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Future 5G platform ecosystems: Case study of a digitalized port stakeholders' new interactions and value configurations

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Abstract

Data and connectivity platforms play a key role in the digitalization of different sectors of our society. The availability of new services that are specialized to the needs of a given vertical sector in a specific location can significantly boost the business opportunities of that ecosystem. 5G in particular is aiming at offering new building blocks to digitalization by enabling fast exchange of increasing amounts of data between different entities. This paper presents a case study of the digitalization of a port which presents an intriguing example of future 5G platform ecosystems. We identify the key stakeholders of the port ecosystem and characterize their interactions in the current situation. We depict and analyze alternative configurations for connectivity and data platforms encompassing centralized, hybrid and fragmented approaches. Finally, we propose three consecutive steps for managing the service roadmap of the converged connectivity and data platforms in the port: fragmented data – fragmented connectivity phase, fragmented data – hybrid connectivity phase and the optimally hybrid data – optimally centralized connectivity phase.

1 INTRODUCTION

5G technologies are expected to transform various traditionally vertically structured local industrial activities by enabling digitalization. The 5G network itself has been considered as a connectivity platform (Ahokangas et al., 2019) and it can be extended towards a data platform, connecting intelligence and services together. In vertical industrial contexts the role of private 5G networks in industrial platforms has emerged as an increasingly important topic (Matinmikko et al., 2017). Extant literature ties this transformation to concepts such as digital platforms and digital ecosystems. Industrial digital ecosystems have recently become a new focus of this research where 5G can act as the enabler for digitalization.

Platforms in general have been categorized as company-internal product platforms where the platform serves only internal purposes, supplier-network platforms that integrate the data of a value chain partners together to serve information flow purposes or ecosystem platforms that may serve various purposes of also changing partners (Gawer & Cusumano, 2014). The former two of the platform types represent traditional vertical industrial and rather closed platform constellations (c.f., Cusumano, 2004) with closed wireless, mobile or WiFi, networks. Due to the industry 4.0 developments (Brettel et al., 2014), there is an increasing need to open vertical industrial data platforms and hence also the wireless networks used in them.

As a result of the industry 4.0 development, industrial verticals are increasingly turning ecosystem platforms, or rather, platform ecosystems where the wireless network is becoming integrated with other ICT infrastructures and services – meaning that connectivity and data platforms are converging and giving rise to a 5G platform ecosystem. This development raises questions concerning the ecosystem configuration and role of stakeholders in these new, more open platform ecosystems: who they are and how their role may change in the future? This challenge (Ahokangas et al., 2019) has been recognized also in the 5G research domain that sees platforms as multi-stakeholder environments: who are novel 5G ecosystem stakeholders and what are their relations with the introduction of 5G?

Modern connectivity platforms concern transport of data via different technologies such as WiFi, 4G, and 5G as a service. Data platforms in turn are needed for providing various data services such as computing or storage. When discussing converging connectivity and data platforms, the question of the configuration

needs to be paid attention to. Traditionally, configurations are based on the modularity of platforms (Langlois, 2002) to address customers' needs, via a service (de Mattos, Fetterman, Cauchic-Miquel, 2019). Modularization may bring about several benefits such as efficiency, configuration, transparency, enhancements—but also increased value perception and higher level of customization (de Mattos et al., 2019). The changing 5G platform ecosystem configuration can thus be approached from service and platform perspectives. Extant literature covers the stakeholder perspective (Freeman, 1984), data platform configuration perspective (Yrjölä, Ahokangas & Matinmikko-Blue, 2019) and technical value configuration perspective of the connectivity platform (Casey et al., 2010; Ballon et al., 2008). All these three perspectives can fundamentally be considered as based on resource configurations (Amit & Han, 2017).

This research concerns the vertical *5G platform ecosystem* of digitalizing future port/harbor. A port constitutes a local industrial activity with clear physical boundaries and where a variety of stakeholders both collaborate and compete and where digitalization could bring substantial benefits. Generally, a port is a transport hub through which goods are shipped and the physical port represents characteristics of industrial ecosystems due to focus on efficiency, optimization and sustainability. Thus, the digitalized port is as a multi-stakeholder environment where conflicting interests of the different stakeholders come together (Frosch & Gallopoulos, 1989).

Opening the traditionally closed port ecosystem with digital platforms—such as connectivity and data platforms—turns it toward a mixed or hybrid ecosystem structure with both closed and open elements or characteristics (Iivari, Ahokangas, Matinmikko-Blue & Yrjölä, 2020). Digitalization of the port ecosystem can thus be considered to take place via a platform that combines 5G connectivity with the various digital operative systems (data platforms) used in the port are, thus turning the port towards a true business platform ecosystem with specific services. The research question addressed in this research concerns the digitalization of the port ecosystem via the introduction of a 5G enabled platform and explores how the port ecosystem is expected to change due to the development of a 5G enabled data platform, especially from the stakeholder perspective. The research seeks to answer the following questions:

1. Who are the key stakeholders what are their relationships in the future 5G enabled digitalized port?
2. How connectivity and data platform configurations in the digitalized port may emerge?
3. What kind of steps could characterize the transition of the platform configurations?

The expected outcomes of the paper are two-fold. First, we examine and show how future ports are developing as platform ecosystems and their stakeholders in the research context chapter. Second, we examine and show how 5G enabled platform ecosystems may emerge in the port context especially from connectivity and data platform perspectives. To achieve its goals, this research applies the anticipatory action learning methodology combined with interpretive case study of the Port of Oulu, Finland (Iivari et al., 2020; Reason & Bradbury, 2008; Andrade, 2009). Two workshops were held in June 2019 and August 2019 to describe, explore, and analyze the port ecosystem in the first place. The data from the workshops was complemented with two interview rounds with the port management in April and May 2020. The interview rounds deepened the data generated in the workshops and provided the researchers an opportunity to analyze the digitalization of the port from the connectivity and data platform perspectives.

The rest of this paper is structured as follows. We start by providing a theory framework that combines ecosystem and stakeholder perspectives and platforms, with a specific focus on connectivity and data platforms, and continue with research methodology and description of the selected research context. The paper is concluded with case analysis and conclusions.

2 UNDERSTANDING 5G PLATFORM ECOSYSTEMS

This chapter provides a conceptual background for the analysis of platform ecosystems and discusses ecosystems and platforms as a context for providing connectivity and data services, specifically from 5G

perspective. As platforms can be considered to “grow” an ecosystem around them, the discussion in this chapter starts with platforms and ecosystems and continues with 5G connectivity and data platforms.

2.1 Platforms and ecosystems

In general, platforms have been conceptualized as “interfaces—often embodied in products, services, or technologies—that can serve to mediate transactions between two or more sides” (McIntyre and Srinivasan, 2017: 143). According to the market-intermediary research stream (Rochet & Tirole, 2006), the platform enables a marketplace, creating market efficiencies in for two-sided or multi-sided markets, providing a device for connecting supply and demand and establishing and exploiting market power (Thomas, Autio & Gann, 2014). From the technical perspective, platforms may be seen to consist of complex networked and layered elements, i.e., a hierarchical system of modular components and interfaces that are located either in the core or periphery and the scope and scale of which reaches beyond the immediate platform actors. In addition, data and algorithms, i.e., the processes that make the platforms functional, have increasingly been included as the key elements of platforms (Gawer, 2014; Kenney & Zysman, 2016).

Tsujimoto, Kajikawa, Tomita and Matsumoto (2018) present four key approaches towards the ecosystem concept: the industrial ecology, business ecosystem, platform management and multi-actor network perspectives. They also claim that any coherent conception of an ecosystem is built on the boundary-setting criteria, a definition, the stakeholders and their attributes within the ecosystem and the dynamics of the ecosystem interaction in terms of behavior, decision-making, and interaction. Freeman (1984) has defined a stakeholder as “any group or individual who can affect or is affected by the achievement of the organization’s objectives”. Ackermann and Eden (2011) have developed a three-phased method for strategic management of stakeholders including identification of stakeholders in specific situations, exploring the impact of stakeholder dynamics and developing stakeholder management strategies. While stakeholder analysis is traditionally applied from one organization’s perspective, it is also applicable for analysing a bigger theme and deriving its stakeholders, their interactions, and management actions towards the achievement of the given goal.

Ecosystem platform architecture or configuration can be defined as the conceptual blueprint that describes how an ecosystem is partitioned into a relatively stable platform, a complementary set of varying modules, and the design rules binding on both (Baldwin & Woodard, 2009; Cusumano & Gawer, 2002). The combined platform and ecosystem discussion point out to look at the degree of openness as a topic. Casadesus-Masanell and Llanes (2011) discuss openness (open edge, open core, open source) in a way that easily lends to ecosystem contexts. In platform contexts this brings the ecosystem and its stakeholders into discussion. Related to openness, complementarity that can be related to production, customers, asset prices, inputs, technologies or innovation (Teece, 2018) can be seen as the basis for converging or combining platforms. This again puts forth the question of platform type—whether internal, supply-chain or industry (Gawer, 2014)—as different types of platforms may exhibit different configuration types and levels (lightly or loosely coupled) of complementarity.

2.2 5G connectivity and data platforms

5G technologies are expected to transform various traditionally vertically structured local industrial activities by enabling densification and extreme capacity through millimeter wave small cells in the access network and localization via distribution of radio and core functions, content and services on the edge clouds for pooling gains, low latency, high reliability, security and privacy, and application. In addition, it enables decomposition of network functions to lift scalability, programmable transport mesh that interconnects the distributed datacenter infrastructure and softwarization of the network with advances in analytics and machine learning enables high level of automatization in management and orchestration. 5G will also bring about slicing, i.e., utilizing the above capabilities for new as-a-Service business models (Morgado, Huq, Mumtaz & Rodriguez, 2018).

A critical aspect of the 5G network, is the ability to create customized network slices, where instances of virtual network resources and applications can be delivered to a new breed of cross-sector services tailored to specific customer needs with service level agreed (SLA) performance on demand. Transformation from the current best effort service towards deterministic connectivity network, enables operators to generate new revenues through customized industrial automation and enterprise services while exploiting the benefits of a common network infrastructure. Application and service providers will be able to use sub-set of the network capabilities in a flexible, configurable and programmable manner depending on their service preference. Furthermore, the software-based network architecture enables efficient infrastructure sharing by different tenants, can open the ecosystem to new players and accelerate time to market by reducing service creation and activation times. Abstracting the slice functionality through open APIs exposure to third party service provisioning enables service-dominant model for the connectivity and underlying network resources e.g., computing, data and intelligence. This can more efficiently balance supply and demand, raise the utilization of infrastructure and ultimately maximize economic value within the ecosystem (Ahokangas et al., 2019)

The cloud embedded in the edge of the network provides the optimized performance and economics for both the virtualized network functions and any other performance critical enterprise or vertical service and can become natural control point of the local connectivity and intelligence. It represents the source and destination of much of the demand combined with data and context analytic-enabled optimization capabilities. Edge cloud use cases considered in 5G are e.g., cloud radio access network, edge security, network and service automation enhancing the network itself, and industrial automation, massive scale IoT, and augmented intelligence with augmented reality/virtual reality (Mell & Grance, 2011). Open interfaces to network data enable operators to combine radio data with a variety of other data such as population data, 3D building maps, and activity data from different sources to automatically manage and orchestrate their networks, resources and services across domains and improve their customers' experience. Moreover, this approach can utilize digital twin concept (Gelernter, 1993) and leverage artificial intelligence/machine learning (AI/ML) algorithms to simulate network behavior 'in digital' world, based on the 5G use cases, each with its own capacity, coverage and performance needs.

3 RESEARCH METHODOLOGY AND CONTEXT

3.1 Research methodology

This research applies the anticipatory action learning methodology combined with interpretive case study of the Port of Oulu, Finland (Andrade, 2009; Reason & Bradbury, 2008). Action research is an interactive process that underlines the necessity of experimenting, reflecting and learning from exercises. This learning is best achieved through collaborative workshops for data and content generation action. In the workshops the various stakeholders of the port ecosystem collaborated to generate data and insight on the port ecosystem's digitalization from connectivity and data platform perspectives. Anticipatory action research presents a participatory style for transforming an organization and society (Inayatullah, 2006) and it can be utilized to validate empirical findings directly with ecosystem members, enabling the discovery of patterns and behavioral developments that have a direct impact on both the ecosystem's development and its boundary conditions (Tsujimoto et al., 2018).

The data for the research was collected in two phases in 2019 and 2020. Two workshops of the first phase were held in June 2019 and August 2019 to describe, explore, and analyze the port ecosystem, its digitalization via digital platform development from connectivity and data perspectives, and the potential antecedents and outcomes of digitalization of the port ecosystem. A total of 30 people from various stakeholders of the port ecosystem attended two workshops within a Finnish research project on 5G for verticals. The participants of the workshops represented the port itself, the companies working within port boundaries, the connectivity and data platform providers and users, the regulators influencing port activities, municipal authorities, as well as the researchers some of whom also facilitated the workshops. The focus of

the first workshop was to get a comprehensive understanding of the general port ecosystem consisting of its key stakeholders and their key activities, interactions, and constraints. The second workshop was organized to analyze the digitalization of the port from the connectivity and data platform perspectives with a focus on the key stakeholders for digitalization. The second phase of data collection was organized in April and May 2020 by interviewing representatives of the port management to complement and deepen the data generated in the workshops.

To ensure research quality, attention was paid to the constructs (i.e., the ecosystem and platform frameworks used), contents (i.e., data collected and used), capacities (i.e., representativeness of stakeholders), and conditions (i.e., the contextual focus) of the research (Floyd, 2012). Before publication, the findings and conclusions of the research were presented to the port ecosystem representatives and port management to ensure that the conclusions were shared by all and considered trustworthy, i.e., credible, transferable, dependable, and confirmable (Miles & Huberman, 1994; Lincoln & Guba, 1995).

3.2 The research context: Port of Oulu

The case study of this paper focuses on a port in the north of Finland – the Port of Oulu. Generally, the port is a transport hub through which mainly local industries transport goods. The port is a multi-stakeholder environment with different roles and goals for the stakeholders. While the actual physical port operations take place within a fenced area, the transport chains span outside of the port area. Digitalization is increasingly impacting the port operations coming from the different stakeholders' own digitalization actions within their own companies as well as joint actions within the case port.

The first step in the stakeholder analysis (Ackermann and Eden 2011) is to identify the stakeholders in the port ecosystem. This was done in two workshops arranged at the port where the representatives from most stakeholders were actually present. Figure 1 illustrates the identified port ecosystem stakeholders. The port ecosystem has a central stakeholder – the port itself – around which the port operations are orchestrated. The key activity of the port is to ensure efficient and smooth port operations for the stakeholders. Through digitalization, the port could facilitate the enhancement of the port stakeholders' operations by providing situational awareness to its stakeholders.

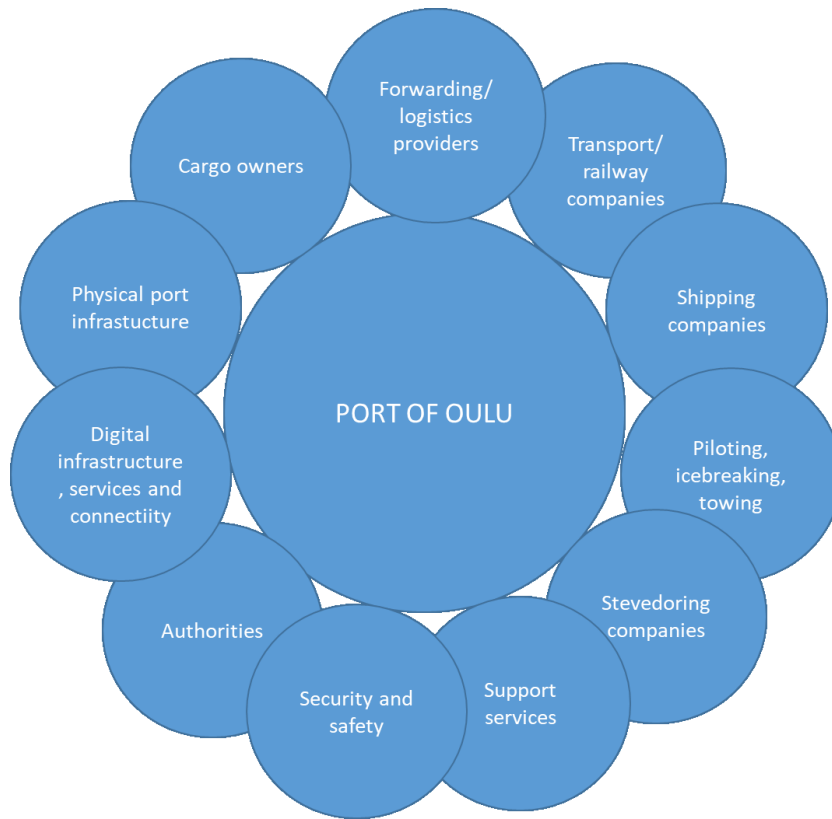


Figure 1. Identified port ecosystem stakeholders.

The second step of the port stakeholder analysis focused on exploring the stakeholder dynamics through understanding the key stakeholders' activities, relation to the central stakeholder the port, relation to platforms for digitalization, and related challenges and expectations. This was done in the two workshops by going through each stakeholder's key activities, partners, needs, constraints, benefits and barriers. The results are collected into Table 1.

Finally, the third step of port stakeholder analysis to develop actual stakeholder management strategies involved a more thorough understanding of how digitalization is actually taking place in the port and is discussed chapter 4.2.

Table 1. Key stakeholders' interactions in the port ecosystem.

Stakeholder	Key Activities	Business relation to port	Relation to platforms	Challenges
Cargo owner	To get its goods delivered. Ownership and liabilities over cargo may change during transportation.	Uses port services via transportation / logistics companies?	Information and tracking of cargo.	Low volumes, Lack of System Integrations and transparency.
Logistics/ transport companies	Efficient transporting of cargo to/from port, loading and unloading.	Represents cargo owner and has direct relationship to the port.	Own tracking system. Need data for situational awareness.	Limited visibility to the logistic chain and other stakeholders' operations/schedule changes.

Stevedoring	Loading and unloading ships/trucks/trains by using their machinery and infrastructures.	Direct contract with the port.	Own platforms?	Competition between other ports and other port operators, labor union, local available infrastructures.
Authorities	Governance through rules/ regulations/laws e.g. on environmental topics, security and safety.	Governing port operations.	Open data sources such as Ice data, vessel call data, weather data, railway data, sea conditions, traffic congestion. Own platforms for internal use.	Data sharing between authorities, multi-operator environment, local interpretations of regulation.
Security and safety providers	Ensure security and safety in the port.	Contracted by port.	Own platforms.	Several different actors, cyberattacks. Not possible to control activities or practices, lack of information exchange in multi-actor environment.
Physical port infrastructure	Lighting, piers, safety equipment, sea fairway signs, terminals, warehouses, and other facilities, roads, rails, construction. container fields, gates, port pool, liquid bulk pipelines.	(Mainly) owned by port	As main port asset, providing data (e.g. IoT) to the platform.	Environmental protection and regulation, natural conditions. Long life cycles -> combining assets along decades, technology expires, massive and costly infrastructure constructions built to last decades.
Data and computing platform providers	Storing of data.	Port buys platform services.	Provides platforms to stakeholders.	Lack of substance, invalid data
Connectivity platform providers	Offer high-quality wireless and wireline infrastructure.	Port buys services from connectivity providers.	Data collected via networks, network data.	MNO's interest in building local capacity; not serving the large public consumer groups, yet requirements for instant revenues Private network solutions; maturity and quality issues in both technology and new service processes

Digital services providers	e.g. Sensors and analytics, video analytics, positioning, edge analytics.	Port buys digital services.	Sensor data and analytics results, visualisations (drones).	Lack of substance.
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4 DATA ANALYSIS

The empirical data of the port case was analyzed against the conceptual framework discussed in chapter 2. For the two platforms discussed, connectivity and data platforms, three alternative platform configurations emerged from the data: fragmented, centralized and hybrid. The combining of the platforms builds on the idea of complementarity as a basis of platform convergence. In the fragmented platform configuration, each of the stakeholders of the port would develop a separated, stakeholder-specific connectivity and data platform developed or acquired for their needs. In the centralized platform configuration, a shared connectivity and data platform would be created to build common and shared services, although each of the stakeholders would maintain systems for managing their internal data and services. The in-between hybrid platform configuration shared elements from both centralized and fragmented configurations. Next, we discuss these three basic configurations in detail.

4.1 Alternative platform configurations

The fragmented platform configuration for the port reflects the situation where each of the port ecosystem stakeholders has developed or acquired for themselves data and connectivity platforms that only serve their own internal needs. Varying performance and functionality requirements are set forth and achieved by the stakeholders with varying costs and benefits. No dominant player exists within the port ecosystem—although the port acts as the common landlord for the other stakeholders—and minimal coordination takes place between the stakeholders as maximum freedom is sought after by them. This configuration resembles the company-internal ecosystem approach in that although the key stakeholder groups—the port itself, logistics/transport companies, stevedoring companies, safety and security companies, companies that build and maintain different physical infrastructures within the port area and the authorities—operate within the port boundaries, there is minimal and for most part one-on-one communications and interaction taking place within the port. This interaction exists to serve cargo owners that are the common customers for all stakeholders although the cargo owners are not themselves present within the port area. Each of the stakeholders have their own siloed connectivity platforms that may consist of WiFi and mobile networks, necessary data platforms and services they need to perform their activities. No shared data-based services exist in the ecosystem although centralized clouds may be used in a remote mode. As fragmented internal solutions dominate, the stakeholders enjoy only a weak situational awareness of port operations. This is explained while also made challenging by the fact that majority of the stakeholders, for example logistics and transportation companies as well as maintenance service providers operate also outside the port. For them, the port is only one location of operations. As a result, special attention needs to be paid to the value add enjoyed by the stakeholders and the ease of data collection in the platform. Figure 2 depicts the fragmented platform configuration.

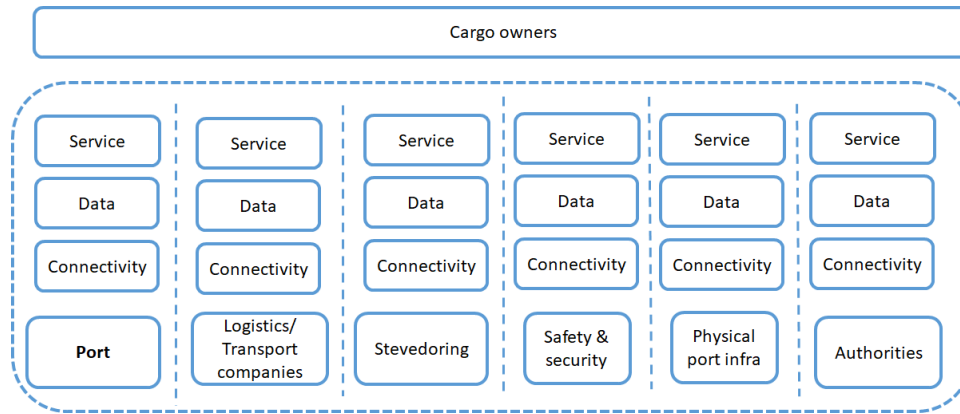


Fig. 2. The fragmented platform configuration.

The centralized data and connectivity platform configuration is depicted in Fig. 3. The centralized configuration is the functional opposite to the fragmented configuration discussed above and has a dominant central coordinating player for the data platform and the connectivity platform which can be the same player. Although it is natural to consider that the port acts as the dominant coordinating player for the ecosystem orchestrating a shared connectivity platform, shared data platform and shared services to provide tailored and guaranteed high-quality performance and functionality for the other port ecosystem stakeholders, in reality the port will not necessarily encompass the capabilities and needs to buy them as services from the outside. As a result, better cost-benefit of platform services and better situational awareness of port activities across other port ecosystem stakeholders can be achieved—the logistics/transport companies, stevedoring companies, safety and security companies, companies that build and maintain different physical infrastructures within the port area and the authorities. This configuration resembles the value-chain ecosystem approach where each of the players not only serve the common customer as if separately but as a part of an organized value chain where the shared platforms and services play a central role. Although the ecosystem stakeholders do have also their internal data and services needs and solutions, the shared platforms fully orchestrated by the central coordinating player enable the stakeholders to enjoy a good situational awareness of ongoing port operations.

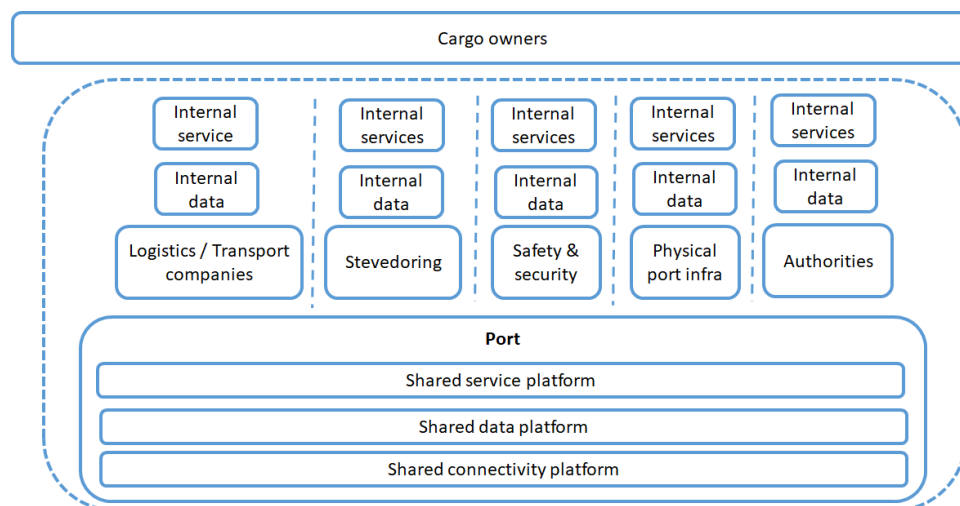


Fig. 3. The centralized platform configuration.

The hybrid platform configuration presented in Fig. 4 shares characteristics of both centralized and fragmented platform configurations. Although the port acts as the central player, it is not assuming a dominant role in the ecosystem but builds a connectivity and data platform with selected services to serve the shared goals of the port ecosystem. Each of the other ecosystem stakeholders—the logistics/transport companies, stevedoring companies, safety and security companies, companies that build and maintain

different physical infrastructures within the port area and the authorities—still focus on data that plays a central role in their operations, whereas connectivity and services based on also other stakeholders’ data may be acquired from the port’s platforms or through their own providers. Although the cost/benefit ratio of this configuration may not be the best in this configuration, it nevertheless enables the provisioning of data services for all stakeholders while also helps to achieve a good situational awareness of relevant port activities across all ecosystem stakeholders.

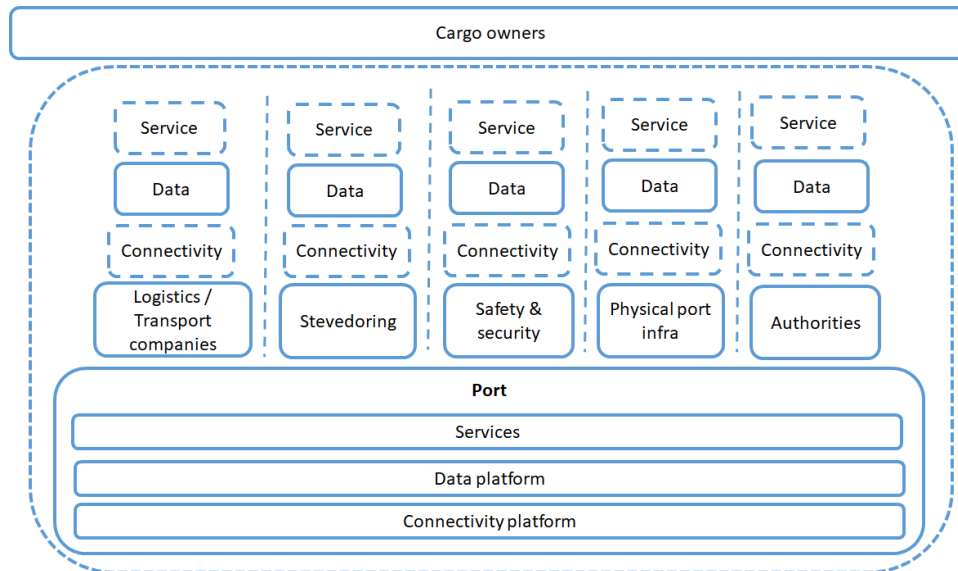


Fig. 4. The hybrid platform configuration.

Table 2 presents a more detailed description of the nine alternative connectivity and data platform configurations by using the centralized-hybrid-fragmented categorization as a basis. Note that this Table indicates the fundamental separation of business roles for data platform, connectivity platform and potentially for each service running on top of these. However, in practice a company, or an actor, may adopt more than one business role. For instance, a data platform provider (e.g., a cloud service provider) may provide via a marketplace both data and connectivity as a service or a connectivity platform provider (e.g., private network operator) may operate also data platform on building on its connectivity platform. But a healthy service ecosystem assumes that multiple actors can operate multiple services on top of a single platform, or that services operating on different data platforms can interconnect using agreed standards.

In the case of centralized connectivity, one dominant player for connectivity, either MNO or a private network operator, provides the connectivity platform and connectivity services. However, if analyzed across different data platform configurations, we may observe quite big differences regarding the role, availability and access to data and services. If data platforms are centralized, all services may become provided as a service by one dominant data player, cloud service provider or a any data intensive stakeholder, whereas if the data platform is of a hybrid type, only platform-specific data may be provided as a service. This may be due to the increased fragmentation of platforms. If the data platforms remain completely fragmented and siloed, self-service and one-on-one data sharing is assumed to prevail. In the case of hybrid connectivity platform and services, several parallel connectivity providers, either MNO, Neutral host or private network operator may exist. Also, the hybridity of the connectivity platform and services is reflected in the wider variation of the data platform. This may be related to the fact that connectivity and data services may become combined in different ways by different providers. In the case of fragmented connectivity platforms and services each stakeholder assumes responsibility of only their own needs and builds the connectivity either themselves or buys it from a mobile network operator while data platforms and services may be assumed to follow the same logic as in the case of centralized connectivity.

Table 2. Connectivity and data platform configurations.

		Data platform configuration		
		Centralized	Hybrid	Fragmented
Connectivity platform configuration	Centralized	Connectivity: One dominant player for connectivity, either MNO or private network operator Data: One dominant player for data, cloud service or local data intensive player Services: As-a-service mode	Connectivity: One dominant player for connectivity, either MNO or private network operator Data: Several data platforms with platform-specific data Services: Data-as-a-services	Connectivity: One dominant player for connectivity, either MNO or private network operator Data: Data in silos, no shared data One-to-one data sharing on demand Services: Self-service with data
	Hybrid	Connectivity: Several parallel connectivity providers, either MNO, Neutral host for connectivity (RAN + multiple core networks) or private network operator Data: One dominant player for data, cloud service or local data intensive player Services: As-a-service mode	Connectivity: Several parallel connectivity providers, either MNO, Neutral host for connectivity (RAN + multiple core networks) or private network operator Data: Several data platforms with platform-specific data Services: Data-as-a-service Connectivity and data services may be combined	Connectivity: Several parallel connectivity providers, either MNO, Neutral host for connectivity (RAN + multiple core networks) or private network operator Data: Data in silos, no shared data One-to-one data sharing on demand Services: Self-service with data
	Fragmented	Connectivity: Everyone takes care of their own connectivity needs MNO provided or own connectivity Data: One dominant player for data, cloud service or any data intensive player Services: As-a-service mode	Connectivity: Everyone takes care of their own connectivity needs MNO provided or own connectivity Data: Several data platforms with platform-specific data Services: Data-as-a-service	Connectivity: Everyone takes care of their own connectivity needs MNO provided or own connectivity Data: Data in silos, no shared data One-to-one data sharing on demand Services: Self-service with data

4.2 Management actions for the digitalizing of the port

To continue with the stakeholder analysis for the port ecosystem, the third step after identification and interactions described in chapter 4.1 involves the defining of the required management actions for port digitalization. Table 2 may be considered as a state diagram which raises the question of possible states and state transitions. This question will be discussed below using the Port of Oulu case and present a roadmap example of the possible transition. The feasibility of our proposed framework can be tested by applying it in a practical case. We perform this by developing a strategic service roadmap for our case port, using the

structures of the framework. This roadmap starts from the typical fragmented port model and ends up to an idealistic model which consists of a centralized connectivity platform and hybrid/centralized data platform. The strategic digitalization steps for any digitalizing port can be listed as follows:

1. Fragmented data vs. fragmented connectivity
 - a. Provide the port stakeholders with solid human coordination (face-to-face, phone, email) and keep this capability as a fall back process when increasing automation in the next steps.
 - b. Provide the port stakeholders with web based manual access to initial centralized port data services on port data platform (over fragmented private networks and through Internet). This may include for instance the basic time tables of all arriving and departing cargos (vehicles, ships, trains) as an elementary service for situational awareness.
2. Fragmented data vs. hybrid connectivity
 - a. Provide the port stakeholders with a unified private connectivity platform (e.g. WiFi or 4G/5G) covering the whole port area for accessing the centralized port data platform. Some port stakeholders still continue using their own fragmented private networks for their internal purposes.
 - b. Provide the port stakeholders with improved web-based situational awareness by adding IoT sensors to the unified private network. Examples include security surveillance (e.g. via automated drones and burglar alarms) and cargo follow-up (e.g. via uniform tagging and monitoring location of containers).
3. Optimally hybrid data vs. optimally centralized connectivity
 - a. Provide the stakeholders with automated interfaces between the stakeholder's internal and the centralized port data platforms. This further improves both the creation and sharing of the port situational awareness by enabling the stakeholders to share some of their specific database and IoT data. The centralized data platform replaces some functions in the stakeholder internal legacy data platforms.
 - b. Enforce and incentivize all stakeholders to participate in the automated use of the unified port network and port data platform.
 - c. Continue optimizing the unified port connectivity (e.g. slicing, edge computing) and data (e.g. federated data platforms, block chain transactions) platforms for more demanding services

Note that this is based on a case example and some ports may well prioritize the order of strategic steps differently due to local history and context. Correspondingly, they may also prioritize the specific services differently.

5 CONCLUSIONS

Situational awareness appears as the starting point and driver for the digitalization of the port. A better situational awareness brings value to all stakeholders in the port ecosystem, thereby giving the impetus for building connectivity and data platforms and enhancing the transformation of the traditionally vertically arranged port ecosystems. By analyzing connectivity and data platform configurations, we have contributed by presenting a platform configuration categorization of fragmented, centralized and hybrid platforms. As discussed in the theory part of this paper, it is often useful to divide the general platform concept into more concrete platforms through separation of concern. This separation can be based on technical, legal, or business criteria. In the context of digital platforms, the separation is between data, connectivity and services because the services ecosystem needs one or more data platforms and one or more connectivity platforms to take place. And because data and connectivity platforms have evolved each as a separate technical and business entity. Correspondingly, a set of data or connectivity platforms can be fragmented (platforms isolated from each other), centralized (dominated by a single platform), or hybrid (multiple interconnected

platforms). The fundamental management questions regarding the platforms is then whether to make or buy them.

In the target configuration, a critical aspect of the 5G network in the multi-tenant port environment, is the ability to create customized network slices, where instances of virtual network resources can be delivered to services tailored to specific stakeholder needs with service level agreed (SLA) performance on demand. Furthermore, the software-based network architecture enables cost efficient infrastructure sharing by different tenants, open the ecosystem to new players, and reduce service creation and activation times. The proliferation of increasingly powerful communication, computing, and analytics resources at the local edge of the network provides the optimized performance and economics for both the connectivity and any other performance critical service. Edge cloud provided by the connectivity provider or cloud service provider can become enabler of the platform convergence and the control point of the local connectivity, data, and services. A hybrid data platform model can improve coordination among stakeholders by sharing data in a centrally coordinated manner.

As each stakeholder have their own data platforms to serve their internal needs, also outside the port context researched in this paper, the convergence of data platforms and further digitalization of the port may only take place when and in areas there is a common interest between the stakeholders. As a result, it is likely that federation of services and matchmaking type of activities emerge in the port context. The proposed optimally hybrid data platform with optimally centralized connectivity appears as likely configuration for converged connectivity and data platforms. The port ecosystem as a multi-stakeholder environment going through digitalization requires a clear central player to orchestrate the development. This role naturally belongs to the port operator itself who then needs to decide what to make by themselves and what to buy from the outside. In the main service identified in the port ecosystem, the situational awareness, virtually all stakeholders play a role as a provider of data for creating the situational awareness, using the situational awareness to enhance own operations or both. Who are the stakeholders that could become the providers of converged connectivity and data platforms and related services in the future? Cloud providers might also offer connectivity as a service as a dealer, and connectivity providers could use their edge cloud for offering data services. As each stakeholder have their own data platforms to serve their internal needs, also outside the port context researched in this paper, the convergence of data platforms and further digitalization of the port may only take place when and in areas there is a common interest between the stakeholders. As a result, it is likely that federation of services and matchmaking type of activities emerge in the port context.

The proposed optimally hybrid data platform with optimally centralized connectivity appears as likely configuration for converged connectivity and data platforms. When it comes to the specifics of the connectivity and data platforms, the actor vs. business role for these two platforms can be an important distinction. These two are technically and process-wise different businesses/business roles but of course the same actor can decide to adopt both business roles. This type of business strategy increases the probability of customers to buy both solutions from the same vendor. For an actor to expand to a new business role it is easier when the new business role (e.g. corporate connectivity platform) is of smaller total value compared to the actor's existing business role (e.g. corporate data platform). Correspondingly, if the customer's value of these platforms has the same relative bias, the vendor's expansion becomes further easier. Finally, requirements for a local ecosystem such as the port to evolve from the fragmented data and connectivity configurations towards the optimally hybrid data and optimally centralized connectivity configuration, include sufficiently advanced ICT technology to enable higher automation, sufficient level of competition (between ports, between similar stakeholders within a port) to incentivize innovation and sufficient level of trust between the port stakeholders, especially with the port operator.

This research has certain limitations regarding generalization and transferability of outcomes. First, it is based on a single, qualitative case study based on anticipatory action learning methodology combined with interpretive case study. Further research is encouraged to be conducted in other ports or other similar contexts to validate and generalize the findings. In addition, further research is suggested to focus on creating more detailed techno-economic value configurations of the converged connectivity and data platform

ecosystems, study the role of edge cloud and cloud service providers in the different kinds of platform ecosystems. Finally, the port provides an interesting research context also to study regulatory starting points and consequences in the intersection of the telecommunications regulations, data privacy and security regulations and vertical-specific regulations.

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