SMART LOGISTICS AND FREIGHT VILLAGES INITIATIVE

Scientific report

SmartLog
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SmartLog
blockchain logistics

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ABBREVIATIONS

Abbreviation	Definition
3D	Three-dimensional
AES	Advanced Encryption Standard
AG	Joint-stock company (in German)
API	Application programming interface
ARIS	Architecture of Integrated Information Systems
B2C	Business-to-Consumer
B/L	Bill of lading
BPM	Business process modeling
CMS	Content management system
CRL	Certificate Revocation List
CRM	Customer Relationship Management
CORDA	Decentralised database platform
CT	Container terminal
DB	Deutsche Bahn (German company)
dd	definition data
DSC	Digital supply chain
DSV	De Sammensluttede Vognmænd (Danish company)
EDI	Electronic data interchange
EPC	Electronic Product Code
ERP	Enterprise resource planning
ETA	Expected time of arrival
EU	European Union
FR	Freselle Logistics Ltd (Estonian company)
FTP	File Transfer Protocol
GDPR	General Data Protection Regulation

Abbreviation	Definition
GIAI	Global Individual Asset Identifier
GPS	Global Positioning System
GS1	Not-for-profit organization that develops and maintains global standards for business communication
HLF	Hyperledger Fabric
IBM	International Business Machines (United States company)
ID	Identifier
IDE	Integrated development environment
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IP	Internet protocol
IT	Information Technology
JSON	JavaScript Object Notation
KPI	Key performance indicator
LCC	Limited liability company
max	maximum
min	minimum
MP	Measurement point
MS	Microsoft (United States company)
MSC	Mediterranean Shipping Company
MSP	Membership Service Provider
North Sea-Baltic	The North Sea-Baltic Transport Corridor
OASIS	Organization for the Advancement of Structured Information Standards
Oy	Limited liability company (in Finnish)
Q	Question
REST	Representational state transfer
RFID	Radio-frequency identification

Abbreviation	Definition
RSA	Rivest–Shamir–Adleman cryptosystem
ScanMed	Scandinavian-Mediterranean Transport Corridor
SDK	Software development kit
SFL	ScandFibre Logistics (Sweden company)
SmartLog	Smart Logistics and Freight Villages Initiative
SMEs	Small and medium-sized enterprises
SMS	Short Message Service
TalTech	Tallinn University of Technology
TWA	Transwagon (Latvian company)
UBL	Universal Business Language
UI	User interface
V, v	Version
WHS	Warehouse
WP	Work package
XML	Extensible Markup Language

EXECUTIVE SUMMARY

Logistics and effective supply chains play a huge role within today's economy. Currently there are several bottlenecks identified on the services that logistics companies provide. Regarding bottlenecks along the delivery routes, most of the time in delivering cargo delivery is lost during waiting at different warehouses or logistic nodes. The bureaucracy concerning procedures, limited digitalization and still existing amount of paperwork offered in these nodes add to the delays and to the cost of services. The amount of manual procedures along the route allows for mistakes to happen, delays and questions regarding validity.

Today's supply chains are becoming more complex and the visibility of key information, events and collaboration across organizational boundaries is increasingly viewed as essential criteria to the long-term competitiveness of the supply chain network. Managers in many industries, especially in manufacturing, are trying to manage supply chains better by putting together roadmaps of digitalized supply chains. Digitization overcomes these barriers and the chain becomes a completely integrated ecosystem that is fully transparent to all the players involved — from the suppliers of raw materials, components, and parts, to the transporters of those supplies and finished products.

The SmartLog project developed a blockchain technology-based solution to solve the abovementioned shortcomings for the logistics and supply chain companies. Blockchain represents the key element for the creation of the digital supply chain. Blockchain technology is disrupting society by enabling new kinds of disintermediated digital platforms. The disruptive technology is regarded as a potential means of establishing the integration of the different actors in the supply chain, enhancing the information flow among them and ensuring the security as well as the cost effectiveness. Blockchain technology has a dual effect of removing the need for actively intermediated data-synchronization and concurrency control.

Companies from Sweden, Finland, Estonia and Latvia were involved in the project along two TEN-T corridors: North Sea – Baltic and Scandinavian – Mediterranean corridor. In total, 648 companies were contacted and thorough communication with detailed analyses was conducted in 151 companies operating along the abovementioned corridors. The aim of these contacts was to gain input to the software development, understand and map their processes, get an understanding on the maturity level of hard- and software and their susceptibility to the new technology. Detailed process maps were created and simulations using these measuring points were done in 48 companies. Finally, developed software was connected to the IT systems of 12 companies and real time data gathered and analyzed.

As a result, we found that today companies are lacking trust in new technologies due to security and privacy concerns. Both small and medium enterprises have very low maturity level of digitalization; the focus needs to be on large companies. Their processes are better mapped and digitalized, their investment and know-how capability is better and IT systems more advanced. Use of closed and private platforms and bilateral integrations poses threat to standardization. Number of competing platforms is in increase and introduces further complexity. Early message exchange standards have been created but are still subject to change and compete with other similar standards (competing technology implementations).

Interest and perceived value were documented above average for blockchain in the logistics industry. Time reductions along the two targeted corridors based on process simulations made up 6.3% and based on data analyses 3.8%. Larger time reductions can be estimated when employees get more accustomed to using the benefits of the new software solution.

Key words: blockchain technology, digital supply chain, supply chain visibility.

INTRODUCTION

The industries of manufacturing, supply chain, logistics, and transportation management are facing substantial change as new technologies come on board. For manufacturers, using IoT (Internet of Things) technologies is no longer an option, but a reality – Smart Factories. Development in EU is not different. Changes in manufacturing processes will dramatically affect how logistics providers of all sizes operate. Transportation cost and delivery time are critical aspects for most manufacturers, and using technology to make transportation more efficient helps reduce overall costs and time of the delivery.

Hence it is crucial for transportation management services, warehouse management systems, and other aspects of logistics to take the IoT systems on board to be able to satisfy the changing needs of the customers. The project SmartLog develops an IoT-solution to the logistics sector and tests it on the logistics companies across the two corridors (ScanMed and North Sea-Baltic). The new solution would optimize all aspects of their integrated services (transportation, warehousing, cross-docking, inventory management, packaging, and freight forwarding) by eliminating the need for routine human interaction with computer systems and giving access to vast amounts of anonymized data outside an organization. That results in decreased operational costs of the companies as well as reduced time of delivery of goods.

There are six partners in the project, covering the regions along two transport corridors and representing logistics companies, regional/local governments and research organizations.

- Kouvola Innovation Oy, Finland (project leader, WP 3 leader)
- Region Örebro county, Sweden
- Transport and Telecommunication Institute, Latvia
- Valga County Development Agency, Estonia
- Sensei LCC, Estonia (WP 1 leader)
- Tallinn University of Technology, Estonia (WP 2 leader)

All partners have good access to the main target group of the project - logistics and transport companies along the two corridors.

1. BACKGROUND

1.1. Digitalization of transport and logistics

1.1.1. Industry 4.0

Digital transformation is described as the process of combining advanced technologies and the integration of physical and digital systems. Thanks to the internet and mobile technology, final users can share information about their needs upward the supply chain. Digitalization of processes has become a key element of supply chains. It decreases a lot of resources like human, time and material. If the vision of Industry 4.0 is to be realized, most enterprise processes must become more digitized. A critical element will be the evolution of traditional supply chains toward a connected, smart, and highly efficient supply chain ecosystem.

Industry 4.0 has created a disruption and made companies rethink the way they design their supply chain. Supply chains need to become much faster, more granular, and much more precise. New trends and strategies across enterprise logistics operations, combined with a new generation of logistics technology, will dramatically change the way leading companies pursue supply chain management. As a result of digitalization there will be a quick growth of data. Companies must act quickly to take control of data growth and complexity. That includes focusing, simplifying and standardizing data analysis through an enterprise data management strategy. Those companies that realize it will be getting meaningful insights that truly matter to their business. These companies will be first to detect changing market conditions, trends and they will be able to innovate and adapt more quickly. There are many benefits of the digitalization of the supply chain. In the future there will be an integrated supply ecosystem rather than a linear supply chain.

This means that the ecosystem will be transparent for all counterparties – customers, suppliers, producers, etc. will have a complete overview of the supply chain. Communication among different members will be more efficient, because all information that is entered into a system will be available for all members simultaneously. Integrated supply chain will be flexible – this means that end customer demand changes are rapidly assessed. Digitalized supply chain will be responsive - real-time response on planning and execution level (across all lines to demand changes). Industry 4.0 transforms traditional production processes into intelligent processes managed by self-controlling mechanisms. Technological trends that are relevant in less than five years are the following: robotics and automation, cloud logistics, big data analytics, augmented reality, low-cost sensor solutions. It is estimated to take more than five years for the following technologies to become relevant: self-driving vehicles, artificial intelligence, 3D printing, unmanned aerial vehicles, blockchain, next-generation wireless, bionic enhancement (more advanced wearable technology), and virtual reality. (Cichosz 2018)

In literature, the digital supply chain is defined in many ways. According to one definition, the term "digital supply chain" is typically used when discussing how the development and implementation of advanced digital technologies (for instance, IoT, blockchain, machine learning, artificial intelligence, etc.) can drive improvements to traditional supply chains. (Johnson, 2019)

According to the second definition, the digital supply chain is the chain of technology companies involved in the delivery of any digital product, such as a website or software platform. For instance, e-commerce website has its digital supply chain which includes the website's developers, its administrators, the cloud services company that hosts the website's data, the CMS provider and the devices that consumers use to access the website. In addition, every third-party technology provider whose code provides functionality to the website, like personalized recommendation engines, inventory tracking solutions, chatbots, should also be considered part of the digital supply chain. (Johnson, 2019) The business goal of the digital supply chain is to deliver the right product to the customer as quickly as possible but also to do this responsively and reliably, while increasing efficiency and cutting costs through automation. This aim cannot be achieved unless the supply chain is fully integrated, connected with different counterparties along the supply chain and driven through a central cloud-based command center. (Meulen, 2018)

Steps to digitalize a company's supply chain – firstly, a company's digital vision and supply chain role must be confirmed. This means that managers of different levels of the company define a vision for the type of digital experience they want the organization to deliver to its customers. Secondly, the company must align the operating model of the supply chain to the digital vision. This means that digital projects across the company are aligned under a single governance process. Thirdly, the company must prioritize digital technology investments. In times of uncertainty, supply chain organizations tend to focus on improving existing operations to boost today's business and forgo the investments needed to support tomorrow's business. In many cases, this conservative approach will not align with today's wider organizational priorities. (Meulen, 2018)

Behind the great potential of the digital supply chain (DSC) lies Industry 4.0, the fourth industrial revolution (Geissbauer, Schrauf et al., 2017). For an effective supply chain and enterprise digitalization, the enterprise must have a strategy that the new digital solutions support. In the future there will be the digital supply chain ecosystem, which will be based on full implementation of a wide range of digital technologies (for example, the cloud, big data, the IoT, 3D printing, augmented reality). Together, they are enabling new business models, the digitization of products and services, and the digitization and integration of every link in a company's value chain: the digital workplace, product development and innovation, engineering and manufacturing, distribution, digital sales channels, and customer relationship management.

The supply chain today is a series of largely discrete, siloed steps taken through marketing, product development, manufacturing, and distribution, and finally into the hands of the customer. Digitization brings down those walls, and the chain becomes a completely integrated ecosystem that is fully transparent to all the players involved — from the suppliers of raw materials, components, and parts, to the transporters of those supplies and finished goods, and finally to the customers demanding fulfilment. This network will depend on a number of key technologies: integrated planning and execution systems, logistics visibility, autonomous logistics, smart procurement and warehousing, spare parts management, and advanced analytics. The result will enable companies to react to disruptions in the supply chain, and even anticipate them, by fully modelling the network, creating "what-if" scenarios, and adjusting the supply chain in real time as conditions change.

Once built — and the components are starting to be developed today — the digital supply "network" will offer a new degree of resiliency and responsiveness enabling companies that get there first to beat the competition in the effort to provide customers with the most efficient and transparent service delivery. (Schrauf and Berttram, 2016)

The digital supply chain consists of eight key elements: integrated planning and execution, logistics visibility, Procurement 4.0, smart warehousing, efficient spare parts management, autonomous and B2C logistics, prescriptive supply chain analytics, and digital supply chain enablers. Supply chains that can put together these main elements into a connected and transparent whole will have serious advantages in customer service, flexibility, efficiency, and cost reduction. New technologies like big data analytics and the cloud drive companies help to develop a smart supply chain. Also, growing expectations of consumers, employees and business partners are pulling companies to promote a more reliable and responsive supply chain. The goal of the digital supply chain is to deliver the right product to the customer as quickly as possible but doing so reliably and responsively by increasing efficiency and cutting costs through automation. Said goal can only be achieved if suppliers, manufacturing, logistics, warehousing, and customers are seamlessly connected through IT-solutions. That enables quick and accurate sharing of information, for instance, signals that trigger events in the supply chain can alert all the members of the supply chain about shortages of raw materials, components, finished goods, spare parts etc. (Schrauf and Berttram, 2016)

1.1.2. Digitalization of data

Several technologies have emerged that are altering traditional ways of working. Besides the need to adapt, supply chains also have the opportunity to reach the next horizon of operational effectiveness, to leverage emerging digital supply chain business models, and to transform the company into a digital supply chain. The amount of data moved in the logistics sector is relatively big and great amounts of data move as paper documents, which are also printed out countless times by the participants of supply chains. The same data (product names, codes, prices, dimensions, weights, etc.) are being re-entered several times into different systems by different people. Depending on the length of the supply chain and numerous participants, data can be entered into different systems by the manufacturer, buyer, warehouse, carrier, distribution center, etc. This is very high resource cost, both in terms of staff time and indirect costs such as electricity or paper, causing also environmental impacts. Digitalization of data gives companies an undeniable competitive edge. This will improve the quality, availability and reliability of the data. If all data was moving digitally between different systems, the amount of manual data input and the number of errors from data entry would be reduced. The data flow would also be several times faster, as the time delay caused by the human factor would be reduced.

Digitized data can be used to analyze much larger amounts of info, and digitalization makes it easier to process that information. This helps to make better business decisions more effectively by increasing company's planning capabilities.

Digitalization enables us to leverage our competitive edge and increase our loyal customer base. The customer would easily be able to track their orders, stocks, invoices, etc. directly from the web without having to spend time emailing or calling to the service provider. Customers are not quite ready for it because it means they have to enter the raw data themselves. This means a cost to them as well as a responsibility to ensure that the raw data is correct. Companies should be more engaged in process digitalization, as it offers the opportunity to make existing processes more cost-effective and increase profits. The implementation of new processes will also be faster.

A supply chain is a network of people and businesses involved in creating and distributing a product or service. It includes everything from the extraction of raw materials to the end consumers who purchase the product or service. A basic supply chain system involves suppliers of materials, manufacturers who turn it into a commodity, the logistics companies that manage the transportation of the raw material and commodities, as well as the final retailers that sell goods to consumers. As supply chains have become global, the simple network of suppliers, manufacturers and retailers described above has developed into a complex environment where various products and materials move through multiple stages managed by different parties and geographically distinct processes. Thus, supply chain management involves integrating sourcing, procurement, manufacturing, distribution, and logistics into a cohesive system. This requires cooperation among a multitude of stakeholders and plays a critical role in the success of a business. Some of the most urgent issues facing supply chains can be addressed through the blockchain technology, as it provides novel ways to record, transmit, and share data.

Many of today's supply chains have good data, which they are able to transfer across supply chain tiers at close to real time speed. There are three areas in assessing the value of the blockchain technology at stake for the supply chain world where it has potential to add value. Firstly, it replaces slow manual processes. Although supply chains can currently handle large, complex data sets, many of their processes, especially those in the lower supply tiers, are slow and rely entirely on paper — often still common in the shipping industry. Secondly, the blockchain technology strengthens traceability. Increasing regulatory and consumer demand for provenance information is already driving change. Moreover, improving traceability also adds value by mitigating the high costs of quality problems, such as recalls, reputational damage, or the loss of revenue from black- or grey-market products. Simplifying a complex supply base offers further value-creation opportunities.

At this stage, this benefit is more theoretical than actual. Bitcoin pays people to validate each block or transaction and requires people who propose a new block to include a fee in their proposal. Such a cost would likely be prohibitive in supply chains because their scale can be staggering. For example, in a 90-day period, a single auto manufacturer would typically issue approximately 10 billion call-offs just to its tier-one suppliers. Also, together all of those transactions would significantly raise demand for data storage, an essential component of blockchain's distributed-ledger approach. In addition, creating and maintaining numerous copies of data sets would be impractical in the supply-chain environment, especially in permissionless blockchains.

Blockchain technology is transforming business in lots of different ways, from production and processing to logistics and accountability. Supply chain management is a particularly important use case, as every stage in the process can be registered and verified to create transparent and immutable records. Therefore, the use of blockchain in supply chains has the potential to eliminate inefficiencies that are common in the traditional management models.

1.2. Blockchain technology

Algorithms that enable the creation of distributed ledgers are powerful, disruptive innovations that could transform the delivery of public and private services and enhance productivity through a wide range of applications. A blockchain is essentially a distributed database of records or public ledger of all transactions or digital events that have been executed and shared among participating parties. Each transaction in the public ledger is verified by consensus of a majority of the participants in the system. And, once entered, can never be erased. The blockchain contains a certain and verifiable record of every single transaction ever made. Blockchain can be defined as a distributed ledger technology that can record transactions between parties in a secure and permanent way. By 'sharing' databases between multiple parties, blockchain essentially removes the need for intermediaries who were previously required to act as trusted third parties to verify, record and coordinate transactions. By facilitating the move from a centralized to a decentralized and distributed system, blockchain effectively liberates data that was previously kept in safeguarded silos. Blockchain technology does not introduce an entirely new paradigm. It builds on the old template of a ledger – something that is used to log transactions over a period of time. Traditional ledgers are owned by one entity (such as a business, organization or group) and controlled by a designated administrator (for example, an accountant). This administrator can implement changes to the ledger without requiring consensus from all of the ledger's stakeholders.

In contrast, blockchain is a shared, distributed ledger among a network of stakeholders that cannot be updated by any one administrator. Instead, it can only be updated with the agreement of network participants and all changes to the distributed ledger are auditable. A similar process can be used to trace other types of asset transfer, to commit new data to a blockchain, and to update data in a blockchain. This 'mutualization of data' in a blockchain-based system is only possible with strong cryptographic techniques that make certain that copies are identical, transactions are not duplicated, and specific permissions are enforced to access stored data. Here, public and private keys are used to ensure confidentiality and privacy. In simple terms, a public key can be likened to the address of a physical mailbox, which is publicly known by senders. A private key is similar to the key or password required to unlock the mailbox; it is safeguarded at all times by the owner and must not be shared with third parties. The transformative power of blockchain comes through the unique combination of its differentiating features and characteristics. Below is a summary of the four key features: data transparency, security, asset management, and smart contracts.

Distributed ledger technology is still at a very early stage of development. The development of blockchain technology is but the first, though very important step towards a disruptive revolution in ledger technology that could transform the conduct of public and private sector organizations. The technology can be adopted so that 'legitimate' changes to ledgers can be made in principle by anyone (an 'unpermissioned' ledger), or by a limited number of individuals or even a single authorized person (in a 'permissioned' ledger). There are many unsolved problems to tackle before the full potential of this and related technologies can be realized, including the resolution of issues of privacy, security, performance and scalability. Successful implementation of a distributed ledger will require a combination of governance to protect the participants and stakeholders and regulation to ensure the system is resilient to systemic risk or criminal activity. The challenge is to strike the balance between safeguarding the interests of participants in the system and the broader interests of society whilst avoiding the stifling of innovation by excessively rigid structures.

2. METHODOLOGY

2.1. Research strategy

Research strategy was worked out based on the need to build up the empirical understanding of the logistics sector digitalization, as it has an impact on both data collection hypothesis and evaluation of the results.

As the blockchain technology was considered mainly unknown for the companies to be involved, it was required to establish methods to estimate digitalization and readiness for new technology integration, data and business processes.

Overall approach in the strategy was to cover required steps to move from general understanding of logistics sector digitalization towards detailed requirements and evaluated impact and finally, to consolidate the individual findings.

2.2. Samples and limitations

2.2.1. Corridors

Corridor target coverage was set to include all land transport (road, rail, sea) but to exclude air transport. As the corridor covers a wide variety of goods transport, it was important to evaluate the nature of the goods also in the research. As the research focused on the companies in selected areas, a narrower focus for limited analysis was set to the Corridors as a crucial north-south axis for the European economy and the North Sea-Baltic Corridor that connects the ports of the Eastern shore of the Baltic Sea with the ports of the North Sea.

Transport routes used by companies in the following corridors were used during the research:

1. The Scandinavian-Mediterranean Corridor (Figure 1) is a crucial north-south axis for the European economy. Crossing the Baltic Sea from Finland to Sweden and passing through Germany, the Alps and Italy, it links the major urban centres and ports of Scandinavia and Northern Germany to continue to the industrialized high production centres of Southern Germany, Austria and Northern Italy further to the Italian ports, and Valletta. The most important projects in this corridor are the fixed Fehmarnbelt crossing and Brenner base tunnel, including their access routes. It extends across the sea from Southern Italy and Sicily to Malta. (Scandinavian-Mediterranean, 2020)

2. The North Sea-Baltic Corridor (Figure 1) connects the ports of the Eastern shore of the Baltic Sea with the ports of the North Sea. The corridor will connect Finland with Estonia by ferry, provide modern road and rail transport links between the three Baltic States on the one hand and Poland, Germany, the Netherlands and Belgium on the other hand.

Between the Oder River and German, Dutch and Flemish ports, it also includes inland waterways. The most important project is "Rail Baltic", a European standard gauge railway between Tallinn, Riga, Kaunas, and North-Eastern Poland. (North Sea-Baltic, 2020)

These corridors cover a wide variety of transport types, hubs (intermodal transport) and various types of goods and companies operating in these in order to determine the flow of goods and to map measuring points from end-to-end (from order to delivery by goods owner to recipient).

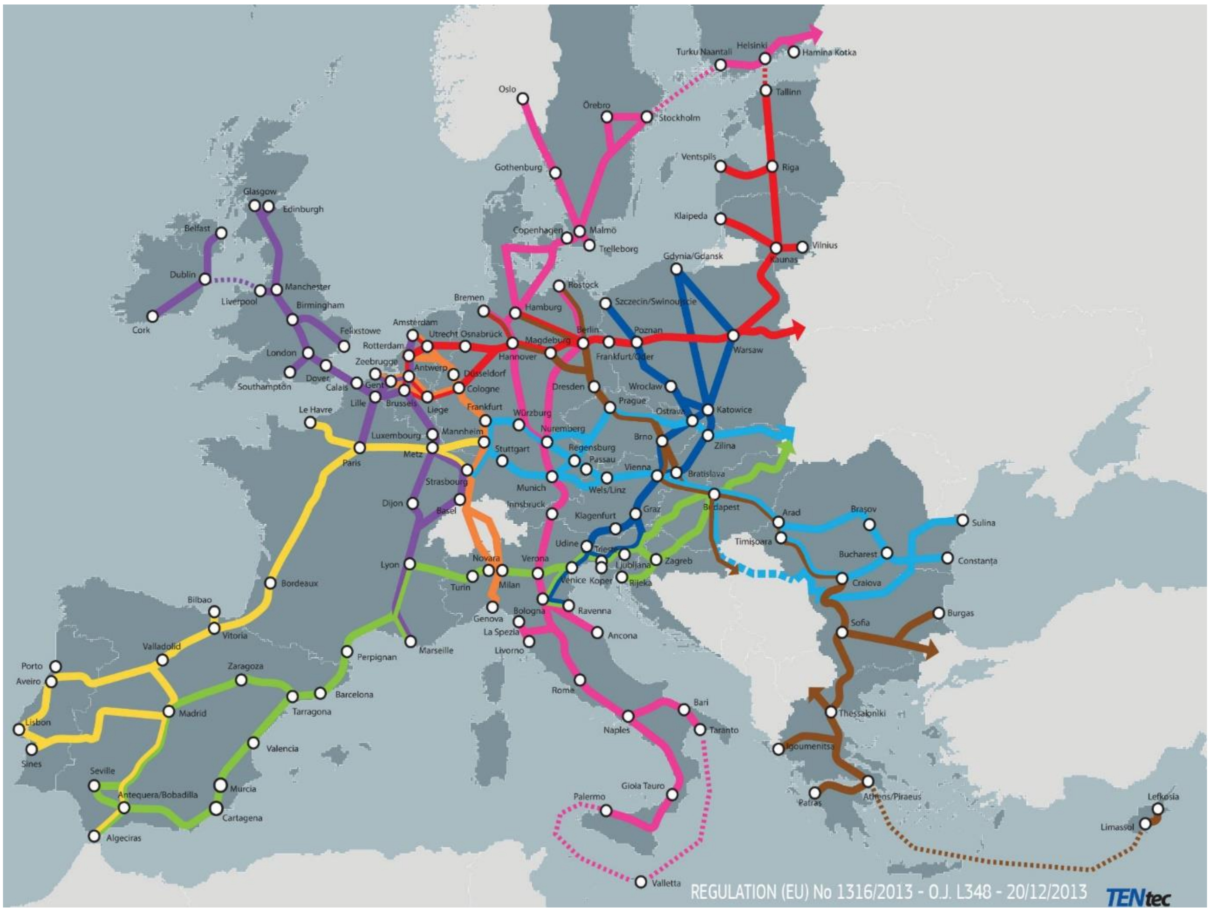

Figure 1. TEN-T corridors: Red – The North Sea-Baltic Corridor, Pink – The Scandinavian-Mediterranean Corridor

2.2.2. Supply chains

Initial strategy was built on the hypothesis that full supply-chain data can be collected and analyzed with the approval and participation of the owners of the goods. A goods owner as the owner and receiver of the logistics data about the transport of their goods is also eligible to approve data access for the parties involved. Due to the technical limitations, the data being scattered and majority of data lacking structured digital form, an unexpected outcome resulted, i.e. regardless of being the owner of the data turned out not equivalent of controlling the data. Based on further process mapping, identification of the measuring points, data attributes, systems and access rights, it became clear that providing a unified approach to collect such data on behalf of the goods owner (as they are not in control of the full chain) cannot be the sub-goal of the project due to its complexity. Early attempts to solve this as a part of the software requirements design, several obstacles were encountered: non-structured data, missing security principles, unwillingness of system owners to provide the data (legal bindings, not allowed to publish information to third party), missing legal approvals, impact and protection on business model (unexpected and unwanted threat if competitors have access to this data). Multiple logistics hubs, like ports, train stations, bigger expeditors and logistics centres, have part of the required dataset (especially critically required timestamps), but also refused to share or support such a request mainly due to legal restrictions.

For the process description of the supply chain process, design tools like Aris, Camunda, Visio and methodologies (BPM model) were used. Due to obstacles in collecting end to end supply chain data, a strategic shift was made to collect data from participating enterprises in supply chains individually and in the analysis phase, to measure the event timestamps in sub-chains that have the biggest expected impact and where data is collectable.

Enterprises selected to be studied were based on the Programme of The Central Baltic (Figure 2) (The Central Baltic…, 2020). The first limitation was related to the programme scope geographically that had limited the corridors where enterprises operate and are subject to being a sender, receiver or operator of physical goods.

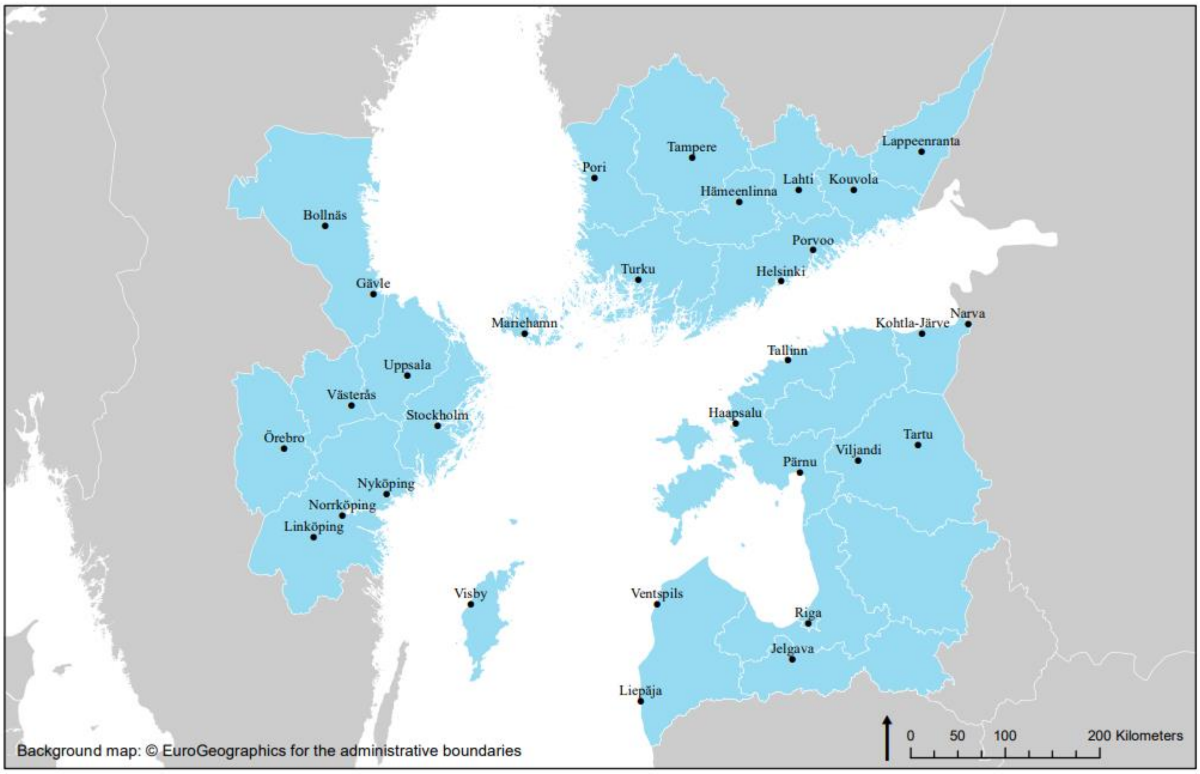

Figure 2. Main areas of origination of participating Enterprises (The Central Baltic…, 2020)

The second consideration and limitation for the sample of companies was related to the type of transport. For the research purposes, selection of companies was limited to transport by road, rail and sea, excluding air transport. The selection was based on keeping focus on local and regional transport and collect data that has direct impact on the selected corridor. As several companies also operate on other corridors and internationally, the focus was to extract business processes and data for the limited corridor and to minimize the impact of other corridors.

The third consideration for samples was related to the type of goods. Here the main aspect was to identify a wide range of different goods, the transportation of which is impacted by transport time (urgency), special requirements for handling (fragile, cold), amounts (bulk or micro amount), cargo types (no cargo, container, pallet, pre-slung), and cost sensitivity. Samples here include various views on goods like various consumer goods, raw materials, food & medicals, building materials and other bulk goods. The rationale was to understand how different types of goods impact the business process and the lead time.

Overall, the target was to select as wide sample of companies as possible and to avoid the influence of a single type of an operator on the research results.

The target number of enterprises for research was to include at least over 300 companies to represent a sample that can provide a significant number of sample points. For analytical purposes, it was required to analyze a wide number of processes to collect empirical insight about the operations and to define universal requirements for the software platform (blockchain technology). The data analytics part required several of these companies to be integrated with the software platform for data collection. Our target was set to have at least 10% (30+) of these companies to be integrated with the platform to monitor the change in the lead time with the use of the blockchain technology.

In total, over 1000 companies were addressed from Estonia, Finland, Sweden, and Latvia by field research. Contact was established with 648 companies and some of them were visited multiple times. Blockchain technology was introduced in detail for 151 companies. Due to various reasons, participation in the complex research was limited (see results). The final number of qualified contacts is given in Table 1.

Table 1. Qualified enterprises and contacts for research

Research field	Country	Number of Companies	Field research group
Survey			
	Sweden	23	Sweden (Örebro)
	Finland	10	Finland
	Estonia	85	South and North Estonia

Research field	Country	Number of Companies	Field research group
	Latvia	5	Latvia (Riga)
Companies targeted			
	Sweden	187	Sweden (Örebro)
	Finland	243	Finland
	Estonia	196	South and North Estonia
	Latvia	22	Latvia (Riga)
Companies visited			
	Sweden	23	Sweden (Örebro)
	Finland	42	Finland
	Estonia	87	South and North Estonia
	Latvia	4	Latvia (Riga)
Expert Interview			
	Sweden	3	Sweden (Örebro)
	Finland	3	Finland
	Estonia	3	South and North Estonia
	Latvia	1	Latvia (Riga)
Detailed process mapping			
	Sweden	7	Sweden (Örebro)

Research field	Country	Number of Companies	Field research group
	Finland	11	Finland
	Estonia	29	South and North Estonia
	Latvia	1	Latvia (Riga)
Data analytics (Blockchain implementation*)			
	Sweden	1	Sweden (Örebro)
	Finland	6	Finland
	Estonia	5	South and North Estonia
	Latvia	-	Latvia (Riga)

2.3. Enterprise-based business process analysis

Business process analysis was a required part of research to be executed for all companies included into the research. For process maps description, a business process modelling was used. As technical tools, ARIS software (ARIS Community, 2020) or similar software was used. It was a required step for collecting basic understanding about the companies and a consolidated overview of transport means, data collection technologies, identification of measuring points, process specialities, security restrictions, actors, roles, type of goods from end-to-end. The process analysis also was a key input for preparing the requirements blueprint to software development and later analysis of the collected data.

Due to different nature of the enterprise operations, the process analysis results covered parts of the supply chain, but rarely mapped the full chain from the goods owner's view. Based on the selection of the companies, most critical events were still identified to make conclusions of the events that have the highest impact on time.

Process maps were also used in the results analysis. For companies that were unable to integrate with the platform and provide data (for technical, organizational or legal reasons), the process maps were analyzed for key events. A process simulation was conducted based on identified measuring points to evaluate the events and their impact on time measuring and evaluate the potential of lead time deduction. For companies that had both process map and data, the results of the data were analyzed and measured.

2.4. LPI survey

The Logistics Performance Index (LPI) is an interactive benchmarking tool created to help countries identify the challenges and opportunities they face in their performance on trade logistics and what they can do to improve their performance. The LPI 2018 allows for comparisons across 160 countries. The LPI is based on a worldwide survey of operators on the ground (global freight forwarders and express carriers), providing feedback on the logistics "friendliness" of the countries in which they operate and those with which they trade. They combine in-depth knowledge of the countries in which they operate with informed qualitative assessments of other countries where they trade and experience of global logistics environment. Feedback from operators is supplemented with quantitative data on the performance of the key components of the logistics chain in the country of work.

Therefore, the LPI consists of both qualitative and quantitative measures and helps build profiles of logistics friendliness for these countries. It measures performance along the logistics supply chain within a country and offers two different perspectives: international and domestic.

Survey as a method was added during the project, mainly due to the fact that research was missing crucial background information about various businesses participating in the project (regardless of the decision to provide or not to provide data). Main target of the survey focus was to qualify and quantify the scenery for selected companies. Survey questionnaire was based on the Logistics Performance Index survey (LPI survey) developed by The World Bank (LPI survey 2020). Survey was developed in two phases: baseline survey (based on LPI) and leap of faith survey (extension to LPI, technology centric) (Appendices 1 and 2).

LPI survey in research is a qualitative and quantitative method to evaluate the current logistics performance situation of the companies and gain detailed insight of logistics digitalization in more granular distribution. The baseline survey based on the LPI target number of respondents was approximately 200 companies in total from Sweden, Finland, Estonia, and Latvia.

The extension survey – Leap of faith survey focused on near future plans (1-3 years) in the use of technology. The LPI survey based on technical questions and blockchain related questions was targeted to the respondents to gain their understanding of the SmartLog platform and blockchain capabilities practically or theoretically. The target number was the total of the baseline responders plus companies that were integrated with the SmartLog platform.

The survey was conducted continuously throughout all year in 2018 and 2019 in parallel with mapping business processes and integration to the blockchain platform. Though there were more responders, several answers were removed because they were not relevant based on limitations or missing data. The remaining part still represents largely the main targeted audience and gives insight to the approached enterprises during the research.

2.5. Expert interviews

Expert interviews were added during the project after a substantial number of field research was conducted and initial feedback and testing results were available. The focus of the expert surveys was on a deeper understanding of the expectation, challenges, alternatives, obstacles and time perspective for integrating the blockchain into the work process and logistics data collection and exchange. The scope was to understand the readiness and reasons for both the decisions to integrate or not to integrate the solution with the SmartLog platform.

Expert interviews were targeted in three phases. Selection of the experts was based on the stage of the project and their earlier participation level in the project. For the interviews, interview topics and templates were prepared by research managers and executed by the research team field members, who had previous insight to the enterprise processes. Technical interviews were conducted by researchers from Tallinn University of Technology who approached the technical experts in full command of regular information about the project.

The first phase was related to pilot and prototype creation, to understand the feasibility of data collection and validation of the prototype. In the pilot phase, 4 logistics companies were interviewed from Estonia, Finland and Sweden and 2 technical data integrators were interviewed from Estonia and Finland.

The second phase was targeted to interviewing experts after the usage of the blockchain platform and experience with the technology, its implementation and value creation. These interviewes targeted the companies participating in the research both with successful and unsuccessful integration. For Estonia, Finland, Sweden, Latvia, 14 companies were targeted (10 qualified received).

The third phase for expert interviews was dedicated to collecting knowledge about the implementation of the blockchain technology and the analysis of the findings with the technology and security experts who have experience with various technology implementations and cycles in several industries and critical knowledge about similar initiatives in the logistics industry (2 qualified blockchain and technology experts were interviewed).

2.6. Requirements for software development

Development analysis for creating the requirements for software development was a step focusing on data architecture, system architecture, including blockchain technology, data semantics and interpretation requirements for later analysis, security architecture, and deployment architecture.

Software development was tightly related to field research and available data collection and feasible integrations. In the initial approach, data collection was based on the corridor analysis and collecting data from good owners but was later altered as a shift in the strategy to collect data from enterprises operating in described supply chains. In parallel, alternatives for blockchain technology were studied, which could suit the research goal. A separate action for preparing a procurement to hire a company to build the required software was planned.

Main research steps focused on the preparation of technical detailed requirements that would match the expected workflow for the platform usage by companies.

Phases of software development foresaw creation of:

1. Prototype version, to validate and evaluate initial data model, integration, assumption and suitability of the blockchain technology
2. Final version to be distributed for companies with stable and documented architecture, the blockchain technology, security principles, integration and deployments options and maintained operations
3. Analytical version targeted to improve the perspective of the final version from data analytics and to add API interface to query and analyze the collected data and standardize found data inconsistencies or gaps.

Data architecture task foresaw the analysis of business processes and identification of key measuring points (logistics events with timestamp and context) subject to later data analysis. For software creation, the focus in the process analysis was to collect and map available data from all participating companies in various formats. The goal was to make the data digitally collectable and standardize the collection methods via various interfaces and develop required tools (user interfaces for manual collection, API and libraries for automated integration). Also, planning possible system integrations and business process proposals was part of this task. Around 50 process descriptions were compiled and analyzed.

Data semantics exercise was targeted to working on various data models and attributes from different sources and unifying the semantics for common understanding. Due to different types of goods, operating models, carrier types, systems used and lack of implemented standards, the uniformity of data was expected to be low. For data description, UBL 2.1 standard was used (Universal Business Language ..., 2013) to develop a common message standard. Business process modelling was used to describe the process and the chain of events for describing the data context.

System architecture task goal was to secure the system compliance for the set project goals but also to identify requirements during the analysis for data, security and operations.

Blockchain technology selection (decentralized database like Hyperledger Fabric and others) and integration to system architecture was a key factor for software development, as at that time, many early phases, competing and immature blockchain solutions were emerging (but not reached version 1.0 release yet). As there was no proven blockchain use case in logistics, neither technical and nor theoretical use of the technology, industry specific impacts had to be taken into consideration.

Security architecture requirement was an important aspect; firstly, to be analyzed from the blockchain component itself (immutable data measuring points). The second aspect of the security architecture was to describe the access mechanisms. During the development phase, architecture requirements were extended further to meet the security and privacy requirements for data owners and suppliers and for distributed deployment (non-sharable data to protect business secrets due to legal obligations).

The goal of the deployment architecture and the network model was to meet the feasible operating model for running the system and make it as easy as possible for companies to join the platform. Due to uncertainty of the architecture, blockchain solution and data integration options, it was expected to be worked out during the project.

2.7. Data analysis

Data analysis task focused on the analysis of the collected data in the blockchain using empiric quantification and qualification. Data analysis tasks included the evaluation of the types of data collected and the impact on time over selected (and integrated) companies and corridors when using the blockchain. For data analysis, data as-is situation and after blockchain usage were measured and compared.

Original expectation was to collect a critical amount of data all over the corridor with an equal distribution of measuring points for various events, including physical transportation events (goods handover, loading, unloading, registrations in hubs, etc.) and non-physical data operational event (issuing, signing, approval, handover of documents like order, bill of lading, invoice, delivery note, loading instruction, customs declarations, and various notifications).

Due to inconsistency and gaps in expected data, strategy shift was made to concentrate mostly on physical events where samples were sufficient, and context could be generalized for analyzed business processes to make conclusions. This also required steps for cleansing and normalization of the data.

In addition to raw data analysis, data simulations were used with raw data as baseline to project the impact (and fill data gaps). As a technical tool, Qlik (Qlik Sense®. Data …, 2020) analysis platform was used.

Interpretations and conclusions of data findings were to be analyzed in the context of the collected and analyzed business process. In addition to technology impact (blockchain), other influencers on data and time were expected to occur as well, such as the technology implementation itself, sample size and structure, motivation of the companies, processes changes, nature of the goods and their transport types, and other external factors.

3. SOFTWARE ANALYSIS AND DEVELOPMENT

3.1. General

Software development was planned into phases based on the input of analyzed business processes and after evaluation of integration feasibility from the field research. Development work was done by Propentus Oy Ltd (2020) based on the requirements by Kouvola Innovation (2020), see Appendix 3.

Development started technically in the late 2016, but the actual production commenced in the early 2017. Different blockchain frameworks of that time were evaluated and Hyperledger Fabric (HLF) was chosen.

- HLF was and is the only framework that is backed by and contributed to by industry stakeholders from all sides.
- Also, most of other frameworks were either too immature, like Etherium or not suitable for the task at hand, like CORDA.

The first development meetings were centered to define the scope of the project and formulating the reasoning and logic behind the basic question: what is it that blockchain can do that existing centralized solutions cannot, or can do but with limitations? The following considerations were pointed out:

- scalability, trust, neutrality – above all, the concept of positioning of the blockchain as a trusted messaging network below the level of centralized applications data storage and networking capabilities, as a network to connect platforms

PROTOTYPE 1

Prototype 1 was planned to be the first attempt to test and use blockchain to store supply chain data reliably and securely. Hyperledger was chosen as the blockchain platform to be used in SmartLog development. Hyperledger had many advantages that supported the selection. One of the main advantages was direct development support from IBM, one of the largest contributors to Hyperledger development.

Being aware that Hyperledger, like most other blockchain products at that point, had not reached its version 1.0 release yet, Prototype 1 was developed with two parallel data storage solutions. Both a traditional relational database and the blockchain were used to store data. This decision was made in order to evaluate the functionality of the Hyperledger blockchain product and to make sure that no data would be lost due to Hyperledger early version issues or programming bugs. Although Hyperledger proved to be working well from the beginning, the decision provided the project with valuable information about blockchain performance and allowed the project to concentrate more on gathering data than battling with early blockchain version issues; also, giving project more time to address actual blockchain design paradigms and plan development steps thoroughly.

For prototype 1, three major software versions were published: version 0.1, version 0.2 and version 0.3. In addition, some minor versions with small improvements and fixes were published between major versions. Version 0.1 was developed for testing purposes only. Version 0.2 and finally 0.3 were developed to store and access data to serve the company Demoday in Tallinn on Wednesday, 21st of June 2018. The goal on the Demoday event was to introduce the SmartLog project to several companies and to show them how transportation of containers could be tracked by using SmartLog blockchain and GPS trackers attached to specific containers.

For Prototype 1, the following components were implemented:

- A blockchain peer was created by using Hyperledger fabric. The peer was hosted in the IBM Bluemix cloud in version 0.1 and in the SmartLog environment in versions 0.2 and 0.3.
- A Hyperledger chain code (smart contract) was developed to store logistics chain information using the blockchain. Smart contracts control the way data is stored in the blockchain and how queries on data are performed. Smart contracts supported a simple data model consisting of a container and tracker information.
- A ready-made Hyperledger access control protocol was used to control the smart contract and data access.
- A SmartLog application containing the blockchain integration code (to access smart contracts), business logic (to control integrations) and a database (for data backups) was developed.
- ERP integrations were developed in order to utilize existing ERP APIs to retrieve real-time data to the blockchain from selected ERP systems.
- Tracker information service was integrated with SmartLog in order retrieve and store tracker data during the Demoday.
- User interfaces were developed for pilot testing, pilot administration and Tallinn Demoday purposes.

ERP integrations were implemented with Ecofleet and TK CONE systems during prototype 1 development. After deploying prototype 1 for pilot use, several negotiations were conducted to extend the scope of these integrations and to develop integrations to other ERP systems. During spring 2018, integration with Almic, a software vendor for the transportation company PL Trans, was developed.

CHALLENGES AND GAINS

Several challenges were encountered during prototype 1 development. First, there were very few ready-made APIs in the investigated ERP-systems and existing APIs do not necessarily provide enough information for supporting the SmartLog project and especially for offering benefits to companies when joining the network. This is a major issue for the project since it is hard to get companies involved without clear incentives. For these reasons, companies were cautious and often not willing to sacrifice time and resources in the development and testing. In addition, it is difficult to point out and prove solution benefits to companies while developing the solution. As a result, the blockchain was seen among companies as an essential asset for the solution since it provides trust among participants. Prototype 1 was the first attempt to both build a proof-of-concept system that has a fully functional blockchain back-end and to prove companies that the project will "change the world". Also, considering technology issues, the lack or a vast variety of standards used to develop the APIs makes the development quite difficult and time consuming.

During the development, it became evident that Hyperledger is not a finished product on any scale. And version 0.6 was an early release which might, and as we eventually found out, it did experience a complete makeover on its way to the first official release. For the project, this meant cautious and proof-of-concept driven development from the beginning. Considering these aspects, the project schedule was very tight, since several issues with both early Hyperledger versions and getting companies to join the project network were involved. Still, it was clear that Hyperledger had lots of potential with its vast development community and reliable blockchain and supporting functionalities. Proof-of-concept implementation successfully stored information to the blockchain and Hyperledger platform seemed to be stable and functioning as expected. During the development with Estonian companies, the need for standard APIs and processes was recognized. Some progress was already made with ERP vendors and it became evident that the project should provide a platform that can be joined through standard APIs and not integrate several systems with custom, system-specific interfaces.

The need for agile development in a research and proof-of-concept style project like this was and is now even more evident. Leading and prioritizing the project is up to the project stakeholders and the development team is kept tightly in the loop. For the project to succeed, project goals need to be clear from the beginning but development plans (and schedules) need to be flexible and adjusted according to progress and new emerging needs. IBM contribution to the project and especially for prototype 1 development was essential.

DECISIONS AND REMARKS BASED ON PROTOTYPE 1

First, it should be noted that Hyperledger is not a finished product and version 0.6 had many flaws and glitches. This might be the reason why SDK and all Hyperledger smart contract APIs are renewed for version 1.0. This will mean some overlapping development when upgrading Hyperledger version 0.6 to 1.0 but fortunately the version-dependent development for version 0.6 was kept at minimum. This is also the reason why prototype 2 needs to be based on Hyperledger 1.0 (and obviously newer versions as they are published): there is no point in developing anything with a solution that will cease to exist. If left out from the loop, the gap between versions will continue to grow, as will the amount of work to take the step from one version to another. It should also be noted that Hyperledger version 1.0 will have its flaws too. Development team should be aware of further development and identified flaws, or bugs, always. IBM will also help achieve this by providing development insights not provided publicly.

Second, communication between the development team and project stakeholders is essential and should be emphasized more during prototype 2 development and later project phases.

Steps have been taken in the right direction during prototype 1 development but there is still work to be done. The project needs to provide companies with more material and guidance, especially when it comes to selling the SmartLog solution to companies and to highlight the benefits the solution provides.

Third, standardization and focusing on the UBL standard is essential. In order to provide and pilot a feasible long-term solution, the project should provide a platform that can be joined through standard (UBL-compliant) APIs and not integrate several systems with custom, system-specific interfaces. Some system-specific integrations may be needed but it should be an exception rather than a policy.

Fourth, it should be noted and considered during the development stage that modifications to existing ERP-systems may require large amounts of work and thus may be very time-consuming, especially for companies and ERP-systems that are not yet UBL compliant. Therefore, in the research, long-term solution development and in the realization of other goals, the SmartLog project should concentrate on developing solutions that are easy and fast to deploy for piloting purposes for companies willing to join the network and should preferably be also lightweight and relatively easy to implement. Not having to invest a lot of time and money immediately on system development that might not pay the effort back any time soon is essential to companies that need to focus on their business but still want to develop their operations on the side. Obviously, long-term solutions need to be developed concurrently.

MOVING TOWARDS PROTOTYPE 2

The most significant steps from prototype 1 towards prototype 2 will be moving to Hyperledger 1.0, providing standard UBL-compliant APIs for companies to join, making deploying SmartLog solution as easy as possible to companies, and eventually merging prototype 1 to prototype 2.

3.2. Application v0.4.x (dd2) – solution description

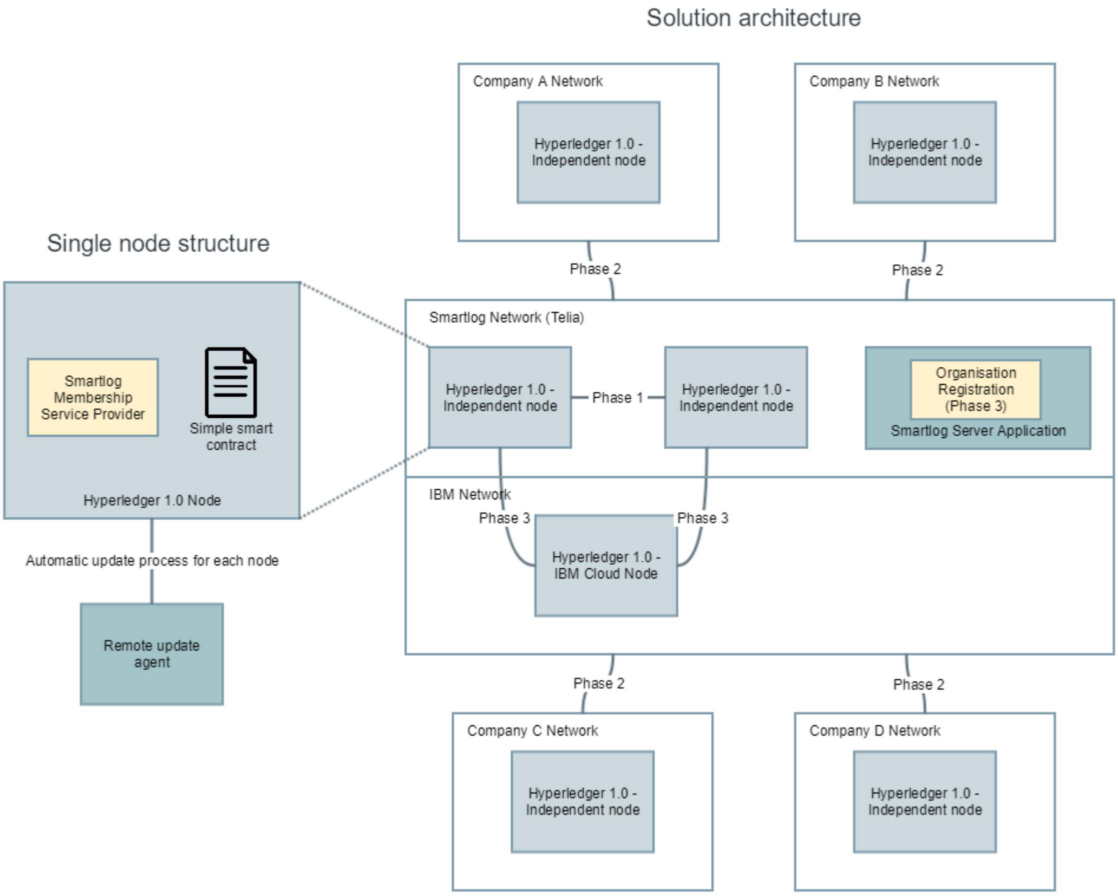

Figure 3. SmartLog software solution architecture using blockchain

The solution architecture for versions 0.4.x presented in Figure 3 consists of the following components:

- Two independent nodes running in the SmartLog network (hosted by Telia): The goal is to achieve two independent Hyperledger nodes that are synchronized and apart from the IBM cloud. This is to prove the capabilities of the nodes to function independently, without the ready-made IBM cloud solution, and to have them synchronize blockchain data to each other. This also requires a simple smart contract implementation to get the blockchain up and running. Implementation phase 1 includes the deployment, testing and synchronization of these two independent nodes. Also, installation instructions for companies are created and tested thoroughly in phase 1.
- Independent nodes connected with one in the IBM cloud: The goal is to achieve three independent nodes that are synchronized, one of which is in the IBM cloud. This is to prove that the cloud node can be accessed from other independent nodes and the security policies (i.e., firewalls, authentication and so on) can be solved.

The cloud node may be vital in the future, so it is important to include it as a node. This will be done in phase 3.

- Independent nodes running in several companies (hosted or in company networks): The goal is to achieve a bigger network of blockchain nodes for testing purposes and to include several companies in the development process. Version 0.4 of the node will be released and distributed to selected companies. This will be done in phase 2. Companies will authenticate and contribute data to the blockchain in future versions.

- SmartLog Server Application with organization registration: The goal is to technically authenticate different organizations and nodes to use the same blockchain still blocking the use of the blockchain from other parties that have no granted access. One organization can have several nodes. At this point, automatic identification of companies based on national or international organization identification solutions is excluded from the scope since it is a completely different, non-technical issue. A SmartLog server application will be developed to handle the organization registration process and the manual phases, for example, organization approval. Blockchain authentication and authorization services will be investigated, designed, implemented and tested in phase 3. The features developed in phase 3 will be updated to environments as version 0.4.1.

SINGLE NODE STRUCTURE

Every node will ultimately have the same structure described below:

- Simple smart contract: A simple smart contract needs to be implemented in order to test independent Hyperledger 1.0 nodes functioning together. This obviously leads to the creation of a local blockchain in each node with very limited data content. At this point, no real-life data is inserted to the blockchain. Simple smart contract for testing will be developed for version 0.4.

- SmartLog Membership Service Provider: A membership service provider is needed for issuing and validating certificates for new nodes in order to authorize them to use the blockchain, and for authenticating these nodes and the companies behind the nodes. Hyperledger 1.0 functionalities need to be further investigated and a custom membership service provider for project SmartLog needs to be designed, developed and tested. The SmartLog membership service provider will be developed for version 0.4.1.

REMOTE UPDATE AGENT

As the Hyperledger nodes are distributed across different companies to join the SmartLog blockchain, the ultimate goal is to have the nodes update themselves as automatically as possible. For version 0.4, the automatic update process will be investigated further and tested using Docker and possibly other relevant solutions. Also, issues with Docker and company-specific certifications will be addressed and solved. Some point of automatization should be achieved already for version 0.4 and the process will be developed further for future versions, for example 0.4.1.

3.3. Component model explained

COMPANY SERVERS

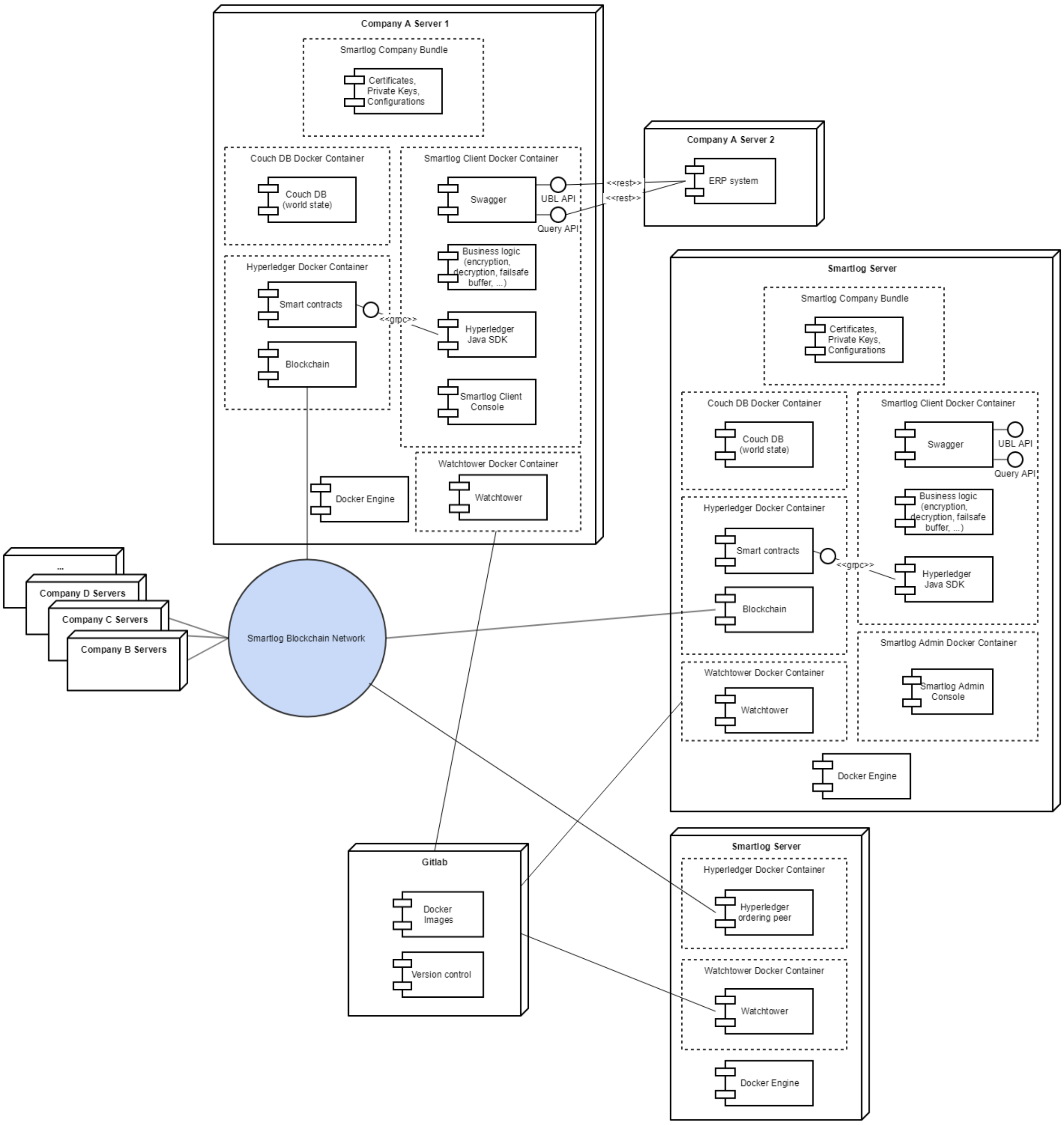

Figure 4. SmartLog solution component model using blockchain

Each company joining the SmartLog network has to have its own (or hosted) server installed. A server is used for hosting Hyperledger container and SmartLog client container, which are both run on Docker engine. Company's private assets like certificates and private keys are also stored on the server (Figure 4).

HYPERLEGDER DOCKER CONTAINER AND COUCH DB DOCKER CONTAINER

Hyperledger docker container is the local blockchain application instance. It includes pre-defined smart contracts and the actual blockchain. Pre-defined smart contracts are the only way to interact with the blockchain and contain operations for storing data and making data queries in the pre-defined SmartLog format. World state database, run on a separate container, contains a simplified version of blockchain content for querying purposes. In Hyperledger, all queries are performed using world state as a data source. It should be noted that world state (and Couch DB) is not a relational database and thus does not store data and relationships in tables. Each database is an actual collection of independent documents and keys.

SMARTLOG CLIENT DOCKER CONTAINER

SmartLog client is the local business logic layer of the project SmartLog. It contains UBL and Query API, provided with Swagger, along with required business logic for encryption, decryption, failsafe buffer. Client uses Hyperledger java SDK to connect with Smart contracts. Client also has a light SmartLog client console, which is used in the early versions of SmartLog client to provide visibility to blockchain (or world state) contents for companies. (It is assumed that not many companies have UBL compliant ERP systems at this point, which leads to the need to provide a light client console.)

SMARTLOG COMPANY BUNDLE

SmartLog company bundle contains each company's private assets like certificates, private keys, and company specific configurations. Certificates are used for connecting Company's Hyperledger instance to the SmartLog network. Private keys are used for decrypting messages received from other companies.

WATCHTOWER

"Watchtower is an application that will monitor running Docker containers and watch for changes to the images that those containers were originally started from (in Docker hub). If watchtower detects that an image has changed, it will automatically restart the container using the new image. With Watchtower containers are updated automatically by pushing a new image to the Docker Hub or your own image registry. Watchtower will pull down your new image, shut down your existing container and restart it with the same options that were used when it was deployed initially." Source and more information (Github, 2020).

SMARTLOG SERVERS

SmartLog servers are centrally hosted servers owned by the project SmartLog. SmartLog servers mostly serve as part of the blockchain network as do companies' installations with a few exceptions. At this point, all endorsing peers are hosted centrally on SmartLog servers to simplify network architecture (mostly needs for complex firewall configurations in companies). In addition, SmartLog server installation is also running SmartLog admin console.

SMARTLOG ADMIN CONSOLE

SmartLog admin console is used for the Hyperledger blockchain channel configuration and maintenance. For example, new companies are added and new installations containers are created with the admin console. Also, the state and block count of the blockchain can be monitored with it. It should be stated that the admin console does not have access to the actual data.

HYPERLEDGER ORDERING PEER

Hyperledger ordering peer (or service in later versions) is hosted centrally on SmartLog servers. The ordering service is responsible for constructing the ledger itself. Source and more information in (Hyperledger, 2017).

VERSION AND DEPLOYMENT MANAGEMENT: GITLAB

GitLab is used for version control and docker image distribution for all SmartLog container types. Versions are managed in private repository, at least for now, and published as new container images.

3.4. Implementation architecture

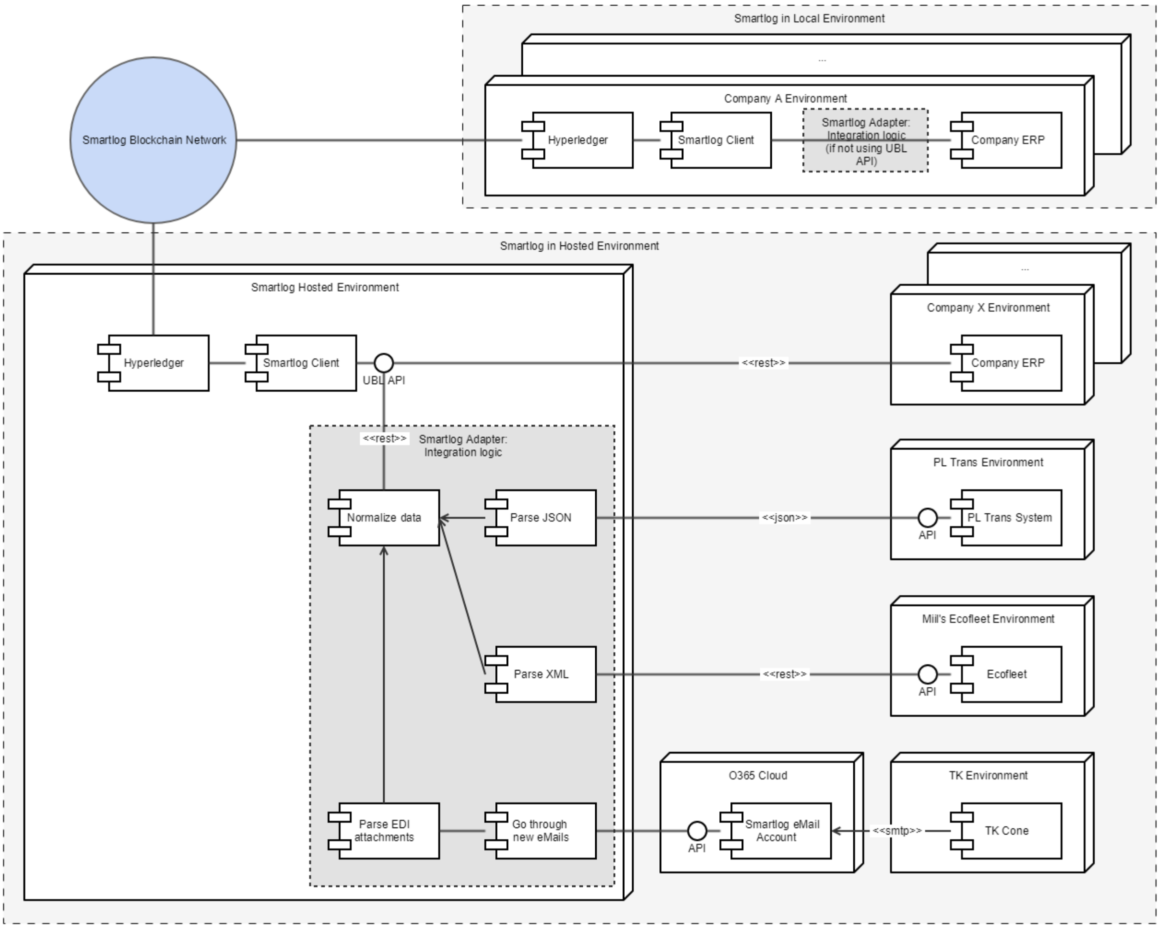

Figure 5. SmartLog software solution implementation architecture in local environment

SMARTLOG IMPLEMENTATION ARCHITECTURE EXPLAINED

SmartLog environment and containers may be run locally (by companies) or hosted (as currently by the SmartLog project). These two models are illustrated in Figure 5. "SmartLog software solution implementation architecture in local environment" illustrates the model hosted by companies (or their partners) joining the SmartLog network and as the development and deployment matures, this will be the only model. "SmartLog in Hosted Environment" illustrates the model where companies only join SmartLog to share data to the network. The APIs and integration logic is hosted centrally by the SmartLog project. This model is currently used in Estonia while developing and using prototype 1 package but cannot be used after prototype 1 due to security issues (in prototype 2, implementation data is encrypted/decrypted and this needs to be done locally to ensure privacy for organizations' private keys).

There are two main ways to connect data sources to the SmartLog blockchain: using the SmartLog UBL API or integrating the system via system-specific adapter implementation. These are described in further detail below.

INTEGRATION VIA UBL API

Integration via UBL API is a straightforward API implementation. SmartLog provides the API from a local client or from a hosted environment (only in prototype 1).

HOSTING A CLIENT

"SmartLog in Local Environment" in Figure 5 illustrates the model hosted by companies (or their partners) joining the SmartLog network. Starting from prototype 2, joining the SmartLog blockchain requires hosting a SmartLog client and (optionally) a Hyperledger peer. Also, starting from prototype 2, implementation data is encrypted/decrypted, which should be done locally to ensure privacy for organizations' private keys. Keys and certificates are distributed along with the client but in a different package to ensure privacy. Hyperledger peer is required if the company wants to be a data host and have control of all the data in the network. A client can also connect to a remote peer, in which case a local peer is not necessary. In version 0.5 (first prototype 2 production version with real data), a Hyperledger peer is also required but in later versions, it will be optional.

USING A HOSTED API

"SmartLog in Hosted Environment" and "Company X" in Figure 5 illustrate the model where a company only joins SmartLog to share data to the network via UBL API. This hosted model is only possible in prototype 1. In prototype 2, a SmartLog client needs to be hosted locally to use the UBL API.

INTEGRATION VIA SMARTLOG ADAPTER

If the company joining the SmartLog network is not UBL compliant and/or has an existing interface to output or provide relevant data, an adapter implementation can be built. The adapter can use an existing API from the source system, or a system-specific API can be built in SmartLog for the system to connect to. In practice, it depends on the capabilities of the system in consideration. All data received from the system is a process, normalized and sent to the SmartLog network using the UBL API. Only in these cases, the UBL API is used internally in the SmartLog client. The graph in Figure 5 illustrates three different adapter implementations built for TK and Ecofleet and to be built for PL Trans. Both Ecofleet and PL Trans are based on the system APIs that are polled in pre-defined intervals by SmartLog to retrieve data. TK is based on an existing process of sending EDI messages as eMail attachments to interested parties. In this case, messages are sent to the SmartLog eMail account. SmartLog parses EDI messages and transforms them into UBL-compliant entries.

The integration model using a SmartLog adapter can be used locally in the client and is valid also in prototype 2 although it is illustrated as part of "SmartLog in Hosted Environment" in Figure 5. The same component is illustrated as a local installation in "Company A Environment".

It should be noted that UBL API should always be prefered to join the network since adapter implementations are almost always company or at least system-specific and require lots of customization work. In the long run, it will be impossible to build company or system-specific interfaces for large volumes. Therefore, a standard UBL API should be used in all possible cases.

3.5. Data encryption model flow

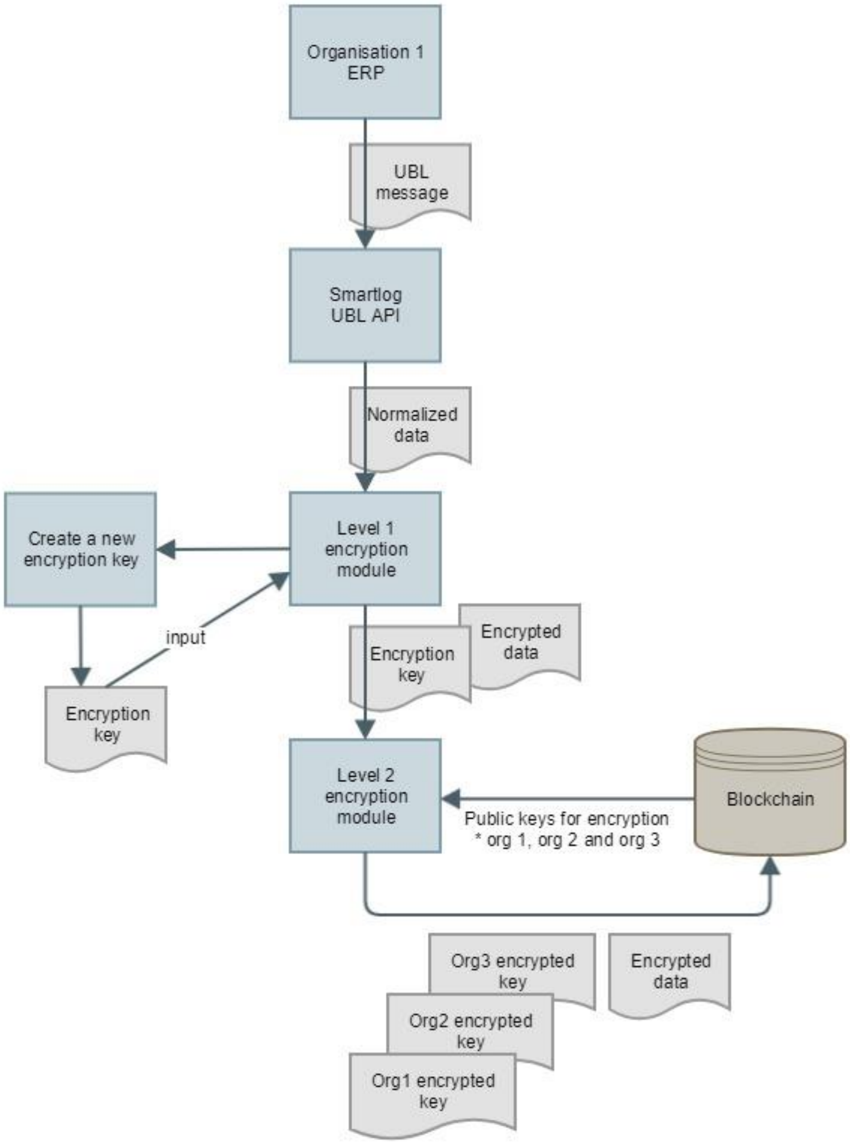

Figure 6. SmartLog software solution data encryption model

The model in Figure 6 shows the following:

- Organization 1 ERP: Organization 1 ERP sends data to the blockchain (creates an event)
  - Data is sent as a standardized (SmartLog) UBL message
- SmartLog UBL API: API receives the data from ERP and normalizes it according to the SmartLog blockchain data model (Figure 6)

- Create a new encryption key: A new encryption key is created to be used only for this event.
    - The created encryption key is bidirectional, so the same key is used both for encryption and decryption.
- Level 1 encryption module: The data is encrypted using the created key. The encryption key used to encrypt the data is then sent to encryption.
- Level 2 encryption module: The encryption key is encrypted using public keys retrieved from the SmartLog blockchain. The encryption is performed using public keys of all the organizations that need to have access to the data (organizations that are part of the current supply chain). Encrypted keys are then stored to the blockchain along with the encrypted data and references to the organizations whose public keys were used to encrypt the key.
- Organizations' public keys are managed and distributed using the blockchain (and the same channel).
- Organizations' encryption keys are unidirectional, containing both public and private keys. The public key is used only for encryption. The private key is used only for decryption.
- To access the data, an organization retrieves the encrypted data and the encrypted key addressed to that organization. The organization then uses their private key to decrypt the encryption key and the encryption key to decrypt the data.
- Some small parts of the data are also stored without encryption for query purposes.
- This applies to identifiers that are used as key query values when retrieving data, for example, container numbers and booking reference numbers (if possible).

TECHNICAL IMPLEMENTATION

Organization’s public keys are stored in Hyperledger Fabric using own Smart contract.

ENCRYPTION

- Organization sends a request to a SmartLog client, which contains message data (in UBL) and a supply chain identifier.
    - The supply chain identifier refers to a supply chain definition (also stored in the blockchain) that contains a list of receiving organizations in correct order.
    - The supply chain is created and updated through a separate UI.
- Client generates randomly one-time use key, using the AES-algorithm.
- Generated AES key is used to encrypt message content.
- Generated AES key is encrypted with RSA for all receiving organizations, with their static public key (Static keys are generated when an organization is created with AdminClient) and saved to ledger with organization id.

- The receiving organizations are pulled from the ordered supply chain definition. The access to the message should be provided always for the first organization in the ordered definition list (the supply chain owner), the organization sending the current message and every organization in the ordered list after the current message sender. This way the message can be decrypted by all organizations operating in the supply chain after the current operator and is inaccessible to those before the current operator (who do not need the information anymore). These organizations are the only ones allowed to decrypt the generated AES key, which can then be used to decrypt the original message.
- Note: for now, all keys are also encrypted for the SmartLog admin organization (Propentus) to ensure that
  - there will be enough reporting data available for the project research team and it can be extended for future versions if needed
  - the unencrypted data field set may be extended for all messages
  - possible errors in data encryption and data storing may be processed and corrected

- Encrypted message is finally stored in the ledger along with document information identified by a generated unique key. The key in this case is an automatically generated unique id to identify the document.

DECRYPTION

- Organization sends a request for a message(s) to the SmartLog client.
  - Request is sent through UBL API.
- Client searches for message with the Client findMessage method by criteria given in the request.
  - At least part of the given criteria is most likely the id of the organization that has the right to decrypt the message.
- Message(s) are found from the ledger and returned to the client. Results include the encrypted message, encrypted keys with corresponding organization MSPIDs and all unencrypted data parsed from the original message.
- Client decrypts the message(s).
  - Client finds the encrypted key referred by the organization's MSPID.
  - Client decrypts the key with the corresponding organization's private key.
  - Client then uses the decrypted key to decrypt the message.
- Client returns the message to the organization.
  - The message is returned in the same format as it was received (UBL).

3.6. Deployment and installation process for v0.4.1 and v0.5

This chapter describes the current process for versions 0.4 and 0.5. In version 0.4, deployment is done with only one organization and channel. The environment is static in version 0.4 and may only be modified with manual updates. Version 0.5 uses multiple organizations and channels. The environment is partly automatic in version 0.5 and channel modifications can be done using a custom UI. The process remains the same in both versions (Figure 7).

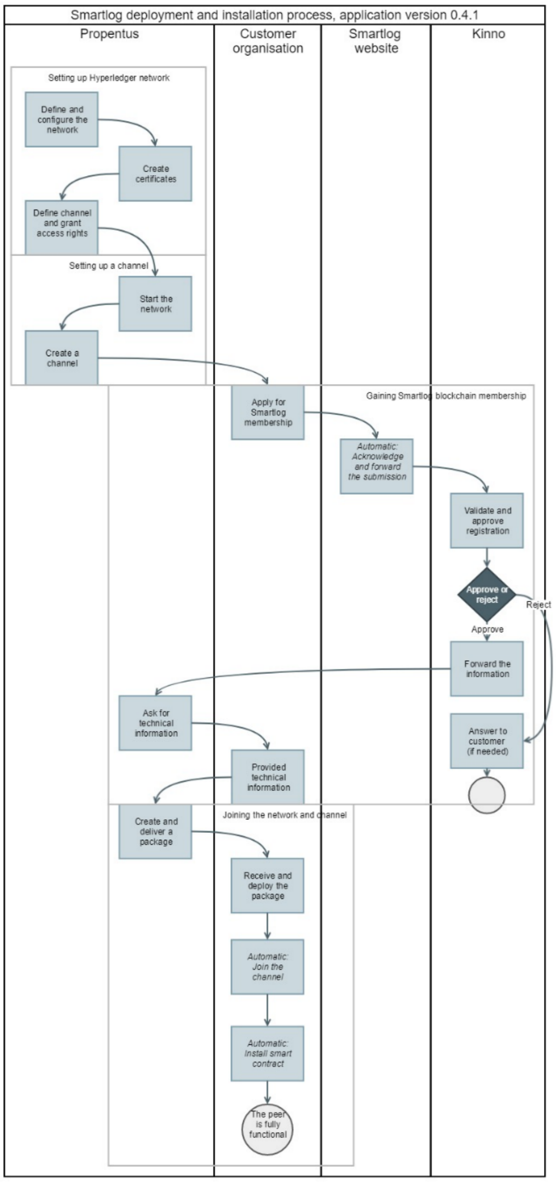

Figure 7. SmartLog software solution deployment and installation process v0.4.1

SETTING UP A HYPERLEDGER NETWORK

- Define and configure the network: Define organizations, peers and users for the network and add them to Hyperledger configurations

- Create certificates: Run Cryptogen tool to create certifications for the configured entities

In version 0.5, the mentioned operations are done using custom UI.

SETTING UP A CHANNEL

- Define a channel and grant access rights: Define organizations that have the right to access a specific channel. These are configured in a separate Hyperledger configuration file. Crptogentx tool is used to create the channel's configuration block based on the configuration file. The configuration block is channel specific.
- Start the network: At this point, the network may be started. In practice, only Hyperledger ordering peer is mandatory but we are also running a hosted SmartLog endorsing peer.
- Create a channel: SmartLog endorsing peer is used to create a channel by using the generated channel configuration block. When the channel is successfully created, a channel genesis block is obtained.

In version 0.5, the mentioned operations are done using custom UI.

GAINING SMARTLOG BLOCKCHAIN MEMBERSHIP

- Apply for SmartLog membership: An organization wants to join the SmartLog blockchain and starts the process by filling and sending a registration form through SmartLog website.
- Technical and administrative contact person information is needed.
- Technical information (like the IP-address of the future peer/client) should not be asked at this point.
- Acknowledge and forward the submission: The registration form submission is automatically acknowledged to the administrative contact person via e-mail by the SmartLog website. Registration form is sent for validation (to Kinno) by e-mail.
- Validate and approve registration: Registration form is approved/rejected manually. Kinno sends a response to the registered organization by e-mail, if needed.
- Forward the information: The e-mail with the registration information is forwarded to Propentus by Kinno.
- Ask for technical information: Propentus asks for the technical information from the technical contact person (IP-address and other relevant info) via e-mail.
- Provide technical information: The technical information needed is provided for Propentus by the customer.

JOINING THE NETWORK AND CHANNEL

- Create and deliver a package: Create and deliver a customer-customized package to the customer. The package contains Hyperledger endorsing peer functionality (with channel configurations) and generated certificates for the customer organization and peer. In version 0.4, all the customer peers are part of the same organization. Since the peer is endorsing, it also contains the smart contract.
- Receive and deploy the package: Receive and deploy the package according to the instructions.
- Join the channel: Once the peer is deployed, it retrieves the configured channel's genesis block and joins the channel.
- Install smart contract: Smart contact is installed on the peer after which the peer is functional and starts working as part of the network. Installing the smart contract creates a new container that hosts the smart contract.

Phases 2 and 3 are automatic, so no customer actions are needed during those phases.

ADDING A NEW CUSTOMER TO THE NETWORK

In version 0.4, the following information (from joining companies) is needed for adding a new peer to the network:

- Public IP-address of the server hosting the peer

3.7. Reporting model description v0.5.1

Version 0.5.1 reporting model is completely based on unencrypted information stored in the SmartLog blockchain. This means that the following set of information can be used for reporting and KPI calculations:

- Organization id: MSPID of the organization that sent the event
- Event id: Unique id for the event log
- Supply chain ID: The supply chain identifier for the event that refers to a supply chain definition that contains a list of receiving organizations in correct order
- Container ID: Unique container name
- Sender party: The party that sent the event
- Timestamp: The exact moment of the event
- Carrier Assigned ID: "Reference number assigned by a carrier or its agent to identify a specific shipment, such as a booking reference number when cargo space is reserved prior to loading."
- Shipping Order ID: "Reference number to identify a Shipping Order"
- RFID EPC number for Transport equipment: Container ID in GIAI format

- RFID EPC number for transport handling unit: Transport handling unit (for example railroad car) ID in GIAI format
- Event description: "A code signifying the type of status provided in a Transportation Status document"
- Event empty/full - indicator: Information about the container status: "Empty" or "Full"
- Participant ids: MSPIDs of all organizations that can decrypt the event message

For version 0.5.1, a separate method will be created for reporting purposes in Query API as part of SmartLog Client implementation. Since Query API in version 0.5 is meant purely for organizations participating in the supply chain, and thus returning only the original UBL message, there is a need for a separate method for reporting purposes. This reporting method should only return unencrypted, and thus unrestricted information from the blockchain. In addition, separate smart contracts may be built for reporting purposes in future versions. These are needed if KPI calculations are to be done in the blockchain environment.

Figure 8 describes the purpose of this method in brief.

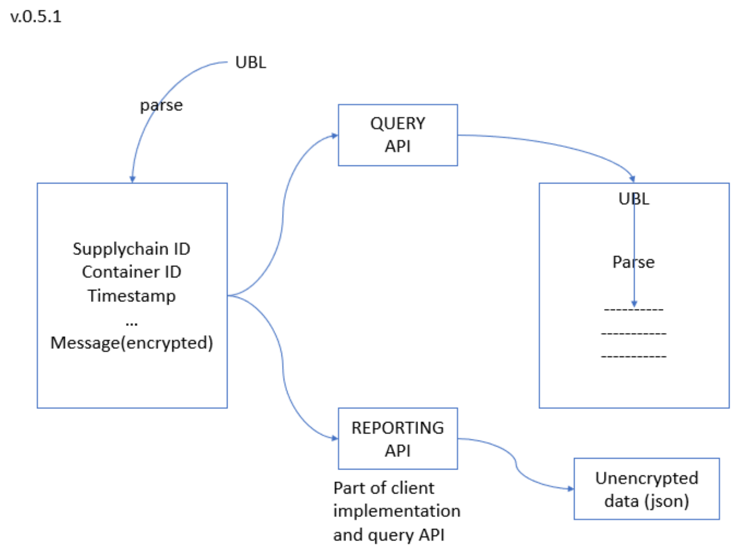

Figure 8. SmartLog software solution reporting model description v0.5.1

Note: for version 0.5.1, all keys are also encrypted for the SmartLog admin organization (Propentus) to ensure that

- there will be enough reporting data available for the project research team and it can be extended for future versions if needed
- the unencrypted data field set may be extended for all messages
- possible errors in data encryption and data storing may be processed and corrected

3.8. Accessing SmartLog blockchain data

SCENARIO A: USING SMARTLOG/SWAGGER UI

Since ERP development during piloting might be an issue (and probably is) for most of the companies, there should be an easy way to access SmartLog blockchain data without further developing existing systems. To tackle this issue, SmartLog provides user interfaces that can be used to access data using a web browser, as illustrated in scenario A.

One way is to use the user interface that Swagger provides for testing APIs. Although Swagger is a practical and easy approach for developers and IT staff, it is hard to use and interpret for most companies joining the SmartLog network. Another way is to use client console user interface developed in the SmartLog project. The goal is to provide a UI that gives access to company's own data through simple, ready-made queries and is as easy to use as possible. The client console should be an easy approach for all user types.

Both user interfaces are included in the SmartLog client container and either locally installed or provided as a service. In both cases, the API that both user interfaces use in the background is responsible for only returning data that the company has access to.

SCENARIO B: ERP POLLING DATA FROM QUERY API

One way of pulling data from the blockchain is by polling the query API, as scenario B illustrates. This is possible if the ERP system (or other system using the data) can make API queries continuously on an interval. The interval could be, for example, a minute or a couple of minutes, making it almost real-time, and should be adjusted according to the company's needs. This scenario should only be used in companies hosting at least the client, and preferably a peer, so that a SaaS-environment does not have to deal with possibly several systems constantly polling the API with potentially burdensome queries. In this scenario, the API is responsible for only returning data that the company has access to.

SCENARIO C: STATUS MESSAGING FROM SMARTLOG

When SmartLog reaches "the critical mass" of participating companies and eventually when moving from piloting to production, companies start using SmartLog provided data to control their processes. At this point, existing ERP systems will need real-time updates on blockchain data. Because of the large volume of companies in the network leading to a massive volume of data, scenario B might no longer be feasible for several reasons. When reaching this state, a SmartLog client should monitor the blockchain state and provide real-time alerts or status messages for connected ERP-systems so that ERP systems could make more precise queries according to the status messages. This way most of the processing could be done locally by the client, thereby balancing the network load efficiently. UBL standard provides a way for status messaging by using UBL Transportation Status documents.

Scenarios are described in figure 9.

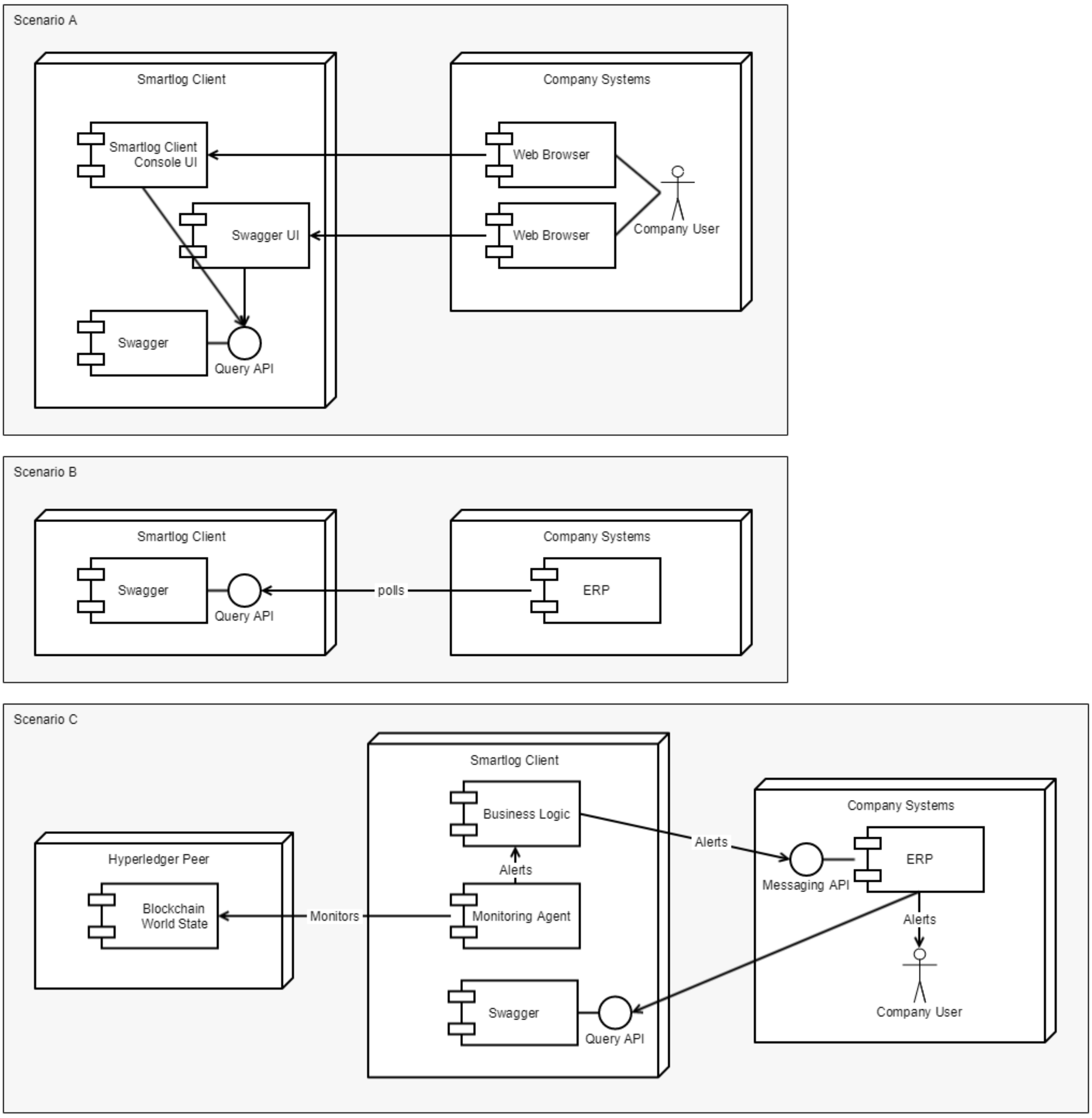

Figure 9. SmartLog software solution access scenarios

3.9. Network architecture

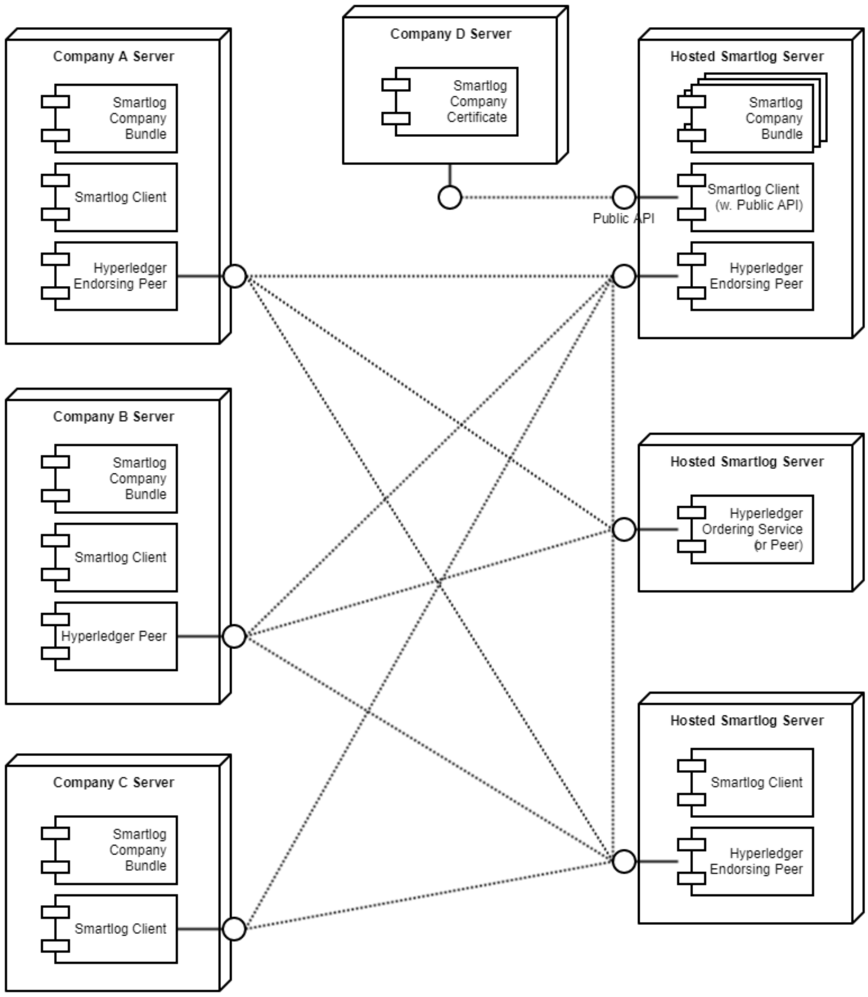

Figure 10. SmartLog software solution network architecture

REMOTE PEERS

As illustrated in Figure 10 with companies A and B, companies can host either normal or endorsing peers. The difference between these is that while both peers contain all the data, a normal peer does not contain smart contracts and thus is not capable of reading or writing data to the blockchain by itself. So, a normal peer needs to connect to an endorsing peer in the network when performing queries or transactions (storing data). Endorsing peers contain smart contracts and can perform queries and transactions, but not without connecting to the network for transaction approval and consensus for transactions.

The reason for providing two different peer types is that while endorsing peers are more challenging to install and need more flexible firewall setups, a normal peer is a lot easier to setup. That is why SmartLog bringing a normal peer is an option for companies with fewer resources or capabilities. Along with endorsing peers with more responsibilities, also normal peers are important so that data is stored securely in multiple locations.

REMOTE CLIENT

Company C in Figure 10 illustrates a scenario where a company joins the SmartLog blockchain network without setting up and hosting a Hyperledger (blockchain) peer and thus without hosting the actual data. The company is only hosting a client that can be used for invoking queries and transactions. For performing these operations, the client connects to an endorsing peer in the network. The endorsing peer then uses smart contracts to interact with the blockchain.

HOSTED CLIENT AND PEER WITH A PUBLIC API

Company D in Figure 10 illustrates a scenario where a company uses a centrally hosted client and a peer to interact with the SmartLog blockchain. In this scenario, the company only needs a SmartLog certificate to connect to the public API. The API is used for invoking queries and performing transactions (storing data) and access to data is controlled by the certificate. The API may be published publicly or by using IP-based access.

In this scenario, in addition to the client and peer, the hosted SmartLog server also hosts the company bundle, containing both public and private keys for encryption and decryption. So, data processing and storing are done completely on the hosted server.

The hosted service may be a "private cloud" or a "shared cloud". The private cloud means that the hosted environment only serves one company and a new environment is needed for every company using the hosted approach. Shared cloud means that several companies may use the same environment. In both hosted scenarios, security and data privacy are ensured with the same methods as with company self-hosted environments. The only differences are the locations where data, encryption keys and company configurations are stored. Even in shared cloud approach, companies are strictly separated from each other.

The hosted environment is meant for companies with fewer resources or capabilities to host their own node, but for creating trust in the network, it is important to take into account that the company self-hosted peers are also needed.

HOSTED SERVICES

At this point, at least the ordering peer/service and at least one endorsing peer are always hosted centrally by the project in order to keep the network fully functional. The ordering service is a set of orderers (or ordering peers) that set up "*a communication fabric that provides delivery guarantees. Ordering service provides a shared communication channel to clients and peers, offering a broadcast service for messages containing transactions*" (…). In other words, the ordering service is responsible for delivering performed transactions to all peers. While an ordering peer is a single peer responsible for network communication, an ordering service is a set of peers and thus also provides fault tolerance.

POSSIBILITIES FOR FUTURE DEVELOPMENT

For future development, at least the following development options will be considered:

- A local decrypted database might be a solution for improving query performance and providing local query possibilities also for normal peers.
- The database contents should be formed from blockchain data by decrypting locally all data relevant to that company (i.e., all the data from the supply chains that company is participating in). This should be done automatically as a batch job on an interval.
- The approach would provide better performance for both queries and the whole blockchain (since all queries are not addressed to the blockchain) and give data control to a normal peer that does not host blockchain data.

3.10. Use cases

USE CASE: USING SMARTLOG TO TRACK SHIPMENTS

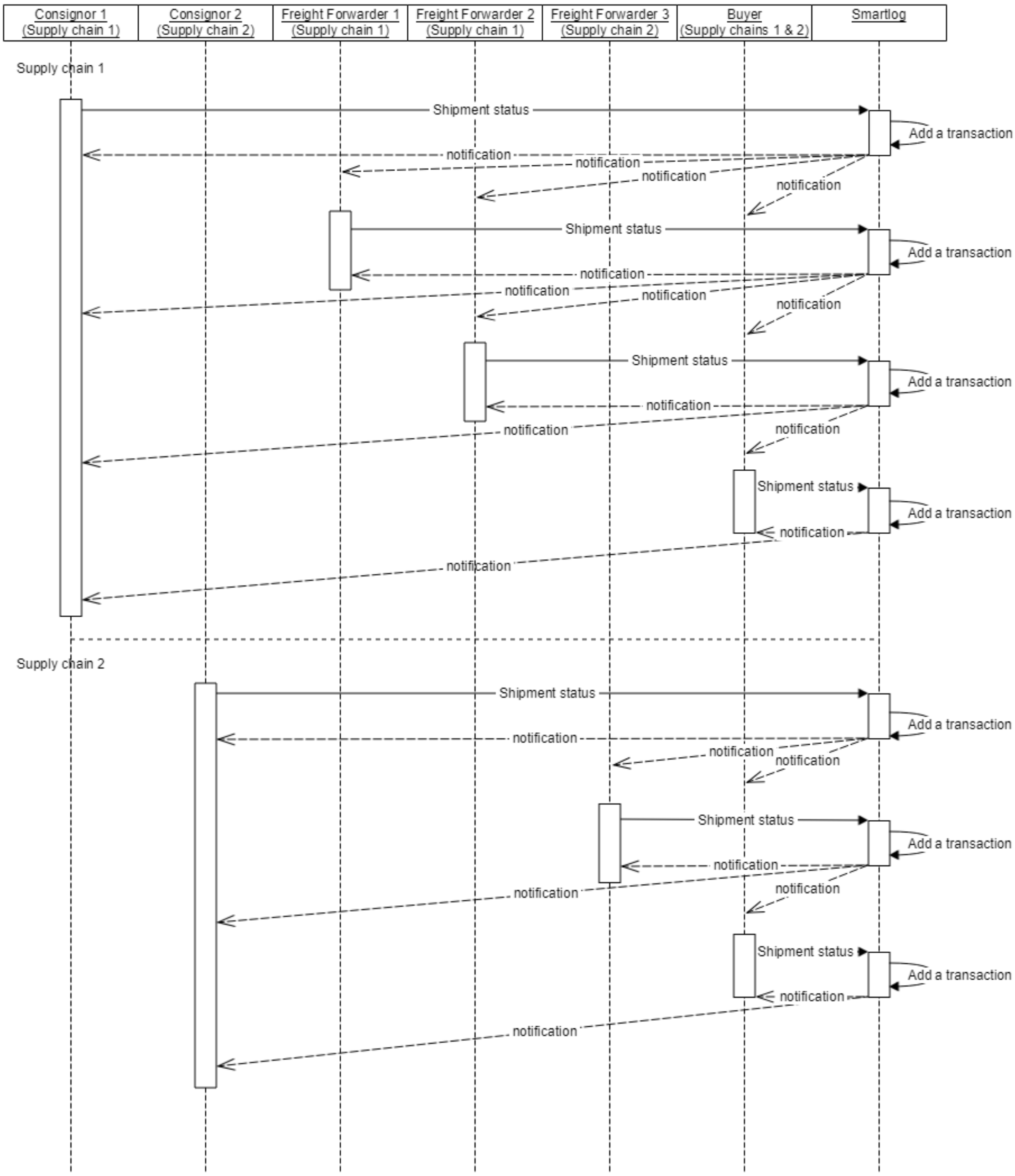

Figure 11. SmartLog software solution sequence model with shipments isolation

When a consignor sends the shipment, a status transaction is sent to the SmartLog blockchain confirming that the shipment has been sent. Along with the status transaction, additional information, such as estimated time of arrival (or eta), can be sent as part of the message. These transactions along with provided additional information are stored in the SmartLog blockchain. Whenever a transaction is added to the blockchain, all related parties (that are part of the same supply chain) are notified of a new transaction. After receiving the notification, the end system may ask for additional details from SmartLog. The same process applies for all phases along the supply chain.

According to the SmartLog data access and encryption model, only the supply chain owner (consignor), the receiver (buyer) and other parties related to the shipment may see the transactions and thus also receive a notification of transactions. The owner and the receiver see all the transactions related to the supply chain; however, other parties (for example, freight forwarders) only see transactions taking place before their own actions in the supply chain. This way other parties can only access data they need to plan their own operations. Also, as illustrated in Figure 11, different supply chains are isolated from each other in SmartLog by means of the SmartLog data access and encryption model (Figure 6). This means that only parties belonging to a supply chain can access data related to that supply chain. In practice, this might be implemented by the client by polling blockchain status on an interval, but the principle remains the same and SmartLog is responsible for sending notifications; it is not illustrated in the diagram to keep it as simple as possible.

Estimated time of arrival

SmartLog blockchain can greatly increase transportation predictability through a corridor. For every transaction, an actor (for example, a consignor / supplier, a freight forwarder, or a buyer) sends a status transaction to SmartLog containing current shipping status with relevant shipment identification and, of course, a timestamp of the status change. Initially, while data is still scarce and insufficient in terms of automatic analysis, actors can also estimate time of arrival to be sent to SmartLog as part of the status transaction. This can be used by following actors in the same supply chain to plan their operations accordingly. The more actors are connected to SmartLog, the more communication goes through it and the more data is in the blockchain. In time, with enough data available for the analysis, SmartLog will be able to calculate the estimated time of arrival based on real-life data taken from previous transactions. This means more predictability and less work for related parties (no need to calculate ETAs manually anymore).

Key benefits of notifications and estimates

- Accurate time of arrival estimates, getting more and more accurate with more data
- Order of incoming shipments (in which order will shipments / containers arrive)
- Which shipments / containers are part of the same delivery
- Can also be used for detecting missing containers / shipments

For the consignor

- Accurate real-time information about shipment status to increase supply chain transparency
- To track shipments real time and ensure everything proceeds as planned
- To increase supply chain transparency and to make supply chain (party) management more efficient for future shipments
- Leads to faster and more efficient supply chains

- Knowledge of missing parts of the shipment early on (if the shipment is divided, for example, in several containers)
- Able to react right after something turned out to be missing

For the buyer

- Time of arrival estimates to plan operations, increase efficiency and save resources and money: both when shipment is on-time and when running late
- Especially when the shipment is running late, information may save a lot of resources (follow-up activities like installations or further transportation can be postponed early on)
- Knowledge of the order of incoming shipments to plan operations and increase efficiency
- Knowledge of missing parts of the shipment early on (if the shipment is divided, for example, in several containers)
- Able to react before the incomplete shipment reaches destination

For freight forwarders (Figure 12)

- Time of arrival estimates to plan operations, increase efficiency and save resources and money: both when shipment is on-time and when running late
- Especially when the shipment is running late, information may save a lot of resources (further transportation can be changed or postponed early on)
- Knowledge of the order of incoming shipments to plan operations and increase efficiency

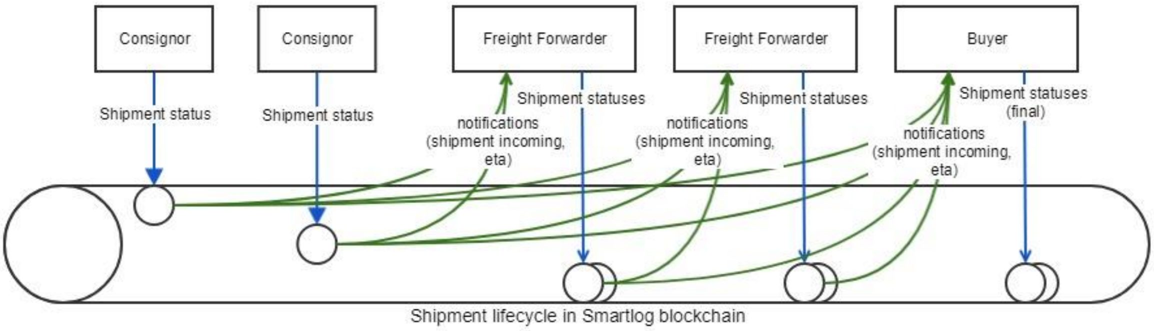

Figure 12. Shipment lifecycle in SmartLog software solution

USE CASE DESCRIPTION: SWEDISH RAILWAYS AND SMARTLOG

The pilot phase (Figure 13)

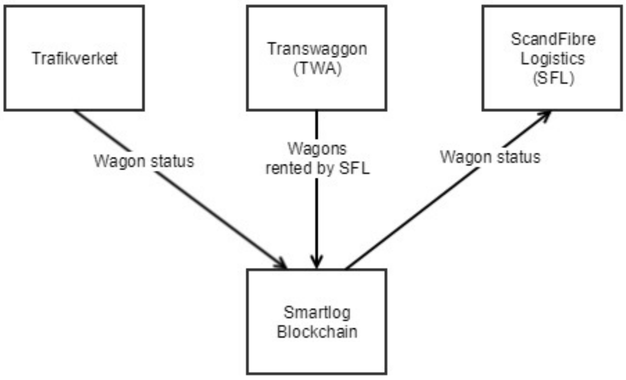

Figure 13. Swedish Railways use case in SmartLog pilot

- Trafikverket provides wagon status information
- TWA provides information about wagons rented for SFL
- SFL uses status information for rented wagons to identify status and order of arriving wagons

Next phase (Figure 14)

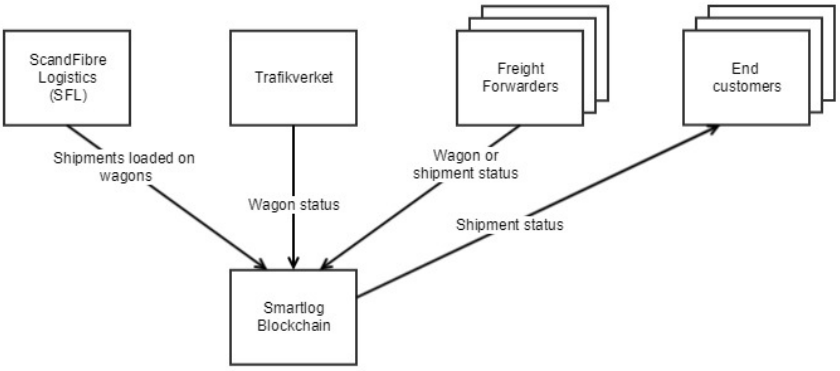

Figure 14. Swedish Railways with enterprises and customers use case in SmartLog pilot

- SFL loads goods on wagons and provides loading status along with possible shipment information linked to specific wagons
- Trafikverket provides wagon status information
- Other freight forwarders provide wagon or shipment status information
- End customers receive shipment status information and provide shipment acknowledgement

Pilot process description (Figure 15)

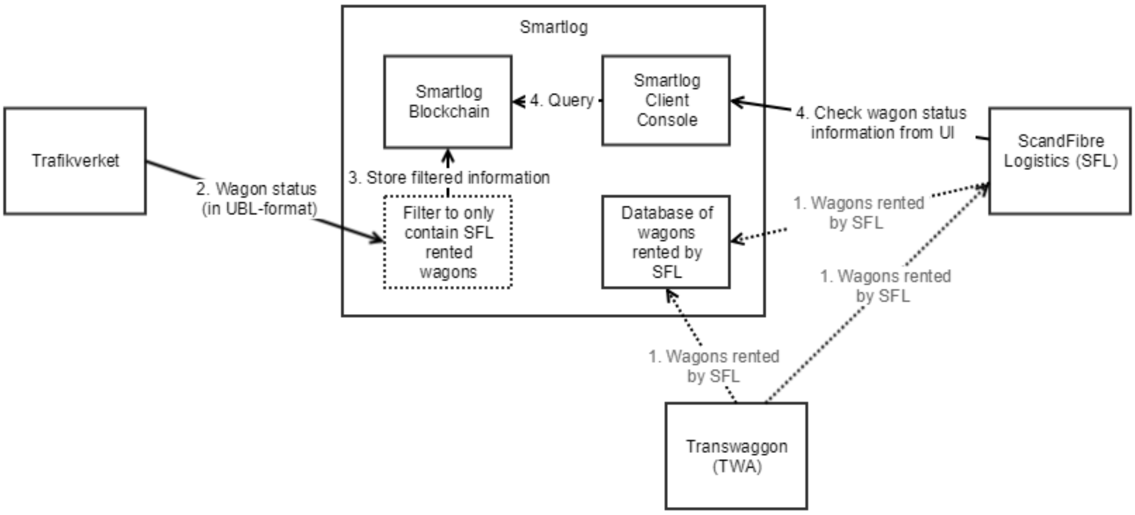

Figure 15. SmartLog pilot use case process description

- TWA provides information about wagons rented by SFL for SmartLog
  - Either directly for SmartLog via API or for SFL that forwards the information for SmartLog via API
- Trafikverket provides wagon status information in UBL-format
- Wagon status information is filtered and stored in the SmartLog blockchain
  - At least during the pilot, SmartLog filters the information and only stores information about wagons rented by SFL
- SFL checks wagon status information by using SmartLog Client Console user interface
  - Client Console queries the SmartLog blockchain for status information

Questions about the pilot process

- How does TWA let SFL know which wagons are rented for SFL?
  - How could this information be sent to SmartLog?
- If, for the first pilot, we are only interested in wagons that are rented by SFL, can Trafikverket filter the information and only send SmartLog information about SFL rented wagons and/or should the filtering be done by SmartLog?
- What is the method used to provide information from Trafikverket to SmartLog? Does Trafikverket have an API for polling or are you able to send GS1-messages straight to SmartLog (GS1) API if one was provided?

Facts and assumptions for the pilot

- Only one RFID reader (needs to be) used since only one data point is needed for the first pilot
    - If possible, multiple data points will be used
- Trafikverket provides an API to get wagon status information (based on RFID) from data points
    - SmartLog will use this API to poll status messages on an interval
- Notification when new shipments arrive at the point of interest

Questions

- Is there an API (from Trafikverket) to use to get status information (based on RFID) from wagons?
    - If there is, how to access this API? Could we have the description? How can we test it?
- Regarding the pilot
    - How to access data from only one RFID reader? Are there different parameters to get status for each data point (RFID reader)?
    - How do we know which shipments are relevant for this case or are all?
    - Do we send the notification to Scanfibre via API, Email, or something else?
        - Via existing API or should a new (perhaps standard) API be designed and implemented?
- How does RFID get attached to other ids of the shipment (for example, the container number)?
    - Could Scanfibre with logistics service provider X provide information about linkage between a container and a wagon (RFID)? Are container numbers used in tracking at all?
        - At which end is irrelevant information filtered out? So, should SmartLog know which information is relevant and only provide Scanfibre with that information or should everything be collected and provided and Scanfibre will filter the information?
- How about detachment when a container gets taken off by a wagon?

3.11. Peer UBL API architecture

ALTERNATIVE 1: USING A REST CLIENT

In alternative 1, a REST Client is used to connect to a peer. A UBL API is implemented for the peer and a smart contract is formed automatically based on the API. Swagger or some other corresponding product should be used for publishing the API. This is almost the same functionality that the Hyperledger Composer currently has. Its difference from the current composer implementation lies in the requirement that there should be a possibility to add functionality, for example, encryption or normalization, between the API and the smart contract. In the current composer implementation, everything retrieved from the API is sent directly to the smart contract without the possibility of modifications before the smart contract. This should not be the case for UBL API fabric implementation. Nothing should be stored in the blockchain before data is processed since this might mean, for example, storing non-encrypted or non-normalized data.

Alternative functional layer could be part of the client implementation, but this means more implementation logic to the client and might take focus further away from the Hyperledger fabric (Figures 16-17).

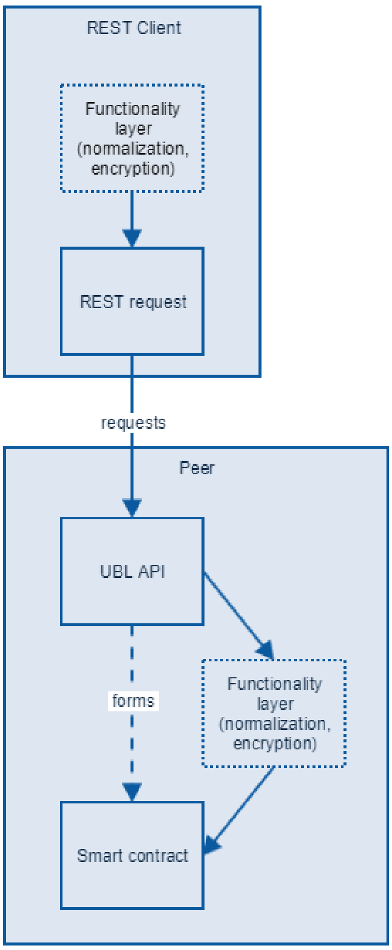

Figure 16. SmartLog software solution access scenario using REST client

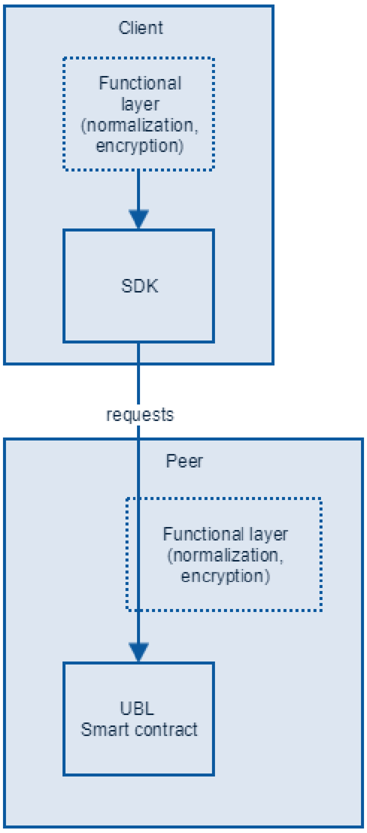

Figure 17. SmartLog software solution access scenario using SDK

ALTERNATIVE 2: USING SDK

In alternative 2, Hyperledger SDK is used to connect to a peer. UBL API is implemented on smart contract level so that SDK needs to be used to connect to the API. As in alternative 1, there should be a possibility to add functionality, for example, encryption or normalization, in peer before the smart contract. Nothing should be stored in the blockchain before data is processed since this might mean, for example, storing non-encrypted or non-normalized data.

As in alternative 1, alternative functional layer could be part of the client implementation. This means more implementation logic to the client and might take focus further away from Hyperledger fabric.

4. RESULTS

4.1. LPI baseline survey: descriptive statistics

RESPONDERS

The task of the target responder group was to get decision makers (managers, responsible units) to be part of research in terms ofe strategical responses about company plans and influencers. This was achieved by both organization level (>70% headquarter or Independent Firm) and position level (>70% on managerial positions). The target was to involve companies of different size (number of employees) to have wide/balanced coverage. Several responders were also participants of companies' detailed process analyses (Figures 18-20).

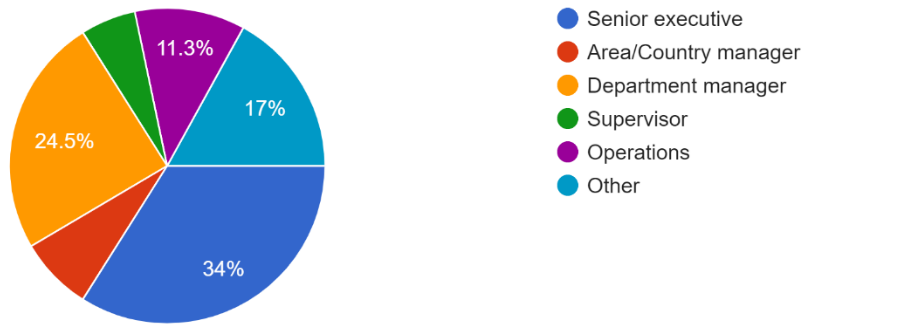

Figure 18. Respondents by position (n=53)

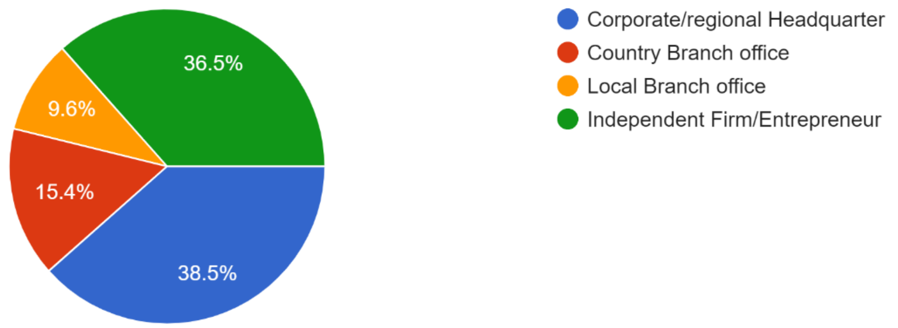

Figure 19. Respondents by organization type (n=52)

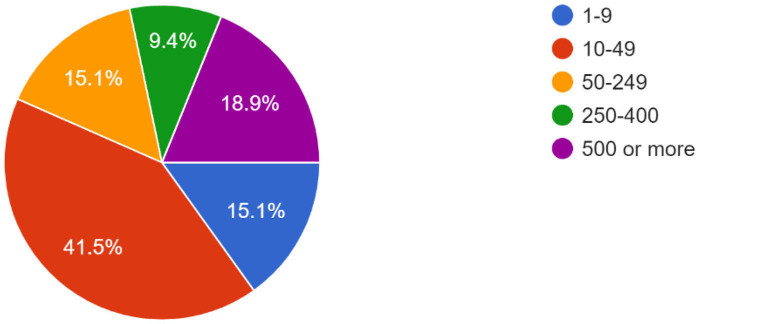

Figure 20. Respondents by staff number (n=53)

ENTERPRISE LOGISTICS TYPE AND AREA

Logistics types, operating area, operating model were matched with set limitations. The aim was to acquire an overall understanding where major impact on some findings is related to domestic road transport; but also export and import are covered where marine and rail transport play a higher role. As for *cargo* type, all types are significantly represented, though containers are the main cargo type (Figures 21-25).

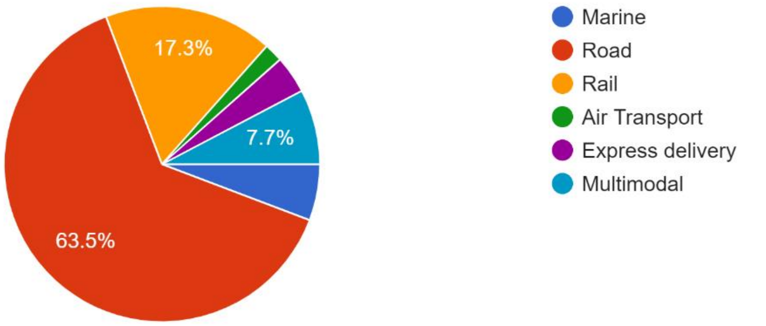

Figure 21. Freight modes (n=52)

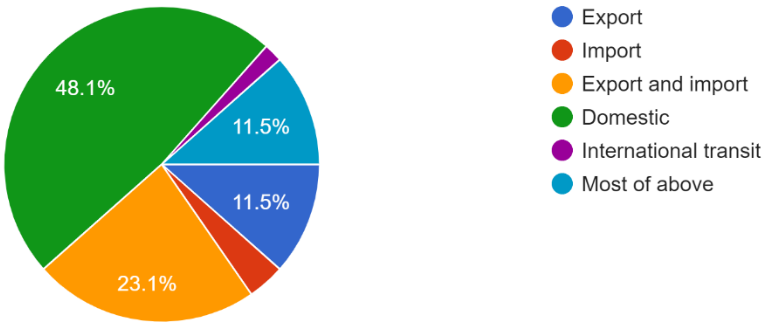

Figure 22. Trade directions (n=52)

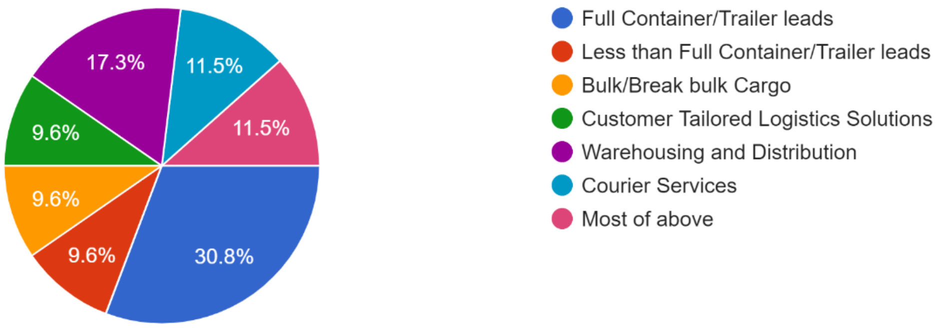

Figure 23. Main fields of activity (n=52)

Figure 24. Geographical regions (n=53)

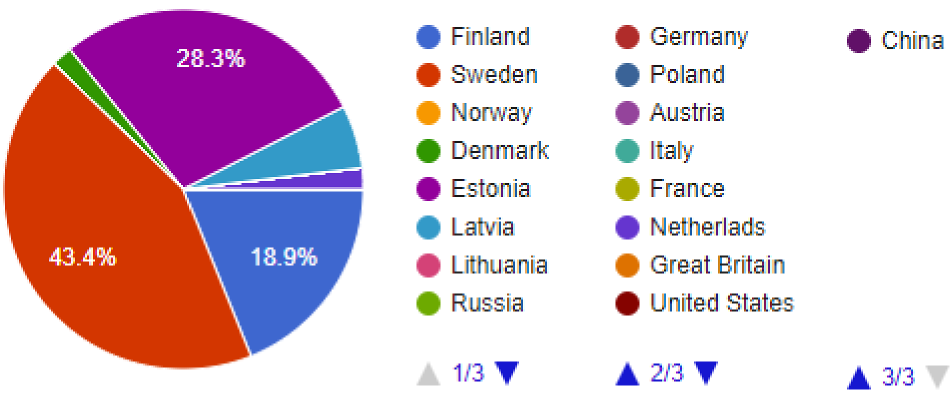

Figure 25. Countries (n=53)

LOGISTICS ENVIRONMENT

Background information about the Logistics environment and expectations helps to understand if it is realistic in an expected timeline to use common platforms. It is a key insight if business processes can be aligned and data shared between parties and how good the industry scenery in general is to implement changes. Also, it gives insight where the main lead time bottleneck and gaps between expectations and reality are.

Although results vary significantly across the countries, these can be considered fairly similar in the region. Most responders evaluate the infrastructure, clearance process, pricing, competences, tracking ability in the region mostly average towards high.

As for environmentally friendly shipment options, it is requested sometimes to rarely, but also *never asked* is still significant (Figures 26-32).

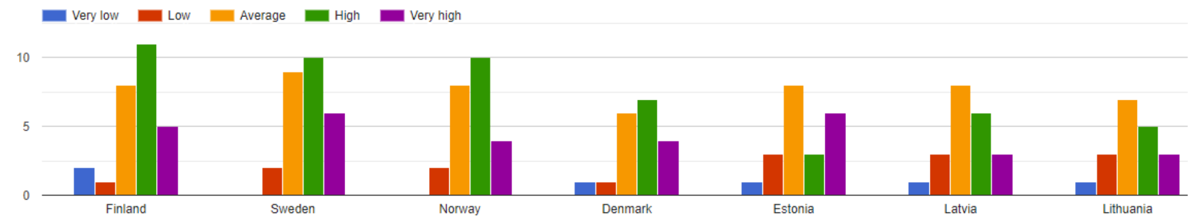

Figure 26. Q10: Rate the efficiency of the clearance process

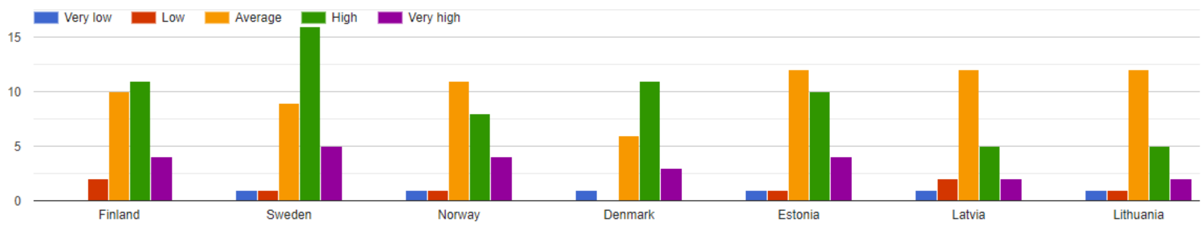

Figure 27. Q11: Quality of trade and transport related infrastructure

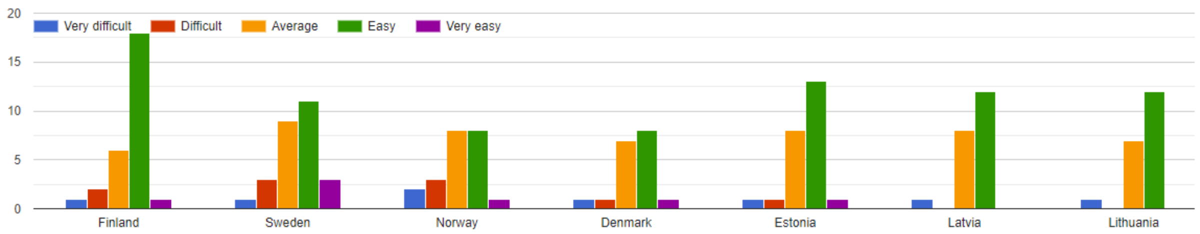

Figure 28. Q12: Easiness of arranging price shipments competitively

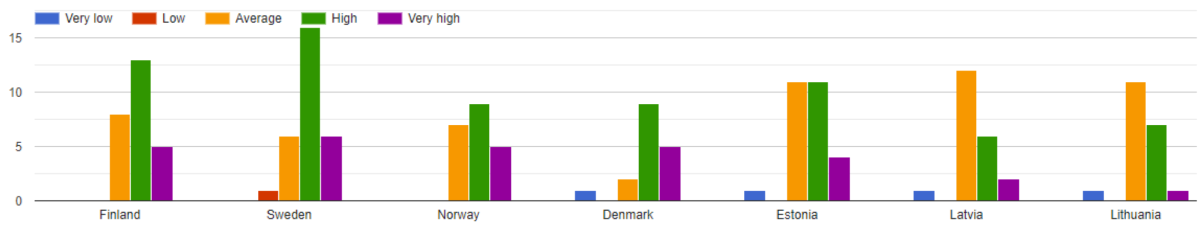

Figure 29. Q13: Overall level of competence and quality of logistics services

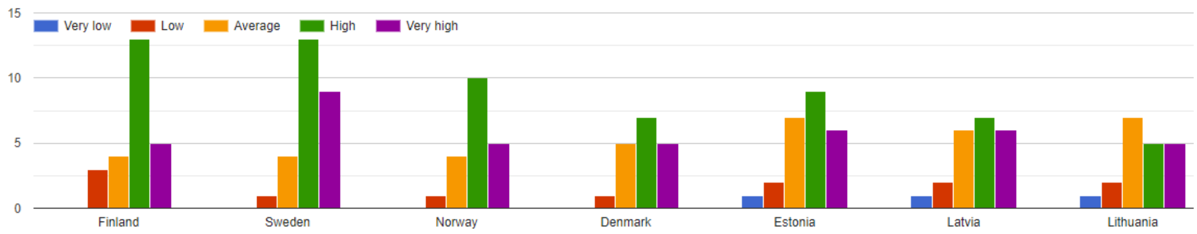

Figure 30. Q14: Ability to track and trace consignments

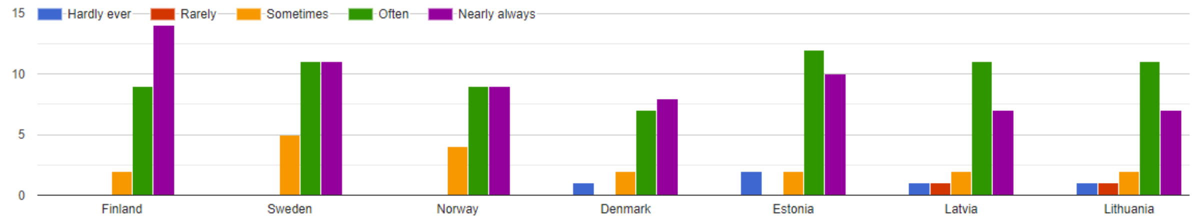

Figure 31. Q15: Reaching scheduled or expected delivery time

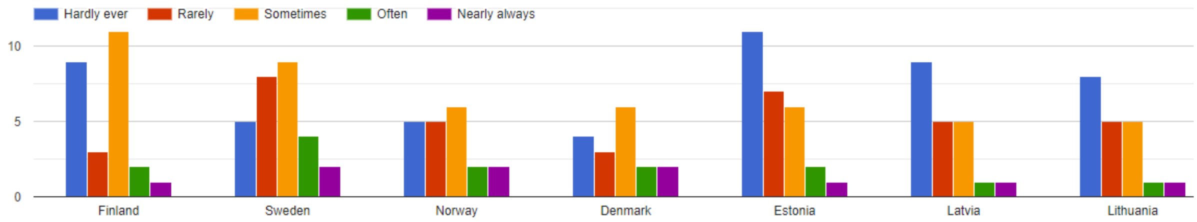

Figure 32. Q16: Shippers requests for environmentally friendly options

LOGISTICS ENVIRONMENT

Charges are estimated mainly high, regardless of type, which leads to the importance of the cost component in the overall process.

Competence and quality of local transportation services and infrastructure are estimated average to high and are similar in many areas (providers, operators, warehousing, brokers, agencies, associations). Overall scenery seems to be on similar level in terms of service quality and is assessed to be already quite efficient.

For time assessment, delays are considered to happen rather rarely.

In overall, all areas have improved year over year but also an increase in new developments has occurred at the same time (rise in demand, increased use of electronic platforms, cybersecurity threats and preparedness for it), see Figures 33-40.

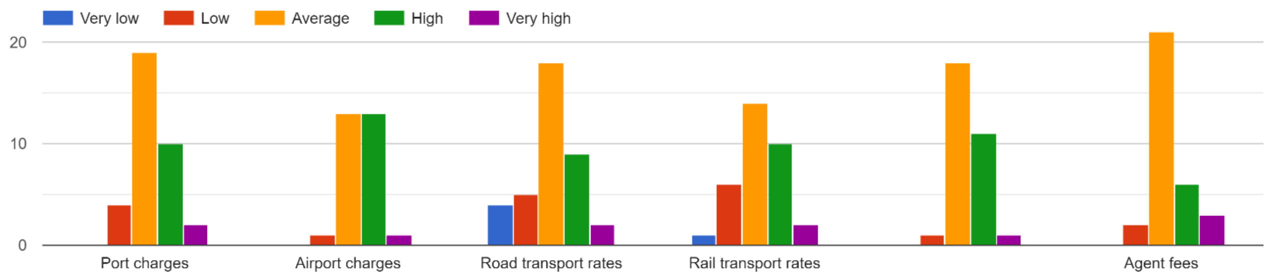

Figure 33. Q17: Options that best describe the operational logistics environment in the country

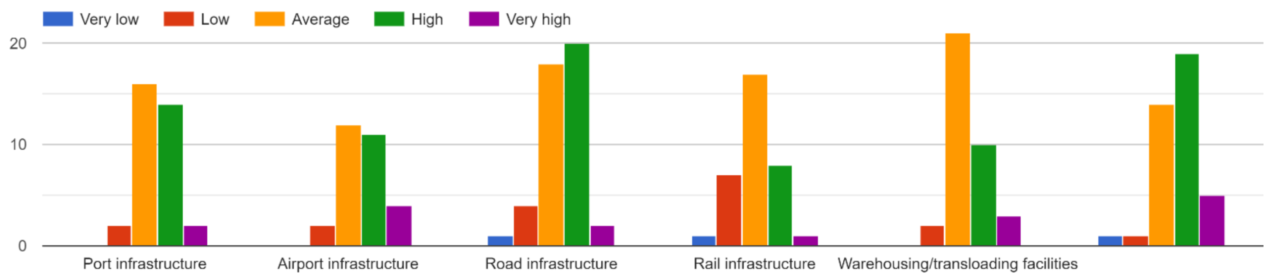

Figure 34. Q17: Options that best describe the operational logistics environment in the country

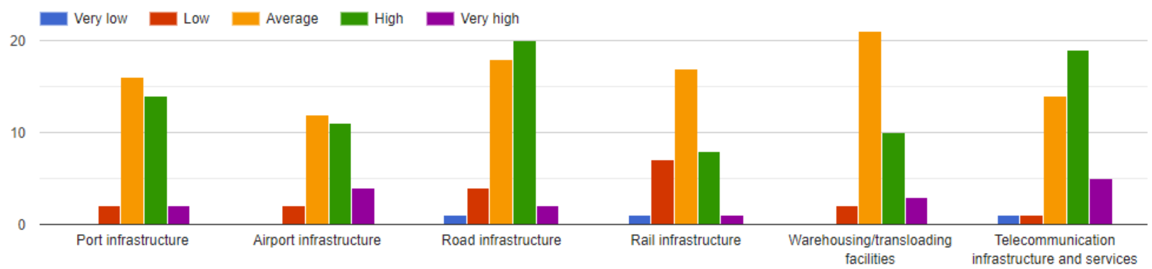

Figure 35. Q18: Quality of trade and transport related infrastructure

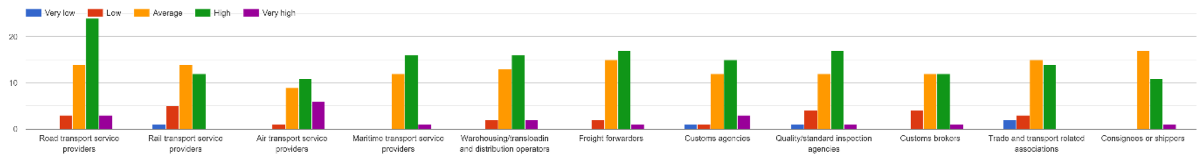

Figure 36. Q19: Competence and quality of service delivered by the following in the country of work

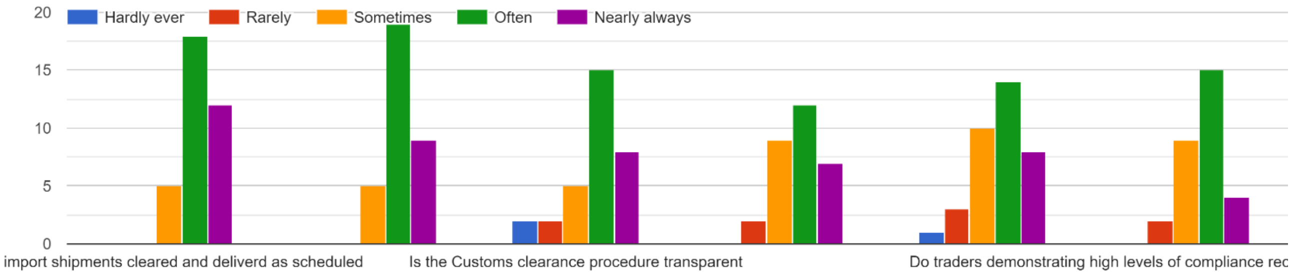

Figure 37. Q20: Efficiency of the following processes in the country of work

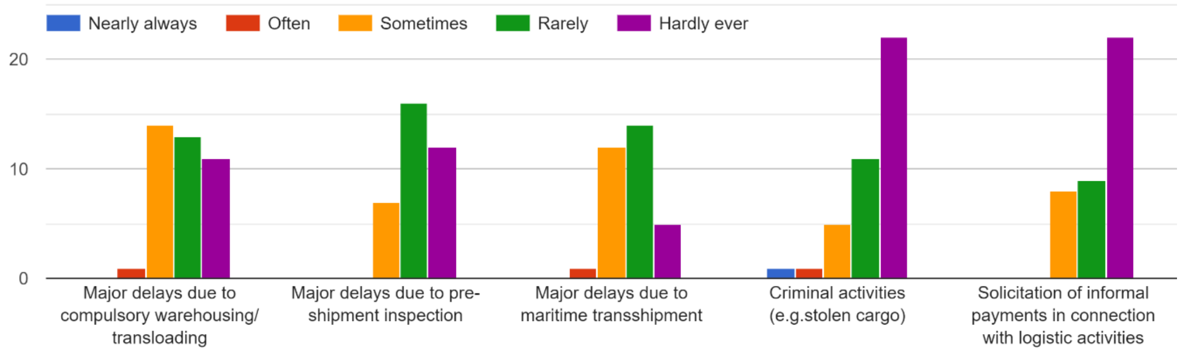

Figure 38. Q21: how often is experienced the following in the country of work

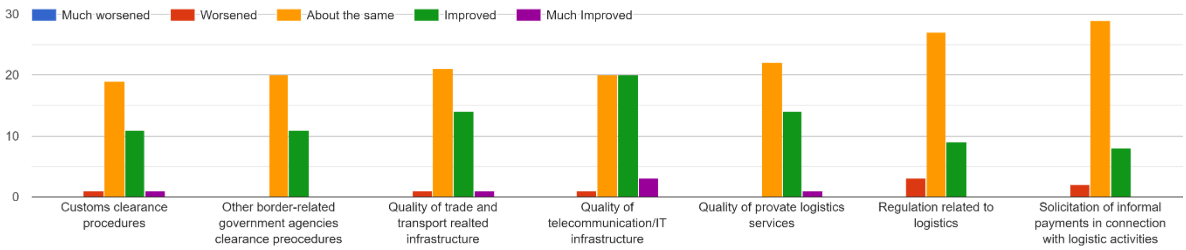

Figure 39. Q22: Since 2017, change in following factors have improved or worsened in the country of work

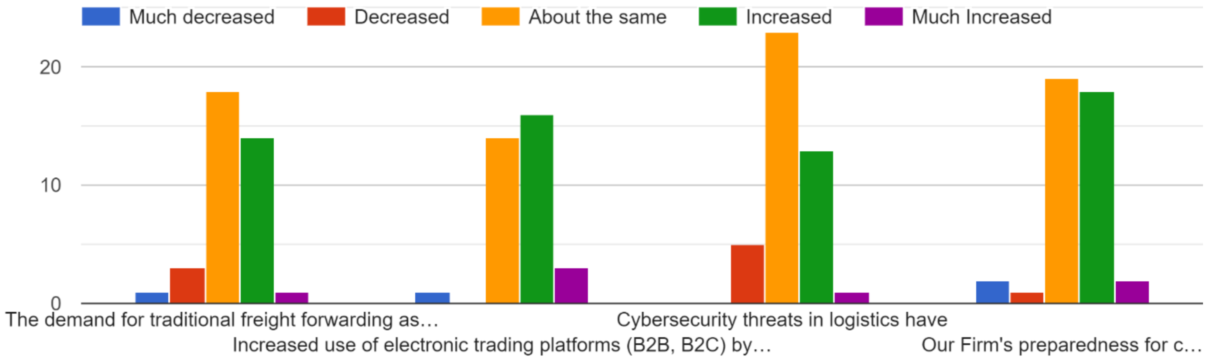

Figure 40. Q23: Since 2017, the developments in the country of work

LOGISTICS METRICS

These metrics of distance and time for importing and exporting using land, air or sea transport are relevant for the survey in terms of having balanced number of enterprises involved and their use as an attribute for measuring if there are significant differences when these metrics vary.

Based on the survey, all different metrics options are covered. As an evaluation, majority of shipments are within distance of 200 to 2000 km and in time of 10 to 90h (as expected for regional and local), see Figures 41-46.

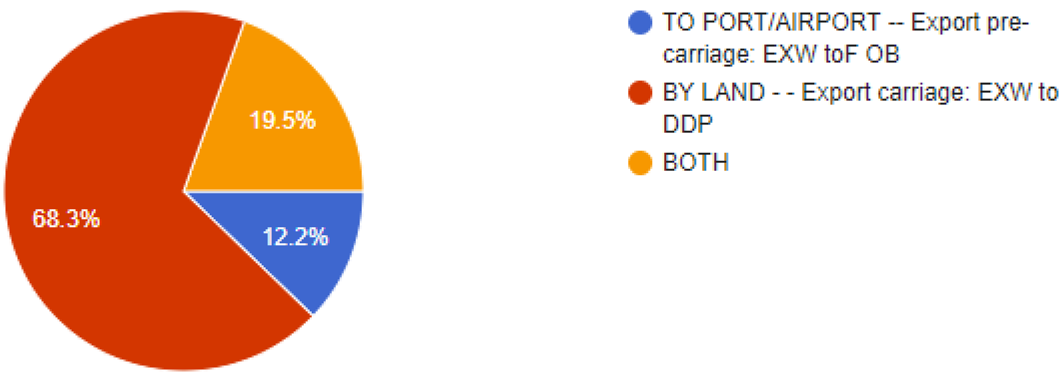

Figure 41. Q24: When exporting a full load from the country of work, the following distance and time parameters

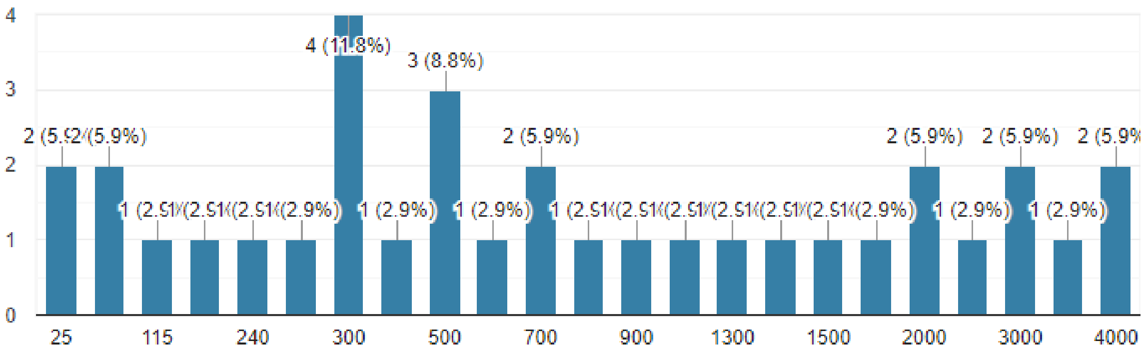

Figure 42. Q24B: When exporting a full load from the country of work, the following distance parameters (km)

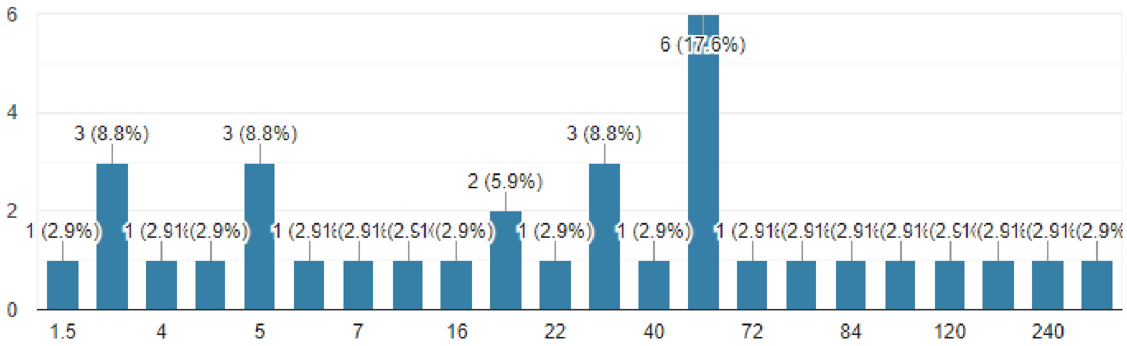

Figure 43. Q24C: When exporting a full load from the country of work, the following time parameters (h)

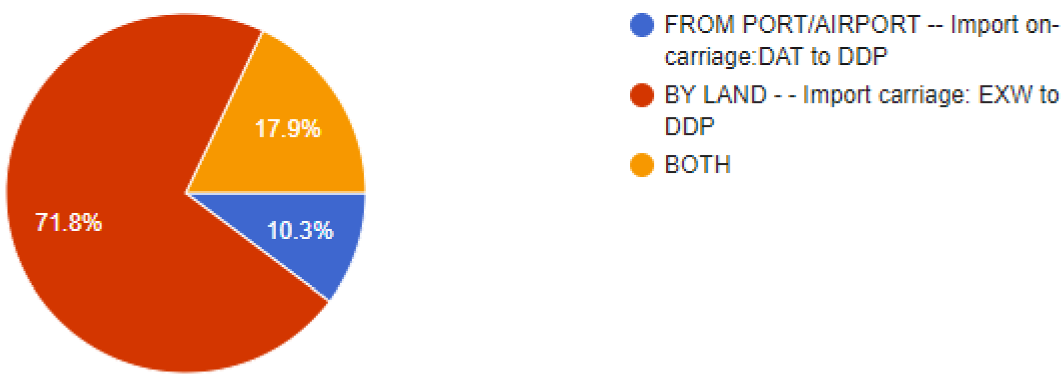

Figure 44. Q25C: When importing a full load from the country of work, the following time parameters (h)

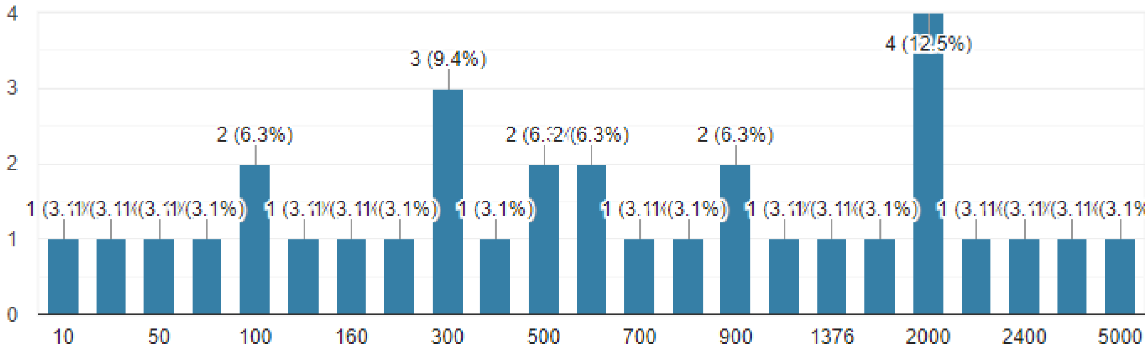

Figure 45. Q25C: When importing a full load from the country of work, the following time parameters (h)

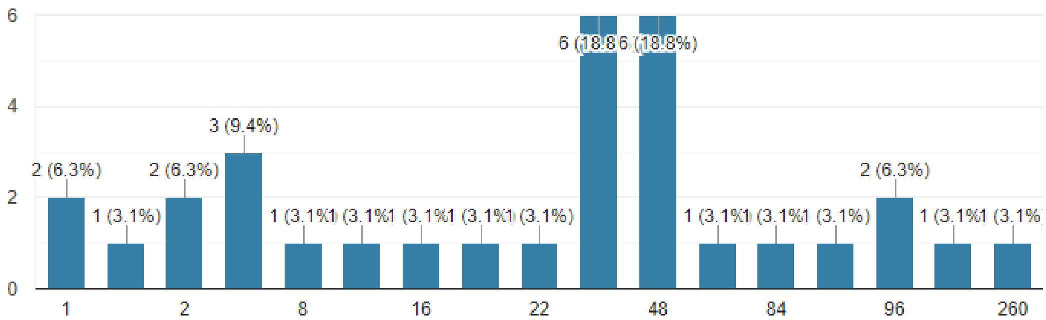

Figure 46. Q25C: When importing a full load from the country of work, the following time parameters (h)

SERVICE LEVEL

Most companies maintain some level of self-set service level metrics. Over 75% of the companies evaluate that in more than 50% of cases they meet the quality criteria, and over 60% of companies indicate that they meet criteria in more than 80% of cases.

For bureaucracy, relatively few government agencies are involved, but regarding to forms, there are several forms required to be submitted, which indicates that automating the data with few agencies but for multiple documents should be considered. Inspections by customs are still regular but automated over half cases and scanning is done seldom. As declarations are already widely accepted electronically, the general environment by regulators is relatively ready for improved automated data exchange in the near years (Figures 47-53).

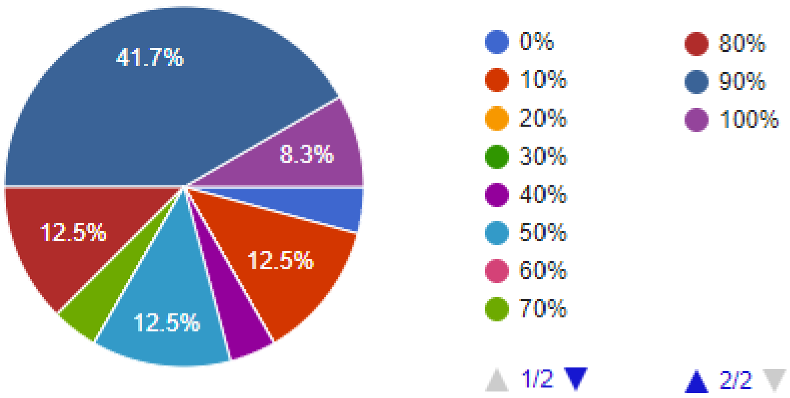

Figure 47. Q26: The percentage of imports to the country of work meeting the quality criteria for delivery to the consignee (if maintaining indicators)

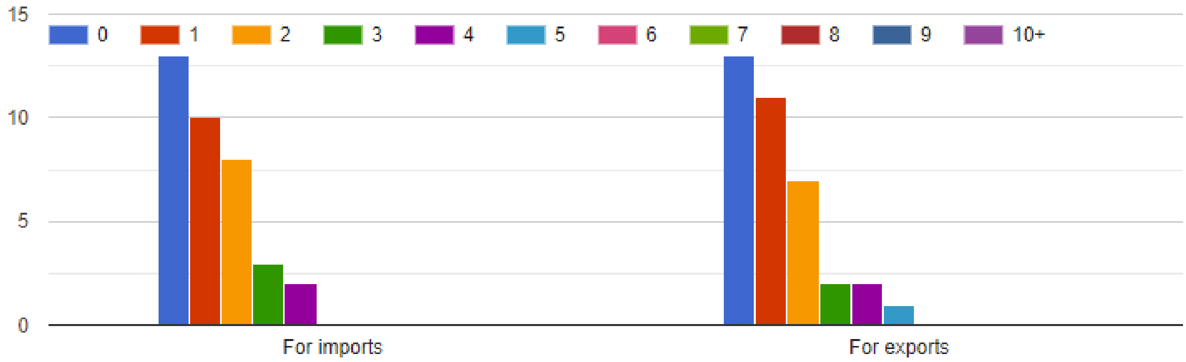

Figure 48. Q27: The number of government agencies involved in the clearance process typically dealt with in the country of work

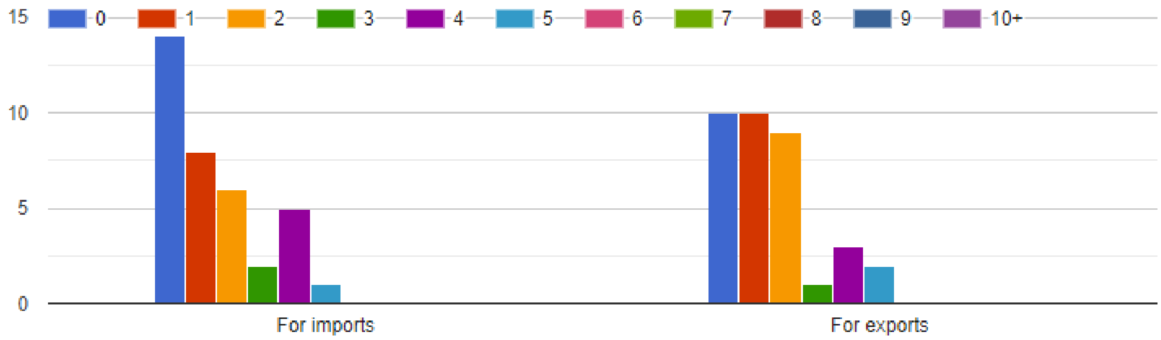

Figure 49. Q28: The number of forms typically submitted, for clearance, in the country of work

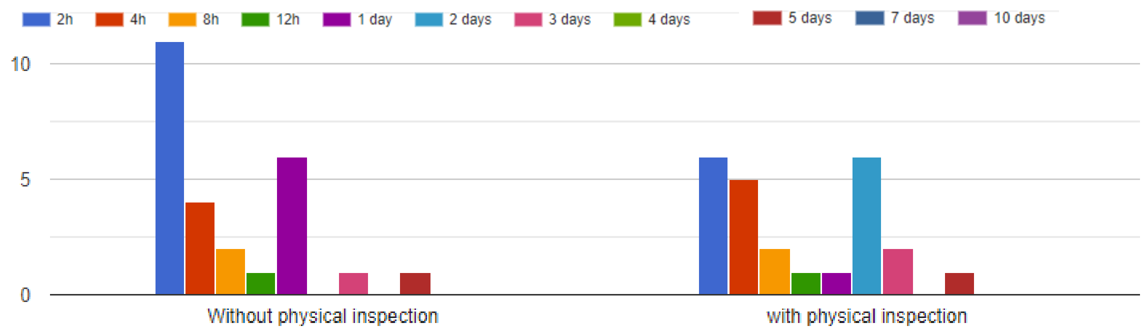

Figure 50. Q29: For imports the average time taken between the submission of an accepted Customs declaration and notification of clearance in the country of work

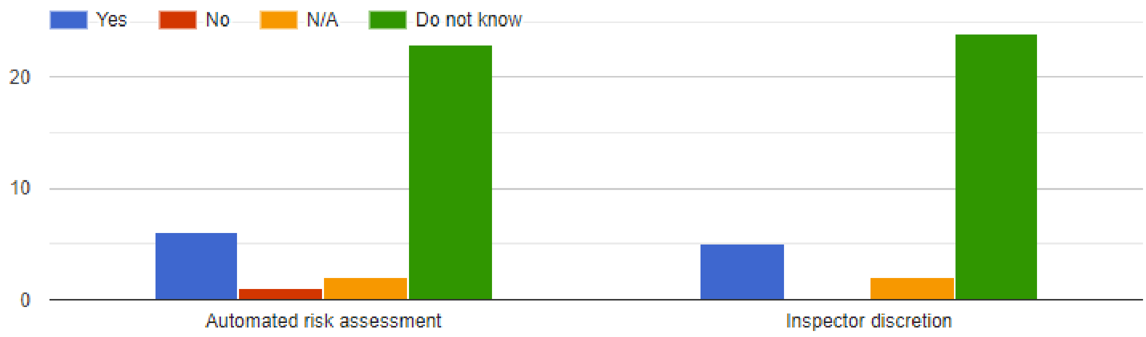

Figure 51. Q30: The main methods for determining whether shipments are physically inspected in Customs

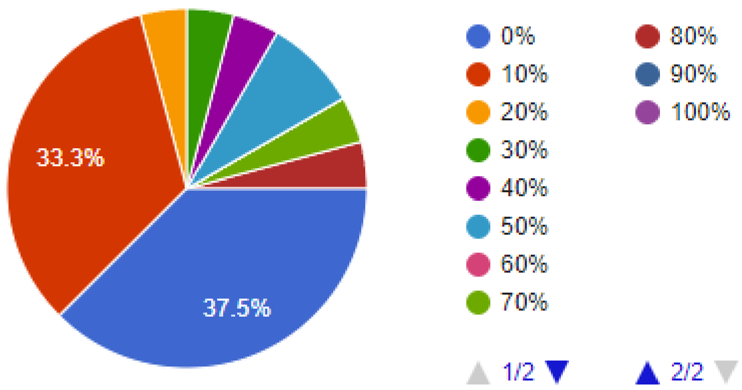

Figure 52. Q31: Average percentage of the import shipments is physically inspected (excluding x-ray and scanning) in the country of work

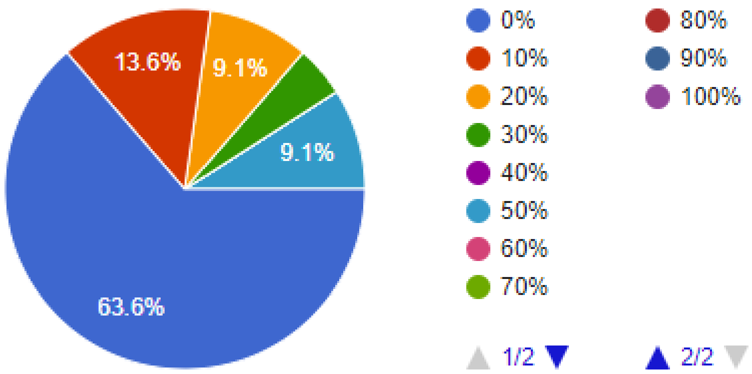

Figure 53. Q32: The percentage of all the import shipments that are physically inspected more than once in the country of work

USE OF TECHNOLOGY

Companies use extensively non-structured data exchange, proprietary systems (EDI) and generic communication channels (email). EDI and ERP implementations are used around 40% of cases, which still shows a below average usage compared to other industries but can be considered already a mainstream approach that is growing. More modern solutions already have some API interfaces and tracking capabilities added to these systems. For tracking (fleet, RFID, barcodes), the scenery is mostly in its early phase of implementation (collection of such data events cannot me extensive today). The wide usage of phones, email, general web portals and intranets (documents, excels) indicates that processes are not organized systematically enough, to use more advanced systems (standardized interfaces). As email is heavily used and based on process analysis, carries a lot of information, including documents, it can be said that majority of information today moves in digital form, but is very loosely structured and standardized. As no common platforms are identified in the industry, most of integration or data exchanges are bilateral and systems in industry not interoperable. Only standardized aspect comes from regulators/ government agencies. For an owner of goods, access, data, systems are mostly provided as they are, and they have no impact on the systems, and need to satisfy mostly data distributed by email (Figures 54-55).

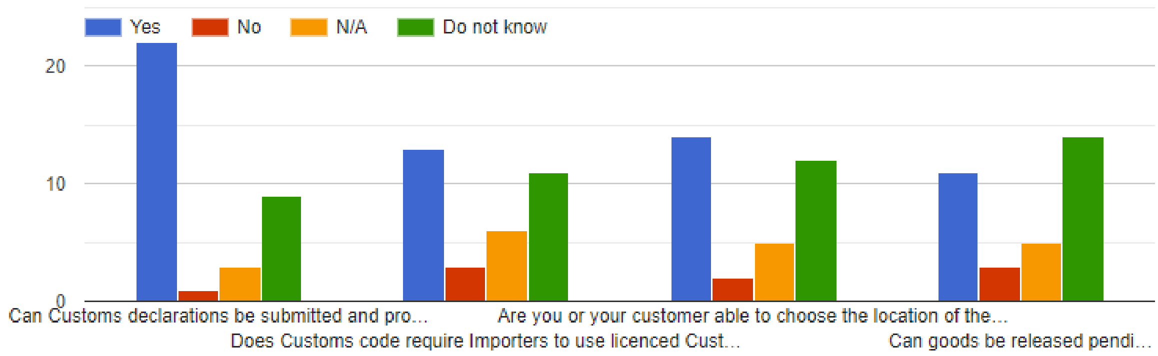

Figure 54. Q33: The statements regarding Customs, in the country of work

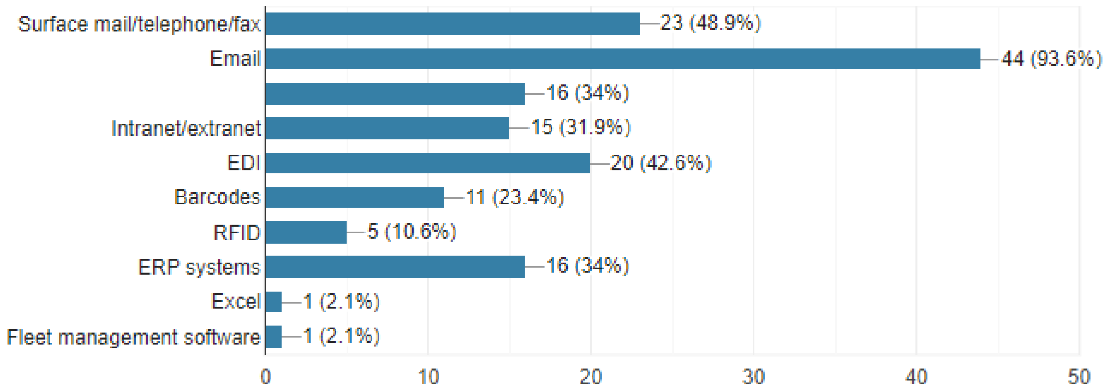

Figure 55. Q34: Telecommunication/IT system methods used in regular bases for managing order-deliver

4.2. Extended survey about blockchain

The target group was the same as for the baseline survey (responses are connected with initial responders), and the findings for the baseline apply also to the extended survey. The extended survey was conducted at the end of the research and software usage at the beginning of 2020, when knowledge about blockchain possibilities, technology and use cases was known to the participant and some companies also had used the platform for at least over 6 months.

The survey is targeted to gain detailed insight to companies' expectations and plans to understand their technology roadmap:

- Majority of companies will be using technology slightly more, and an expected increase in the integrated platform and tracking systems is to be expected.

- Value of the blockchain is still slightly unclear and intentions for strategical plans for using the blockchain in a 3-year horizon can be estimated that usage is probable, if it is mature (answers yes or maybe).
- At the same time, use of several structured systems (EDI, ERP, API interfaces, open access platforms) is on the rise and could increase by 50% (but still not yet adopted for more than 60% in the best case scenario).
- Tracking system implementation is growing rapidly (RFID, tracking, fleet management, barcodes) and could be three times higher compared to today but will remain implemented up to 50% of cases.
- Email will remain the main data exchange and communication channel but it is expected to be complemented strongly by other systems and could move to a position of informal notification channels as a less business process critical tool, see Figures 56-62.

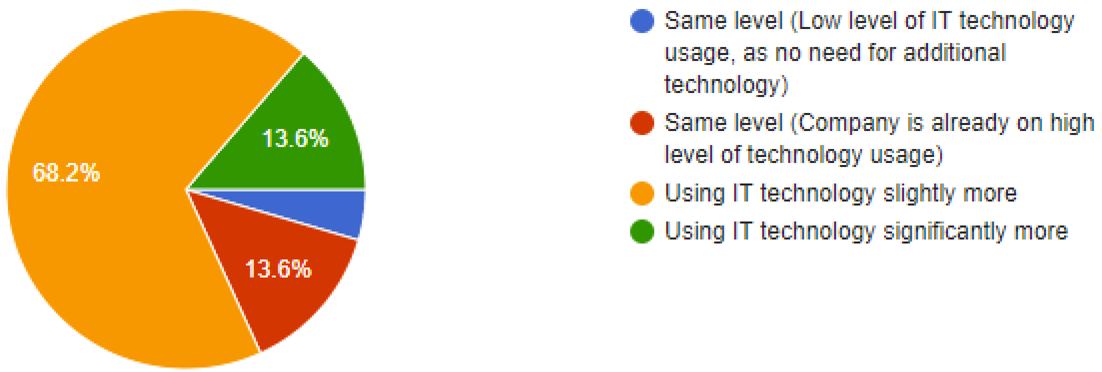

Figure 56. Q1: Where is company seen in technology usage in 1-2 years (IT, communication, tracking systems, data exchange etc)

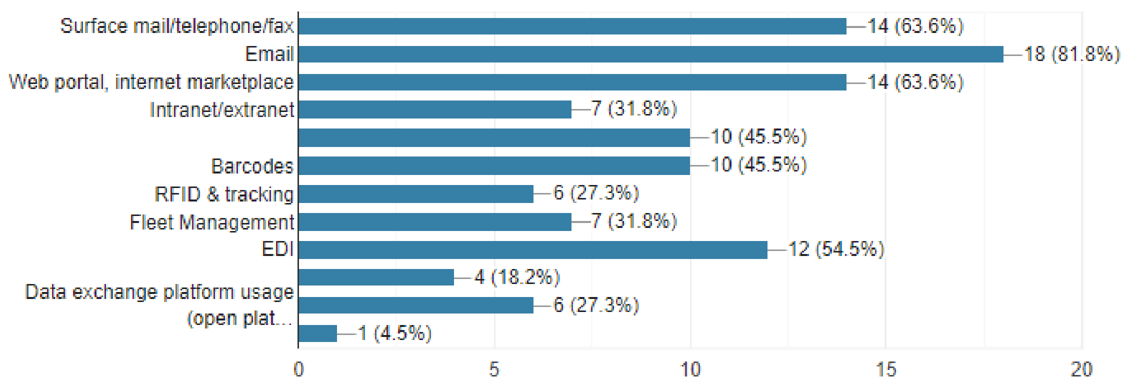

Figure 57. Q2: Telecommunication/IT system methods used in regular bases for managing order-delivery (in 3+ years)

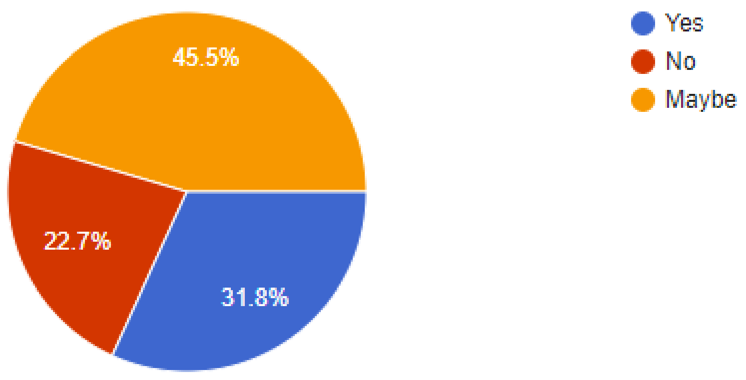

Figure 58. Q3: The benefits of blockchain seen to company in short run (1-2 years)

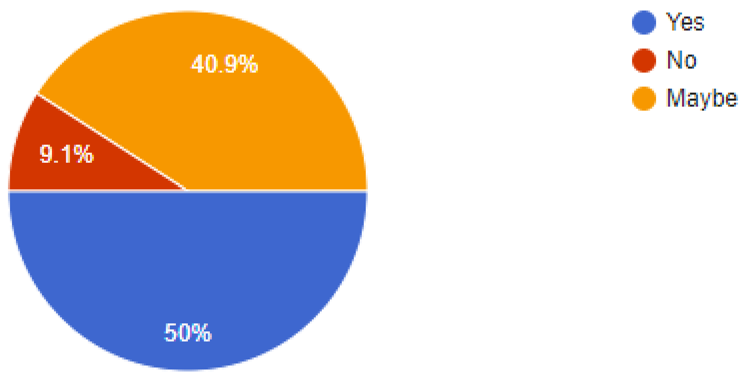

Figure 59. Q4: The benefits of blockchain seen to company in long (3+ years)

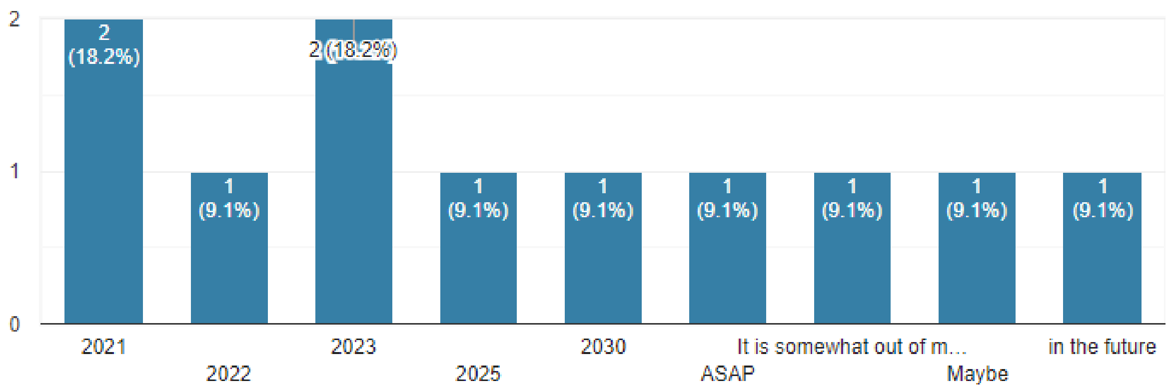

Figure 60. Q5: When is planned to join some logistics blockchain platform if blockchain is seen beneficial for the company (year)

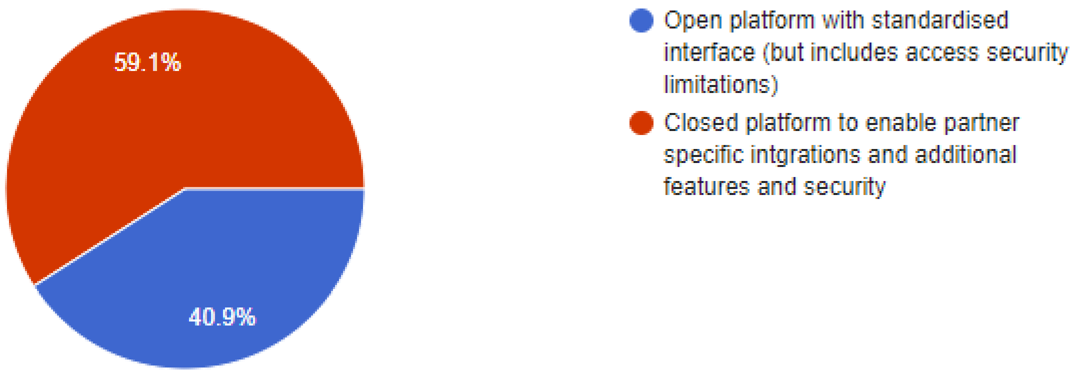

Figure 61. Q6: Is blockchain (or other proofing data exchange) considered to be open for anyone to join or closed for only between dedicated partners

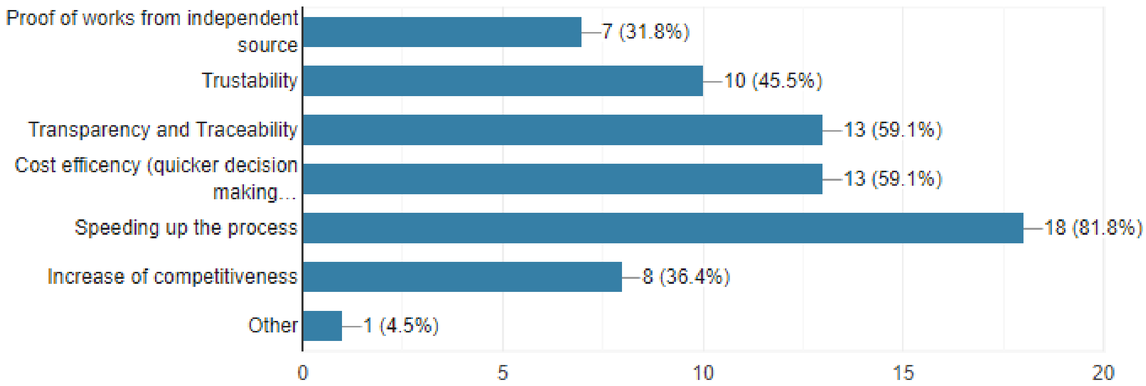

Figure 62. Q7: The main expected benefits from blockchain platform.

4.3. Process map analysis

4.3.1. General

Process map analysis is targeted to support development, provide context for data analysis, and execute process simulation for additional result analysis.

Process analysis was executed in detail for 48 different companies in region, and some additional insight was collected from another 100 companies during initial interviews. During the analysis, a wide selection of different companies based on size, operating model, type of goods and corridors was used. The goal of a wide approach was to collect and unify the findings that can be standardized for a common approach both for technology implementation and data analysis. This resulted in the vastly different nature of supply chains analyzed where events found in the processes varied from 10 to 200. Average number of events was approximately to 20. Although process sequences and main events were similar, a number of actors, subcontractors, subevents and systems varied largely. Micro companies and SMEs have in general low complexity and small automation with an average of 30 main events, 2 systems in process, 5 actors whereas large companies use several subcontractors and have an average of 100 events, 6 systems, 20 actors in the process. A process for mapping the required several iterations to compile, verify and improve the details of the process is to be finally approved by the process owner for an accurate description and further usage for requirements.

A process map attempts to cover several business process layers that are analyzed in the context, each of them having a different scope and timing impact. Data containers and transport containers move in different ways (Figure 63).

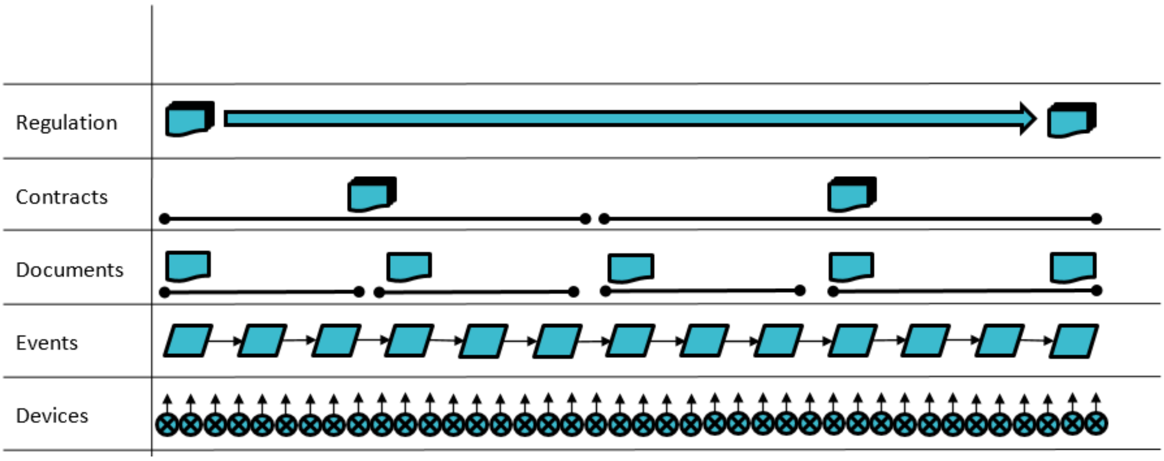

Figure 63. Information layers in the business process

See a set of process map samples compiled and analyzed during the research, business process model with swim lanes in Appendices 4-5 (tools used Aris, Camunda, Visio, BpmOnline, Draw.io).

EVENTS

Main identified events over the process were as follows:

- Ordering events (shipment and goods information, agreements, client registration)
- Goods identification events (verification, measurement, weighting)
- Loading and unloading events (pickup, unloading, transfer)
- Schedule and planning events (train schedule, ship schedule, road transport schedule, loading schedule, entry pass, booking, tickets issuing)
- Handover (departure/arrival) events
- Tracking events (GPS, RFID, scanning, fleet monitoring, gate control)

- Document events (order, bill of lading, delivery note, customs declaration, invoice, tickets)
- Financial events (invoice, issue, payment, insurance, guarantee, escrow, subcontractor invoices/payments)
- Subcontractor related special events (ordering, signing, approval subservice)
- Notification events (email, SMS, mobile app, approval, information request, information providing)
- Customs events (submission, declaration, approval, inspection)

The identified and categorized events selected for system requirements, data collection and measurements – measuring points - based on the value and technical feasibility were as follows: order, pickup, loading, unloading, registration in gateway, invoice, arrival handover, GPS tracker events in case of availability and document handover (bill of lading etc.). As for attributes, source, actor, type, location, format, timestamp were feasible to be collected. Events were categorized with related actors and systems in context and for simulation purposes, the impact on time was estimated.

A separate distribution exercise was done to sort digitalized events and non-digitalized events and to sort physical events and document related events for structural analysis.

The following key attributes for events were analyzed within the process to collect to the blockchain and to use in the result analysis:

- timestamp,
- time type (inbound, outbound),
- sender,
- type (context, name, nature),
- location (GPS, name, type),
- actor (triggering, executing),
- actor (sender, receiver, source),
- system (processed, stored event data),
- message protocol,
- format,
- status,
- goods type,
- cargo type,
- standard used,
- digitalization level (paper, email, structured system, API),

- access requirements (who is eligible to access the event data),
- security (encryption, legal protection),
- related organization (beneficiary),
- proof value,
- scope (internal value or across supply chain),
- unique attributes (back trackable to order),
- rigidness to change (impact of fixed time schedules),
- impact on lead time.

As part of system requirements, these events were additionally allocated to UBL standardization; so, regardless of the source, these could be unified for a similar structure. This is a related part of the requirement to provide common API interface in the SmartLog blockchain platform.

During the development, some of the following UBL semantical descriptions were used:

- UBL 3.1.4. Bill of Lading - information about an instance of a transportation service
- UBL 3.1.26 Goods Item Itinerary - details relating to transport movement, identification of equipment and goods, subcontracted service providers, etc.
- UBL 3.1.55 Transport Execution Plan - a document used in the negotiation of a transport service between a transport user and a transport service provider
- UBL 3.1.56 Transport Execution Plan Request - sent by a transport user to request a transport service from a transport service provider
- UBL 3.1.57 Transport Progress Status - status regarding the transport infrastructure from Transport Network Managers
- UBL 3.1.61 Transportation Status - status report from the Transport Service Provider

SYSTEMS

During mapping, a wide range of systems were identified, like phone calls, emails, papers, CRM-s, ERP-s with internal databases, Edi interfaces, web portals, intranets with local documents (MS Excel spreadsheets), cloud storage, ftp-s, external partner systems, customs systems, etc. The dominating system was mostly through email. For larger companies, for partial processes in house, ERP/CRM system was present and occasionally some tracking system (with limited time/GPS event only). Overall process digitalization for companies was found, though relatively low; thus, also process maturity and automation were low, which later resulted in very limited data collection. This means that a substantial manual work was done for data processing, even if it is shared in digital form. Regardless of different processes and source origination for digitalized events, the selected events were allocated under common standardization for collection and measurement purposes (described as standardized UBL messages, or common interpretation by type).

GOODS

During goods categorization, it was found amongst other things that some supply chains consisted of low value goods (bulk wood, crushed stone etc). For these cases, the impact on the reduction of event's time was estimated very low, as there is no time critical expectation for goods movement; on the contrary, these cases are cost sensitive.

PROCESS OWNERS AND OPERATORS

Part of the mapping process was to identify the process owner, i.e. the stakeholder controlling the supply chain for evaluation of the direct and indirect parties that influence the implementation of the shared blockchain platform (operators in their sub process in the supply chain) most and who the main beneficiaries of the system (in most cases identified as the export company/goods owner) are.

Another finding from the cases that have no impact on the reduction of event time was the gateway events like arrival and departure to transport hubs like railway stations, port that are critical, but mostly unaffectable due to their preplanned and fixed schedules. As several multimodal transport schemes were identified in the corridor, several impacts of time measurements are expected to be of local nature only and not influencing overall lead time.

4.3.2. Process simulation results

Process simulations were conducted to estimate the impact on the lead time when using shared platforms for data exchange. As actual data was limited, the goal of the simulation was to estimate where in the process (supply chain step), when and what events and operating models may impact the lead time. Then, the findings were compared and correlated with data analysis and additional context and results were provided.

For process simulation, the first categorization was to evaluate separately complex (belonging mainly to large companies and multimodal operators) and simple processes regardless of their current system maturity level on an event level. During the analysis, the aim was to evaluate the impact of each events on the lead time through the aspect of its digitalization possibility, proof value, automatization opportunity, shareability, rigidity to change, financial value, and verification need. Some events or processes were categorized as of high rigidity to change based on the operating model and type of goods and were discarded. As most financial events were evaluated to be too rigid to change in the process in short term, they were dismissed. Other events from the processes that had potential to be automated and to be shared with better process design and support by blockchain (or similar) systems were given an estimation of 25% of improvement compared to the best case scenario (remove time waste). Estimation was based on the findings of data measurements and expected systems improvement rate, resulting from the survey analysis and balanced feedback from process owners during process mapping). The average improvement in the lead time was estimated to be increased by 6.8%, but potential is expected to be much higher (if rigidity to change can be reduced).

The second task related to the processes was to evaluate the impact on various information layers by looking at physical and non-physical events. Physical events are covered mostly on individual event level measurement. No exact measurements were calculated for the majority of non-physical events at the document and contract level. This impact will be a gamechanger for the industry if it can move to digital economy; at the moment, these results cannot be estimated due to a number of different factors that may impact it (standardization, technology, industry leaders initiatives, regulation).

4.3.3. Data analysis results

OVERVIEW OF DATA COLLECTION

The research task of the SmartLog project included provision of requirements to collect data and analyze the collected data. First step was to collect data about supply chain's events from several participants (original process owners for corridor, later from selected logistics companies approached by field team) and store it into the SmartLog blockchain platform. The goal of the data collection was to analyze and understand the variety of events, availability of data, data structure and identify the value of the provided dataset. The second goal was to measure events datapoints and time variations in supply chain when some proof of an event is available in the platform for participants.

In the second step, data analysis was targeted to identify the similarities and differences based on the supply chain process, corridors, transport types, company types and sizes, and transportable goods. Due to the challenges for technical data gathering, technical aspects were also analyzed if data can be normalized to comparable structure and impute missing data (where it is possible to calculate). For accurate understanding of data, datasets provided by the company were explicitly compared with the company supply chain process to map the key datapoints. As for time variation measuring datapoints, a sequence was to be identified and each process for a company had to be mapped in order to identify every event's order in the process and its start and end time. The main reason was that data was not always collected at the time of the event due to delays of event registration and in system integration or data loading.

DATA PROVIDERS

Main data was provided by Tallguru, Livesoft and Speys via system integration (including data for multiple companies), which means that very few direct connections to dedicated company systems were done. Some data was collected also via manual interface, but from total samples it was an insignificant sample. In total, data from 12 different companies were collected (some companies had multiple routes and operation models).

Data was collected to the SmartLog blockchain platform. The structured data was extracted from a variety of structured and unstructured source messages (but standardized during the process) and datasets that carry a logistics event information.

Data was entered to the blockchain platform over API or dedicated portal:

- Data provider's (e.g. logistic company) system has integration to send standardized messages to the platform API instantly when registered by the data provider and data is extracted from messages.
- Data is cleansed, structured and loaded in batches by the data provider to the platform (over API) on scheduled times.
- Data provider has manually entered event information to the platform directly.

Identified datasets were loaded from the blockchain platform into the data analysis tool. Data for final findings was extracted to the analysis tool, Qlik as of 27 January, 2020 from the SmartLog blockchain. Main key attributes for datasets are given in Table 2.

Table 2. Key attributes for datasets

NAME	Primary key	Description
documentID		Referral id
organisationID		Company participant in shipment
supplyChainID		Identified corridor for shipment
containerID		Unique shipment container, package
timestamp		Event timestamp
shippingOrderID		Unique client order related to shipment
contentType		Event type
senderParty		Shipment sender
carrierAssignedID		Shipment carrier during event
contentTypeSchemeVersion		

NAME	Primary key	Description
statusLocationId		Event location
__KEY_root	Primary key	ID

QUANTITY OF DATA

Dataset on the snapshot for 12 months of collection (with some technical pauses) had 1567101 events registered since 28 February 2019 until 27 January 2020 (but continuing as of today). Although a significant amount of events is registered, the majority is mainly originated from one source (Tallguru); nevertheless, other sources also have started to provide small datasets since August 2010 (Speys), and therefore, it is too biased to make any conclusions for all corridors relevant for the research. For source data, it is relevant to mention that it has information of several companies and narrower routes. The created data integrations and input interfaces in the platform proved to be usable. These can be refined for both existing sources and used as template for new interfaces, but data gathering itself is highly dependent on the availability of data in business processes and systems (limiting factor for data collection).

QUALITY OF DATA

Data has basic attributes of source and time available, but very often is missing insight to corridor, location, container, and unique client. As for other required attributes, there is often no available information for the type of event and the type of goods. Some event types could be derived though by using the process mappings. For most timestamps, it is impossible to identify if the event is inbound or outbound, but on some occasions it can be improved using process map sequences. Although some data imputation is done during loading and can be done further (interviewing company for the nature of shipments), it is insufficient for proper findings in some cases (Figures 64-65).

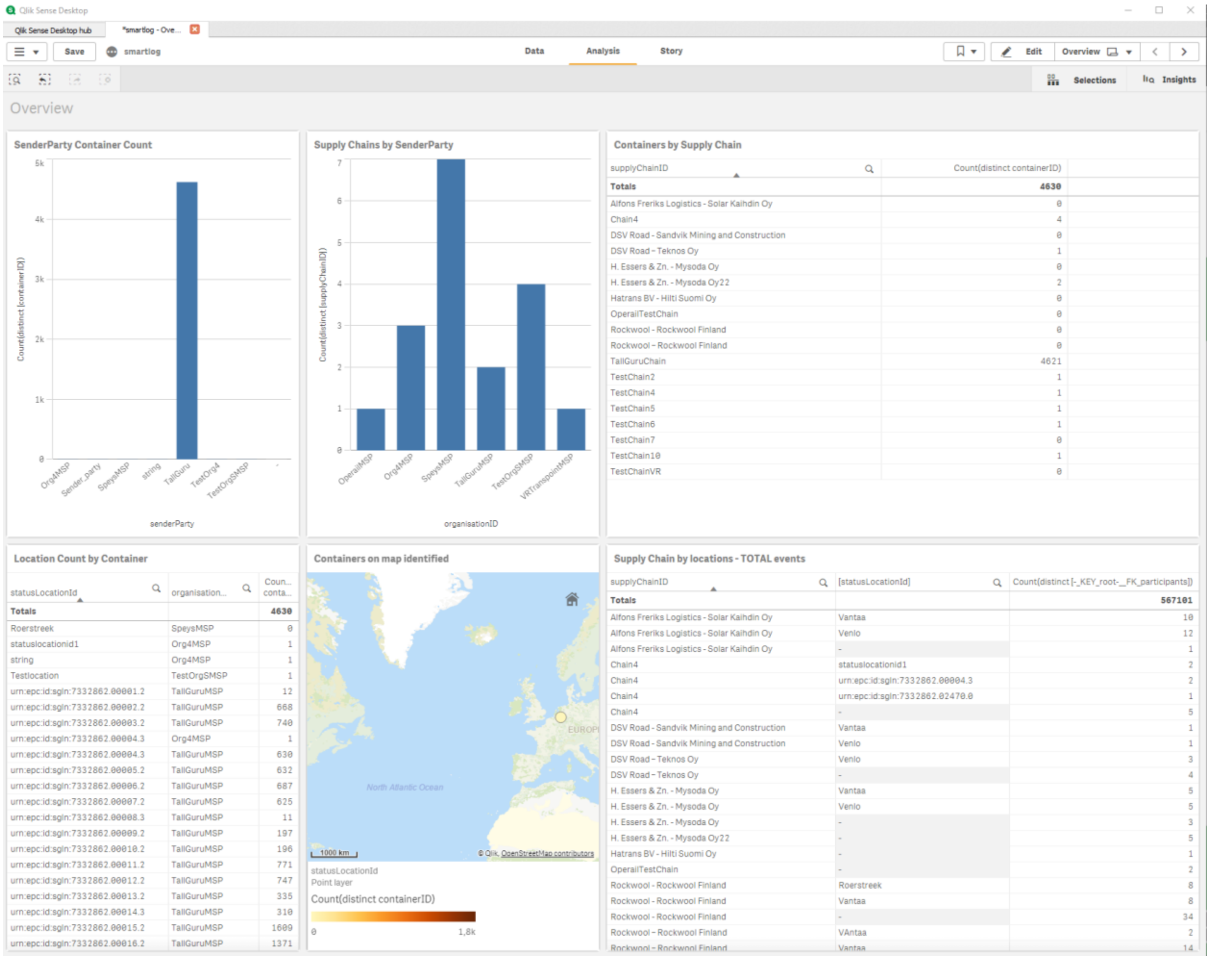

Figure 64. Main findings of data analysis using Qlik

root REST_httpscloud.projectsmartlog.comreportingApidownloadEnrichedData — Fields: 12

documentID	organisationID	supplyChainID	containerID	timestamp	shippingOrderID	contentType	senderParty	carrierAssig...	contentType...	statusLocationId	__KEY_root
2019-07-19 06:55:10+00:00	Org4MSP	TestChain4	-	2019-07-19 06:55:10+00:00	-	-	-	-	-	-	566956
2019-09-06 11:09:28+00:00	SpeysMSP	Rockwool - Rockwool Finland	-	2019-09-06 11:09:28+00:00	842	-	-	-	-	-	566981
2019-09-06 11:17:55+00:00	SpeysMSP	Rockwool - Rockwool Finland	-	2019-09-06 11:17:55+00:00	842	-	-	-	-	-	566982
2019-09-09 05:52:24+00:00	SpeysMSP	Rockwool - Rockwool Finland	-	2019-09-09 05:52:24+00:00	842	-	-	-	-	Roerstreek	566984
2019-09-09 05:52:35+00:00	SpeysMSP	Rockwool - Rockwool Finland	-	2019-09-09 05:52:35+00:00	842	-	-	-	-	-	566985
2019-09-09 07:09:47+00:00	SpeysMSP	Rockwool - Rockwool Finland	-	2019-09-09 07:09:47+00:00	842	-	-	-	-	-	566986

Figure 65. Sample of dataset

CONCLUSION ON DATA MEASUREMENT

Due to insufficient quantity of data over corridors and lack of good quality input of identifying events by type and proper analysis of measuring times, it is impossible to draw significant conclusions based on data only. There were some routes where subset corridor measurement was feasible. Based on the measurements where quality was good, average lead time reduction was measured to be 3.8%.

Regardless of non-usability as the only source for final conclusions for quantification and measurements, the dataset gives though good insights to the type of data possible to standardize for the collection and to the ability of larger companies to provide via API-s. As a live dataset with actual events, albeit its flaws, it has been a valuable sample how and what data can be collected, can be made meaningful for the end users and research purposes. Insight to datasets together with process maps has given a much broader look to various supply chains for unified data collection. The main reason for inconsistent data has been the technical obstacles for integration, lack of originated data, missing standards and reluctance of sharing the private data. These have been the main challenges to overcome and require efforts of both field and research teams to persuade companies on case by case.

MAIN FINDINGS

- Over 1.5 million events collected - 1567101 events registered since 28.02.2019 by 27 January 2020 and ongoing).
- Data shows several events (by type) that have time waste, which can be reduced (too strict pre-planned pickup times, waiting times for loading, delays in receiving orders, waiting approval of plans, fixed planning to match with fixed schedule, etc.).
- Data measurement average lead time reduction is 3.8% (removing time waste).
- Based on additional simulation of data samples, estimated average lead time reduction is 6.3%. This finding is based on hypothetical scenarios what if part of planning could be more flexible by 25% and 25% of documents are handled in parallel just in time with cargo transport (excluding fixed schedule related documents that have little impact).
- Time reduction 3-8% should be realistically achievable with shared data in process (road transport, multimodal, documents etc.).
- Time reduction is evaluated both by impact on process change and benefits of using the technology.
- Some events timing is fixed that may not be impacted (train & ship schedules). Data has repetitive schedule blocks for those events throughout the corridor, and can be impacted only before such event, but not the event itself.
- Results in time savings may be delayed due to incremental growth of critical mass of users (requires multiple parties) and impact of reorganization of processes. (More participants require more data processing and if not automated, e.g. using smart contracts, will become a new bottleneck for speed in the process).
- Mostly physical events as of today are collected (integrated systems do not provide many document events), higher impact is expected from smart contracts (documents).
- Visibility to all parties about full shipment is possible with instant event information (compared to internal/local access only).

However, the testing period was too short for detailed results covering all events, with a longer period it would be possible to achieve more significant results and to integrate a larger number of companies to collect significant samples.

4.4. Expert interview results

4.4.1. General

During the pilot and blockchain implementation, several questions and technical challenges arose for the participants. Regardless of hundreds of companies contacted, over fifty companies participated in the detailed process analysis and a small number of companies were able to be finally integrated to use the platform. Many of those challenges were analyzed and discussed during detailed interviews.

The topics addressed to the companies during the interview were mainly the following:

1. What was the reason the integration was/was not realized between the company system and the SmartLog blockchain platform?
2. What do you think about using the described solution/Blockchain technology in the logistics and supply chain industry in general?
3. What benefits, if any, do you see in the blockchain platform and in which expected timeline do you consider to be using it?
    a. Where do you see your company in terms of technology in 1-2 years (IT, communication, tracking systems, data exchange etc.)?
    b. Telecommunication/IT system methods used on regular bases for managing order-delivery (in 3+ years)?
    c. Assessment of how mature Blockchain is for use and integration in general?
    d. Structure and quality of your data, what problems do you feel exist?
    e. On which basis do you want to acquire the blockchain technology? There are other ways to solve the data sharing that you do not have access to today. Are there other options? What would be decisive (price, security etc.)?

The technology experts were involved in the discussion of findings from the companies and comparison with other industries and their blockchain implementations. The following topics were addressed: managing the hype curve of technology implementation in general; where the process is currently standing; what is expected in near future in the technology perspective; what are the key technical solutions that provide value; what is the potential in relation to the economic impact of the technology; what investments are further required; what preconditions need to be met for successful implementation of the technology in logistics.

4.4.2. Main findings from the company's perspective

Technology challenges for implementation of the SmartLog blockchain platform:

- Issues about the technology maturity relatively high entry threshold to be able to implement the system and other parties in the supply chain
- Sceptical about Blockchain as a technology because it generates too much traffic, and therefore is resource hungry
- A lot of technical specific challenges to be addressed for infrastructure (firewalls, certificates, message standardization) to join the platform

Organizational challenges:

- Lack of enterprise management approval to invest resources (as lack of resources or allocated already to other developments)
- Information sharing was identified as a key issue in order to optimize various processes involved with supply chains
- Difficult to get approvals from multiple parties in the supply chain to share shipment data with third parties, due to legal constraints in bilateral agreements
- Majority of companies had no or limited knowledge about blockchain and convincing and educating takes time
- Lack of need, clear use case or solving immediate problem to justify changes in the systems and processes to implement non-production solution
- Blockchain requires that many must adopt the technology in order for it to work. As early adopter it is extra difficult to start with.
- Lead operator who insists on the use of common system (as hard for smaller companies to influence it) is often required.
- Alternatives technologies in use or under development:
  - API-s (from infrastructure and transport companies, e.g. rail companies, ports, roads;
  - Competing centralised platforms (initiatives like "Single window").
- The old way is working well (Secure FTP and XML files might be hard to beat due to their simplicity).
- Lack of cooperation between logistics companies. Mostly bilateral partnering is used.
- Current company business model may be avoiding transparency by design that the blockchain will change (undesired effect).

Expected Benefits from the Blockchain

- No quick benefit immediately, until major players in the market have driven the development of the blockchain into wider usage (if you are a relatively micro, small or medium size company)
- Currently, it is hard to estimate the future usage, but still some blockchain initiatives continue to be developed to identify potential use cases (e.g. logistics transaction store). Evaluation continues on case by case basis and in operational context.
- Many companies are remaining expectant about the future benefits of the technology, as they are realized in the near future. At the same time, they are not aware of any alternative solutions which would focus on sharing confidential business messages and related information in distributed information architectures.
- Origination of goods can be tracked, manufacturer info (food, forest, electronics etc.)
- The technology will be useful if multiple financial transactions are carried out during multimodal transportation (e.g. during cargo transhipment, their intermediate storage in warehouses for consolidation or distribution of the product).
- It may be an extremely useful technology for state fiscal authorities to control the transparency of all commodity and financial operations in the process of transporting goods.
- Data sharing possibilities and potentials as the most promising benefit.
- Increase of understanding the blockchain approach has widened options of technical possibilities for data sharing concepts (timestamp, immutability, controlling speed).

Expectations in changes of technology and systems

- EDI usage is slowly transitioning to API
- Use more of the API, i.e. interface solutions, as there is more point-to-point communication with API (that blockchain may lack)
- For normal business confidentiality reasons – lean towards closed or at least controlled environments
- Increase in usage of telemetry and status information
- Current level of data quality and structure for medium size and bigger companies is on the level that satisfies them. Data moving one way only, no efforts are done to make it move both ways with consumers.

4.4.3. Main findings from the technology implementation perspective

For most challenges, technology experts agreed with the company's feedback seen from the point of an individual actor in the system, especially as it was impossible to get out the full corridor and goods owners' approach.

Based on technology implementation, the following findings were pointed out:

- New technology requires process changes, technology itself cannot be a solution. This also addresses a requirement for each participant to develop and change their processes.
- From the commercial aspect, a substation revenue, even if in the long run, must be achievable. As for the blockchain case, the running of platform/operating platform to gain revenue or gain better data and automated process (cost reduction) is the driver for big players in industry to drive the research and development. For joining parties, it is a marketplace that improves the efficiency and reduces the need for developing their own system (integrating is more cost effective than developing and distributing own system).
- Support in standardization should come from governments and public institutions, as main beneficiaries of data processing digitally and users of transparency.
- A core value of the blockchain is timestamps and immutability that could have a dedicated focus just to provide this feature (not full data sharing). It may be only required, though in specific use cases, not always.
- Blockchain approach of not being the core database, but a toolkit on top of database(s), was sometimes missed by participants.
- Blockchain has passed through the technology hype phase on the same period during the project and is understandable, getting a mix of results from "believers", "advocates" and "disappointed" on the peak of inflated expectations through disillusionment, see Gartner Hype Cycle (2020).
- Majority of blockchain implementations in a number of industries have shown the areas where blockchain does not suite, yet the investigation continues to test new fields. It is a learning process that sometimes will produce results that may be usable in the implementation context or some other areas, see examples in (O'Marah, 2016).
- During the SmartLog project, implementation of the blockchain was unsuccessful on the business processes and events where:
    - Data immutability is critical in the business context, but where transparency, traceability and data immutability would have been a key benefit (Time stamping).
    - Registration and sharing of document related events (order, invoices, handover, customs etc.) in the business context (Smart Contracts).

  - End user (orderer) was not clearly identified or included and their requirements were not taken into account fully in the platform.
  - No time for investigation of alternative deployment approaches (public, private, limited access, fully centrally controlled).
- Inability to evaluate the opportunity cost and evaluate the inefficiency of the current process (when not using the blockchain system).
- Only digital elite is good at using data efficiently and for their benefit.
- Approaching "real life containers" different from "data containers".
- Low interoperability and data standardization between systems in industry in general.

4.5. Result distribution and presentation

During the course of the SmartLog project, the amount of companies and specialists approached has been significant. In every country, field package representatives have attended events, visited companies and held meetings initially to map the needs and prospects of companies. Their employee qualifications, hardware and software on the one hand and the visibility needs along the supply chain are required to start designing blockchain solutions. After the software development, the same companies and interested new ones were approached to invite them to test and use the solution. During Pilot 1 Demo Day, a large scale event was held in Muuga and a follow up seminar for pilot participants in Tallinn.

Besides individual approaches and seminars, conferences were attended (numerous times in the role of speaking): at the end of the project in February 2020, seminars were held in Örebro, Helsinki, Valga and Tallinn. The events in Helsinki, Valga and Örebro were targeted to smaller audience events where the project and its results were presented and larger discussions were followed amongst stakeholders. In Tallinn, the nature of the event was broader, with 180 invited participants (98 attendees).

The project process and idea were presented in the following scientific conferences:

- Research and Academic Conference "Research and Technology – Step into the Future" 2017 (Kabashkins and Gromovs, 2017);
- International Scientific Conference "Transport Problems" 2017 (Gromovs and Lammi, 2017);
- International Conference "Network and System Security" 2017 (Kabashkins, 2017);
- International Conference on Service Operations and Logistics, and Informatics SOLI 2018 (Kuhi et al., 2018).

The project results will be also published during 2020 in the form of a scientific paper. During the course of the project, students writing their final theses have approached the SmartLog team and received input to their theses. Contact has been established and various input given to 16 students from all over Europe.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Blockchain value needs still to be proven in the logistics industry.
2. Suitable blockchain technologies and distribution models are available and tested and can be used (Hyperledger Fabric or similar) today.
3. There is lack of data exchange standards, unification of messages, protocols, availability of APIs for logistics data exchange.
4. Physical event messages (transport of goods) may have higher availability, can be more easily standardized and have lower privacy requirement compared to non-physical events (transport of documents).
5. Gain in the non-physical events is complex to measure due to low process standardization but is expected to have high impact in some scenarios on both decreasing in lead time and cost (use cases where fixed time schedules are not used).
6. Use of closed and private platforms and bilateral integrations poses threat to standardization. Number of competing platforms is in increase and introduces further complexity.
7. Data privacy concerns of shared platform exist for involved parties (business secrets about).
8. Implementation and integration challenges are significant – IT development and integration, financial cost, skilled human resources, knowhow of technical solution and process design. These challenges are realistic only for big companies or consortiums.
9. Level of maturity of in-house processes and linking to external processes is low for majority of companies (poor understanding and digitalization).
10. Level of digitalization and use of technology is below average in logistics compared to other industries; low knowledge of platforms.
11. Maturity of technology (blockchain implementations) has been low but is improving quickly.
12. Interest and perceived value are above average for blockchain in the logistics industry.
13. Companies estimate that their IT maturity level will be significantly improved in the next three years.

14. Blockchain adoption is more realistic for large companies.
15. Maturity of technology is on the rise in the next three years, and early adopters are ready today (large companies). Blockchain hype phase is passed, stabilization is in progress.
16. Early standards have been created but are still subject to change and compete with other similar standards (competing technology implementations).
17. Data security concerns are relevant, though are solvable within the technology.
18. Several blockchain implementation failures have resulted where it cannot be used (context used is wide due to hype). In logistics, failure is not yet proved and therefore still feasible.
19. The main benefit expected is **speed**.
20. Both real data measurement and process simulations when using a common data sharing platform (including using blockchain) show improvement in the lead time (speed).
21. Opportunity cost is complex to measure, but is perceived high for today (due to the need to ensure process quality, additional controlling, lack of trust).
22. Speed improvement is related by using process improvement and technology together; technology usage singly has no impact.
23. Common platform approach enables traceability and trust for third parties outside of the logistics sector (finance, insurance, auditing, owner of goods) for better service and lowering costs.

RECOMMENDATIONS

24. Continued standardization is required for message exchange.
25. Development of platforms using open standards is preferred (message formats, protocols, API interfaces, blockchain technology).
26. Focusing on larger companies (both transportation operators and good owners) is required for platform development.
27. Designing a blockchain solution with security principles in mind for multiparty access, deployment and data privacy (GDPR, contractual legal aspects) is required.
28. Designing a platform as a service is expected to be used by small and midsized companies due to high investment costs (open, semi-open or private based on parties).
29. Continuation of blockchain implementation has still high expectations and value is perceived by the logistics industry and using that momentum is now.

30. Blockchain component is to be included to logistics IT systems development (using timestamping, signature and proofing for controlling and immutability on top of IT systems).

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APPENDICES

Appendix 1. SmartLog LPI survey (baseline) questionnaire

Section 1 of 6

Smartlog LPI survey

Logistics Performance Index baseline survey for Smartlog project for research purposes (by TalTech University)

Email address *

Valid email address

This form is collecting email addresses. Change settings

Company Name *

Short answer text

1.Your position in your Company

- Senior executive
- Area/Country manager
- Department manager
- Supervisor
- Operations
- Other

2. Organisation level

- Corporate/regional Headquarter
- Country Branch office
- Local Branch office
- Independent Firm/Entrepreneur

3. What is the number of employees for your company

- 1-9
- 10-49
- 50-249
- 250-400
- 500 or more

After section 1 Continue to next section

Section 2 of 6

Logistics type and area

Description (optional)

4. The freight mode you typically deal with in your work

- ◯ Marine
- ◯ Road
- ◯ Rail
- ◯ Air Transport
- ◯ Express delivery
- ◯ Multimodal

5. Direction of trade and transport you are primarily dealing with

- ◯ Export
- ◯ Import
- ◯ Export and import
- ◯ Domestic
- ◯ International transit
- ◯ Most of above

6. Main line of your work

- ◯ Full Container/Trailer leads
- ◯ Less than Full Container/Trailer leads
- ◯ Bulk/Break bulk Cargo
- ◯ Customer Tailored Logistics Solutions
- ◯ Warehousing and Distribution
- ◯ Courier Services
- ◯ Most of above

7. Which of the following geographical regions do you deal with most in your work

(choose one)

- ◯ Africa
- ◯ North Africa
- ◯ Sub-Saharan Africa
- ◯ Antarctica
- ◯ Asia
- ◯ East Asia
- ◯ North Asia

- West & Central Asia
- South & Southeast Asia
- Europe
- North & Cental America
- Caribbean Islands
- Mesoamerica
- North America
- Oceania
- South America

8. The Country you are currently working in

- Finland
- Sweden
- Norway
- Denmark
- Estonia
- Latvia
- Lithuania
- Russia
- Germany
- Poland
- Austria
- Italy
- France
- Netherlads
- Great Britain
- United States
- China

9. City/Area of your Facility

Short answer text

After section 2 Continue to next section

Section 3 of 6

Logistics environment assessment

Countries

10. Rate the efficency of the clearance process

i.e speed, simplicity and predictability of formalities by border control agencies, including Customs in

	Very low	Low	Average	High	Very high
Finland					
Sweden					
Norway					
Denmark					
Estonia					
Latvia					
Lithuania					
Russia					
Germany					
Poland					
Austria					
Italy					
France					
Netherlads					
Great Britain					
United States					
China					

11. Evaluate the quality of trade and transport related infrastructure

e.g ports, railroads, roads, information techology in

	Very low	Low	Average	High	Very high
Finland					
Sweden					
Norway					
Denmark					
Estonia					
Latvia					
Lithuania					
Russia					
Germany					
Poland					
Austria					
Italy					

France	○	○	○	○	○
Netherlads	○	○	○	○	○
Great Britain	○	○	○	○	○
United States	○	○	○	○	○
China	○	○	○	○	○

12. Assess the ease of arranging competitively price shipments to

	Very difficult	Difficult	Average	Easy	Very easy
Finland	○	○	○	○	○
Sweden	○	○	○	○	○
Norway	○	○	○	○	○
Denmark	○	○	○	○	○
Estonia	○	○	○	○	○
Latvia	○	○	○	○	○
Lithuania	○	○	○	○	○
Russian Federa...	○	○	○	○	○
Germany	○	○	○	○	○
Poland	○	○	○	○	○
Austria	○	○	○	○	○
Italy	○	○	○	○	○
France	○	○	○	○	○
Netherlands	○	○	○	○	○
United Kingdom	○	○	○	○	○
United States	○	○	○	○	○
China	○	○	○	○	○

13. Evaluate the overall level of competence and quality of logistics services

e.g. transport operators, customs brokers

	Very low	Low	Average	High	Very high
Finland	○	○	○	○	○
Sweden	○	○	○	○	○
Norway	○	○	○	○	○
Denmark	○	○	○	○	○
Estonia	○	○	○	○	○
Latvia	○	○	○	○	○
Lithuania	○	○	○	○	○

Russian Federa...					
Germany					
Poland					
Austria					
Italy					
France					
Netherlands					
United Kingdom					
United States					
China					

14. Rate the ability to track and trace your consignments when shippint to...

	Very low	Low	Average	High	Very high
Finland					
Sweden					
Norway					
Denmark					
Estonia					
Latvia					
Lithuania					
Russian Federa...					
Germany					
Poland					
Austria					
Italy					
France					
Netherlands					
United Kingdom					
United States					
China					

15. When arranging shipments to the countries listed below, how often do they reach the consignee within the scheduled or expected delivery time?

	Hardly ever	Rarely	Sometimes	Often	Nearly always
Finland					
Sweden					

Norway					
Denmark					
Estonia					
Latvia					
Lithuania					
Russian Federa...					
Germany					
Poland					
Austria					
Italy					
France					
Netherlands					
United Kingdom					
United States					
China					

16. How often do shippers ask for environmentally friendly options

e.g. in view of emission levels, choice of routes, vehicles, schedules, tc. When shipping to

	Hardly ever	Rarely	Sometimes	Often	Nearly always
Finland					
Sweden					
Norway					
Denmark					
Estonia					
Latvia					
Lithuania					
Russian Federa...					
Germany					
Poland					
Austria					
Italy					
France					
Netherlands					
United Kingdom					
United States					
China					

After section 3 Continue to next section

Section 4 of 6

Logistics environment assessment

Infrastructure, services, processes in your country of work

17. Based on your experience in international logistics please select the options that best describe the operational logistics environment in your country of work

	Very low	Low	Average	High	Very high
Port charges	○	○	○	○	○
Airport charges	○	○	○	○	○
Road transport ...	○	○	○	○	○
Rail transport r...	○	○	○	○	○
Warehousing/tr...	○	○	○	○	○
Agent fees	○	○	○	○	○

18. Evaluate the quality of trade and transport related infrastructure

e,g ports, roads, airports, information technologu in your country of work

	Very low	Low	Average	High	Very high
Port infrastruct...	○	○	○	○	○
Airport infrastr...	○	○	○	○	○
Road infrastruc...	○	○	○	○	○
Rail infrastruct...	○	○	○	○	○
Warehousing/tr...	○	○	○	○	○
Telecommunic...	○	○	○	○	○

19. Evaluate the competence and quality of service delivered by the following in your country of work

	Very low	Low	Average	High	Very high
Road transport ...	○	○	○	○	○
Rail transport s...	○	○	○	○	○
Air transport se...	○	○	○	○	○
Maritime trans...	○	○	○	○	○
Warehousing/tr...	○	○	○	○	○
Freight forward...	○	○	○	○	○
Customs agenc...	○	○	○	○	○
Quality/standar...	○	○	○	○	○

Customs brokers	○	○	○	○	○
Trade and trans...	○	○	○	○	○
Consignees or ...	○	○	○	○	○

20. Evaluate the efficency of the following processes in your country of work

	Hardly ever	Rarely	Sometimes	Often	Nearly always
Are import ship...	○	○	○	○	○
Are export ship...	○	○	○	○	○
Is the Customs ...	○	○	○	○	○
Is the clearance...	○	○	○	○	○
Do you receive ...	○	○	○	○	○
Do traders dem...	○	○	○	○	○

21. In your country of work, how often do you experience

	Nearly always	Often	Sometimes	Rarely	Hardly ever
Major delays d...	○	○	○	○	○
Major delays d...	○	○	○	○	○
Major delays d...	○	○	○	○	○
Criminal activiti...	○	○	○	○	○
Solicitation of i...	○	○	○	○	○

22. Since 2017, have the following factors improved or worsened in your country of work

	Much worsened	Worsened	About the same	Improved	Much Improved
Customs cleara...	○	○	○	○	○
Other border-rel...	○	○	○	○	○
Quality of trade...	○	○	○	○	○
Quality of telec...	○	○	○	○	○
Quality of prova...	○	○	○	○	○
Regulation relat...	○	○	○	○	○
Solicitation of i...	○	○	○	○	○

23. Since 2017, please assess the following developments in your country of work

	Much decreased	Decreased	About the same	Increased	Much Increased
The demand fo...	○	○	○	○	○
Increased use o...	○	○	○	○	○
Cybersecurity t...	○	○	○	○	○

Our Firm's prep...

After section 4 Continue to next section

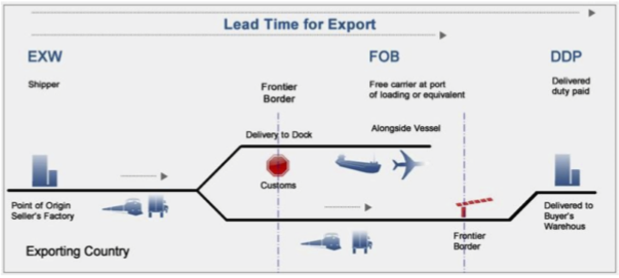
Section 5 of 6

Logistics metrics assessments

Description (optional)

24. When exporting a full load from your country of work, please estimate the following distance and time parameters

Please select from below the portion of the supply chain that best describes your work



◯ TO PORT/AIRPORT -- Export pre-carriage: EXW toF OB

◯ BY LAND - - Export carriage: EXW to DDP

◯ BOTH

24.Distance (km)

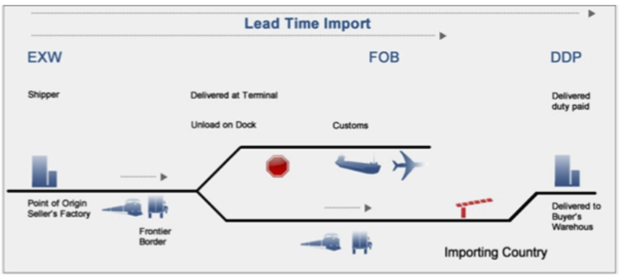
Short answer text

25.Time (h)

Short answer text

25. When importing a full load to your country of work, please estimate the following distance and time parameters

Please select from below the portion of the supply chain that best describes your work



◯ FROM PORT/AIRPORT -- Import on-carriage:DAT to DDP

◯ BY LAND - - Import carriage: EXW to DDP

◯ BOTH

25.Distance (km)

Short answer text

25.Time (h)

Short answer text

After section 5 Continue to next section

Section 6 of 6

Untitled Section

Description (optional)

26. As a logistics provider, do you maintain indicators of service level to client? If yes, what is the percentage of imports to your country of work meeting your quality criteria for delivery to the consignee

1. 0%
2. 10%
3. 20%
4. 30%
5. 40%
6. 50%
7. 60%
8. 70%
9. 80%
10. 90%
11. 100%

27. How many government agencies involved in the clearance process do you typically deal with in your country of work

	0	1	2	3	4	5	6	7	8	9	10+
For im...	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯
For ex...	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

28. How many forms do you typically have to submit, for clearance, in your country of work

	0	1	2	3	4	5	6	7	8	9	10+
For im...	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

For ex...	○	○	○	○	○	○	○	○	○	○	○

29. For imports estimate the average time taken between the submission of an accepted Customs declaration and notification of clearance in your country of work

	2h	4h	8h	12h	1 day	2 days	3 days	4 days	5 days	7 days	10 days
Witho...	○	○	○	○	○	○	○	○	○	○	○
with p...	○	○	○	○	○	○	○	○	○	○	○

30. What are the main methods for determining whether shipments are physically inspected in Customs

	Yes	No	N/A	Do not know
Automated risk ass...	○	○	○	○
Inspector discretion	○	○	○	○

31. On average what percentage of your import shipments is physically inspected (excluding x-ray and scanning) in your country of work

1. 0%
2. 10%
3. 20%
4. 30%
5. 40%
6. 50%
7. 60%
8. 70%
9. 80%
10. 90%
11. 100%

32. Of all the import shipments what percentage are physically inspected more than once in your country of work

1. 0%
2. 10%
3. 20%
4. 30%
5. 40%
6. 50%
7. 60%
8. 70%
9. 80%

10. 90%

11. 100%

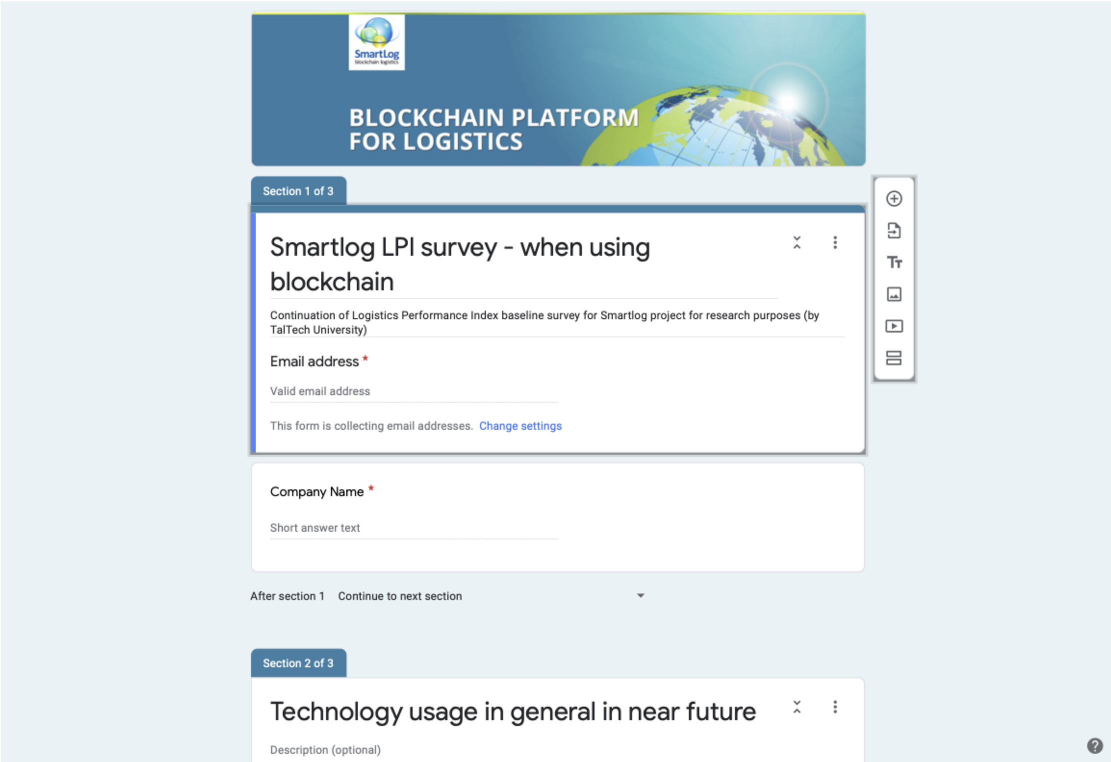
33. Please evaluate the following statements regarding Customs, in your country of work

	Yes	No	N/A	Do not know
Can Customs decla...	○	○	○	○
Does Customs cod...	○	○	○	○
Are you or your cus...	○	○	○	○
Can goods be relea...	○	○	○	○

34. Telecommunication/IT system methods used in regular bases for managing order-delivery

- [ ] Surface mail/telephone/fax
- [ ] Email
- [ ] Web based portl, internet marketplace
- [ ] Intranet/extranet
- [ ] EDI
- [ ] Barcodes
- [ ] RFID
- [ ] ERP systems
- [ ] Other...

Appendix 2. SmartLog extended survey (blockchain) questionnaire



SmartLog

BLOCKCHAIN PLATFORM FOR LOGISTICS

Section 1 of 3

Smartlog LPI survey - when using blockchain

Continuation of Logistics Performance Index baseline survey for Smartlog project for research purposes (by TalTech University)

Email address *

Valid email address

This form is collecting email addresses. Change settings

Company Name *

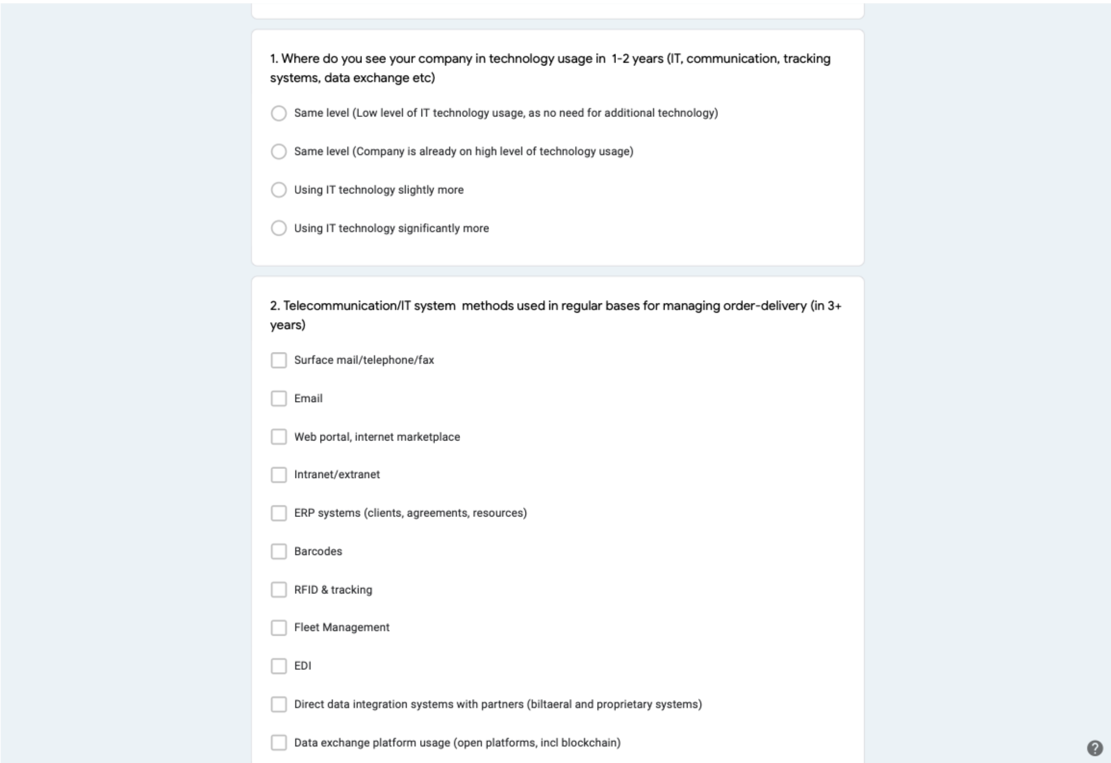
Short answer text

After section 1 Continue to next section

Section 2 of 3

Technology usage in general in near future

Description (optional)



1. Where do you see your company in technology usage in 1-2 years (IT, communication, tracking systems, data exchange etc)

- Same level (Low level of IT technology usage, as no need for additional technology)
- Same level (Company is already on high level of technology usage)
- Using IT technology slightly more
- Using IT technology significantly more

2. Telecommunication/IT system methods used in regular bases for managing order-delivery (in 3+ years)

- Surface mail/telephone/fax
- Email
- Web portal, internet marketplace
- Intranet/extranet
- ERP systems (clients, agreements, resources)
- Barcodes
- RFID & tracking
- Fleet Management
- EDI
- Direct data integration systems with partners (biltaeral and proprietary systems)
- Data exchange platform usage (open platforms, incl blockchain)

☐ Other...

After section 2 Continue to next section

Section 3 of 3

Blockchain usage

Description (optional)

3. Do you see the benefits of blockchain to your company in short run (1-2 years)

○ Yes

○ No

○ Maybe

4. Do you see the benefits of blockchain to your company in long (3+ years)

○ Yes

○ No

○ Maybe

5. If you see blockchain beneficial for company, when are you planning to join some logistics blockchain platform (year)

Short answer text

6. Do you see blockchain (or other proofing data exchange) to be open for anyone to join or closed for only between dedicated partners.

○ Open platform with standardised interface (but includes access security limitations)

○ Closed platform to enable partner specific intgrations and additional features and security

7. What are the main expected benefits from blockchain platform.

☐ Proof of works from independent source

☐ Trustability

☐ Transparency and Traceability

☐ Cost efficency (quicker decision making, less data duplication etc)

☐ Speeding up the process

☐ Increase of competitiveness

☐ Other

Please comment selected benefits (how much)

Long answer text

Appendix 3. Software development steps

1. SmartLog admin client

Admin Client is used to maintenance the SmartLog-network. Its main purpose is to edit channel configurations, create new organizations and generate configurations and certificates for Client. It uses fabric-java-sdk with some of our own modifications to talk with the Hyperledger Fabric instance. Without the Admin Client we would need to use the underlying binaries straight from the terminal to generate the configurations and certificates, so Admin Client abstracts and automates a lot of the maintenance processes and enables those to be fully automated in upcoming versions.

CONFIGURATION

Admin Client's configuration can be altered from AdminClientConfig.java that can be found from fabric-java-sdk. Configtxlator configurations are separated from the AdminClientConfig into its own class called ConfigtxlatorConfiguration. Base url for the configtxlator can be changed by giving the -Dconfigtxlator.baseurl application parameter.

AUTHENTICATION AND ACCESS MANAGEMENT

Admin Client is secured using username and password and it can only be accessed from Propentus intra. Access management is handled in SecurityInterceptor and authentication actions like login and logout can be found from AuthController. SecurityInterceptor checks if user has signed in and if not, user gets redirected to login view. SecurityInterceptor is called in every request so user must always be authenticated when doing anything with the Admin Client (Figure 66).

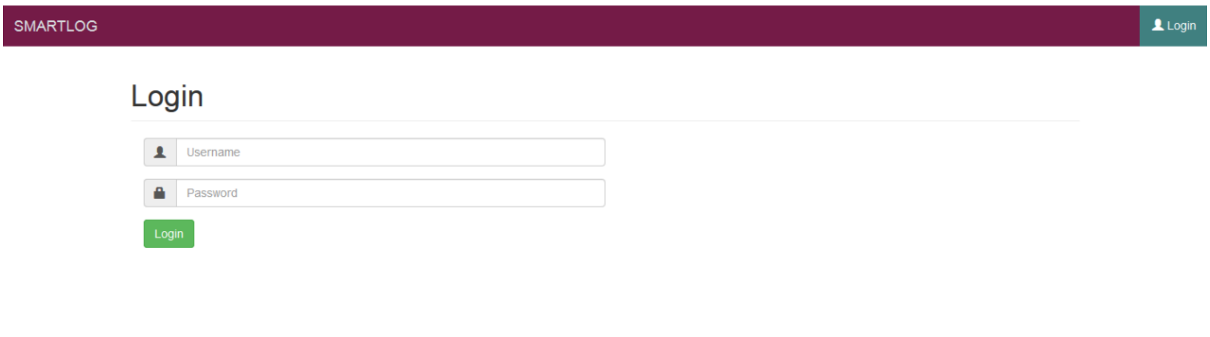


Figure 66. SmartLog software solution authentication view

OVERVIEW OF THE NETWORK STATUS

Overview page shows some basic information about the network. All of the information gets asynchronously loaded after the page has loaded. New information can be added to _dashboardInfos.gsp-template (Figure 67).

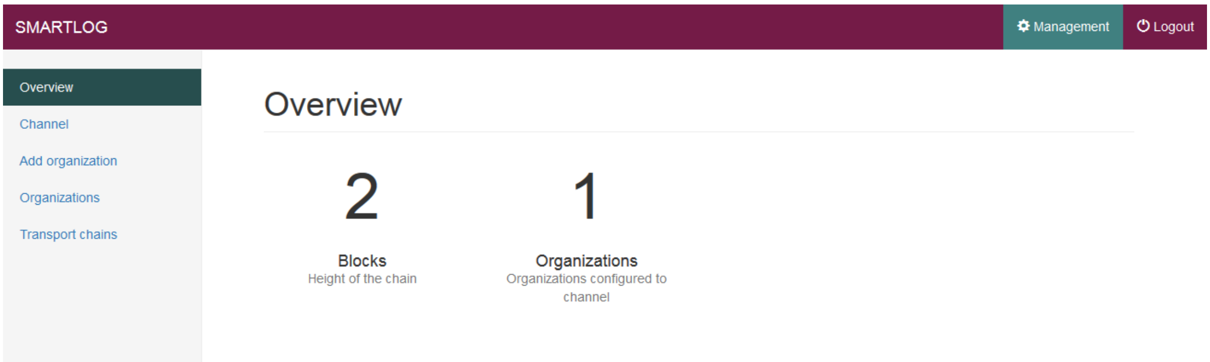


Figure 67. SmartLog software solution dashboard view

CHANNEL

Channel view shows if the admin organization signing policy is enabled in channel, for the debugging purposes it also shows the channel's configuration block in JSON format and at the bottom it is shown if Admin Cryptography is added to blockchain (Figure 68).

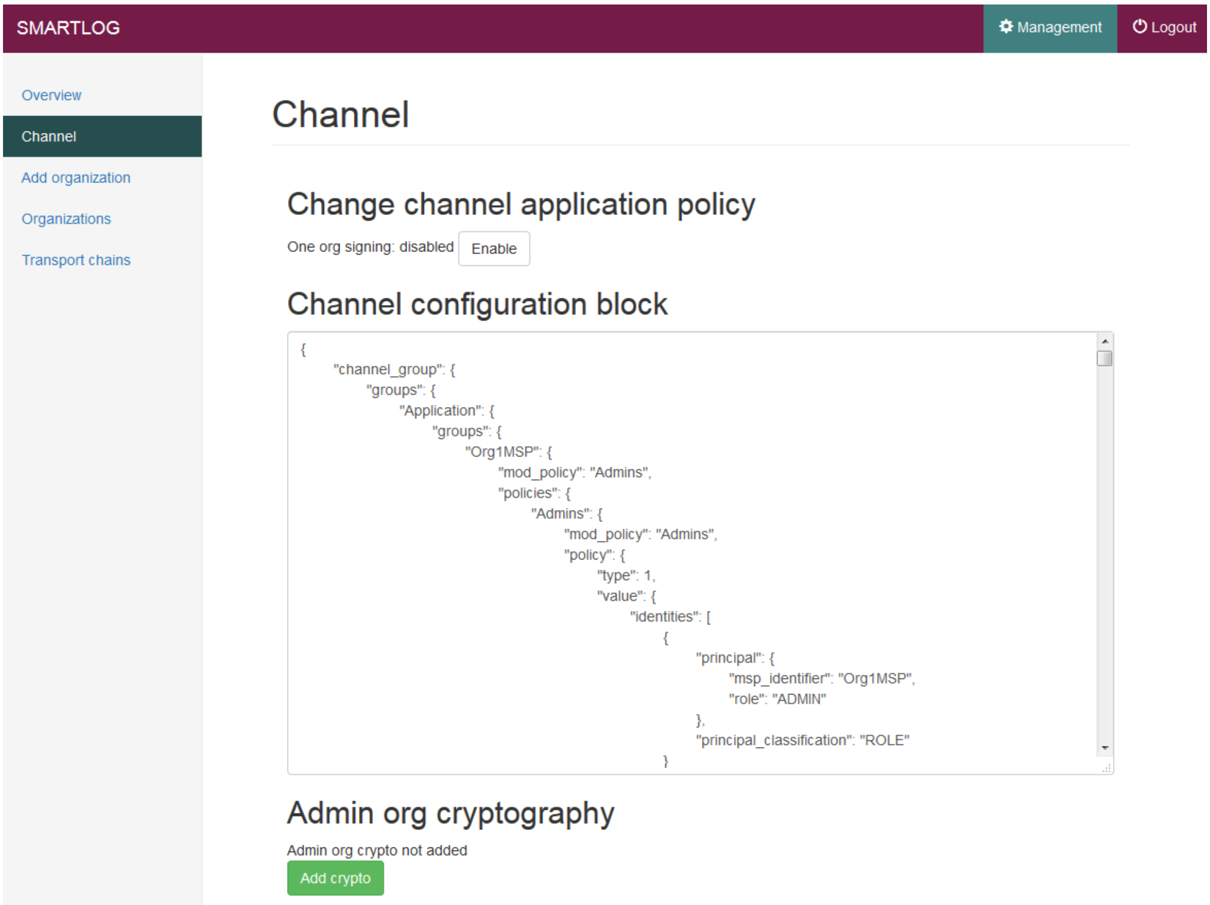


Figure 68. SmartLog software solution channel view

ADD NEW ORGANIZATION

With this form, we can add new organization to channel and generate configurations and certificates for the organization and its Client (Figure 69).

Form has some validations:

- No empty values (Every input is required)
- No duplicate MSP values (if organization with that MSP is already configured to channel)

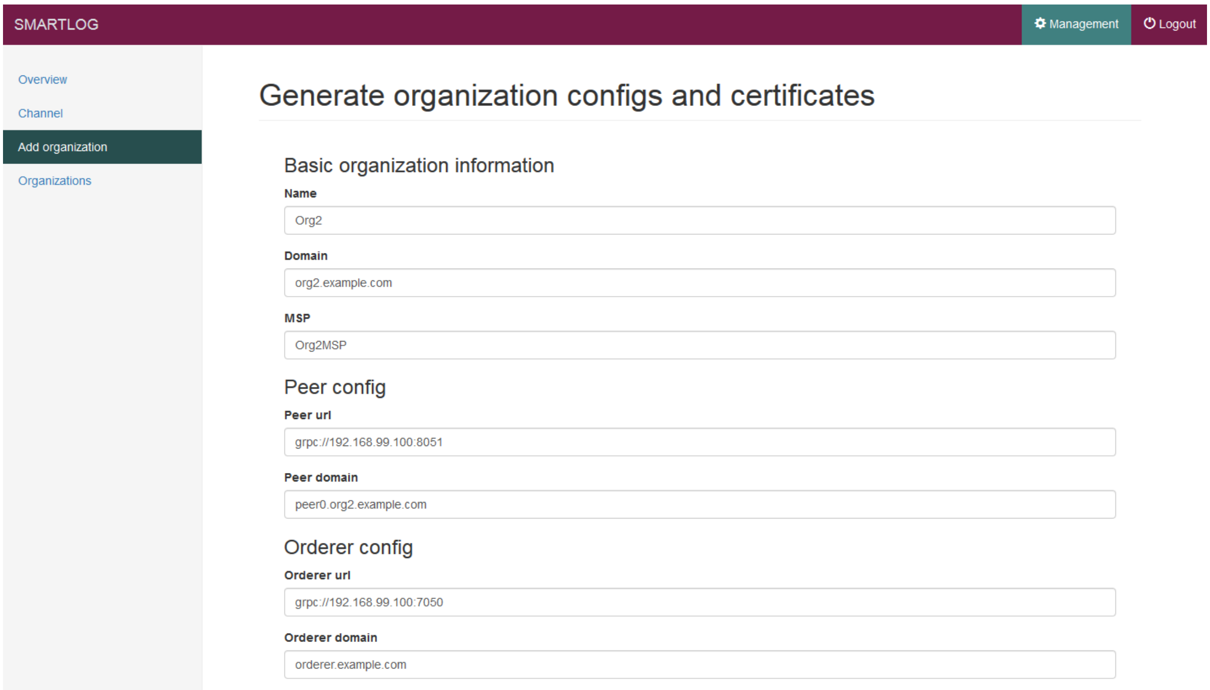


Figure 69. SmartLog software solution adding organisation view

- Name of the organization can be anything, but maybe registering organization name is good one
- Domain is the main domain of the organization, for example SmartLog.propentus.com
- MSP always ends with "MSP", used to identify different organizations in Hyperledger network. ex. PropentusMSP. When creating MSP use organizationname + MSP
- Peer url needs to be grpc-protocol. This is the IP of the server that customer is going to install. Needs to be static. Ex. grpc://10.170.6.133:7051 port number is always 7051
- Peer domain is peerX.domain where X is number from 0 to anything and domain is the organizations domain, but in these cases, you can use number 0. Ex. peer0.SmartLog.propentus.com

- Orderer is always the same for every organization. You can check from organization page an example, just open propentus.projectSmartLog.com organization accordion and see the client config for example.
- Select ENDORSEMENT as peerType

LIST OF CONFIGURATION AND CERTIFICATE THAT ARE GENERATED AND SAVED TO DISK

- config.json
- Configuration for Client
- configtx.yaml
- Used to generate new organization JSON using configtxgen which is appended to channel config.
- crypto-config.yaml
- Used to generate certificates for that organization using cryptogen
- new organization JSON (ex. Org2.json)
- crypto-config
- contains all the certificates for the organization (Admin certificates, CA-certificates...)
- messaging certificates
- can be found under /crypto-config/ and contains private.key and public.key

LIST OF ORGANIZATIONS

Shows list of organizations and client configurations. Configs and certificates can be downloaded using the "Download configs"-button. Also shows if that organization is configured to channel (Figure 70).

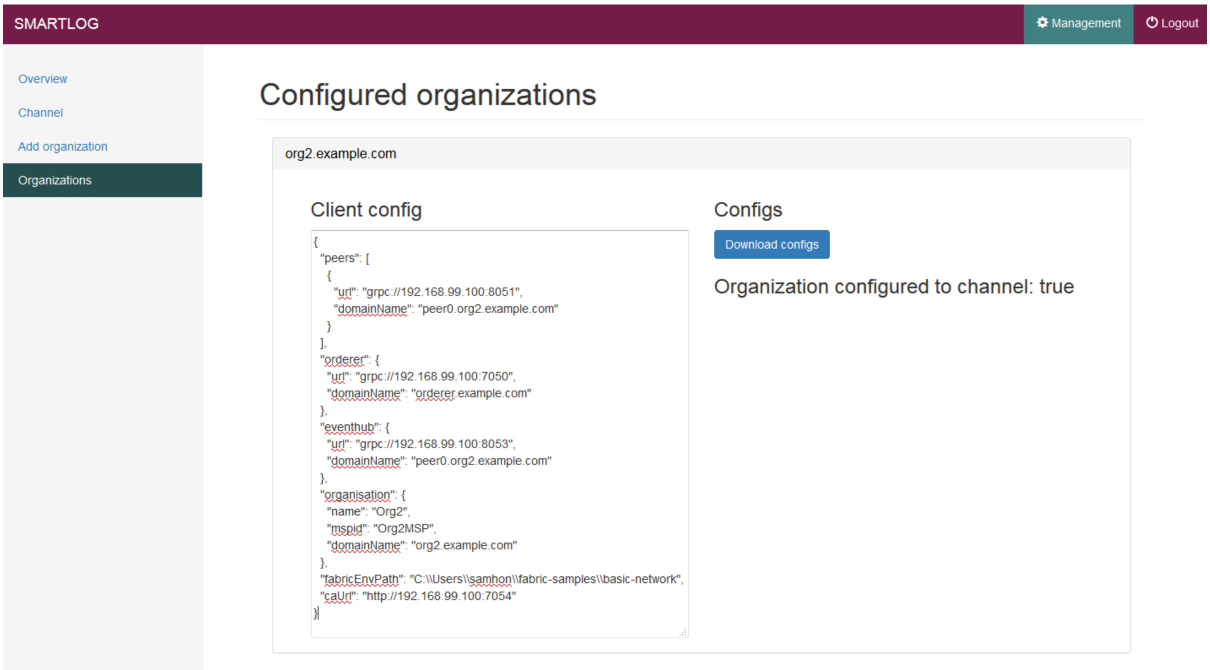


Figure 70. SmartLog software solution configuration of organisation view

TRANSPORTATION CHAINS

This view is used to manage transportation chains in the network. Organizations can be added to the "Add new chain" -form by clicking the organization on the right. Chains can be easily edited by clicking the wanted chain from the "Chains" list. It automatically inserts the name and chain to the "Edit / remove chains" form. Now the removing of the chain is not implemented (Figure 71).

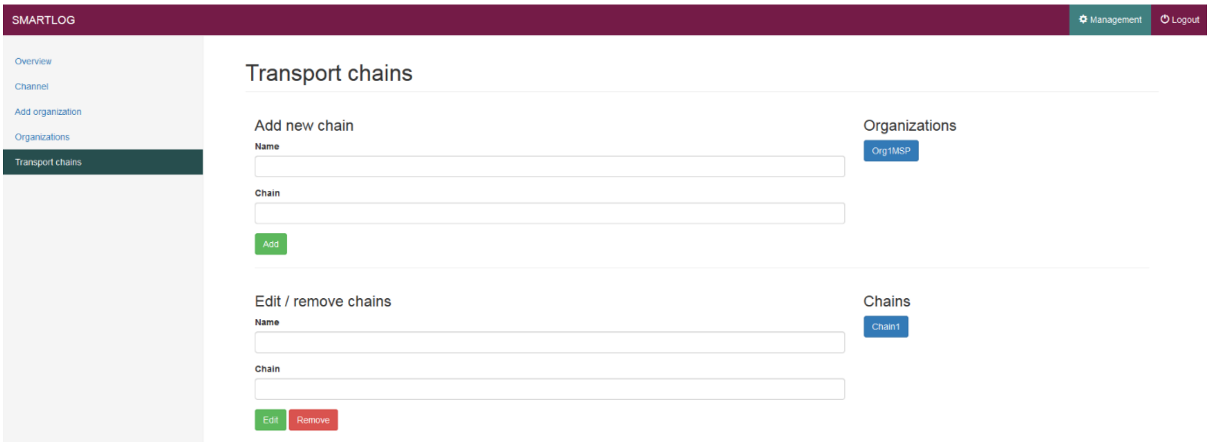


Figure 71. SmartLog software solution transportation chain view

API USERS

API users are used when Client is in CLOUD-mode. User gets recognized from the authentication and the user-context is set as that organization. When ApiUser is created, client certificate gets generated for it using ApiCertificateGenerator and openssl. When deleting ApiUser, client certificate gets automatically revoked using openssl. If CRL (Certificate Revocation List) is not found from the configured path, it gets created (Figure 72).

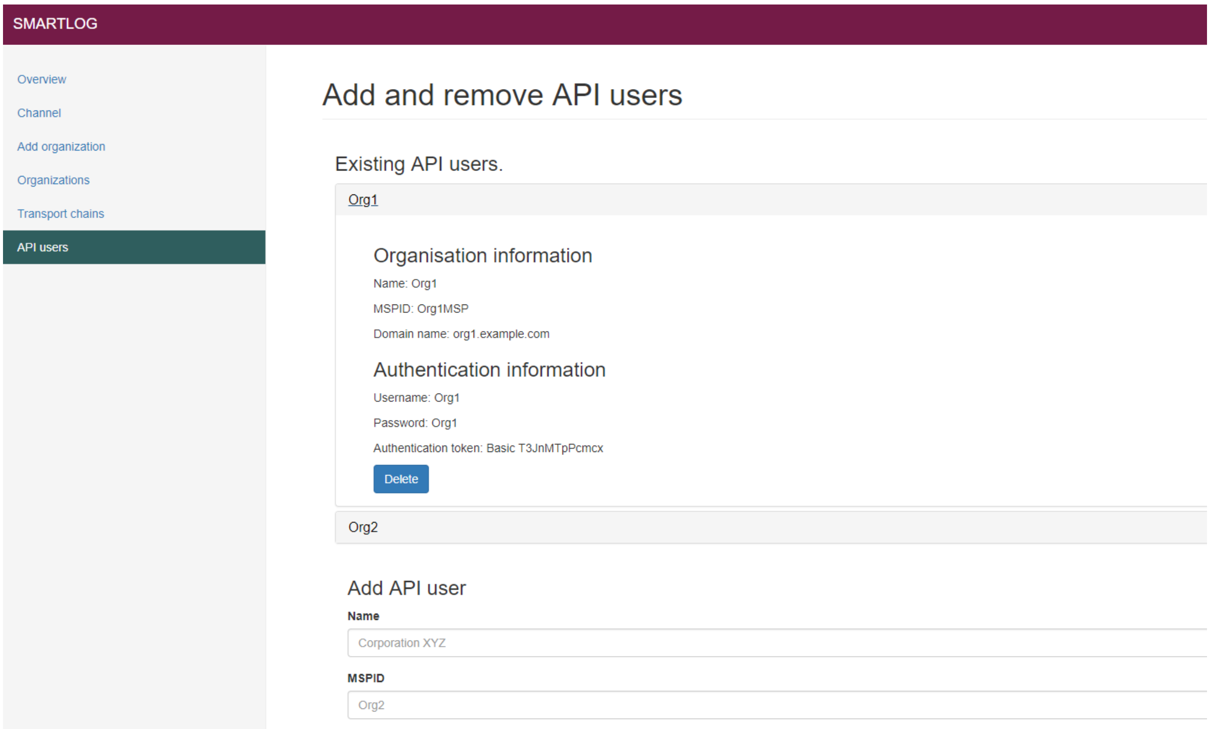


Figure 72. SmartLog software solution API users configurations view

ADDING NEW API USER

If you need to add new API User, this is how to fill those parameters:

- Name: can be anything, but use organization name if possible
- MSPID: Organization's MSP
- Domain name: must be the same as organization's domain, check from organizations-page.
- Basic authentication username: can be anything, but use something that relates to the organization for example Propentus, Vedia etc.
- Basic authentication password: Use only basic characters Aa09 and minimum length 16.
- When you have given those parameters, click Generate token and wait for the response to show in input.
- Then when everything is filled, check those values again.
- If everything is OK, press save, and it should start creating certificates for user.

2. SmartLog client console

Client console can be used to read UBL-messages which are in the blockchain. If client type is NORMAL or ENDORSEMENT, console automatically shows the messages for that local organization. Otherwise if client type is CLOUD it gets the organization information from the authentication that is done when accessing the console.

Console uses ConsoleController where it serves the API's to load messages and authenticate to console. ConsoleInterceptor checks if connection to blockchain is valid and if user has authenticated properly in CLOUD-mode.

CONSOLE AUTHENTICATION IN CLOUD MODE

Login credentials are configured in Admin client's "API users" -page. When login credentials are correct, user gets redirected to the console but if credentials are incorrect, user gets redirected back to login-screen with an error message. If session expires for the user, user gets redirected to the login page with error message (Figure 73).

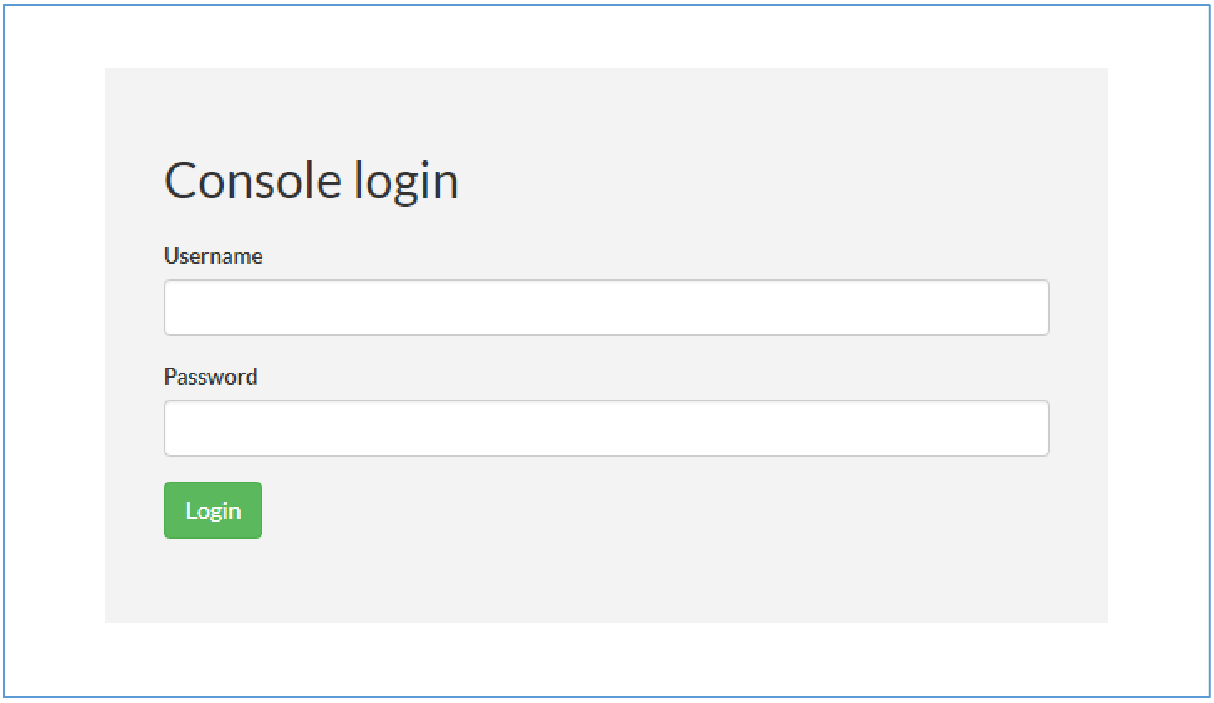


Figure 73. SmartLog software solution console login view

CONSOLE

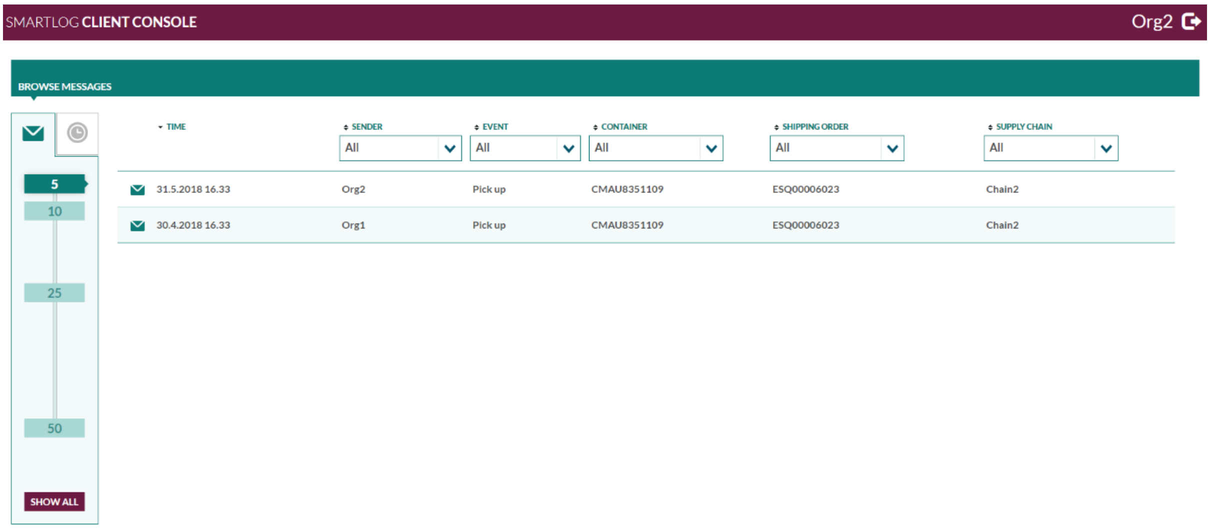


Figure 74. SmartLog software solution console view

Message list shows all the messages that current organization is participant in. Default filters for the table is (Figure 74):

- 5 messages
- No time filters
- Time desc

Messages can be sorted using the titles in table header and filtered using the selects in table header. Filters and sorting are saved in cookie, so even if you refresh your page, same messages are shown (Figure 75).

CREATING A NEW MESSAGE FROM CONSOLE

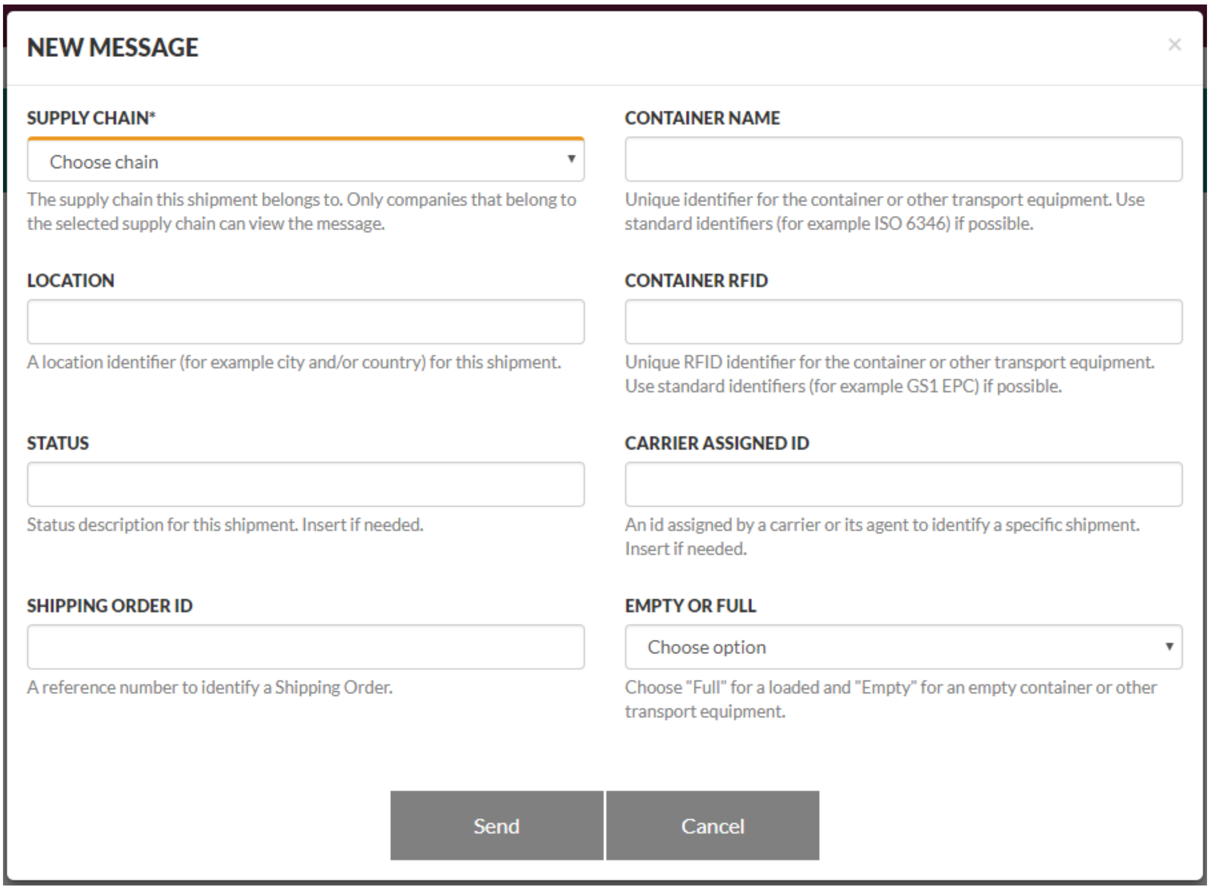


Figure 75. SmartLog software solution creating new message ion console view

When creating a new message through console the user has 8 fields to fill in manually:

- Supply chain
- Container name
- Location
- Container RFID
- Status
- Carrier assigned ID
- Shipping order ID
- Empty or full

Only the supply chain field is mandatory right now, so it's optional to input any additional information. The send button remains disabled until a supply chain is chosen. Each field has a short instruction text under them to clarify what kind of information it should contain. There are also some invisible fields that are filled automatically when the message is sent:

- Sender party
- Document ID
- Timestamp

3. Setup development environment (WIP)

DOWNLOAD AND INSTALL IDE SUPPORTING GRAILS 3

Install your preferred IDE that supports version 3 of Grails framework. We recommend IntelliJ, since it has full support for the framework and this documentation is made based on experience with it.

DOWNLOAD AND INSTALL NEWEST JAVA 8 JDK

Version 8 of Java JDK (2020) is recommended since so far the project has been developed using it. However newer versions should also be fine but they haven't been tested.

CLONE PROJECTS FROM GITLAB

You can clone projects from GitLab using the IntelliJ Git-integration or running Git-commands straight from the command line.

Projects needed:

- SmartLog-client
- SmartLog-admin
- SmartLog-chaincodes

ADD CLIENT AND ADMIN-CLIENT TO INTELLIJ

Open IntelliJ and select File → Module from existing sources. Search the directory where you cloned the projects and select the main-directory for example SmartLog-admin. Next IntelliJ asks what build tool do you want to use. Grails 3 uses Gradle so select that. In the next screen, IntelliJ asks some settings for the Gradle but you don't need to worry about those, just click "Finish" and Gradle should start building the project. This process should be similar with any other IDE that supports Grails.

DOWNLOAD AND INSTALL HYPERLEDGER 1.2

Step 1: Install Docker and other extras

If you are using Windows older than 10, install Docker Toolbox. If you are using Windows 10, install Docker Community Edition

MacOSX, *nix, or Windows 10: Docker Docker version 17.06.2-ce or greater is required.

Older versions of Windows: Docker Toolbox - again, Docker version Docker 17.06.2-ce or greater is required

No need to do things that need Node.js or Python, because we are not using Node.js-SDK.

Step 2: Get fabric-samples -project and platform specific binaries

Remember to change the version in curl command to 1.2.0 instead of 1.2.1. SmartLog has been developed and tested on version 1.2.0 so even thought it should work on newer versions, it is not guaranteed.

Step 3: Get the orderer up and running

When you have downloaded the fabric-samples from GitHub, you are ready to set the environment up. Go to fabric-samples/basic-network directory and write to your shell: "docker-compose -f docker-compose.yml up -d orderer.example.com", this will launch orderer in the background. If you want to leave orderer running in a window for troubleshooting etc. just remove the "-d" flag from the command.

Step 4: Set up admin client

Create directory "C:/etc/fabric-admin/" and copy crypto-config folder from "/fabric-samples/basic-network" to it.

Copy templates-folder from your SmartLog-admin git-folder to fabric-admin.

Create config.json under fabric-admin and copy this code block's content to it:

```
{
  "peers": [
    {
      "url": "grpc://localhost:7051",
      "domainName": "peer0.org1.example.com"
    }
  ],
  "orderer": {
    "url": "grpc://localhost:7050",
    "domainName": "orderer.example.com"
  },
  "eventhub": {
```

```
    "url": "grpc://localhost:7053",
    "domainName": "peer0.org1.example.com"
  },
  "organisation": {
    "name": "peerOrg1",
    "mspid": "Org1MSP",
    "domainName": "org1.example.com"
  },
  "fabricEnvPath": "C:/etc/fabric-admin/",
  "caUrl": "http://localhost:7054",
  "peerType": "NORMAL",
  "channel": "mychannel",
  "couchDbUrl": "http://localhost:5984",
  "privateKeyPath": "C:/etc/fabric-admin/crypto-config/private.key",
  "publicKeyPath": "C:/etc/fabric-admin/crypto-config/public.key",
  "couchDbUsername": "test",
  "couchDbPassword": "test",
  "cloudKeyPath": "C:/etc/fabric-admin/generated"
}
```

Step 5: Make sure that the version is 1.2.0 and, if not, change it

Make sure the version in working directory to 1.2.0.

Step 6: Edit grails configurations

And the last thing you need to do is to edit grails (Figures 76-77) configurations for the apps you are about to run (SmartLog-admin and SmartLog-client).

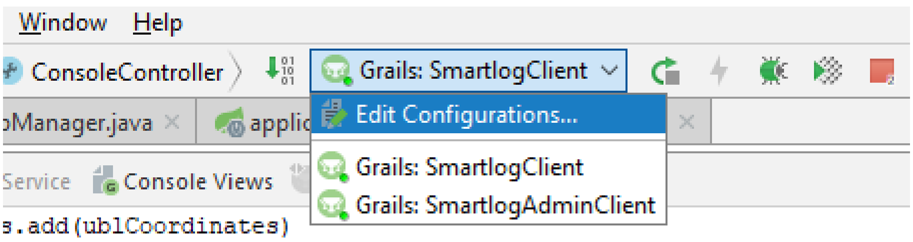


Figure 76. SmartLog software solution editing grail configuration view

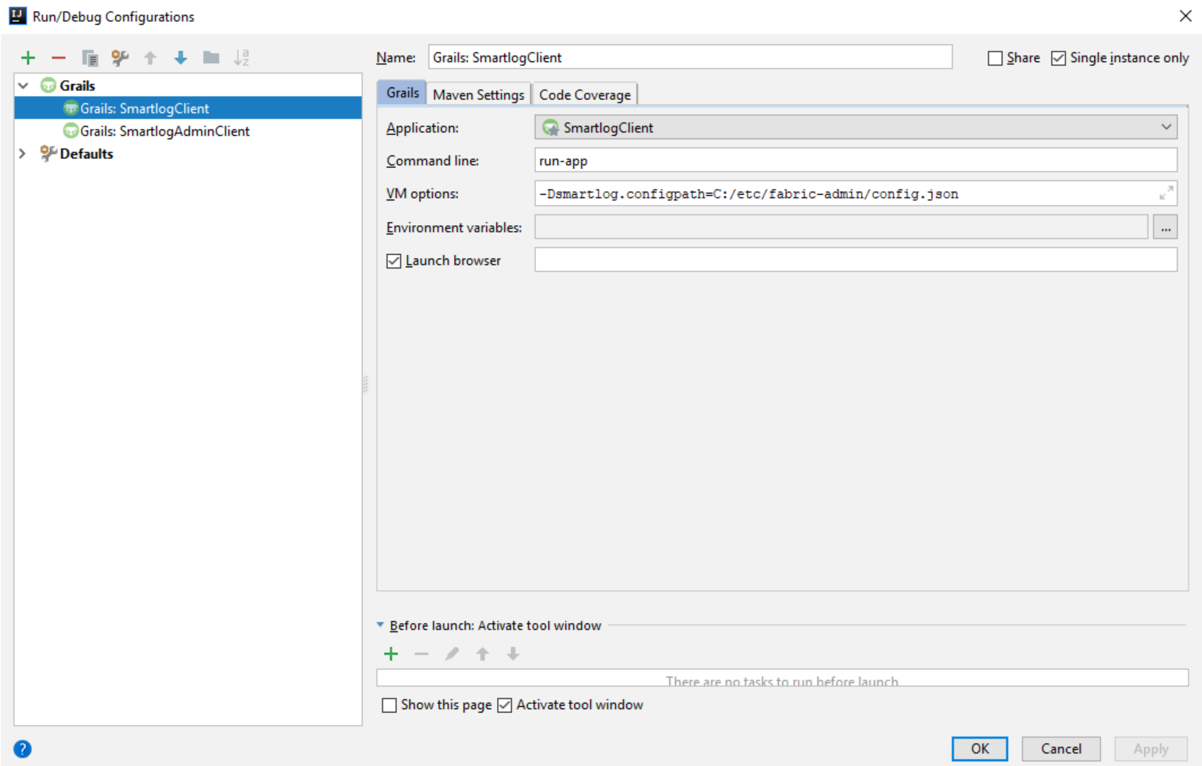


Figure 77. SmartLog software solution configuration options view

Add path to config as an application parameter: -DSmartLog.configpath=C:/etc/fabric-admin/config.json

Now when you run the applications, your specified config path gets used rather than the default one. (/etc/fabric-admin/config.json)

Step 7: Extract the fabric-admin package

Extract the fabric-admin.zip package directly to you C:/ drive.

Step 8: Launch the SmartLog client

Launch the client from you IDE. Launching will take a while because it will automatically set up the network first. Once the network is set up a dashboard should open in a browser. First three tows should show a check mark on a green background and the last one should be cross on a red background. This means that everything is going fine so far.

Step 9: Launch the admin client

Launch the admin client just like client was launched in the previous step. Browser should open showing a login page. Default login credentials can be found in AdminCleintConfig.class file and they should be changed as soon as possible.

Step 10: Configure the channel and add TestChain

From channel tab enable one org signing and add admin org crypto as shown in the picture below (Figure 78).

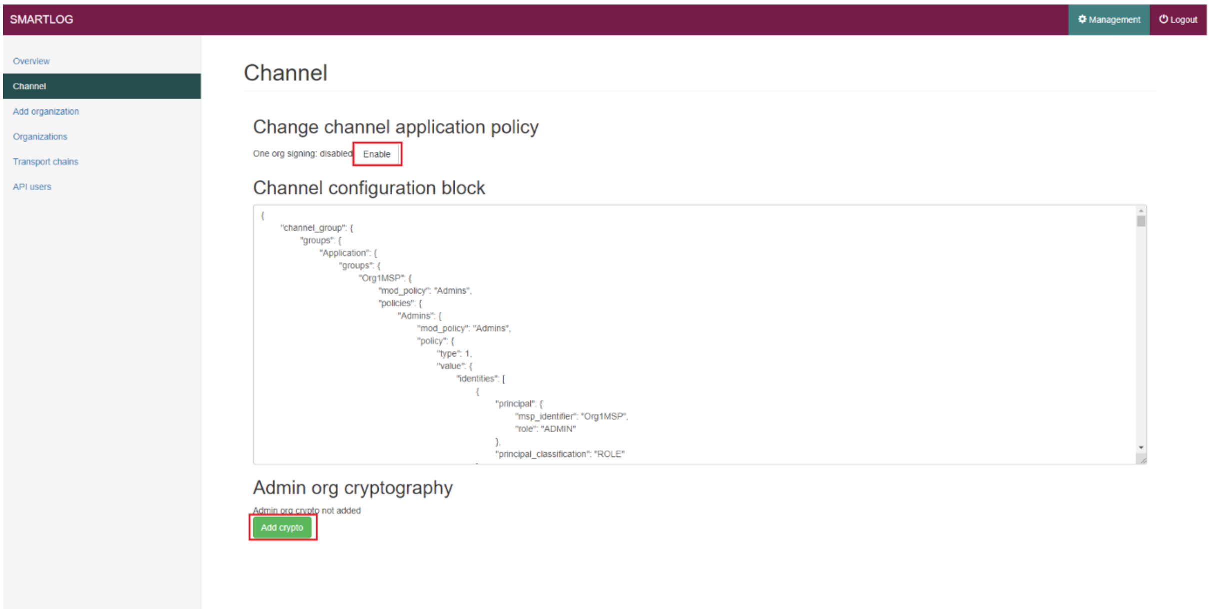


Figure 78. SmartLog software solution channel configuration view

If previous actions were completed successfully, change to transport chains tab and add a new transport chain called testChain and include organization in use to that chain as shown in the image below. testChain is used to check the connection to blockchain in the dashboard so after adding this transport chain, dashboard should show green check marks on all four rows. If any of those health checks still fail, something went wrong in the install process (Figure 79).

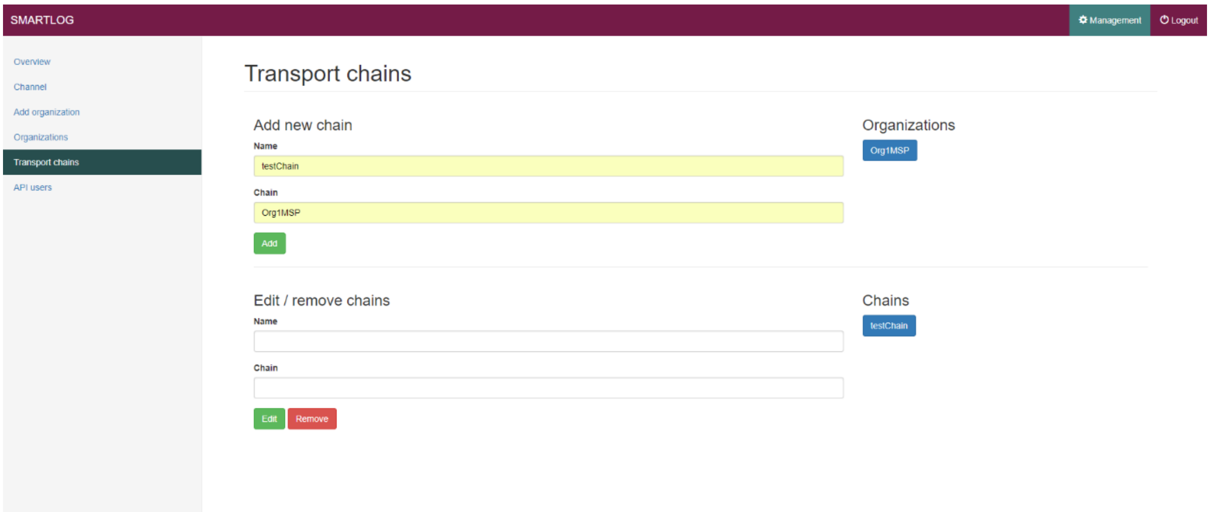


Figure 79. SmartLog software solution transport chain configuration view

When running start.sh, docker-compose fails with error: Driver failed programming external connectivity on endpoint

If this happens, just restart Docker and it should work.

Appendix 4. SmartLog supply chain corridor analysis

1. Kouvola-Muuga, Kouvola-Šestokai

OVERVIEW

Start event(s)	New transportation need
End event(s)	Delivered to Rotterdam
Input	Container
Output	Container
Assigned processes	Kouvola-Muuga Muuga CT-Šestokai

MODEL GRAPHIC

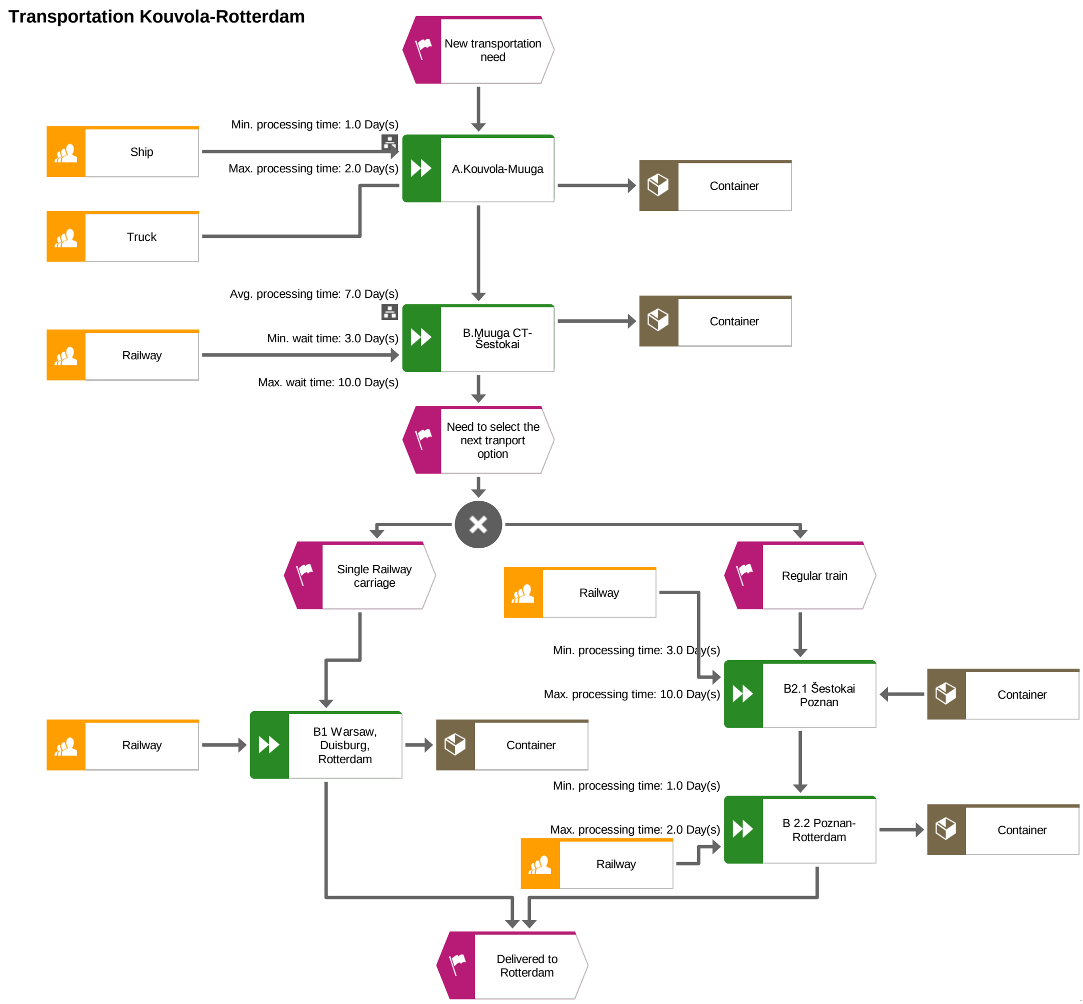


Figure 80. SmartLog transportation corridor process map for Kuovola-Rotterdam

2. Kouvola-Helsinki

OVERVIEW

Start event(s)	New transportation need
End event(s)	Delivered to Rotterdam
Output	Container
Assigned processes	Kouvola-Helsinki

MODEL GRAPHIC

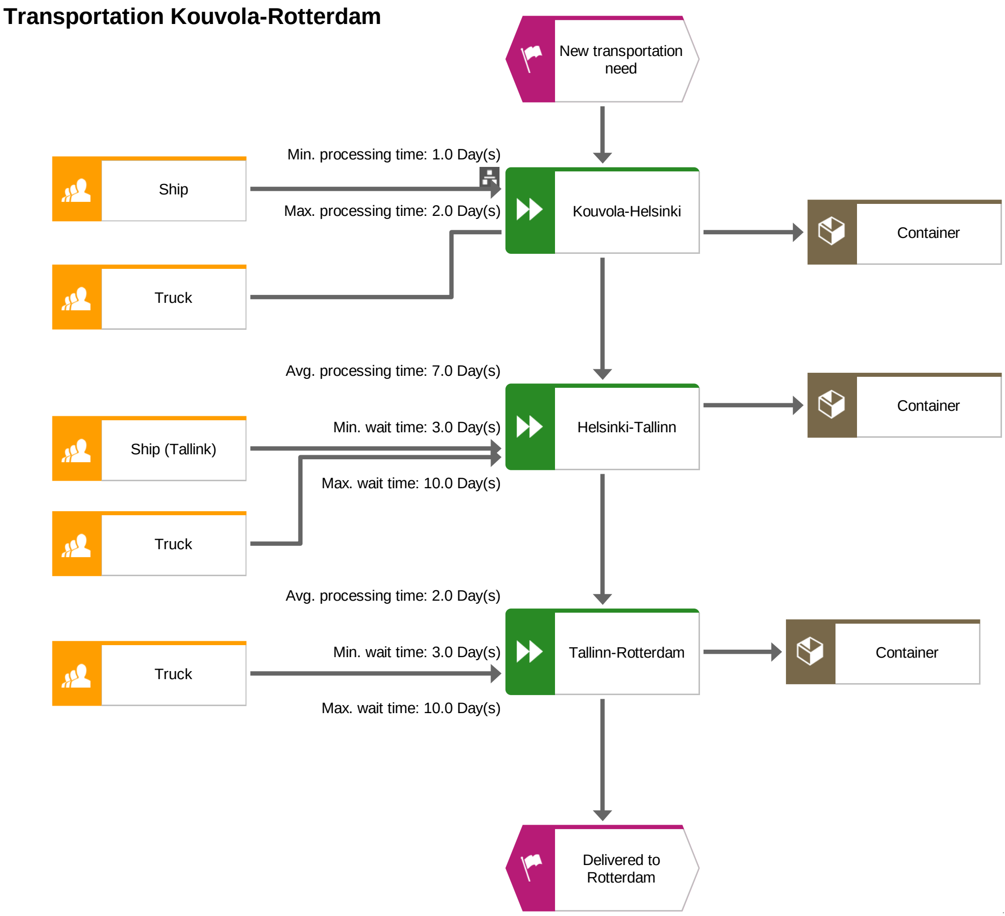


Figure 81. SmartLog transportation corridor process map for Kuovola-Helsinki

OVERVIEW

Start event(s)	New transportation need
End event(s)	Truck with Container are ready for shipment
Input	Empty container
Output	Container
Superior processes	Kouvola-Rotterdam

Model graphic

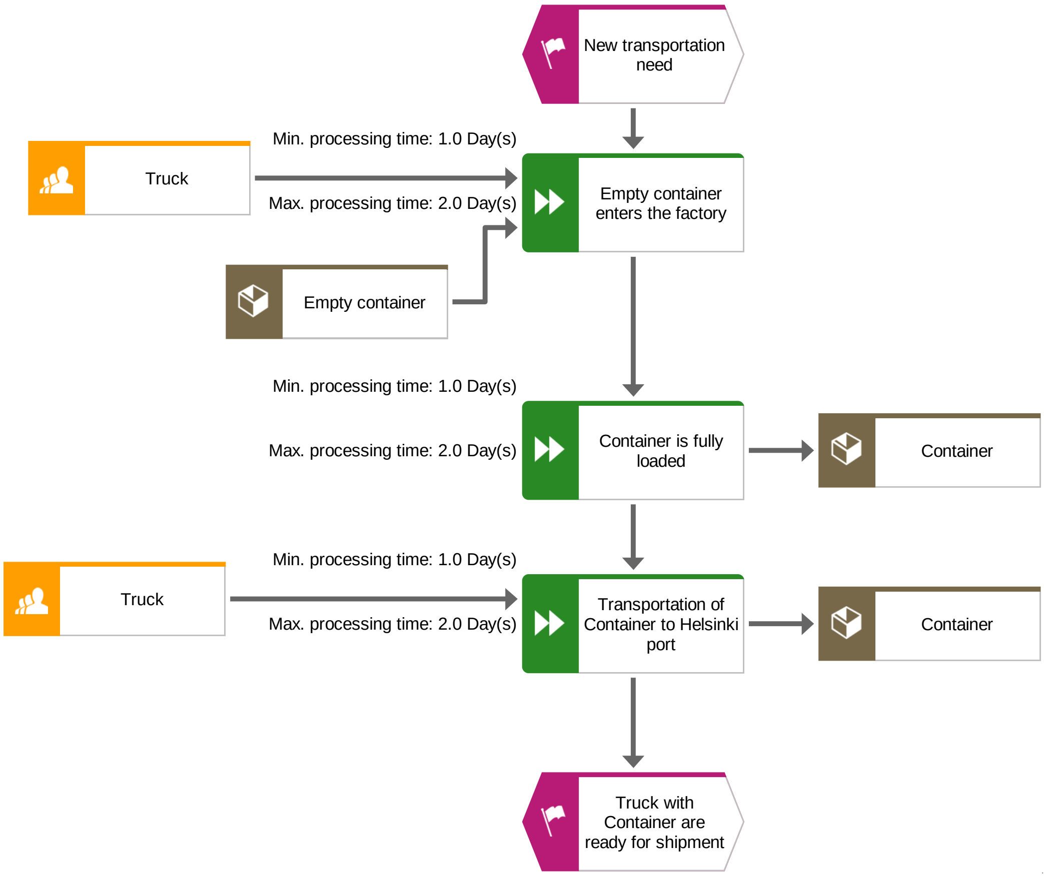


Figure 82. SmartLog transportation corridor process map for Kuovola-Rotterdam (Truck with Container)

3. Kotka-Rotterdam, Kouvola-Kotka

OVERVIEW

Start event(s)	New transportation need
End event(s)	Delivered to Rotterdam
Output	Container
Assigned processes	Kotka-Rotterdam; Kouvola-Kotka

MODEL GRAPHIC

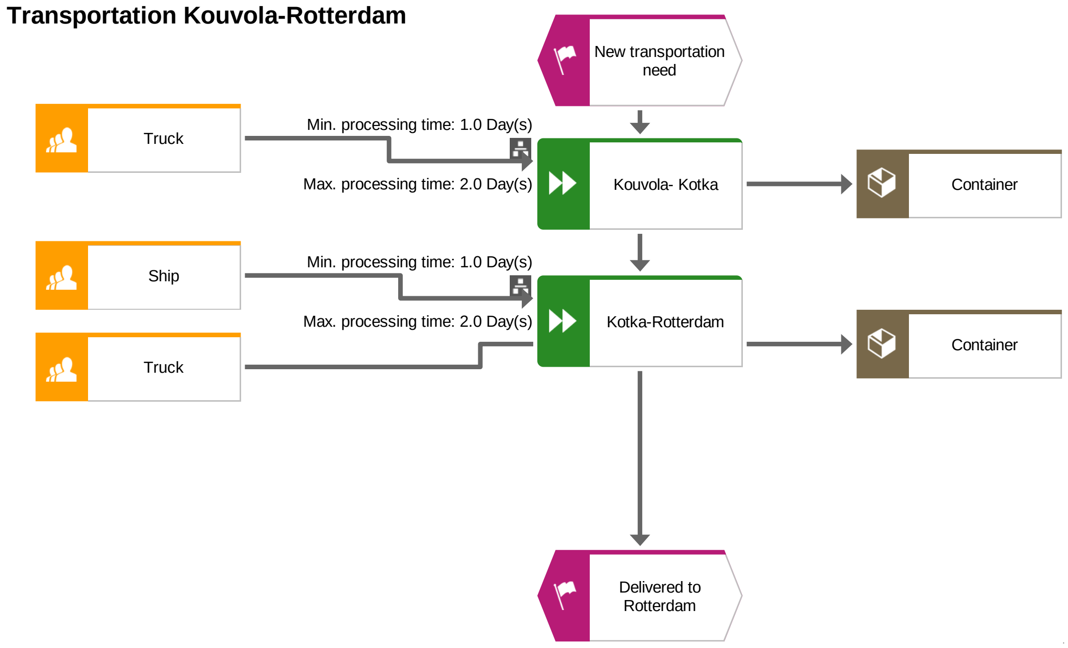


Figure 83. SmartLog transportation corridor process map for Kuovola-Rotterdam (Truck)

OVERVIEW

Start event(s)	Container is ready for shipment
End event(s)	Container is delivered to Rotterdam
Output	Container
Superior processes	Kouvola-Rotterdam

MODEL GRAPHIC

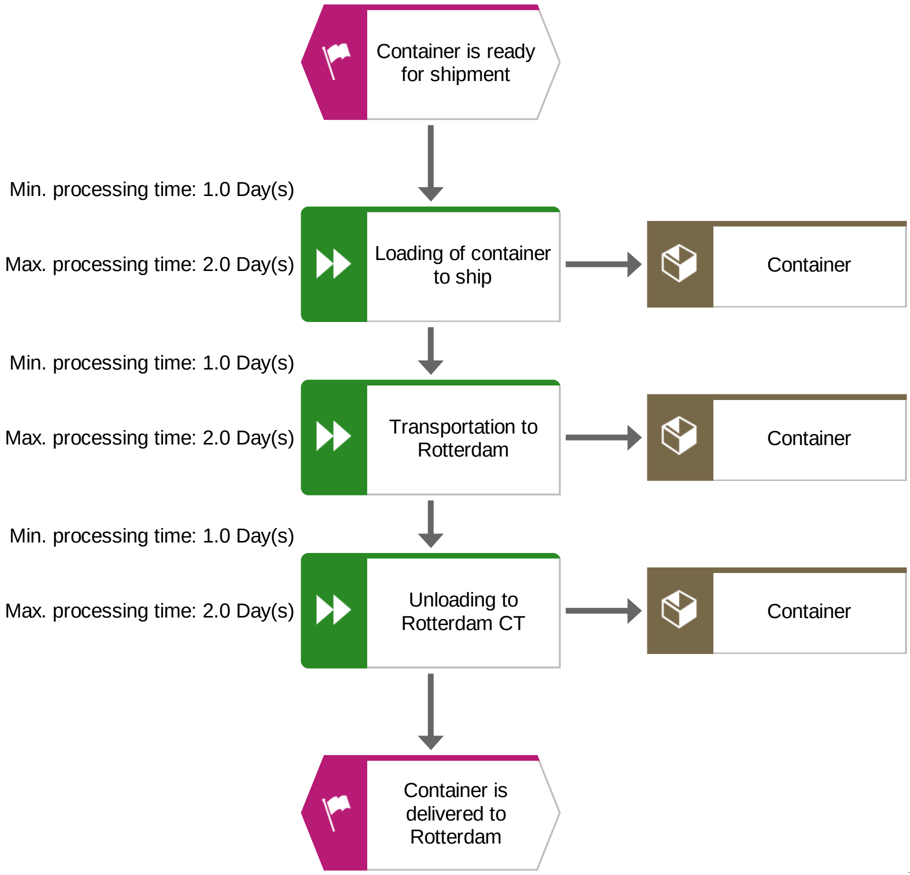


Figure 84. SmartLog transportation corridor process map for Kuovola-Rotterdam (Ship)

OVERVIEW

Start event(s)	New transportation need
End event(s)	Container is ready for shipment
Input	Empty container
Output	Container
Superior processes	Kouvola-Rotterdam

MODEL GRAPHIC

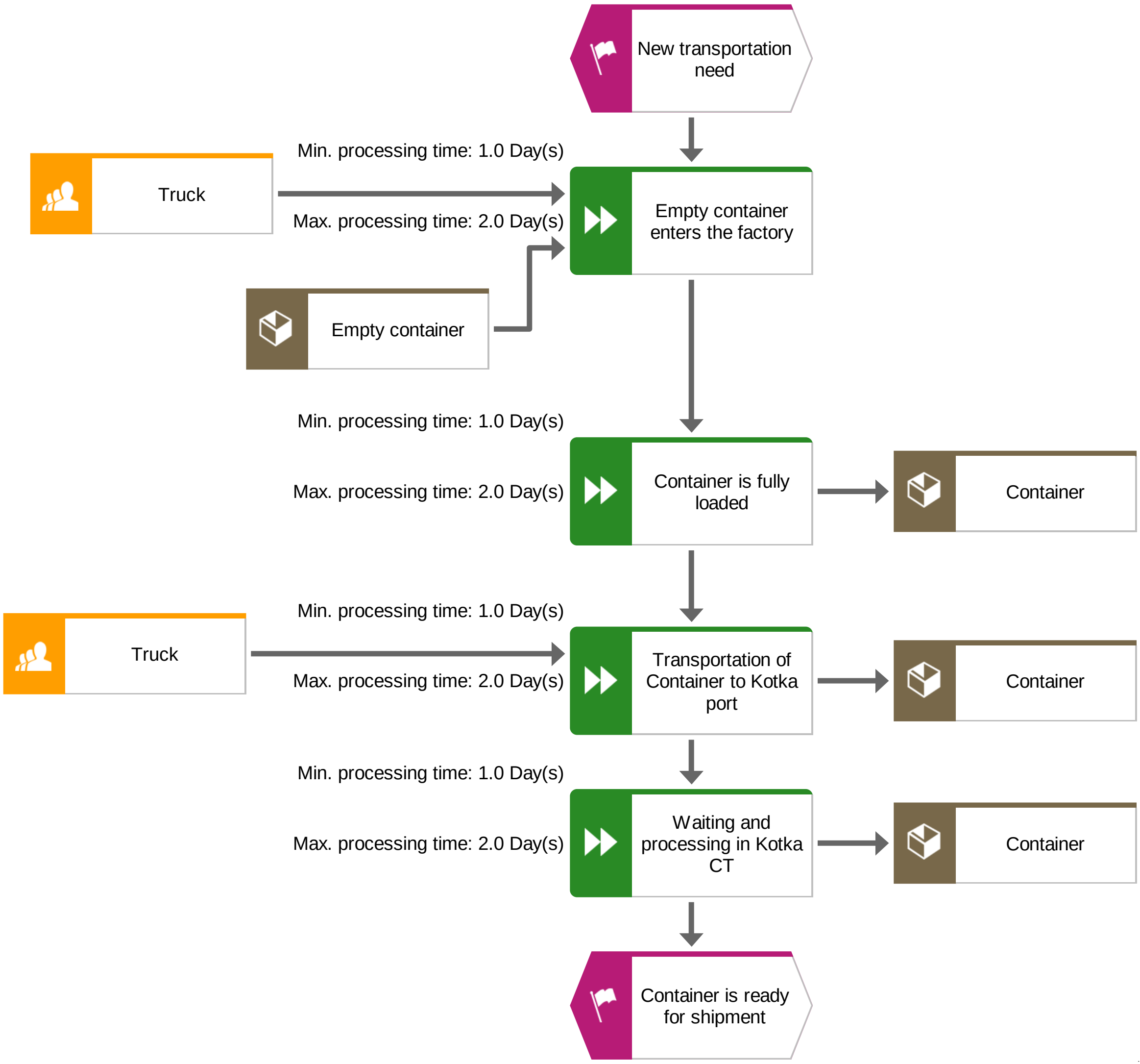


Figure 85. SmartLog transportation corridor process map for Kuovola-Rotterdam (Truck Empty)

4. ScanMed

OVERVIEW

Start event(s)	New transportation need
Output	Container
Assigned processes	Maschen shunting yard in Hamburg; Distribution by Rail Cargo Logistics in Italy

MODEL GRAPHIC

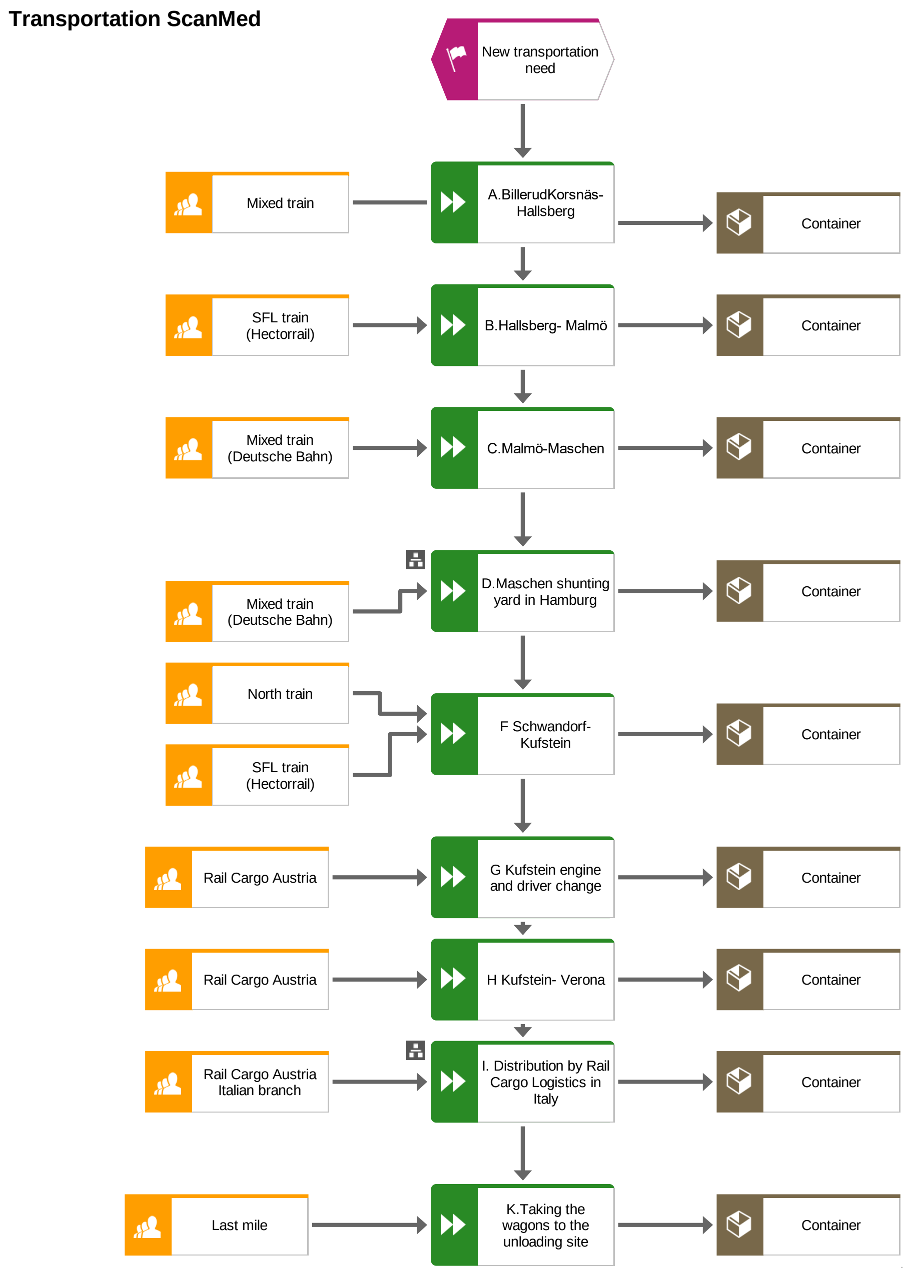


Figure 86. SmartLog transportation corridor process map for Scanmed (Hamburg)

OVERVIEW

Start event(s)	Need to select the next transport option
End event(s)	transport option is selected
Superior processes	ScanMed

MODEL GRAPHIC

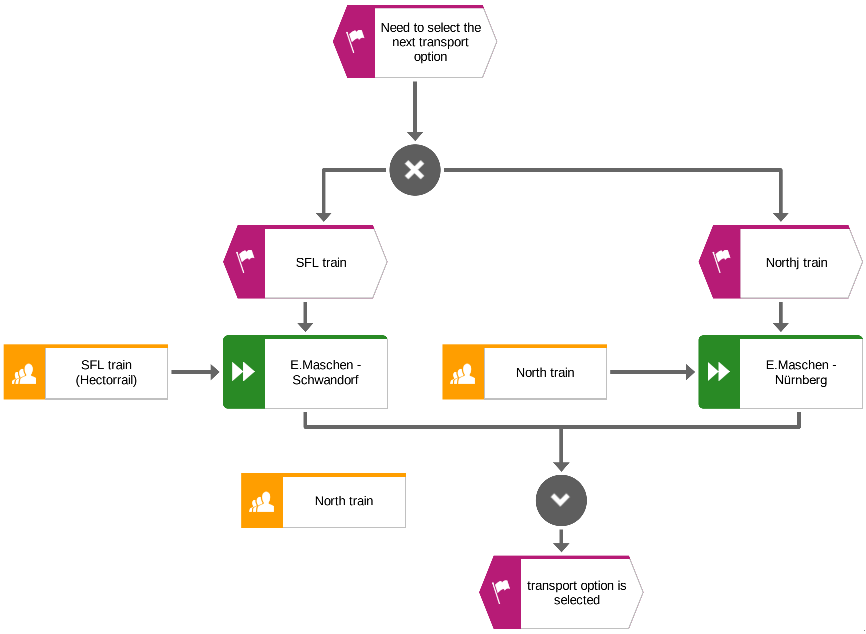


Figure 87. SmartLog transportation corridor process map for Scanmed (selecting transport)

OVERVIEW

Start event(s)	Need to select the next shunting yard
End event(s)	shunting yard is selected
Superior processes	D. ScanMed

MODEL GRAPHIC

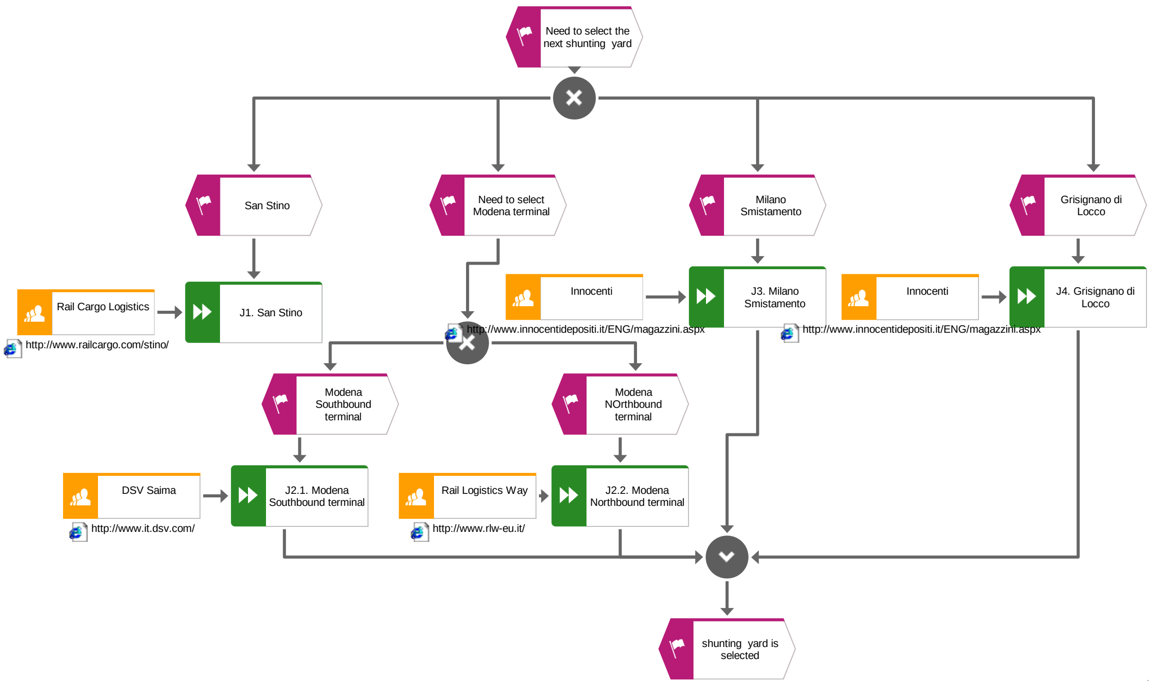


Figure 88. SmartLog transportation corridor process map for Scanmed (selecting shunting yard)

ACTIVITIES

Name	**Description**
A. Billerud-Korsnäs-Hallsberg	Green Cargo is offering wagon load system. Mixed trains from all over the Sweden arrive to Hallsberg station, which is a bit south of Örebro, and the biggest in Northern Europe (Kouvola of Sweden).
B. Hallsberg- Malmö	In Hallsberg only SFL trains are consolidated. Hectorrail is pulling the SFL trains to Malmö.
C. Malmö-Maschen	Next leg is Malmö-Maschen where DB (Deutsche Bahn) takes mixed trains again. One of the reason of mixing the trains in Malmö is, that there is longer allowed train length in Denmark compared to Sweden.
D. Maschen shunting yard in Hamburg	Maschen in Hamburg is next shunting yard. One of the biggest in North-Germany.

Name	Description
F. Schwandorf-Kufstein	
G. Kufstein engine and driver change	In Kufstein engine and driver are changed for Rail Cargo Austria.
H. Kufstein- Verona	Next stop is Verona (Italian hub), where trains are split and consolidated on their way back. In Verona no loading/unloading takes place.
I. Distribution by Rail Cargo Logistics in Italy	Distribution is done by Rail Cargo Austria Italian branch (branded as Rail Cargo Logistics in Italy)
K. Taking the wagons to the unloading site	Last mile is taking the wagons from the end station or shunting yard to the unloading site at the customer's warehouse by a terminal or customer owned engine. In Italy part of the problem is, that SFL does not have agreement with the terminals, but customers/shippers do.
E. Maschen - Nürnberg	Next leg is by DB to Schwandorf close to Nürnberg. Mixed trains.
F. Maschen - Schwandorf	Next leg is by DB to Schwandorf close to Nürnberg. Mixed trains.
J1. San Stino	Distribution is done by Rail Cargo Austria Italian branch (branded as Rail Cargo Logistics in Italy)
J2.1. Modena Southbound terminal	Modena Southbound terminal - DSV Saima (http://www.it.dsv.com/)
J2.2. Modena Northbound terminal	Modena Northbound terminal - Rail Logistics Way (http://www.rlw-eu.it/), their main customer is Essinge Rail (http://www.essingerail.se/)
J3. Milano Smistamento	Milano Smistamento – Innocenti (http://www.innocentidepositi.it/ENG/magazzini.aspx)
J4. Grisignano di Locco	Milano Smistamento – Innocenti (http://www.innocentidepositi.it/ENG/magazzini.aspx)

ORGANIZATIONS

Name	Description
Mixed train	
SFL train (Hectorrail)	
Mixed train (Deutsche Bahn)	
North train	
Rail Cargo Austria	
Rail Cargo Austria Italian branch	
Last mile	
North train	
SFL train (Hectorrail)	
Rail Cargo Logistics	
DSV Saima	

Name	Description
Rail Logistics Way	
Innocenti	

Appendix 5. Process maps

1. Sample process maps Finland

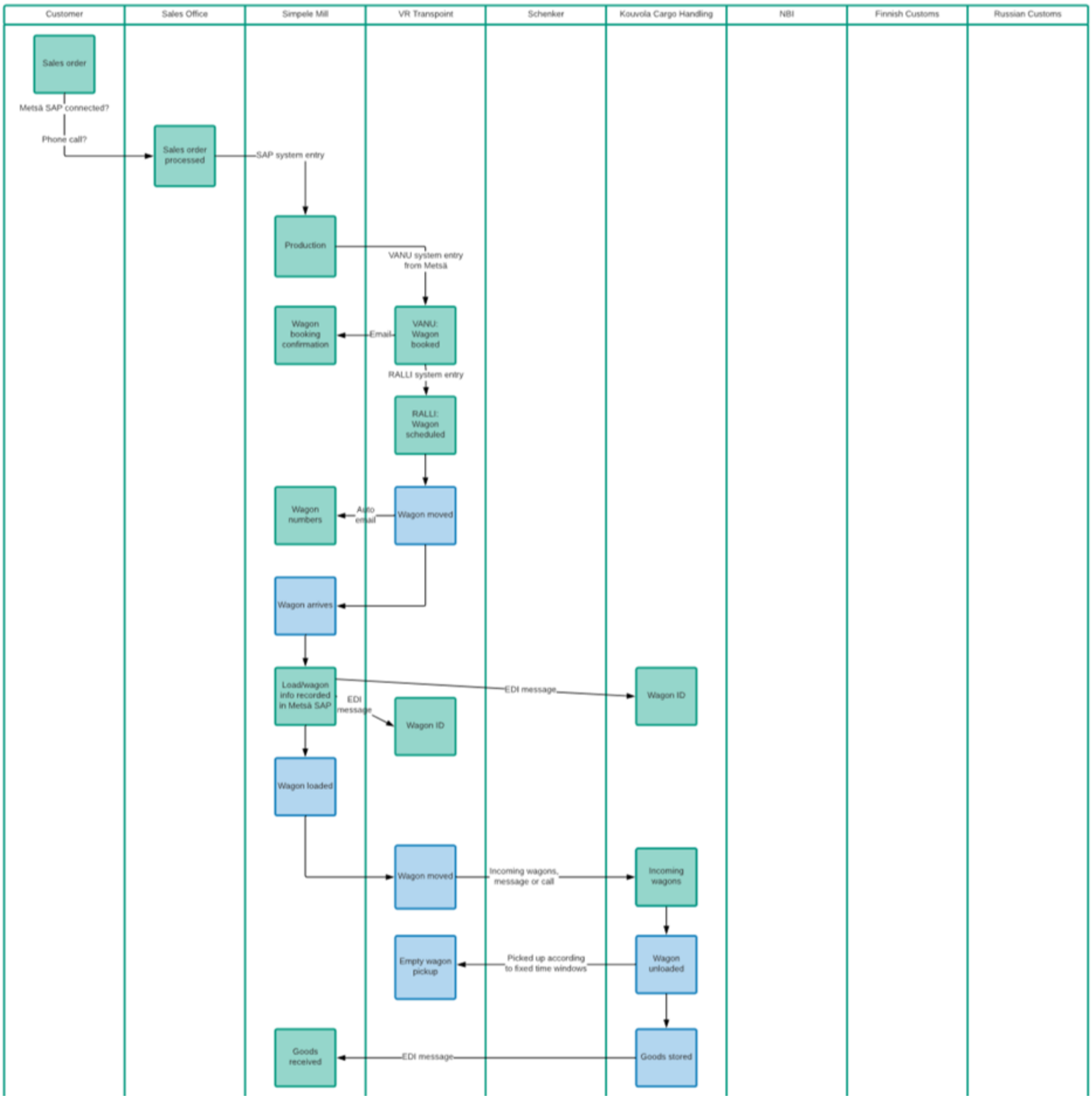


Figure 89. Sample 1 – Finland company A

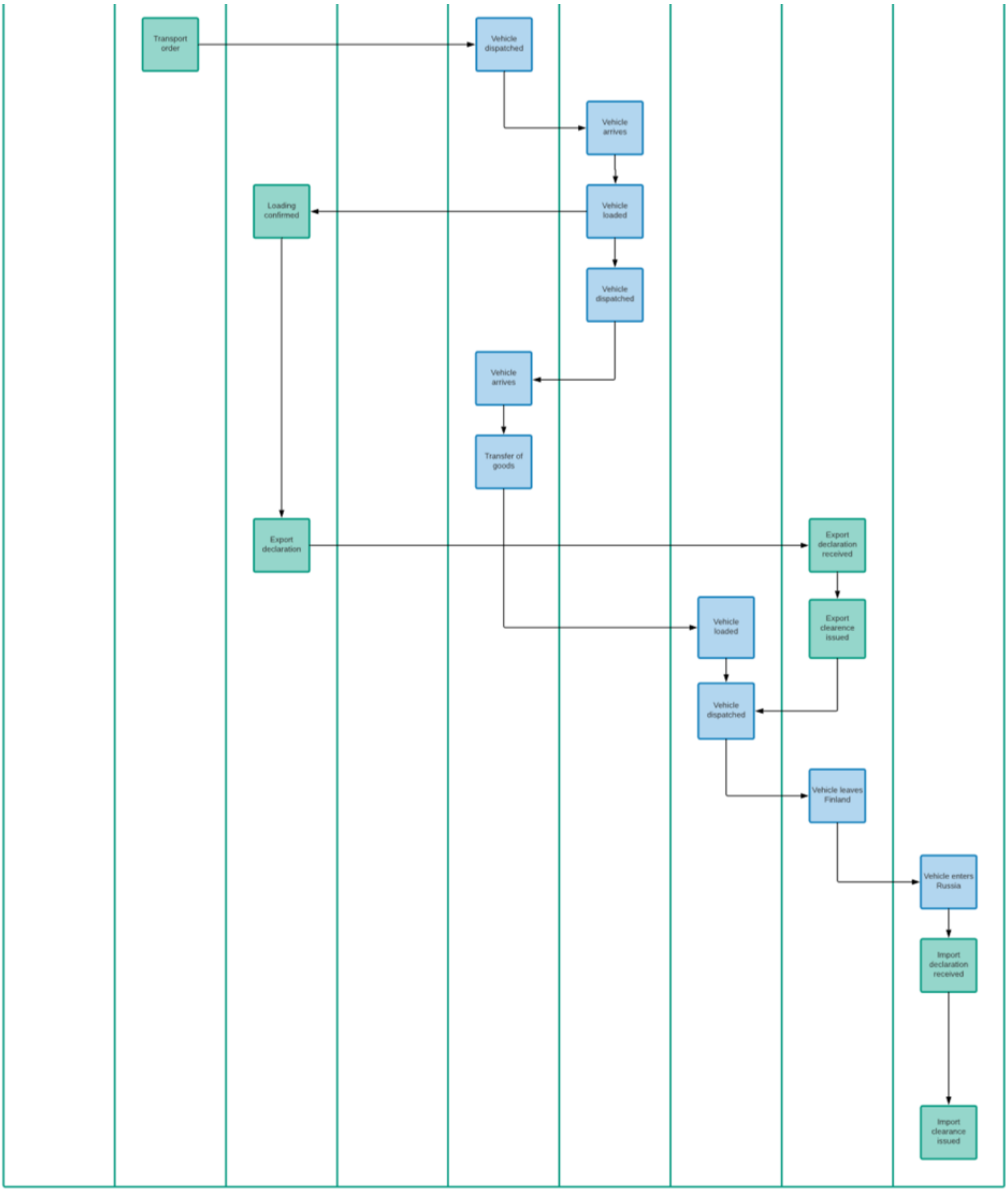


Figure 90. Sample 2 – Finland company B

2. Sample process maps Estonia

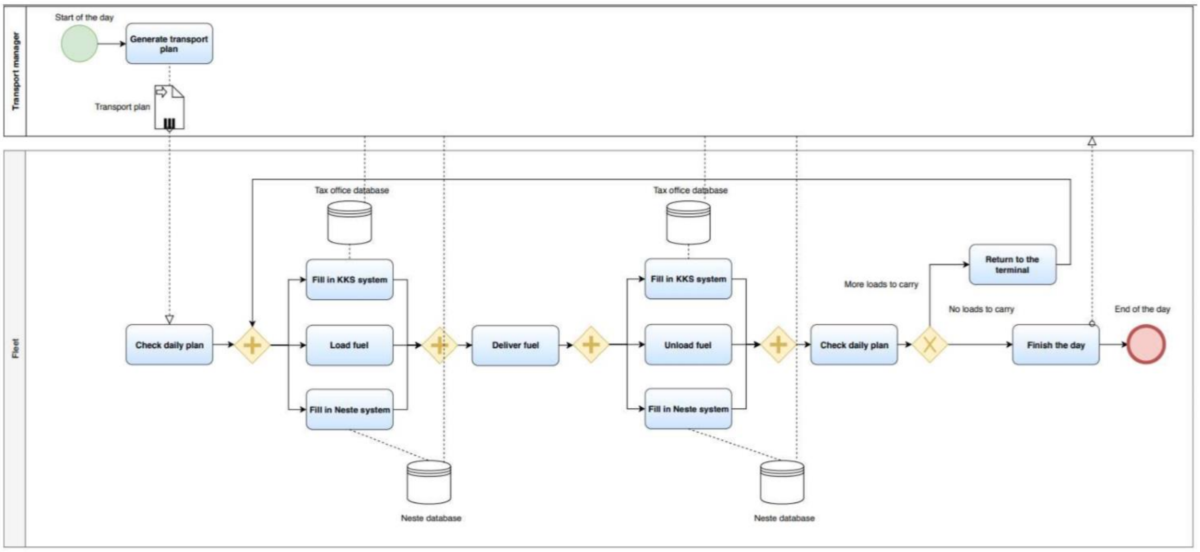


Figure 91. Sample 3 – Estonian Company A

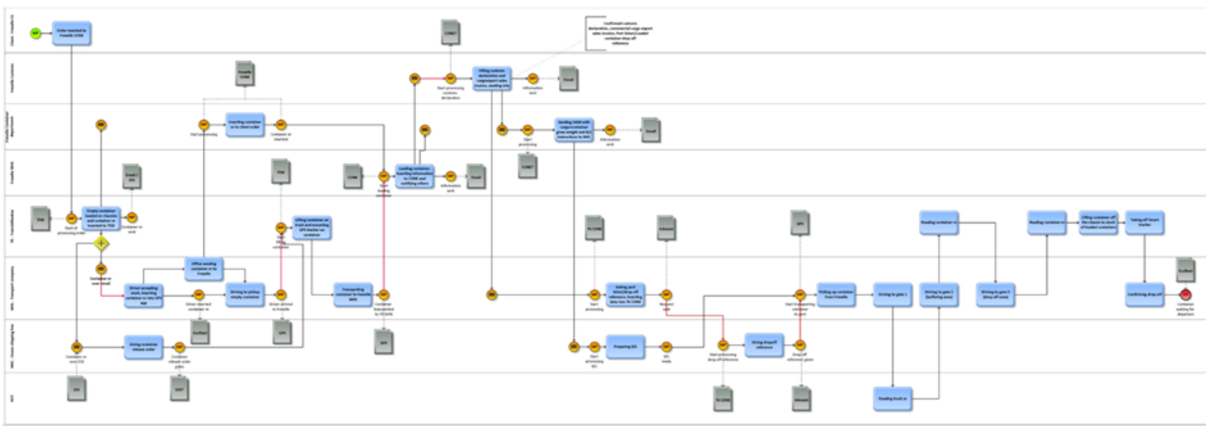


Figure 92. Sample 4 – Estonian company B

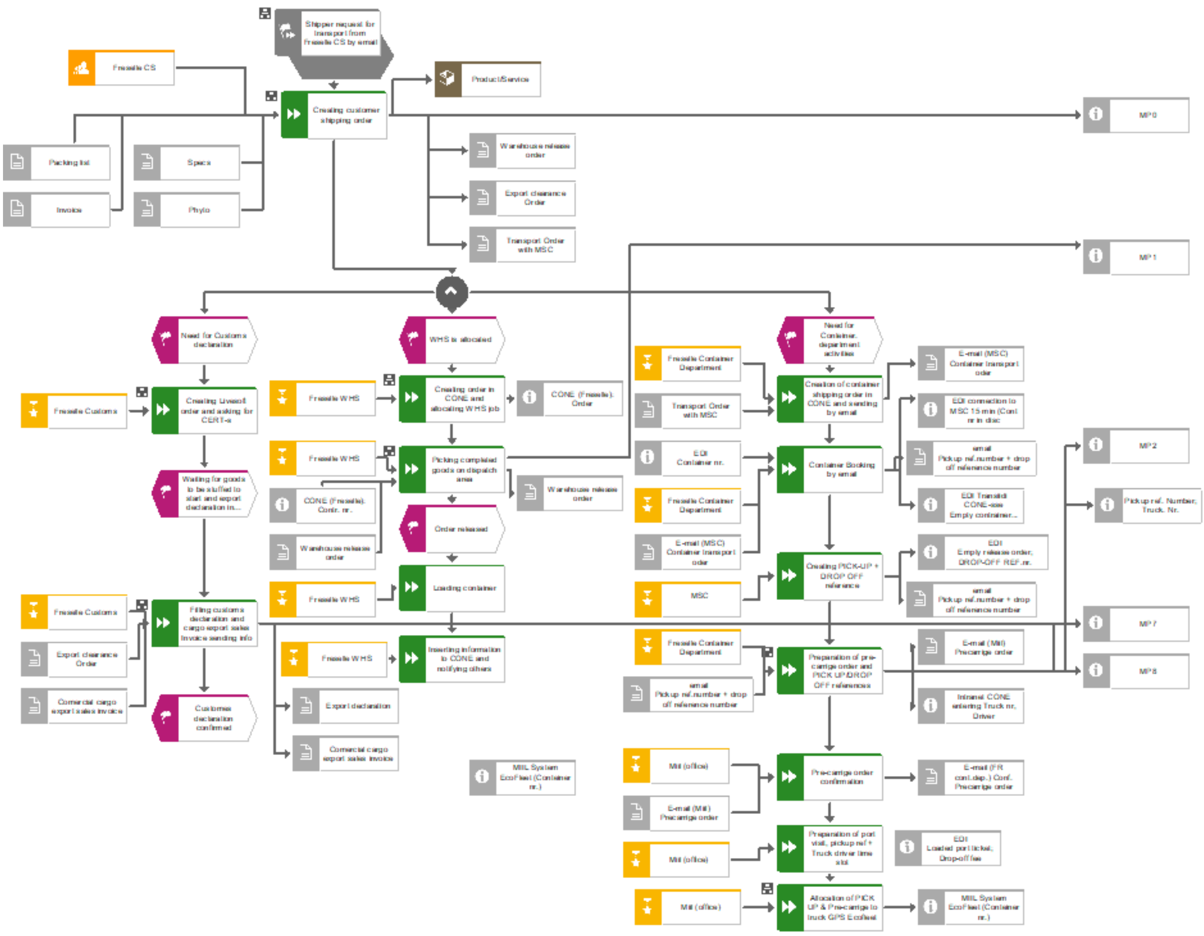


Figure 93. Sample 5 – Estonian companies, C (Pilot)