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Achieving Implementation Success in Ubiquitous Computing Environments: Understanding the Role of Psychological Ownership

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ABSTRACT

This paper proposes the use of general systems theory and systems diagramming techniques to identify pervasive computing opportunities. The Garrity and Sanders' model of information systems success is used to provide a framework to view implementation and the variable psychological ownership is identified as a potential major factor for pervasive computing implementation success.

INTRODUCTION

The rapid development of and diffusion of new information technologies such as wireless and mobile communication technology, the Internet, hand-held computing devices, and cellular telephones is beginning to have a dramatic impact on business and organizational computing environments. New computing applications are quickly emerging and are changing how work is performed and the way organizations are structured. In general, the use of these technologies enables a new distribution of work within and between organizations and is leading to a new set of computing capabilities termed – *Ubiquitous, Pervasive or Nomadic Computing* (Note: We will use the term *Pervasive computing* to denote those applications which allow computing and communication from virtually any location.) Lyytinen and Yoo (2001) define Nomadic computing as *a heterogeneous assemblage of interconnected technological and organizational elements, which enables physical and social mobility of computing and communication services between organizational actors both within and across organizational borders (p.1)*. In order to better understand how organizations can best apply these technologies for competitive advantage and to better understand how to systematically study these emerging applications, this paper proposes (1) a practical way of identifying pervasive computing opportunities along with a research framework based on systems theory, and (2) the use of Psychological Ownership as an important dimension to advance our understanding of information system implementation success.

This paper is organized as follows. Section 2 reviews characteristics of pervasive computing environments and discusses how general systems theory may be used as a tool to examine these areas and as a way to identify potential areas of application for pervasive computing. Section 3 discusses the dimensions of information systems success and how they are pertinent to pervasive computing. Section 4 discusses the concept of Psychological Ownership and how it relates to achieving success in the implementation of pervasive computing applications. Section 5 is the summary and conclusions.

CHARACTERISTICS OF PERVASIVE COMPUTING ENVIRONMENTS

Technological developments and business needs and trends have both been responsible for the emergence of pervasive computing. Technology such as wireless and mobile communication technology, the Internet, hand-held computing devices, and cellular telephones have all been key factors enabling computation and communication from virtually any location. In addition, the term digital convergence denotes the increasing use of embedded microprocessors in numerous products thus providing computing capabilities in hand-held devices or embedded within traditional products or environments. Wireless transmission in combination with embedded or miniature devices means that information can be transferred relatively easily; thus allowing transaction processing, workflow, customer service and management decision making all to be performed at alternative locations and times.

While computing technology has enabled pervasive computing, the needs of businesses have also provided a strong impetus for corporations to seek pervasive computing. The globalization of business has meant an increasing need to connect various organizational units and members and to share information to enable faster decision making. In addition, increasing global competition has forced companies to stay closer to customers and provide better and more responsive customer service. Because of these business and technology trends, pervasive computing has emerged as an important area of study for researchers and IT professionals.

The Essence of Pervasive Computing

The essence of pervasive computing, in a physical sense, is the *embedded nature of the technology*. In other words, due to the technological advances referred to earlier, computing power and digital communication or information transfer can take place from virtually any location. Because of the location independence of computation and information transfer, the conduct of business can be fundamentally altered. In essence, these sets of communication technologies allow for virtual teams within organizations, location independence, or what Lyytinen and Yoo (2001) call *virtualization*. Many of the previous assumptions regarding where and how work must be performed can now be questioned and altered. This paper proposes the use of two models or viewpoints to address how best to manage these impacts: (1) the use of systems theory and (2) the use of a socio-technical viewpoint that gives greater attention to the human, social and psychological aspects of the interaction of humans and technology within work systems.

Organizational-based Pervasive Computing and General Systems Theory

Pervasive computing has the potential to greatly impact the nature of work within companies. In the case of intra-organizational computing, numerous examples exist of how companies have incorporated the use of information technology to improve productivity or decision making. Sipior and Garrity (1990) describe a case where the early adoption of laptop computers and expert system software helped salesmen provide expert, technical product advice to customers. Prior to the adoption of this technology there were long delays in finding expert advice, and long delays mean lower levels of customer service and lost sales. Essentially, this use of pervasive computing meant that an expert could be available, or virtually available, on demand.

Currently, a major, national Pharmacy (MNP) is in the process of using Internet and communications technology to balance the work load of retail pharmacy stores. Specifically, some MNP outlets experience low volume prescription sales while others are heavy volume. MNP is in the process of sending basic customer profile information from heavy load stores to lighter load stores. The low volume stores can then utilize their pharmacy work force to do data entry and basic prescription checking – without causing inconvenience to customers (i.e., customers still have their prescriptions actually, physically filled at their normal location). This example illustrates the tremendous flexibility afforded by pervasive computing – work can be performed where it is more convenient for company productivity, not necessarily limited to the traditional or historical physical location. Meanwhile customer service is actually improved as heavy volume stores do not overburden the pharmacy workforce.

These examples beg the question – "How does one go about identifying potential areas for the application of pervasive computing?" We recommend the use of general systems theory because by examining work systems abstractly we can remove various forms of bias or preconceived notions regarding technology application or traditional business thinking and business rules.

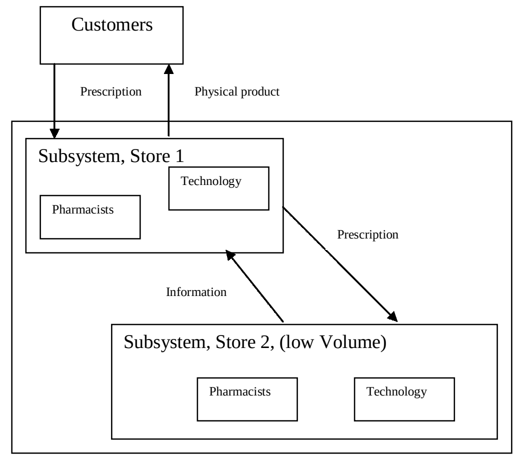
Specifically, in the MNP example above, we can diagram the situation abstractly using systems theory and focusing on the sub-systems, information flow, components (computer technology and human components) and boundaries (See Figure 1).

In Figure 1 above, the fast and easy transfer of digital information from store 1 to store 2 made this particular pervasive computing example possible. Similarly, the OpBright expert system example above is another example of pervasive computing because information (and knowledge) was easily transmitted to the location where it was needed most – at the sales site, where expert advice could be rendered to provide customer service, support, and aid in the process of selling products. In both of these cases, the key ingredient was the rapid availability of information and computing power and the ability to have work performed or transferred to the location where it most matters. The use of a general systems theory approach with the aid of a diagramming technique as shown above (or using data flow diagramming or similar systems analysis and design tools), allows the business analyst a degree of objectivity and open mindedness because such tools allow one to abstract the essential features of the situation without being constrained by current technology considerations. In other words, we are suggesting that traditional systems analysis and design techniques can and should be applied to the study of potential pervasive computing applications.

In a similar fashion, one may still use the same analysis and design techniques for the design of the entire work system, regardless of whether the work is performed within the organization, externally along the supply chain, or externally by a more efficient system or company (i.e., outsourcing work to another firm).

Again this is accomplished through the ability to quickly transfer digital information to a different physical location. Similarly, one may diagram or abstractly represent this work and information transfer using various system diagramming techniques (based on systems theory). The power of this technique is that *less is represented* – only the essential features need to be modeled – data flow, data storage, and data transformation (i.e., processes or transformations). Whether a human or a computer-based system does the data transformation is unimportant in identifying opportunities for the use of pervasive computing. These details, or implementation concerns, are best handled after the initial design of "where" work should best be performed.

Figure 1. MNP's system



Once opportunities have been identified and a fundamental redesign of work has been accomplished, one must still implement the new work design within an organizational setting. In order to better understand the issues involved in achieving implementation success the next section discusses the dimensions of information systems success.

DIMENSIONS OF INFORMATION SYSTEM SUCCESS

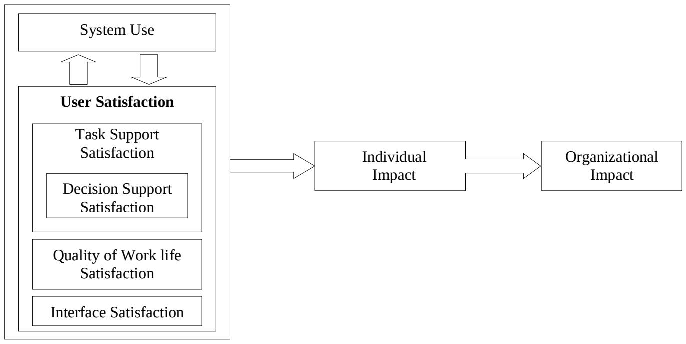
Garrity and Sanders (1998) extended the DeLone & McLean (1992) model of information systems success and proposed an alternative model in the context of organizational and socio-technical systems (Figure 2). The model identifies four sub-dimensions of User Satisfaction: Interface Satisfaction, Decision Support Satisfaction, Task Support Satisfaction, and Quality of Work Life Satisfaction. These factors were derived from an extensive review of IS success research and reasoning from basic principles of systems and general systems theory. The four factors correspond with three viewpoints of information systems: the organizational viewpoint (that IS as a component of the larger organization system), the human-machine viewpoint (which focuses on the computer interface and the user as components of a work system), and the socio-technical viewpoint (that considers humans as also having goals that are separate from the organization and whereby the IT or technical artifact impacts the human component in this realm).

Both Task Support Satisfaction and Decision Support Satisfaction attempt to assess the effectiveness of an IS within the context of the organizational viewpoint of systems. The Task Support Satisfaction dimension captures the overall set of tasks associated with job activities while Decision Support Satisfaction is more focused on decision support (i.e. structuring, analyzing, and implementing a decision).

Interface Satisfaction assesses IS success from the human-machine viewpoint. Interface Satisfaction measures the quality of the interface in terms of presentation, format, and processing efficiency. The quality of the interface is related to both Task Support and Decision Support Satisfaction. An improperly designed interface can cause users difficulty with task completion or it can impair their ability to make decisions.

The fourth dimension of the Garrity and Sanders' model is Quality of Work-life Satisfaction. This dimension addresses the fit between an IS and the socio-technical work world of the respective users. Specifically, Quality of work-life satisfaction is concerned with the user's physiological, psychological and higher order needs as they relate to intrinsic

Figure 2. Garrity and Sanders model of IS success (1998)



rewards, job satisfaction, pleasure, feelings of worth and importance. Items for this dimension include assessments of the worker's span of control, autonomy, how well the system supports the individual's psychological well-being and is thus closely related to the technology's impact on the user's job satisfaction. Quality of work-life satisfaction is an important dimension of success in organizational settings.

The last dimension of IS success, Quality of work-life satisfaction is especially relevant for pervasive computing environments since pervasive computing often demands that computer technology be embedded within our existing products and services and therefore it must work in a seamless, transparent fashion for technology to effectively act as a tool while not negatively impacting our personal lives and our general well-being.

PSYCHOLOGICAL OWNERSHIP AND ACHIEVING SUCCESS IN THE IMPLEMENTATION OF PERVASIVE COMPUTING

Pervasive computing offers a number of challenges for developers and designers trying to achieve implementation success along the four dimensions discussed in section 3. In order to understand why, we first develop a broad, working definition of pervasive computing:

Pervasive computing involves the set of technologies that allow for location transparency in the performance of organizational tasks, transactions, and or decision making.

The key elements of the above definition are: (1) *Tasks* can be performed in many different locations – location independence (corresponding with task support satisfaction), (2) *Decisions* can be performed in many different locations – location independence (corresponding with decision support satisfaction). We have purposely not included the types of technology involved in pervasive computing in our definition because the sets of technologies are ever evolving. However, at present these technologies all involve getting information and knowledge from one location to another in a fast and effective fashion in order to provide support for task accomplishment, (documented and transferred as transaction processing) and decision making. Because of the nature of the technologies involved (e.g., wireless communications, RFID), pervasive computing tends to be embedded more tightly within the social system (both inside organizations and externally). Thus, we have a much tighter coupling with the socio-technical system and a greater potential impact on the human element of systems – with a corresponding greater need to assess impacts of pervasive computing technology on users' Quality of Worklife satisfaction. As businesses increasingly seek to use pervasive computing technologies there will also be a greater demand on designing proper user interfaces to support users' Task support, Decision Support and Quality of Worklife satisfaction.

Central to the discussion of implementation success of pervasive computing will be finding ways to incorporate technology into the user's work-world, life-world, or socio-technical world so that they will find it both helpful in meeting their work, task or decision needs but also acceptable in meeting their personal or quality of life needs. A major factor that influences one's job satisfaction and that has received much research attention lately is the factor – Psychological Ownership. The next section explores this variable in greater detail and examines its likely impact on pervasive computing implementation success.

Psychological Ownership

Psychological ownership is defined as the state in which an individual feels as though the target of ownership belongs to them (Pierce et al., 1992). Enhancing workers feelings of possession or ownership may be important considerations for organizations. For example, Brown (1989) stated that psychological ownership will be the key to organizational competitiveness during the 21st century and others have noted that Harley Davidson was able to make its successful turnaround largely due to creating feelings of ownership among its employees (Peters, 1988).

Pierce et al. (1991) and others (Peters, 1988; Stayer, 1990) have proposed that psychological ownership is associated with positive behavioral and social-psychological consequences. Pierce et al. (2004) note that there are clinically based observations suggesting that responsibility, caring, stewardship, and acts of citizenship are enhanced when individuals experience feelings of ownership toward the target object. Further, Vandewalle et al. (1995) provided empirical support to demonstrate that psychological ownership was positively related to extra-role behavior and in positive social psychological states including organizational commitment and satisfaction.

Determinants of Psychological Ownership

Pierce et al. (1991) have suggested that control is an important structural component contributing to the experienced state of ownership. Researchers in the area of human development have proposed that as young children begin to explore their environment, they discover things that can and things that cannot be controlled.

This initiates the beginning of a distinction between self and not-self. Objects for which there appears to the child to be a near-perfect correlation between their motor command and the visual feedback of their movement are experienced as parts of (i.e., one with) the self (cf. Seligman, 1975). Those objects that cannot be controlled fall within the domain of not-self. Similarly, through socialization practices, other people (e.g., parents) start to draw the line between what can and cannot be touched, moved, and controlled. Fearing for the safety of the child and passing along their own possession or ownership values, adults send strong messages..... It is through such direct experiences and socialization practices that a boundary gets constructed around possessions, along with the beliefs and feelings associated with the control of possession (p. 512, Pierce, et al., 2004).

Prelinger (1959) provided empirical support for the link between object control and possession or psychological ownership. He found that the more an individual feels he has control over and can manipulate an object, the more likely that the object will be perceived as part of the self.

Implications of Psychological Ownership for Implementation Success

Pervasive computing applications demand a closer linkage between users in their social and socio-technical work worlds and computer technology. For example, when computer applications require close links with consumers, as is the case with radio-frequency identification technology for products (RFID), issues of control and privacy (a personal or social concern) become important. As eloquently stated by Weiser (1991), "The social problem associated with ubiquitous computing, while often couched in terms of privacy, is really one of control." The recent empirical study by Gunther and Spiekermann (2005) attests to the fact that consumers feel helpless and lack control over the RFID technology. Subjects in their study felt little control over their ability to control the RFID equipment, and the feelings of loss of control were even greater for the more highly educated consumers.

Whether the pervasive computing technology is used within, or between organizations or to outside stakeholders, a key issue for implementation success will be to develop mechanisms that allow users (or consumers) the ability to control the technology and thus ultimately to develop a sense of psychological ownership. Within organizations one strategy is to involve users in a participative development process since participation in systems development and participative decision making are related to increased feelings of control. When the pervasive technology involves the consumer or other stakeholders outside the organization, careful development of interfaces will be a critical success factor since the interface is essentially the information technology artifact (object) and since the interface exerts such a strong influence on the other dimensions of information systems success.

SUMMARY AND CONCLUSIONS

This paper has proposed a system approach to help identify pervasive computing opportunities and has demonstrated how systems diagramming may be used to provide an abstract and objective view to enable the discovery of these opportunities. Secondly, this paper has noted that as organizations implement more pervasive computing applications, it will become increasingly important to be especially cognizant of the impact of these systems on users' socio-technical work world. This is because pervasive computing is inherently closely tied to users' work environments, products, and social lives. A key factor that must be managed is the user's feelings of psychological ownership, since this is likely to have a tremendous impact on the effective use of pervasive computing applications. The Garrity and Sanders' (1998) model was used as a way to view implementation success of these applications.

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