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# **A Metaphor-Based Sociotechnical Perspective on Spatial Data Infrastructure Implementations: Some Lessons from India**

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## ABSTRACT

Some of the more popular metaphors that have been used to frame and understand spatial data infrastructures (SDIs) are those of the superhighway and the marketplace. These metaphors do not bring out the sociotechnical nature of SDI design and implementation. On the contrary, they emphasize top-down approaches, centralized control, and the view of information as a tradable commodity, while marginalizing the role of communities in shaping infrastructure development. These metaphors also tend to ignore the historically contingent nature of SDI development and the existing ground realities in developing countries like India, for which the rainbow metaphor provides a more appropriate and fuller perspective. The relevance and effectiveness of the rainbow metaphor are demonstrated by a case study in India.

## INTRODUCTION

Metaphors have been used for analyzing social phenomena in various fields including organization studies, law, information systems, and more recently the information infrastructure<sup>1</sup> (II) domain. We draw upon some of these experiences in examining the phenomenon of spatial data infrastructure (SDI) implementation. We consider some of the dominant metaphors being used to guide SDI research and practice: information superhighway, marketplace, and rainbow. We believe such an analysis will contribute to developing a stronger sociotechnical perspective on the dynamics of SDI implementation. We discuss how different metaphors can shape implementation processes in different ways and empirically apply the rainbow metaphor to the national spatial data infrastructure (NSDI) of India.

Infrastructures, whether physical (roads, rail, ports, airports, telecommunications, electricity, etc.) or virtual (digital libraries, health care infrastructures, information infrastructures, SDIs, etc.), have important differences, but also similarities. In this article, we argue that the key metaphors guiding SDI implementation to date have focused on the D in SDI, as evidenced by the dominance of the information superhighway metaphor (Mosco 1998). We see an urgent need to shift the focus from the D to the I in SDI so as to give the issues of usage proper weight. Focusing on the I in SDI can also facilitate exploration of new metaphors that transcend some of the constraints of the superhighway metaphor. This refocusing can provide richer sociotechnical insights into the dynamics of SDI implementation.

Below, we discuss the power of metaphors in social analysis and draw upon the rainbow metaphor to analyze the Indian NSDI.

## POWER OF METAPHORS

A metaphor is a linguistic mechanism (a figure of speech) used to aid the understanding of one phenomenon in terms of another (Drummond and Hodgson 2003), “a way of thinking and a way of seeing that pervade how we understand our world generally” (Morgan 1986, p. 12). For example, the description of a heart as a “pump” and the corrective treatment of clogged arteries that supply blood to this pump as “bypass” surgery helps nonmedical people visualize the procedure and relate it to their everyday experience. Giddens (1991) and Castells (1996) have developed the metaphors of the “runaway world” and “network society,” respectively, to analyze different dynamics around modernity and globalization: our world’s out-of-control nature in the case of the former and interconnectedness in the case of the latter.

Metaphors provide an analytical bridge between positivist epistemology and everyday subjective experiences in the process of knowledge development (Ortony 1979, p. 1). Metaphors do not merely embellish language but play a fundamentally constitutive role in our comprehension schemata (Sfard 1998). Checkland (1989) suggests that facts and logic alone do not present the full import of human situations; myths and meanings by which humans make sense of this world are equally important. Lakoff and Johnson (2003, p. 3) also argue that metaphors are pervasive in everyday life, not just in language but in thought and action. Similarly, Ortony (1979, p. 3) emphasizes the communicative potential of metaphors in language, politics, poetry, psychology, cognitive linguistics, philosophy, religion, and architecture (Lakoff and Johnson 2003). Metaphors may often hide as much as they reveal (*ibid.*). For example, the description of a man

as a lion emphasizes his physical prowess but may hide his tender and affable disposition. Hirschheim and Newman (1991, p. 37), drawing from the information systems (IS) domain, also caution us that metaphors, although pervasive and sometimes helpful, may also mislead and can be “really dangerous fantasies.” For example, Drummond and Hodgson (2003) use a “chimpanzees’ tea party” metaphor to explain how efforts to exercise increased control in IT-related project management may actually be counterproductive and lead to chaos. This metaphor tends to ignore the predominant role of institutional politics and power in shaping the eventual success or failure of such projects (Beck 2002).

The power of metaphors is being recognized in various domains, including law. In her study on the use of metaphors in jurisprudence, Gore (2003, p. 406) argues that “no matter how apt or misguided the analogy may prove to be, the spoils of legal victory often go to the proponent of the most persuasive metaphor.” Judges, courts, and juries regularly resort to analogies and metaphors of existing technologies to gain some level of comfort and decide to what extent established legal principles cover the new technology (*ibid.*). According to Blavin and Cohen (2002), courts and commentators employ metaphors as heuristics to generate hypotheses about the application of law to novel, unexplored domains, such as the Internet. These researchers argue that when “courts encounter new technologies not yet anticipated by law, their reliance on analogical reasoning plays a profoundly important role in the application of legal rules. By failing to adopt appropriate metaphors in regulating new technologies, courts risk creating bad law” (*ibid.*, p. 268). IS and II research has also in recent years started to explore the power of metaphors, as discussed below.

#### METAPHORS FOR INFORMATION INFRASTRUCTURES

The use of metaphors as a heuristic device for thinking about national information infrastructures and SDIs has received considerable attention in recent times (e.g., Sawhney 1992, 1996; NRC 1994; Rohrer 1995; White 1996; Clement and Shade 1998). We analyze the use of three of these metaphors: superhighway, marketplace, and rainbow.

The information superhighway metaphor derives its power from its apparent ability to fill the “investment-benefit” conceptual gap of IIs. It evokes an easy-to-grasp, clean, obedient, and mechanistic model of an infrastructure, with emphasis on predictability, procedures, and efficiency of delivery (OECD 2000; Streeter 2003). The metaphor implies a key role for central government in promoting II development, a top-down “construction” with intimate government direction, the assumption of harmonious collaboration between various governmental agencies (NRC 1994), and an emphasis on technical access guided by the needs of commerce and government (White 1996). For example, the U.S. General Accounting Office (GAO) (1995) refers to “a meta-network that will seamlessly link thousands of broadband digital networks, [. . .] allow a two-way flow of information, with users being able to receive and transmit large volumes of digital information, and enable equal access for service and network providers” (p. 11). The GAO report projects the investment required for the information superhighway to be several billion dollars (p. 2), with the implicit assumption that the financial venture will eventually pay off similarly to the transportation infrastructure of the past.

The information marketplace metaphor evokes an image of a market where buyers meet sellers across the boundaries of space and time to engage in commercial transactions (Mosco 2003). The metaphor goes beyond the mechanical access to information to encompass the utility of information, traded by e-literate people in a laissez-faire, market-driven environment, with the role of governmental regulation largely ambiguous (NRC 1994). Because of the metaphor's emphasis on the utility of information, ethical questions (such as which uses are encouraged, allowed, discouraged, or forbidden) become prominent (*ibid.*).

The marketplace metaphor also casts a shadow on the civic life aspect of a marketplace, better captured in the "electronic agora" and "marketplace of ideas" variations (NRC 1994). It also treats information primarily as a commodity and downplays the fact that geographic information in particular possesses the classic characteristics of a public good<sup>2</sup> (Georgiadou and Groot 2002). Onsrud (2004) suggests that the digital library is a far more appropriate metaphor for exploring possible future directions for SDIs and for providing incentives to public data collectors to document their spatial datasets.

The marketplace rhetoric was also evident in the report of the Task Force on Financial Mechanisms (TFFM 2004) commissioned by the Secretary General of the United Nations to study the issue of financing the information society and bridging the global digital divide. The TFFM report (2004, pp. 73–74) acknowledges that rural areas and poor communities around the world pose a challenge to the marketplace approach for the information society. However the report's discourse adheres to the prevalence of the market and glorifies the 50 percent of the world's population that lacks access to information as a vast, untapped opportunity for market expansion. Various civil society groups have criticized the market-driven, private-investment, private-ownership model of the information and communication technology (ICT) infrastructure promoted in this key report. For example, Peyer et al. (2005, p. 12) note that:

[. . .] apart from the ongoing success of some decades-old publicly owned networks, this ignores more recent waves of experience. India is making significant strides in rural and village access by putting in place publicly-owned networks. In Stockholm, Amsterdam and many U.S. urban and rural municipalities, publicly-owned broadband networks and services are offering services, either retail or wholesale, designed to maximize overall benefits to the city . . . Cooperative ownership is a growing option in many rural areas. Some are there because the private sector has failed; others are simply providing a service by the best means possible, and sometimes competing with private networks.

The marketplace metaphor emphasizes private investment and ownership, thereby undermining the vast and largely untapped potential of harnessing local community resources to support network development. Besides lowering costs and improving services, participatory development of such networks also enhances community empowerment (Peyer et al. 2005, p. 19). The marketplace metaphor tends to ignore history and how the current marketplace is shaped by legacy systems, both technical and institutional.

Sawhney (2003, p. 25) makes a similar point with respect to information infrastructures, arguing that "a new technology does not strike roots and grow

on a virgin ground. Instead, it encounters a terrain marked by old technologies. The new technology's growth then is shaped not only by its own potentialities but also the opportunities and restraints created by the systems based on old technologies.”

Table 1 lists the key II features emphasized or overlooked by the superhighway metaphor and the marketplace metaphor. We posit that the rainbow metaphor, discussed in reference to the Indian NSDI below, may help address some of the concerns with respect to the neglect of history (by the information infrastructure metaphor) and the assumptions of universal access and connectivity (by the marketplace metaphor).

Metaphor	II implementation features	
	Emphasized	Overlooked
Information superhighway	Interconnectedness (like that of a road network), top-down design, government control	History (in trying to build from scratch)
Marketplace	Importance of user (market) needs in shaping demand	Public good, history, role of communities in shaping development, inequities in access and connectivity

Table 1. Key features of the information superhighway and marketplace metaphors.

## INDIAN NSDI

The NSDI of India was inspired in part by the superhighway and marketplace metaphors. We base this statement on secondary data (such as conference presentations and minutes of meetings held at various stages of implementation), informal meetings with officials, and focused interviews with members of the national task force in 2005.

Development of the Indian NSDI was initiated in 2000 jointly by the Department of Science and Technology (DST) and the Indian Space Research Organization (ISRO) through the establishment of a national task force to prepare an action plan under the aegis of DST. The influence of the information highway metaphor is evident in the following statement of the secretary of DST (DST 2001, p. 5, Foreword by Secretary, DST):

There is a widespread consensus, internationally, that spatial data sets need to be integrated to create what is called a geo-spatial data infrastructure. Such infrastructures have been likened to information highways, linking a variety of databases and providing for the flow of information from local to national levels and eventually to the global community.

The NSDI initiative can be viewed as largely technology driven (Winner 1989). The influence of the marketplace metaphor can be seen in the following statement of the secretary of DST (DST 2001, p. 5, foreword by Secretary, DST):

In the emerging market-place, geographic or geo-spatial information occupies a pre-eminent position. In fact, the use of high quality, reliable, geo-spatial information is crucial for every sphere of socio-economic activity—disaster management, forestry, urban planning, land management, agriculture, infrastructure development, business demographics etc.

A comprehensive review conducted in 2003 at Agra (<http://www.nsdiindia.org/publication/>) described the NSDI as “another Taj in the making,” to metaphorically reflect the rather grandiose, top-down nature of the vision (similar to an information superhighway).<sup>3</sup>

In an interview with one of the private-sector members of the national task force, we were told that:

The scientific institutions are still contesting who should be in charge. Each is saying that “they are the SDI” rather than discussing how they can facilitate the establishment of an effective SDI.

The CEO of a large GIS consultancy service, whom we interviewed in February 2005, was critical of the approach adopted by the government scientists and technocrats in DST and ISRO for involving the private sector in the NSDI. She said, “Those in charge of NSDI have formulated no clear-cut policy or tested a business model for data sharing amongst the NSDI stakeholders. The fact is that those not used to sharing are now in charge of the entire process, with no viable strategy in sight.” A senior executive in another large private-sector organization expressed his disenchantment as follows:

NSDI was conceptualized and is being implemented by the government, for the government, within the bureaucratic framework of the government. . . We would not participate in NSDI unless it is established outside the pale of the government, and functions as an enlightened, independent body.

The above brief description of the Indian NSDI highlights the information superhighway and marketplace metaphors emphasized in the rhetoric of the implementation planning and their negation in actual practice. For example, the information superhighway metaphor is espoused by the policy makers in emphasizing universal connectivity, while historically, the government’s control over topographic maps makes this promise difficult to implement in practice. Similarly, the marketplace metaphor emphasizes that the users will have their own needs and demands which will drive the process of supply. However, in practice, the users have been almost totally neglected in the designing of NSDI, which makes it difficult for them to understand or shape the supply dynamics. Also, in a state-controlled domain where the private sector has literally had no role to play until recently and where the use of maps is not historically evident (Sahay and Walsham 1997), the assumptions of a marketplace approach contradict the historical realities on the ground.

Below we examine how the use of the rainbow metaphor may be more relevant in the Indian case, given the historical and contextual realities.

#### RAINBOW METAPHOR

Gurstein (2004) has criticized the overwhelming emphasis of the superhighway metaphor on access. This emphasis undermines the importance of analyzing how, by whom, and for what this access might be used. The information superhighway metaphor fails to clarify what access to the information infrastructure encompasses and does not account for the intricate relationships between the social and technical architectures of the information infrastructure (Clement and

Shade 1997, p. 34). Some aspects of the importance of people and their transactions may be better captured by the rainbow metaphor.

The rainbow metaphor for access to information infrastructure was proposed by Clement and Shade (1997) with the intention to strengthen public policy perspectives in the Canadian II debate. Clement and Shade are at odds with the corporate view of cyberspace as a shopping mall and advocate the view of cyberspace as a public space (O'Brien 2001). The rainbow metaphor recognizes the multiple usage patterns in retrieving and creating relevant content, encompasses conventional and new media, and emphasizes the interplay of social and technical dimensions in infrastructure development, helping to define which services are essential to whom. Most importantly, it helps to identify access gaps, in other words, those social segments likely to be left out by market forces acting alone, and hence emphasizes the need for their protection via collective public initiatives. The seven layers conceptualized for the rainbow metaphor are carriage, devices, software, content, service/access provision, literacy, and governance; these also correspond to the important regulatory distinctions between carriage and content.

Table 2 lists the seven layers of the rainbow metaphor for the Canadian network (Clement and Shade 2000) and alternative conceptualizations for the Indian NSDI. The table illustrates how the rainbow metaphor, while emphasizing the

Layer	Characteristics for the following NSDI conceptualization:	
	Current (Canada)	Alternative (India)
Carriage	Multiplicity of networks, key role of the Internet, promotion of access at affordable costs	Universal connectivity through a wide range of telecommunication technologies and the Internet, reduction of inequities in service provision
Devices	Proliferation of device forms and increasing affordability, wireless connectivity, and use of PDAs and mobile phones	Affordable ICT devices based on needs, community-based models for sharing device resources
Software tools	Increased embedding of software; affordable, multilingual, interoperable, privacy-enhancing applications	Free and open-source applications in local languages
Content/services	Provision of a wide range of information to user groups; enabling information to speak to other information; affordability, reliability, cultural compatibility, freedom from censorship	Accommodation of a wide range of users based on participatory principles; reduction of government controls to make spatial data more freely available to civil society; identification of services not provided by market forces but required by civil society
Service/access provision	Access primarily through employers or educational institutions; need for access to affordable network providers	Need for government departments owning spatial data to become more user-friendly and marketing oriented; alternative intermediary institutions (e.g., NGOs) facilitating access and quality control of data; identification of central (provider-specific) and local (user-specific) databases and mechanisms for their interaction
Literacy/social facilitation	Inclusion of expertise based on formal and informal education relevant to everyday life	Building awareness and culture around spatial data; reform of university curricula to include II/SDI-specific education; key role of training institutions in the private sector for shorter-term capacity building
Governance	Multiplicity of stakeholders, inculcating democratic participatory process still a challenge	Inclusion of users, private sector, research organizations, and universities; bottom-up participatory process; access to SDI as not an end in itself but a means of addressing development and business concerns

Table 2. Rainbow metaphor characteristics.

Clement and Shade 2000.

various interconnected layers of the NSDI implementation effort, can also facilitate exploration of locally developed solutions. This reconceptualization provides more effective alternatives than those dictated by the information superhighway and marketplace metaphors. We look at several locally inspired technological initiatives in India from the last decade or so to demonstrate the usefulness of the rainbow metaphor.

**Carriage: STD booths.** The indigenous development of digital switching hardware and software for rural automatic exchanges (RAX) by the Centre for Development of Telematics was the key driver behind India's telecom revolution of the late 1980s and early 1990s. These designs were appropriate not only for the hot, humid, and dusty operating environment but also for the social settings. Subscriber trunk dialing (STD) facilitated by this infrastructure provides national and international telephonic connectivity to people through more than 700,000 STD "booths" that dot the urban and rural landscapes of India. These booths are owned and managed largely by private entrepreneurs. Chakravarty (2004, p. 242) comments, "Although a seemingly modest accomplishment by the technological standards of the day, the STD booth phenomenon has truly transformed the communications landscape in urban, and increasingly rural India."

This example points to the need to adopt locally supported technologies compatible with historically based social relations and customs.

**Devices: Gyandoot.** An innovative experiment called Gyandoot (meaning "purveyor of knowledge") was aimed at using ICT to empower local communities. It was initiated in 1999 in one of the most underdeveloped tribal areas of the country (Dhar district of Madhya Pradesh state). Communities were actively involved, for example, in providing locally relevant input for system design and service prioritization. The main objective of the Gyandoot project was to establish a distributed computer network in the district so as to provide online information to the local people on subjects and problems that are part and parcel of everyday rural life in India. It also facilitated access to district government departments for residents who in the past had to physically travel long distances to the district headquarters (Rajora 2002). In analyzing Gyandoot's success, Warschauer (2003a, p. 38) observed:

While the number of users is a small percentage of the population, but the benefits of this project, such as improved government services, eventually ripple outwards to friends, families and co-workers. . . . the underlying approach—a combination of well-planned and low-cost infusions of technology with content development and educational campaigns targeted to social development—is surely a healthy alternative to projects that rely on planting computers and waiting for something to grow.

A lesson for the NSDI is that the ICT-based applications need to be socially sensitive and consonant with end user perspectives.

**Software tools: GRAM.** The development of GRAM (Geo-Referenced Area Management) (in local parlance, gram means "village") was initiated in the early 1990s by the Centre of Studies in Resources Engineering (CSRE), Indian Institute of Technology, Mumbai, to provide cheaper, easily understood GIS software consistent with the specific needs of India's rural sector for spatial applications. GRAM, now fully operational, does not provide some of the more sophisticated

and high-end features included in commercial GIS packages. While catering to commonly used GIS features, GRAM also provides an excellent learning platform to potential future users of spatial technologies. Such indigenous development efforts need to be acknowledged and incorporated into NSDI thinking, which is currently being shaped by external vendors. Systems like GRAM also offer significant cost savings compared to commercial products.

**Content/services: Bhoomi.** The recent Bhoomi (meaning “land”) project in the state of Karnataka in India is aimed at digitalizing land records, which provide ownership information. Authenticated copies of land ownership information are often needed by individual farmers for many reasons: for example, applying for a bank loan, obtaining an electricity connection, and so forth. Before these records were digitalized, the ownership certificates had to be obtained from the local patwari (a junior official in the land records department located at subdistrict level). In addition, these records were not regularly updated (such as incorporating transfer/sale deeds into the existing records). Warschauer (2003b) describes how the Bhoomi project helped verify land sales and update 20 million records. Copies of these records can now be purchased for about 30 U.S. cents without long waiting periods or the need to make several visits. The earlier unethical practice of the patwari extracting “unofficial payments” from the needy farmers has also been, by and large, done away with.

The Bhoomi initiative represents a simple, yet effective spatial application which caters to a massive local need, demonstrating that often the simplest information is the most valuable. The Indian NSDI initiative should be more oriented towards providing such uncomplicated but much needed services initially before moving on to more complex application fields, involving, for example, 3D modeling and simulations.

**Service/access provision: GIS implementation in Anantapur district.** The development and use of spatial technologies like GIS in India has generally been characterized by top-down approaches and a marked absence of user participation (Sahay and Walsham 1996, 1997), resulting in project failures (Walsham and Sahay 1999). More recently, bottom-up approaches drawing on the potential of ICT in local development contexts, mainly driven by political initiatives (like in Andhra Pradesh), have also been promoted. These approaches encourage the incorporation of indigenous domain knowledge into microlevel programs: for example, knowledge around wise land use and water harvesting in local settings, accumulated by farming communities through trial and error over generations (Mathias 1994).

In the Anantapur district of Andhra Pradesh, for example, the requisite spatial data was collected by local teams composed of technicians, nongovernmental organizations (NGOs), and farmers (using handheld GPS devices). The superior technical infrastructure and scientific knowledge available at premier national-level organizations (like the National Remote Sensing Agency) was then drawn upon to construct a geographically consistent GIS database according to prescribed rigorous standards of accuracy. The database and the accompanying applications were used to support local development plans. The use of this database improved land productivity as well as contributed to more efficient water harvesting in this historically drought-prone area (Puri and Sahay 2003).

An implication of this for the NSDI program is the need to incorporate bottom-up design approaches as well as to be able to realistically support microlevel needs of spatial data and its analysis. Embracing a judicious mix of top-down and bottom-up methods has also been emphasized in the SDI literature (Groot and McLaughlin 2000; Georgiadou et al. 2005).

**Literacy/social facilitation: role of intermediary agencies.** NGOs have come to play increasing advocacy and intermediary roles vis-à-vis governments and people. These agencies are generally able to effectively communicate with government officials because of their educational background, experience, and contacts with the media and can serve as “gateways” between people and officials. The increasingly significant role of local governmental agencies and NGOs as mediators between global challenges and local concerns of exclusion and marginalization also needs to be recognized (Beck et al. 2004). In the NSDI context, active attempts need to be made to identify and encourage technically competent and locally rooted NGOs and academics to act as mediators between scientific departments and end users such as district and subdistrict government agencies. This could potentially foster user participation as well as provide more effective communication channels to enhance mutual understanding among designers and users of technologies like the NSDI.

**Governance.** The above illustrations of relatively successful applications of ICTs in developmental scenarios underscore several common themes: (1) locally relevant hardware and software, (2) multiplicity of stakeholders (including end users) involved in design and implementation, (3) bottom-up and participatory processes, (4) involvement of end users based on respect for their knowledge and aspirations, and (5) ICT not as an end but as a means of addressing development concerns. These characteristics constitute the governance layer of the rainbow metaphor envisaged for the Indian NSDI.

## CONCLUSIONS

This sociotechnical thinking inspired by the use of metaphors emphasizes the need to examine technological and organizational characteristics together rather than in mutual exclusion. Kling et al. (2000) point out that, in contrast to standard task-technology models, sociotechnical network approaches underscore work practices, conceptual understanding of the actors, and the realization that “[socio-technical] configurations interact with human activities, such as work” (p. 46). These approaches focus on improving work practices and understanding how collaborative learning takes place. Skill development takes precedence over improving efficiencies. Sociotechnical design approaches are not yet evident in the Indian NSDI case, and end user participation is nearly nonexistent. As a result, end user organizations remain limited in their ability to meaningfully apply spatial data in specific contexts, which is the *raison d’être* of the NSDI. The focus needs to shift from the D in SDI to the I. Since an NSDI is large, layered, and complex, and “because it means different things locally” (Star 1999, p. 382), its development cannot be top-down but must involve negotiations among different stakeholders to accommodate their competing interests. The rainbow metaphor can help NSDI planners to visualize why and how sociotechnical approaches can promote successful SDI design and implementation.

## ENDNOTES

1. Information infrastructures are heterogeneous networks subsuming varied technologies, networks, and standards to support a diversity of information system application areas over time and space (Hanseth 2000). SDI is a special case of II specifically geared towards geographic information. A national SDI comprises all relevant geographic data of a country.
2. Public goods are nonrival in consumption and nonexcludable. Hence, they can elicit in consumers the temptation for free riding as well as unwillingness to reveal their level of demand. Markets are unable to supply nonexcludable goods. As a result, public goods are underprovided, unless the government intervenes. In the case of geographic data, government intervenes by producing the data itself.
3. The famous Taj Mahal, one of the Seven Wonders of the World, is located in Agra, India.

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