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# The significance and barriers to organizational interoperability in smart service ecosystems: A socio-Technical Systems approach

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## Abstract.

Smart service ecosystems (SSEs) struggle a lot with interoperability. Interoperability consists of many types but two are of interest in this paper: - (1) syntactic and semantic interoperability, and (2) organizational interoperability. While both have received a fair amount of attention in the literature, there's little discussion on the alignment between (1) and (2), which we argue, is a key enabler of dynamic service integration in SSEs.

This paper explores the significance of (mis)alignment between (1) and (2), and the barriers to organizational interoperability in smart service ecosystems. The empirical data for the paper comes from an ongoing innovation project in Norway that aims to develop a smart, secure, and cost-effective home access solution for senior care homes in the municipality of Lillehammer. The empirical findings emphasize the significance of organizational contexts, and demonstrate in part, the theoretical limitations of the socio-technical systems approach when applied to the SSE perspective.

**Keywords:** Smart services, Smart service ecosystems, Ecosystems, organizational interoperability, Socio-Technical Systems Approach.

## 1 Introduction

Advances in information technology particularly in industry 4.0, ubiquitous computing, and device miniaturization have led to rapid innovation in services. As a result, smart service innovations have emerged to address some of society's complex challenges [1]. The term smart service means "a service delivered through intelligent products that feature awareness and connectivity" [2]. The nature of value creation of smart services

is built around product or service platforms that leverage resources and technologies of hundreds of value chain actors (suppliers, competitors, etc.) hence the concept of smart service ecosystems [3, 4].

An ecosystem can be defined as a community of loose but interdependent actors that engage in complementary value co-creation [2, 5]. Ecosystems “enable intensive data and information interactions among people and organizations to improve their decision making and operations” [2, 6]: and have self-configuration and regulation capabilities. By this characterization, smart service ecosystems (SSEs) infer technology-mediated service systems where value co-creation occurs by mutual cooperation and resource sharing across different actors, each with their own value/service offerings [1,3,7].

The development (and co-production) of a smart service in an SSE environment requires multiple organizations to interact at two layers of interoperability. The technical layer, i.e., syntactic and semantic interoperability, and the organizational layer, i.e., organizational interoperability [8,9]. Technical interoperability involves machine-to-machine interactions whose standards such as TCP/IP, HTML, SOAP, etc. are relatively well developed both in the information systems (IS) literature [6,7] and in the ISO standards. In this paper, we specifically focus on ISO9241 and ISO23903. Organizational interoperability however largely depends on generic frameworks such as the European interoperability framework (EIF), e-government Interoperability Framework (eGIF), Level of Information System Interoperability System (LISI), etc [10]. This paper shall specifically focus on the more comprehensive EIF.

While the two interoperability layers demonstrate a comprehensive backbone for value co-creation in most SSE, they are domain-specific and rarely linked [9,11]. SSE attributes demand that individual actors cope with the interaction complexity that comes with the multiple actors, different technology platforms, and their different data and information exchange models – often involving heterogeneous user devices, protocols, and system architectures [1, 2, 6]. Some level of alignment of both technical and organizational layers is expected, yet this has gone unnoticed in the organizational sciences (OS) literature [8, 12].

In this paper, we want to argue for the significance of alignment of the technical and the organizational interoperability layers, and then outline some of the barriers to organizational interoperability in the design and production of smart services. The significance of such an alignment in the development of smart service ecosystems is twofold. First, the additional cost of attracting new, innovative actors to participate in the further development of platform-interdependent services will be considerably low due to the ease of fit amongst all actors at the two interoperability levels layers [13]. And second, the quality of service (QoS) improves due to the ease of the available actionable data and information that is negotiated consistently across each actor's organizational boundaries in the entire SSE [2].

The aim and contribution of the paper are to advance new knowledge about the significance and the challenges of translating technical standards and frameworks into inter-organizational interoperability in SSEs. According to Kosanke [11], new frameworks and standards are needed to address interoperability beyond data syntaxes and more as the basis for cross-enterprise decision support in order to increase information

usability and the quality of decisions at the operational level. This is precisely what organizational interoperability aims to address.

This paper is organized as follows. First, we briefly review relevant literature on interoperability challenges in SSE environments; second, we describe the methods used; third, we discuss the findings from a project which aims to design and deploy an IoT-based solution for home care services, and finally, we present the synthesis and key learning points including theoretical implications.

## 2 The significance and challenges of interoperability in SSEs

The concept of “interoperability” has long been associated with the ability of systems to provide and exchange services with other systems and can accept services from other systems based on agreed operational semantics [12,14]. However, in the OS literature, the human-technology-organization interface is usually the focal point, where interoperability is seen as the “ability of an enterprise to cooperate with its business partners and to efficiently establish, conduct, and develop IT-supported business relationships with the objective of creating value” [10, p.3].

Several studies [3, 9, 14] suggest that ecosystems, in general, depend on inter-organizational cooperation as a basic building block for human-technology cooperation even at the enterprise systems architectural level. Broy et al., [15] show how cyber-plant systems increase user value because of a better connection between things and people and between things and providers. Weichhart et al., [13] maintain that enterprise integration supports informational and knowledge exchange which in turn supports interoperability of IT applications. Heiler [14] provides some useful examples of the significance of human-system cooperation enabling better interoperability, i.e., that human intelligence is needed to resolve mismatches in semantic information, while the documentation of semantics of legacy systems requires human interventions.

In sum, technical (machine, syntactic and semantic) interoperability levels require context which resides at the organizational level. Organizational contexts provide resources, workflow mechanisms, and processes that allow data and information sharing across different organizational boundaries [12]. SSEs that appropriate the most value tend to be those that efficiently integrate both technical (syntactic and semantic) and organization interoperability at both the enterprise level and the ecosystem level.

While the linkage between technical and organizational interoperability is notably challenging in practice [7], we have argued that the feasibility of such a linkage is critical for the viability and deployment of SSEs and other similar digital service solutions. In a study of cyber plant systems, Broy et al., [15] classify interoperability challenges into two groups: social challenges and technological/engineering challenges. Examples of social challenges cited include i) the design of suitable human-system cooperation, (ii) suitability of the system to task, and (iii) explainability and fault tolerance of the system. Technological challenges cited include, (i) integrating different domains into the system, (ii) interoperation of infrastructures or reference architectures, and (iii) modeling non-functional requirements and privacy aspects.

To conclude, there exists an admissible link between technical and organizational interoperability despite the idiosyncratic challenges each from their knowledge domain. Most importantly, the blurred line between the IS and OS literature on interoperability barriers provides reason to adopt the socio-technical systems (STS) lens going forward.

### **3 Research setting, methods, and empirics**

#### **3.1 Conceptual framework**

Building further on the literature, we adopt the STS approach to frame the forthcoming analysis and discussion. The STS approach offers the view of organizations through the social (people, processes, and relationships) and technical (equipment and technology) subsystems [9]. We contextualize the development of interoperable SSEs as environments that demand a holistic lens across both the technical areas such as data, security, platforms, etc. and the non-technical areas such as culture, organizational policies, local coalitions, business models, etc [9]. The STS approach strongly emphasizes interaction and communication, and collective action in the development of technical artifacts as a system of work [16]. Our departure point is the principle of interdependence and contextual understanding of information acquisition, analysis, and diagnosis (e.g., of actors, roles and interests, and interfaces). This aligns nicely with the multilayer framework for service system analysis of Frost et al [6].

#### **3.2 Methods and Material**

The paper is a qualitative inquiry based on the case study method [17]. It draws empirical data from an ongoing innovation project called “internet of my things” (<https://www.internetofmythings.no/>) (the IoMt project). The IoMt project aims to develop a proof of concept (POC) for a load-bearing structure of an internet of things (IoT)-based system where elderly inhabitants in Lillehammer municipality can use their privately owned devices to access home care services offered by the municipality.

While the scope of the project is much wider than what we can present in this paper, we specifically focus on the processes involving the development of the POC for a smart-door lock solution. In this regard, the municipality hopes it will replace the mechanical “key and key box” located at the door of each home care service receiver in the municipality. More details of the case are presented in the next section. However, the central idea behind the project is to develop a robust, well-integrated IoT-based architecture using the smart-doorlock solution as the starting point. Such systems do exist already in Norway and abroad, but most are not well integrated between users and homecare workers. Besides the proposed solution shall give more power to users to be able to digitally give and withdraw consent/and access to their homes as they wish.

In this case study, several organizations are involved in the POC development, but we focus on 5 as the main source of data for the paper. This excludes 2 R&D partners. The 5 actors include a platform owner, a hardware supplier, the service owner, a solution support company, and an internet infrastructure service company. The empirical data sources included: 4 in-person interviews, 6 stakeholder workshops, 5 focus group discussion (FGD) workshops, 2 internal project meetings, and numerous secondary data

that have been collected into *Miro*, a data visualization and collaboration tool. This data is sufficient for case research whose aim is theory generation [17].

### 3.3 A brief case description and the empirical basis for discussion

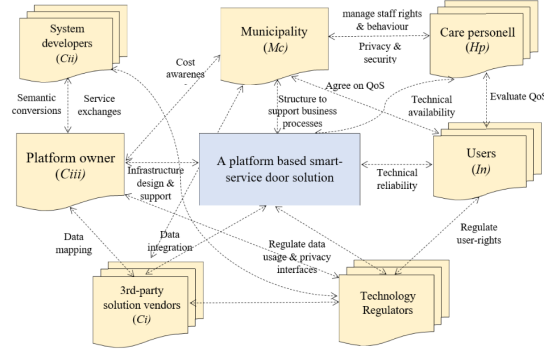
Homecare services in Norway are regulated by the *Health and Care Services Act* which gives municipalities the overall responsibility to ensure that all inhabitants have comprehensive access to health and home care services (*Health and Care Services Act § 3-1*). Some of these services, such as home care visits, user-managed personal assistance (BPA) services, occupational therapy, drug-assisted rehabilitation services, etc. are offered at the home of a patient by home care nurses and BPA assistants. 24-hour/7day access to patient homes is available through physical keys located in “key boxes” at the patients’ homes where care nurses or BPA assistants follow a defined schedule for home visits. Currently, the key handling and administration procedures are far too complex, inefficient, not user-centered, and can involve several security risks. The municipality wants to overhaul the entire “key and key box” system hence the ioMt project.

The project was a result of a need by the municipality of Lillehammer to digitalize the key handling procedures thus the proposed smart-doorlock solution. Compared to the traditional “keys and key box”, the benefit of the proposed smart-door lock solution would give the care-receiver ownership and control of the access rights to their home. This involves giving and withdrawing permission of access for planned visits by the municipality and unplanned visits when the patient needs emergency help. The municipality believes the new service will reduce cost and inefficiency in the “keys and key box” system. The unit purchase cost of the “keys and keybox” solution is about 1650 NOK ( $\approx$  \$165 or €155). The new solution will be economically cheaper in the long run.

**What are the main interests?** Benefits aside, the development of the smart doorlock solution (i.e., the POC) highlights several emergent technical and organizational issues and interests that we emphasize in **Fig.1**. The most important ones identified in FGD workshops were reliability, trust, and data privacy of the solution. The municipality’s home care services department needs to trust that the smart doorlock can be opened whenever they have service needs based on the agreed day’s plan and that the patient can trust that the digital technology and data that are logged with the municipality’s homecare service is used according to the inhabitant’s individual privacy preferences.

**Who are the key actors?** For this paper, we chose to limit the ecosystem to the actors directly involved in the POC development as presented in a simplified SSE structure in **Fig.1**. The patient or inhabitant (*In*) “purchases” home care services from the municipality (*Mc*) and is given access to the solution by *Mc*. The homecare personnel (*Hp*) have access to all patient data (EPJ) through a *Mobile Lifecare Pleie* app (LMP). *Ci* is a 3<sup>rd</sup> party supplier that provides technical support to *Mc* in healthcare. In this SSE, *Ci* works to develop data trust systems as a service solution to the municipality. Another company *Cii* provides an application programming interface (API) in which the hardware (the smart doorlock) and the IoT gateway speak to each other. Software for the IoT gateway is provided by another company *Ciii* which owns a robust IoT business platform on which the smart doorlock solution is to be hosted. *Ciii*’s IoT

platform already hosts numerous applications for other companies involved in energy-loss monitoring, fire protection, moisture monitoring, air-quality monitoring, etc.



**Fig. 1.** A simplified service development ecosystem for the smart door solution

**What are the key interfaces in this SSE?** In Fig. 1., we identified several interfaces, but we grouped all the SSE actors into 3 main schemas based on the strength of the interaction intensity in their interests' using data from the FGDs. From these schemas, we identified overlap areas across 3 schemas shown in Table 1. These overlaps are the most convergent interoperability dimensions that we discuss further in section 5.

- In **the solution–Mc–Hp–In interface**, the primary beneficiary *In* is interested in trust and privacy (e.g., data protection), the QoS, and reliability of the service. *Hp* is largely interested in the technical availability and reliability of the service. *Mc* is interested in ensuring consistency of the solution and coherence with the existing “key and key box” processes, role and policy clarity, the cost-effectiveness of the solution, and alignment with organizational strategy and vision.
- In **the solution–Ci–Cii–Ciii interface**, the platform owner *Ciii* is interested in the alignment of data semantics, and the platform deployment model with *Cii*, while the vendor *Ci* who represents *Mc*'s technical interests seeks to ensure that platform's information exchange models, schemas, and interfaces are aligned with *Mc*'s infrastructure, data policies, business processes, and resources.
- In **the solution–In–regulators interface**, the interest of regulators (*reg.*) is that solution does not breach the national data protection laws and the EU's General Data Protection Regulations laws concerning the rights of *In*, and *Hp*. *Mc* and *Ci* work to embed these legal requirements in their data governance policies.

**Table 1.** Identifying the most aligned interoperability dimensions.

Schema	<i>Mc</i>	<i>Hp</i>	<i>In</i>	<i>Reg.</i>	<i>Ci</i>	<i>Cii</i>	<i>Ciii</i>	Overlapping interests
Solution–Mc–Hp–In interface	–	–	–	✓	✓	–	✓	business processes: organizational policies & strategy: cost
Solution–Ci–Cii–Ciii interface	✓	–	–	✓	–	–	–	data integration standards: semantic matching
Solution–In–regulators' interface	✓	–	–	–	✓	✓	✓	common understanding of legislation: internal policies and rules



## 4 Discussion, conclusions, and further research

Getting back to the significance of alignment of the technical and organizational interoperability layers, our findings show us that alignment is possible because all actors that participate in service ecosystems tend to have common methods and routines of organizing work and interactions. At an abstract level, most organizations are similarly structured [9]. **Table 1** highlights these overlapping themes such as strategy and business process alignment, and organizational design comparability. The OS literature would suggest that organizations are by nature social structures whose governance and work routines tend to have similar patterns [2, 9]. These characterizations are partly consistent with Liu et al. [18] however a notable distinction of our study from Liu et al. is the significance of organizational contexts which in this case, appears to limit alignment and integration when more specific themes such as business model designs, ethics and cultures, and idiosyncratic knowledge are considered – c.f. [9, 12, 14].

We found similar evidence across the technological layer. As one moved away from the general themes to more specific dimensions, SSE actors' interests differed significantly, especially in their infrastructure models and how they applied the different technical standards. While all actors agreed that trust and privacy were important themes of the project, each actor's knowledge of trust and privacy for the doorlock solution varied. The reason for this variation was the ever-changing standards and interests within each organization. Even in the adoption of standards frameworks, domain-specific extensions and ontologies exist and are not covered comprehensively by standards [7, 8].

With regard to the challenges to organizational interoperability in the design and co-production of smart services, SSEs appear to present unique barriers that are unknown in practice and theory. We found several barriers mainly as a result of ecosystem heterogeneity. The common barriers included varied data semantics and representations, different data, and information exchange models, as well how each actor sought to deploy resources in the POC or the solution. Perhaps the biggest barrier as also noted by [8, 12] was the different competence levels among SSE actors, which increases the complexity as new platforms and new devices emerge.

In short, attaining full-scale social and technological interoperability in projects involving the design and deployment of smart services is near impossible – particularly in SSE environments. This study highlights some factors which support this position. Conversely, there are also overarching factors that can support successful interoperation. These include the existence of (1) enterprise interoperability frameworks and (2) global standards. The most used framework is the EIF, and two International Organization for Standardization (ISO) standards, i.e., ISO9241 (human-centered design principles and activities for computer-based interactive systems, 2020) and ISO23903 (interoperability and integration reference architecture for Health informatics, 2021). Our main takeaway is that familiar interoperability frameworks and standards will tend to “enforce” organizational interoperability, but shared interests enable it – c.f. [9, 18].

#### 4.1 Towards refinement of the Socio-Technical Systems Approach

We attempted to frame the interoperability problem in the development of smart services using the STS approach. However, the criticism of STS theory that's emerged out of this paper is the overall abstractness of the approach which makes it difficult for empirical testing. The other challenge emerges from the limited constructs available within STS to enable detailed deconstruction of social and organizational complexity in SSEs (e.g., reconciling different technical interests). Therefore, to refine the STS perspective we propose expanding the STS lexicon. The other approach proposed by [16] seeks to combine STS thinking with the socio-technical systems engineering (STSE) perspective to change mindsets and convince engineers of the STS's value.

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