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The Role of Handheld Computers in Controlling Inter-Organizational Data Transactions

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THE ROLE OF HANDHELD COMPUTERS IN CONTROLLING INTER-ORGANIZATIONAL DATA TRANSACTIONS

Completed Research Paper

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Abstract

In spite of prior extensive research on the role of information systems (IS) in controlling inter-organizational transactions, very little has been said about the role of handheld computers in inter-organizational control. The literature on handheld computers suggests that their facilities of mobility and connectivity engender usability patterns that are significantly different from those related to static and bulkier computers. Yet, the IS field lacks elaborate models explaining the role of handheld computers in inter-organizational control. This paper draws upon the philosophical assumptions of transactions costs theory to analyze this role. Four scenarios resulting from this analysis are appropriation and institutionalization of technology, and interaction and comprehension between the organizations. It further synthesizes these scenarios to propose four socio-technical systems of control that make electronic data transactions with handheld computers efficient. It argues that handheld computers supplant bureaucratic control, and engender more diverse and resilient systems of inter-organizational control. These roles will require IS researchers to rethink the sufficiency of traditional mechanisms of control suitable for efficient inter-organizational transactions, and induce the next wave of research on the control of electronic data transactions with inter-organizational IS.

Keywords: Inter-organizational information systems, handheld computers, control, transactions costs

Introduction

Over the years, the organization of human activities has experienced paradigm shifts in response to the co-evolution of information technology (IT) and organizational behavior (Yates 1993). Technology and organization are seen to be co-evolving because the evolution of one is both an antecedent and consequent of the other (Orlikowski and Barley 2001). Thus, on the one hand, continuous technology development has been driven by humans' desire to improve upon the way we organize our activities through the production of more efficient means. This development is captioned luridly by Latour's (1991) as "technology is society made durable". On the other hand, newly developed technologies have induced organizations to, for example, structure (Barley 1986) and re-engineer their processes (Davenport and Short 1990), manage their knowledge (Swan et al. 1999), geographically-distribute their activities (Hinds and Kiesler 2002), and monitor, control and coordinate their interests from remote locations (Olson and Olson 2000, Wiredu and Sørensen 2006).

Currently, one of the resultants of this co-evolution is inter-organizational (IO) transactions controlled or mediated by handheld computer information systems (IS). Handheld is a generic description of various miniature computers such as personal digital assistants (PDAs), mobile phones, smartphones, and portable electronic cash registers (PECRs). Handheld computers are small, movable, connectible, and close to their users. These devices are increasingly becoming commonplace in inter-organizational relationships where they are combined with traditional mechanisms of control to govern electronic data transactions. This deployment can be seen in sales tax administration systems, in public electronic procurement systems, and in mobile-commerce systems. Traditionally, the suitable mechanism of organizational control (market, bureaucracy, clan or network) has been understood as a function of conditions that increase transactions costs (performance ambiguity and goal incongruence) (Ouchi 1980). However, given the peculiar structural and communicative facilities of handheld computers, their deployment for inter-organizational transactions will engender different control mechanisms. The suitable mechanisms of control will be determined by how these facilities of handheld computers relate with the conditions that increase transactions costs.

By virtue of the miniaturization, mobility, connectivity and proximity of handheld computers, user discretion is relatively high (Wiredu 2007). Mobility and proximity, in particular, are unique facilities that engender organizational consequences quite different from the consequences engendered by facilities of static and bulky computers. This implies that handheld computers must be engaged with in sufficient rigor (Orlikowski and Iacono 2001) to model its relationship with conditions that increase transactions costs. Distance between the cooperating organizations also does matter (Olson and Olson 2000), and a plethora of distance-related factors can undermine an organization's ability to control transactions efficiently (Wiredu and Sørensen 2006). Therefore, determining the social and technical mechanisms needed for controlling inter-organizational transactions that are mediated by handheld computers is a contemporary challenge facing IS research.

Lyytinen and Yoo (2002) hinted on this challenge when they commented about the scope and complexity of inter-organizational coordination and business data transactions involving multiple actors. They did not dedicate their commentary to inter-organizational information systems, and so they could not model detailed systems for controlling inter-organizational transactions. But they called for IS research into the social and technical mechanisms needed to support inter-organizational transactions that are mediated by handheld computers. But up till now, we do not understand the relationship between handheld information technologies and conditions that increase costs of electronic data transactions. This is likely to affect future research on IO systems in general, and on handheld computer-based IO systems in particular, leaving the IS discipline bereft of current ideas on how to govern inter-organizational electronic data transactions.

The aim of this paper is to analyze the role of handheld computers in controlling IO data transactions efficiently. The analysis is based on a review of the relevant interdisciplinary literature on the conditions that increase the costs of IO transactions, on how they are controlled, and on how the facilities of handheld computers relate with them. Thus, the conditions – performance ambiguity and goal incongruence – are related with the mobility and connectivity of handheld computers. Four scenarios resulting from these relationships are appropriation and institutionalization of technology, and interaction and comprehension between the organizations. The synthesis of these scenarios leads me to propose four systems of social and technical mechanisms that make electronic data transactions with handheld computers more efficient. The paper's main arguments concerning the role of handheld computers are that they engender more diverse and resilient systems of inter-organizational control, and that they

supplant bureaucratic control. These roles will require IS researchers to rethink the sufficiency of traditional mechanisms of control suitable for efficient inter-organizational transactions. The propositions and implication can serve as agenda for the next wave of research on the control of electronic data transactions in inter-organizational IS.

The scope of this review and underlying assumptions are stated in the next section. Then, the literatures on the conditions that increase transactions costs and on control mechanisms are reviewed in both intra-organizational and inter-organizational contexts. Following this, the facilities of handheld computers are also reviewed, leading to an analysis of the relationship between these facilities and the conditions that increase transactions costs. The resultants of these relationships are also cross-examined to propose socio-technical systems of control that will engender efficient data transactions in inter-organizational relationships. The paper concludes with explanations of the role of handheld computers with their implications for future information systems research on inter-organizational control.

Scope and assumptions

This paper focuses on transactions of electronic data only. The discussions preclude transactions of physical or material products which are typical of buyer-supplier relationships in electronic commerce. Another scope is dyadic relationships between cooperating organizations. This scope can be extended to relationships between an organization and others in multiple dyads, as it is between a tax revenue organization and enterprises in a country. Furthermore, it is assumed that the transactions between these organizational dyads are being governed by traditional hierarchical or bureaucratic relationships, for example, national legislative instruments. Traditional bureaucracies are non-technological mechanisms such as rules, regulations and routines used for controlling inter-organizational transactions. Traditional bureaucracies will be contrasted with electronic bureaucracies that are technology-based.

Control and Transactions Costs

Controlling organizational activities is one of the key functions used to ensure appropriate productive behaviors and outcomes. Control manifests overtly or covertly, strongly or weakly, and, in terms of inter-organizational transactions, remotely or locally. Over the years, many scholars have defined and redefined the concept diversely in terms of power structuring (e.g. Etzioni 1965), of activity structuring (e.g. Child 1972a, b), of environmental dependencies and vulnerabilities (e.g. Jacobs 1974), of behavioral surveillance and output measurement (e.g. Ouchi and Maguire 1975, Ouchi 1979, 1980, Eisenhardt 1985, Flamholtz and Das 1985), of regulation of resource flows (e.g. Gamoran and Dreeben 1986), of formal and informal modelling (e.g. Kirsch 1996, 1997), and of combining processes and structures (e.g. Nidumolu and Subramani 2004). But all of them seem to converge on the problem of uncertainties in terms of behaviors and outcomes that confront organizations and engender the need for these diverse control mechanisms. For instance, Etzioni's (1965) idea of power structuring is about the different allocations of power by an organization to elicit the behaviors and outcomes it needs and to check whether their quantities and qualities are in accordance with their specifications. Eisenhardt (1985) also explains control strategy as a function of task characteristics, placing emphasis on the ability to program tasks and measure outcomes. Thus, all the explanations of the concept seem to be summarized by Ouchi and Maguire (1975), who deemed behavior and outcome as the two broad and independent functions of control.

When an organization seeks to control its employees' behavior, ambiguity of their performance will challenge behavior control. Likewise, when it seeks to control employees' outcomes, incongruence between their goals and the organization's goals will challenge outcome control. Thus, the organization's ability to exercise control depends on the mechanisms adopted to address the various degrees of performance ambiguity and goal incongruence. To this end, Ouchi (1979) draws upon Williamson's transactions cost economics (1981, 1991) to further conceptualize control in terms of mechanisms or relationships that mediate transactions between individuals. These mechanisms of control, according to Ouchi (1980), are markets, bureaucracies and clans. The efficiency of these mechanisms is dependent on the degrees of goal incongruence and performance ambiguity between cooperating parties. Goal incongruence and performance ambiguity are conditions that increase the costs of transactions between them.

A fundamental problem of cooperation between parties is that they only have few overlapping goals, indicating that they normally pursue incongruent goals (Barnard 1968, Mayo 1945). For example, there are few overlapping goals between a bank and a university because banks are normally judged by the profits they generate while universities are normally judged by their research output. Incongruent goals also mean that if the parties are left to pursue their individual choices, then those choices will be uncoordinated and costly. To control these parties' cooperation in the face of their incongruent goals, transaction cost economics (Ouchi 1980, Williamson 1981) suggest that reducing the degrees of the conditions that increase transactions costs is the most suitable way of ensuring equitable interdependencies between the parties. The transactions between cooperating parties are mediated by price mechanisms that should ensure equity in their interdependencies. Equity is so central to the sustentation of their collective effort that investment must be made in it to ensure the standards of reciprocity and avoidance of opportunism are met. It is this investment that defines transactions costs.

When transactions are mediated by a market relationship, equity therein is determined by existing prices of similar commodities, and this may require simple contracts to govern them. For example, existing prices of stationery widely known in a market are sufficient guides for determining equity between and stationeries supplier and a university. However, if an exceptional good or service is being sold, and there is only one buyer, then market forces would not be sufficient to govern the transactions. Governance will require additional experts as well as expensive and complete contracts to ensure equity. Otherwise, each party will have to invest additional resources to value the goods or audit the service of the other. But any of these alternatives will add costs to the transactions. Thus, transactions costs increase in market relationships when it is difficult to value any party's contribution in their cooperation because the difficulty must be overcome with more investments. But even in some instances, none of these alternatives is feasible, suggesting that market relationships can fail due to opportunistic behaviors and bounded rationality (Simon 1945).

The failure of market relationships, resulting from unbearable transactions costs, gives rise to control by bureaucratic relationships. This is because the high transactions costs of bureaucratic relationships are still preferable to the higher transactions costs of market relationships (Ouchi 1980). But bureaucracies can also fail when the costs of evaluating performance of employees rises above the costs which bring about market failure. Performance evaluation becomes ambiguous because the standards which superiors in bureaucratic organizations apply to match employee behavior against output are subject to idiosyncratic interpretation. This is normally the case in tasks that are undertaken by groups of employees where each one's specific contribution to the output is difficult to determine, as in a manufacturing where different people play different roles in the processing of raw materials into finished goods. Because employees depend on employers to distribute performance or output rewards equitably, performance ambiguity can make employees feel they are being treated unfairly. Consequently, they will demand additional guarantees for equity in systems such as union representation. This will also increase the bureaucratic organization's transactions costs and cause its failure. Ouchi (1980, p.135) summarizes efficiency in markets and bureaucracies this way:

> "market relations are efficient when there is little ambiguity over performance, so the parties can tolerate relatively high levels of opportunism and goal incongruence. And bureaucratic relations are efficient when both performance ambiguity and goal incongruence are moderately high"

When bureaucratic relations fail, clan relations become the most appropriate means of control. Clan relations are the most efficient means of lowering transactions costs when performance ambiguity is high and goal incongruence or opportunism is low. Clans are dependent on high degrees of socialization between clients that produce a strong sense of community (Van Maanen 1975). High degrees of socialization are premised on high inclusion (Etzioni 1965), and disciplined immersion of each party's interests in the collective interest (Kanter 1972). These premises of goal congruence reduce opportunism and increase the likelihood of equity in rewards, leading to low transactions costs in clan relationships. These premises also tolerate high degrees of ambiguous performance. Thus, performance is determined by "subtle reading of signals that is possible among intimate workers but which cannot be translated into explicit, verifiable measures" (Ouchi 1980, p. 137).

Table 1: Conditions that Increase Transactions Costs and Control Mechanisms

Source: Adapted from Ouchi (1980)

Control mechanism	**Performance ambiguity (behavior-related)**	**Goal incongruence (outcome-related)**
Market (price)	Low	High
Bureaucracy (rules)	High	High
Clan (norms)	High	Low
Network (mutual relations)	Low	Low

The appropriate mechanism of control – market, bureaucracy, or clan – that ensure efficient transactions is judged from a comparative analysis of the transaction costs of those alternatives. A market is most appropriate when performance ambiguity is low but goal incongruence is high. A bureaucracy is most appropriate under conditions of both high performance ambiguity and high goal incongruence. A clan relationship is most efficient when performance ambiguity is high but goal incongruence is low. However, in circumstances when both performance ambiguity and goal incongruence are low, Powell's (1990) network relationship seems to be the most appropriate mechanism (Table 1). It seems to be so because low levels of these conditions require mere mutual relations between cooperating parties to ensure efficient transactions. Network forms of organization are typified by reciprocal, sequential, long-term to indefinite patterns of interactions. They are more social, more dependent on mutual relationships and less guided by formal structures of authority.

Although these mechanisms are useful bases for understanding the concept of control, the choice of a market, bureaucracy or clan will constitute a reaction to performance ambiguity and goal incongruence. Recently, Nidumolu and Subramani (2004) have provided a comprehensive matrix of control by drawing upon both behavior and output control models. Their matrix is important because, rather than reacting to behaviors and outcomes, their approach aims at influencing them. In the matrix, they have reconceptualized behavior and output control as a process approach to control, and have complemented this approach with a structure approach, apparently drawing from Child (1972a, 1972b). They explain structure in terms of standardization of methods and decentralization of authority. Their combination of the process and structure approaches results in a matrix of control (see Table 2).

Table 2: Matrix of Control

Source: Adapted from Nidumolu and Subramani (2004)

		Process Approach	
		Methods (behavior control)	**Performance Criteria (outcome control)**
Structure Approach	**Centrally-devised standards (Standardization)**	Standardization of methods (construction of Coordination Mechanisms)	Standardization of performance criteria
	Delegation of authority for decision-making (Decentralization)	Decentralization of methods	Decentralization of performance criteria

Although standardization and decentralization seem to be contrary concepts, the success of each of them is dependent on the quality of representations which are applied for control purposes. The matrix has interesting implications for IT-based control because modern ITs can signify representations of standardizations and even decentralization. ITs possess complex arrays of designed programs and facilities that are intended to increase human

effectiveness. Thus, aspects of human-based control processes and structures can be inscribed into ITs as a means of standardising control, and representing its more predictable relations (Hanseth and Monteiro 1997). Latour's (1991) maxim "technology is society made durable" expresses this idea of representations tersely. Expositions by sociologists of technology (e.g., Wartofsky 1979, Zuboff 1988, Winner 1993, Bijker and Law 1992, Kallinikos 2005) also confirm clearly the standardization of organizing functions (e.g. control) into technology artifacts. These expositions are normally premised on the conception of technology in terms of Luhmann's (1993) idea of functional simplification and closure.

> "Functional simplification involves the demarcation of an operational domain within which the complexity of the world is reconstructed as a simplified set of causal relations. Functional closure implies the construction of protective cocoon that is placed around the selected causal sequences to ensure their recurrent unfolding" (Kallinikos 2005, p.485).

However, modern ITs, recognizing their interoperability and connectivity in networks, are rather complex and do challenge traditional notions of control (Kallinikos 2005). Their complexity, interestingly, holds sufficient potential for both standardization and decentralization of methods and performance criteria. Thus, behavior and outcome controlling intentions of organizational authorities can be inscribed into information technologies to achieve standardization and decentralization at the same times (Hanseth and Monteiro 1997, Kallinikos 2004).

Control of Inter-organizational Relationships

Just as relations between an employee and his or her employer are controlled to ensure equity, so are relations between two organizations controlled for the same purpose. In this context too, the governance form is determined significantly by the transaction costs of exchange. Instances of such inter-organizational relationships that have implications for control are found in international joint ventures (e.g. Groot and Merchant 2000), outsourcing relationships (e.g. Anderson et al. 2000), and integrative buyer-supplier relationships (e.g. Frances and Garnsey 1996). Inclusive in the equity teleology is the importance of reducing the uncertainties that emanate from opportunistic behavior, bounded rationality and even poor performance. But compared with employee-organization or person-person relationships, inter-organizational relationships present more challenges for management control because "the scope of activity of management control is enlarged and is no longer confined within the legal boundaries of the organization" (e.g. Otley 1994, p.293).

Concerning these challenges and how to address them, suitable mechanisms of control are determined by two main elements – asset specificity, and the transaction environment. Inter-organizational transactions normally require specific investments called transaction-specific assets (Zaheer and Venkatraman 1995). Examples of specific assets are highly-qualified professionals and custom-designed technologies. Specific assets require control mechanisms that will safeguard them so that they are not objects of opportunism. Williamson (1975) proposes that bureaucracies are the most suitable mechanisms for safeguarding transactions that have transaction-specific investments.

Apart from influence by the parties' likely opportunistic behaviors and bounded rationality, the mechanism of control can also be influenced significantly by institutional arrangements and social embeddedness of the transaction (Granovetter 1985, Griesinger 1990). Macro-level institutions, such as central or regional governments, that define the legal rules and policies governing organizations will also influence the control mechanism that cooperating organizations should adopt to reduce their transactions costs (van der Meer-Kooistra and Vosselman 2000). Concerning social embeddedness, Zaheer and Venkatraman (1995, p.389), for example, assert that "there exists a significant social component in exchange relationships which may be masked or missed in economic explanations of exchange." The social context of inter-organizational transactions implies, therefore, that trust is an important additional mechanism for control (Nooteboom et al. 1997, Dekker 2004), especially of long-term transactions that are challenged by considerable uncertainties. The mechanism of trust resonates very much with Ouchi's (1980) idea of clan relationships in which socialization, high degrees of inclusion and immersion of individual organizations' interests are typical.

Technology Control of Inter-organizational Transactions

As the evolution of IT is presenting us with a more interconnected world (Kallinikos 2005), organizations are increasingly making use of their networking capabilities to control transactions between them. Thus, the co-evolution of IT and organizational behavior has resulted in IO control that is heavily dependent on modern ITs. In response to this, the control of inter-organizational transactions with technology has been a subject of interest since the birth of the Internet in the middle of the last century. The subject has been researched extensively in domains such as electronic markets (e.g. Malone et al. 1987), electronic commerce (e.g. Johnston and Mak 2000, Hart and Saunders 1997), customer-supplier relations (e.g. Son et al. 2005, e.g. Tillquist 2005), strategic partnerships between organizations (e.g. Bensaou 1997), inter-bank settlements (e.g. Boateng 2009), and indirect control of individuals' or organizations' behavior (e.g. Schultze and Orlikowski 2004). It has also attracted reviews and conceptual framework formulations by Elgarah and colleagues (2005), Robey and colleagues (2008) and Reimers and colleagues (2008).

Two of these reviews (Robey et al. 2008, Reimers et al. 2008), for example, discuss how the material structure of technology shapes users' actions and influences the restructuring of inter-organizational relationships. The influential role of technology as a conditioner of social forces in organizations has also been discussed in terms of technology as an occasion for structuring (Barley 1986) and of the entanglement of technology and work (Orlikowski and Scott 2008). Thus, inter-organizational relationships are faced with technology as an additional mediating variable that will, undoubtedly, affect both reactive and proactive mechanisms of control.

Of interest is the technology which has evolved from the standalone mainframe computer to handheld-networked computer. Both the material and communicative facilities of the handheld computer will be of interest to this review because its use can shape the user's behaviors and outcomes, and the ability to control them. This interest is due to the assumption of their portable and communicative facilities as specific assets of inter-organizational transactions. The asset-specificity of its portable and communicative properties stems from its peculiar epistemology of usability which differs significantly from that of static and bulky computers. Usability of handheld computers is a function of the user's skills, knowledge, experience and self-centered satisfaction (Wiredu 2007); and is understood in terms of human asset specificity (Zaheer and Venkatraman 1995). It is important, therefore, to understand the control and efficiency of inter-organizational transactions in terms of how these properties of handheld computers relate with the conditions that increase transactions costs.

To this end, I want to apply the behavior and outcome control aims to analyze the role of handheld computers in controlling inter-organizational data transactions in terms of how their uses can help us understand the suitable socio-technical systems required for reducing transactions costs. I will conceptualize these systems of control in terms of how the facilities of handheld computers can reduce performance ambiguity and goal incongruence. In this conceptualization, a key assumption is that technology is a proactive mechanism of control being used by a focal organization to standardize and/or decentralize the behaviors and outcomes of another organization. Thus, the conceptualization will centre on how the technology facilities and users' reactions to them relate with performance ambiguity and goal incongruence to increase or reduce the costs of transactions. I discuss the technology's portable properties in terms of mobility and proximity; and the communicative properties in terms of connectivity.

Handheld Computers and Inter-organizational Transactions

Handheld computers have resulted from the co-evolution of IT and organization. This has been going on since the invention of the first computers, and can be understood in terms of three main periods – before 1980, early 1980 to mid-1990s, and since mid-1990s.

Before the 1980s, the mainframe and super computer were the main technology used by organizations. Thus, only few people in an organization would be in charge of their maintenance and use. These users and their activities could be monitored and controlled directly by managers because of proximity, signifying the relatively low discretion that could be exercised by users. Any external organizational activities could only be monitored and controlled effectively through rudimentary methods such as transfers, visits and reports. Information systems were

largely useful for data processing and management reporting from internal sources, thus organizations' control of their external interests were fairly limited to non-technological means.

The early 1980s saw the invention of the personal or desktop computer which began the revolution of the proliferation of computers in homes and offices. Individuals could now own computers for their personal home use or could be given personal computers to use in offices to achieve organizational goals. In spite of this revolution, organizational use of computers could still be monitored and controlled directly by managers because of the collocation of work, which could signify low levels of user discretion. However, various degrees of private uses could be allowed by managers or could be achieved by users by stealth. Thus, user discretion could be deemed as low-to-medium. Organizational control of external transactions in the early part of this period was still largely limited to visits and reporting. However, in the latter parts when computer networks were very advanced and global, IT-based control of external activities became more commonplace.

Personal computers are still popular in offices and homes today, especially because of the invention of the World Wide Web which has ensured their networking over wide areas such as a country's entire landscape. However, since the mid-1990s, the world has witnessed the invention of smaller handheld computers that are gaining popularity by the day. This latest invention couples with both wire signals over fiber-optic and wireless signals over Wi-Fi and VSAT technologies to enable their use by organizations to monitor and control geographically-distributed activities. This coupling has resulted in what is referred to as anytime anywhere or ubiquitous computing (Lyytinen and Yoo 2002, Kleinrock 1996); and the facilities of these handhelds are being exploited for controlling inter-organizational transactions.

Facilities of Handheld Computers

Handheld is a generic description of various miniature computers such as personal digital assistants (PDAs), mobile phones, smartphones, and portable electronic cash registers (PECRs). PECRs are popularly known as handheld terminals and used in shops and restaurants. Their functionalities vary when considered individually. For example, mobile phones and smartphones support voice, data and image transmissions; PECRs and PDAs normally support only data communications; and PECRs have inbuilt printers that are used to issue receipts to customers immediately after a transaction. When considered collectively, however, their common functionality lies in their ability to communicate with other remote devices, big and small. These functionalities depend on the increasing power and capacity of microprocessors, and on the proliferation of cellular telecommunications infrastructure, wireless local area networks, and Bluetooth personal area networks. In view of these functionalities and their dependants, handheld computers are being widely adopted and deployed by both private and public sector organizations around the world. The portability and functionalities of handheld computers project two underlying and distinct yet discrete facilities of their uses – mobility and connectivity. I proceed to explain the discreteness of these facilities. I also explain how each of them relates with the performance ambiguity and goal incongruence to engender socio-technical systems that will make inter-organizational transactions more efficient.

Mobility

Handheld computers are known to possess a facility of mobility because they can be moved from one place to another without necessarily affecting their functionalities. The manifestation of this facility is witnessed in the users' exhibition of mobile computing or computing-on-the move. The importance of mobile computing in IS research is seen in the numerous publications from research on the subject (see, for example, Wiberg and Ljungberg 2001, Weilenmann 2001, Arnold 2003, Sørensen and Pica 2005, Cousins and Robey 2005, Scheepers et al. 2006, Wiredu and Sørensen 2006). The mobility of handheld computers depends on human movement (Dix et al. 2000). Thus, the mobility of computers implies a fusion of human-and-object mobility. This fusion is dictated by the biological and environmental needs of humans that motivate and direct their activities. This point clarifies the relationship between human movements and the motives behind them: mobile computing depends on human mobility and necessarily on human motives (Wiredu 2007). Thus, the need to operate handheld computers may themselves be the motives that induce human movement.

The proximity of handheld computers is subsumed under their mobility because the very description of handheld suggests the closeness of the technology to the bodies of users. The closeness also enables users to wear them (Geisler 2003). The mobile phone handset, for example, is "small and light enough to fit in a pocket or handbag, and is designed to be taken anywhere" (Arnold 2003, p.243). This wearing, combined with the facility of mobility, enable what is known as ubiquitous computing – ability to use the technology anytime anywhere, but not necessarily everytime everywhere (Kleinrock 1996, Wiberg and Ljungberg 2001). The facility of proximity has also been of central interest to researchers of the use of handheld computers. This interest is normally aroused by the challenge posed by circumstances such as modality of human movement (e.g. Kristoffersen and Ljungberg 2000), work practices (e.g. Scheepers et al. 2006, Sørensen and Al Taitoon 2008), and distance-related contradictory motives (e.g. Wiredu and Sørensen 2006, Kietzmann 2008). Proximity is one of the facilities of handheld technologies that engender personalization by their users. Personalization is understood as the user's appropriation of the technology to serve his or her personal motives, as opposed to organizational ones (Wiredu 2007).

Connectivity

For mobile computing to be of optimal benefit to the user, the handheld computer must be connected or connectible to other information technologies. Connectivity extends the perspective of computing in inter-organizational transactions from personal to network because it enables the user to source information not only from the proximal device but also from remote ones. The power of connectivity between IT devices, both static and mobile, induced Caincross (1997) to announce the death of distance. By the same power and influence of interconnectivity, Kleinrock (1996), in a more positive tone, espoused the possibility of interacting with computers anytime anywhere – nomadic computing. While the manifestation of the facilities of mobility and proximity are largely dependent on the user's actions and reactions, the facility of connectivity is verily dependent on telecommunications infrastructure and wireless networks which are external to both device and user. Connectivity promotes interactivity between two parties, overcoming space and time boundaries as well as creating instant awareness of remote circumstances. However, it can also be a catalyst for interaction overload (Ljungberg and Sørensen 2000, Mathiassen and Sørensen 2008). Interaction overload is understood as excessive requests for communications made by one actor to another, which excesses are contrary to the preferences of the receiving actor. It is mostly experienced when the proximity and mobility facilities are also being employed by the user at the same time.

Relating Technology Facilities to Conditions that Increase Transactions Costs

By relating the conditions that give rise to transaction costs and the facilities of handheld computers, four diverse scenarios of relationships can be described (Table 3). Besides, the distinction between mobility and connectivity helps to understand each of the conditions in terms of two respective dimensions – use and task. Use-related performance is particularly about the usability of technology that may not be task-related. Use-related goal is particularly about the sustained acceptance of the technology by both parties for their transactions. Task-related performance is particularly about work-based behavior that is part of periodic transactions, and task-related goal is particularly about the sustained equitability of the outcomes of transactions. The distinction between mobility and connectivity also helps to distinguish between traditional and electronic forms of markets, bureaucracies, clans and networks, thereby clarifying the systems of control being espoused. Traditional forms are devoid of IT, while electronic forms are IT-based.

Table 3: Scenarios of Relationships between Facilities of Handheld Computers and Conditions that Increase Transactions Costs

FACILITIES OF HANDHELD COMPUTERS	CONDITIONS THAT INCREASE TRANSACTION COSTS	
	Performance ambiguity (behavior control)	Goal incongruence (outcome control)
Mobility (use)	APPROPRIATION of technology will **increase use-related performance ambiguity** HIGH Reactive Technology will be used to **decentralize procedures** to accommodate use-related performance ambiguity **HIGH**	ADAPTATION to technology will **increase use-related goal incongruence** HIGH Proactive Technology will be programmed to **standardize structures** to reduce use-related goal incongruence: INSTITUTIONALIZATION: **LOW**
Connectivity (task)	INTERACTION with user organization will **reduce task-related performance ambiguity** LOW Proactive Technology will be used to **standardize information** to sustain low performance ambiguity **LOW**	COMPREHENSION of user organization will **reduce task-related goal incongruence** LOW Proactive Technology will be used to **standardize connection** to sustain low goal incongruence **LOW**

Appropriation (Wiredu 2007) of handheld computers is a normal result of an attempt to control user behavior via the handheld's facilities of mobility and proximity. These are facilities that enable users to translate others' interests into their own to satisfy their self-centered (personal or private) motives. Appropriation of handheld technologies is normally a negotiation about power and control over the configuration, uses and benefits of handheld computers (Bar et al. 2007). Because of their sizes and proximity to users, handheld computers are very susceptible to privatization by users. Wiredu's (2007) study reports such users who could not use organizational functions in their PDAs for learning but could happily use the personal functions for private information management. Privatization of handhelds occurs in inter-organizational transactions when an organization in the relationship derives self-centered benefits from the technology. Interestingly, user behavior characterized as appropriation is a necessary concession that the organization controlling the transactions should make because it (appropriation) is an important incentive for easy handling, user satisfaction and acceptance of the technology (Scheepers et al. 2006). Easy handling and acceptance dictate the inscription of loose structures that decentralize acceptable user behaviors into handheld computers for behavior control (Hanseth and Monteiro 1997). User appropriation coerces the controlling organization to cede some of its authority to the user organization to sustain technology-based transactions. As a result, it will be difficult for the controlling organization to direct user behavior on a daily basis, and, hence, difficult to closely monitor performance. To wit, the mobility of handheld computers undermines behavior control because it engenders user appropriation, it decentralizes user behavior, and increases use-related performance ambiguity.

When user appropriation is accommodated for the sake of easy handling and acceptance, it leads eventually to the user's *adaptation* to the technology. But this form of adaptation may be still aligned with the selfish goals of the user organization, thereby maintaining or increasing use-related goal incongruence between the transacting organizations. In this scenario, bureaucracy is an intermediate control mechanism that will offer additional surveillance in the face of high performance ambiguity and high goal incongruence. Thus, while the user organization is making use of the technology's facilities of mobility and proximity to transact, the controlling organization must concurrently be applying its mechanism of bureaucracy to check against the user organization's opportunistic behavior.

But a bureaucratic relationship may not be efficient in the long run because it is an expensive mechanism, at least compared with a market relationship (Ouchi 1980, Williamson 1975). To overcome this challenge, the bureaucratic relationship, combined with the technology's programmable facilities, will be used proactively to realign the selfish form of adaptation to the collective goals of the inter-organizational relationship. Information technology can be programmed with standardized expected goals to institutionalize collective outcomes, and to enforce them even from remote locations (Hanseth and Monteiro 1997). This is done by inscribing tighter structures or standards into the technology to coerce the user organization to conform to the collective goals of the cooperative. Realignment allows the controlling organization to control the transactions by *institutionalizing* common output standards which the user organization should abide by. In this scenario, remote outcome control that lowers goal incongruence can be achieved.

Interaction is a function of the instant, real-time and continuous communicative functions provided by handheld computers when they are linked by electronic networks. Interconnections between the handheld(s) of the user organization and a handheld or other computer of the controlling organization is a facility that enables their interactions. It allows for the remote monitoring of, and learning about the activities of, people in distant locations (Sørensen and Al Taitoon 2008, Kietzmann 2008). Thus, interactions that lead to the visibility of the activities of user organizations are not only useful for surveillance but also for evaluating performance and giving directions to control behaviors remotely. This means that high degrees of visibility of the user organization's activities are sure means of reducing the ambiguity surrounding the evaluation of its task-related performance, signifying that the connectivity of handheld computers facilitates the control of even remote task-related behaviors. To prevent adverse reactions from the user organization (e.g. confusion) and to sustain their visibility, controlling organizations normally standardize the connections, the information being exchanged, and their templates (e.g. with extranets) (Mathiassen and Sørensen 2008).

When the aim is to control outcomes to reduce task-related goal incongruity, the connectivity of handheld technologies will enhance the *comprehension* of the user organization by the controlling organization. Controlling organizations that employ telecommunications infrastructure and networks are able to gain a greater understanding of the user organization because organizations learn more about the motivations, preferences and actions of other organizations through continuous interactions. This helps in the development of shared mental models which will be useful for reducing goal incongruence between cooperating organizations (Denzau and North 2000). Thus, connectivity of handheld computers can create avenues for cooperating organizations to negotiate and renegotiate their goals in the face of changing institutional circumstances to reduce goal incongruity.

Socio-technical Systems of Control for Efficient Transactions

These four categories of relationships in Table 3 inform us that control of inter-organizational transactions with computers is a more complex and multifaceted challenge than control of transactions without them or with other bulkier technologies. On the one hand, behavior control aimed at reducing performance ambiguity in this relationship is understood anew in terms of the two dimensions of appropriation and interaction. Appropriation increases use-related performance ambiguity while interaction reduces the task-related version. On the other, outcome control aimed at reducing goal incongruity is now understood in terms of institutionalization and comprehension dimensions. Institutionalization reduces use-related performance ambiguity while comprehension reduces task-related goal incongruence. Relating the low and high states of the two dimensions to each other engenders various systems of control that will make transactions more efficient in the face of this multifaceted challenge. Each of these systems is constituted by a combination of both organizational and technological mechanisms (see Figure 1). Thus, the control of inter-organizational transactions for their efficiency is more than a simple choice of a market, a bureaucracy or a clan relationship.

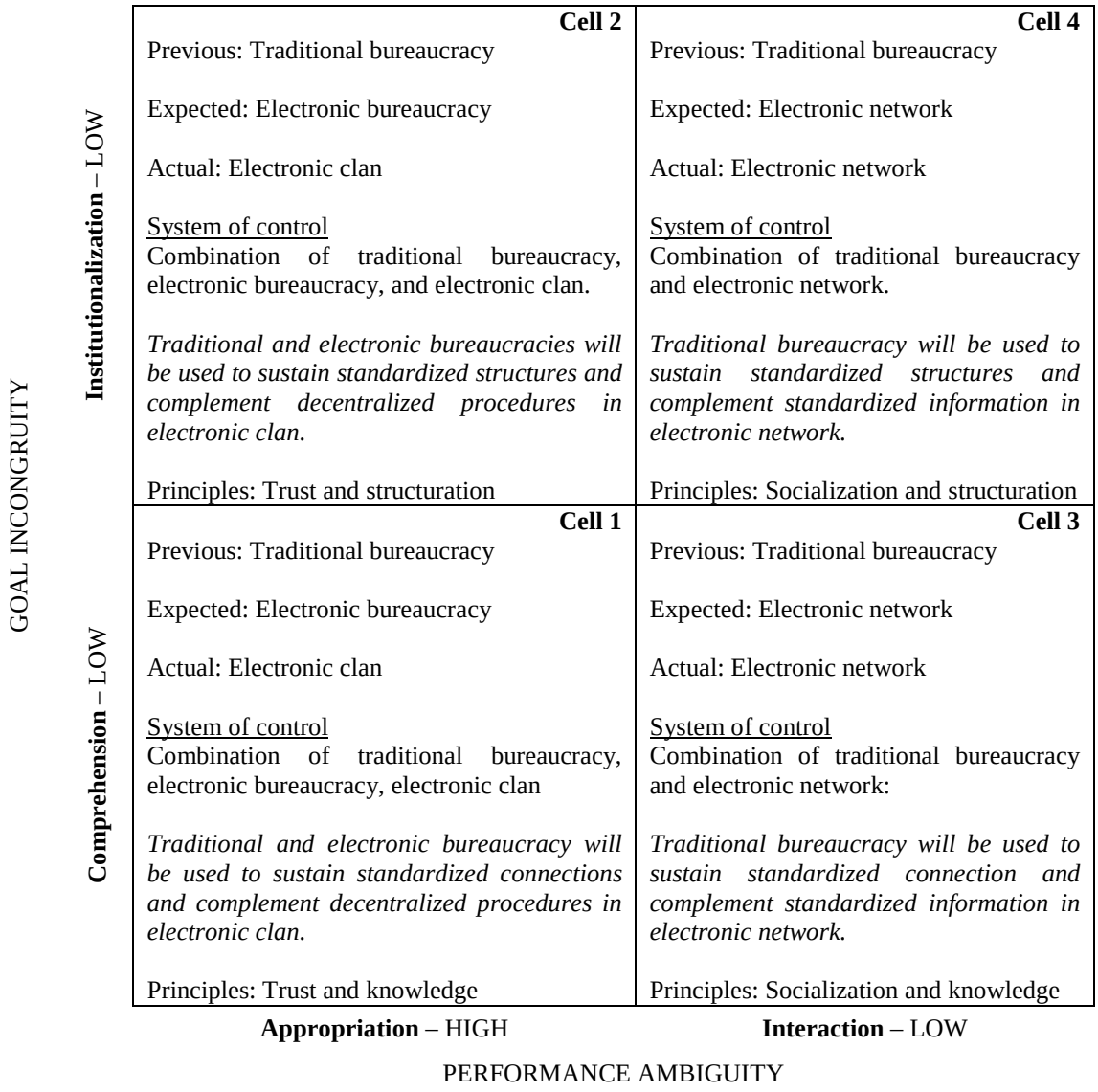

Figure 1: Socio-technical Systems of Control

When appropriation makes performance highly ambiguous and comprehension lowers goal incongruence (Cell 1), then the most efficient system for controlling that aspect of transactions will be a combination of electronic clan, and traditional and electronic bureaucracies. Traditionally, transactions characterized by tolerance of high ambiguous performance and lowering of goal incongruence are most efficiently controlled by a traditional clan mechanism (Ouchi 1980). This mechanism is normally subsumed under intra-organizational contexts. In the inter-organizational context, however, the technology facilities of mobility and connectivity stimulate an electronic clan. An example of an electronic clan is a relationship between a tax revenue organization and an enterprise where the enterprise's interests are consciously incorporated in the development, implementation, and use of the mediating technology. To sustain the low goal incongruity between the cooperating organizations, the electronic clan will be complemented by both traditional and electronic forms of bureaucracy. This complementation will uphold the standardized connection between them that will support a better knowledge of the user organization, and leave them open to explicit auditing and evaluation. As the user organization's appropriation of the technology will engender decentralized procedures in the electronic clan, these forms of bureaucracy will also be useful for guarding those procedures from abuse. The principles that should guide this system of control are trust and knowledge. Trust is a necessary accompaniment to

decentralize the processes of transactions and to entrust the user organization to appropriate the technology within broad perimeters of acceptable use (Hart and Saunders 1997). For instance, the tax revenue organization should trust the enterprise to use the technology for IO transactions and other private purposes without abusing it. Alongside the principle of trust, the controlling organization will operate the principle of knowledge to ensure inter-organizational learning and goal congruity in the cooperative (Lui 2009). Thus, the revenue organization should use the technology to know how comfortable or frustrating it is for the enterprise to use the technology to capture and transmit sales tax information. Upon this knowledge, the revenue organization can institute measures to address the usability challenges facing the enterprise. Therefore, the relationship that will exist between mechanisms of this system of control is:

Proposition 1: *Traditional and electronic bureaucracy will be used to sustain standardized connections and complement decentralized procedures in electronic clan.*

When appropriation makes performance highly ambiguous, and institutionalization lowers goal incongruence (Cell 2), the most efficient system of control will also be a combination of electronic clan, and traditional and electronic bureaucracies. Like the system in Cell 1, the controlling organization will apply its traditional and electronic bureaucracies to complement the decentralized procedures engendered by user organization's appropriation of the technology. The difference between these systems, however, is that these forms of bureaucracy will be applied to sustain the standardized structures engendered by institutionalization. The principles that should guide this system of control are trust (Hart and Saunders 1997) and structuration (Giddens 1984). Technology is an occasion for structuring (Barley 1986, Orlikowski 2000). Thus, a trust-based relationship that is acceptable to the organizations should be structured by the institutionalization of handheld computers. In the relationship between the revenue organization and the enterprise, structuration is exemplified where the technology is programmed to standardize the enterprise's tax returns format and timing (outcome), leaving tax entry and private use of the technology (performance) at its discretion. Therefore, the relationship between the mechanisms of this system of control is:

Proposition 2: *Traditional and electronic bureaucracies will be used to sustain standardized structures and complement decentralized procedures in electronic clan.*

Proper use of connectivity means that the programmable facilities of computer networks have been employed as representations of traditional bureaucracy to standardize connectivity. This enables the controlling organization to interact with and comprehend the other better (Cell 3). Cooperating organizations that use connectivity properly will witness low task-related performance ambiguity and low goal incongruence. Going by the philosophical assumptions of transaction cost economics, this combination is the most ideal set of conditions reflecting the low cost transactions because their costs are very minimal. But rarely (e.g. Etzioni 1965, Weick 1979) or hardly ever (e.g. Simon 1945) does this ideal scenario manifests into reality because of the continuous tension between individual and collective interests that attend cooperation. This means that it can only manifest imperfectly and in the short run. Granted that it is well sustained, connectivity between the organizations' technologies will stimulate an electronic network. Network forms of exchange depend on relationships thriving on mutual interests and reputations that are less guided by formal structures of authority (Powell 1990). Similarly, electronic networks will be non-hierarchical relationships between cooperatives that flourish by technology-mediated exchanges that are informal and presupposed. In this system, the controlling organization will need its traditional bureaucracy to complement the electronic network and to sustain the high efficiency in its transactions. The traditional bureaucracy will be used to sustain the standardized connection, and to complement the standardized information characterizing interactions between the cooperating organizations. The principles of socialization and knowledge should guide the exchanges. Socialization or social control is an informal means of achieving inter-organizational control that complements formal means such as markets and bureaucracies. It is sustained by trust building through joint decision making and problem solving (Dekker 2004). The following relationship will define the mechanisms in this system of control:

Proposition 3: *Traditional bureaucracy will be used to sustain standardized structures and complement standardized information in electronic network.*

When interaction reduces performance ambiguity, and institutionalization also reduces goal incongruity, the resultant system of control will also be an electronic network (Cell 4). In this system too, the controlling organization will need its traditional bureaucracy to sustain the standardized structures underlying its transactions with the user organization. However, the bureaucracy will be used to complement standardized information in their interactions. This system of control should be underpinned by the principle of socialization. However, the

technology will occasion the structuring or restructuring of the collective goals and agreed standards of performance in the relationship, implying that the principle of structuration is equally necessary. Therefore,

Proposition 4: *Traditional bureaucracy will be used to sustain standardized connection and complement standardized information in electronic network.*

Conclusions and Implications for Future Inter-organizational IS Research

This purpose of this paper was to analyze the role of handheld computers in controlling inter-organizational data transactions, and to model socio-technical systems that will ensure efficiency of the transactions. Against this backdrop, the paper has examined the specific ways by which the relationships between the facilities of handheld computers and the conditions that increase transactions costs challenge traditional mechanisms of inter-organizational control. The analysis suggests that understanding the fitting mechanisms for controlling inter-organizational data transactions with handheld computers is not a simple choice of a market, bureaucracy, clan, or network relationship.

Thus, the paper argues, first, that the role of handheld computers in the control of inter-organizational data transactions lies in the idea that these technologies engender more diverse systems of control. The diversity stems from the multiple facilities of handheld computers, and the reactive and proactive responses they elicit from cooperating organizations. There are diverse strands of inter-organizational transactions that reflect diversities in data type, security and form, as well as in frequency and volume of exchange (McCann and Ferry 1979). The diversity in the systems of control suggests their applicability to different stands of transactions that reflect different sets of data and exchange characteristics. Thus, in the face of one set of characteristics, a controlling organization may de-activate one facility of the technology and activate the other in order to operate one system of control instead of all four. Another organization, in the face of a different set of data circumstances, may activate both facilities to operate all four systems. This means that inter-organizational IS based on handheld computers provide greater advantages in terms of the scope of application to diverse strands of inter-organizational transactions than those based on desktop computers.

The second role argument is that handheld computers engender more resilient systems of control. They increase the resilience of inter-organizational IS significantly because the technology can be deployed and used for controlling transactions in changing organizational circumstances of the same relationship. The dynamic organizational circumstances can be the user organization's skill and knowledge level of technology use (citation?), the relationship's maturity (citation?), its social embeddedness (Granovetter 1985, Griesinger 1990), and the macro-level institutions governing the relationship (van der Meer-Kooistra and Vosselman 2000). In one circumstance, the controlling organization can focus on one or two systems at the expense of the others, and then in another circumstance the focus can be shifted onto the erstwhile overseen systems. This means that inter-organizational IS based on handheld computers have greater advantages in terms of their adaptability even to transactions emanating from dynamic inter-organizational relationships than those based on desktop computers.

The third role argument, derived from the high ambiguous performance associated with handheld computers, is that they supplant bureaucratic relations instead of enhancing them, generally speaking. They induce clan and network systems at the expense of bureaucratic ones, thereby strengthening the position of the user organization in the relationship. They are occasions for de-structuring bureaucratic structures and for structuring trust-based ones at the same time. They are more fitting for decentralizing methods and, therefore, less suitable for decentralized behavior control. This means that inter-organizational IS based on handheld computers hold more promises for building trust-based systems of control and less for bureaucratic ones.

These roles imply further that the deployment and use of handheld computers in inter-organizational transactions will require IS researchers to rethink traditional control mechanisms in future research on the subject. The efficiency of transactions has previously been understood in simple terms of traditional market, bureaucracy, clans and networks relationships. These are control mechanisms applied to deal with various combinations of low and high levels of conditions that increase transactions costs – performance ambiguity and goal incongruence. Previously also, technology control relative to these conditions has also been discussed to model the pervasive character of

modern information technologies (e.g. Malone et al. 1987, Kallinikos 2005, Boateng 2009). But these models do not unearth the ramifications of the relationships between handheld computers and these conditions. Therefore, analyzing these relationships to question traditional notions of inter-organizational control and of technology control will lead to novel problem formulations in future research on technology control, on inter-organizational information systems, and on handheld computing.

All of these outcomes have important implications for future research on technology control because these facilities of handheld technologies are known to possess significant potentialities for high user discretion. The placement of handheld computers in the territories of the user and far away from the controlling organization is a catalyst for seriously undermining control. The facility of connectivity, for instance, can be usurped by the user to interoperate with other networks, thereby extending its zone of interoperability. This extension, according to Kallinikos (2005), increases the complexity of circumstances that can be controlled from afar and the susceptibility of the electronic network to malicious intrusions. Connectivity, essentially, takes technology out of the controlled order associated with traditional technologies. Likewise, the facility of mobility, as explained in my analysis, also makes handheld computers susceptible to user appropriation, thereby undermining technology control. Therefore, IS researchers studying technology control with handheld computers will have to consider user discretion equally to explain the new orders of technology control shaped by these peculiar facilities.

The proximity of handheld computers to the user and their susceptibility to personalization leads to tighter coupling between social and technical phenomena in inter-organizational relationships. Tighter coupling between the social and the technical present opportunities for IS researchers to study the usability of handheld computers in inter-organizational settings. In these studies, how the programmability of task and the measurability of outcomes can be measured by these socio-technical systems of control is a crucial challenge. Eisenhardt (1985), for example, identified these challenges and their corresponding information systems as significant functions of control strategy. These future studies will lead to the formulation of models and practical guidelines for the design of socio-technical environments that can control inter-organizational data transactions efficiently.

Information technology will continue to evolve, and we will see more advanced handheld computers and more of them being deployed in various organizational endeavors. IS research will have to match up to this challenge to explain the role of the IT artifact (Orlikowski and Iacono 2001) in the evolution of organizations. To this end, engagement with the handheld computers to make close examinations of the dynamics of appropriation and institutionalization will be required. Close examinations of these dynamics are important for explaining the role of the technology and its unique facilities in its adoption by user organizations. Other questions concerning organizational use of handheld computers, which prior examinations of the role of portable IT artifacts have unearthed, are equally relevant for future examinations in the inter-organizational context. Questions about whether the artifact situates or mediates interactions, or in which circumstances it is transparent and in which it is opaque, are very interesting instances that will challenge future IS research.

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