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ORIGINAL ARTICLE

Designing a ‘concept of operations’ architecture for next-generation multi-organisational service networks

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Abstract Networked service organisations are increasingly adopting a ‘smarter networking’ philosophy in their design of more agile and customer-focused supply models. Changing consumer behaviours and the emergence of transformative technologies—industry 4.0, artificial intelligence, big data analytics, the Internet of Things—are driving a series of innovations, in terms of ‘products’ and business models, with major implications for the industrial enterprise, in their design of more ‘digitalised’ supply chains. For B2B systems, emerging ‘product-service’ offerings are requiring greater visibility, alignment and integration across an increasingly complex network of multiple partners and collaborators, in order to deliver a better service and customer ‘experience’. To support the design and operation of these multi-organisational service networks, we outline a concept of operations architecture here, underpinned by the literature and network theory, and demonstrate application using a series of exemplar case studies. Focusing on relational elements and the processes key to network integration within service supply networks, the cases inform a set of operating principles and protocols—applicable to all stakeholders ‘cooperating’, within a ‘shared’ environment. Equally critical is to understand how digital technologies may influence future operating philosophies. This article extends our theoretical understanding of network organisations, from a traditional ‘product’ perspective to that of ‘services’, and presents the case for developing a common, unified approach to designing diverse forms of multi-partner service networks.

Keywords Multi-organisational service networks · Product-service systems · Network and data integration · Digital technologies · Operating principles and protocols

1 Introduction

Organisations are now proactively looking to connect, network and collaborate for increased visibility and better decision-making, in order to facilitate delivery of better customer experience and service (Harrington et al. 2015). Here, the identification and understanding of the key ‘touch points’, in an enterprise’s dealings both with external actors and across business units, is becoming increasingly more critical (Srai 2011). In this paper, we focus on B2B systems, where emerging ‘product-service’ offerings are requiring greater alignment and integration—in terms of resources, organisational processes, and data—across networks of interconnected organisations, in order to deliver final ‘product-service’ solutions (Ellram et al. 2004; Sengupta et al. 2006; Baltacioglu et al. 2007; Srai 2011; Harrington and Srai 2012a).

From a manufacturer’s perspective, the move towards integrating services into core product offerings—the ‘servitisation’ of manufacturing—presents both opportunities for revenue growth (Vandermerwe and Rada 1988; Quinn 1992; Knecht et al. 1993; Anderson et al. 1997; Poole 2003; Oliva and Kallenberg 2003; Neely 2009; Schmenner 2009; Harrington et al. 2014) and in enhancing competitive differentiation (Heskett et al. 1997; Baines et al. 2007; Harrington et al. 2014). For customers, a

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'product-service system' (PSS) often means greater emphasis on 'service outcomes', rather than delivering on conventional spares and maintenance (Harrington et al. 2014). In response, multiple 'primes', as partners, are now delivering different and significant service elements of a PSS. This may involve greater interaction with multiple, globally dispersed specialist actors across the entire value chain to deliver services, from R&D right through to 'point-of-use'—it's not *just* about 'after-sales'. This evolving landscape introduces new challenges for the design of increasingly complex service supply networks. How do organisations best align and collaborate with multiple network partners, often dispersed globally, all with different specialisms and their own strategic objectives? It is clear that multi-entity service model concepts need to be developed, in order to aid partners in understanding their network role(s) and interrelationships in service delivery.

One such approach is to establish a common set of operating principles or a 'value system' that is relevant to all network stakeholders operating in a 'shared' system. As part of a unified approach to the high-level design of a *multi-organisational service network* (MOSN), we introduce the idea of a *concept of operations* (*ConOps*), which may be particularly effective given the increasing complexity (greater dispersion of service activities, geographically) and interdependency (increasing dispersion of activities across organisational boundaries) in such operations (Harrington and Srai 2012a). Drawing on a series of service research concepts, associated methodologies and a review of different types of industry models in practice today, a series of attributes for an emerging *ConOps* architecture have been identified, and which any MOSN *should* exhibit. The architecture was then applied, using a series of targeted case studies, in order to explore a broad array of MOSNs—ranging from simple dyadic relationships with symmetry of power, to companies who tend to partner with smaller companies—thus potentially creating a power asymmetry, to, finally—application in more complex service arrangements. At a practice level, this service network design approach can inform multi-partner firm networks on how best to effectively design their increasingly dispersed operational networks for integrated product-service delivery.

2 Concept of operations

ConOps terminology has already been used in a series of operational contexts where there is a requirement for multiple equipment and/or service providers to collaborate—with agreed protocols—within a 'shared' environment (Brennan et al. 2015). A *ConOps* has previously been defined as '*a verbal and graphic statement…of an organisation's assumptions or intent in regard to an operation or series of operations*' (ISO/IEC/IEEE 2011, p. 4). It typically may be in the form of an all-encompassing, user-oriented document—applicable to all stakeholders—by which individual organisations and their dispersed business units can develop specific operational guidance, tactics, techniques and procedures. Examples of existing domains and applications where the approach has been used include software development (Cohen 1999, 2000), financial services (DoD 2006), maritime and defence (DoD 2007), aviation (JPDO 2011), high-value engineering (Harrington and Srai 2012a) and construction services (Harrington and Srai 2012b, c). The concept is designed to give an overall picture of the organisation's operations—providing an overview as well as a strategic objective of an operation or series of operations based on a definition of the roles and responsibilities of all the related parties in the organisation's network. For example, the *ConOps* of the US Air Force may refer to a particular method of deploying resources for a particular military session (JPDO 2011), while a *ConOps* for product lines in software represents a system user's operational view of a system under development (Cohen 1999, 2000).

In the next sections of this paper, we set out the key elements to be considered in developing a *ConOps* protocol, which is applicable to *all* stakeholders operating within a network of multiple partners. While different types of company-focused *ConOps*-type models broadly identify a series of elements, they are not properly defined in many cases. Any *ConOps* for MOSNs should demonstrate how it specifically contributes to achieving the strategic objectives of a network, for example, in terms of greater efficiency, improved innovation capability and flexibility. Hence, the approach we take integrates a series of service research concepts and supporting methodologies in order to 'fill the gaps' involving current models in practice. The development of a common and agreed *ConOps* architecture may best provide guidance, for networked service organisations, on the operating principles and protocols to be used in the design and operation of complex MOSNs.

3 Service supply network design

In a B2B context, we are seeing improved levels of service across various sectors, with 'smart' supply chains having the capabilities to deliver 'just-in-time', 'just-in-place' or 'just-in-sequence' (Harrington et al. 2015). To add to levels of complexity, increasingly dispersed global operations for after-market support have also seen more service providers co-located at customer sites, which require more effective on-site integration (Farris et al. 2005; Harrington and Srai 2012a; Harrington et al. 2014).

One critical challenge here for 'servitising' organisations is how best to effect a service transition, given the difficulty in defining a 'service' and associated 'service' processes (Ellram et al. 2004; Bretthauer 2004; Sengupta et al. 2006; Baltacioglu et al. 2007; Martinez et al. 2010). What are the different partnering approaches and organisational behaviours required for such service delivery? What key strategic and operational capabilities are essential? Are traditional, product-oriented performance measures valid for new service-based models? In order to help answer these specific questions, in the context of emerging MOSNs, we first need to define a '*service supply network'*. We propose it to be '*a network of interconnected organisations that utilises resources, and transforms their inputs (skills and knowledge) into the service offering, to enhance the delivery of a "flexible" customised solution*'. Operationally, it involves '*the integration of those processes and resources, across the network of interdependent organisations in the value chain, involved in the provision of the service solution'* (Ellram et al. 2004; Sengupta et al. 2006; Baltacioglu et al. 2007; Srai 2011).

Secondly, we build on insights into the latest new supply chain thinking emerging from leading firms as they look to push the boundaries of conventional thinking, to deliver modern solutions that will bring value across a variety of industrial ecosystems. Organisations are designing more agile and customer-focused supply chains and are actively exploiting the potential of, for example, big data analytics and social media to innovate in terms of business model and supply chain design (Harrington et al. 2015). Critical to this is the idea of 'open systems'—that networks are mutually dependent on the surrounding environment and are constantly adapting to it (Scott and Davis 2006)—and in understanding how changing consumer behaviours and technological advances in, for example, artificial intelligence (AI), digitalisation and the Internet of Things (IoT) will reshape supply network capabilities and influence any future service context. IoT is already beginning to give supply chain professionals a new set of viable tools to connect people, products and processes (Harrington et al. 2015). In AI, there has also been much progress in replicating some specific elements of intellectual ability by using the IoT as a foundation of 'knowledge' (SCAF 2015). Beyond simple automation, these functions may well include predictive analysis, learning capabilities, autonomous decision-making, complex programmable responses—what Boden (2015) has described as 'combinational' creativity, in a sense, putting already existing ideas together in 'unfamiliar ways'. It is clear that, while 'digital' organisations will need to strategically balance the need for AI and human involvement across their supply networks in the future (SCAF 2015), the nature of work and our roles will certainly still involve tasks around innovative thinking—those 'things' machines 'don't do well' (Byrnes 2015).

In the ongoing debate on technology and society, Gill (2015 p. 139) raises a concern whether 'intelligent architectures', 'organisational structures' and 'policy institutions' are ready to handle 'distributed selves, identities, affiliations, commitments and even locations'. In order to reduce complexity and provide practical guidance for networked service organisations, on the operating principles and protocols to be used in the design and operation of their distributed MOSNs, we examine the attributes to be considered in developing a *ConOps* protocol, by using a three-level approach involving *relationships*, *processes* (*and data*), and *operating philosophy* (see Fig. 1). In addition to protocols, as various technologies are rapidly changing the way organisations and their 'digital' networks work, where they can operate, and often influence who their competitors will be (Byrnes 2015), a ConOps should have the 'flexibility' to assess how a variety or combination of existing and emerging technologies will influence future network design and operating philosophies.

- *Level 1* Relationships
  Within a highly partnered, MOSN context, emerging customer–supplier and supplier–supplier relationships have given rise to the creation of shared *multi-entity* environments (Srai 2011; Harrington et al. 2012)—see Fig. 1. Here, the idea of 'collective intelligence' (Malone and Bernstein 2015) or being 'cleverer together' is perceived to be an opportunity to drive growth by, ultimately, allowing networks of firms to improve the service they could deliver (Harrington et al. 2015). Enterprises are also looking to devise clever ways to get supply chain efficiencies through collaboration, despite not owning the business decisions or relationships (ibid). With the need to develop emerging, and sustain new and existing supplier–supplier/customer–supplier relationships, how do these complex, multi-partnered networks best define, for example, a set of governance rules? This level of the approach examines the nature of such relationships, in the form of multi-entity service model concepts and partnering options. In terms of a *ConOps* architecture, the focus centres on criteria that best captures the business and operational environment, specific strategic intents, service contexts, common objectives and target outcomes for a MOSN.
- *Level 2* Processes and data
  Shorter product life cycles are forcing organisations to speed up their decision-making. In the future, supply chain-driven enterprises may well look to organise themselves around more agile business processes, and better tailor their supply chain KPIs and incentives to a

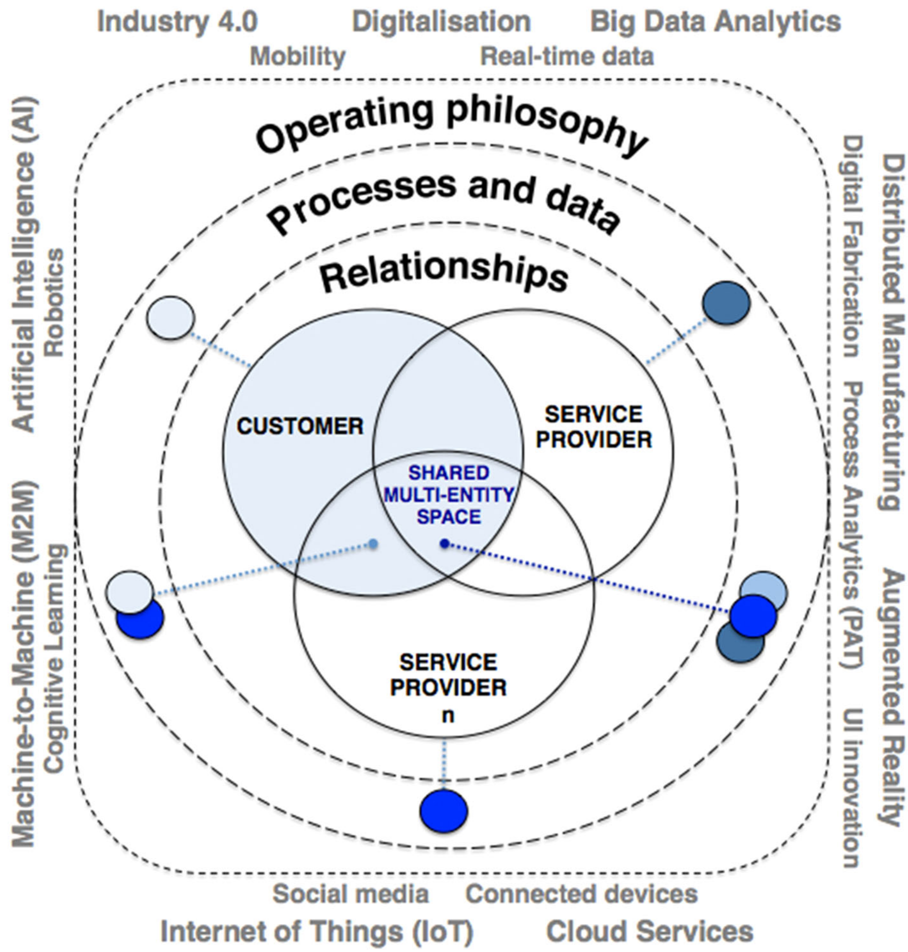

Fig. 1 Three-level approach to designing multi-organisational service networks—relationships, processes and data, and operating philosophy (adapted from Harrington et al. 2014). Equally critical is the influence of transformative technologies on the design and operating philosophy of MOSNs

particular business model involving a series of partners (Harrington et al. 2015). This level of the approach focuses on the identification, alignment and integration of network-critical processes and data across a MOSN. As represented in Fig. 1, data and processes may be (a) customer or service provider-specific, (b) more dyadic in nature, and specific to a customer–service provider or service provider–service relationship or (c) multi-organisational network specific, that are applicable to *all* stakeholders involved in service provision. Here, the development of any operational framework will need to be supported by agreed organisational or network 'routines', some of which may be service model specific. It is definitely not a 'one size fits all' approach (Harrington et al. 2016).
In terms of a *ConOps* architecture, we focus on criteria that will best inform aspects concerning *operational processes* and *target outcomes.* We also recognise the difficulty of finding objective measures to monitor the successful integration of organisations that must work together in the supply of a service (Harrington et al. 2012). Hence, ConOps elements need to be supported by a clear definition of the key performance indicators, in assessing the effectiveness of those organisations that create new service supply networks when they servitise.

- *Level 3* Operating philosophy
  For any new or existing relationships to be sustainable, the development of a common 'value system' is seen as an important step in supporting collaborative behaviour over time (Harrington and Srai 2011).

This element of a *ConOps* explores the operating principles and protocols to be used in the design and operation of a specific multi-partnered network, and focuses on values, motivations, intent and those organisational factors required to support a more integrated solution.

4 Methodology

We first explored the relevant academic literature and theory in order to inform service network design criteria, for example, how best to represent operational elements of service and supply networks from the perspectives of context, relationships, partnering modes, organisational features, processes and capabilities. Specifically, focus centred on:

- Informing business and operational environment contexts, through exploring 'strategic intent' and 'industrial context' definitions from the academic literature
- Identifying, aligning and integrating processes and data across the service network to achieve operational objectives, through exploring (a) process capability models, in order to identify integration-critical processes and data, (b) 'output-based' capability models, in order to define end-user needs and (c) integration theory, in order to capture 'touch points' and 'levels' (hierarchies) of integration
- Establishing service network operating principles as part of a high-level network configuration design through (a) exploring network configuration models and network theory and (b) drawing on 'individual' and 'firm-based' 'values', then extending to a MOSN context.

We next drew on findings from a series of multi-organisational case studies, which took a network perspective (Iakovaki and Srai 2008, 2009; Iakovaki et al. 2009; Srai 2011; Harrington and Srai 2011; Harrington and Srai 2012a; Harrington et al. 2012). These case studies were specifically selected, as they were indicative of the growing shift towards information and knowledge-intensive activities involving multiple 'partners', increasing flows of information between contract manufacturing, engineering and services, and activities that were geographically dispersed. The cases exhibited a variety of complex multi-partner arrangements, which served to highlight major challenges and opportunities for research in the design, integration and coordination of dispersed multi-organisational business networks. The cases involved the dyadic collaboration of two equal firms cooperating in an attempt to build better 'products', a company who historically had acted as the more powerful party within a relationship (requiring large control over its service supply chains, thus creating dependency), two firms selected from a single service supply chain in order to investigate the complex nature of longer-term relationships, and a case chosen due to a specific focus on aligning 'values' within an enterprise and extending these to its partners. In summary, the process involved:

- Accessing a series of exemplar service programmes
- Deconstructing the key business processes where significant interfacing was required
- Identifying 'end-user' capability requirements, initially through customer requirement models
- Taking a 'through-life' perspective, when exchanging and reviewing 'partner' capability, in order to identify 'touch points' between principal actors
- Reviewing levels of alignment with respect to 'strategic intent', and the extent to which key integrating process capabilities were in place for a given service network

Finally, a review of models in current practice (capability and process models, enterprise architecture models, and 'lines of development')[1] also examined where individual organisations and networks had developed specific operational guidance, tactics, techniques and procedures.

Building on the outputs from this section, the key emerging design criteria and supporting methodologies for the design of MOSNs—in terms of relationships, processes and data, and operating philosophy—are summarised in the following sections.

[1]

CADMID (Concept, Assessment, Design, Manufacture, In Service and Disposal): Through-Life Capability Management (TLCM) approach capturing the behaviours, systems, processes and tools used to deliver and manage projects through the acquisition lifecycle.
CMMI (Capability Maturity Model Integration): Organisational development approach providing firms with the essential elements for effective process improvement across a project, a division, or an entire organisation.
CMMI-SVC (CMMI for services): Model that provides guidance to service provider organisations for establishing, managing and delivering services—focusing on processes and integrating bodies of knowledge essential for successful service delivery.
TRAiDE: Decision support environment for TLCM, aiding more objective, better-evidenced decisions on capability delivery. Process involves making good 'trades' between solution options, through combining method, data management, tools, process and visualisation.
MODAF (Ministry of Defence Architectural Framework): Standardised way of conducting enterprise architecture, providing a means to model, understand, analyse and specify capabilities, systems, systems of systems and business processes.
TOGAF (The Open Group Architecture Framework): Approach to designing, planning, implementing, and governing enterprise information architecture. Typically modelled at four levels or domains, i.e. business, application, data and technology.
DOTMLPF (Doctrine-Organisation-Training-Materiel-Leadership and education-Personnel-Facilities): US DoD Joint Capabilities Integration Development System (JCIDS) process, providing a basis for considering solutions involving any combination of DOTMLPF.
TEPIDOIL (Training-Equipment-Personnel-Information-Concepts and Doctrine-Organisation-Infrastructure-Logistics): UK Defence Lines of Development—a holistic approach to capability integration.

5 Relationships

The drive towards multi-partner collaboration has recently been articulated through the idea of 'smarter networking'—that is, developing a more 'sophisticated' approach to networking by sharing more information, aligning KPIs across network partners and operating as a 'community' (Harrington et al. 2016). Using the term 'relationships', we look to enable the identification and understanding of the key 'touch points', in an organisation's dealings with external organisations, across business units (and ultimately with the end-customer).

5.1 Main objectives and contextual environments

Networks in different contexts will have different strategic objectives. In addition, these networks will often require different sets of capabilities, organisational features and partnering mechanisms. The industrial context concept (Zhang et al. 2007; Lin et al. 2009; Harrington and Srai 2012a) is extended here to refer to the environmental features of networked service organisations, which are influenced by internal and external factors (institutional trends, industrial trends and firm level strategies), in order to specify the '*objectives*' and '*target outcomes'* in terms of a *ConOps.* These internal and external factors will also have an influence on configuration and processes for a specific MOSN. Furthermore, an industrial ecosystem mapping methodology previously developed (Srai et al. 2014; Srai 2016) can be used to help capture the '*contextual environment of operations'*, by both identifying the main industry actors, and by setting out the current business and operational environment, constraints, key problems and contracting types for a specific MOSN. Some examples of questions that organisations and their networks look to explore, from our studies, include:

- What is the 'ecosystem' or 'service network' we are looking to define?
- What is the service network supposed to deliver?
- How will a service network achieve its strategic objectives, in certain contexts?
- What kinds of processes and capabilities are required to achieve these objectives?
- How does one best design or configure the network to deliver these capabilities?
- How does a network effectively measure its performance?
- How well does the network currently 'perform'?
- How do partners effectively use data across the network, and what are the mechanisms to deal with data ownership and protection?
- What other 'systems' will the network 'interact' with?
- How could technology and data facilitate the integration of other 'systems'? For example, the integration of health and social care systems?
- Where else could the service network be used? There is scope for organisations to develop specific industrial capabilities and explore how different projects compare, in terms of industrial capability requirements.

This component may also look to identify key priorities, in terms of trends, barriers and future customer requirements, to which organisations, and their networks, may have to respond. For example, how a network of health services may approach the issue of 'free at the point of care' in the future, in light of national budgets being distressed. Ultimately, answering these questions can help develop a common 'network' language—aid dispersed network partners, their extended business networks and their internal functions to communicate with each other, achieve consensus and/or identify common problems. In turn, it enables a clearer specification of common objectives and target outcome(s) for network partners, effectively describing the 'system' as it currently exists and the precise problems or 'dilemma' to be resolved.

5.2 Organisational structure, relationship with partners and support infrastructure

Network members should be organised and coordinated consistently to benefit the overall strategic objectives of a MOSN. In changing environments, organisations and their extended networks are looking at ways to create, integrate and reconfigure resources into new sources of competitive advantage (Teece et al. 1997; Helfat et al. 2007). As a result, different types of customer-focused and dynamic organisations are emerging with more agile supply chains that increasingly cut across business units, functions and geography, putting new emphasis on the importance of cross-network collaboration (Harrington et al. 2015). In the specific case of service partners working directly with end-customers, often co-located at the customer's site, these new customer–service provider and service provider–service provider partnerships often bring particularly high risk and exposure (Harrington et al. 2014).

An ability to identify and re-organise around future 'capability' requirements has also become increasingly important, especially where these 'capabilities' play a critical role in future organisational design and network partner selection. The concept of dynamic (or dynamic technology) capabilities is also considered here and examines those organisational and strategic 'routines', that may be influenced by technology or influence how technology is used, by which a future 'digital' organisation may achieve a new resource configuration design, as markets emerge and evolve (Eisenhardt and Martin

2000; Winter et al. 2003; McLaughlin 2016). In addition, organisations also need to make decisions in this space, about the 'level' of collaboration that should exist between partners, whether it should be purely transactional ('arm's length') or strategic (a 'marriage'). Hence, 'capability' features such as skills, knowledge, technology and organisational processes are integral to any emerging network design criteria and/or capability acquisition assessment.

The network configuration approach we use here focuses on establishing patterns, profiles and archetypes, as according to configuration theory, the alignment of strategy, systems or routines is often reflected in practice (Harrington and Srai 2012a). Analysis, informed by the network configuration models derived from the literature and applied in engineering, production, nascent, emerging and mature supply network contexts (Harrington and Srai 2016), can capture *'organisational structure'*, *'relationship with partners'* and '*support infrastructure'* aspects of a ConOps architecture. These criteria help explore the various linkages between customers, suppliers, key network partners, inter-firm relationships and partnering modes, and begin to inform a common set of operating principles as part of a high-level configuration design, supported by MOSN configuration design tools, and examining dimensions such as network structure, dispersion, levels of interdependency, network dynamics/flow, governance and coordination, partnering/collaboration models and product-service configuration. Additional questions for a ConOps checklist, from our studies, can help the members of a service supply network to better understand the following:

- How to achieve the strategic objectives in certain contextual circumstances?
- How will the service network then operate? Network members should be organised and coordinated consistently in order to meet the strategic objectives, in terms of the development and definition of a core network agenda, supporting documents, data sources, time horizons and subsequent roles and responsibilities using mechanisms such as RACI,[2] in order to deliver the desired outcomes.
- What 'capabilities', data, and support infrastructures are required to achieve these main objectives?
- How best to design or configure the network to deliver such 'capabilities', and measure performance?

6 Processes and data

Identifying, aligning and integrating the 'touch points' or business-critical processes and data, across the service network, needs to be particularly effective in the case of MOSNs, given an increasing complexity and interdependency in such operations (Harrington et al. 2012; Harrington and Srai 2012a). This may often involve the selection of certain service operating models, devising new ways of operating, and in many cases, the progressive transfer of operational processes and data between customer and service supply organisations. Here, we look to better understand and identify the key network integration processes, encompassing both organisations and their external partners.

6.1 Operational capabilities and target outcomes

In prescribing how best to design complex multi-partner collaborations, we use the positive correlation between network integration and business performance that has been reported widely in the operations and strategic management literature (Lambert and Cooper 2000; Ellinger 2000; Frohlich and Westbrook 2001; Swink et al. 2007; Harrington et al. 2012). However, despite the benefits of increased levels of integration between multiple partners and organisational forms being well documented, network collaboration mechanisms, to a large extent, remain poorly understood (Barratt 2004; Nyaga et al. 2010). Network integration continues to be difficult to operationalise, with emerging multi-partner arrangements in service presenting major challenges, in this regard (Croxton et al. 2001; McCarthy and Golicic 2005; Iakovaki and Srai 2008, 2009; Iakovaki et al. 2009; Lockstrom et al. 2010; Nyaga et al. 2010; Harrington et al. 2012). Joining up data across the ecosystem and misalignment is a major cause of service system inefficiency (Srai 2011; Harrington et al. 2014) as processes, capabilities, routines and procedures become increasingly critical in terms of the performance of a service network.

Despite the many intricacies, integration challenges may be rationalised by concentrating on those key processes or 'linkages' between partners (Iakovaki et al. 2009; Srai 2011; Harrington et al. 2014). Conversely, some organisations are also starting to think about innovative ways to further reduce supply network complexity, by displacing or eliminating some of these linkages to traditional

[2] **RACI** is an acronym derived from 4 key responsibilities: **R**esponsible, **A**ccountable, **C**onsulted, and **I**nformed and may be used to effectively define roles and responsibilities for a MOSN.

- **Responsible** refers to network actors who will do the work to achieve a specific task, although others may be delegated to assist, as required
- **Accountable** (also approver or final approving authority) refers to network actors ultimately answerable for the correct and thorough completion of a deliverable or task
- **Consulted** refers to network actors whose opinions are sought (typically subject matter experts)
- **Informed** refers to network actors who are kept up-to-date on progress, often only on completion of the task or deliverable.

intermediaries who have previously played a key part in the flow of materials or information. 'Disintermediation' strategies may, in certain circumstances, offer both an alternative route to network optimisation (Rosenberg and Srai 2015). In addition what effect will the emergence of platforms, modelled on *Upwork* and *TaskRabbit*, have in connecting emerging freelance labour markets with customers and service networks (Byrnes 2015)? While integrating or removing any of these 'processes' has often been more difficult to perform, given the increasingly complex nature of coordination between individuals and teams (Barney 1991; Grant 1991; Mills and Platts 2003), leading organisations are starting to experience real benefits, for example, from bringing together the 'physical' with the 'digital' in the context of end-to-end supply chain integration (Harrington et al. 2015). However, while this rapid development of digital supply chains has enabled improved service delivery, it has also served to further highlight the challenges, problems and multiple (yet unrealised) opportunities for data sharing and systems integration in areas such as e-tailing, conventional retail, parcel delivery and transport systems (Stefansson 2002; Yu 2015; Harrington et al. 2016).

A methodology for identifying network integration processes has been previously reported (Iakovaki et al. 2009), which helps to define the important cross-network business processes and identifies the key enablers for integration. Evaluation of operational processes, versus a set of network integration enablers—*common goals, shared risks and rewards, network synchronisation, collaborative resources, knowledge sharing*—has already helped identify those critical process-based capabilities in MOSNs (Iakovaki et al. 2009). These processes may also be classified hierarchically in four layers—namely business goals, strategic capabilities, operational capabilities and activities—and could also influence partnering options within complex operational networks, and the selection of appropriate partnering arrangements for different multi-entity contracting, partnering and subcontracting models (Sampson 2000; Farris et al. 2005).

Adaptation of process hierarchy, network integration and disintermediation methodologies inform *operational processes or capabilities* and *target outcomes* elements of the ConOps architecture. These criteria can then be used to define a MOSN-specific hierarchy of capabilities, supported by a process-capability hierarchy toolset, and identify those processes key to network integration, assessed against a set of network integration enablers.

6.2 Performance measures

In the future, MOSNs will face non-traditional supply chain challenges and will need to develop a new set of competences across people, processes, products, technologies and data to support new business models (Harrington et al. 2015). Indeed, we are increasingly seeing traditional industrial efficiency dimensions and measures being re-orientated to capture greater consumer participation, social considerations and multi-stakeholder service outcomes (Harrington et al. 2016).

This element of the *ConOps* architecture focuses on enabling clear definitions of the key performance indicators in the service aspect of a business, and to ensure alignment with an organisation's 'service' strategy. A methodology for service metrics development, which involves assessment of the degree to which integration 'enablers' are in place for any complex product-service network, has been previously reported (Harrington et al. 2012). This methodology enables identification of those key performance indicators that will best align with a particular service model and captures relational, collaborative and qualitative aspects of network integration, rather than just solely focusing on cost and quantitative metrics (ibid).

7 Operating philosophy

In terms of an *operating philosophy* for a MOSN, approaches are required that provide guidance, for networked service organisations, on the operating principles and protocols to be used in the design and operation of a complex PSS. Where activities are co-located at a customer site, an architecture, from which a single set of governance rules can emerge to support the integration of multi-partner processes and data, is critical. This section explores the key elements that may to be considered in developing such protocols, which must be applicable to *all* stakeholders operating within a network of multiple partners.

As networks are typically formed by a variety of autonomous entities, it is likely that each individual network member possesses a distinctive set of values (Abreu and Camarinha-Matos 2008). Alignment of each 'value set' (forming a shared 'value system', for a given MOSN) is critical to sustaining collaborative behaviour over time (Abreu and Camarinha-Matos 2008, Harrington and Srai 2011). In the context of MOSNs, 'value sets' have previously been described as '*a list of normative beliefs that guide the behaviour of a collaborative network of firms which are co-created and sustained for the mutual benefit of all actors*' (Harrington and Srai 2009). The associated methodology focuses on perceptions of shared value within multi-entity service networks and builds on literature focusing on individual and firm-based values, and on findings from a series of MOSN case studies (Harrington and Srai 2011). It introduces and identifies a set of generic socio-ethical values, which organisations may perceive to be useful and relevant in sustaining relationships with partners. These may include considerations such as co-operation, trust, respect of IP, data security, commitment to objectives, equal rewards, commonality of objectives, defined roles, responsiveness to partners/problems, and communication. These criteria support the development of a common 'value set' across all service network partners, and can promote the establishment of an agreed set of operating principles and protocols for a specific MOSN.

8 *ConOps* architecture for MOSNs

While previous *ConOps* models, reviewed as part of this study, have broadly identified a series of elements, they are not properly defined. The *ConOps* architecture for MOSNs introduced here—and summarised in Table 1—aims to set out an operating philosophy for service supply networks. It provides a standard definition of the main elements of what a ConOps should capture and a structured set of associated outcomes. To further illustrate these points, examples involving a variety of product-service solutions are presented in Table 1, in addition to the methodologies employed for each *ConOps* element.

This *ConOps* supports better clarity on the motivations, challenges and target outcomes that organisations, and their respective networks, face in terms of future performance and behaviours. The criteria identified also help establish a set of attributes that any service supply network should exhibit. As these are applicable to all stakeholders, it is from these elements that individual organisations and networks may develop specific operational guidance, tactics, techniques and procedures. The *ConOps* architecture, applied in a consistent manner, can also provide the platform for valuable cross-case analysis and learnings.

8.1 Extending MOSN concepts to digital pharma and e-healthcare contexts

Future healthcare solutions will require more end-2-end (E2E) collaboration at a system level, in developing new models of care based around improved patient compliance, adherence and 'personalisation'. As part of the Reconfiguring Medicines End-2-End Supply (ReMediES) programme, the methodologies, outlined in Table 1, will be utilised to define operating principles and protocols in a variety of pharma/healthcare contexts where there is a specific focus on servitisation and service transformation for a series of 'alternative' manufacturing paradigms and novel business model concepts. Future service network configuration options, the 'touch-point' processes for better network integration, and the data requirements in supporting the effective implementation of a series of service strategy scenarios in pharma/healthcare will specifically involve:

- extending 'concepts of operations' and service 'outcome' contracting models to an e-healthcare context (for example, in architecting digital supply chains—for the provision of care and the treatment of diabetes—product-service design may focus on developing more collaborative solutions that better support self-management by patients)
- moving towards more distributed 'make-to-order' service models for pharmaceutical supply—driven by 'digital' manufacturing (continuous processing, process analytics) and supply chain concepts, and 'activated' patients
- promoting new institutional governance models in healthcare—re-defining the role beyond that of traditional regulatory control and governance tasks, to one of being able to facilitate performance 'outcomes', as part of a more partnered approach involving patients, healthcare system stakeholders, and the pharmaceutical sector.

9 Discussion and conclusion

Organisations are increasingly looking to take a more proactive approach to the design of new, responsive and more customer-focused networks. This paper set out a *concept of operations* (*ConOps*) architecture to provide guidance for organisations on the operating principles to be used in designing the next generation of *multi-organisational service networks* (MOSNs).

ConOps terminology has already been used in many operational contexts where multiple equipment and service providers operate in a shared environment. It can provide an overview, as well as a strategic objective of an operation or series of operations, based on a definition of the roles and responsibilities of all the relevant stakeholders in an organisation or network. A summary of the relevant academic literature was presented, in order to better understand the characteristics of MOSNs, and to critique the key components of the different *ConOps*-type models in practice today. In order to reduce complexity and provide practical guidance, we examined the attributes to be considered, and integrated our research activities and supporting methodologies on industrial context definition, the design and configuration of product-service networks, the identification of enabling processes key to effective network integration, and the development of a 'value system' for MOSNs, on three levels—exploring *relationships*, *processes and data*, and *operating philosophy*.

Table 1 *ConOps* architecture for MOSNs—setting out the key elements for service supply network design

Level	Element of a *ConOps* architecture	Description	Outcomes	Service exemplars	Supporting methodologies and tools
Relationships	Main objectives	Strategic intent definition	Specifying objectives and target outcomes	Construction services (Harrington and Srai 2012b, c)—defining B2B multi-partner service model concepts to aid partners understand their specific roles and responsibilities in service delivery	Industrial context (Zhang et al. 2007; Lin et al. 2009; Harrington and Srai 2012a)
	Contextual environments	Service network context definition	Setting out the main industry actors, the current business and operational environment, constraints, key problems and contracting type	Software development (Cohen 1999, 2000)—constraints focus; Aviation (JPDO 2011)—capturing specific industry challenges and future trends	Industrial ecosystem mapping (Srai et al. 2014; Srai 2016)
	Organisational structure; relationship with partners; support infrastructure	Definition of the structure, roles, responsibilities, and strategic partnerships with key suppliers, customers or users	High-level network configuration design, based on network structure, dynamics, governance, partnering models, product configuration	Maritime, defence (DoD 2007)—promoting inter-agency coordination, defining critical infrastructure for 'community' data sharing	Product-service network configuration (Harrington and Srai 2012a) Supply network stages model (Harrington and Srai 2016)
Processes and data	Operational processes; target outcomes	Process definition, required capabilities to achieve operational goals and procedures to align activities and data	Hierarchy of stakeholder processes, identification of processes and data key to network integration—through assessment versus a set of network integration enablers	Aviation (JPDO 2011)—Specific capabilities identified, supporting eight key concepts, required to deliver next-generation outcomes	Process hierarchy and network integration (Iakovaki and Srai 2008, 2009; Iakovaki et al. 2009; Srai 2011; Harrington et al. 2014) Disintermediation (Rosenberg and Srai 2015)
	Performance measures	Methodology for service metrics development	Definition of the key performance indicators that will align with a service model and assessment of the degree to which network integration enablers are in place for any complex product-service system	Engineering function (Harrington and Srai 2012a)—network-specific performance measures, aligned with strategic goals	Performance metrics for network integration enablers (Harrington et al. 2012)
Operating philosophy	Operating principles and protocols	Defining a common value set amongst key network stakeholders	Creation of a '*Value system*'—covering e.g. co-operation, trust, respect of IP, data security, commitment to objectives, equal rewards, commonality of objectives, defined roles, responsiveness, communication	Financial services (DoD 2006)—informing business process interconnections; Software development (Cohen 1999, 2000)—forming the basis for long-term planning	Shared value dimensions within MOSNs (Harrington and Srai 2011); Multi-stakeholder framework for solution design (Harrington et al. 2016)

Application of the resultant *ConOps* architecture, across a diverse set of case study networks and exemplar *ConOps*-type models, demonstrated the applicability of the approach and its ability to provide new insights into re-designing dispersed networks. It is argued that the criteria we established form the basis of a set of attributes that any service supply network should exhibit, addresses a key gap in the literature on service context setting, and also contributes to theory on network integration. Application also extends our theoretical understanding of 'networked' organisations, from a traditional 'product' standpoint to 'product-service' or 'service' perspectives, and may aid a variety of organisations, as they look to servitise, to effectively design and operate their service supply networks.

Discussions with industry actors, as part of this study, also highlighted a strong correlation between the need for innovation and enabling the next generation of supply chains—stressing the importance of reducing time to market, and delivering more responsive customer service. Equally critical to industrialists going forward will be to understand how technology developments will reshape the capability of their manufacturing operations and supply chains, right through to the consumer. With the development of new routes-to-market, partly driven by innovative e-commerce initiatives, new improved modes of customer-centric service delivery (B2C) in various sectors are already emerging. In a B2B context, digitally enabled 'smart' supply chains are looking to deliver 'just-in-time' and 'just-in sequence'. With advances in robotic capabilities and as IoT matures, many industrial systems are expected to add more robotic and AI functions to traditional industrial and consumer applications. What implications will such emerging technologies have for business model and service supply network design in the future? As part of our emerging technology research agenda, we will examine the 'informating' of future supply network phenomena, and how IT-enabled and e-commerce-based supply chains are changing the roles of information and knowledge. Future work, in the area of servitisation, will aim to capture those generic patterns that may be valuable for service networks, in particular contexts—where a variety of emerging technologies may work or may not work; part, replenishment and production characteristics; emerging product-process archetypes, as examples. Finally, our *ConOps* architecture will inform the development of more practical tools and processes to aid supply network strategists to both optimise current service supply networks or design 'next-generation' networks—in line with future requirements and linked to evolving consumer and market behaviours. In parallel, application of the approach, in a series of non-service contexts, will look to examine transition paths for rapidly evolving industries, the subsequent implications for organisations, industry and government, and the policy and regulatory changes required to support nascent and emerging network development.

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