BUILDING SITUATIONAL AWARENESS IN THE AGE OF SERVICE ECOSYSTEMS

Research paper

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Abstract

We discuss the little-explored construct of situational awareness, which will arguably become increasingly important for strategic decision-making in the age of distributed service ecosystems, digital infrastructures, and microservices. Guided by a design science approach, we introduce a mapping artefact with the ability to enhance situational awareness within, and across, horizontal value chains, and evaluate its application in the field amongst both IS practitioners and IS researchers. We make suggestions for further research into both construct and artefact, and provide insights on their use in practice.

Keywords: Situational awareness, Distributed systems, Design Science, Strategy, Digital Ecosystems, Digital Infrastructure, modularity, servitization.

1 Introduction

There is increasing acceptance within the Information Systems (IS) literature that the dynamics of digital service platforms are co-created together by 'ecosystems' of technologies and stakeholders (Ceccagnoli et al., 2012; Lusch and Nambisan, 2015). For example, video production today entails a complex, ever-evolving value chain, or 'service ecosystem' (Lusch and Nambisan, 2015): a self-adjusting system of service exchange comprising content creators, publishing tools, content management specialists, enablers, monetizers, and aggregation portals. Competent participation within this service ecosystem thus entails the evolution and maintenance of a collective understanding amongst participants about the unfolding dynamic between the end product (completed video), the platform(s) and technologies upon which they are innovating (Eisenmann et al., 2006), and the respective positioning of each participant in relation to other ecosystem members with whom they must interact.

However, the requirement to perceive, understand, and make informed decisions within a broader ecosystem of human and material actors now extends far beyond the world video production. Such service ecosystems increasingly characterise the field of information systems, in which common digital infrastructure enables componentisation of business functions (Gawer, 2009; Yoo et al., 2010) into fields of dynamically evolving services "mashed up" in various ways – manifest either in software development effort (in which monolithic applications are increasingly replaced by microservices) or in the exploitation of platforms and web services. Such services are in a state of constant evolution and potential replacement by higher-order systems (Nielsen and Aanestad, 2006; Wagelaar and Van Der Straeten, 2007; Jin and Robey, 2008), and thus the continual evolution of the wider digital infrastructure

(Hanseth and Lyytinen, 2010) in which business ecosystems are embedded means that decisions always occur against a backdrop of accelerating commoditisation (Gannon, 2013; Brown et al., 2017).

In order to make the decisions needed to function effectively within this 'collective whole', ecosystem participants must develop and maintain a constant *awareness* – both of the respective positioning of components in relation to others (e.g. Guo et al., 2013; Anderson et al., 2014; Busquets, 2015)– as well as of movement within this dynamic environment as a whole: for example, building an expensive data centre may make little sense if one is aware that upcoming developments offering cheaper, utility storage may render such an investment ill-advised within two years.

Accordingly, our motivation in this paper is twofold. First: to establish the strategic significance of the construct of ***situational awareness*** for IS practitioners and researchers for understanding and navigating this constantly shifting landscape of digital infrastructure and services, and second: to demonstrate an emerging technique developed by one of the authors – that of **Wardley *Mapping*** (hereafter 'mapping') - that may assist practitioners and researchers in understanding digital ecosystems. In investigating 'how situational awareness and Mapping could enable people to do strategy better', we draw lightly on Hevner et al's (2004) design science approach as a sensitising framework. Design science encourages the creation and discussion of new artefacts within the IS literature that "define the ideas, practices, technical capabilities, and products through which the analysis, design, implementation, management, and use of information systems can be effectively and efficiently accomplished" (ibid.: 76). In evaluating the use of Wardley Mapping in practice, this paper aims to give answer to the following research question: **How is situational awareness, in relation to the ever-changing components in digital ecosystems, achieved in practice with Wardley Mapping?**

The paper is structured as follows. In the ensuing literature review, we present the current state of research and justify the development of a mapping artefact with the ability to enhance situational awareness in the age of service ecosystems. An Artefact Description section follows, describing the mapping artefact and the kernel theory that sustains it, followed by an Evaluation section describing the methods and findings of a qualitative evaluation. The paper ends with Discussion and Conclusion sections which describe the relational, temporal and performative nature of the mapping, which includes recommendations for future research, and summarise the key contributions.

2 Literature Review

In this section we provide an account of the key concepts underpinning the construct of situational awareness and its related artefact, value chain mapping.

2.1 Situational awareness

'Situational awareness' is a phenomenon that has been recognised in the fields of engineering and cognitive science since the 1980s. The construct was first identified during World War I by Oswald Boelke in relation to the need to model a pre-emptive awareness of the enemy (Gilson, 1995), although it remained comparatively undiscussed until the 1980s when it became associated with aviation, particularly through the work of Endsley, who defines it as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" (1995, p. 36).

Since that time, interest in situational awareness has grown as a way of making sense of "dynamic, event-driven, and multitask fields of practice" (Sarter and Woods, 1995, p. 16), and other, similar definitions have been offered, such as "the state of knowledge about the world, or the model of external reality that enables adaptive decisions to be made in uncertainty" (Taylor and Selcon, 1991, p. 789). Thus defined, the construct has become applicable to decision-making within complex systems such as aircraft, air traffic control, flexible manufacturing, refineries, nuclear power plants, military and police command (Endsley, 1995, p. 33), although it still remains relatively unknown outside these domains, and almost completely unresearched within the field of information systems. Although authors differ on whether the construct of situational awareness should be the 'model' itself (Taylor, 1990; Endsley, 1995; Endsley, 2015) or an ongoing perpetual process (e.g. Adams et al., 1995; Smith and Hancock, 1995), common to all definitions is a recognition of the core dimensions of position and movement: an ability to understand the unfolding understandings of various participants that has been likened to a "knowing of knowing" (Phillips, 1986).

To date however, we are unaware of work within the field of information systems that applies the construct of situational awareness to assist mutual sensemaking – knowing of knowing – within ecosystems of digital collaboration. This is despite recent, increasing acknowledgement of the need for "a common set of business and cultural assumptions, evaluation methods, and/or mental frameworks" that enable "shared situational awareness" within digital service ecosystems (Lusch and Nambisan 2015, p.165) comprising dissolved organisational forms (Eaton et al., 2015) composed of value chains of services provided by different organisations in constant flux, and which lack sensemaking artefacts of the kind exemplified at industry level in the Gartner and Forrester models (Pollock and Williams, 2010).

2.2 Mapping as a sensemaking tool

In this paper we present Wardley Mapping as a technique and a practice used by decision-makers to acquire situational awareness for strategic sensemaking of digital ecosystems. Earlier literature has researched cognitive mapping techniques, most prominently causal mapping, including semantic mapping and concept mapping (Eden, 1992; Fiol and Huff, 1992; Markíczy and Goldberg, 1995; Clarke and Mackaness, 2001; Eden, 2004; Hodgkinson et al., 2004; Siau and Tan, 2008). However, to our knowledge, none has focused on mapping to enhance situational awareness. Furthermore, literature on cognitive mapping presents mapping as a research technique for mental representation (Clarke and Mackaness, 2001; Ahmad and Ali, 2003; Hodgkinson et al., 2004). Our study of mapping is closer to Eden (2004), Fiol and Huff (1992) or Siau and Tan (2008), who study mapping as a support tool in organisational decision-making "in an uncertain world" (Fiol and Huff, 1992). Distinctively our approach moves from cognitivist approaches to see mapping not just as a tool (the map) but as a social practice of sensemaking (Weick, 1995). We argue that Wardley Maps are indeed used as a cognitive aid, but they do so providing a common frame for mapping, a socially accepted way of focusing attention to particular dimensions. In our analysis we illustrate how Wardley mapping is perceived as a form of enhancing communication and collaborative sensemaking.

2.3 Componentisation and modularisation

Our interest in situational awareness, and associated argument for a more dynamic and structural understanding of digital ecosystems is founded on recent "profound changes" in the way organisations innovate their information systems (Yoo et al., 2010). Such changes can be understood in the context of a steady dis-integration of monolithic IT systems beginning with IBM's famous system/360 modular mainframe in 1964 (Baldwin and Clark, 2000) and UNIX's modular design (Campbell-Kelly, 2003), and became more prevalent with the advent of PCs (Ceruzzi, 2002), object-orientation, IT outsourcing and software globalisation (Friedman, 2005; Willcocks and Lacity, 2009; Willcocks et al., 2011). A central feature of such dis-integration is a growth in *modularisation* (Baldwin and Clark, 2000; Yoo et al., 2010):

> "Modularity is a general systems concept…describing the degree in which a system's components can be separated and recombined and it refers both to the tightness of coupling between components and the degree to which the "rules" of the system architecture enable (or prohibit) the mixing and matching of components." (Schilling, 2000, p. 312).

Loose coupling is important in enabling modularisation and digital value chain innovation (Nielsen and Aanestad, 2006) but, it is argued, requires significant management control (Busquets, 2010; Tiwana et al., 2010). Such control aims at minimizing the interdependencies between decomposed subsystems (Simon, 1965; Sanchez and Mahoney, 1996) while maintaining overall tight control over the holistic system being developed; for example, Hora the famous watchmaker controlled his modules, and thus the development and the ultimate form of his watch (Simon, 1965).

Componentisation has accelerated with the emergence of internet-enabled platforms, themselves comprised of loosely coupled layers of devices, networks, services and content (Yoo et al., 2010) and heterogeneous software components which exploit these platforms (Mathiassen and Sørensen, 2008). The componentised structure of digital value chains (Porter and Millar, 1985) enables them to exploit software's dematerialised and liquid properties (Normann, 2001, p. 50; Kallinikos, 2011), enabling extreme flexibility (Yoo et al., 2010; Kallinikos et al., 2013) and generativity (Zittrain, 2008).

2.4 Visibility and control within digital ecosystems

Componentisation and modularisation has progressively undermined the achievement of 'management control' within modern software and service ecosystems, which has become progressively anarchic and networked (Lyytinen et al., 2016), as digital platforms and infrastructure have allowed system components to be spread across digital ecosystems which are globally distributed, and are themselves constituted from internet-enabled modular platforms and components which are increasingly commoditised (Nielsen and Aanestad, 2006; Wagelaar and Van Der Straeten, 2007; Jin and Robey, 2008). Components can also be shared between different organisations (e.g. as shared services or cloud services) creating poorly understood coupling between those harnessing them (Malhotra et al., 2005). This ensures that "IT infrastructures are… increasingly difficult to coordinate from a single governance point of view such as the corporate chief information officer's because they span beyond the boundaries of a single corporation. Traditional rules and mechanisms of alignment, centralisation, and cost control need to be augmented with new governance principles" (Yoo et al., 2010, p. 732).

Thus, the "watchmaker" (unless they are a keystone/orchestrator organisation (Iansiti and Levien, 2004; Markus and Loebbecke, 2013) with control over an ecosystem such as Apple with iOS) cannot fully control the distributed components of their "watch" as these evolve and change; this is also a feature of digital innovation projects, which have registered increased demand for coordination (Venters et al., 2014; Lyytinen et al., 2016). Such demand is reflected in the rise of service-oriented architectures (SOA) (Bardhan et al., 2010), cloud computing (Armbrust et al., 2010; Venters and Whitley, 2012) and most recently containerisation and microservices architectures which, for many, are becoming the default architecture for co-ordinating enterprise applications (Lewis and Fowler, 2014) and the next step in software development (Weissman, 2016). Microservices demonstrates an increase in the number of components involved in service as it is "an approach to developing a single application as a suite of small services, each running in its own process and communicating with lightweight mechanisms…These services are built around business capabilities and independently deployable by fully automated deployment machinery" (Lewis and Fowler, 2014). Microservices are now widely used, including within IBM, Microsoft, Netflix and the BBC (Balalaie et al., 2016).

These innovations, and the subsequent changes in innovation practices, create a complex context in which large numbers of, potentially globally distributed, components are coupled to provide a required digital value chain (Lyytinen et al., 2016). The design of modular components and of their linkages within a value chain is a "value-seeking process" and "over time, this value-seeking process gives rise to an ever more complex, diverse and dispersed modular system" (Baldwin and Clark, 2000, p. 246). Such change "exponentially increases the number of possible configurations achievable from a given set of inputs, greatly increasing the flexibility of a system" (Schilling, 2000, p. 312). Ideally, a digital ecosystem will enable components to be altered while the whole continues to function such that a "tight-loose" style of governance is achieved (Tiwana et al., 2010). This is central to the ideas of "DevOps" whereby development of modules and ecosystems continues while the whole remains in use (Balalaie et al., 2016) and is epitomised by Amazon's notion of "you build, you run it". However, such constant adaptation requires strong social norms across the service ecosystem (similar to those of open-source communities) and must be supported by relevant infrastructures (Lyytinen et al., 2016) to ensure that they are maintained – something that is difficult to achieve when ecosystems are extended beyond the "watchmaker's" control.

In summary, increased modularity and distributed control within digital infrastructure and services enables fluid dynamic of constantly shifting changes and evolutions within the components of an ecosystem which, in turn, requires situational awareness of the overall movements such change entails within the ecosystem. Similarly, as components are added, substituted, or decomposed into new microservices so there is an increase in the complexity of the ecosystem requiring situational awareness of the position of these components in relation to each other and to the whole.

Gaining such situational awareness is however problematic, since the "locus of innovation activities" is often shifted into associated ecosystems at the periphery of organisations. This change dissolves the organisation's form (Eaton et al., 2015) such that it is only comprehensible in relation to this broader, partly cloud-based, organic whole. Digital infrastructures have been implicated in devolving siloed organisations into more complex cross-functional and devolved interfirm processes (Nielsen and Aanestad, 2006; Rai et al., 2006), with increasing interdependencies (Jin and Robey, 2008). Boundaries between elements of the value chain must thus be understood and managed over time (Jin and Robey, 2008) and are often manifested only within the technical APIs and interfaces of the modules – so often hidden from strategic oversight by their technical complexity. This suggests a considerable challenge gaining situational awareness of such digital value chains, and of the ecosystem(s) from which they are constituted (Eisenmann et al., 2006), since these ecosystems represent complex networks of distributed stakeholders (Venters et al., 2014) undertaking a wide variety of potential actions (Gnyawali et al., 2010; Ceccagnoli et al., 2012).

In this context, strategic decisions that involve (re)thinking the technological infrastructure and investments required to bring value to customers can benefit from techniques that enhance visibility and control via the development of situational awareness. To this aim, in this paper we present a mapping artefact which captures the structure of the digital ecosystem and the situation of its components across both position and movement dimensions.

2.5 Dynamic digital value chains

Value chains are defined as coordinated activities, which design, produce and deliver value (delivered through a product or service) to a customer (Porter and Millar, 1985). Such activities can occur within an organisation or external to it (e.g. through outsourcing or external suppliers). Koulopoulos and Champy (2005) extend this idea through the term "digital value chain" to describe how tighter integration of information and software should be considered within value chain analysis (Note this describes the digital/computing-related elements of any value chain – which is distinguishable from the term's use to describe wholly digital value chains such as MP3 music (e.g. Buxmann et al., 2007; Lanzolla and Anderson, 2010)).

By using digital value chains as a core construct for our design, our focus on digital ecosystems is shifted to service outputs – how these enhance value to the customer- rather than inputs – i.e. the infrastructural nature of the technology. This construct is supported in recent research by Leimeister, et al. (2010) who argue that the advent of cloud computing has led traditional value chains to become more complex and "break up into a myriad of different combinations of actors and their interactions to depict rather a network than a sequential chain" – leading them to define a "cloud computing value network… where various cloud computing resources from different levels (infrastructure, platform services and applications) are integrated and offered to the customer. By composing different services, complex business processes can be supported and accessed". These authors conceptually model such networks diagrammatically. As networks, Leimeister's models are directionless (they do not place the customer as the primary focus of value), and their focus on technical components says little about the relationship between these, or their relative value. While useful when such technical components are significant (e.g. in the case of cloud computing), we see this as problematic in the case of microservices and enterprise IT in which huge numbers of such components exist.

In contrast, our modelling is of value networks as directional: that is, the customer is placed at the top of the chain which flows downwards (moving further from direct customer value). We then model digital value chains as graphs of vertices and edges.

Through various technological changes (e.g. those associated with cloud computing (Venters and Whitley, 2012)) and the ease of combining digital modules, we have seen significant increase in the speed of digital innovation (Zammuto et al., 2007): "Innovation networks for digital technologies are… likely to be dynamic, uncertain and equivocal, as well as subject to political power and influences" (Lyytinen et al., 2016). Situational awareness therefore requires a clear understanding of these dynamics of innovation in relation to a digital value network.

In 1959 Gregory Bateson described a truck reversing while attached to a chain of trailers with each added trailer denoting a drastic decrease in control from jack-knifing. The world, Bateson argued "is made up of a very complex network (rather than chain) of such entities which have this sort of relation to each other, but with this difference, that many of the entities have their own supplies of energy and perhaps even their own ideas of where they would like to go". We contend that digital value chains are similar to these trailers – connected, but with their own direction and energy. In order to model such movement and energy in the components of the graph we move towards a mapping of these graphs in terms of dynamic movement and intention.

3 Wardley Maps: Dynamic Value Chain Mapping

We now describe our artefact, dynamic value chain mapping, in relation to the sensitising framework of design science. Dynamic value chain mapping is intended to address the problem domain of enabling situational awareness within digital value chains by building a collective understanding of mutual positioning and movement amongst value chain participants. Our artefact fits closely with Peffers et al.'s (2007) definition of "the final objective of a design science research methodology process [which] is to provide a mental model", quoting Johnson-Laird and Byrne's (2000) definition of a mental model as a "small-scale [model] of reality…[that] can be constructed from perception, imagination, or the comprehension of the discourse. [Mental models] are akin to architects' models or to physicists' diagrams in that their structure is analogous to the structure of the situation that they represent, unlike, say, the structure of logical forms used in formal rule theories" (ibid. p.52). In exposing, and modelling, "the structure of the situation" (ibid.), we show how dynamic value chain mapping reveals possibilities for strategic action—and thus how the design artefact enables participants not only to document unfolding reality, but also to *create* it.

Various authors have highlighted that innovation of digital value chains requires that their hinterland be visualisable (e.g. Guo et al., 2013; Anderson et al., 2014; Busquets, 2015). In our design we therefore map our undirected graph onto a Y dimension in which value to the digital ecosystem's customer is delivered at the top. The various vertices involved in delivering the value are thus mapped downwards on Y in relation to their hiddenness (or lack of visibility) to the customer of the value chain. For example, a Sales-Support app delivering value to a salesperson might have an iPhone towards to the top of Y (it is held by the salesperson when using the app), whereas the data-centre holding the data is hidden much further away as it is invisible and only mediated through other vertices. Such judgements are subjective but are intended to provide a means of considering how vertices provide value in relation to the overall digital value chain.

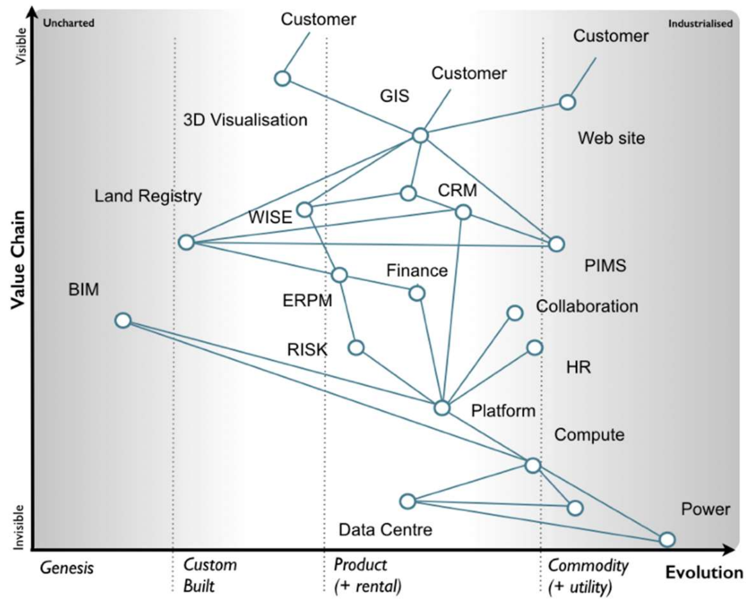

Figure 1: Example of a map

Figure 1 presents the mapping artefact through an example of the value chain of the IT function within the UK's High Speed 2 rail project – a large public sector infrastructure project. The CIO of the project took the initiative to map the HS2 project to be able to articulate the strategy. Given the complexity of the project, mapping was the result of team work, and was perceived as a good aid for decision-making. The map is visual and context specific, that is, it includes the components that influence a business or service provider at that moment in time. A value chain delivers value to its customer (who may be external end-users, internal, suppliers or others parts of a wider value chain) (Normann and Ramirez, 1993). Therefore, the mapping artefact always contains an anchor which is the customer and their needs. Once these are defined, the position of components in the map are shown relative to that user on a value chain, represented by the y-axis.

Each component needs the component below it, however the higher up the map a component is then the more visible it becomes to the user. Tracing one chain in Figure 1 for example, provision of updated information to a customer regarding the siting of the new railway requires a geographical information system (GIS) capability, which in turn draws on customer records contained in a customer relationship management system (CRM), which in turn is maintained on a digital platform, requiring access to a data centre, computing capacity and electric power.

The map also positions the components in relation to an x-axis, which represents a snapshot of the ongoing commodification of such components, reflecting the earlier observation that ecosystems are not static, and strategic decisions might depend on the expected changes in the environment. For example, Figure 1 shows a range of relatively standard enterprise applications such as GIS, CRM, Finance, Risk Management and HR in the 'Product (+ rental) space, since whilst most organizations would no longer consider building such software from scratch themselves (the Genesis and 'Custom Built' spaces), these still generally require implementation of a product, rather than consumption of a generic service. Finally, Figure 1 shows power, computing capacity (cloud), the Plant Information Management System (PIMS), and even the simple website to be commodities that are consumed, rather than bespoked or implemented. Thus, the relative position of each of these modular capabilities in relation to the others relates directly to both their visibility to the customer, and the extent to which they have become commoditised; their two-dimensional location is a function of both.

4 Evaluation

4.1 Data collection and analysis

In keeping with Hevner et al (2004) we adopt an observational approach to evaluation to establish the validity of the artefact, and its effective use in practice. A first proxy indicator of the usefulness of Wardley Mapping in practice is the increasing interest that it is acquiring among practitioners. Wardley Mapping was developed by Simon Wardley (one of the authors), and made openly available via an online book (https://medium.com/wardleymaps). Companies publicly sharing their use of the technique include UK Government, Amazon, Co-Op (UK), HS2, RNLI, NHS, UK Dept of Education, Police, Photobox, Food Standards Agency (UK), UN (Global Platform). The 2017 flagship Map Camp London hosted 180 people (+130 on waiting list), by 2018 this was 460 (+250). Planning 2019 involves hiring a large London Theatre. Other events have been organised in Belgrade, Atlanta, Germany and Scotland. Additionally, Simon undertakes over 50 presentations / events yearly. Derivative spin-offs include Maturity mapping, Power Maps, Burja Mapping, and "Cynefin and Wardley" Maps.

The qualitative evaluation was performed through observation and interviews, as specified in Table 2.

Observation	Interviews
• 2 annual Map Camps in London • Online discussions and sharing practices (Slack, Twitter, blogs, etc.)	25 semi-structured interviews with: - International participants (UK, Russia, Poland, Italy, USA, etc.) - Public/private sector & NGOs - CEOs, CIOs, CTOs, consultants, entrepreneurs

Table 2. Sources of data collection for the evaluation of the mapping artefact

Observation methods of data collection include the participation in the 2017 and 2018 flagship Maps Camps. We were also participant observers in social media and other online environments where an international community of practitioners interested in mapping share and debate ideas and maps.

To gain a more in-depth understanding of participants' views on the mapping artefact, we undertook 25 semi-structured interviews with a wide range of practitioners, including consultants, CEOs, CIOs, CTOs, and strategists in organisations in the public and private sector and of all sizes. Participants were users of these maps or had an interest in mapping, and were recruited in the workshops, via social media, and also following a snowballing process. Some of the interviews were conducted face-to-face, but mostly via videoconference, due to the international nature of participants. The duration of the interviews was approximately 1 hour. Interviews were recorded and transcribed to facilitate analysis, and most participants shared and explained their own maps.

Collection and analysis of data was guided by the aim to evaluate the artefact, and therefore by the theoretical concepts presented, but it also included a more inductive dimension as we wanted to understand mapping in practice and individual understandings/uses of maps. The analysis was conducted iteratively and using N-Vivo to facilitate coding and analysis.

We need to acknowledge some limitations in our study and areas of further research associated to methodological decisions. The aim of the qualitative part of the research was to understand how and why practitioners use Wardley Mapping, and therefore non-users were excluded, and theoretical (rather than representative) sampling undertaken (Eisenhardt and Graebner, 2007). Future experimental research might examine non-users to assess the value they see in the tool. Our focus, however, is on the *practice* of mapping, and we show how mapping is perceived by practitioners to have helped in making sense of the complex dynamic digital ecosystems, and for taking strategic decisions. Future research could study in more detail the effects and success of mapping, in terms of implications for organisations and resulting strategies. This could be done, for instance, through an in-depth comparative case study approach. Future research could also analyse the possible differences in the practice of mapping according to various organisational sectors, sizes, incumbency, etc.

4.2 Findings

Observations and the data presented earlier provides some evidence that Wardley Mapping is attracting the interest and it is being used by an increasing number of practitioners around the world. Overall, this signals that an international community of practitioners finds mapping to be a useful and effective approach in guiding strategic decision-making. The presentations in the Map Camps, and the interviews conducted, allowed us to gain a more detailed understanding of the specific value practitioners see in mapping and the ways it is done in practice. We now present the most salient findings.

4.2.1 Value of maps and situational awareness for strategic decision-making and cost-saving

Overall practitioners expressed that mapping helped them rationalise, codify and visualise the components necessary to deliver value to customers, and that the mapping of (technological) components according to the value chain and evolution axes, i.e. situational awareness, was highly relevant for taking strategic decisions such as where/how to invest in technological solutions, taking into consideration what competitors and service providers are already offering. For instance, one of our participants explained:

> *"I had to use the situational awareness aspect of Mapping when I mapped strategy for X and the reason I had to use it was I was coming from … a kind of CIO role in the public sector and I had an idea that I could create a digital business that could deliver for government departments. But I had to understand the marketplace to check my thinking before I dived in. So I'd come from having a 300 million budget to coming to a company that turns over four million. And so what I wanted to do was use situational awareness to see was there room in the marketplace for a company like X before I came in."*

Our participants shared with us some of the maps they had produced and explained the strategic decisions that maps facilitated. We highlight 3 recurrent themes in terms of the value of maps for strategic decision making:

- **Outsourcing:** The positioning of the necessary components to deliver value to customers in the map helped participants make sense of the extent to which such components should be built in-house, acquired off the shelf technology, or outsourced. It might make sense to develop in-house a new technology when trying to offer something really novel, for which no solutions or technologies are readily available and are close to costumers' needs (top left). However, it might make sense to outsource or use cloud services for components that are far from the consumers in the value chain and are a commodity (bottom right).

- **A move towards** serverless and cloud computing**:** Related to the previous point, we could see that several of our participants are involved (or work as consultants) in the move towards serverless, cloud computing. There might be a reinforcing mechanism by which mapping makes visible the advantages of cloud computing, so those who defend or see value in such move use mapping as a way of convincing other stakeholders (or selling their services), particularly about the evolution of software towards cloud and the future dynamics of the software marketplace.
- **Avoiding redundancy:** Mapping the technological infrastructure and services of big organisations can help make duplication of components visible, and in turn remove redundancy and save costs. Various participants, particularly (but not exclusively) in the public sector showed us 'before and after' maps, where it was possible to appreciate how for instance different departments in an organisation were using different technologies for the same purposes, and how relying on one of them could cover the needs of both units.

  The following quote nicely exemplifies theme 1 and 2. The participant explains how the use of Maps helped her both identify duplications, and identify technology that could be outsourced or acquired through cloud computing as it was a commodity. Tackling this, helped her reduce important costs on IT in a Department of the UK public sector:

  > *"So the first use of the Map was to map out the IT estate at Department for X. So if you had a customer at the top of the map and then map out all of the different applications that the business use with a view to having a look at where you've got duplication first of all, then overlay the contracts that you've got with third parties to have a look at the spin profile. And then have a look at where generic software had been built yet there was commodity software available. So the very first, the very first ask really was about taking cost out of an IT service, in a controlled manner, over a period of time. And the outcome of using the Map for that was actually the creation of a business case that took 35 million pound out of the IT spend over a five-year period. So that was… what we did using Maps for the very first time."*

- Whereas the previous themes are not always related to strategy but to cost saving, a clearly **strategic use of maps** of our participants was to support decisions around what services or technologies to develop or invest in, considering competitors' offerings, and expectations of future developments. That is, defining what an organisation can offer in relation to competitors, and what components/technologies are available as part of the value chain that would be needed to deliver value to consumers. As an example:

  > *"…Some people had been playing with a few maps within there [Organisation Z] and it gave a really good conversation starter in terms of strategy and what kind of things we might do next, and were you know, looking at future strategies and how we might approach them in terms of what technologies we might need to build and what other competitors were doing. And so I've kind of taken some of that information and put that back into what I'm doing at the moment which is looking at a start-up myself."*

We should add that various participants expressed that Maps can be useful for very different purposes, and not even related to decisions involving technology (even if this seems to be the most common use). For instance, a participant said:

> *"I think it serves the purpose of communication but I think the powerful thing for me with maps is that it provides a view of many different lenses. So you can look at it from a what do we hold onto, what do we invest in, what do we retire. You can overlay your contracts base and say what should be outsourced, what should we retain internal. And then you could use it to create an operating model within a business, not just the IT but who do you need to support what and why. So it has lots of different uses. And I have used the maps in lots of different ways."*

As a participant expressed, the (predominant) technology-centric approach to mapping can be problematic:

> *"So I think one of the challenges and on at least one of the occasions when I've used Maps this has been a pitfall that we fell into is one can get quite focused on componentisation, like components and processes and forget about people. And people are such a core part of anything*

that you do, that would be my kind of like when you're doing a Map, be careful not to forget about the people bit."

In our qualitative evaluation we also asked participants about the limitations and challenges of Mapping. To summarise:

1) **Learning curve**: mapping is not an easy task, and can generate some insecurity the first time people try to do it

   "And many people find those symbols and components on a map and they don't trust their own skills in the beginning. It actually, it has nothing to do with skills at all. They wonder whether they will create their map in a proper way."

2) **Defining costumer needs** is not straight forward (particularly for entrepreneurs).

3) **Imprecision**: Some participants expressed that the map could gain in precision, for instance, adding additional dimensions or developing a scale for the y-axis

   "There is a conversation going on at the moment in the Slack Community about the purpose of the Y axis. It's asked should it have a scale. And I've often thought that, you know, what are we trying, what are, what is the Y axis showing?"

   Nevertheless, as we will discuss further in the next section most users do not seem to worry about the precision of maps; in fact they claim that all maps are imperfect.

4) **Lack of tools** to represent/produce maps

   "I think some of the tools around Mapping could be improved because when you're in a conversation like this, and you think okay, let's start mapping quickly, what would be nice is to have a kind of intelligent tool that makes it so easy to pull up a map, start labelling the components in real time."

4.2.2 Mapping as a practice

Following a more traditional design science approach, the previous section offers an evaluation of the artefact in terms of assessing the extent to which it delivers what it promises, and how it is used for the purposes of taking strategic decisions. But in our evaluation we also took a more inductive approach to try to understand the practices in which mapping is embedded. Such approach allowed us to see how the value of mapping overflows that of the artefact; that is, as expressed by several participants it is the practice of *mapping* itself that is valuable. As one participant expressed:

"So you might as well just build a quick map and then have the discussions around it and it's not about getting the right map. The value is getting a map that then gives you the discussion points afterwards (...) the outcome that I'm after is not the map. The outcome is the..., what would the outcome be? So if you take it that it's a map, what you're interested in is the route."

Our inductive coding suggested some prominent themes in this regard, even if frequently interrelated:

1) **Codification & making knowledge explicit:** Many participants volunteered that maps helped to make knowledge explicit, which enabled them to take decisions on a more rational basis. As expressed by one of the participants:

   "And frankly, decomposing that into a system, a representation of a system that could be even wrong still but gives you the basis to form some rationale and present that rationale to others who can then counter it and so on. That's valuable because it means that you're seeing things consistently that other people are not." And it helps elicit the unknown or untold: *"there's been like three different contexts that I've mapped in. In each of those different situations, there's been something come up that was blatantly obvious and none of us were talking about, either because it was difficult or embarrassing or maybe it was just so in front of us we couldn't even see it. So the maps were really helpful for bringing out those conversations."*

2) **Visualisation:** One of the perceived strengths of Maps is that they offer a very useful visualisation tool, which compresses knowledge:

   "All maps are wrong. If you made a map of France that was correct, it would be France. So as soon as you start shrinking it and simplifying it, then you've applied the compression algorithm.

> *But what it does allow then is quickly, one is triggering conversations but with the help of that example, it saved me time. I just looked at it and thought, okay, it validates my hypothesis"* And another participant: *"they were pretty experienced strategy practitioners in the sense that they've been doing strategy in different companies but more intuitively. They just felt that wow, this is cool because now we can more easily communicate around it and sort of make those hidden intuitions visible and challengeable."*

3) C**ommunication:** In connection to the previous two points, participants suggest that Mapping works somehow as a boundary object (Star and Griesemer, 1989) that facilitates communication

   > *"Because that was literally me going, here's a picture and then a 15-20-minute conversation all over the Internet and then we came out with this thing. and I'm like, that makes perfect sense to me. But we'd had, because we'd had a shared visual representation that we both had an understanding of what that meant, we could talk about it."*

   Mapping is also seen as a legitimising representation, a good tool to convey and convince other stakeholders of the strategies proposed, for instance when looking for funding in the case of an entrepreneur, or when looking for approval for a strategic decision.

4) **Collaboration**: As many participants conveyed, the conversations that Mapping facilitates frequently result in useful feedback and learning that can be then integrated into a new version of a map. Indeed, many participants expressed the collaborative character of mapping, either through these feedback loops, or more explicitly by producing maps as a form of team work. As one of the participants said:

   > *"So I think you could say, potentially you can do it on your own, right? But I think, I think that would be a shame because I think the beauty really of it is in the collaboration. It's in the fact that it creates a common language for you to use together to have these difficult conversations about understanding where we are, understanding where we need to be, understanding how we can affect those movements."*

5 Discussion

In this paper we have presented evidence that practitioners recognise significant utility in the process of elucidating, discussing, challenging, and planning for future configurations of value chain components relationally, as they map their respective positions in the value chain, and temporally, as they map their respective movement in relation to ongoing digital commoditization. In turn, our research confirms situational (relational, temporal) awareness as a potentially important competency for organizations seeking to harness the generative potential (Zittrain, 2008) of digital platforms, ubiquitous infrastructure (Hanseth and Lyytinen, 2010), modular software (Schilling, 2000) and "tight-loose" architecture (Nielsen and Aanestad, 2006) to achieve combinatorial innovation (Yoo et al., 2012). Our data suggests that practitioners see value in the associated mapping artefact as a technique to support the development of situational awareness, with relevance for strategic decisions.

Indeed, as a tool for visualisation, communication, rationalisation, and collaboration around the building of situational awareness, it is interesting to consider how some of the limitations of the maps (lack of precision, and difficulty in producing maps) are downplayed by several practitioners who argue that maps are and cannot be perfect, but they help start conversations that lead to strategic decisions, and ensuing actions, in a manner that we find highly performative. Thus, during our analysis we were struck by the way in which both maps and the act of mapping – the building of situational awareness itself – were reflective of the relational, temporal and performative facets of Garud et al. (2014)'s narrative perspective on entrepreneurial innovation. In particular, the narrative perspective offers a useful lens through which to address a relative omission of attention to the 'organizing vision' (Swanson and Ramiller, 1997) through which digital infrastructure and services evolve in practice – an omission that has recently received recognition (e.g. Yoo et al., 2010; Lyytinen et al., 2016) within a literature that remains focused predominantly on generative capability of the technology itself.

Reflecting Garud et al.'s (2014) facets, maps were relational – charting dynamic positions of artefacts and enabling sensemaking of the diverse digital ecosystems of organisations. They were temporal –

charting the evolving past and future movement of such ecosystems, and they were performative – acting and constituting reality. During the remainder of this discussion, we employ these facets within the narrative perspective as a useful lens to uncover new insights for digital innovation offered by the construct of situational awareness and associated mapping activity.

5.1 Maps as relational

The construct of situational awareness and the associated artefact of mapping are inherently relational: that is, they develop a view of the strategic significance of relative positions between value-generating configurations of organisational infrastructures. Mapping of outsourcing, microservices, serverless and cloud were undertaken in relation to other services and the customers value. In reviewing our findings, we were also struck by the way in which producing maps of organisations' digital ecosystems revealed significant duplication of identical generative platforms and innovative services within and sometimes even across many enterprises. Interviewees' usual explanation for this phenomenon is business units' historical arrangement in discrete silos, within which development of duplication has frequently occurred unnoticed – with the outcome that different groups or units within the same organization harness the generative potential of the digital infrastructure in almost identical ways. This was summarised in a tweet on Mapping stating "*Levels of duplication such as 2x, 5x are the fantasy lands of start-ups for many corporates. I tend to more commonly see duplication at the 10x, 100x and 1000x level"*. Better understanding of this replication within digital ecosystems, and of the missed technological and commercial opportunities such replication may represent, offers a promising direction for further research to extend our understanding of generativity within digital infrastructure research.

5.2 Maps as temporal

Situational awareness and associated mapping are also temporal, harnessing remembered past and projected future and providing a means of better imagining the narrative of achieving that future (Denning, 2000). By charting innovation as "moving" from genesis to utility, mapping encourages participants to conceptualise innovation as an unfolding temporal journey (Van den Ven et al., 1999). Past and future are entwined within maps, and harnessing maps is always orientated toward the future, where past/present/future are dynamically constituted (Adam, 1990; Barrett and Scott, 2004). For example, Salesforce, periodic users of the mapping technique, build and maintain situational awareness of their digital platform – to both themselves and customers – within an unfolding temporal narrative about the accelerating commoditisation of cloud-based technology and services. Whilst for many years Salesforce maintained that they intended to continue hosting core services on their own infrastructure, one prominent interviewee had used maps to predict that accelerating commoditisation of public cloud over time would inevitably mean a strategic part-move to public cloud datacenters – which the company eventually did, announcing a relationship with AWS in 2016.

Thus, use of mapping to develop situational awareness emerges as a useful way to develop strategic predictions about likely future direction of digital technology, infrastructure and services. Future research might examine and develop the implications of this to interrogate prominent predictive models with which academic research has yet to engage in any committed way, such as Gartner's 'magic quadrant', described on Gartner's website as showing "direction and maturity of markets and their vendors", which are acknowledged as influential to both supply-and demand-sides of the software marketplace (Pollock and Williams, 2010) – indeed, the Magic Quadrant is argued to be "one of the most referenced research tools in the IT Sector" (Pollock and Williams, 2010, p. 212) – yet highly contested and not produced through systematic research (Rip, 2006).

5.3 Maps as performative

Just as Garud et al. (2014) show narratives as *performative,* where "to say something is to *do* something" ((Austin, 1975, p. 12; italics in original) – for a review of the term see (Gond et al., 2016)) so maps themselves *perform*. Like other narrative devices, our findings show maps not as purely mapping the "outside the world(s) to which they refer", but also that they are "actively engaged in the constitution of the reality that they describe" (Callon, 2007, p. 318). Like other narrative devices, maps "and their world are caught in a process of co-evolution" (Callon, 2007, p.329). We observed in our findings the production of maps to be sometimes an act of rebellion through which strategic change was achieved. In one instance, the past digital ecosystem of an organisation was rendered clearly unsustainable in a ‘fur-ball’ of nodes and vertices on a demonstratively complex map. This could then be used to justify significant change in infrastructure within a number of organisations.

In another example, Map Camp was dominated by a narrative of “Before” and “After” in which speakers explained how their previous maps became either cleaner or more strategic (e.g. better reliant on utility service) following further mapping, analysis and discussion. For instance, arrows were added to show movement from “Bad” to “Good” within these performative narratives – narratives which had literally changed the self-understanding and strategic intentions of organisations represented. Viewed thus, the performance of mapping by a group of individuals engaged in the process of developing situational awareness offers a potentially valuable new avenue for researchers seeking to study how relational, temporal, and performative facets of unfolding narrative come to shape technology choices, and even the strategic direction of technology offerings themselves.

6 Conclusion

This paper makes three significant contributions to the study of IS strategy in the digital age. First, we offer a counter to an acknowledged focus in the existing literature on digital capabilities at the expense of attention to how digital infrastructure and services continually evolve via an ‘organizing vision’ (Swanson and Ramiller, 1997). In developing the notion of situational awareness – a little-used construct within the IS literature – we highlight an important ingredient to the ongoing process of sensemaking that colours strategic decision-making about technology, and in so doing, contributes to shaping the evolution paths for software and services, especially those located in the cloud. Second, we explore an artefact through which growing numbers of practitioners develop their situational awareness: value chain mapping. Using in-depth data from a broad range of practitioners, we highlight a number of themes that show how it is the practice of mapping, rather than the maps themselves, that people engaging in strategic decision-making find valuable; we also discuss some limitations and challenges articulated about the approach. Third, we deploy a narrative perspective on technology to reveal the process of developing, and narrating, situational awareness via mapping, and the relative positioning of components on the maps themselves, as deriving from a nexus of relational, temporal, and performative dimensions that both shapes, and is shaped by, such narrative. We identify some limitations and several directions for future research.

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