Balancing the technical and social contexts of Spatial Data Infrastructure (SDI

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Abstract

One special characteristic of spatial data is that they can be shared to be used for many purposes other than the one for which they were initially produced. To facilitate their efficient sharing and reuse, they need to be properly managed in the form of a Spatial Data Infrastructure (SDI). This study argues that developing a successful SDI must be seen as a socio-technical, rather than a purely technical exercise. It urges that SDI practitioners need to understand the significance of human and societal issues as much as technical issues, all of which contribute to the successful implementation of SDI.

Keywords: *spatial data, SDI, ANT, Socio-technical networks*

Introduction

Public and private organizations are committing considerable resources and making important long-term decisions concerning spatial data handling - collection, management, use and dissemination. While these actions are influenced by current policies, priorities, opportunities and challenges, their ultimate success depends on future developments and trends e.g. changing technologies, societal needs and institutional structures.

Spatial Data Infrastructure (SDI) can be defined as an umbrella of policies, standards, terminology and procedures under which organizations and technologies interact to foster more efficient use, management and production of spatial data (Nebert [1]). In such, it consists of organisations and individuals who generate and / or use spatial data, the technologies that facilitate use and transfer of spatial data, and the actual spatial data. SDI is not all about networks and technology; it will not function if the data has not been generated, neither if communication channels, standards, procedures, and partnership models have not been developed. SDI provides a basis for spatial data discovery, evaluation and application for users and producers within all levels of Government, the commercial sector, the non-profit sector, academia and private individuals.

An estimated 95% of all information used by national governments has spatial characteristics or attributes (Mavima & Noongo [2]). It is thus not surprising that the focus has lately shifted to the challenges associated with integrating broadly sourced spatial data as an effort to create manageable frameworks. The concept of SDI therefore, has evolved in response to a growing recognition of the importance of spatial data, and the increasing needs of society to use shared spatial data. A SDI is about facilitation and coordination of the exchange, sharing, accessibility, and use of spatial data within the spatial data community through standardization and routinization. SDIs are dynamic, integrated and multi-leveled practices.

The SDI phenomenon emerged around the early 1990 (Masser [3]). Since then development of SDIs have become an important subject and platform in geoinformation science to facilitate and coordinate the exchange and sharing of spatial data between stakeholders in the spatial data community. Its significance is demonstrated by numerous initiatives by many countries at different jurisdictional levels (Noongo [4]). The need for SDIs has also been intensified by new technologies such as Global Positioning Systems (GPS), satellite navigation systems for cars, and a new generation of mobile phone services that can also display map-based information (Crompvoets [5]). The proliferation of web-based spatial information services such as Google Earth also makes it possible for users to view different parts of the world at the click of a mouse. These technological developments mean that the majority of people, consciously or unconsciously, are now users of spatial information. Consequently, new spatial knowledge is being generated continuously. SDIs rely on spatial data and on geoinformation technology (De Man [6]; Eelderink, Crompvoets, & De Man [7]). Therefore, SDIs represent specialized functionalities.

A common approach to information infrastructure construction is to focus on the technical aspects, and to treat the “social” as the context in which its development takes place. Approaches of this type assume that all outcomes of technological change are attributable to the “technological” rather than the “social”. It is essential that SDI practitioners understand the significance of human and societal issues as much as technical issues, all of which contribute to the success of SDI construction. Key issues include overall information policies, sustaining a culture of sharing, political support, establishing a common language, maintaining reliable financial support, clarifying the business objectives which the SDI is expected to achieve, and enlisting the cooperation of all members of the spatial data community. This paper argues that developing a successful SDI must be seen as a socio-technical, rather than a purely technical exercise.

Social aspects are also often overlooked in SDI assessments. SDIs assessment criteria are often shaped with technical and financial aspects (Crompvoets & Grus [8]; Eelderink et al [7]). When some SDI development is celebrated as a success, often technical features are mentioned while social issues are not incorporated in the analysis. When the implementation is proclaimed as a failure, social factors are mostly blamed. This is a clear signal that a better understanding of organizing is needed and that both technical and social aspects should be incorporated in SDI frameworks. SDI policy advisors are most of the time aware of social aspects, but do not consider them as important, let alone they treat them as manageable phenomena or too hard to conceptualize.

This paper views SDI through Actor Network theory (ANT) as a socio-technical practice – an interplay between heterogeneous humans and non-human (e.g. technologies and organizations) actors and their intermediaries (e.g. agreements) within a social and political context. It argues against perceiving SDI construction as primarily a technical issue, but as a complex social and technical charged matter where multiple actors influence and possibly compete with each other. Consequently, neither social nor technical accounts should be privileged in SDI developments.

Concept of Actor-Network Theory

Actor-Network Theory (ANT) emerged during the mid-1980s, primarily with the work of Bruno Latour, Michel Callon and John Law. Emerging from a Science and Technology Studies (STS), ANT asserts that the world is full of hybrid entities containing both human and non-human elements and that nothing is purely social or purely technical. It offers the notion of heterogeneity to describe technology implementations in social settings, implying that humans and non-humans should be integrated into the same conceptual framework.

An actor, is any agent, collective or individual, that can associate or disassociate with other agents (Latour [9]). ANT accepts humans, non-humans (e.g. technologies and organisations), and their intermediaries (e.g. agreements) as actors. Actors are not fixed and do not have significance in and of themselves, instead, they derive significance through relations with other entities (Latour [9]). Individual actors are not static or unitary; they change over time, across social and political contexts, and in their relation with other actors. Both human and non-human actors are considered equal for the purpose of critical analysis and in as much as they have the ability to act and be acted upon (Latour [9]). By considering actors equally, the analytical focus shifts from them (the actors) to the characteristics and behavior of interactions between society and techno-science. Basically, ANT's primary interest in actors is not their context, but their interactions and effects on other actors (Law [10]; Singleton & Michael [11]).

Individual actors in the network are usually associated with different networks of their own interests. When delineated, this makes some networks fractal or contracting infinitely (William-Jones & Graham [12]). A network viewed as fractal is unwieldy, complex and all but useless for coherent analysis (William-Jones & Graham [12]). Given this density, individual networks may be simplified or "black boxed" to look like a single point (Latour [9]). This means that behind each actor in the network there hide other actors more or less effectively drawn together. It also means that any changes in the actor-network affect not only actors directly involved, but also the networks they simplify. The entry of new actors, desertion of existing actors or change in alliances can cause the black boxes to be opened and their contents to be reconsidered. Actor-networks rely on a continued maintenance of its simplification for its continued existence. These simplifications are under constant challenge and if they break down the network may collapse, and may reform in different configurations.

The complex network of spatial data

Spatial data are items of information which identify geographic location and characteristics of natural or constructed features and boundaries on the earth. The information may be derived from - among other things - remote sensing (spaceborne and airborne imagery), Global Positioning System (GPS), Geographic Information Systems (GIS), cartographic techniques, Computer Aided Design (CAD), and surveying techniques. Spatial data are particularly valuable for planning and development efforts because they describe the spatial distribution of economic resources, population and other relevant factors that can contribute to mitigate problems of uneven development in a society. They have the potential to impact widely on society, due to their ability to represent a host of important characteristics spatially.

Spatial data is about space and the objects and processes therein. Space is more than geo-referenced location – it matters for what it affords not for what it is (Smith & Mark [13]). Space is subjectively conceived by individuals, and individuals could even conceive it differently at different spatial levels. Space is shared with others, meaning that space is also a setting for social life (Crompvoets, Rajabifard, Van Loenen & Fernández [14]). The intensity of social encounters and social life in general depends on the degree of "social capital" (Putman [15]), which is also different at different spatial levels. These dynamics are likely to have a significant influence on the way spatial data is understood by different people in terms of content, role, and complexity. It implies that spatial data are multifaceted, and new spatial knowledge is being generated continuously. The newly generated knowledge is always subjected to time and space. Knowledge that was generated many years ago might have appeared perfect at that moment though afterwards it might have been proven counterfeit.

Spatial decision problems often require that a large number of feasible alternatives be evaluated on the basis of multiple criteria. It translates that spatial decisions are multi-criteria in nature. Multi criteria decision making is complex as it requires finding an alternative that dominates all others with respect to all criteria. The number of human actors involved in the decision making process also influences the complexity of spatial decision problems.

Spatial data is one of the most critical elements underpinning decision-making for many disciplines. Over the last decades, many governments and private sector have invested tens of billions of monies in the development of geographic information, for the most part to serve specific purposes (e.g. urban/rural planning, forestry, parcel records management, health care, and forestry, etc) within a local, regional, national and even international framework (Noongo [4]; Crompvoets [5]; Eelderink et al [7]). Nevertheless, the need for multi-criteria decision making makes the need for integration of spatial data obligatory. Different user groups have different views of the world. As De Man [16] argues that though spatial data is obviously about space, space matters differently at different spatial levels. Spatial data handling thus, requires special skills in handling space, elevating the need for specializations dealing with space, time and geography.

Spatial data handling may vary in quality and even portray some kind of pathology (Crompvoets et al [14]). The complexities of spatial data handling as a networked performance inevitably introduces conflicts and dilemmas, arising when there is a need for data collection, manipulation, analyses, presentation and distribution. Conflicts are usually experienced in the form of exclusion (access denial), fragmentation, isolation from use, and discontinuity, while dilemmas are usually between standardizations, bureaucratic control towards uniformity, and facilitation of deliberations (De Man [16]; Noongo [4]; Crompvoets et al [14]).

Socio-technical networks of SDI through ANT lens

In a report entitled *Understanding Infrastructures,* Edwards, Jackson, Bowker & Knobel [17], elaborates on the notion of information infrastructure and establishes a comparison between systems, networks and infrastructures. Systems are compounds of known elements. They are absolutely controlled because input, outputs and processes involved are known and pre-defined. Their boundaries are closed and stable. Everything is under control and so “control” is the main function. Networks are integrations of systems. Although their elements (systems) can be known, their boundaries are open and reconfigurable. So they should be conducted by control and coordination functions. Infrastructures are integrations of networks. Their boundaries are not only open and reconfigurable, but virtual. There is no control on the elements (networks) but they depend on full coordination for functioning. Coordination mechanism in this regard could mean protocols, policies, standards and legal frameworks – including human actors who conduct the coordination actions.

Taking the abstract definition of infrastructure, SDI is a genuine example of an infrastructure - a complex phenomenon characterized by its multi-faceted nature (De Man [6]) and its multi-perspective meaning. SDI is a networked performance of human actors, technological artifacts and information artifacts. The actors are tied together by various interests and are continuously negotiating and aligning those interests.

GSDI Cookbook: An implementation Guide (Nebert [1]) distinguishes five SDI components: access network, standards, policy, people and spatial data. The access network component is critical from a technological perspective to facilitate the use of data by people. It seeks to facilitate access to relevant spatial data sources and services; e.g. access and distribution networks, web services for data browsing, viewing, downloading and warehousing, etc. The standards component defines the technical characteristics of the datasets. It ensures interoperability amongst the datasets and the access mechanisms; e.g. coordinate reference systems, data transfer formats, data models, metadata standards, etc. The data component refers to the spatial datasets to be shared and exchanged between technological platforms, organizations and individual users. These datasets are produced within organizational frameworks and must comply with the technical standards defined to be compatible when shared and exchanged. The policy component is critical for the construction, maintenance and access of application standards and datasets. Commonly, SDI policies are required for data collection, processing, integration, storing, distribution, pricing and licensing, custodianship and standards. The people component refers to a multitude of heterogeneous stakeholders including all data producers, users, custodians and value-adding agents in the public or private companies, and all individuals that interact to drive the construction of an SDI.

Understanding SDI as a networked performance finds support in ANT. The different components of SDI are all actors, and they are all doing something to make a difference. Actors also make other actors do things through translations between them. While computer technology is at the heart of SDI construction, data and information always require some form of infrastructure beyond source and destination regardless of the technology. Spatial data is the indispensable focal actor in SDI. It means that all other actors have an interest in spatial data – they all want to reap benefits from such data. Being indispensable, spatial data is understood to be performing –"doing something" – pulling together all other actors in a network regardless of their other varying interests. Other actors act upon this data in a networked circle. Each of the actors in SDI can shape the construction process of SDI to their own ends. They may modify it, deflect it, betray it, add to it, appropriate it or let it drop. Translations between actors impact each other and society at large. This clearly suggests that SDI construction is an integrated and complex socio-technical charged matter where multiple actors influence and possibly compete with each other to achieve their interests. This in turn reflects the dynamic nature of the whole SDI concept where neither social nor technical accounts can be privileged.

Under ANT lens, components of a functional SDI can be broken down into two groups based on the different nature of their interactions within the SDI. Given the substantial translations and fundamental roles between people and data, these two components can form one group. People are the key to transaction processing and decision making. All decisions require data. However, as data become more volatile human issues of data sharing, security and access forge the need for more defined relationships between people and data. The rights, restrictions and responsibilities influencing this relationship become increasingly complex through compelling and often competing societal issues. The second group can be considered consisting of the main technical components: the technology, policy and standards. Anyone wishing to access datasets must utilize the technological network. The nature of both groups is very dynamic due to the rapidity of technological development and the changes occurring in society - their needs and ongoing requirements for different sets of data and services. The two groups are logical networks with own interests and may react to situations in different ways. When black boxed, these two networks form the SDI, in which the actors affect the resulting SDI vision and succeeding concepts. This again, clearly illustrates that SDIs are integral and characteristics of socio-technical contexts.

A socio-technical SDI recognizes that even if it is assumed that SDI succeeds on a technical level, its successful development and implementation still will ultimately depend on how well implementation strategies address the respective community barriers. For the same thought, Pickels [18] argues that SDIs are also susceptive to geopolitical, economic, and socio-cultural issues and all the associated opportunities and threats of cyber spaces and interactions. These points recognize that societal aspects can be equally critical in determining the success of SDIs and possibly of other information infrastructures alike.

Concluding Remarks

Spatial data, and consequently SDIs, and other information infrastructures alike are different at different spatial levels because of differentiated social contexts. This paper has argued that SDIs are dynamic, integrated, and networked performance of human actors, technological artifacts and information artifacts. A closer look at the components of SDI reveals that SDI is an integration of socio-technical networks with open, reconfigurable and virtual boundaries, without control and basically based on coordination mechanisms. Technical and societal actors of an SDI translate their interests in a networked manner while, collectively as well as individually, each having fundamental impacts on performance of an SDI. It is hoped that the consideration of socio-technical construction of SDI presented in this paper will raise consciousness on the importance of social matters often neglected within SDI developments and implementations.

References

[1] Nebert, D.D., (Ed). (2004). *Developing spatial data infrastructures GSDI. The Cookbook: version 2.0*. Available at www.gsdi.org/docs2004/Cookbook/cookbookV2.0.pdf, Last Accessed: 09 November 2009.

[2] Mavima R and Noongo E. N, 2004, *Spatial Data Infrastructures in SADC Countries: Status and Future Directions,* www.sadc-fanr.org.zw/rrsu/clrnghse/SDI%20News/MavimaNoongo.pdf, Last Accessed: 10 November 2005.

[3] Masser, I. (2005). *GIS Worlds: Creating Spatial Data Infrastructures*. Redlands, ESRI.

[4] Noongo, E.N. (2007). The *Implementation of Geographic Information*

Systems in Namibia. Ph.D. Thesis, Joensuu University, Finland.

[5] Crompvoets, J. (2006). *National spatial data clearinghouses, worldwide developments and impact*. Ph. D. Thesis, Wageningen University, The Netherlands.

[6] De Man, E. (2007). Are spatial data infrastructures special?. In Onsrud H. (Ed). *Research and theory in advancing spatial data infrastructure concepts*. Redlands: ESRI Press, pp. 33-54.

[7] Eelderink, L. Crompvoets, J.W.H.C. and de Man, W.H.E. (2008). Towards key variables to assess national spatial data infrastructures NSDIs in developing countries. In Crompvoets et al (Ed.), A multi-view framework to assess SDIs. Melbourne ; Melbourne University Press, 2008. ISBN 90-0-7325-1623-9 pp. 307-325.

[8] Crompvoets, J. and L. Grus, (2007). Workshop Report 'Multi-view framework to assess (National) Spatial data Infrastructures (N)SDI's', 23-25 may 2007 Wageningen, the Netherlands.

[9] Latour, B. (1987). *Science in Action. Harvard University Press*. Cambridge, MA.

[10] Law, J. (1992). Notes on the Theory of Actor-Network: Ordering, Strategy, and Heterogeneity. *Systems Practice*, 5(4), 379-393.

[11] Singleton, V. and Mike, M. (1993). Actor-Networks and Ambivalence: General Practitioners in the UK Cervical Screening Programme. *Social Studies of Science*, 23(2), 227-264.

[12] William-Jones, B. and Graham, J.E. (2003). Actor-network theory: a tool to support ethical analysis of commercial genetic testing. *New Genet Soc,* 22(3), 271-296.

[13] Smith, B., and Mark, D. (2001). Geographic categories: An ontological investigation. *International Journal of GIS,* 15(7), 591 – 612.

[14] Crompvoets, J., Rajabifard, A., Van Loenen, B., and Delgado Fernández, T., Eds., (2008). *A Multi-View Framework to Assess Spatial Data Infrastructures*. Space for Geo-Information (RGI), Wageningen/Centre for SDIs and Land Administration, Department of Geomatics, The University of Melbourne, Wageningen/Melbourne.

[15] Putnam, R. D. (1995). Bowling alone: America's declining social capital. *Journal of Democracy*, 6(1), 65-78.

[16] De Man, W.H.E. (2006). Understanding SDI; complexity and institutionalization. *International Journal of Geographical Information Science*, 20(3), 329–343.

[17] Edwards, P.N., Jackson, S.J., Bowker, G.C., & Knobel, C. (2007). *Understanding infrastructure: dynamics, tensions, and design, NSF Report of a Workshop: History and theory of infrastructure: lessons for new scientific cyberinfrastructures*. http://hdl.handle.net/2027.42/49353. Last Accessed: 6 February 2010.

[18]Pickles, J. (2004). *A History of Spaces: Cartographic Reason, Mapping and M the Geo-Coded world*. Routledge, NY.