

## **A Bigger Picture: Information Systems and Spatial Data Infrastructure Research Perspectives**

Yola Georgiadou<sup>1</sup> and Francis Harvey<sup>2</sup>

<sup>1</sup>International Institute for Geo-Information Science and Earth Observation (ITC),  
Hengelosestraat 99, P.O.B. 6, 7500 AA Enschede, The Netherlands [[georgiadou@itc.nl](mailto:georgiadou@itc.nl)]

<sup>2</sup>Department of Geography, University of Leicester, Bennett Building,  
Leicester, LE1 7RH, United Kingdom [[francis.harvey@gmail.com](mailto:francis.harvey@gmail.com)]

### **ABSTRACT**

A weakness of spatial data infrastructure (SDI) studies has been the limited uptake of research outside of positivist and scientific-technological perspectives. To put it simply, a study of a SDI without considering other philosophies of knowledge will be greatly constrained to technical and administrative organizational dimensions. The ontological uniformity of SDI studies is unnecessarily restrictive. While valuable in a narrowly defined framework of project, SDI studies should consider the larger set of interactions involving actors in political, administrative and socio-technical domains. We review the development of information system research approaches and consider key positions from its diverse ontologies (positivism and interpretivism) and theories (strategic alignment, interactionism and social construction). We point to possible ways to consider these positions in SDI research.

### **INTRODUCTION**

Since the 1950s information technology has been applied towards improving organisational activities of government with limited success (e.g. Bolstrom and Heinen, 1977; Markus, 1983), a finding paralleled by studies of GIS data sharing activities (Budic, 1994; Campbell and Masser, 1995; Gould, 1994). SDI research in recent years continues to echo these findings. The positivist accounts in most SDI research may help in understanding information system implementation, when the geographical, economic, cultural, historical, experiential 'distance' between the context of design and the context of use of the information system is small or negligible. However, for infrastructural information systems, like SDI, that span numerous contexts spread out globally, the exclusive reliance on positivism is unlikely to provide rich insights of how different actors strike and sustain a dynamic, often precarious balance between global uniformity and local contextual solutions (Georgiadou, 2006). This stands in contrast to research in the field of information systems that since the early nineties has taken up a number of different competing philosophical and theoretical frameworks with corresponding ontological diversity for the study of information systems (incl. GIS) as well as for the study of information infrastructures.

### **INFORMATION SYSTEMS RESEARCH**

The Information Systems (IS) field studies the design and management of information and communication technologies in organized human enterprise. The field arose in the 1970s as a rebellion against viewing the two faces of information systems as separate social and technical systems. As a result, "...the IS field fought hard against the long-held opinion in the social sciences and management that information technology is only a minor and unimportant element in human enterprise and will continue to be so. Likewise the IS scholars have long challenged the dominant views among computer scientists that the engineering of IT artefacts does not need to take into account and understand the social and organizational issues surrounding computing" (Lyytinen and King 2004, p. 240). As IS matured it gradually moved beyond the designing and building of systems, and into understanding the organizational mission, adoption, diffusion, and effects of such systems, by importing ideas from several intellectual perspectives, e.g. computer, management, organisation & cognitive science, economics and sociology. Ever since the inception of the IS field in the 1970s, IS researchers and practitioners have questioned the field's fundamental tenets, contents, philosophical

frameworks, methodologies and practical relevance in dozens of articles. This reflexivity is arguably responsible for the ontological diversity and theoretical richness of the field as well as for recent advances made in theorizing the design of information infrastructures. Below, we illustrate the trajectory of IS research from the 1980s through the 1990s and up to the present using two influential review articles, –Orlikowski and Baroudi (1991) and Orlikowski and Iacono (2001)– as milestones.

### **Towards ontological diversity in information systems research**

Orlikowski and Baroudi (1991) reviewed 155 information system research articles published in the eighties and concluded with a call for more ontological diversity in IS research. They identified a single positivist set of *"philosophical assumptions regarding the nature of the phenomena studied by information systems researchers, and what constitutes valid knowledge about these phenomena"* (p. 1). They discuss key ontological aspects of positivism in the natural sciences and their relevance to information system studies: objects of study are tangible with clear universal characteristics, researcher and objects of study are independent, generalized statements with fixed and invariant meanings are possible, distinct cause-effect relationships can be established through deductive logic, inquiry is value free.

Positivist research approaches construct a set of assumptions that define the object of study, the nature of knowledge, and relationships between knowledge and the empirical world. Organizations, as the object of study, are understood to have a structure and reality beyond their members that a researcher can discover through precise measurements of the aspects of this structure and reality that interest the researcher. Understanding organizations becomes a problem of modeling and measurement in which the researcher does not intervene and is passive and neutral. The relationships between individuals and organisations is possible because human action is assumed to be rational (at least to some degree) in a relatively stable and orderly setting without conflict and contradiction in the organization. Any conflict is understood to be a signal for a disruptive problem that can be corrected. Knowledge in positivist research of information systems is found through empirical testing of theories that are verified or falsified in a search for universal laws or principles and a close linkage between explanation, prediction, and control.

In the nineties, IS researchers moved on to different ontological directions and cross-fertilizations with other fields and intellectual perspectives. More studies followed what is known as an interpretative research philosophy, usually with the presumption that socially meaningful facts and things are socially constructed, several with an empirical basis involving GIS systems. See e.g. Sahay (1998), Sahay and Walsham, (1997), Sahay and Walsham (1996), Walsham and Sahay (1998).

### **From information systems to information infrastructures**

The nineties signalled also the move from 'information systems' to 'information infrastructure' to explain the complexity of factors and multiplicity of outcomes involved in large-scale ICT projects. Three distinct theoretical accounts of information infrastructure (see figure 1) emerged in the nineties literature, based on empirical data from global corporations, health care, banking etc.

Weill and Broadbent's (1998) account emphasizes technical and human resources, while information infrastructure is viewed as an assembly of ICT components converted to useful shared ICT services by a human ICT infrastructure of knowledge, skills, architecture and experience. A key question is whether a firm's investment in ICT is in harmony with its strategic objectives, thus providing business value. This state of harmony is referred to as strategic 'alignment'. *"Alignment between strategic context and the information technology portfolio requires planned and purposeful management processes, within both business and information technology disciplines. Complete alignment can never be achieved as the demands of business, competitor activity, management needs and technology choices are constantly changing."* (ibid. p. 337).

Information Infrastructure account	Information infrastructure as:	Informed by:	Exemplary proponents:
<b>Positivist</b>	an assembly of technical and human resources; a proxy for competitiveness of the (global) firm	management science - strategic alignment	e.g. Weill and Broadbent (1998)
<b>Interpretive</b>	an ensemble of social relations (or interactions)	symbolic interactionism theory	e.g. Star and Ruhleder (1994)
<b>Interpretive</b>	a heterogeneous collage of mutually constitutive technologies, networks, standards to support a diversity of application areas over time and space	actor-network theory (ANT)	e.g. Ciborra and associates (2000) & Nielsen (2006)

**Figure 1:** Accounts of information infrastructure in IS research in the nineties.

In Star and Ruhleder’s (1994) conceptualisation of information infrastructure, the technical artifacts and people are de-emphasized. The focus is on relations or interactions, as arguably the only thing that is knowable. *“What is infrastructure? Common metaphors present it as a substrate: something upon which something else “runs” or “operates,”[...]. Such a metaphor is neither useful nor accurate. [...] we hold that infrastructure is fundamentally and always a relation, never a thing. This can be seen via [...] an “infrastructural inversion”: a figure-ground gestalt shift in studies of large scale technological change [...]. This inversion de-emphasizes things or people as the only causes of change, and focuses on infrastructural relations (e.g. between railroads, timetables, and management structures in bureaucracies). It inverts traditional historical explanations and reveals how choices and politics embedded in such systems become articulated components. Substrate becomes substance.”* (ibid. p.253).

The theory of Ciborra & associates (2000) and Nielsen (2006) on information infrastructure design and evolution takes into account the multi-generational and emergent aspects of technological artifacts that arise as designers, developers, users, regulators, and other stakeholders engage with evolving artifacts over time and across a variety of contexts. Their perspective emphasizes that the social and technical are not separable and are instead constituted and constitutive of one another. Information infrastructures are described as heterogeneous networks subsuming varied technologies, networks, standards to support a diversity of application areas over time and space.

Despite these theoretical developments, the question of Orlikowski and Iacono’s (2001) second influential review article is still a powerful stimulus for further understanding and theorising of information infrastructures: *„[w]here are the theories of how such large-scale and densely interconnected IT artifacts coevolve with the various social institutions and communities (both local and global) that develop, regulate, use, and change them? ”* (ibid, p. 132-133).

**SDI RESEARCH: A BIGGER PICTURE**

The perceived challenges in current SDI research are twofold. The first relates to conducting independent, verifiable, and repeatable research to provide hard, as opposed to anecdotal, evidence of the positive short-, medium term and macroeconomic impacts of SDI implementation. However, public administration scholars warn against uni-directional causal relationships between ICT and governance and speak on purpose about ‘implications’ because “*autonomous political, legal, economic and professional developments in and around public administration, and the changes in ideas and ideals for that matter, are as important for the effects of ICT applications on public administration as the technological developments themselves*” (van de Donk and Snellen, 2002, p. 11). The second challenge relates to improving institutional arrangements as well as human resources capacity so that global geospatial technology innovations can disappear in the woodwork and become infrastructure in specific social contexts. However, the implied normative, prescriptive stance only points to ‘where we want to go’ but not ‘how to get there’ (Georgiadou, 2006).

Taking up Orlikowski & Baroudi’s (1991) and Orlikowski and Iacono’s (2001) insightful work, we argue that interpretative accounts and ontological diversity have a great deal to offer to studies of SDI. Even more importantly, SDI research has a great deal to offer to IS research for two reasons: Firstly, the empirical setting of SDI phenomena is predominantly public governance and not the corporate sphere, while the current theoretical accounts of information infrastructures in IS research have emerged from the empirical basis of global private corporations and universal infrastructures (in particular, the Internet), and not in public governance settings. Interactions between SDI agents – imbued with different rationalities, interests and beliefs– take place across the three spheres –political, public administration and societal spheres– of a public governance system and are profoundly different from interactions of agents in corporate governance (Grönlund, 2004). Secondly, the ‘public good’ nature of SDI offers opportunities to understand how the properties of inclusiveness and non-rivalry of public goods are socially constructed over time and space (Kaul et al, 1999).

SDI studies should consider the larger set of interactions involving human agents and institutions in the political, public administration and societal spheres of public governance. From the broad field of interpretative approaches in information system research, we wish to focus analytically (i) on the importance of interactions of actors in public governance and (ii) on the importance of human agency in socially constructing the SDI as a ‘public good’. The first focus is hermeneutic while the second has the potential to create policy proposals.

#### **SDI as social phenomenon: An analytical focus on interactions**

A consideration of relations or interactions in interpretative approaches understands interactions in multiple ways: interactions among individuals, interactions among institutions, including organizations, political groups, etc. and interactions involving knowledge. Significant to interactions are the activities - both collaborative and conflictual- that individuals pursue related to their roles for the development and maintenance of a SDI. Activities have economic, technical, social, cultural, and political dimensions. The interactions among institutions include the same dimensions, but need to be considered in terms of a multiplicity of desired outcomes, even contradictory outcomes, and the history of interactions. Institutions refers as well to all formal organisations and informal groups that exert or withdraw from the process of developing a SDI. Knowledge interactions takes off from a notion of mobile knowledge that holds that knowledge is part of a process of communication. The dimensions of knowledge are the same; however, they must be understood in terms of the individuals and groups professing or disputing a claim to knowledge. Further, these three ways are inclusive, which means that all three must be considered concomitantly in analysis.

#### **SDI as public good: An analytical focus on human agents**

An alternative analytical focus would be on the importance of human agency in the social construction of SDI as a public good. This perspective views the 'public' nature of a good as a socio-political construction rather than as an inherent quality of the good. Human agents actively build the conditions for non-exclusion and non-rivalry. With the lines between 'public' and 'private' blurred and constantly changing, 'public' and 'private' are not anymore fixed but time-variable properties of goods. Although some researchers suggest to abandon the public-private distinction altogether, others argue forcefully that a good's properties should be made explicit- even though they may be of a temporary nature – because they determine the provision strategy for the good and affect actors' decisions to reveal their preference and level of demand. They assert that the good's 'publicness' is a social construct. And that the public or private *nature of a good is not a given but a matter of policy choice* made by a multiplicity of SDI 'builders.' Privileging human agency over technical and social structures, the multiple agencies of the different 'builders' in the construction of SDI as public good, as well as the role of institutions and SDI in shaping human agency need to be better understood.

### CONCLUDING REMARK

We hope that the consideration of interactionism and social construction presented here will raise awareness of the need of a plurality of research perspectives. A bigger picture for SDI means researchers can hope to successfully meet the challenges of the infinite complexity of the social world. SDI studies can, in return, bring rich examples of the interactions between government and technology to information systems research. We look forward to considerations of hybrid methodologies from information systems research, discussions of ontological diversification of SDI research and further discussions on the philosophical foundations that underpin SDI research.

### BIBLIOGRAPHY

- Bolstrom , R. P., & Heinen, J. S., 1977. *MIS problems and failures: a social-technical perspective*, Part 1: The causes. *MIS Quarterly*, 1(3), 17-32.
- Budic, Z. D., 1994. *Effectiveness of geographic information systems in local planning*, *APA Journal(Spring)*, 244-263.
- Campbell, H., & Masser, I., 1995. *GIS and Organizations. How effective are GIS in practice?* London: Taylor & Francis.
- Ciborra, C. and Associates. 2000. *From control to drift: The Dynamics of corporate information infrastructures*, New York: Oxford University Press Inc.
- van de Donk, W.B.H.J. and Snellen, I.Th.M., 2002. *Towards a theory of public administration in an information age?*, in *Public Administration in an information age*, eds. I.Th.M. Snellen and W.B.H.J. van de Donk, IOS Press, ISSN 0928-9038, pp. 3-19
- Georgiadou, Y., 2006. *SDI ontology and implications for research in the developing world* : editorial, *International journal of spatial data infrastructures research (IJS DIR)*, 1 (2006)1, 51-64. Available at <http://ijsdir.jrc.it/editorials/georgiadou.pdf>
- Gould, M., 1994. *GIS design: A hermeneutic view*, *Photogrammetric Engineering and Remote Sensing*, 60(9), 1105-1115.
- Grönlund, Å., 2004. *Introducing e-Gov: History, Definitions, and Issues*, *Communications of the Association for Information Systems*, 15, 713-729.
- Harvey, F., & Tulloch, D. L., 2006. *Local Government Data Sharing: Evaluating the Foundations of Spatial Data Infrastructures*. *International Journal of Geographical Information Science*, 20(7), 743-768.
- Kaul, I., Grunberg, I., Stern, M. A., 1999. *Global Public Goods: International cooperation in the 21<sup>st</sup> century*, (Eds.), Published for the UNDP, Oxford University Press.

- Lyytinen, K. and King J.L., 2004. *Nothing At The Center?: Academic Legitimacy in the Information Systems Field*, Journal of the Association for Information Systems Vol. 5 No. 6, 220-246, June 2004.
- Markus, M. L., 1983. *Power, politics and MIS Implementation*. Communications of the ACM, 26(6), 430-444.
- Nielsen, P., 2006. *A conceptual framework of information infrastructure building*, Available at <http://heim.ifi.uio.no/~pnielsen/PHD/NielsenPetterThesis.pdf>
- Orlikowski, W.J. and Baroudi, J.J., 1991. *Studying information technology in organizations: Research approaches and assumptions*, Information Systems Research, 2, 1, 1-28.
- Orlikowski, W. J. and Iacono, C.S., 2001. *Research Commentary: Desperately Seeking the "IT" in IT Research - A Call to Theorizing the IT Artifact*. Information Systems Research, 12 (2), pp. 121-134.
- Sahay, S., 1998. *Implementing GIS technology in India: some issues of time and space*, Accounting, Management and Information Technologies, 8, 147-188.
- Sahay, S. and Walsham, G., 1996. *Implementation of GIS in India: Organizational issues and implications*. International Journal of Geographical Information Systems, 10, 4, 385-404.
- Sahay, S. and Walsham, G., 1997. *Social structure and managerial agency in India*, Organization Studies, 18, 3, 415-444.
- Sahay, S. and Walsham, G., 1997. *Social structure and managerial agency in India*, Organization Studies, 18, 3, 415-444.
- Star, S. Leigh and Ruhleder, K., 1994. *Steps towards an ecology of infrastructure: complex problems in design and access for large-scale collaborative systems*, Proceedings of the 1994 ACM conference on Computer supported cooperative work CSCW '94, Publisher ACM Press, October 1994, pp. 253-264
- Walsham, G. and Sahay, S., 1998. *GIS technology for district administration in India: some problems and opportunities*, MIS Quarterly, 23, 1, 39-66, (special issue on intensive research).
- Weill, P. and Broadbent, M., 1999. *Four views of IT infrastructures*. In *Beyond the IT Productivity Paradox*. Willcocks, Leslie P. and Lester Stephanie (eds.) Wiley Series in Information Systems, p.335-362