

Preliminary Insights into Dominant Issues, Theories and Methodologies in Platform Interoperability Research

Completed Research Paper

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Abstract

This study presents preliminary insights on the dominant issues, theories, and methodologies in existing research on platform interoperability. The authors illustrate their position by analysing the various issues, theoretical approaches and research methodologies found in these studies. A total of 70 papers obtained from five academic literature databases from 2008 to 2018 were reviewed. The findings suggest that the reviewed studies largely lack theorisation. As such, we suggest that theorisation underpins future interoperability research. These research should, first, explore the antecedents of platform interoperability and how differing interests of stakeholders are unified and implemented. Second future research should explore technological and non-technological (process, administrative and structural) changes that organizations undergo while attempting to adopt interoperability and how the change shapes the outcome of the process. Lastly, future research needs to also examine the context-based factors that influence interoperability and how these factors compare or contrast across private and public sector organizations.

Keywords

Interoperability, information systems, platform interoperability, literature review

Introduction

Interoperable systems make organisations interoperable (Gottschalk, 2009). Interoperability, also known as platform interoperability, is a means of exchanging information that allows multiple information systems components to work together as a single system (Wang, Wang, & Gördes, 2018). It can also be defined as the ability of systems and organisations to work together (Gottschalk, 2009; Innocenti, Vullo, & Ross, 2010). Some sectors in which interoperability has emerged include library management (Alemu, Stevens, & Ross, 2012; MacKeigan, 2014), tourism and hospitality (Buhalis & Leung, 2018; Reino, Alzua-Sorzabal, & Baggio, 2016), government and corporate organisational systems (Guijarro, 2009; Sharma & Panigrahi, 2015), e-business (Novakouski & Lewis, 2012; Rezaei, Chiew, & Lee, 2014) and healthcare and telemedicine (Biltoft & Finneman, 2018; Zhang, Han, & Tang, 2017).

Interoperable systems or platforms are known to provide a number of benefits, most importantly the ability for ‘independent’ systems to exchange and share information (Jardim-Goncalves, Grilo, Agostinho, Lampathaki, & Charalabidis, 2013; Mattiello-Francisco, Martins, Cavalli, & Yano, 2012). Interoperable government websites, for example, display governmental information so that citizens can interact with government departments online to fulfil their service requests (Sharma & Panigrahi, 2015). Additionally, through integration, both citizens and businesses are able to access necessary government services through a window in which every aspect of that particular government-to-citizen (G2C) or government-to-business (G2B) transaction or interaction takes place (Scholl & Klischewski, 2007). Hospitals are also

introducing new interoperable technologies that are capable of producing integrative synergy if implemented effectively (Gottschalk, 2009).

Studies on interoperability have been recently carried out in different fields (Daclin, Daclin, Chapurlat, & Vallespir, 2016). Although these studies provide useful insights into interoperability, some knowledge gaps remain, warranting additional research and review of relevant studies. For example, there is a need to carry out studies on trending issues related to platform interoperability like has been done for social media (see Ahmed & Stockdale, 2014; Ngai, Tao, & Moon, 2015) and cloud computing (see Yang & Tate, 2012).

Additionally, platform interoperability is becoming an emerging area and is of interest to both private and public sector institutions (Janssen & Feenstra, 2010; Sharma & Panigrahi, 2015). For governments, interoperability provides advantages such as lower costs and transparency in governance systems and processes as it eliminates corruption by providing new possibilities for resolving poverty and inequality among citizens (Wadia, 2000) and is considered as one of the indicators for determining the maturity of the e-government systems (Estermann, Riedl, & Neuron, 2009). Despite these advantages that interoperability brings, there are still a number of challenges and limitations to its proliferation, as it is a complex phenomenon with constraints in various dimensions such as technology, organizational capabilities, syntactic and semantics (Scholl & Klischewski, 2007). The complexity is compounded by the fact that these constraints differ from the context in which they are deployed (for example, country to country) as they are dependent on the prevailing political, economic, social and technological conditions (Sharma & Panigrahi, 2015). In this respect, taking stock of extant research through a review may provide insights which can inform future research that seeks explore interoperability and how to address the outlined challenges (Senyo Addae, & Boateng, 2018).

This study seeks to review relevant literature to establish key research issues, theoretical and conceptual approaches and methodological approaches that have been used to study platform interoperability. This paper is structured into 7 sections. Section 1 presents the introduction. Section 2 presents the methodology that is used in the conduct of this study. Section 3 discusses the dominant themes while Section 4 discusses the conceptual approaches identified in the papers. Section 5 discusses the methodologies used in papers that were reviewed while Sections 6 and 7 explore the gaps for future research and the conclusion of the study respectively.

Methodology for Review

The search was conducted with the phrase “platform interoperability” and keyword “interoperability” on the abstracts, keywords and titles ‘search spaces’ across the databases. Collecting literature from electronic sources is mostly performed by researchers to gather literature that provides justification for arguments or assertions they make in their study on a particular subject (Petter & McLean, 2009). Searches were conducted in five journal databases: Online Wiley, Emerald, EBSCOhost, ScienceDirect, and Taylor & Francis. A contributory reason for the use of these five databases was the lack of identifiable papers that discuss the concept of platform interoperability. However, in the view of Levy and Ellis (2006), these journal databases are ranked as part of the sources of the top fifty information systems journals. As such, we believe a fair representation has been made in this regard. The study sought for journal papers published within the past decade (i.e. from 2008 to 2018).

Inclusion and Exclusion Criteria

Three criteria were used to gather appropriate and reliable literature that will enable us to fulfil the purpose of this study. First, for a paper to be considered for use in this study, it must be a recognisable peer review article or journal. Thus, we eliminated conference papers, doctorate dissertations and master’s theses, textbooks and magazine publications. Second, the paper should provide a substantial discussion on interoperability of systems or platforms. As such papers that did not substantial details and a clear discussion on the concept of interoperability of systems or platforms were excluded (e.g. Zengenene, 2013). Third, its subject should be related to this review’s conceptualisation of the term. Papers that sought to conceptualise the topic of interoperability or platform interoperability were also

considered and included in the study as long as they met the first three conditions. As this study sought to review studies published within the past decade, the search was filtered to return only scholarly journal articles published from 2008 to 2018.

Data Extraction and Synthesis

A total of 80 papers were initially identified and downloaded from the search of the electronic databases. However, after downloading the papers from the electronic databases, a total of 70 papers were deemed to meet the selection criteria and were used for the analysis. To clearly indicate the purpose of this study, these papers were summarised according to three themes: dominant issues about platform interoperability, dominant conceptual or theoretical approaches to studying platform interoperability and dominant methodological approaches to studying platform interoperability.

Dominant Issues in Platform Interoperability Research

The review classified interoperability into four major themes, each of which was further classified into sub-themes. The four major themes were *dimension*, *perspective*, *levels* and *domain*, and *application*. The classification of schemes in literature is challenging as all aspects must be taken into consideration (Senyo *et al.*, 2018). Therefore, the classification scheme for this study was primarily adopted from three studies with some modifications to reflect changes in the literature (Rezaei, Chiew & Lee, 2014; Senyo *et al.* 2018; Tripathi, Gupta & Bhattacharya, 2012).

The *dimension* theme relates to the technological adoption space of the studies concerning platforms. The sub-themes on the dimensions were data integration, which refers to the combination of data from different sources and provision of the user with a unified view of this data (Halevy, 2001); process integration, which refers to different processes that are developed (Tripathi, Gupta, & Bhattacharya, 2012); communication integration, which refers to the use of electronic computers, computer software and computer networks to convert, store, protect, process, transmit and securely retrieve information (Vernadat, 2010); and multi-dimension, which refers to papers that discussed more than one technological adoption space. In total, 54 papers (77%) were based on process integration, 10 (14%) were based on data integration, 3 (4%) were based on communication integration and 3 (4%) were multi-dimensional. The *perspective* theme relates to the perspectives on the solution that have been developed. The sub-themes are service orientation and database perspective (Rezaei *et al.*, 2014; Weichhart, Stary, & Vernadat, 2018). The former focuses on processes and functions developed as serviceable resources, while the latter considers the contribution of interoperable platforms to the provision of services based on storage and manipulation of data. In total, 56 papers (80%) were service-oriented and 14 (20%) had a database perspective.

The *levels* theme relates to the levels at which interoperability can be attained and requires resolution (Morris, Levine, Meyers, & Plakosh, 2004; Munk, 2002). There are four sub-themes: technical, syntactic, semantic and organisational interoperability. Technical interoperability refers to hardware or software components, systems, and platforms that enable machine-to-machine communication and are focused on communication protocols and the infrastructure required for those protocols to function (Rezaei *et al.*, 2014; Van der Veer & Wiles, 2008). Syntactic interoperability refers to the ability of two systems or platforms to exchange data, and it is usually associated with message transfer by communication protocols as well as defined syntax and encoding (Rezaei *et al.*, 2014; Van der Veer & Wiles, 2008). Semantic interoperability is normally related to the definition of content, and it deals with humans' rather than machines' interpretation of this content. Organisational interoperability refers to the capability of organisations to effectively communicate and transfer information despite using a variety of information systems across significantly different types of infrastructure and, possibly, across various geographic regions and cultures. We identified 13 papers (19%) to be technical, 8 (11%) to be syntactic, 23 (33%) to be organisational and 26 (37%) to be semantic. The *domains and applications* theme borders on a specific sector of society where interoperability has had an impact. The sub-themes include hospitality, e-government, information technology, e-business, education, and knowledge management and health. Based on our review, 3 papers (4%) were related to hospitality, 9 (13%) were related to e-government, 10 (14%) were related to information technology, 7 (10%) were related to e-business, 24 (34%) were related to education and knowledge management and 5 (7%) were related to health. Additionally, 3 papers (4%)

concerned more than one sector and so were classified under the cross-domain sub-theme, and 9 papers (13%) could not be classified under any particular theme and so were placed under the general issues sub-theme.

Themes	Sub-Themes	Number of Papers	Percentage
Dimensions	Process integration	54	77%
	Data integration	10	14%
	Communication integration	3	4%
	Multi-dimension	3	4%
	Total	70	100%
Perspective	Service-oriented	56	80
	Database perspective	14	20%
	Total	70	100%
Levels	Technical	13	19%
	Syntactic	8	11%
	Organisational	23	33%
	Semantic	26	37%
	Total	70	100%
Domains & Applications	Hospitality	3	4%
	E-government	9	13%
	Information technology	10	14%
	E-business	7	10%
	Education and knowledge management	24	34%
	Health	5	7%
	Cross domain	3	4%
	General issues	9	13%
	Total	70	100%

Table 1. Dominant Issues in Platform Interoperability Studies

Dominant Conceptual Approaches in Platform Interoperability Research

Our review of the downloaded papers indicates that they used a number of different theories, frameworks, models, and concepts. Some studies used more than one theory, framework or model, while others did not have any identifiable theory, framework, model or concept. The complex adaptive systems (CAS) theory (see Weichhart, 2015) was a theory used to conceptualize the dynamics of interoperable systems which learn and be concurrently functionally dependent (integrated with others) and independent (be changed without affecting others). Frameworks included the resource description framework (RDF), which was used by Puustjärvi (2008), who studied semantic interoperability in electronic auctions by examining the advantages and disadvantages of using hard-coding and semantic messages for communication between the auction system and participants in the auction, and the government interoperability frameworks (GIFs), which were used by Ray, Gulla and Dash (2011) for a critical survey of selected government interoperability frameworks.

Several studies used more than one theory, framework or model. Nayar and Beldona (2010) used the technology co-adoption model, interorganisational systems standards and process innovations (IOS SPI (IOS SPI) model, and institutional theory to evaluate the strategic perspectives of key industry players

regarding the potential of interoperability technology and examine the factors pertaining to their adoption. Guijarro (2009) combined the eGovernment Interoperability Framework (eGIF), the Danish eGovernment Interoperability Framework (DIF) and the Le Cadre Commun d'Intéropérabilité (CCI) to survey how e-government agencies in Europe and the United States have developed tools such as interoperability frameworks and enterprise architectures. Specifically, the study looks at how semantic technologies and standards have been incorporated into interoperability frameworks. Some studies primarily used models (less theoretically inspired frameworks) rather than theories or theoretical frameworks. Prodanović and Vulić (2017), for example, used the certification authority trust model to study a model of PKI interoperability in Serbia. It is also worth noting papers that conceptualised models to study platform interoperability, including the study performed by Ghenassia *et al.* (2017) regarding a generic method for improving the spatial interoperability of medical and ecological databases.

Other studies used no framework. For example, Birrell, Dunsire, and Menzies (2010) summarised the methodology and findings of the Online Catalogue and Repository Interoperability (OCRIS), a project that was recently carried out by the Centre for Digital Library Research at the University of Strathclyde and was funded by the Joint Information Systems Committee (JISC). Janssen and Feenstra (2010) also introduced the concept of a service portfolio, which is a pragmatic web instrument used to support the composition and reconfiguration of manufacturing chains. In view of this, we argue that many of the studies done on cloud platform interoperability research utilized little or in some cases no theoretical frameworks or models. We, therefore, posit that there is a need for more theorisation in platform interoperability research. Table 1 shows the use of frameworks, models, theories, and concepts in existing studies. In total, 51 articles (73%) did not involve any framework, model, theory or concept, while 2 articles (3%) used conceptualised frameworks.

Research Framework	No. of Papers	Percentage
Conceptual	2	3%
No framework	51	73%
Certification authority trust model	1	1%
Technology co-adoption model and institutional theory	1	1%
RDF	2	3%
GIFs	1	1%
Foundation for Intelligent Physical Agents Contract Net Protocol	1	1%
Industry Foundation Processes	1	1%
eGIFs, Danish eGovernment Interoperability Framework, CCI	1	1%
Enterprise Resource Planning interoperability frameworks	2	3%
Policy and quality interoperability framework	1	1%
FLEXINET ontology	1	1%
Web Feature Service	1	1%
Existing e-business interoperability framework	1	1%
CAS theory	1	1%
Reference model for supporting a technology classification of mobile content and service delivery platforms	1	1%
Standards and Interoperability (S&I) Framework by Office of the National Coordinator for Health IT (ONC)	1	1%
Total	70	100%

Table 2. Dominant Research Frameworks, Models, Theories and Concepts Used in Platform Interoperability Research

Dominant Methodological Approaches to Studying Platform Interoperability

The reviewed papers employed recognisable methodologies to study platform interoperability, including quantitative, qualitative, mixed methods and design science methodologies. Some employed no method. 35 articles used a qualitative approach, 14 articles used a design science, 11 articles used no methodology, 6 articles used a quantitative approach and 4 articles used a mixed methods approach.

A number of articles used a qualitative approach, including those of Henning (2016), who studied a theoretical framework concerning the determinants of organisational adoption of interoperability standards in government information networks, and Sandy and Freeland (2016), who studied the importance of interoperability in the context of the Digital Public Library of America. Studies that employed a design science approach include those of Golzarpoor, Haas, Rayside, Kang and Weston, (2018), who studied ways to improve the interoperability of construction industry processes and industry foundation processes, and Alfaro, Rodríguez-Rodríguez, Verdecho and Ortiz (2009), who studied business process interoperability and collaborative performance measurement.

Some studies did not have any identifiable methodology. Examples include those of Buhalis and Leung (2018), who conceptualised smart and agile hospitality enterprises of the future and proposed a smart hospitality ecosystem that adds value to all stakeholders, and Llanes-Padrón & Pastor-Sánchez (2017), who examined the records in context conceptual model proposed by the International Council on Archives (ICA) based on the archival description and proposed an W3C Web Language (OWL) ontology for its implementation in the semantic web. One possible explanation of why these studies are not underpinned by research methodology could be that there are studies in the domain that are purely conceptual – and do not collect any form of data and as such this study provides insight into what platform interoperability researchers may focus on in terms of methodology in order to add more rigour to their studies.

Some articles adopted a quantitative approach. For example, Tripathi *et al.* (2012) examined the interoperability of government and corporate portals in a technological adoption space in India in terms of three critical dimensions: data integration, process integration and communication integration. Birrell, Dunsire and Menzies (2010) summarised the methodology and findings of the Online Catalogue and Repository Interoperability (OCRIS), a project recently carried out by the Centre for Digital Library Research at the University of Strathclyde and funded by the JISC. Finally, studies applying a mixed methods approach include those of Maheshwari and Janssen (2014), who described an interoperability measurement instrument combining technical and organisational interoperability, and Ghezzi, Cortimiglia and Balocco (2012), who developed a technology classification model for mobile content and service delivery platforms, the core of mobile middleware technology providers' value propositions.

Research Gaps and Priorities for Future Research

The identified gaps in the literature align with three main themes: planning and implementation, the characteristics of interoperability and the impacts and limitations of interoperability.

Adoption of Interoperable Platforms

Our review of existing literature on interoperability shows there are several factors that must be considered in developing interoperable systems in developing countries, such as layers of interoperability, the need for standards, information sharing capabilities, and the need for single identity and digital signatures for authenticating transactions (Pardo & Tayi, 2007). Kubicek and Cimander (2009) identify and emphasise four layers of interoperability: technical, syntactical, semantic and organisational. The reviewed studies present different dimensions and contexts for interoperability, which form the basis for studies or research that enable the faster proliferation of interoperability capabilities, especially between government departments. According to Guijarro (2007) and Kubicek, Cimander and Scholl (2011), the use of open standards plays an important role in the operability of government systems. Additionally, techniques for implementing interoperable systems are based on the tasks in which different applications

are involved, owned and run. While such systems may be easy to implement in much smaller countries, it may be more difficult in larger developed countries due to the influence of jurisdiction, authority and politics (Sharma & Panigrahi, 2015). Moreover, to adopt interoperable platforms and take advantage of the standardisation they offer, organisations will have to change their technical and organisational processes (Gogan, Williams, & Fedorowicz, 2007). There is, therefore, a need to explore the techniques adopted by organisations and governmental institutions, especially those in developing countries in implementing interoperability. We propose the following research questions to be explored in future studies:

- i. What techniques should organizations adopt in order to implement interoperability in developing countries?
- ii. What technological and non-technological (process, administrative and structural) changes do organizations undergo while attempting to adopt interoperability in developing countries?

Impact and Limitations of Platform Interoperability

Despite the advantages of interoperability for citizens and governments, there are several challenges and limitations to its proliferation, as it is a complex phenomenon with constraints related to, for example, technology, organisational capabilities, syntactic and semantics (Guijarro, 2007; Scholl, Kubicek, Cimander & Klischewski, 2012). The complexity is compounded by the fact that these constraints depend upon the prevailing political, economic, social and technological conditions, and thus there is a wide disparity among countries with respect to the maturity of e-government services (United Nations, 2014).

In addition, there are some limitations that hinder interoperability from proceeding efficiently (Tripathi *et al.*, 2013). For example, Scholl *et al.* (2012) identify nine constraints on the implementation of interoperable platforms: constitutional or legal constraints, jurisdictional constraints, collaborative constraints, organisational constraints, informational constraints, managerial constraints, cost constraints, technological constraints and performance constraints. These create an environment that favours certain intergovernmental interactions but limits others at various levels. Novakouski and Lewis (2012) describe how to address interoperability requirements and describe the challenges that policymakers and system developers face regarding interoperability in e-government systems.

There is a need to further understand the problem of interoperability and account for context-dependent factors that influence its implementation. The following questions could be explored in future research:

- i. What are the antecedents of platform interoperability in the public sector and how are the differing interests of stakeholders unified and implemented?
- ii. What are the context-based (such as technological, institutional, and environmental (including policy/legal) factors that influence interoperability? How do these factors compare or contrast across private and public sector organizations?

Conclusion

This study is one of the first to review the dominant issues in studies on platform interoperability. It makes two primary contributions to the literature. First, it presents insights into existing studies on interoperability. Second, it highlights the dominant issues in studies on interoperability and identifies the various issues, theoretical approaches and research methodologies these studies used. As compared to developed countries, there is a need for more studies examining developing countries, as a number of innovations are being adopted by both governments and organisations in the private sector (Nunoo, 2018). Because the studies we reviewed largely lack theorisation, we suggest that future interoperability research should be conducted with a theoretical lens. Despite the insights generated, this study was limited by the number of papers it used and by the characteristics of the databases from which papers were collected. It could have been strengthened by searching other databases, like IEEE Explore which is more likely to include articles from other disciplines. Future work related to this research area, which is part of a wider study on platform interoperability in developing countries, should be extended to account for studies focusing on digital government platforms in developing countries.

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