Dialectic Tensions in the Context of Inter-organizational Integration

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Abstract

This study compares the perspectives on inter-organizational integration of information between stakeholders of the architecture, engineering, construction, and facilities management (AEC/FM) industry in Finland. Our findings are grounded on semi-structured interviews with practitioners that participated in a project of the Finnish government. Applying the theoretical framework of dialectical analysis, we identified six dimensions where conflicting points of view may arise regarding shared information: Ontology, standards, storage, openness, monetization and the involvement of the public sector. We argue that stakeholders will have stronger motivation to integrate with new actors if they share the same vision about one or more of such challenge areas. Awareness of these tensions helps to understand and guide the development of inter-organizational information systems in networked industries.

Keywords: information systems, inter-organizational integration, dialectics, AEC/FM

Introduction

The Architecture, Engineering and Construction (AEC) industry is usually described as fragmented and unintegrated (Nam and Tatum 1992; Papadonikolaki et al. 2017; Papadonikolaki and Wamelink 2017). It operates as a project-based network of stakeholders that must coordinate specialized and differentiated tasks (Dubois and Gadde 2002; Gann and Salter 2000) to produce investment goods such as buildings, roads or bridges according to unique specifications (Kamara et al. 2002). Stakeholder involvement tends to be highly dissociated throughout the various stages of the building lifecycle, because the AEC processes are often performed by different teams than the ones in charge of the building operations, also called Facility Management or FM (Vanlande et al. 2008). Already 30 years ago, scholars observed that AEC/FM industry had more vertical fragmentation (i.e. between project phases) and horizontal fragmentation (i.e. between specialists at any given project phase) than manufacturing, negatively affecting the productivity and competitiveness of the sector (Howard et al. 1989). For these reasons, AEC/FM practitioners widely agree that sharing or exchanging information across organizational boundaries is a fundamental requirement to achieve more efficient resource usage (Volk et al. 2014), time and cost reduction (Vanlande et al. 2008), increased productivity, improved business performance and overall quality of buildings (Ahmad et al. 1995; Nam and Tatum 1992).

The development of Building Information Modelling (BIM) software tools since the early 2000s has provided new opportunities to reduce fragmentation in the AEC/FM industry and increased the exchange

of data between actors from different organizations in the supply chain network. From a technical perspective, BIM broadly refers to the domain of loosely coupled information systems (IS) used to generate (authoring tools), control (model checking tools) and manage (planning tools) building information (Papadonikolaki and Wamelink 2017) in terms of their 3D geometric and non-geometric (functional) attributes and relationships (Ghaffarianhoseini et al. 2017) in an interoperable and reusable way throughout the lifecycle of the building (Papadonikolaki and Wamelink 2017; Vanlande et al. 2008). BIM has been described as a new paradigm and evolutionary step of Computer-Aided Design (CAD) (Bryde et al. 2013; Succar 2009; Vanlande et al. 2008) allowing to support not only the design activities but also the procurement, fabrication and construction processes of a building project, as well as the operation and maintenance after the building has been completed (Azhar 2011).

Among industry practitioners, the acronym of BIM has been increasingly referenced as "Building Information Management", with the aim of bringing attention to other dimensions besides the technology – namely the process and people needed to create, enable or manage the building information (Lindgren and Widén 2018). Consequently, BIM software tools are now considered as just one component to achieve closer collaboration between companies. In recent IS literature, these sociotechnical integration phenomena have been described as digital infrastructures (Lyytinen et al. 2017) supported by inter-organizational information systems (IOIS) that spread through the boundaries of at least two autonomous organizations, who use them jointly to benefit from common or shared IT capabilities through standardized interfaces (Lyytinen and Damsgaard 2011; Reimers et al. 2010).

From a practical perspective, AEC/FM practitioners are certainly interested in the possibilities to integrate with other actors and develop common platform ecosystems across the industry (e.g. by using BIM), but the organizational implications and challenges of such projects are often unclear. Our review of previous studies suggests that integrating information of common interest for multiple stakeholder groups across an entire industry is a topic that has not been sufficiently covered in the IS or AEC/FM fields from the perspective of the practitioners themselves. The existing literature about IOIS has extensively explored the adoption and implementation of such systems within specific time-bound projects, without providing thorough theoretical models to understand their evolution across longer lifecycles (Reimers et al. 2014). Similar limitations may be found in dedicated AEC/FM studies, which have covered BIM adoption mostly from the perspective of individual actors while overlooking the holistic view of the inter-organizational dependencies and decision-making that are fundamental in a networked industry (Papadonikolaki et al. 2017).

To address these research gaps, we adopt a dialectical approach that highlights how the diverging opinions of industry stakeholders about sharing information across company borders can lead to tensions. Thus, the primary aim of this paper is to explore and compare the heterogeneous perspectives of diverse AEC/FM practitioners about the information they must (and are willing to) exchange with other stakeholders across organizational boundaries. These goals are summarized with the research questions "*How do the opinions about integrating information across organizational boundaries differ between the stakeholders of a networked industry?"* and *"How do the emerging dialectic tensions between these stakeholders influence the development of inter-organizational information systems?"* Even though the phenomenon of the inter-organizational integration of information – and the conflicting points of view of different actors about the topic – is not exclusive to the AEC/FM industry, we consider it as an ideal study context due to its networked and fragmented nature. Thus, we present a case study taking the whole AEC/FM industry in Finland as its unit of analysis.

The theoretical lens of dialectics employed in this research has been previously deemed suitable to explain both the persistence and the transformation of IOIS over time (Reimers et al. 2014). It has been used in prior IS, management and software engineering (SE) studies to describe the motivations and methods of organizational change (van de Ven and Poole 1995) as well as the conflicting interests arising during the development and implementation of enterprise systems (Moe et al. 2017; Nordheim and Päivärinta 2006; Robey et al. 2002; Soh et al. 2003). We build upon and expand the previous contributions by applying the dialectical analysis in the context of a whole industry, with multiple stakeholders struggling between the *status quo* and potential new business opportunities resulting from inter-organizational integration. We consider dialectics a suitable theoretical lens to approach this issue, because it transforms any "lessons learned" from our case study into action points for practitioners. To support the sensemaking process and give meaning to our research findings, we also frame our discussion in higher-level theories by Tilson et al.

(2010) and Lyytinen et al. (2017), which portray the evolution of digital infrastructures as the result of dialectical tensions. By applying these theories in our case study, we provide new opportunities to improve our current understanding of how the development and implementation of IOIS can be guided by opposing industry forces.

Our results derive from semi-structured interviews with key representatives of the Finnish AEC/FM industry during 2018, who were enquired about the technological, business and socio-organizational challenges to integrate the information of buildings across their organizational boundaries. We identified six key aspects where the stakeholders' points of view can clash and lead to tensions. From the perspective of practitioners, this study provides a theoretical framework that helps managers and other decision-makers define clearer strategies for their inter-organizational integration projects. From the scholarly perspective, this paper contributes to existing IS research by extending the scope of dialectical analysis from a single company or project into a network of dissimilar organizations collaborating in the same industry over long timeframes. We also expand the discussion about the relationship between the concepts of IOIS and digital infrastructures. To position our own findings within current IS literature, we apply previous theories that describe the changes in these sociotechnical systems as the result of dialectical tensions.

The paper is structured as follows: Firstly, we review the theory about integration and dialectical analysis. The next section introduces the case study background and the research methodology used to choose the research participants, collect data and analyze our findings. We present our key observations from the interview data, which are later contrasted to previous IS studies. Finally, we summarize the limitations, future opportunities and conclusions of our research.

Background

We present in this section the theoretical basis of our study, reviewing previous research on inter-organizational integration of information and dialectics.

Inter-organizational integration of information

Integration is an encompassing concept that has been approached in IS, management or software engineering literature from various angles, depending on the aim or focus of the study (Barki and Pinsonneault 2005). Organizational research applies the term in general to describe the efforts undertaken in connecting business structures to facilitate cross-functional processes. To guide such ventures, previous IS studies have developed extensive theories which explain how information technology (IT) solutions at the data, application and systems level – or in general terms simply "information integration", support the integration of functions, units or entire organizations (Berente et al. 2009). Literature reviews about integration in an organizational context have concluded that this phenomenon entails technical, organizational, business and social aspects (Chowanetz et al. 2012). Accordingly, integration can be studied from three perspectives that are intertwined and cumulatively built on top of each other: technical, business and socio-organizational (Kähkönen 2017).

Scholars have also proposed different categories of integration aiming to explain – among other aspects – the question of "at what scope" is the integration occurring. This latter dimension, named integration reach (Chowanetz et al. 2012), takes the process chain of the organizations as an overarching reference and can be either internal (i.e. intra-organizational) or external (i.e. inter-organizational or cross-organizational), depending on whether the integrated process in question has to go across the boundaries of an individual or multiple organizations (Barki and Pinsonneault 2005). An IOIS exists in the context of at least two autonomous organizations but can encompass a whole industry along with the suppliers and customers of the organizations operating in it (Lyytinen and Damsgaard 2011; Reimers et al. 2010). Consequently, we define the phenomenon of "inter-organizational integration of information" as the integration of an IOIS, which enables to share and exchange information across the boundaries of various autonomous organizations, to support the business processes that demand their mutual communication and coordination. This concept accounts for the technical, business and socio-organizational layers of integration alike.

To integrate information across organizational boundaries, different industry stakeholders may decide to adapt their existing IT systems or implement entirely new software platforms that can be used by other

companies. In previous IS research, such resources enabling the operations of multiple actors at the corporate, industry, national, regional or global level have been conceptualized under the name of digital infrastructures. This high-level term refers to "shared, unbounded, open, heterogeneous and evolving socio-technical systems, composed of IT capabilities and their design, operations and user communities" (Hanseth and Lyytinen 2010; Tilson et al. 2010).

Our observations and discussion are focused on the development and evolution of digital infrastructures within one specific industry: The Finnish AEC/FM sector. In this study, we consider digital infrastructures and IOIS the same[1], because in either case the phenomenon under study is the exchange of information between multiple organizations. For this reason, observing the tensions that emerge between stakeholders helps to understand both the development of IOIS and the evolution of digital infrastructures spanning across an entire industry.

Dialectics

Dialectical theories aim to explain stability and change as the result of a power struggle between two or more opposing entities, who subscribe to certain thesis or antithesis, respectively (van de Ven and Poole 1995). The researcher focuses on the difference between these entities' ideas and actions, the mediation of their interests and the recognition of their different power positions, which signal their capacity to control the direction of events (Benson 1977). The inherent motivation behind dialectic thinking is to overcome dualism in favor of a higher-order integration or a synthesis of the conflicting parts (Bledow et al. 2009). Such synthesis often represents a novel construction derived from both the thesis and antithesis, which will become a new thesis on its own right as the dialectical process continues. Thus, dialectics differ from simple contradictions (i.e. "either-or" choices between two alternatives) and paradoxes (i.e. dilemmas that demand impossible choices), by allowing to embrace both poles of the conflict and merge opposite views (Gibbs 2009). This result can be considered by the involved parties as a compromise (Moe et al. 2017). Other potential outcomes are the maintenance of the pluralist or conflicting *status quo* (i.e. no resolution), or the survival of either the thesis or the antithesis alone (Nordheim and Päivärinta 2006).

Through the lens of dialectics, organizations are seen in a permanent "state of becoming" rather than as fixed and determinate entities. Scholars are increasingly recognizing duality as a normal and inevitable characteristic of organizations, which becomes exacerbated in decoupled teams (Gibbs 2009). Previous literature has also characterized organizational innovation as an inherently dialectic process, where the resulting innovation is the specific instance of a synthesis carrying the old and embracing the new at the same time (Bledow et al. 2009). Consequently, theories derived from dialectical analysis connect scholarship with practice and contribute actively to the continuous process of reconstructing organizations (Benson 1977).

In the IS field, dialectical analysis has been used to understand the procurement, development and implementation of Enterprise Resource Planning (Moe et al. 2017; Robey et al. 2002; Soh et al. 2003) or Enterprise Content Management (Nordheim and Päivärinta 2006) systems, as well as the organizational consequences brought by the introduction of such technologies. Such examples suggest a strong focus of previous research on the observation of time-bound software projects linked to some specific organization, or with providers and suppliers in relatively well-defined business environment. A notable exception is the study by Lewis et al. (2010), who concluded that stakeholder tensions are also inherent to the structure of collaborative inter-organizational relationships, as participants frequently struggle with issues of formality and flexibility that must be handled through communication. This study extends the existing theory, by covering the conflicting perspectives of stakeholders across an entire industry (AEC/FM), who participate in a permanent and continuous dialogue about integration.

[1] Even though we employ the concepts of digital infrastructures and IOIS interchangeably, some digital infrastructures may not fit under the category of IOIS. For example, an internal software platform maintained by a single organization can be considered a digital infrastructure but not an IOIS. Digital infrastructures can also differ from software platforms in their design complexity or their behavior over time, but here we treat both indistinctively as IOIS. We refer the reader to the work by Hanseth and Lyytinen (2010) for a more detailed term comparison.

Methodology

Our research was conducted as a case study, a qualitative empirical method that investigates in depth a contemporary phenomenon (i.e. inter-organizational integration of information) to provide a holistic understanding about it (Yin 2018). We observed that the following two conditions were fulfilled to deem this method as adequate: (1) unlike in experimental research, the boundaries between the case and its context are not always clear and (2) the case should be more than an abstraction and provide some distinctive real-world manifestation. Both features are present in the AEC/FM industry, which has fuzzy boundaries but produces very tangible results. Even though case studies often focus on a single person, an organization or a project, at a less concrete level they can also refer to communities, relationships, decisions, partnerships or industry sectors within the economy (Creswell and Poth 2018; Yin 2018).

This paper examines the case of the whole AEC/FM industry in Finland and relies on the pool of practitioners involved in the KIRA-digi project that ran between 2016 and 2018. It was under responsibility of the Ministry of Environment, along with a steering group and strategic management team comprised by officers at State and local levels of government, private partners and professional association representatives. Because of the wide range of stakeholders participating in this project and the potentially conflicting perspectives emerging between them over a long timeframe, we deemed it a unique opportunity to capture our observations of the inter-organizational integration phenomena in the industry. It is worth noting that neither the present research paper nor its authors were sponsored by or affiliated to KIRA-digi. Nevertheless, it was still possible for us to voluntarily recruit the interviewees and obtain data for our study, given the public and open nature of the project.

Our case selection was not random or statistical but theoretical or purposive, choosing the participants who were likely to help replicate or extend our emergent theory, clarify its logic and the relationships among its constructs (Easterbrook et al. 2008; Eisenhardt 1989; Eisenhardt and Graebner 2007). Since we were not sampling the people *per se* but the concepts they discussed, we conducted interviews iteratively until a point of "saturation" was reached and the codes or categories derived from the primary data could not be expanded further in terms of their properties or variation (Corbin and Strauss 2015). We applied the discriminant sampling strategy suggested by Creswell and Poth (2018), which consists in verifying if the codes and categories derived from the initial interviews were consistent to explain also the answers given by any subsequent study participants. In our study, the first interviewees were the "gatekeepers" or representatives of the organizations participating in the KIRA-digi project, who were identified mainly from news articles and whitepapers about the local AEC/FM industry and the KIRA-digi project. Each one of them was asked for names of other key people to interview next, until the additional discussions did not reveal any significant new insights (Runeson and Höst 2009).

The findings of this study are grounded on the data from 24 semi-structured practitioner interviews during the first half of 2018. This data collection method employed planned questions that were not necessarily asked in the same order as originally listed (Runeson and Höst 2009), thus allowing to maintain a balance between improvisation and exploration of the relevant study topics. All the interviewees had participated or collaborated with the KIRA-digi project of the Finnish Ministry of Environment, so they were likely interested in or at least acquainted with the topic of the study. To procure a thorough representation of the target sector, the participants were selected to cover altogether every stakeholder group from the model of innovation and knowledge flows in construction by Gann and Salter (2000). Table 1 summarizes the profile of the study participants. The names of these practitioners and their organizations have been intentionally removed to preserve anonymity.

List of practitioners interviewed for this study

Stakeholder group	Organization	Role	Participant ID
Regulatory and institutional framework	A: Public sector, real estate	Senior Expert	P1
	B: Public sector, State government	Senior Specialist	P2
	C: Public sector, State government	R&D Specialist	P3
	D: Public sector, local authorities	Special Planner	P4

List of practitioners interviewed for this study			
Stakeholder group	Organization	Role	Participant ID
	E: Public sector, State government	Senior Adviser	P5
Project-based firms	F: Construction contractor	Chief Information Officer	P6
		Development Manager	P7
	G: Technology consultancy services	Senior Enterprise Architect	P8
	H: Construction consultancy services	Partner and Senior Advisor	P9
	I: Construction contractor	Chief Technology Officer	P10
		Development Manager	P11
	J: Engineering sub-contractor	Research Project Manager	P12
	K: Construction consultancy services	Project Manager	P13
Technical support infrastructure	L: Professional association, public-private partnership projects	Chief Digital Officer	P14
		Project Assistant	P15
	M: Universities and research institutes	BIM Professor, Architect	P16
Supply network	N: BIM software provider	Business Director	P17*
		Product Manager	P18*
	O: BIM software provider	Product Development Director	P19**
		Customer Success Manager	P20**
	Q: Trade union partnership, software provider	Development Manager	P21
	R: FM software provider	Technology Director	P22
	S: Trade union	Managing Director	P23
Projects	T: Association of property owners, landlords and tenants	Project Manager	P24

Table 1. Study interview participants (*, ** = Interviewed simultaneously)

Our interview protocol included both closed and open-ended questions to discuss foreseen topics while giving also the opportunity to get unexpected insights into the participants' experiences (Seaman 1999). To improve construct validity, we pilot-tested the interview protocol with other researchers besides the one who conducted the interviews (Easterbrook et al. 2008) and continuously refined it with better wording to unambiguously address the pertinent issues (Lethbridge et al. 2005). Each practitioner was interviewed separately, except for two group interviews in which two participants were present at the same time. The length of the conversation ranged from 45 to 90 minutes, giving interviewees the opportunity at the end to complement their previous answers or suggest new ideas previously unforeseen. An audio recorder was used under consent of the participants to reduce distractions and to facilitate the subsequent analysis of the interviews. Both data collection and transcription were performed by the same researcher, allowing to include in the transcript text any unspoken cues that were visible only to the interviewer, such as the tone, gestures or attitudes adopted by the study participants during the conversation. To improve the trustworthiness of the account, the researcher recorded the initial codes using the *Atlas.ti* tool while transcribing the interviews (Ezzy 2002; Saldaña 2016), thus letting the initial open codes emerge directly

from the data itself without *a priori* assumptions or hypotheses. The initial coding was done by a single researcher, whereas the analysis of the higher-level codes and categories was performed by both authors of this paper. As suggested by Eisenhardt (1989), the analysis was first done for each interview transcript and later across interviews to compare the similarities and differences in the answers of participants. Categories with a higher level of abstraction were also derived from the constant comparison of the interview notes and analysis memos written by the main researcher, providing a logical link between the initial codes identified from the raw data.

A theory based on dialectic forces can be either identified *a priori* or induced during data analysis (Robey et al. 2002). Our study followed the latter process, because we derived our findings from the continuous interpretation and comparison of the raw data from interviews. Table 2 summarizes the six key dimensions associated to the main category "dialectic tensions in the context of inter-organizational integration", which emerged as the result of the iterative analysis and the continuous refinement of lower-level codes into categories. We do not intend to provide an exhaustive list of all possible integration challenges or dialectical conflicts faced by the AEC/FM industry, but rather focus on the most relevant concerns of practitioners in terms of sharing or exchanging building information. These six key dimensions were rarely mentioned explicitly by the participants but could be still inferred from their testimonials and examples. For instance, whenever an interviewee referred to the need to understand better the language or concepts used by other actors, this comment was coded with the "ontology" label regardless of the exact wording used. Any previous or subsequent interviews were analyzed to determine if other participants referred to the same dimension. This process continued until the point of saturation, i.e. when the inclusion and analysis of additional interview transcripts did not provide new dimensions or significant variations on the ones previously identified. Thus, we ensured all our findings were grounded on the actual interview data.

Dialectic tensions in the context of inter-organizational integration		
Dimension	**Description**	**Opposing stakeholder views (Thesis vs. Antithesis)**
Ontology	Understanding what information must be integrated and its intended meaning	Harmonizing concepts across industry domains vs. Maintaining domain-specific vocabulary
Standards	Selecting and agreeing on technical norms for the access points to integrate the information	Waiting for industry consensus vs. Developing own proprietary alternatives
Storage	Defining the physical or virtual location where the information is to be kept	Centralizing information into the same location vs. Maintaining information separately
Openness	Limiting specific actors who are eligible to share or exchange the information	Providing interfaces for anyone vs. Restricting access to partners
Monetization	Demanding an economic compensation to access, store, use or exchange the information	Free-to-use vs. Fee-to-use
Public sector involvement	Establishing the role and responsibilities of public agencies providing information or the infrastructure to access, store and exchange it	Public sector as enabler or facilitator vs. Public sector as enforcer of rules

Table 2. Opposing stakeholder views and dialectic tensions observed in the Finnish AEC/FM industry

Findings

In this section, we present the diverging stakeholder views about inter-organizational integration of information and provide contrasting interview excerpts to demonstrate the dialectic tensions that can arise from each pair of opposing perspectives. We observed that sharing or exchanging information across organizational boundaries forces the industry stakeholders to choose between diverging options across six key areas, which are listed in Table 2. We refer to these points of contention as "dimensions", because they

all contribute to the same phenomenon: The emergence of dialectical tensions that will either result in maintaining the *status quo* in the industry or shaping new business partnerships and alliances. We argue that stakeholders will have stronger motivation to integrate with each other if they share the same view about one or more of these dimensions. Otherwise, they will be prone to continue working with their existing partner network. In other words, the decision of the stakeholders to integrate is a power struggle that persists until an alignment is reached across all dimensions.

Two aspects should be noted regarding the findings presented in this section. First, the dimensions listed in Table 2 are not intended to be approached separately or sequentially. They should rather be assessed together as entwined and overlapping concerns of the actors involved in inter-organizational integration projects. Second, since our case study and interviews focused on a whole industry rather than a time-bound project, the stakeholders' decision on whether to change or maintain the *status quo* should be understood as part of a continuous discussion. Thus, practitioners expressed the current "result" of this dialectic process in terms of their past experiences and future intentions, as shown by the interview excerpts provided in the following sub-sections.

Ontology: Harmonizing concepts across industry domains vs. Maintaining domain-specific vocabulary

Inter-organizational integration of information in the local AEC/FM industry requires communication between stakeholders across various domains (e.g. architecture, engineering, facility maintenance, etc.) who may assign different meanings to the same terms. An example frequently mentioned was the Finnish word that in some cases refers to the land area where a property is located, but which can be also used to describe both the land *and* the real estate property built on top of it. Some practitioners believe the ambiguous interpretation of key industry concepts reduces the possibility of implementing IOIS to manage the whole building lifecycle, because their cross-organizational processes cannot be represented consistently as digital entities.

For this reason, interviewees often mentioned that integration firstly demands a basic mutual understanding of key concepts and their relations across AEC/FM domains standards and the tools, stressing that the development of a common vocabulary for the whole industry is required before any other technical implementation aspects can be effectively covered. These practitioners advocate for the development of an ontology, or high-level model of knowledge formally representing things, concepts and phenomena that must be shared by many people in an explicit and machine-readable way (Devedzić 2002; Hofferer 2007). According to interviewees aligned with this perspective, if two domains employ the same concept for different purposes, then both sides need to find and agree on a new shared term that can be used to describe unequivocally the same idea. Each of the organizations involved should thus designate a person responsible for harmonizing the semantics in their fields of expertise with other domains.

Opposing stakeholder views regarding ontology	
Thesis: Harmonizing concepts across industry domains	Antithesis: Maintaining domain-specific vocabulary
P11, project-based firms: *"there is a database and then we have- or **we will** have the API descriptions […] but you can't have the API descriptions if you don't know what information you want to have, so there are a lot of chicken or egg problems […] you can't have this technical stuff before you have the concepts ready."*	P21, supply network: *"everyone has its unit and it is not an official term, but it's something that you own or use […] for real estate business, it could be a cost center of one company which owns a couple of buildings, the cost center could be one building or in some cases the cost center could be (just) one apartment."*

Table 3. Example of dialectic tensions related to ontology

Interviewees also justified in some cases the need to maintain divergent conceptual definitions between stakeholders, due to the high specialization and fragmentation of work in the AEC/FM industry. Since each participant has different work requirements and goals, harmonizing the vocabulary across the entire industry may not provide additional business value to the individual organization but rather complicate its

operations. For instance, among real estate companies the same concept of target unit can refer to a group of buildings, a single building or a single apartment. In this case, the differentiation is needed for administrative, financial or accounting purposes, since each company for instance can organize its cost centers or manage its project portfolio in different ways.

Standards: Waiting for industry consensus vs. Developing own proprietary alternatives

Establishing a strategy for wider adoption of standards in the local AEC/FM industry was one of the KIRA-digi project goals that demanded the participation of stakeholders from diverse domains. Despite the general perception that standards can facilitate the technical integration of systems, consequently improving the exchange of information and bringing business benefits to all parties involved, interviewees within large construction companies expressed doubts about the current pace of development and approval process of the standards. From their perspective, waiting for an industry consensus can slow down innovation and affect their competitive advantage.

Performance and efficiency also seemed to play an important role in measuring the trust of private actors on the industry standards. For instance, both software vendors and customers indicated that the files created with the ISO 16739 standard, commonly known as Industry Foundation Classes (IFC), offer a simple solution to exchange data about built assets across various AEC/FM domains, using a single format that is compatible with different BIM tools. At the same time, IFC was regarded as an inefficient method to exchange all the necessary information across the various stages of the building lifecycle, because the size and load time of the files increases significantly over time. Thus, promoting a *de facto* standard from private alliances was often mentioned as an option to overcome such technical limitations.

Opposing stakeholder views regarding standards	
Thesis: Waiting for industry consensus	Antithesis: Developing own proprietary alternatives
P19, project-based firms: *"there is a lot of standardization and then if you think about data – geospatial data, infrastructure data, building data – they **just meet** and they need to be compatible […] how do you charge for it, how do you make sure that the data has the quality that was agreed or is usable for the next phase? Based on the standards."*	P10, project-based firms: *"we are lacking proper standards, so we have to form some sort of group who can agree on something that **at least we** can use […] So why wait? Who would be the standardization body? There is none. BuildingSMART? [laughs] it won't work, we have already seen that it's too slow, so we need some sort of alliance to fix that."*

Table 4. Example of dialectic tensions related to standards

Storage: Centralizing information into the same location vs. Maintaining information separately

Throughout the study, interviewees discussed current and future opportunities to keep the building information stored in the same location, for instance by combining the BIM models maintained by different parties, or by developing software platforms that can be utilized by multiple companies to store and retrieve shared data. Achieving a complete view of the lifecycle of a building was considered as a long-time ambition of many AEC/FM practitioners, thus motivating interviewees to reflect whether such goal can be reached by keeping a central data repository that can be used to enrich the IFC files of BIM models (e.g. by adding work-flow metadata or detailed explanations about decisions taken by various stake-holders at different points in time). From such discussions, we also identified diverging opinions between the stakeholders, both from a technical and business perspective.

At the technical level, some practitioners explained they have already established mechanisms to combine building information from various sources, while others dismissed it as an unattainable goal, mainly because of the technical limitations of BIM and IFC. Besides the technical implementation aspects,

centralization of data required stakeholders to consider the organizational dimension as well, since they had to establish for example who was responsible for integrating all the necessary information. According to the study participants, the information shared between different actors or maintained separately by each stakeholder has been traditionally determined on a per-project basis, rather than as the result of industry-wide consensus or established practices. Even as practitioners acknowledged being unable to fully centralize all the required BIM data because of technical and performance limitations, they still expressed interest in the potential business value of keeping and managing by themselves the building information. This suggests that stakeholder perspectives about information storage differed not only because of the technical limitations explicitly described, but also due to unspoken issues about data ownership and assignment of roles and responsibilities for the integration.

Opposing stakeholder views regarding storage	
Thesis: Centralizing information into the same location	Antithesis: Maintaining information separately
P13, project-based firms: *"We have a combined model, which is up-to-date and our first source of design information […] We have a separate BIM coordinator who combines the model […] then we have this kind of meeting every two weeks to see the combined model and what has been changed, what errors are there, what clashes are there and what should be fixed."*	P17 and P18, supply network: *P17: "Maybe you have read what the government has done in UK. They were aiming to combine all data models in one location. That will not happen."* *P18: "Never."* *P17: "Never, because there's so many changes and so much information which has to be reachable."*

Table 5. Example of dialectic tensions related to storage

Openness: Providing interfaces for anyone vs. Restricting access to partners

The information ownership issues mentioned above became more evident when interviewees had to reflect with whom to integrate and allow the exchange of information, balancing the required level of openness against the importance of their existing business partnerships. Study participants described a deep-rooted struggle in the AEC/FM industry between the need to preserve the strategic information which can provide competitive advantage and the desire to achieve new business benefits through greater inter-organizational integration. Interviewees expressed accordingly their interest in developing "platform ecosystems" open to any actor in the industry or inclined rather toward more closed software solutions available only to their partners.

Opposing stakeholder views regarding openness	
Thesis: Providing interfaces for anyone	Antithesis: Restricting access to partners
P9, project-based firms: *"Data was earlier part of a company's IPR, an asset of the company, but industries today also understand they are part of a larger value network."*	P15, technical support infrastructure: *"You have your own core knowledge and you want to keep it as secret as possible, because that is all you have […] everybody is playing with secrets and with their close partners in the industry."*

Table 6. Example of dialectic tensions related to openness

Among the various stakeholder groups, participants from project-based AEC firms were the least willing to develop open interfaces to their systems. These organizations have already extended some functionalities provided by third-party software vendors and developed *in-house* solutions that fit better their own needs as well as the needs of their partners within the building projects. The changes needed to integrate with other industry stakeholders with whom they do not maintain such a close business relationship, such as the government or FM organizations, were either perceived as too costly or not delivering any foreseeable value

in the future. Interviewees were aware of similar or overlapping proprietary software platforms being developed simultaneously by competing AEC/FM companies to exchange building information, whose scope, business model and technical architecture are determined only by a handful of partner organizations.

Monetization: Free-to-use vs. Fee-to-use

Diverging perspectives were also observed when the practitioners explained whether and how to reimburse the costs incurred in developing and implementing the inter-organizational systems. According to interviewees, alliance model contracts have become a strong incentive for the inter-organizational integration of the local AEC/FM industry. Companies operating under such contractual arrangements may find already enough compensation for the efforts to establish the required information flows. A different scenario was described in the case of third-party software vendors. Since their customers can often access the data directly via API calls rather than by acquiring a full package of licensed software applications or tools, practitioners from this stakeholder group expressed their interest in finding new revenue models over their existing products and services, for instance by monetizing on the direct access to their databases and the usage of their APIs.

Interview answers also suggest that some organizations in the industry are better positioned than others to demand payments for accessing data through their applications or platforms. For instance, software providers entering binding agreements with main contractors can restrict the access to building information which is otherwise available for free. To mitigate these risks, other AEC/FM stakeholder groups which have not been traditionally focused on software development activities, such as trade unions or building material suppliers, may develop increasingly more data services and APIs for their customers to access directly, thus bypassing the restrictions imposed by software vendors.

Opposing stakeholder views regarding monetization	
Thesis: Free-to-use	Antithesis: Fee-to-use
P23, supply network: *"They [the software vendor] try to collect data into their own cloud and become partners with construction companies. After they have made the contract, they go to the wholesalers and manufacturers and ask for something like €200K a year to allow their own product data (to be transferred) into the construction companies' systems. They have become like a door closing or opening with that price tag […] (so our) strategy now is to give that (same) data free of charge to the whole supply chain."*	P19, supply network: *"If our customers are using our application, they get free access to our API […] but maybe it will change, if there is a drastic change (such as) that nobody is using our app but only (our) database […] we understand our customers and see where they are going […] if they get value from something that we provide, they will pay for it […] if they depend on some platform or application, they will pay for it, if it's good."*

Table 7. Example of dialectic tensions related to monetization

Involvement of the public sector: Facilitator or enabler vs. Enforcer of rules

The perspectives of practitioners differed on the role that government should play in the integration of the local AEC/FM industry. On one hand, the KIRA-digi project was often cited as an example of positive collaboration between private and public actors, through which the latter raise awareness of the current technical limitations or process deficiencies in the sector, provide funding to support the development of innovative IT solutions, and motivate all stakeholders to reach a shared vision and work together. On the other hand, interviewees also noted that private actors alone may find it difficult to agree by themselves on a more integrated industry setting because of their conflicting interests (such as the ones already described in the sections above). For this reason, they argued that the public sector should adopt a more active role in fostering inter-organizational integration, for example by requiring the adoption of certain standards, BIM tools or IS managed by the government, especially if public funds have been invested.

One of the governmental projects discussed during various interviews was the ongoing development of a public services infrastructure to allow the exchange of building information between any AEC/FM

stakeholder in a standardized format. Some interviewees referred to this solution with hesitance, arguing that other commercial platforms constitute better alternatives for the same purpose. Furthermore, coordinating technical integrations with the representatives of the public sector was often described as a demanding task, because agencies are organized under different organizational structures and keep high autonomy within their own branches of administration. These interviewees strongly argued that government should act simply as a facilitator for private companies. Yet in some other cases, interviewees did not observe a conflict regarding the involvement of the public sector, arguing that it can act as an enabler *and* enforcer of rules at the same time. However, the question of *to what extent* should government actors perform either role remained as an unanswered or puzzling matter.

Opposing stakeholder views regarding the involvement of the public sector	
Thesis: Facilitator or enabler	Antithesis: Enforcer of rules
P3, regulatory and institutional framework: *"Technically the integration could be done with commercial integration systems, but there has also been the development of this national service architecture that we adopted from Estonia [...] it has been criticized because not everyone wants to have this compulsory technical exchange layer."*	P5, regulatory and institutional framework: *"There are private sector actors who understand, who wish to participate and who see that the work that we [the public sector] are currently doing and pushing forward is the way to go."*

Table 8. Example of dialectic tensions related to the involvement of the public sector

Discussion

As mentioned in previous sections, the evolution of IOIS or digital infrastructures at the industry level has not yet been fully explored using the dialectical lens. Previous IS studies have used dialectics mostly in the context of time-bound projects, to understand the implementation and adoption of specific software products. However, we identified two higher-level theories by Lyytinen et al. (2017) and Tilson et al. (2010), which have attempted to explain how stakeholder tensions or paradoxes can become the engines of change in more complex systems, such as those used to connect actors across the entire AEC/FM industry in Finland. The selected theories are not constrained by geographical or industrial context, thus being generic enough to be applied in our case study and assist us in giving meaning to our findings.

According to Tilson et al. (2010), the traditional infrastructures of modernity, such as the railway networks or the electric grid, differ from digital infrastructures because the latter are capable of transforming on its own as the result of conflicts between (1) stability and flexibility, and (2) openness and control. These clashes derive into what the cited authors call the paradoxes of change and control, respectively. In our case study, we observed the first of those paradoxes represented by the BIM standards currently employed in the AEC/FM industry. On one hand, BIM has provided a strong foundation to facilitate the inter-organizational integration of information between actors along the value chain of AEC projects. The improvements in terms of efficiency and automation (e.g. through the exchange of IFC files, use of combined domain models, timely clash detections, etc.) have become tangible for the industry stakeholders, to the extent that most of these actors are now eager to explore new applications extending the information exchange across the whole lifecycle of a building, covering not only its construction but also the land use planning and facility maintenance phases. Such an idea becomes technically and financially viable as the standardization of building design, modelling and management through BIM allows new players like property technology ("PropTech") start-ups to develop and provide tools for the large industry incumbents. Thus, standards act simultaneously as an anchor of stability and an engine of growth, leading to tensions when the stakeholders look for alternatives to overcome their technical constraints, or when the strategic alliances with partners rearrange and blur their organizational boundaries. Consequently, we argue that BIM standards and tools play a fundamental role as part of the *installed base* in AEC/FM digital infrastructures (Hanseth and Lyytinen 2010; Tilson et al. 2010). BIM can be also understood as a *boundary structure* of an IOIS aligning the views of different communities of knowledge/practice or industry domains (Reimers et al. 2014).

The second paradox proposed by Tilson et al. (2010), the paradox of control, pervades all dimensions shown in Table 2, because they all relate to the strategic actions of industry stakeholders who want to establish control points for future changes in their digital infrastructures. Even though our codes and categories were grounded exclusively in the interview data and defined *prior to* reviewing any previous research, we found they matched aspects already listed *explicitly* by Tilson et al. (2010) as triggers for the paradox of control, such as: The changes in ownership of data ("storage") and their definitions ("ontology"), the control of critical resources through APIs ("openness"), the appropriation of value ("monetization"), or the role of public policymakers and regulation ("involvement of the public sector"). Thus, we consider the six dimensions presented in this study not only portray the phenomenon of inter-organizational integration of information but also help to understand the power struggles between different actors for the control of a digital infrastructure or a socio-technical ecosystem e.g. by utilizing a software platform or IT system that extends at the industry level.

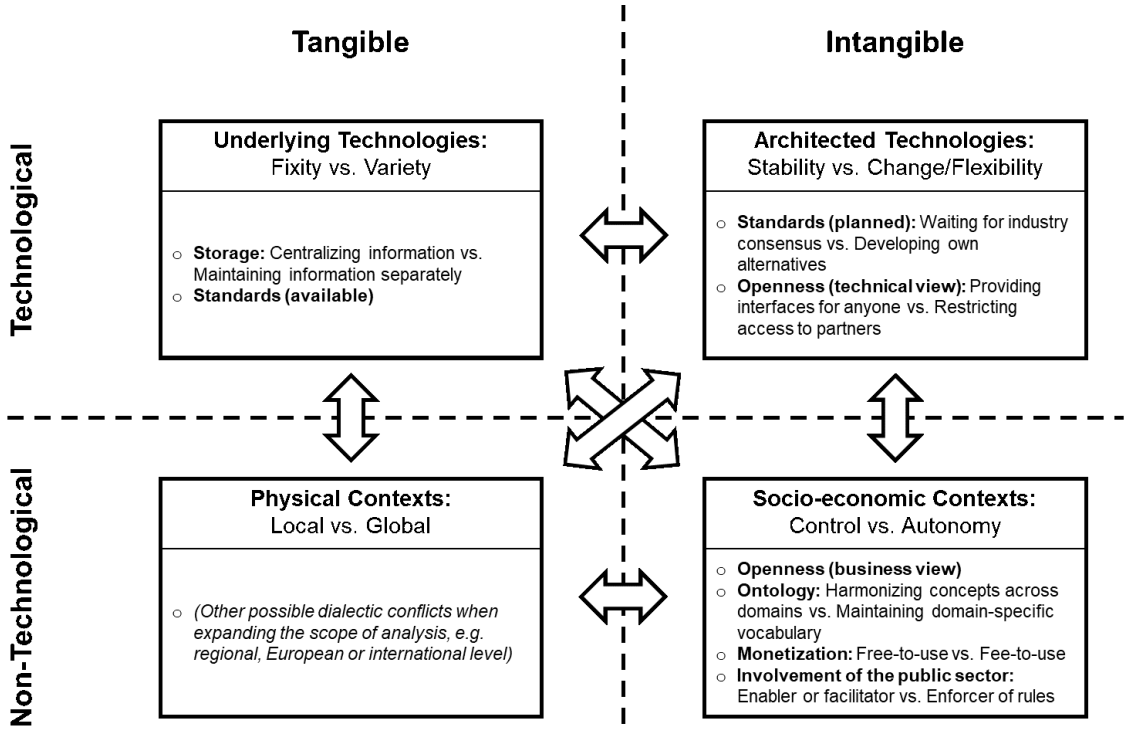

Figure 1. Challenges for the inter-organizational integration of information in the AEC/FM industry within the model of digital infrastructures generativity by Lyytinen et al. (2017)

Lyytinen et al. (2017) elaborate on the idea of Tilson et al. (2010), proposing a model which further develops the original two drivers of growth into four interrelated paradoxes. Unlike the original study, their expanded version of the model does not directly attribute the tensions to the dialogue between industry stakeholders but presents them as the result of contradicting features inherent to any digital infrastructure along two dimensions: (1) Its technological and non-technological aspects on one hand, and (2) its tangible and intangible character on the other. As shown in Figure 1, our six tensions from Table 2 can be related simultaneously to one or more of the paradoxes proposed by Lyytinen et al. (2017), covering all quadrants of their model. A notable exception is the non-technological/tangible dimension associated to the physical contexts, which was not explored in our study as it was purposefully limited to the scope of the Finnish AEC/FM industry and its socio-economic conditions. However, we consider plausible that further challenges for inter-organizational integration may emerge in terms of the local vs. global tension if were to extend our observations about the AEC/FM industry to the Nordic, European or global levels. We also observed that most of the dimensions identified in this paper refer to the quadrant of socio-economic contexts, where the interactions between stakeholders have the most relevance in comparison with the tangible technical elements of the IOIS or digital infrastructure. This may be explained by our choice of research methods, since we relied primarily on semi-structured interviews with practitioners, without evaluating directly their technical artefacts (e.g. BIM tools, databases and other types of IT systems).

Based on our analysis of the case study data and the application of existing frameworks, we corroborate dialectics is an adequate lens for understanding and explaining the development of IOIS, as well as of digital infrastructures spanning over an entire industry. Furthermore, we believe our six dialectic tensions can be effectively used as a framework to study the evolutionary processes of IS, by pinpointing the areas of interest where opposing industry actors will concentrate their power struggle to decide whether they integrate with other similar-minded players.

Practical implications

Integration is a phenomenon that entails technical, business and socio-organizational aspects. From the perspective of practitioners in AEC/FM and other industries, the tensions presented in this paper serve as a reminder that inter-organizational integration projects cannot be approached by addressing technical issues alone. The decision about standards, open interfaces or storage mechanisms that an IOIS employs depends on human motivations as much as on technical factors. Thus, our findings provide guidance on how to plan and operate IOIS on an industry-wide scale, by bringing attention to six areas where clashes with other actors may occur. It is not enough for practitioners to recognize these potential tensions, but such understanding must be translated into action: Timely planning, clear communication and effective negotiation can certainly help to align the interests of project participants, thus providing a mutually beneficial synthesis or even avoiding any dialectical conflicts altogether. A concrete recommendation for companies planning to implement an IOIS is to explicitly address in the contractual agreements and project discussions all six dimensions that may lead to tensions between the involved parties.

This study invites researchers and practitioners in the AEC/FM field to observe holistically the complex interactions taking place beyond the scope or timeframe of specific construction projects. As the development of BIM, cloud and service technologies enables the exchange of building information with increased flexibility and at a wider scale, giving deeper attention to the dimensions presented in this paper can bring awareness to – and hopefully help to solve – the integration issues of the industry at the technical, business and socio-organizational levels.

Limitations and future work

This paper presented the dialectical tensions we observed between stakeholders of the AEC/FM industry. We assessed the trustworthiness of our exploratory inquiry in terms of four established criteria for qualitative research that suit our interpretive approach: credibility, transferability, dependability and confirmability (Eriksson and Kovalainen 2008; Guba 1981; Shenton 2004). Even though the activities of data collection and initial coding were mostly performed by a single researcher, this does not represent a liability but rather an advantage of our study, because it allowed to include in the transcripts any unspoken contextual cues that were only evidenced by the interviewer. Our interview guide was pilot-tested by multiple researchers, our codes were written without *a priori* assumptions and checked with the participants themselves in subsequent interviews, as suggested by Saldaña (2016), thus maintaining the credibility and confirmability of our findings. In terms of dependability, we have provided a thorough description of the steps we followed for data collection and analysis. Our research process could be enhanced with the inclusion of research methods relying not only on the opinions of practitioners but also looking at the technical artefacts they refer to, e.g. their BIM tools and software platforms. To improve transferability, the tensions summarized in Table 2 should be discussed more thoroughly in future studies by other authors (i.e. researcher triangulation) to determine how accurately such dimensions describe the inter-organizational integration of information in different sectors other than AEC/FM. We also highlight the importance of evaluating and re-defining our original case study boundaries to an international or global level, which could give insight on new dimensions of dialectical tensions and include other relevant actors who were not part of the KIRA-digi project.

Conclusions

This study presented the question "*How do the opinions about integrating information across organizational boundaries differ between the stakeholders of a networked industry?"* Based on the qualitative analysis of our interviews with field practitioners, we identified six areas of significantly contraposing perspectives that may originate dialectic tensions: Ontology, standards, storage, openness,

monetization and the involvement of the public sector. We also inquired *"How do the emerging dialectic tensions between these stakeholders influence the development of inter-organizational information systems?"*. According to our observations, matching the points of view along the aforementioned six key dimensions can determine whether the actors will continue operating with their existing partners or integrate with new stakeholders, thus guiding their course of action for the development and implementation of IOIS.

Industry practitioners must concentrate their strategic efforts in these tension areas if they want to share or exchange information across organizational boundaries. By framing our findings in previous IS models, we believe that such opposing views are not exclusive to AEC/FM but can be observed in other industries as well, because of the paradoxical relations between the technological/non-technological and the tangible/intangible attributes of any digital infrastructures. This provides an interesting opportunity for IS researchers to further test our proposed dialectic tensions and potentially discover new ones. In the specific context of our case study, BIM currently stands at the crossroads of an evolutionary process: Its standards and tools act as the *boundary structures* of an IOIS, which enables sharing and exchanging information across the industry. Thus, BIM helps to align the perspectives of different actors across the AEC/FM industry sub-domains or communities of practice. As it develops and becomes widely adopted, BIM will also constitute the new *installed base* of emerging AEC/FM digital infrastructures.

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