BEST PRACTICE ANALYSIS

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Introduction

The purpose of this document is to collect and analyses the best practices and most recent developments on ICT tools for enhancing maritime and multimodal transport. The main goal is to present those developments for an easy access to all partners and interested stakeholders and to see what can be used to enhance maritime and multimodal transport in the area and beyond. For this purpose, the easy methodology will be followed: each technology will be explained in short, main advantages presented as well as example of the best practices for its use.
The technologies that will be presented: Blockchain, 5G, IoT applications, Digital Twin, Truck Appointment System and all combinations that can be made from mentioned technologies.

Blockchain

Blockchain is, simply speaking, a database that allows transparent information sharing. The blockchain term is used because the data is stored in blocks that are linked together in a chain – Blockchain.
The most important aspects of the blockchain are the unchangeable records linked in the chain. That means that, in a business transaction, all information (such as track orders, payments, accounts, production, ownership, position, temperature, damages etc.) regarding certain product (tangible or intangible) are shared in an unchangeable chain. That means that all participants have access to the same information (product ledger) where transactions are recorded only once, eliminating the duplications. Moreover, no participant can change or tamper with a transaction after it has been recorded. Each transaction is recorded as a block, and data in the block can contain information of the user's choice (who, what, when, where, how much and even the condition — such as the temperature of a food shipment), each block is connected to the ones before and after it which creates a clear chain of information which confirms the exact time and sequence of transactions and it is not possible to tamper or alter this chain.
The main advantage of this technology is the near instant sharing of information, transparency of transactions and easy data verification.
The main advantage in the transport industry (especially cargo transport) is the possibility to easier keep track of the location and condition of cargo. Using shared records of ownership, location and movement, carriers can improve their load utilization, while senders and receivers can speed delivery by clearing customs in transit instead of waiting at the terminal. The main idea is to simplify the procedure from the point of origin to the final destination. This is especially important when

handling perishable goods to avoid the delays and possibilities of loss due to the delayed reactions. Some sources reports that the mislabelled, mis-shipped and stolen cargo alone accounts for at least $50 billion in losses every year.[1]

The example of the companies that successfully use the blockchain technology are:

Slync.io - a SaaS operating platform for global shippers and logistics services providers that delivers higher productivity and process efficiency through Intelligent Automation. They combine blockchain and AI to give retailers, manufacturers and suppliers real-time insights into all of their local and global shipments. The platform allows shippers to automate monotonous workflows, predict bottlenecks or challenges in a logistics process and even get a real-time overview of shipment activity.

Chronicled - a technology company based in San Francisco, CA that enables automation, trust, and automatic settlement for transactions between companies in the Life Sciences industry. Every year, $500 billion in pharmaceutical medication is dispensed to patients in the US. Chronicled combines blockchain with AI and IoT devices to automate traceability and instantaneously approve financial transactions in the shipping industry. Chronicled's blockchain-enabled IoT devices give logistics companies better insights into environmental conditions and transfer-of-custody processes. As a result, businesses can securely and efficiently move their products all over the world.

Hamburg Port – Hamburg port – a smart thinking port - have been one of the leading examples of the use of technology in recent years. They support the development of different ICT tools such as 5G, Blockchain, IoT etc. German IT supplier and port community system experts DAKOSY AG and dbh Logistics IT AG have laid the foundation for standardizing and digitalizing the release process for import containers in the German seaports of Hamburg, Bremerhaven, Bremen and Wilhelmshaven. They will use blockchain technology for the release of imported containers.

5G technology

5G stands for the 5th generation wireless. It is the latest iteration of cellular technology. The main goal of this technology is to greatly increase the speed and responsiveness of wireless networks as well as to provide more usable radio channels. Data shows that 5G is able to support over 1000 more devices as compared to 4G for every meter of coverage at the speeds of 100 times faster.

That means that 5G will provide faster speeds, lower lag times as well as larger number of connected smart devices for the easier real-time data sharing. This will enable transport and logistics operators

[1] https://builtin.com/blockchain/blockchain-supply-chain-logistics-uses

to use time sensitive device applications in real time as well as facilitate data-driven analytics and decision-making development.

5G as such is not the technology used in transport, but it facilitates and enable to use of other technologies that are dependent on real-time data exchange such as Internet of Things technology and artificial intelligence.

5G technology should enable better global tracking and condition monitoring capabilities, monitoring the location, temperature, humidity and other key elements of the shipped goods in the global shipping industry. It can also help with the development of the self-driving systems, not only on the roads, but in ports as well. Ports of Livorno and Hamburg have been testing beds for a new 5G-enabled innovative digitalized platforms.

By using the 5G, ports can enhance the exchange of real-time information among actors in the port which can lead to a reduction in movements during cargo handling which means reduced operational costs, fuel consumptions (and GHG emissions) and machine working hours, increased operation speed rates, reliability and greater capacity.

IoT application

IoT stands for Internet of Things. IoT is a network connecting “smart” devices or “things”. “Things” in this case means physical objects with sensors, software and other technologies for the purpose of connecting and exchanging data, and the purpose of IoT is to facilitate communication between devices and the cloud, as well as devices themselves. IoT works on the principle of the real-time collection and exchange of data. It has three main components[2]:

- Smart device that has computing capability and can collect data from environment and user inputs and communicates it through Internet or other closed network to and from its IoT application
- IoT application – a collection of services and software that integrates data received from various IoT devices. It uses machine learning or artificial intelligence (AI) technology to analyse this data and make informed decisions. These decisions are communicated back to the IoT device and the IoT device then responds intelligently to inputs.
- A graphical user interface - The IoT device or fleet of devices can be managed through a graphical user interface. Common examples include a mobile application or website that can be used to register and control smart devices.

[2] https://aws.amazon.com/what-is/iot/

In transport and logistic sector, IoT have been gaining the more importance than ever. Especially since the onset of the Covid 19 pandemic. In the pandemic and post-pandemic time, the shortcomings in the transportation and logistics industry have revealed themselves in the form of supply-chain shortages and labour challenges. This situation especially has revealed the need for transformation in the Transportation and Logistics industry to enable the flexibility required to respond to quickly evolving global conditions.

IoT in the transport and logistics industry is often called telematics, which is the foundational technology behind fleet tracking and fleet management software. Using the in-built sensors and on-board diagnostics systems in vehicles enables managers to track vehicles and respond to the changing environment in the real time, enabling immediate decisions to facilitate on time delivery. It also reduces the need for paperwork for both drivers and managers, allowing them to focus on more essential activities. Some other benefits are also improved safety, regulatory compliance, cost reduction, resource optimization and route management. IoT also facilitates the storage of goods and management of stock levels.

The example of successful use of IoT is the Port of Rotterdam. The Port of Rotterdam is the largest seaport in Europe. In 2019 the Port of Rotterdam - with the partnership of IBM, Cisco, Esri and Axians - implemented an IoT based platform to optimize port operations and to reach a higher level of safety. The first application that was put into operation includes a network of sensors capable of collecting water and meteorological data for the planning and management of seaside operations. Using the IoT platform, it is possible to determine the best time to enter the port, allowing lower fuel consumption with the consequent positive impact on both costs and sustainability. In addition, it ensures a safer and faster ship arrival.

IoT is often used with other technologies to create more efficient exchange of information on all levels. The example is the digital BoL.

Digital BoL – digital bill of lading

A bill of lading is a legal document issued by a carrier (transportation company) to a shipper that details the type, quantity, and destination of the goods being carried. A bill of lading also serves as a shipment receipt when the carrier delivers the goods at a predetermined destination.

When combined with blockchain technology, IoT applications can be used to create a digital bill of lading (BOL). This allows a company and its customers to trace products during delivery, creating transparency in the supply chain.[3]

[3] https://onomondo.com/resource-hub/iot-in-logistics-and-transportation/

The digital BOL is one of many constituents within smart contract solutions facilitated by the combination of IoT and blockchain technologies. Along with sensors and GPS trackers, these solutions enable monitoring throughout the delivery process. This allows both company and customer to track the location of the product and measure the temperature, humidity, and other parameters during the delivery process to ensure that all contract conditions are met.

Combining IoT and blockchain technologies makes it possible to:

- Store all data surrounding the delivery in the blockchain, significantly reducing the probability of data theft or cyberattacks,
- Cancel a contract if it is breached, e.g., due to delayed delivery or spoiled cargo, and
- Further enforce the security, transparency, and traceability of the supply chain by maintaining two-way authority over the contract specifications.

When combining IoT with machine learning and artificial intelligence, we come to the autonomous and self-driving vehicles.

Autonomous vehicles and robots

Autonomous vehicle is a vehicle that uses a combination of sensors, cameras, radar and artificial intelligence (AI) to travel between destinations without a human operator. The idea behind autonomous vehicle is to compensate for the shortage of truck drivers, increase the number of drives in the same amount of time (due to the fact that driver needs breaks) increased safety – the fact is that 90% of all road accidents are due to the human mistakes. Beside autonomous vehicles, this branch is also looking for the use of robots in logistics – in warehouses and ports.

Digital Twin (DT)

A Digital Twin[4] is the virtual representation of a physical object or system.

[4] https://www.envisionesl.com/blog/digital-twins-and-smart-ports#:~:text=A%20digital%20twin%20is%20a,be%20followed%20easily%20and%20quickly.

A digital twin of a port or a terminal is a virtual representation that serves as the real-time digital counterpart of the physical port or terminal. In the digital twin, each port facility (infrastructures, vehicles, cranes and other port elements) is represented and virtually simulated.
Digital twin is a technology that will be used more and more as ports adopt digital technology within their operations. Digital twins can help ports execute missions, improve safety processes and allow maritime stakeholders to effectively share data.
The success of the digital twin depends on the quality of data – the use of the wrong equipment, sensors and other settings can affect the quality of data. To solve this problem, data is extracted from an actual vessel, mimicking its desired characteristics. This can ensure the better quality of data by tailoring it for the specific ship.
Using this, digital twin can simulate how the ship will perform without needing to test it in the real world. This concept can also allow access to every bit of information on a ship, from engine performance to full integrity, available at a glance throughout the full lifetime of the vessel.

The digital twin takes in data ranging anywhere from Internet of Things (IoT) sources including AIS information and cargo-hold from carriers to performance statistics, maintenance status of port tractors and carriers.
Some may confuse a digital twin with simulation technologies, however there are key differences between the two. A digital twin can utilize the regular intake of real-time data from a port complex of cargo movement or trucking congestion, compared to traditional simulations which may not integrate real-time information, for example – increasing accuracy.
By combining the virtual and physical worlds within which we work, Digital Twins allow us to undertake detailed analysis of the data and use monitoring systems to deal with problems even before they occur. By using real-time data, simulation, and machine learning. Digital Twins allow businesses and organizations to maximize efficiencies, develop new opportunities, and create detailed simulations. In effect, Digital Twins are modernizing the entire process with which organizations can capture, analyse, and interpret data ensuring more effective decision-making.
The example of the Digital Twin is in the Port of Livorno, one of the largest Italian seaports. It has been recently developed in partnership with the company Ericsson. The DT focuses mainly on improving efficiency in general cargo logistics. Unlike containers that have a regular shape, the heterogeneity of this type of cargo leads to handling inefficiencies.
The port of Livorno has implemented a DT by using smart sensors, 3D LIDARs and Wide Dynamic Range (WDR) cameras that enable the collection of big data. All of these technologies use a 5G connectivity that is part of the European Project H2020 Corealis. The main elements modelled in DT are the yard area and goods. WDR cameras are used to identify and track boxes so that the AI-based

operational control system can determine a more appropriate and efficient sequencing of logistics tasks and activities.

Truck Appointment System

The problem of road congestion in the port context is increasingly crucial, as it causes an increase in the cost and time of port operations, a reduction in the productivity of the terminals and in the level of service to trucks, as well as the generation of negative externalities also related to safety (e.g., accidents). These congestion issues are due to two concomitant phenomena. On the one hand, the constant increase, starting from 1970, in the volumes of goods moved by sea (with exceptions due to the financial crisis of 2008-2009 and the COVID-19 pandemic of 2020-2021) with future forecasts of increasing freight flows. On the other hand, the naval giantism phenomenon which significantly modifies the organizational models of ship loading/unloading, introducing traffic peaks to be managed in limited time intervals.
When the terminal is overloaded, congestions can occur in the yard or at the road gate resulting in longer waiting time for trucks that represents an added cost to terminal customers. The negative effects caused by congestion are even worse when ports are embedded in the city fabric, as is the case with many Italian and Croatian ports.
The maximum capacity of the terminal in terms of trucks served per hour can be predicted while the demand for incoming trucks on an hourly basis is unpredictable. This leads both to periods of "overload" when demand exceeds the maximum capacity of the terminal, leading to higher truck turnaround times and consequently lower service level for hauliers, but also to periods of terminal underuse. Idle manpower and handling equipment correspond to inefficiencies and costs for terminals.
To achieve efficiency, supply needs to match demand: a way to achieve this match is to control the demand of trucks over time.
A Truck Appointment System (TAS), also called Gate Appointment System or Vehicle Booking System, is a digital platform that allows transport companies to book a precise time slot when the truck can enter the terminal gate.

TAS is one of the best and most frequently utilized methods of communication between truck companies and the container terminal. Trucking companies preschedule their truck working times, giving each truck an appointed time, and terminals predetermine the allocation of equipment for the yard. By controlling the distribution of truck arrivals, the waiting time is expected to decrease

and thereby emissions from idling truck engines are reduced. The original aim is to control the long queue and large emissions from trucks; however, the practical performances of the Truck Appointment System are not uniform.

In case a terminal is equipped with a TAS, the typical steps are as follows:
1. the terminal operator determines the appointment quota for each time slot (i.e., the number of containers/trucks that can be handled per time slot) while trying to meet certain performances/goals (e.g., maximize its resource productivity, minimize truck service time, reduce gate congestion or maximize the number of trucks handled by the terminal);
2. available appointments are posted on the terminal website/application (or other on-line tools such as the PCS-Port Community System) to be available to trucking companies;
3. each truck selects one time slot to make the delivery or pick up of its container (Info: ID container, company, truck plate, trucker ID, booking number, etc.). If the preferred time slot is fully booked, the trucker will have to choose another one;
4. booked appointments are communicated to the Terminal Operating System (TOS) to schedule terminal operations;
5. once the slot is booked, the truck can arrive at the container terminal gate to deliver or pick up its container.
Each Truck Appointment System has specific features:

- **appointment windows** which is the time interval within which the truck must arrive at the entrance gate of the terminal (typically 1 or 2 hours);
- **penalties** which can be included in case of not showing up, late/early arrival, multiple bookings for the same truck etc.;
- **deadline for an appointment** which represents the maximum limit for making an appointment;
- **different rates for appointments** e.g., during peak times;
- **refund vouchers** which are sometimes included and are paid by the terminal if it cannot serve the truck in the booked time window, or the agreed upon level of service is lower than expected.

In theory, TAS can be very successful – it has the potential to concretely increase the terminal ability to handle trucks. However, there may occur several problems that needs to be taken into consideration:
1. INSUFFICIENT APPOINTMENTS: truckers may not be able to perform all their trips (to reach marginality) on a timely basis;

2. LACK OF FLEXIBILITY: TAS may not allow for appointment changes, for substitution of other containers, or for double moves;
3. LACK OF A RESET OPTION: Many existing TAS do not have explicit provisions for resetting successive appointments without penalties if terminal problems delay the driver (causes: system failure, inability to locate a container, equipment condition issues);
4. LACK OF TRANSPARENCY: without transparency, truckers may suspect favouritism and terminal manipulation; moreover, the need for transparency is even greater when fees or penalties are involved;
5. LACK OF STANDARDIZATION: in many cases it may be a "conflict" between standardization and flexibility since for trucking companies and other users within a port that has several port terminals, there is a strong desire for standardization and uniformity in practice but for terminals, customized systems are preferable to optimize their individual operativity and commercial interests;
6. PENALTIES AND SANCTIONS: penalties may be difficult to recover from customers in the highly competitive drayage industry; many trucking companies find it hard to pass on fees, penalties, or additional administrative costs to customers;
7. LACK OF INVOLVEMENT OF TRUCKING COMPANIES: some appointment systems have been developed with significant trucking companies input, but others have been developed by terminals without their involvement; development efforts that do not include trucking companies may foster their resentment and obstructionism as they may view TAS as impediments to their own operations.
A Truck Appointment System is an effective tool to increase operational efficiency, enhance terminal productivity and reduce congestion and environmental issues at ports but as previously said there are some possible drawbacks that should be carefully taken into account.

The example of efficient TAS system implemented in the port if the Port of Hamburg. The Port of Hamburg implemented TAS system in 2017 with the aim of avoiding bottlenecks and congestion consequent to the increased volume of traffic. Today, in the port of Hamburg, the use of such slot booking platform is mandatory at the HHLA and Eurogate container terminals, at three additional container depots and the veterinary and import offices. The use of TAS allows a faster pick-up and delivery process of the containers, a greater efficiency and transparency of available resources since the terminal capacity utilization display is visible online.

Conclusion

The improvement in digital and communication technology has a great impact in all industries, and especially in transport and logistic one. In the last 30 years, we moved from the first Port community systems and simple digital communications to the creation of automated vehicles and robots. The development of one technology is facilitating and enabling the development of other technologies. While some ideas may be there for a long time (such as robotics and automated vehicles), their implementation in the real life were not possible until some other technologies have been created – such as the possibility of the 5G network and real-time exchange of information.

Transport and logistics industries are sectors that can profit greatly from the ICT development, and many companies and ports have recognized this need. As a prime example have been ports of Hamburg and Livorno that are testing the use of 5G technology and its application in other connected technologies.