Research Commentary: The Next Wave of *Nomadic* Computing

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A nomadic information environment is a heterogeneous assemblage of interconnected technological, and social, and organizational elements that enable the physical and social mobility of computing and communication services between organizational actors both within and across organizational borders. We analyze such environments based on their prevalent features of mobility, digital convergence, and mass scale, along with their mutual interdependencies. By using a framework that organizes research topics in nomadic information environments at the individual, team, organizational, and interorganizational levels and is comprised of both service and infrastructure development, we assess the opportunities and challenges for IS research. These deal with the design, use, adoption, and impacts of nomadic information environments. We conclude by discussing research challenges posed by nomadic information environments for information systems research skills and methods. These deal with the need to invent novel research methods and shift our research focus, the necessity to question the divide between the technical and the social, and the need to better integrate developmental and behavioral (empirical) research modes.
(*Mobile Computing*; *IS Research*; *Information Environments*)

Introduction

Rapid developments in information technology (IT) are substantially changing the landscape of organizational computing. Concepts like pervasive or ubiquitous computing,[1] triggered by dramatic developments in mobile and wireless communication technologies such as WAP,[2] Bluetooth™,[3] and 3G mobile phones[4] (Cerf 2001, Kleinrock 2001), and the continued miniaturization of computing devices suggest radically new types of computing based on users' nomadic behaviors. Here, nomadicity means that systems can support a rich set of computing and communication capabilities and services for nomads as they move in a transparent, integrated, convenient, and adaptive manner (Kleinrock 2001). Handheld computing devices will also lead to a more encompassing digitalization, miniaturization, and integration of diverse sets of information (personal, organizational, public) and

[1]See, for example, "The Evolution of Computing," ⟨www.technologyreview.com/magazine/jan01/buderi.asp⟩ and ⟨www.acm.org/technews/articles/2001–3/0131w.html#item19⟩, or for its impact on the different industries denoted as "gadget wars" see ⟨www.acm.org/technews/articles/2001–3/0316f.html#item12⟩.

[2]WAP stands for Wireless Application Protocol. It is an open, global standard that specifies standards for mobile users information and service access. For more information, refer to ⟨www.wapforum.org⟩.

[3]Bluetooth™ is a de facto standard for wireless communication among various devices in short to medium distance. For more information, refer to ⟨www.bluetooth.com⟩.

[4]3G refers to the third generation mobile phone systems that allow broadband access for enhanced wireless service. For more information, refer to ⟨www.3gpp.org⟩.

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offer unprecedented possibilities to access, manipulate, and share information on the move. This resulting *nomadic information environment* is a heterogeneous assemblage of interconnected technological and organizational elements, which enables the physical and social mobility of computing and communication services between organizational actors both within and across organizational borders.

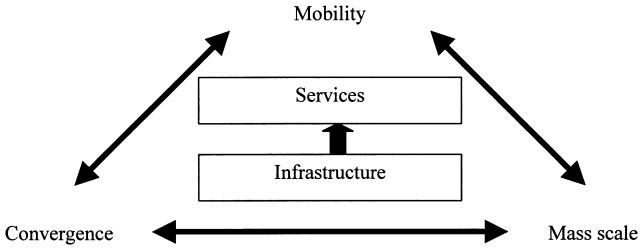
The creation of information environments utilizing nomadic technology necessitates a research agenda that encompasses several disciplines and involves multiple levels of analysis. The disciplinary matrix for studying such phenomena will cover areas such as computer science, human-computer interaction, organizational design, cognitive psychology, ergonomics, and economics. In this paper, we formulate glimpses of a research agenda for nomadic information environments from an information systems (IS) perspective. This research agenda is articulated based on our recognition that IS researchers are uniquely positioned to understand how to integrate diverse technological, social, and managerial issues while designing, building, and managing such environments.

The rest of the paper is organized as follows. In the next section, we present the essential characteristics of the emerging nomadic information environments that cover both the technical and nontechnical features instrumental to designing, building, and managing such environments. We, then, discuss the research implications of nomadic information environments for IS research as organized into eight themes covering individuals, teams, and organizations. For each theme, we will identify a set of research questions that will guide future research efforts. We conclude our paper by discussing three theoretical and methodological challenges that we anticipate in this line of inquiry.

A Blueprint of Nomadic Information Environments

The essential features of a nomadic information environment are high levels of *mobility*, consequent *large scale* services and infrastructures, and the diverse ways in which data are processed and transmitted—often called *digital convergence* (see Figure 1). These three key drivers—*mobility, digital convergence, and mass scale*—

Figure 1 A Framework of Nomadic Information Environments



influence and enable developments in both *infrastructure* and *services*. The infrastructure is defined here as the whole set of technological specifications, standards, and protocols and their technical implementations necessary to support mobility, large scale, and digital convergence, and the associated family of institutions and communities needed to develop and sustain such standards and technical implementations. The services here cover any functional application of the infrastructure resources to provide a computational solution to a client's needs.

We see these three drivers as distinct in the sense that we can achieve, for example, a high degree of mobility without extensive digital convergence (e.g., current cellular services or low-level mobile data services), or we can provide a high level of digital convergence without a high level of mobility (e.g., current CD-rom-based multimedia applications). Yet, when these three are combined, they reciprocally influence and shape the future of computing. Below we discuss each driver in more detail.

Fundamental Drivers Towards Nomadic Information Environments

Mobility. In the past, computing services were always provided in a stationary location. Accordingly, users had to come to the physical site to receive the service. For example, a user of desktop computer needs to come to his or her office to use it. In a nomadic information environment, however, all this will change: services will come to the users whenever and wherever they are needed. Furthermore, identical or similar services will be provided through multiple devices at different sites, and on the move; services will

move across and between devices even during the delivery. Accordingly, the infrastructure will have capability to recognize differences in the deployed devices and will thus adjust the content and rendering mechanisms to fit the device.

The need to support all forms of mobility will lead to important changes in input/output terminals. Their size (smaller), shape (more diverse, ergonomic, and stylistic), and functional diversity (from simple mobile phones to portable laptops offering complex virtual reality environments or embedded chips in our body) will be increasingly varied in the future. Moreover, our capability to configure them into varied service platforms will have to grow rapidly.

Digital Convergence. The evolution of computing has made the computer a universal media machine due to an increasingly low-cost digitization and open standards. Digital processing of all forms of data (text, audio, video, etc.) across different carriers (radio waves, electromagnetic phenomena, optical phenomena) with multiple devices (PC's, mobile terminals, or consumer electronic devices like digital TV's) becomes the fundamental enabler of all emerging communication and computing tools. It will also integrate multiple types of data that are displayed on the same device. At the same time, emerging open standards, such as WLAN (IEEE 802.11b), Bluetooth™, TCP/IP (v6), and WAP, are critical to digital convergence and the support of physical mobility. Finally, digital convergence requires that various devices share information and interoperate seamlessly while providing services across heterogeneous computing networks. Such seamless data sharing will depend on the availability of data communication and service protocols between mobile tools and other computing resources embedded in physical environments such as walls, furniture, or desktop computers.

Mass Scale. Mobility and convergence will make it necessary for nomadic information environments to be available, in principle, at a global level (yes, we literally mean global), resulting in an unforeseen increase in service volume, service types, and the number of users. Consider the following statistics. The number of Internet-capable mobile devices is expected to reach 1 billion by 2003 (Wireless Strategic Initiative 2000). In 2000 alone, the market for PDAs in the United States has grown to $1.03 billion, more than twice the $436.5 million market in 1999 (Tam 2001). It is also expected that the amount of monthly data transfer via wireless connection will be ca. 200 Megabytes per user by 2006.[5] This change will not be an easy one because issues of scale, reliability, the integration of services, and new interfaces to the existing infrastructure will have to be successfully addressed.

Infrastructure and Services

As we show in Figure 1, nomadic information environments will become organized into two layers. The lower layer encompasses the emerging global information infrastructure for nomadic services, which covers both telecommunications services, wired and wireless, and multimedia-based computing and representation services. Such an infrastructure will be technically heterogeneous, geographically dispersed, and institutionally complex without any centralized coordination mechanism. This infrastructure must be based on a common platform of protocols and data standards to ensure interoperability, stability, reliability and persistence.

The higher level includes all types of digital services, which can be accessed by the mobile users through different channels. Accordingly, services will be configured dynamically and they will be obtained from many sources. This will require novel means of the creation, configuration, and distribution of services for dynamic service discovery, assembly, and purging (Larsen and Beute 2001, Banavar et al. 2000). In addition, nomadic services will require personalization, dynamic mobility for services and users, and associated channel adaptation; services must be dynamically configured, modified, and combined to meet the personal needs of the mobile users. Services provided by a specific infrastructural element, such as an enterprise-planning system or a customer-relationship management system, have to be customized accordingly and combined with personal and public services that are needed by the particular user.

[5]For an estimation see Qualcomm's analysis of economics of data transfer at ⟨www.thinkmobile.com/Content/Detail.asp?CTID=1&ID=3272⟩.

Research Issues for Nomadic Information Environments

In this section we will examine a series of research issues that need to be addressed in light of the emerging technological and managerial challenges established by the three key drivers: mobility, convergence, and mass scale. We will accomplish this by analyzing the changes in demand of services and infrastructures at individual, team, organizational, and interorganizational levels that are triggered by the drivers. Our discussion is motivated by the concept that IS research is driven by the rise and consequences of radical improvements in the IT base (King 1993).

We argue that IS researchers will have to be cognizant of design and management issues at the individual, team, organizational, and interorganizational levels, which are related to both services and infrastructure. At the level of services, IS researchers need to address the design, use, adoption, and impact of services. With respect to infrastructure, the development and construction (both technical and social) processes of key enabling capabilities through which services will be provided, as well as the governance and control of these capabilities, will become the major topics. Accordingly, in Table 1, we organize eight research themes that deserve IS researchers' attention with respect to nomadic computing, and for each theme we identify several focal challenges. Next, we will discuss each theme in more detail and describe within each theme a set of key research questions that we expect to shape the IS research agenda.

Theme 1: Individual-Level Services. At the individual level, future nomadic environments are expected to provide a high degree of personalization of services. Personalized and mobile services will require fundamentally different approaches in requirements analysis and systems design (Banavar et al. 2000, Fricke et al. 2001). One of them will be how to take into account an increased separation between content and medium of services. In the past, system developers could make assumptions about a particular medium by which particular content would be delivered. In nomadic information environments, however, such an assumption does not hold. As a consequence, the designers of services can only make minimal assumptions about physical computing devices to provide a maximum level of personalization and mobility. Additional research challenges will emerge from the diversity of the types of computing devices that are available, their integration into our bodily experience (smart clothing, users as cyborgs), and the need to understand information and communication service as a multiplatform engagement for the users.

Research Question 1.1. How do we design and integrate sets of personalized mobile services that support users' task execution in multiple social and physical contexts?

In the realm of adoption and use of nomadic information environments, managing personal information access across multiple channels (synchronization and personalization) (Swanson 1987) will become a key issue. While the acceptance and adoption of IT services has been one of the most popular IS research topics (Davis et al. 1989, Taylor and Todd 1995), the pervasiveness of nomadic information environments will raise new questions, such as how to integrate software and hardware design with the principles of industrial design and ergonomics (Rhodes 1997, Rhodes et al. 1999, Sawhney and Schmandt 1997) and how to understand usability in the mobile contexts populated by a variety of devices (Dey et al. 1998). The evolution and avalanche-like diffusion of some Internet-based peer-to-peer services, such as Napster™ or the immense popularity of short-messaging services in Scandinavia (Kivimäki and Fomin 2001), demonstrate the difficulty of using traditional models to predict the adoption of such services.

Research Question 1.2. What factors explain the adoption and use of individual services across multiple channels, and how do social, personal, and usability factors intervene in such processes?

Finally, in assessing the impact of nomadic information environments, while traditional variables such as learning and team performance will continue to be important, it will be critical to understand how the constant availability of information in multiple social and physical contexts and the potential information overload (Schultz and Vandenbosch 1998) will impact user learning and performance.

Research Question 1.3. How do we define and measure new aspects of information availability (or

Table 1 Emergent Research Issues in Nomadic Information Environments

	Individual level	Team level	Organizational level	Interorganizational level
Services	Theme 1: Individual-level services	Theme 3: Team-level services	Theme 5: Organizational-level services	Theme 7: Interorganizational-level services
Design	• Personalization • Content and medium independence	• Socio-technical transactive memory • Integration of physical and social mobility	• Enterprise services and architectures • New workflow and organizational structure • Social ontology models	• Interorganizational agents • Coordination and business transaction mechanisms
Use and adoption	• Use and adoption of multiple information channels • Management of personal information	• Team-level adoption and configuration of services • Team process design and management—leadership, decision making, communications	• Organizationwide use and adoption of services	• Industry adoption and network externalities • Emergence, coordination, and control of standards and services
Impact	• Efficiency and effectiveness of decision making • Information overload • Learning	• Team performance (efficiency and effectiveness) • Team development (trust and learning)	• Organizational performance and competitive advantage • Organizational learning and agility • Placeless processes	• Emergence of new industry structures and value chains • Transformation of industry structure
Infrastructure	Theme 2: Infrastructure for individual level	Theme 4: Infrastructure for team level	Theme 6: Infrastructure for organizational level	Theme 8: Infrastructure for interorganizational level
Enabling capabilities	• Micro-mobility • Synchronization • Directory information	• Awareness support • Simultaneous local and remote mobility	• Integration and maintenance of heterogeneous systems • Partnerships in services • Maintenance of geographically dispersed computing resources	• Standard development • Interoperability • Shared social ontologies • Business frameworks
Governance and control	• Access privileges • Security • Privacy • Visibility of personal and public knowledge	• Team-level ownership and control of data and information • Access and control of services	• IT services governance • Enterprise architectures • Pricing and control of IT resources	• Regulatory policy and instruments • Pricing • Security and privacy
		Fundamental drivers • Mobility • Convergence • Mass scale		

overload) and their impact on user learning and performance?

Theme 2: Infrastructure for the Individual Level. To build truly personal and mobile services, we need to erect infrastructures that provide seamlessly critical capabilities for nomadic computing that include support for micromobility, synchronization, and directory services (Luff and Heath 1998). Micromobility refers to the way in which small artifacts, such as books and notepads, can be mobilized and manipulated "at hand," and how they relate to our bodily experience (Luff and Heath 1998). Small distance radio-wave

technologies like Bluetooth™ will enhance micromobility through Personal Area Networks (PAN) (Wireless Strategic Initiative 2000). These tools, combined with stationary sensors, can be used to deliver personalized information to users (e.g., location, remote sensing, personal sensing). Finally, nomadic environments that consist of a heterogeneous set of devices and networks will require peer-to-peer synchronization and directory services to provide seamless data integration and sharing. The construction of such an infrastructure will involve both technical and social dimensions.

Research Question 2.1. How can we provide mechanisms and protocols that enable the mobility of services, data, and users across different devices and locations?

In the realm of governance and control of infrastructures, the control and ownership of personal and public knowledge across various media in multiple contexts will be a key challenge (Asokan 1994). There are many different levels of personal information, some work related and some completely private and confidential. Because personalization implies an integration of different types of personal information onto a single device, it is important that these systems and services can provide access and visibility control for different types of information.

Research Question 2.2. What is an effective blend of social and technical mechanisms by which different degrees of visibility of information can be maintained without compromising the mobility and personalization of services?

Theme 3: Team-Level Services. To support various activities at the team level, the design of services in nomadic information environments should consider the support of awareness of distributed knowledge resources (Fagrell et al. 1999) and the integration of social and physical mobility. Nomadic information environments equipped with sensors that interact with personal area networks and location-aware services can provide essential information to the remote collaborators, such as the location, availability, and changes in the status of organizational actors and persons. Increased awareness, however, is not limited to knowledge of the status and availability of other individuals, but rather includes information about the status of technology-mediated knowledge resources. Recently, the concept of transactive memory—metaknowledge about other team members' expertise—has emerged as a framework to be used in understanding knowledge sharing (Moreland et al. 1996, Wegner 1987). Similarly, given that knowledge resources in nomadic environments include mobile individuals and technological tools, one should create "sociotechnical transactive memory" service mechanisms that enlist actors and coordinate their activities in terms of access rights, transaction completeness, and security. These mechanisms should also provide awareness of the status of activities and offer features such as reminders, organized communication support, etc., which help teams coordinate their activities and share ideas across temporal and spatial boundaries (Karsten and Lyytinen 1999).

In the study of team services, it is critical to take into account both "physical" and "social" mobility. Social mobility refers here to the ways in which, and the ease with which, individuals can move across different social contexts (e.g., office, meetings, home, etc.) and social roles (e.g., manager, colleague, parent, etc.) and still be supported by the appropriate services. Research within the Computer Supported Collaborative Work (CSCW) field has focused on the support of "physical" mobility (Bellotti and Bly 1996, Luff and Heath 1998). In the future, however, it will be equally important to consider "social" mobility while designing mobile services. As society and organizations become more fluid and dynamic, individuals will adopt multiple social roles at an increased intensity. Their information services have to be adjusted accordingly. Although social mobility can be supported without physical mobility, these two types of mobility often comingle, and increased physical mobility normally precipitates social mobility. For example, when a mobile phone user moves from one location to another, he/she often changes the social context as well (e.g. attends a meeting with a specific role).

Research Question 3.1. How do we design sociotechnical transactive memory systems to support the integration of the social and physical mobility of team members?

Two salient issues related to the adoption and use

of nomadic information environments will be team-level acceptance and new team process. So far, only limited research has been conducted to understand team-level acceptance factors related to technologies that are designed to support teams such as group support systems (Chin and Gopal 1995), e-mail (Fulk 1993), or groupware (Yoo 1998). Given the flexible and pervasive nature of nomadic information environments, however, it will be important to understand how teams adopt and then configure these environments differently. New mobile services and associated service platforms will also enable totally novel team configurations for "old" tasks such as decision-making processes, leadership, or problem solving.

Research Question 3.2. How do teams adopt and configure nomadic information environments, and how will such services enable novel team configurations?

The impact of nomadic information environments on teams can be assessed both in terms of team performance (efficiency and effectiveness) and team development (distributed cognition, trust, cohesion, and learning). While recent research has started to deal with these issues in virtual teams (Ahuja and Carley 1999, Jarvenpaa et al. 1998, Jarvenpaa and Leidner 1999, Maznevski and Chudoba 2000), most of them assume that team members need to go to specific locations to access their information and computing resources. Future research needs to focus on what will happen if the restrictions on time, location, and devices are removed.

Research Question 3.3. How will the increased information availability across time, space, and multiple devices influence virtual team performance and development?

Theme 4: Infrastructure for the Team Level. Nomadic services for teams will demand novel and scalable infrastructures that do not yet exist. We have a poor understanding of how to integrate and codevelop both social and technical elements that support and enable both social and physical mobility (e.g., incentives, cultural changes, changes in personal identity as expressed both in the physical and the virtual world). We also have a dearth of knowledge concerning the usefulness of location awareness to coordinate and mobilize shared information at the team level (Schmidt et al. 1999, 2000). In particular, team-level services demand both local and remote mobility support (Bellotti and Bly 1996). Local mobility involves real-time interactions between people and technologies in the same "location" or "site," while remote mobility supports both asynchronous and synchronous collaboration among individuals who move around distant locations (Luff and Heath 1998). While 3G mobile phones and global positioning systems (GPS) are designed to support remote mobility and increase the awareness of our movement through physical space, other emerging technologies like Bluetooth™ and WLAN (IEEE 802.11b) support micro and local mobility, respectively, enabling new forms of information sharing and control with available computing resources (like printers, screens, or coffee-makers).

Research Question 4.1. How do we seamlessly blend social and technical mobility to enable awareness support as well as simultaneous support of local and remote mobility for team activity?

The governance and control of nomadic information environments will create a new set of research issues in the areas of identity, ownership, control, and access privileges for team members (Ackerman et al. 2001). Because individuals will carry many roles in different contexts, availability of the means by which individuals can share public knowledge with other members, while protecting their private information, will be an important issue.

Research Question 4.2. How do we define and measure a team and its members' identity, ownership, control, and access rights in nomadic information environments?

Theme 5: Organizational-Level Services. At the organizational level, emerging enterprise applications, architectures, and frameworks will enable new services and workflow configurations that will foster changes in organizational structures. Consequently, future organizational design will take place through the simultaneous and continued coevolution and alignment of organizational and technical elements (Chandler et al. 1999, Nadler and Tushman 1997). When we consider this trend along with a large-scale

change in nomadic computing, we will have to challenge some of the assumptions underlying systems development that include separate "applications," time frame of development, or the rigidity of the rendering platforms. As Lyytinen et al. (1998) argue, substantial changes in software development content, scope, and organization need to take place. This calls for sustained and intense investigation on the part of IS researchers.

The development of nomadic information environments at the organizational level also requires the development of "social ontologies" that define social roles, associated behaviors, and their linkages with various organizational contexts and capabilities. A simple example of a social ontology is the granting of varying access privileges to different types of users in an Intranet based on their organizational position, skill, or experience. In this case, the types of users are socially constructed (Berger and Luckmann 1967), while the access privileges and functions themselves are technically defined. Such ontology and its representations will thus embrace both social negotiations and agreements and the technical design and implementation of the ontology. Social ontology and its embeddedness into the infrastructure are critical for social mobility and building nomadic information environments.

Research Question 5.1. How do we develop, integrate, and maintain new enterprisewide mobile service architecture that supports virtual workflow design and organizational forms?

IS researchers' ongoing interest in the organizationwide adoption and diffusion of services will demand fresh thinking and original theoretical work. Though topics related to the usability and adoption of innovations have been commonly studied in the IS literature (Fichman and Kemerer 1997, Swanson 1994, Zmud 1984), the large scale and diversity of future information environments will make it difficult to draw upon past theoretical models. We need to shift our focus from understanding how a single user adopts and exploits a specific application and/or technology to understanding how users adopt, configure, use, reshape, and transfer varying and dynamic sets of services, over time on multiple devices, across multiple organizational contexts.

Research Question 5.2. How do we explain the dynamics of adoption of sets of enterprisewide nomadic services by groups of users over time?

The impact of nomadic information environments can be studied not only through traditional organizational performance measures of effectiveness, but also through capability related concepts of organizational structure, learning, and agility. In addition, nomadic information environments will permit "placeless" processes and transactions that call for new models of organizational structure and behavior. While the past research in this area has examined the impact of such new organizational structure on individual workers (e.g., Staples et al. 1999), future work needs to also examine organizational design issues such as governance, control, and boundary in such emerging organizational forms.

Research Question 5.3. How will nomadic information environments influence organizational operation, structure, performance and effectiveness? Will they enable the creation of new organizational forms?

Theme 6: Infrastructure for the Organizational Level. A necessary element of a nomadic infrastructure is that it will provide a minimum set of *common infrastructure services* such as a user and service directory and social ontology. A critical challenge is to create, integrate, and maintain heterogeneous, geographically distributed computing resources. The mass scale also poses new challenges. From a technical standpoint, mass scale will require continued attention to interoperability, scalability, reliability, and performance of services (March et al. 2000). Thus, the complexity of nomadic information environments, both in terms of building the infrastructure and the managing the services, will greatly exceed that of a traditional, corporate information management function. Drawing from the bitterly learned experiences of the past two decades in managing fixed information services, we can predict that information management in organizations will hit a new wall of complexity when organizations migrate to mobile environments.

Research Question 6.1. How do we design, integrate, and maintain highly distributed and heterogeneous computing resources with high degrees of

interoperability, scalability, reliability and quality of service?

The enterprisewide IT control and governance has been an important issue in the traditional IS literature since the emergence of several applications and technologies (Brown and Magill 1994, Brown and Sambamurthy 1999). The multiplicity of technologies and the complexity of their interactions combined with the pervasive nature of nomadic computing will call for a new level of managerial attention. Organizations will not be able to manage the increased complexity of nomadic services without a sound organizational strategy and a supporting infrastructure that spans far beyond an organization's boundaries. Managing infrastructure and strategy options in such an immensely complex environment that incorporates both extraorganizational and intraorganizational relational structures will become a major challenge for IS researchers (Sambamurthy and Zmud 2000).

Research Questions 6.2. What are the effective IT governance structures including pricing, maintenance, and ownership, for nomadic information infrastructures?

Theme 7: Interorganizational-Level Services. The increased level of social and physical mobility will intensify the scope and the complexity of interorganizational coordination and business transactions involving multiple actors, such as, for example, electronic payment systems in mobile commerce (Kalakota and Robinson 2002). New social and technical mechanisms need to be developed to facilitate such business transaction and coordination among actors without jeopardizing their ability to protect proprietary knowledge.

Research Question 7.1. What social and technical mechanisms are needed to support multiparty, mobile interorganizational transactions and coordination without constraining interorganizational business practices, and how do such services emerge over time?

In the realm of service adoption and use, the creation, coordination, and control of industrywide standards that specify interorganizational services and transaction mechanisms across a variety of service channels will become important issues (Brunner et al. 2001, Papazoglou 2001, Valera et al. 2001).

Research Question 7.2. How are nomadic services that transcend the boundary of a single organization adopted and configured by organizations?

Finally, the impact of nomadic information environments will likely go beyond a single organization. The rapid convergence of media, service, and product companies will cause fundamental shifts in industry structures and will lead to radical transformations in the industry value chain. (Chandler et al. 1999, Christensen 1997).

Research Question 7.3. How do nomadic information environments transform the existing industry structures and value chains?

Theme 8: Infrastructure for the Interorganizational Level. The infrastructure for interorganizational services will raise similar research challenges that we discussed for individuals, teams, and organizations. Additional research themes will be the development of a shared infrastructure that provides the capability to operate across heterogeneous (both technical and social) and loosely coupled networks. This necessitates the establishment of a shareable minimal social ontology to offer such services.

Research Question 8.1. How do we develop infrastructure capabilities that support both the physical and social mobility caused by increasing interorganizational arrangements?

The establishment of standards for interoperable services, which includes business frameworks, will become a key policy issue (Jakobs 2000). In the realm of governance and control, regulatory policies and instruments that cover pricing security and privacy will need to receive IS researchers' increased attention.

Research Question 8.2. What are effective policies that govern pricing, security, and privacy in emerging mobile interorganizational services?

Conclusions

In this paper, we suggest that recent developments in telecommunications and mobile computing will re-

quire us to rethink many fundamental assumptions underlying the IS research. Such assumptions include: the bodily embedding of computing among and within users is not important in understanding their behaviors; computing takes place in fixed physical sites, ergo sites do count; we are interested in discrete applications or technologies, not in complex environments that enable organizations to mobilize information and its sharing; computing is a remote abstract functionality, not something that concretely moves around and takes place within varying contexts and enables new forms of organizational structure, capability, and agility; or technological features of the service and the supporting infrastructure form an important part of the research problem. We believe that questioning some of these traditional assumptions will lead to new and novel problem formulations and will considerably extend our methodological and theoretical discourses.

Based on the recognition of key drivers, we identified 8 themes and 20 research questions in nomadic computing that IS researchers need to carefully investigate if we seek to offer guidance and provide intellectual leadership. As our analysis suggests, the impact of the nomadic computing concepts on our research agenda will be substantial. We will have to return to the many old and established topics that seemed to be passé (e.g., adoption of individual services or how to design systems) and reanalyze them in light of radical improvements in the computing capability. Simultaneously, unexplored territories will be opened for IS researchers, which will expand our research agenda. We believe that IS researchers are perfectly positioned to respond to this challenge if we redirect our research agenda by capitalizing on our intellectual heritage and core capabilities that allow us to combine eclectic social and technical issues in theories and research approaches.

The emergence of nomadic computing environments provides a unique opportunity for the IS community to gain intellectual leadership in shaping how the design and use of nomadic technology in organizations will take shape. There are two complementary perspectives that the IS community can provide. First, IS researchers can participate in formulating theoretical concepts and practical guidelines for the design of nomadic information environments as sociotechnical ensembles, thus injecting new forms of systems thinking into this process (Churchman 1968). Because IS research is uniquely positioned between the technical and social worlds and their reciprocal interactions, and because the community is fundamentally concerned with shaping the world through design, we should be able to position ourselves in the center of this activity.

Second, the design and use of nomadic computing tools will shape and be shaped by value positions held by important actors, including designers, vendors, managers, policy makers, users, etc. While we maintain the cautious optimism concerning the technology's transforming capability, IS researchers can provide a balanced story of the likely difficulties and barriers of designing and adopting nomadic information environments. The choice and the use of certain technologies are often made to explicitly promote certain value positions in the society, such as free speech. In other cases, the use of technology can have inadvertent consequences of promoting certain value positions. The widespread use of mobile tools, for example, will raise unprecedented concerns with regard to security, surveillance, monitoring, privacy, and new time regimes of work.

Regardless of the perspective one adopts to study nomadic information environments, we recognize the challenges *in research approaches* that IS researchers need to master if they want to advance the field. We will conclude this paper by identifying three such challenges. First, the personalized and localized nature of nomadic knowledge and computing demands an "up-close" examination of phenomena as it unfolds. This will require us to extensively utilize data-intensive research methodologies such as anthropology, ethnomethodology, or action research. Many times, investigations will demand access to sensitive and personal knowledge and will have to consider information access and use as bodily experiences. This requires developing new types of research partnerships and trust. Given the global nature of nomadic information environments, the central idea within established data-intensive methodologies of studying *local behaviors* or *meanings* outside the reach of a global technology and service is foregone. Instead, we need to tailor methodologies so that we can study interrelationships and patterns among various individuals and technological tools dispersed across time and vast geographical spaces. This requires that we deploy both diachronic

and synchronic analyses with relatively large data sets. The paradoxical nature of nomadic computing creates a challenging research domain in which researchers will need to continually craft research methodologies and sharpen data collection tools to cope with this paradox.

Second, it is becoming extremely difficult to distinguish between social (or nontechnical) and technical elements in information environments. Consequently, new theories and methodological tools need to be developed to address this challenge. While traditional social network analysis has been helpful in shedding light on how individuals interact, it has ignored how technical elements mediate, enable, or constrain the social network in the making. One promising approach to overcome this limitation is to use actor network theory that simultaneously considers both technical and nontechnical elements and their symmetrical relations *cum* inscriptions as a methodological tool (Akrich 1992, Akrich and Latour 1992, Latour 1987, Latour and Woolgar 1979).

Third, many of the nomadic technologies are still in their infancy, though new tools and solutions are being developed at a very rapid speed. This pace of change challenges the traditional distinction between "technical" (or developmental) research and "behavioral" (or organizational) research. Therefore, new alliances need to be forged and IS researchers should be actively involved in studies where technologies are being built and tried out—not after the fact when they enter the market. Since the social and the technical have become blurred, IS researchers need to better integrate the strands of both technical and behavioral research. Behavioral IS researchers must desperately seek the "IT" in their IT research (Orlikowski and Iacono 2001), while the technical IS researchers must deeply appreciate how the "social" becomes IT in their IT research. This will require us to be more open and engage ourselves in innovative interdisciplinary research efforts.

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