating actions outsourced, standardized, atomic service components. This new marketplace allows new products and services to be launched at an unprecedented speed. As the speed of delivery is a key competitiveness factor in supply chain management, innovative ICT solutions become a multi-billion dollar business.

From the organisational point of view the main impact is the creation of 'virtual' organisations working on a specific delivery contract. They involve components and organisations from different communities, working together through loose coordination to achieve some given ends.

B. Cross-Border Trade challenges

The challenges related to supply chain management are especially acute in the domain of cross-border trade, where firms need to be managed as single entities crossing national borders. In particular, these actors need to deal with the regulations in all of the states where the goods are moved. This means dealing with ICT systems operated and developed by several additional actors, often operating under fundamentally different business logics. For instance, a customs agency may focus on preventing smuggling and ensuring that the goods being transported do not present a security or safety risks – goals that may be orthogonal to timely delivery and ensuring that the goods arrive at their destination without being tampered with.

Successful cross-border trade thus requires collaborative, cross-organisational and –sectoral action. The financial stakes are extremely high: on the regional level, WTO (World Trade Organization) puts the value of global merchandise exports in 2011 at US$ 16.7 trillion [1], and the global annual value of exports of transportation services (trade facilitation) is reported as US$ 860 billion [2].

C. Evolving ICT in the Cross-Border trade context

The breakdown of the business model into its components is also happening in the ICT domain, most recently driven by the Cloud computing paradigm. Hence the complex, federated value chain described above increasingly relies on ICT systems and services that are independently outsourced by the commercial and governmental actors involved. While in normal operations this process is transparent to the users, it presents a challenge in the security and management contexts when preparing for anomalous situations.

On the system level, outsourcing is often invisible, uncoordinated and managed on ad-hoc basis within each of the organisations. As a primary consequence, this brings in potential for new single points of failure in the supply chain.

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While a transport ecosystem around a single harbour might host tens of companies providing the same logistics service, this apparent redundancy disappears if most of them rely on an identical software suite that all of the companies run on the same Cloud service provider's infrastructure. As a secondary impact, even if such single points of failures are avoided, it is likely that the IT service management practices are not sufficient for rapid detection of anomalies, identification of the scope of their impact and launching of coherent recovery actions when dealing with multi-layered, interconnected subcontracting arrangements.

II. ICT IN SUPPLY CHAINS AND CROSS-BORDER TRADE

Supply chains may be viewed as sets of organizations that create a virtual network or a pipeline through which services/products, information and finances flow. The common goal of this network is to transform raw materials into components, and products that are delivered to final consumers, at the right time, quality and place. The role of Information and Communication Technology (ICT) in cost-efficiency improvements is crucial [3], in particular through providing common and consistent access to data for the different actors in the supply chain (e.g. suppliers, transport providers, manufacturers, distributors, importers, retailers etc.). The typical functions and applications that can be built upon the data available in supply chain companies (for instance in their Enterprise Resource Planning systems) include: financial, manufacturing, inventory, supply replenishment, human resource management, service, sales and delivery and finally reporting to senior managers [4] [5].

In today's cross-border trade information is shared not only between the private companies in the supply chain but also with governmental agencies trying to guarantee the safety and security of the communities where the goods are manufactured, transported or distributed. For instance, a company willing to trade its products abroad has to ensure that the safety, quality and security requirements established in the foreign country are strictly followed. In addition, whenever the products are imported into the destination countries, the companies have to produce export and import declarations, with licenses and other permits attached, to demonstrate compliance. It is obvious that the administrative burden on the companies is considerable and raises costs significantly. In Europe, customs administrations are processing almost 200 million declarations every year (for example in 2007 it was 183 million)[6]. Each of these declarations consists of roughly 40 typologies of documents and in total about 200 data elements need to be exchanged between business and governmental entities, resulting in highly complex and costly data transfer, processing and storage challenges [7]. This situation is a fundamental challenge for enterprises, especially SMEs, but also a demonstrated bottleneck for the competitiveness and economic development of countries.

Many experts believe that the introduction of electronic information sharing may eliminate unnecessary delays and reduce paper redundancy and in this way reduce costs to companies and governments. In Europe, recommendations related to the usage of customs electronic systems and data harmonization are laid out in the regulation 1875/2006 as well as the Multi Annual Strategic Plan (MASP) [8]. In particular, the MASP provides crucial guidelines for legal changes, operational requirements, development, and implementation of ICT customs systems and training. The guidelines are relevant for all member states aiming to implement a *"single window"* system[1] to facilitate the interagency information exchange as well as business to customs communication.

In Europe, e-Customs platforms (or Single Window systems) are used – among other purposes – to file customs declarations or as hubs for companies to acquire international trade related documentation. These e-Customs platforms are heavily promoted by governments - for instance, Germany accepts customs declarations only through their web interface while Portugal and Denmark promote electronic documents [9] but accept also paper versions. These systems appear to be effective and bring cost savings but tend to be reliant on ICT and involve numerous stakeholders from both the operator and user side, bringing in exactly the complexity seen in other federated ICT scenarios.

III. FEDERATED ICT MANAGEMENT

Increased distribution and federation has been a clear trend in IT over the last decade. Where ICT tended to be an in-house facility operated by directly employed staff, today commercial and public sector organisations are increasingly outsourcing these services to cloud computing providers and other subcontractors. While clouds solutions themselves are not necessarily federated, their use is increasingly becoming so through hybrid and multi cloud approaches, driven by customer requirements related to compliance or risk management that make single-supplier solution impossible. Research organisations have traditionally used federation as the primary tool to reach economies of scale by pooling resources from individual computing facilities to national and regional infrastructures. However, the addition of outsourcing through inclusion of cloud resources will not necessarily represent a fundamental change in the service delivery model – physical facilities in the pool may just be complemented by virtual ones from cloud providers.

In general, while drivers and starting points are different, both research and commercial ICT are becoming more and more federated structures consisting of in-house and outsourced services, relying on common components both on technical and management levels. Maintaining high levels of quality of service in these kinds of environments requires developing management approaches that can span different organisations, jurisdictions, languages and sectors.

The federation of resources has progressed to most advanced state in the ICT services for research, where some federations, such as the European Grid Infrastructure (EGI), incorporate hundreds of different organisations and hundreds of thousands of computers into single distributed, federated system[11]. This has necessitated conquering considerable technical challenges in progressing from experimental to operational systems. Despite the well-document technical and

[1] Portal that allows submitting all of the documents in single location

operational successes, the management challenges associated with these complex structures were addressed mainly after the systems became operational. Initially it was possible – to a degree – to "piggyback" the ICT management on the management processes of the global collaborations (such as High Energy Physics) supported by the federated ICT. However, the management level issues have became more acute concern as more and more of the users and user groups do not belong to highly formalised collaboration structures.

The main challenge in developing the comprehensive management structure for federated ICT services is that federation implies a lack of central control and hierarchical binding agreements. Central control and formal agreements are the basis for managing service delivery based on traditional ITSM standards (such as ISO/IEC 2000) or best practice frameworks (such as ITIL, the IT Infrastructure Library). These models need to be augmented to take into account lateral management and coordination, as well as agreements between organisations that – at least in all of the cases – may not be formal, legal or contractual in nature. These challenges are independent of the technology used, and refer to the complexities of a federation, especially community structure that is based on cooperation rather than hierarchical structure based on bilateral contracts between clients and suppliers.

Attempts have been made to support federation in IT Service Management (ITSM) techniques, however early work tended to focus on technical approaches to service management, rather than coherent management level approaches (such as SLA based Grid scheduling [15] and automated SLA negotiation [16]). More recent initiatives, such as the gSLM [12] and FedSM projects have looked at ways to approach these complex, multi-organisational structures by adapting existing ITSM (management level) processes to them. In general this involves several approaches, such as putting the ITSM best practices into a vocabulary familiar to the sector in question, paring down ITSM to the essentials needed and relevant, and showing incremental paths for improvement rather than advocating wholesale or dramatic change [13]. Familiar vocabulary enables efficient internal marketing that is the key success factor already in traditional ITSM initiatives, as well managed systems rely on the buy-in of those participating in them, from upper management to those in more operational roles. The incremental approach is an important new requirement, as individual actors in federated systems tend to have a lower tolerance to imbalances in the investment/benefit relationships than, for example, different business units within a single corporation. It is hard to justify major strategic investment across multiple organisations, if the benefits are felt only by some of the organisations - or are visible only on the federation level, but not having a positive impact on the performance metrics of all of the individual participants.

As an example, an improvement path might be the following. First, use an analysis framework written for this area to assess current ITSM maturity in an organisation. From this, to then show that they already manage services and use the results to make ITSM less foreign. Next to identify areas of weakness and the analysis model to demonstrate what specific changes would need to be made to improve capability in this area. Finally to reassess the new situation, both using the analysis framework and in more general, qualitative ways to show the improvement.

Taking this analytical approach characterised by incremental steps also helps with other problems, such as difficulties in capturing the overall status of a federation or understanding its real operational costs. Cost saving has been held up as a driver of adoption of Cloud solutions, but in federated scenarios cost savings may be illusory, as while upfront costs are reduced there are very high risks and associated costs with outsourcing and accepting single points of failure. However, well-managed systems are easier to assess for potential risks and operating and setup costs. Improving the overall IT service management can also be seen as a prerequisite for ramping up the operations to reap benefits from economies of scale factors and increased flexibility of ICT resource allocation through Cloud that can make dealing with local demand peaks easier.

IV. CHALLENGES

A. *Challenges posed by the Cross-border Environment*

Cross-border trade implies the intersection of commercial and public sector needs, which are often different if not contradictory. States are concerned primarily with safety and security issues, leading to the involvement of law enforcement and other state bodies with quite specific interests and requirements [14]. In comparison, companies engaging in trade are likely to be interested primarily in financial issues or strategic positioning in the marketplace, which are not necessarily aligned with safety and security.

In some cases the interests of states and companies align, - for instance packaging for pharmaceuticals. This kind of cargo is not of high intrinsic value but can be used by criminals to package counterfeit drugs that seem legitimate, leading to criminal profits and a public safety issue. Both the states and commercial companies shipping cargoes will want to exercise considerable care in dealing with such a cargo.

In other cases the priorities of the two sides maybe less well aligned. Governmental agencies are supposed to act on societal interests and for many years have been primarily concerned on ensuring the safety and security of food. Only recently, the focus has been moved on trade facilitation, however there are still challenges about how to operationally speed up flows of goods at country borders while ensuring security. Trade facilitation initiatives may support private companies to easily understand regulations, procedures and data required by authorities to clear containers. In such a situation delivery uncertainty is strongly reduced leading to savings for companies, e.g. reduced safety stocks or pipeline inventories, less costs allocated in recovery operations etc. To be effective in as broad range of circumstances as possible, these trade facilitation initiatives should include studies and recommendations covering cross-organisational ICT systems. These should cover not only the technical interoperability of the ICT-systems, but also the compatibility and robustness of the management processes - especially as they relate to error detection, diagnosis and recovery.

Dealing with many stakeholders who must interact without being in a clear hierarchy, and who have different priorities and

requirements is clearly complex, and has analogies to the challenges seen in managing federated computing systems. It is not possible to enforce top-down solutions, as in many cases there is no clear highest authority (it is hard to say which customers organisation of the four countries a cargo passes through is the "most important"). Even where there is a central authority such as a regional or international organisation, it is rarely able to impose solutions. Rather such bodies must work via consensus. As ICT adds additional layers of complexity to already complex systems, there is a need for experience from any area that has approaches that can help manage these sorts of situation, and make consensus more achievable.

B. *Evolving IT service delivery in Cross-border trade*

As we have discussed, the introduction of ICT is often seen as a way to simplify operations, and can bring many benefits, but also additional complexities. Most of the scenarios in ICT for cross-border trade are inherently cooperative (if not federated), and when one considers the range of stakeholders and the various systems they must or chose to adopt, the community to federate (and ICT services to manage) becomes extremely complex.

Even if there is an agreement on what information is needed, two companies or two customs agencies may require different granularities, or different reporting periods. While technical solutions are often quite easy to implement, they make management of the whole system considerably more complex.

Equally, even if relations between community members are quite clear, there is potential 'hidden' outsourcing risks if distributed, 'cloud-like' IT solutions (SaaS, PaaS, BPaaS,..) are adopted as they impose vendor-lock-in and single points of failure. While federated solutions (for instance hybrid clouds that mix in-house and external resources) offer ways around these issues they also add management complexity.

Introducing ICT can in fact be detrimental to the robustness of the overall system (especially in emergency situations) if it introduces unforeseen risks that are hard to mitigate. For instance, a paper based customs declaration system, while less efficient, can be processed in multiple ways, by different agencies and people. Should the individuals normally responsible be unavailable, others should be able to cover them. If the system is fully electronic, this is not always the case. Even if the submission service is on an independent server, it may rely on entry through the main website for the customs organisations, which might be down for some other reasons, from an attack by a hacker to the web developer updating parts of a public site. Equally, the service will become reliant on the working of many small technical components, which can be hard to manage reliably. While professional IT service organisations may be effective at this sort of challenge, public sector organisations tend to be less able, and these systems are often not fully outsourced for security reasons.

Systems that do not attend to management tend to operate effectively at a small scale, or at a low level of reliability, but cannot scale to larger size or greater reliability and efficiency. Given the cost of inefficiency in the cross-border trade sector, it is not only generally sensible but also financially advantageous to consider how best to manage the complex ICT structures involved in international trade.

V. Toward applying Federated ICT Management Techniques to Cross-Border Trade

We can foresee applying two sets of knowledge from federated ICT management to the cross-border trade sector. The first is generic knowledge and understanding of mapping and managing complex federation or collaborations of stakeholders. The second is more specifically in managing IT services across organisations, as these kind of service scenarios will almost certainly occur increasingly in cross-border trade scenarios. In both of these cases we would imagine the following generic steps as an optimal way to proceed:

- Community mapping – identify the organisations involved and define relationships between them, both current and those desired in the future.
- Key processes identification – define the activities that are carried out to keep the federation operating and try and group them into processes.
- Pre-standardisation – define a realistic and comprehensible set of states that would allow for better service management, based on existing standards where possible.
- Capability modelling – create a framework that allows assessment versus the standard on specific areas, use this to assess current status and to make an execution plan to reach and verify achieving the goals

These steps are explained in more detail in the following sections.

A. *Community mapping*

In many cases of complex communities, there will be crucial relationships that are underemphasised and entirely extraneous ones that are overemphasised. An example of the former would be links between an undocumented service provided by someone outside their formal duties that is used by a large group of individuals from different organisations as a "shortcut" that in fact is crucial for maintaining the expected quality of service of the overall system. An opposite example might be a complex formal model (e.g. due to slightly misguided process improvement efforts) for communicating non-critical "cosmetic" feature requests to the system that are usually bypassed by a phone call and suggestion to include the change in the next revision as a bug fix.

For example, in case of the EGI community, it is possible to offer several interpretations as to who are the clients ***and*** the service providers of the different services provided by the EGI community. This results from the organic way the community has developed from a testbed mode (where everyone essentially have to be able to speak to everyone) to production mode. Looking at the current structure, there are some obvious relationships missing or poorly defined, while others exist but are not helpful in managing the overall service.

To identify the crucial targets for management intervention, a model should be developed that could be described as "aspirational reality". It should represent a community model achievable from the current status, but that concentrates on key relationships and ignores or deprecates others from the analysis of the production mode process optimisation. The mapping essentially provides a map of the parties and the relationships between them that services must be managed over.

B. Key process identification

Once the key relationships have been identified, the next step is identifying the management processes (either IT management processes or activity areas) that need to be coordinated at a federation- or community-wide level. In general, for a given community or federation structure only some of the processes will be federated, while others can and should be managed locally. Even if the end result is that only few of the processes can be operated at a federation level, identifying the key processes makes the responsibilities clear for all members of the community.

In the ICT sector these processes can be described and categorised based on established frameworks such as ISO/IEC 20000 or ITIL, while similar conceptual frameworks can be adapted or created for non-ICT management. It should be noted that these are processes needed in *managing* the service rather than in providing the service itself. For instance negotiating SLAs or other service agreements for a shipping company is part of a management process but actually moving a package around is part of the main service itself. The management aspects are everything that has to be provided in addition to the fundamental service itself to make it attractive to customers.

C. Pre-standardisation

Based on the identification of the key relationships and the processes that are crucial for maintaining them, a loose standard describing the minimum criteria for reaching stable operations with improved management level oversight and maturity can be created. This *pre-standard* should state overall goals in simple terms and not aim at jumping directly to a highly optimised management. The role of the pre-standard is to provide simple, achievable guidance (less complex than a full standard) which community members will accept and that can act as a stepping stone towards compliance with full standards.

D. Capability modelling

Once the overall goal for the baseline federated service management is established, it is advantageous to build a model that allows capability in fulfilling these processes to be assessed and mapped to an overall maturity of the organisation or group in carrying out management. This should be aligned to the pre-standard, such that it divides the content of it into processes, and finer grained activities and criteria within them.

Capability modelling allows the current state of capability and maturity to be understood, by checking the service provider against a list of criteria; it also allows improvement to be planned by looking at the criteria that were not met and planning future improvement as a series of criteria to meet incrementally.

Overall, incremental steps should be stressed and the material generated in steps A to C used to illustrate how (eventually) the improvements on the system level will benefit all of the participants. There will be an unavoidable organisational resistance to almost any change needed, and this phenomenon will be especially pronounced in federated environments if the proposed change is seen either as too drastic (and therefore unachievable) or disconnected from the day-to-day reality (and therefore irrelevant). The importance of marketing the improvements within the community or federation must not be underestimated, since it can improve engagement with client communities for all of the organisations. Already within the traditional, mature IT Service Management field marketing is considered a critical success factor in improvement of management, and this is even more important in a federated environment where many of the benefits of the improved management practices are less immediately felt.

These techniques are successfully being using in improving the management of federated ICT infrastructures, via the FedSM project. FedSM has three committed 'clients' implementing these approaches, each representing an e-Infrastructure organization. Implementation begins n 2013 and will be complete by 2015. These approaches are technology- and field-neutral and can be applied to cross-border trade scenarios, both generally and more specifically around ICT issues. In fact issues may be somewhat simpler in cross-border trade as the financial bottom line may drive improvement more simply than it does in the academic community.

VI. The Swedish Single Window

A. Background

An example of a cross-border trade scenario where federated ICT may be applicable is the Swedish Single Window, an e-Customs platform is the that is accessible by trading companies through the website of the customs administration. The services that are available to traders include [10]:

- Submission of Electronic Customs Declaration.
- Application for import and export licenses.
- Access to current and upcoming changes in trade regulations.
- Interactive training courses.
- Creation and customization of a personal virtual customs office.

The stakeholders that are involved in processing the messages related to the above services include:

- The Swedish Customs (leading agency).
- The Swedish Board of agriculture.

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- The National board of Trade.
- National board of Taxation (import VAT debts information is forwarded to the National Board of Taxation).
- CSB, Swedish Statistics Office (Customs declarations are sent to CSB and used to generate trade statistics).
- The Swedish National Debt offices (payment of Customs duties)
- The National Inspectorate of Strategic Products.
- The Swedish Police
- Norwegian Customs
- Russian Customs
- European Union

Today about 12,000 companies (importers, exporters and customs brokers) access the Swedish Single Window and exchange more than 100,000 electronic messages every day. About 7,000 private citizens have also access to the platform.

Data may be submitted to the platform using the UN/EDIFACT or XML standard, through the web-based customs portal, or in paper format. In the last case, the declaration is entered into the system by a Customs officer. The format of the Customs declarations follows the recommendations of international standards: CUSDEC (CUStoms DEClaration Message) and CUSRES (CUStoms RESponse message).

The drivers for adopting a Single Window platform in Sweden were cost and time savings, reduction in errors and streamlining or inter-organisational processes. The benefits include reduction of time for documentary control, reduced uncertainty and delays at the borders and overall facilitation of trade [10]. Unfortunately, there are only rough quantifications of the potential benefits of such platforms for their commercial users. Companies often do not measure the costs related to customs operations and thereby are able to make only "educated guesses") [9]. Nevertheless, it has been estimated that in Sweden compliance costs have decreased by 20%-50% for each individual operator. Considering that average compliance costs in Switzerland have been estimated as 56 CHF per declaration (min 3 CHF, MAX 190CHF), the savings could be substantial [9].The Swedish governmental agencies have also experienced a marginal increment of tax revenues since the full implementation of the Single Window (although it was already 99.5% of the theoretical value before the Single Window introduction), while the Swedish Customs has been able to decrease the time spent for documentary controls by 50% and the Board of Agriculture has cut its processing time by 40% [10].

B. The potential fo the federated ICT mabagement approach

Despite difficulty in precisely quantifying the overall benefits, these examples indicate that there are advantages to these systems. However their reliance on ICT also introduces additional risks and complexities. ICT systems involving multiple agencies tend to be complex and need to access multiple independent systems, even in countries like Sweden with relatively tightly integrated government services. If Cloud adoption continues, these systems may also become federated by combining services from different providers, with the federation hidden by the cloud interface. We might generalise that while these systems are highly effective and provide cost and efficiency related benefits when working as expected, failures can be very difficult to identify and address, and migration to Cloud will make this challenge even more difficult.

While federated ICT management techniques should help deal with large complex problems for new systems, they can equally be applied to more routine issues under normal circumstances. For instance, though the stakeholders were identified in implementing the Swedish Single Window, initial understanding of their relationships failed to recognise that SMEs did not have the capabilities to submit their information electronically [10]. Hence, to accommodate these companies the technical framework had to be extended to allow communication by means of web technology and/or text messages over mobile phones. While this single issue was solved, it is exactly the type of issue the federated ICT management approach would have avoided. Stakeholders were identified but not at a fine enough granularity, as smaller SME capabilities and their limitations were not initially recognised. These then had an impact on the implementation of a process within the system, which could not accommodate them. Had the process been better defined an a pre-standard applied (that for instance spelled out the requirements on users of the system) this problem would have been identified, and capability modelling could have been used to identify specifically what extra capabilities were missing and make plans to meet them.

In this case the problem was identified and circumvented, but in a complex federation it is likely that other problems, many dealing with ICT, will occur. Application of a formal management approach would help to avoid these issues and further save costs by avoiding the need for later 'fixes' to solve issues caused by federation complexity.

VII. TOPICS FOR FURTHER INVESTIGATION

The early tests of these approaches in the ICT domain have been successful and they are currently being implemented across sets of organisations and multinational federations. The long-term successes of these implementations should be assessed as soon as possible, both to see where they can be improved and to look at their applicability to areas such as cross-border trade. Current ICT domain implementations run from 2012-2015, and preliminary results allowing initial assessment will likely be available from late 2013.

However, in parallel with the first steps described here, modelling and assessment of the cross-organisational

management issues related to cross-border trade can be carried out for relatively low costs. Adapting the approach to the cross-border trade sector would bring novel management approaches to a sector where any process improvement will have a considerable direct socioeconomic impact. It may be instructive to take a limited case, such as trade between the small set of nations in a particular region, such that management can be examined in detail without the scale of the problem making data collection unrealistic.

VIII. Conclusions

Cross-border trade is a sector worth trillions of euros, which has grown and will continue to grow as the world becomes increasingly globalised. It operates across a highly complex landscape which involves state and private organisations, involves potentially hundreds of different languages and jurisdictions, and incompatible bureaucratic procedures.

ICT has shown its potential to drastically improve this sector, but current state of the art in federated ICT management is not sufficient to reach the full potential. ICT based systems are more likely to be designed and deployed at a national rather than regional or global levels, and so the benefits may not be felt at a larger scale due to competing national ICT solutions. Even where this can be avoided, ICT solutions to cross-border trade issues will almost inevitably involve federation of different ICT systems. This imposes complex management challenges, as providing reliable services based on federations is not trivial. Federation is also likely to extend to Cloud and other distributed systems, which may add another level of federations, and despite appearance of redundancy and infinite scalability, introduce single points of failure.

In general, attempts to address these issues have concentrated on technical problems and solutions, but it is vital that the overall management of the services is also considered and developed. This situation mirrors the one seen in federated ICT systems for the research sector, such as Grid computing and multi-cloud infrastructures. The approaches developed in these sectors, to combat initial weaknesses in management, can be translated for the cross-border trade sector, and see likely to help deal with the problems identified.

At heart, these techniques are those needed to introduce rational management structures to complex communities, often used to operating based on *de facto* processes based on common understanding between the interacting parties. This is a feature shared by both the federated ICT sphere and the cross-border trade environment. As such, heavy-handed top-down solutions, which might be more workable within single organisations, are very unlikely to work. Rather more bottom-up approaches that stress incremental change and show small 'deltas' to improve management are more realistic. In fact, even on the level of a single organisation, where solutions can – at least in theory – be decided on by top management, a parallel bottom up approach to convince employees of the effectiveness and realism of new management processes is almost always needed. Likewise, ensuring that change is described using the terminology of the community in questions appears to be crucial is showing how approaches from other communities, however successful, can be introduced.

Even if global solutions for these problems can be developed, the speed at which they can be implemented would be very slow, and an approach such as that described here would both speed the process and make initial improvements that later, more concerted efforts could build on.

In the cross-border trade sector, the positive results of these changes should be visible in lower costs and increased profits. Even small improvements could mean considerable economic benefits for regions such as Europe, where so much of the trade is cross-border in nature – considerable enough to make the necessary investments in the modelling, pre-standardisation and management intervention seem very modest in comparison.

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