A Theory of Task/Technology Fit for Mobile Applications to Support Organizational Processes[1]

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Abstract

In this paper, we propose a theory of task/technology fit for mobile applications to support organizational processes (tasks). We adapt the concept of task/technology fit developed by Zigurs and Buckland (1998) and Goodhue and Thompson (1995), to account for the fact that mobile applications, as a type of IT infrastructure, potentially cover a wider area of tasks than the specific applications discussed in the earlier papers. Our analysis of the technology reveals a general trade-off between functionality and mobility, which has implications for application development. Our theory suggests that advancements that ensure compatibility between the IS requirements of a task and the IS capabilities of an application are ultimately more successful. We support our findings with reported case studies, as well as with insights from a project that we conducted in cooperation with Motorola. In the conclusions, we discuss the concept as part of a more comprehensive framework and suggest future research directions.

Keywords: mobile technologies, organizational processes, task/technology fit, technology development

[1] Valuable comments have been provided by Frank Land, London School of Economics; Joseph Mahoney and Matthew L. Nelson, University of Illinois at Urbana-Champaign; and the participants at a seminar of the National Laboratory for Tourism and eCommerce at the University of Illinois at Urbana-Champaign. We thank Dean Haacker, Motorola, Inc. for his continuous support, as well as the study participants for their time and effort.

Introduction

Information technology (IT) innovations, such as mobile and wireless technologies, can only be successful when "molded" into applications and subsequently put to use. Although wireless telephony and the application of mobile consumer transactions have received much attention and showed considerable growth, some developments have been disappointing in the U.S. (Ovum studies, referenced by Scudder 2002), as well as in Europe (Durlacher 1999). Many questions remain open concerning technology development (mobile clients, communications infrastructure, location issues, security); applications and business models; and global issues (Tarasewich et al. 2002, Smith et al. 2002). The questions that we address include: How are mobile applications different from other IT applications? How can firms benefit from the specifics? What factors are critical to improve existing applications?

In line with calls to the information systems (IS) community to describe and assess IS technology more explicitly, in particular when reviewing IS systems from an organizational or behavioral perspective (Huber 1990, Orlikowski and Iacono 2000), we focus specifically on mobile applications. Our considerations are based on traditional IS research, in particular the concept of task/technology fit as developed by Goodhue and Thompson (1995) and Zigurs and Buckland (1998).

To develop the theory, we first review different organizational tasks and typical IS support, then focus on mobile technology. After deriving a set of propositions, we provide empirical evidence from a project that we participated in. In our conclusions, we put the theory into perspective with other approaches and factors that are relevant to assess the success of mobile applications and point out directions for future research.

Learning from Information Systems Research – Task/Technology Fit as a Precondition to Benefit from Information Systems

Information systems (IS) research has long examined the value of IS implementations, their impacts, risks, and success factors. The focus has naturally been on existing IS applications, such as data processing, including functional systems, enterprise resource and planning (ERP) systems, management information systems (MIS); decision support systems (DSS), and expert systems (Hoffer et al. 2002, Turban et al. 2001). Research in innovation and diffusion has pointed out the importance of matching IS with the organizational tasks to be supported or automated (Tornatzki and Klein 1982, Kimberly 1981). Related is Daft and Lengel's (1986) widely used formulation that the information-processing needs of an organizational structure should fit with its information-processing capabilities.

The general concept of task/technology fit has been applied to different information technologies. Cooper and Zmud (1990) examine the interaction of task and technology characteristics upon the implementation success of material requirements planning (MRP) systems to support production and inventory control. Bensaou and Venkatraman (1995) extend Daft and Lengel's (1986) work to interorganizational relationships and include task characteristics and information technology into their set of variables. Their research examines the structure of interorganizational relationships in the automotive industry in the U.S. and Japan, with particular emphasis on organization-spanning processes in purchasing and design, and electronic data interchange (EDI) technology. Explicitly proposing a theory of task/technology fit, Goodhue and Thompson (1995) and Zigurs and Buckland (1998) integrate concepts from IS and organizational research and discuss the relevance of fitting group support applications with group task requirements for performance and process quality. Specific emphasis is put on the aspect of task complexity (see also Jarvenpaa 1989, and Mathieson and Keil 1998).

An application of the concept of task/technology fit to mobile technologies has to take into consideration the fact that mobile applications can cover a broader range of usage than applications with a specific purpose, such as group support systems. Within the framework of IS applications proposed by Farbey et al. (1995), mobile applications fall into the category of infrastructure making an upfront evaluation difficult. Our extensions to the traditional theory of task/technology fit concern the tasks as well as the technology.

Tasks

Tasks have been analyzed on different levels and according to different characteristics, including structure, repetitiveness, complexity of cognitive processes, ambiguity etc. In organizational and social sciences, tasks are typically assessed according to their complexity (simple vs. complex) (March and Simon 1958, Simon 1977, McGrath 1984, Campbell 1988). Thompson (1967) identifies three forms of interdependencies between organizational tasks (sequential, pooled, reciprocal) and suggests the application of appropriate organizational technologies (long-linked, intensive, mediating) to ensure task coordination. The management and strategy literature focuses on different functions within the organization, such as *management and leadership* tasks versus *operational and administrative* tasks (Anthony 1965, Mintzberg 1973). In recent years, information and knowledge tasks have received particular attention (Davenport et al. 1996). Overlaps exist of course, as the use of information systems happens in the context of business organizations.

Operational Tasks

A common distinction is made between simple and complex tasks. Typically, simple tasks (also known as operational or administrative tasks) have limited discussion and are primarily used to distinguish and discuss more complex processes. In this sense, simple tasks are often described as structured, repetitive (March and Simon 1958), and programmable (Simon 1977). Interdependencies between subtasks are most likely sequential (Thompson 1967). Campbell (1988) emphasizes the lack of multiplicity of outcomes and solution schemes and conflicting interdependencies. Davis and Olson

(1985) mention transaction processing as the processing of orders, shipments, and receipts, for which well-defined rules could be put in place. They include routine activities in accounting, procurement, payroll processing, patient records processing, or the input of data collected in a market research survey. It is noteworthy that virtually all business functions, including higher-level managers, carry out operational tasks when submitting expense reports for travel activities or processing purchasing requests. Operational tasks are often guided by corporate rules and captured by the use of forms.

Management Tasks

In a continuum, management tasks may be placed opposite from operational tasks. Compared to simple operational activities, repetition of the same instance rarely occurs and simple rules cannot be implemented.

Campbell (1988) proposes a framework of four dimensions to determine the *complexity* of a task: outcome multiplicity, solution scheme multiplicity, conflicting interdependence, and solution scheme-outcome multiplicity. Tasks where none of the dimensions is present are referred to as simple tasks; tasks where one or several of the dimensions are present are complex tasks. Campbell (1988) then defines four categories of complex tasks, each featuring a different combination of the four dimensions (problem tasks, decision tasks, judgment tasks, and fuzzy tasks).

Anthony (1965) describes three groups of management activities, each with a different time frames: strategic planning relates to long-range goals and policies for resource allocation; management control oversees the acquisition and efficient use of resources in the accomplishment of organizational goals; and operational control is responsible for efficient and effective execution of specific tasks. For all three types of activities, the time horizon is typically longer than for simple administrative tasks.

Mintzberg (1973) discusses a number of different management roles and points to the fact that managers often switch between different activities. Much time is spent in meetings, and common activities include planning, internal and external negotiations, the assignment of tasks and budgets, and the communication of plans and directions. After a change or a project have been initiated, management and leadership require following up on progress, conflict resolution, and swift emergency handling.

Informational Tasks

We can place informational tasks between administrative tasks (well structured, predetermined output) and management tasks (poorly structured, ill-defined output). Information workers are experts who solve problems by collecting information, by managing knowledge and analyzing data, and by developing solutions, thus, ultimately preparing for the decisions on actions to be taken. Named professionals by Mintzberg (1989) the function of information workers has received considerable attention in recent years, as customer relationship management and consulting have come to public attention. More traditional examples of information workers include service professionals, such as teachers, doctors, and lawyers. The job profiles often require the development of solutions and problem solving, following careful data collection (monitoring of internal and external data sources), and data analysis, often in collaboration with a customer, client, or patient. As part of the problem solving process, Stabell and Fjeldstad (1998) also include the choice of a treatment, execution, and subsequent control and evaluation of the results into their corresponding concept of a value shop. Cognitive requirements are high and the main characteristics include task complexity and the need for flexible information access (Davenport et al. 1996). Projects are often done in teams, involving specialists, establishing a need for group management, and increasing the complexity of decision processes.

IS Support

IS research provides examples and suggestions for IS support of the different tasks. Davis and Olson's (1985) classic understanding of management information systems clearly points to the three types of organizational tasks that we discussed above: A management information system is "an integrated, user-machine system for providing information to operations, management, and decision-making functions in an organization" (Davis and Olson 1985, p. 6).

Given the inherent structure and repetitiveness, support for operational and administrative processes has long been available through data processing systems, including automated data input, processing, storage, and retrieval (Hoffer et al. 2002, see also Turban et al. 2001). Examples include systems to support and automate billing, inventory management, financial analysis, and report preparation (DeSanctis and Poole 1994). The emphasis is on efficiency and the avoidance of double data entries to ensure productivity of the users, to reduce errors, and to allow for (near) real-time updates of the enterprise data systems. Process standardization can be an additional desired result, for example, to ensure compliance with corporate purchasing procedures. Besides workflow automation, the system may also provide documentation about processing rules, procurement contracts, and help-functionality explaining system features.

Compared to operational tasks, information and communication requirements for informational and management tasks are complex and unstructured. Daft and Lengel (1986) discuss the question of why organizations process information and propose two reasons: to reduce uncertainty (absence of information) and to reduce equivocality (multiple, conflicting interpretations of a situation, messy). Their considerations can help explain IS support for these two kinds of tasks.

A situation of uncertainty will resolve itself over time. It can best be associated with the tasks of information and knowledge management, and can in principle be solved with sufficient information, in particular when combined with adequate forecasting and problem solving techniques. March and Simon (1958) point out how managers try to find decision rules, information sources, and structural designs that help to cope with uncertainty (see also Perrow 1986). Adequate IS support includes flexible and ad hoc access to raw as well as aggregated data, e.g., on customer interaction, best practices, and external knowledge. In addition, analytical tools support cognitive processes required for problem solving. For this type of tasks, decision support systems have been developed to provide guidance in identifying problems, finding and evaluating alternative solutions, and selecting or comparing alternatives. For our purposes, we note that the requirements for computing power to adequately support information and knowledge management tasks are very high in terms of complexity, volume of information to be provided and processed, and flexibility (toolbox).

The issue of equivocality is more difficult to resolve than uncertainty, insofar, as it relates to situations that are ill-defined and lack a clear answer, even in the future (Daft and Lengel 1986). This type of situation is most often associated with management and leadership tasks. The tasks owners face fuzziness in addition to complexity, and have a frequent need to apply their own judgment and intuition. As was pointed out earlier, managers tend to spend much time in meetings, as well as with planning and decision making activities. Efforts during the 1980s to develop comprehensive management information systems to support the management function with aggregated data have failed. The result is interesting. Although management and leadership tasks probably involve the most complicated cognitive processes of organizational tasks, much of the actual information processing and decision-making is not covered by the IS, but left to the individual manager with the result of relatively low requirements for computing power. The emphasis is on person-to-person communication, typically conducted in face-to-face meetings, during phone conversations, and via memos and presentations (King and Xia 1997). Productivity applications such as scheduling support, text processing, and presentation tools play a role besides applications to ensure others can reach the manager. In addition, managers require access to information to help decision-making processes and to oversee projects or performance. Many times, however, the data and results of these analytic processes are presented to the managers by their staff.

To conclude, in terms of functionality and required computing power, we can distinguish between communication processes, including simple messaging; structured data processing; and information access and analysis. In general, more complex tasks require more complex IS support (Zigurs and Buckland 1998). In cases where limits have been reached, and IS support is not feasible to fully cover and to ultimately automate a task, targeted support is typically provided, e.g., to enable communication or to prepare a decision in the case of management and leadership tasks. We can also state that the less structured the task, the more flexible the IS has to be. Table 1 provides a summarizing overview of IS support for the different organizational tasks that we discussed, including the benefits to be derived.

Table 1 - IS Support for Different Organizational Tasks[2]

Task and characteristics	**Generic activities**	**Typical IS support**	**Benefits of IS support**
Operational tasks - Simple - Structured - Repetitive - Predictable outcome - Frequent, routine - Process knowledge	- Familiarize with procedures - Process forms - Obtain authorizations (if required) - Follow prescribed workflow - Trigger: notification, event related, e.g., travel, predefined periods	Data processing and transaction systems - Support or automate data input and processing (batch) - Predefined menus and routines (structure!) - Workflow support (integrate organization internal reporting structure) - Access to procedural information and guidelines	Improve productivity, avoid double data entries, reduce errors, increase speed and improve visibility of enterprise data
Informational tasks - Complex - Semi-structured - Problem solving - Interaction with client (patient, customer, student etc.) and other experts - Expert knowledge	- Identify problem or task (possibly together with client) - Locate and retrieve information to solve problem - Interact with other experts to find solution - Analyze results - Present solution to client - Select treatment or methods to solve problem - Apply treatment, execute solution - Monitor, control and document process, create reports - Trigger: task often assigned to the expert by a customer (internal or external)	Information access and analysis, problem solving, decision support, and expert systems - Provide toolbox and flexible access to data, information, and best practices - Aggregate data from different sources - Support for data analysis and interpretation, and selection of solutions - Support for report generation, presentation of results. - Support calendaring, scheduling and communication	Improve quality and speed of cognitive processes, e.g., problem identification and analysis, decisions; capture and preserve knowledge
Management tasks - Complex and	- Assign budgets and tasks, delegate, authorize	Communication, productivity systems	Improve agility (ability to handle unforeseen situations), ensure

[2] Note that a job typically consists of a combination of all types of tasks.

equivocal - Unstructured - Non-repetitive, non-routine - High uncertainties - Organizational knowledge	- Judgment, decisions, planning activities - Negotiations (internal, external) - Monitor internal and external events, receive input and information from staff - Establish and maintain external and internal relationships - Represent and motivate - Initiate change, revolve conflicts - Handle emergencies	- IS support to ensure and manage reachability - Support for communication, calendar and scheduling - Productivity tools Emphasis is on flexible support to ensure reachability and to support communication, rather than on automation or complete coverage of the cognitive processes	control, improve coordination by supporting internal and external links

Mobile Technology

One of the prerequisites to obtain the benefits of an information system is physical access to its functionality. In cases where the workforce is not stationary, achieving the benefits of IS functionality consequently requires access to IS functionality that is stationed in remote locations, or depends on the availability of mobile solutions.

Two factors are relevant in this context: reachability and access to computing power. Reachability allows others (human or machine) to reach the mobile person and notify him or her about an event or the need to perform a task. Notification can effectively be achieved with comparatively little computing power, in particular in cases where information is coded, such as a phone number to be called for more information (pager, short messaging devices). Subsequent access to IS functionality (e.g., after receiving an alert) requires more effort and depends on the task to be performed.

Similar to traditional IS, mobile technologies can be reviewed according to three dimensions: devices (corresponding with hardware in IS), network connectivity, and functionality (software). And similar to traditional IS there are certain relationships and trade-offs between the different factors.

Devices

Mobile technologies bring back to attention the devices that are used to access and utilize IS functionality. No longer can we assume more or less one kind of access device, namely a stationary terminal or personal computer (PC) with a standard monitor and keyboard that is utilized for a variety of applications. Devices have instead become portable, including cellular phones, personal digital assistants (PDAs), laptops, pocket and tablet PCs, and one- or two-way pagers. Developments are ongoing and new devices reach the market constantly (Durlacher 1999, Ovum 2002, Scudder 2002, see Smith et al. 2002, Tarasewich et al. 2002 for discussions of open issues).

The devices differ in size, weight, performance, storage capacity, display (screen) and input (keyboard) dimensions, and other so-called form-factors (including cost). Portability, as determined by the weight and size of a device, is an essential usage factor for the mobile workforce, and arguably also the most idiosyncratic factor to distinguish mobile systems from traditional, stationary IS. In this sense, we propose to position the devices according to a portability continuum: On one end of the continuum, stationary IS systems, such as desktop PCs are typically used from one location only and not moved. They allow for comparatively large screens and keyboards, high performance, and large storage capacity. At the other end of the continuum, we place pocket-sized (or even smaller) devices built specifically to be carried by the mobile workforce.[3] These devices include cell phones, pagers, and pocket sized PDAs. With the smaller size and weight of the devices come smaller screens, keyboards (oftentimes none at all), less performance and less storage. Somewhat portable devices such as laptop, pocket, and tablet PCs can be placed in the middle of the continuum.

Portability is both an enabler and a limiting factor of mobile commerce.

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[3] Combinations provide an interesting case, where parts of an otherwise stationary device become portable, such as USB drives.

Connectivity

Network connectivity is another factor that is relevant to support a workforce without constant physical access to a stationary IS. Typically, connectivity allows access to common IS features as provided by an internal enterprise system as well as the public Internet. Distinguishing factors for network connectivity are bandwidth, geographic network coverage, interoperability between networks, and whether the connection is permanent or not. For our purposes, we focus on the intensity of the connection (ranging from permanent to never) and its capacity (bandwidth).

Network availability, including incompatibilities between different network providers, and connection fees might be the most important inhibitors of "always-on" connectivity, in particular for a traveling workforce.

At this point, we would like to emphasize that network connections can be wireless, but do not have to be. Varshney and Vetter (2000) discussed the difference between portability of a device, i.e., it can be moved, and wireless interfaces, i.e., network access does not require a wired connection. Both instances are most often, although not necessarily, relevant in combination. "Mobile users do not necessarily need to use wireless interfaces and wireless interfaces do not necessarily support mobility" (Varshney and Vetter 2000). To illustrate this point, Table 2 combines portability and connectivity of communication and IS devices, as experienced by the end-user. It depicts the difference between the type of network access (wired vs. wireless) and mobility (mobile vs. stationary, ease with which the device can be moved). Given the rapid developments in this sector, the devices are listed as examples to illustrate the features.

Our primary focus of attention is on devices that are non-stationary (portable or mobile, including portable PCs, PDAs, pagers and cell phones). These devices typically have network access at some point in time (wired or wireless), but in many cases they are not constantly connected (see shaded area in Table 2).

Table 2 - Connectivity and Mobility of Devices (examples)

	Stationary (does not move)	**Portable (can move)**	**Mobile (constantly moves)**
No connection (stand alone)	PC without network connection	Laptop without network connection	PDA without network connection
Wired network access (network cards or modems)	PC with network connection (Ethernet or modem)	Laptop w/ network connection (Ethernet, modem)	PDA connected to wired PC (with cradle)
Wireless	PC connected with radio modem	Laptop connected with wireless modem/LAN card	PDA with wireless modem Web-enabled Cell phone

Functionality

In terms of functionality, mobile devices tend to differ not all that much from traditional information systems. In principle, the entire spectrum of application is covered, including support or automation of communication (voice, text, graphics), data processing (inventory management, delivery services, data collection), and information management activities (customer relationship management, sales activities). The next section lists a number of examples. While the computer processing power required to enable and support basic text and voice communication (e.g., provided by pagers and cell phones) is relatively low, it increases for pre-structured data processing, and is highest to support complex tasks, involving access to multiple information sources, interpretation of results and decision making processes.

Compared to developments that occurred in the (personal) computer industry approximately two decades ago, mobile applications have yet to experience the same extent of modularization. No widely available standard hardware platforms or operating systems exist, which limits the emergence and availability of standard applications. Despite some developments into this direction (Windows CE), the type of information and communication functionality that is provided by a mobile device is often built-in by the manufacturer.

Applications

Traditionally, the use of mobile technologies in business environments has been concentrated in two areas. First, specialized applications have supported logistics, delivery, and sales processes (Frito-Lay, UPS) by allowing information to be entered into special-purpose mobile devices on location (point of sales or delivery, warehouse). The device was subsequently linked to an enterprise system, which could then be updated without the need to re-key the data. Second, cellular telephones based on analog technologies have long enabled mobile voice communication (www.privateline.com for more information on the underlying technology). Only with the emergence of wireless digital network technology has it become possible to transmit digital data cost efficiently, effectively marking the start of today's mobile commerce developments.

While some wireless devices, such as numeric pagers, allow for one-way communication only (notification), others, such as cell phones, include a wider spectrum of functionality and enable interactive communication. New application developments have enlarged the areas of use for some devices, e.g., cell phones, to allow for the transmission of both data and voice. Specially equipped cell-phones add text and email messaging to traditional voice communication, as well as access to Web-based information (stock quotes or news updates) and enterprise data systems. This again provides the user with access to intranet functionality, including inventory management, service management, or product locating and shopping. Specially equipped two-way pagers and PDAs often provide similar functionality. Devices such as tablet PCs and PDAs support data entries directly through the screen with a stylo, either requiring a specific code of writing or even allowing the users to store memos or graphs in their own handwriting (e.g., copied during a presentation). In terms of IS functionality, wireless LAN-based Internet appliances, such as specially equipped laptop PCs, currently offer the broadest functionality (Varshney and Vetter 2001, see also Durlacher 1999).

The following table summarizes a number of representative examples of mobile applications in terms of functionality, mobility, and benefits:

Table 3 - Mobile Applications

Example	Functionality (n=notification, alerts, c=communication, dp=data processing, field force automation, ir=ad hoc information retrieval and analysis, document creation)	Device and connectivity (mobility)	Benefits
1. Alert systems	Alert medical and technical staff about events or emergencies requiring response (n, c)	Pagers (receive numeric/text messages), cell phones	Ensure reachability
2. "Typical" use of a cell phone	Alerts, synchronous (voice) and asynchronous (voice mail, text messages) communication (n, c)	Cell phones	Ensure reachability, enable communication to support decisions, shorten process cycle times, improve flexibility (react to emergency situations)
3. Courier services, deliveries (UPS, Fedex, Frito-Lay)[4]	Provide information on delivery schedules and routes, log data on location (dp)	Handhelds (special purpose, e.g., with barcode scanner, printer), periodic updates (synchronization)	Reduce paper work and double data entries, improve accuracy of databases, allow real-time tracking
4. Store management system (Armani)[5]	Stockroom workers keep track of incoming merchandise (dp)	Handheld (PDA), logged onto wireless LAN	Eliminate double data entries, increase supply chain transparency, real-time updates of inventory databases
5. Farming support[6]	Farmers monitor growth of crops and pests, log harvest data (dp)	Handhelds, possibly with GPS, synchronization	Eliminate double data entries reduce errors, improve accuracy of databases
6. Plant maintenance (utility plant in Germany)[7]	Plant maintenance engineers: download job information to laptop and to PDA (including information about required tools), log job data on site with PDA (dp)	Laptop plus handhelds (synchronization)	Eliminate double data entries, no need to pick up job orders in office or to drop expense reports, faster updates of plant maintenance databases

[4] Applegate, L. M., F. W. McFarlan, and J. L. Mckenney (1996), *Corporate Information Systems Management: Text and Cases*, 4th ed., Chigago, IL: Irwin.

[5] Ewalt, D. M. (2002) "Loose Connections", *Informationweek*, June 17, 37-44.

[6] Thomas, Owen (2002) "Farmer on a Dell (and an iPac, and…)", *Business 2.0* (July), 29.

[7] Imhoff, J. (2002) "IBM Wireless e-business", Presentation at University of Frankfurt, April 25.

7. Ordering system in restaurant (Skyline Chili) [8]	Waiters send orders to kitchen directly from guest table (dp)	Tablet PCs linked to wireless LAN	Faster services, fewer errors, clock for waiters
8. Freight expediting (TST) (Smith et al. 2002)	Support for internal management of shipping fleet and to enable customer tracking (dp)	Satellite technologies, feed data into Windows based system, accessible over the Internet	Instant visibility of truck positions, improve dispatching and customer service
9. Support for hospital staff (doctors and nurses) (simulation study reported in Ammenwerth et al. 2000)	Communication for doctors and nurses, documentation and access to patient data (c, dp, ir)	Notebook PCs, wireless modems	Ensure reachability, reduce double data entries, improve information processes and communication
10. Electronic patient medication system (hospital group in Denmark)[9]	Doctors enter prescriptions electronically while visiting patients, nurses identify patients before administrating medicine (dp)	Portable computers (doctors), PDAs with barcode scanner (nurses), all connected to wireless LAN	Operational and informational: Reduce errors, eliminate double data entry (= paper), real-time data updates
11. Procurement and other business processes (Motorola) (Gebauer et al. 2002)	Wireless email, directory lookup, and access to procurement system (esp. notification about and processing of waiting approval requests) (n, c, dp)	Specially equipped cell phones	Improve reachability (notification), increase productivity, speed up processes
12. Police support (Lonson Police Services, Ontario) (Smith et al. 2002)	Support communication of police officers with headquarters, allow access to information system directly from police cars, enable report uploading (dp, ir)	Laptops with access to police radio system	Eliminate double data entries, reduce errors, improve security through better information access and (almost real-time) availability of reports to others
13. Insurance brokers, sales staff	Support to issue quotes at customer sites (dp, ir)	Laptops with constant or periodic connectivity	Informational: support sales and customer service

A Theory of Task/Technology Fit for Mobile Applications

Based on our review of organizational tasks and mobile technologies to support them, we now lay out a theory of task/technology fit that can be used to advance mobile applications.

[8] Ewalt, D. M. (2002) “Loose Connections”, *Informationweek,* June 17, 37-44.

[9] Andersen, R. et al. (2002). “Implementation of Electronic Patient Medication at a Department of Internal Medicine“, Abstract submitted to 7th European Forum on Quality Improvement in Health Care.

The theory consists of three main propositions, which we will discuss in the following:

1. A trade-off exists between functionality and mobility of mobile applications.
2. The better the fit between the *IS requirements of organizational tasks* with *IS capabilities of the mobile applications*, the better the chances for success.
3. In cases where limitations inherent in the technology prohibit more complex IS functionality, targeted support in combination with process changes and adaptations provide an alternative solution.

After elaborating on the three propositions we provide empirical evidence from a project we participated in at Motorola and point out further methodological and research implications.

The Trade-Off Between Functionality and Mobility

In Figure 1, each of the examples of mobile applications listed in Table 3 is positioned according to its functionality and level of mobility. Functionality roughly corresponds with computing power required for its performance, while mobility is a combination of portability, primarily represented by weight and dimensions of the device, and connectivity, presented by bandwidth and the cost or technical difficulties to establish a permanent network connection. Portability and connectivity have been combined into one factor, as they are typically very closely related (the more portable a device, the more expensive/difficult it is to establish a permanent network connection at a given bandwidth).

The graph supports our proposition of an inverse relationship between mobility and the inherent computer power of a device. According to the proposition, the smaller and therefore more portable a device, the less functionality it can offer. In addition, the more computing power a task requires to be performed, the more expensive a constant network connection tends to be.

With all other factors equal, the proposition suggests that improving the functionality of an application would require cut backs of portability and/or network connectivity.

Similarly, attempts to improve portability and connectivity would require reductions in functionality (corresponding with a movement along the dotted line in Figure 1). Technological innovations towards more portable devices, better networks, or more advanced functionality can shift the curve outward, as we will discuss.

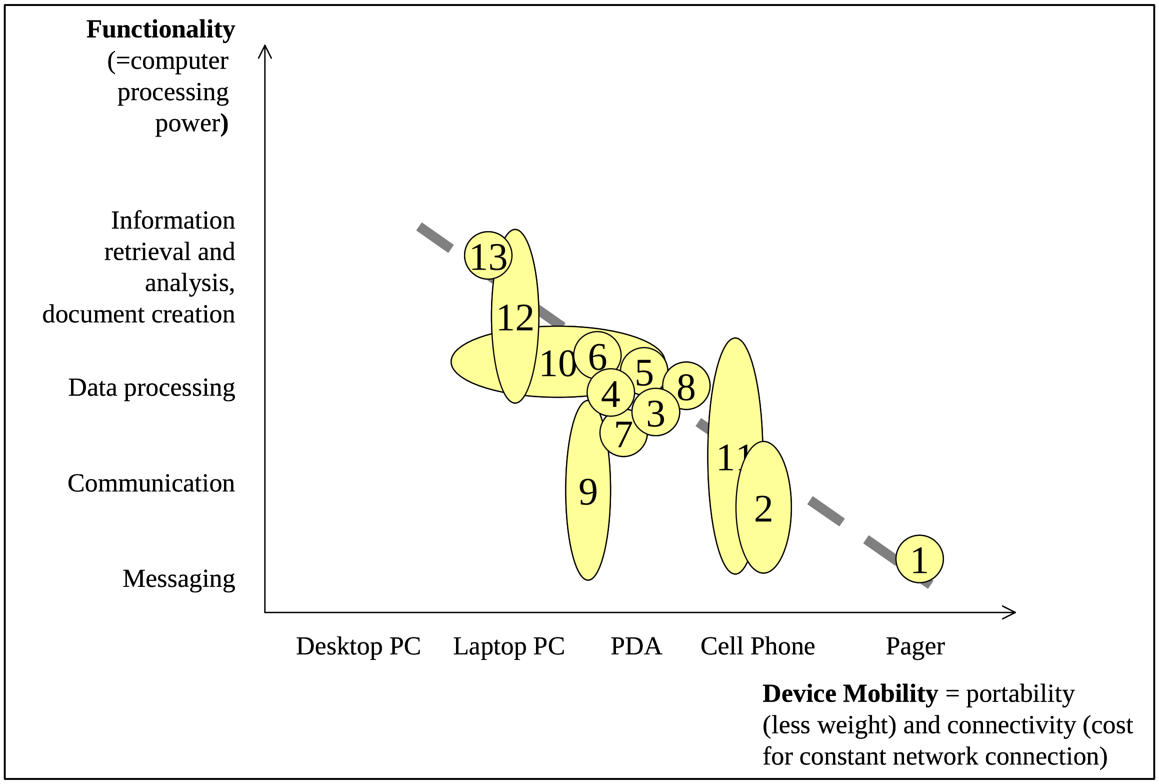

Figure 1 – Mobile Applications: Mobility vs. Functionality (numbers correspond with examples in Table 3)

More research needs to be conducted to further verify the proposed relationship and to investigate it in more detail.

Fitting IS Requirements of Tasks with IS Capabilities of Mobile Applications

Earlier in this paper, we have identified three types of organizational tasks (operational, informational, and management) and discussed their requirements regarding IS functionality, including notification, communication, data processing and information retrieval and analysis. Typically, operational tasks are supported (or even automated) by data processing applications, informational tasks rely on knowledge management tools, decision support systems and so on while management tasks are typically supported with communication technology and productivity tools. The pairings can give evidence for the relevance of task/technology fit but also provide information about the typical IS environment and usage of a particular member of the organization.

After reviewing mobile applications with respect to the scope of IS functionality that the applications cover, we stated a general trade-off between functionality and mobility, the latter largely being determined by size and connectivity of the device. The relationship points to areas of mobile IS support for organizational tasks but also shows limitations.

Combining both aspects, we now propose that the fit between the information processing requirements of a task and the information processing capabilities of a mobile application generally supports the success of the applications. Figure 2 adapts Daft and Lengel's (1986) classic figure of fitting information requirements with information processing capabilities according to media richness to mobile applications to support organizational tasks.

What are the implications of the fit-requirement? We propose that there might be a propensity for users to utilize a specific device for a given set of purposes only. For example, cell phones are typically used for notification, messaging, or communication, and might be difficult to reach acceptance for data processing, information retrieval, or complex information analyses. The better the fit between the IS requirements of the task and the IS capabilities that the application has to offer, the better the chances for success of the application.

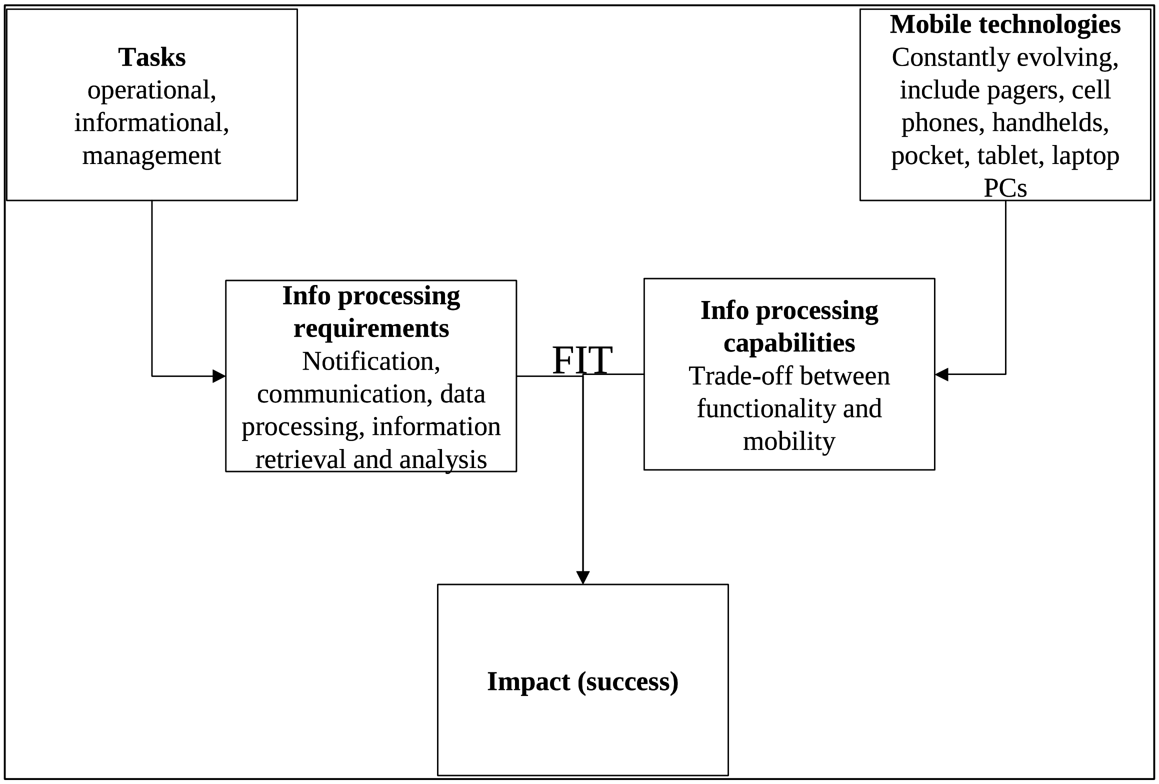

Figure 2 – Task/Technology Fit as a Precondition for the Success of Mobile Applications

More research needs to be done to clearly identify and ultimately measure the factors that determine the fit between IS requirements and capabilities. The question of how to determine success (impact) more precisely is also open. Given the nature of mobile applications as an infrastructure (Farbey et al. 1995), the definition of success, as well as adequate measures for its evaluation depend on the actual application. It concerns factors such as improvements of productivity, decision quality, and flexibility (see Tables 1 and 2). As a precondition for success, actual usage of the applications also needs to be taken into consideration.

Strategies to Advance Mobile Applications

The question remains how mobile applications can be advanced to provide IS functionality to organizational areas where this was not economically or technically feasible before. Returning to our earlier considerations (Figure 1), progress means pushing the limits of mobile applications with improved devices and networks ("B" in Figure 3), improved functionality ("C"), or a combination of both.

Initiatives to provide laptops for insurance agents or PDAs to realtors, and constantly "shrinking" cell phones are examples for developments where existing (e.g., PC-based) functionality, such as sales support, listing support, and communication, are moved to smaller devices, thus improving portability and connectivity ("B"). Much of the current research and development efforts focus on this effect, resulting in a constant stream of new mobile devices, targeting the consumer markets in particular (see for example www.cebit.de). For the manufacturers, risks and cost involved with launching new mobile devices or network infrastructures are high, due to development and marketing costs, but also as a result of the level of change required from the users upon adopting the new technology. In addition, actual usage patterns might in fact be different than what was intended originally, in particular in the case of infrastructure/general purpose IS (Caminer et al. 1998).

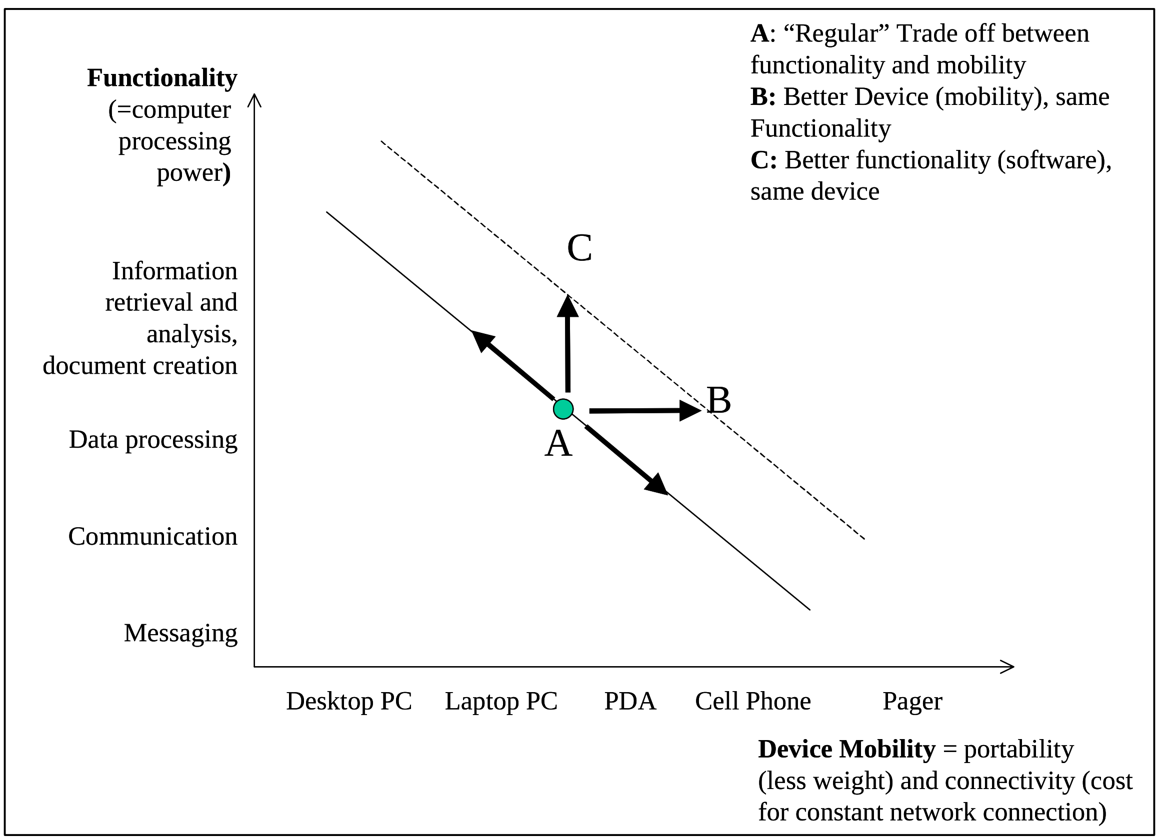

Figure 3 – Advancing Mobile Applications

Initiatives to advance mobile applications by adding functionality to existing devices depict a shift of the curve upwards ("C"). An example is Motorola's new suite of mobile software applications that adds data processing and other functionality to an existing type of devices, namely cell phones. While possibly cheaper than developing (and selling) new devices (hardware), the attempt to add new functionality (software) to existing devices is not a trivial issue, but might be very difficult or even impossible to achieve given the inherent limitations of the specific devices. Usability factors to be considered include login and security procedures, screens and keyboard size restrictions, and performance management (connectivity, bandwidth) (Gebauer et al. 2002).

An alternative solution can be derived from our theory, in cases where economic and technical limitations of the applications are reached. We suggest that improvements can be made within the established range of functionality of the devices by providing targeted support for specific activities, accompanied by process changes. These changes could include rethinking and possibly recomposing the steps of a task and intelligent new ways of collaboration between mobile and stationary members of the workforce. Given the low level of change required from the users (no new devices and/or radically new processes), the risk for such improvements could be kept within reason, in addition to low development costs.

For example, the attempt to add complex functionality to a regular cell-phone may soon reach limits of usability, given the small screen and keyboard size, connectivity cost and network availability. In cases where powerful devices (e.g., large screen mobile phones) or adequate network coverage are not available to support the entire process, solutions of targeted, yet partial support might be preferable. Following notification of a waiting request for approval, a traveling manager in charge of a purchasing budget could decide to delegate the entire approval task to a member of his staff. Alternatively, using the phone as a tool for voice communication or short messages, the manager can ask for additional information from a supplier or requestor to prepare for the actual approval process to be performed upon return to a stationary IS. Instead of covering an entire task, the mobile solution might just cover parts of it, thus effectively unbundling its subtasks. Compared to full coverage, in particular of structured processes, however, targeted support calls for a more modularized and ultimately more flexible mobile application, including access to corporate directory data and other enterprise information to facilitate contact and to support decisions.

More research is necessary to assess the requirements for such targeted process support, including the combination of voice and data communication, online and offline data access, and the modularization of tasks. The advantage is a more efficient utilization of available resources, thus stretching the limits otherwise posed by the trade-off between functionality and mobility.

Mobile Applications to Support Business Processes at Motorola – Evidence for the Relevance of Task/Technology Fit

Motorola is developing a suite of applications to support its mobile workforce. The suite provides cell phone-based functionality in three functional areas. First, it gives users mobile access to Motorola's electronic procurement system. Managers can receive notifications on their cell phones about purchasing requests waiting for approval and subsequently process the requests. Second, users can receive and send email messages, and third access the corporate directory system wirelessly. We had the opportunity to closely monitor the progress of the project and to gather early feedback from the participants of a trial study (Gebauer, Shaw, and Zhao 2002, Gribbins and Shaw 2002). Additional data are available from a related study on the usage of Motorola's non-mobile electronic procurement system (Subramaniam and Shaw 2002).

According to our first proposition, a trade-off exists between functionality and portability of mobile applications. This means that there are limitations to the functionality that can be included in a particular device, given the restrictions regarding size (including screen and keyboard), and network connectivity. Cell phones have proven useful and well adopted for communication purposes, including voice interaction, short text messaging, and notification by alerts. Their usage has not yet been successfully extended to include complex functionality, such as data processing or even complex information analysis and management.

The experiences made at Motorola support our theory. Although the procurement approvers participating in the survey indicated that on average eighty percent of the approvals could be processed by the mobile procurement application (Figure 4, see also Gebauer et al. 2002), actual usage numbers have been low. As inhibitors survey participants cited complex logon procedures (due to required security measures), slow system performance and usability issues.

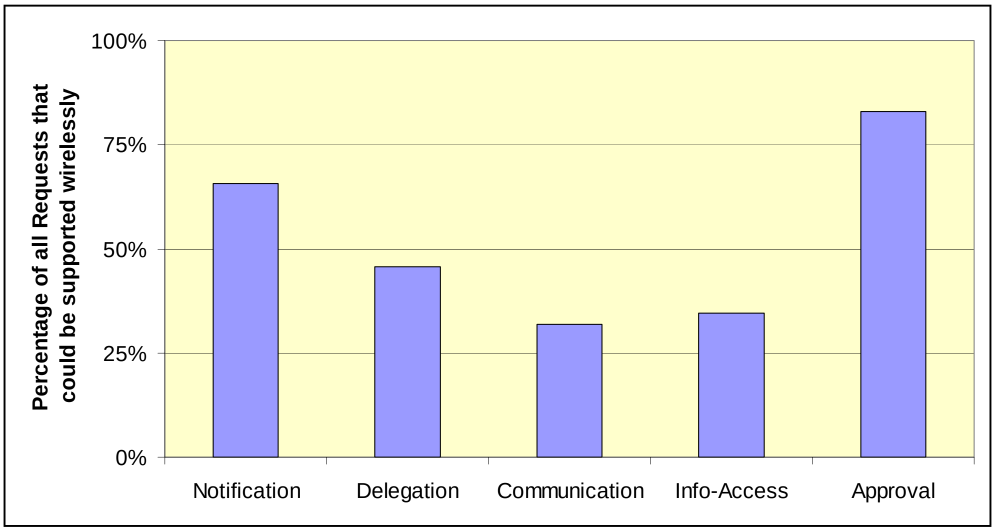

Figure 4 - Mobile Support for Approval Processes (potential, as indicated by the users) (source: Gebauer et al. 2002)

Early usage reports, and the results from a second survey lead us to expect that system usage will be higher for the notification of managers about incoming approval requests (Gribbins and Shaw 2002). Managers welcome the possibility to stay connected with their home base while away from the office and to have the possibility to decide about approval requests individually after notification. Rather than having to delegate all approval authority up front, approvers expect to benefit from notification, better handling of emergency situations, reduced overall processing time, but also convenient system access (Figure 5).

The second user group had access to the full suite of mobile applications, including procurement approvals, email and directory access. Overall, users indicated a preference for the simpler applications of directory access and email, rather than the more complex procurement application. In addition, users contend to benefit from keeping in touch while mobile, but would rather wait to regain access to a laptop or desktop computer to perform more complex tasks. For example, mobile email is used significantly more often to check and browse messages than to create documents or send lengthy responses (Gribbins and Shaw 2002).

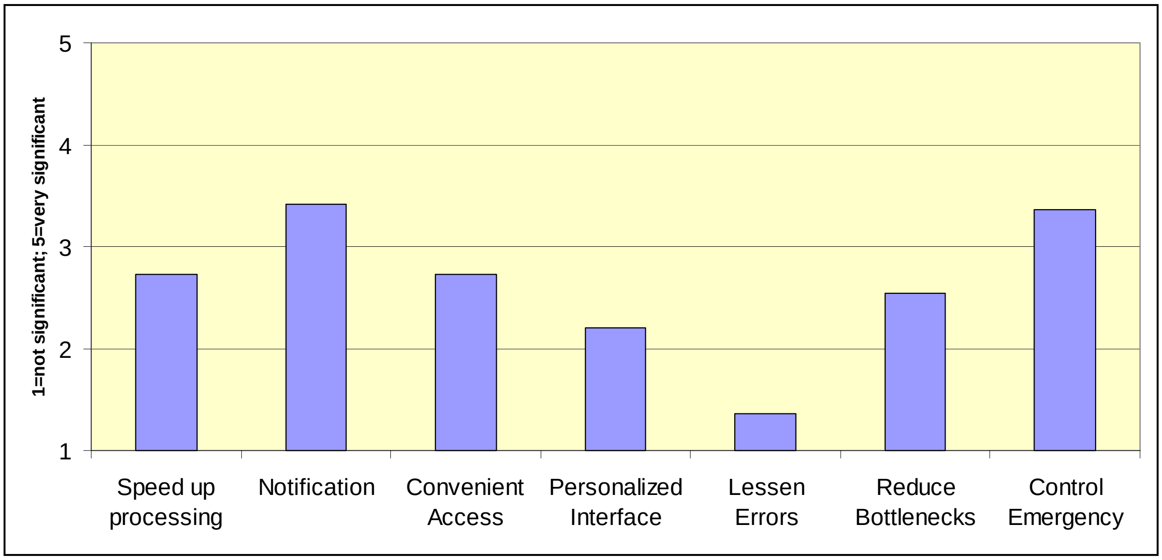

Figure 5 – Expected Benefits From Mobile Support for Procurement Approval Processes (source: Gebauer et al. 2002)

More insights can be gained by differentiating between two groups of users who are both involved in the approval process: managers and financial accountants. Compared to approving managers, the task of financial approvers is more structured and straightforward. It is concerned less with budgeting or management decisions, but rather includes checks whether procedural requirements have been followed correctly, and falls into the category of operational tasks, rather than management tasks. Finance approvers process higher volumes of requests for approval than managers and are less often out of their offices (Gebauer et al. 2002). The results from both studies show greater interest among finance approvers to utilize the mobile solution to actually process approvals while approving managers prefer to be notified (Gebauer et al. 2002, Gribbins and Shaw 2002). The related study on the usage of the non-mobile procurement application showed that finance approvers are typically more concerned with system performance while management approvers value ease of use (Subramaniam and Shaw 2002).

We can conclude that in addition to a general fit between tasks and IS technology, user-specific factors play a role. The study participants prefer mobile applications that pose relatively little change to their established IS usage. While managers generally rely on communication support, finance approvers are more frequent users of data processing applications. In both cases, the requirements for task support are extended to the mobile solutions. Consequently, the chances for success (=usage) of the mobile applications seem better for communication (notification, access to email and directory information) in the case of the managers, while (limited) data processing functionality could be provided to the finance approvers.

Summary and Outlook

In this paper, we have put mobile applications into perspective with traditional IS. Being clear about the specific factors allows us to address the question of how we can maximize benefits from the new technology.

Mobile applications are complementary to traditional ("stationary") IS, as they bring IS functionality to a mobile workforce, thus making IS benefits more widely available. Automation and IS support of operational and informational tasks are now economically feasible in areas where this was not the case before, such as in healthcare or law enforcement (handhelds for doctors and nurses, laptops for police officers). A manager who approves purchasing requests while traveling improves his or her productivity as well as the productivity of colleagues who depend on the decisions. Fewer double data entries reduce errors, improve speed and allow for instant updates of enterprise information. Benefits for information tasks include better and possibly faster decisions due to improved information access, which in essence also true for communication tasks.

The ability to react faster increases flexibility and agility, in particular when combined with instant notification. Both elements are crucial: reachability (based on constant connectivity) as well adequate system access to actually performing a task. In cases where full coverage of a particular task cannot be provided due to technical or economic limitations, the effective use of available devices to provide support can help achieve the goals.

Our considerations have led us to propose a theory of task/technology fit for mobile applications that is based on a set of propositions, each of which provides insights of the topic area, but also calls for further research.

The main thesis is that *wireless technology can best be applied when there is a good fit between the technology and the underlying tasks*. Processes such as operations, information management, and leadership can be broken down into generic tasks, such as notification, communication, data processing, information access and analysis. These tasks differ with respect to the amount of information processing needed, as well as with respect to time or mission criticality (e.g., alert in approval or any event-driven communication). Our considerations imply that mobile applications based on small, portable devices should be appropriate to support tasks that require comparatively little computer power, such as alerting or seeking authorization; the fit is less for tasks that require larger quantities of information to be processed, as in document creation and the composition of longer email messages. This conclusion leads us to suggest a concept of targeted support, where mobile technology is applied to those parts of a task where the fit is good. Subtasks where the fit is poor could be delegated to other parts of the enterprise infrastructure, or processed upon regaining access to alternate IS. Again, more research is necessary to examine in more detail the interrelationships, and to allow the formulation of more specific guidelines.

In this paper, we have directed our attention primarily to two factors: mobile applications and organizational tasks, guided mainly by the newness of the technology. Traditional IS research, however, tells us that additional factors play a key role for the success of technology implementation, maybe most importantly user-related and social factors. There might be differences, for example, between managers and operational staff, as we pointed out. Explicitly including the perspective of the user into the analysis will also allow us to extend the so far static equilibrium model and to examine dynamic aspects. For example, as they occur over time user learning processes can impact the conditions for the task/technology fit. It has been shown that as users get more familiar with new technologies their perceptions of the appropriateness to support a given task can change (King and Xia 1997). Approaches of co-evolution and co-invention emphasize the role of the user as innovator (Caminer et al. 1998, Breshahan and Greenstein 1996, Mitleton-Kelly and Papaefthimiou 2001). Oftentimes in the history of information systems the users have played a crucial role in innovation leading to both developments in technology and in the process of using the technology. Given the generic infrastructure-like character of many mobile technologies we expect developments of co-evolution and co-invention to be of relevance.

Our research can be viewed as "action research" in the sense that we as the researchers not only make observations of the implementation of mobile applications (at Motorola), but our research at the same time also influences the way the system is being implemented. An international expansion of the study promises additional insights from cross-culture differences. In terms of theory development, we call for refined system analysis tools to understand the requirements of the processes, tasks, and the information infrastructure. To validate and advance our theory, we plan to conduct further field research, consisting of system analysis, interviews, surveys of users and IT managers, and longitudinal follow-up studies.

References

Anthony, R. N. (1965) *Planning and Control Systems: A Framework for Analysis*, Cambridge, Mass.: Harvard University Graduate School of Business.

Ammenwerth, E. et al. (2000) "Mobile Information and Communication Tools in the Hospital", *International Journal of Medical Informatics* 57, pp. 21-40.

Breshahan, T. and S. Greenstein (1996). "Technical Progress and Co-Invention in Computing and in the Uses of Computing", *Brookings Papers in Economic Activity: Microeconomics* 1996, pp. 1-77.

Caminer, P., J. Aris, P. Hermon, and F. Land (1998) *LEO: The Incredible Story of the World's First Business Computer*, New York, NY: McGraw-Hill.

Campbell, D. J. (1988) "Task Complexity: A Review and Analysis", *Academy of Management Review* 13 (1), pp. 40-52.

Cooper, R. B. and R. W. Zmud (1990). "Information Technology Implementation Research: A Technological Diffusion Approach", *Management Science* 36 (2), pp. 123-139.

Daft, R. L. and R. H. Lengel, (1986) "Organizational Information Requirements, Media Richness, and Structural Design", *Management Science* 36 (6), pp. 689-703.

Davenport, T. H., S. L. Jarvenpaa, and M. C. Beers (1996), "Improving knowledge work processes", *Sloan Management Review* 37 (4), pp. 53-65.

Davis, G. B., and M. H. Olson (1985) *Management Information Systems: Conceptual Foundations, Structure, and Development*, New York/NY: McGraw-Hill.

Durlacher (1999). Mobile Commerce Report. Durlacher Research, http://www.durlacher.com/downloads/mcomreport.pdf (current 8/8/2002).

DeSanctis, G., and M. Scott Poole (1994) "Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory", *Organization Science* 5 (2), pp. 121-147.

Farbey, B., F. F. Land, and D. Targett (1995) "A Taxonomy of Information System Applications: The Benefits' Evaluation Ladder", *European Journal of Information Systems* 4, pp. 41-50.

Gebauer, J., M. J. Shaw, and K. Zhao (2002) "The Efficacy of Wireless B2B E-Procurement: A Pilot Study", Paper accepted for presentation at the 36th Hawaii Conference on System Sciences (HICSS36).

Goodhue, D. L., and R. L. Thompson (1995) "Task-Technology Fit and Individual Performance", *MIS Quarterly* 19 (2), pp. 213-236.

Gribbins, M., and M. J. Shaw (2002) "Mobile Commerce into the Workplace: Factors that Influence the Acceptance of Mobile Technology by Employees", Working Paper, University of Illinois at Urbana-Champaign.

Hoffer, J. A., J. F. George, J. S. Valacich, Joseph S. (2002) *Modern Systems Analysis and Design, 3rd ed.*, Upper Saddle River, NJ: Prentice Hall.

Huber, G. P. (1990) „A Theory of the Effects of Advanced Information Technologies on Organizational Design, Intelligence, and Decision Making", *The Academy of Management Review* 15 (1), pp. 47-71.

Jarvenpaa, S. L. (1989) "The Effect of Task Demands and Graphical Format on Information Processing Strategies", *Management Science* 35 (3), pp. 285-303.

Kimberly, J. R. (1981) "Managerial Innovation", in Nystrom, P. C. and Starbuck, W. H. (Eds.), *Handbook of Organizational Design*, London: Oxford University Press.

King, R. C. and W. Xia (1997) "Media Appropriateness: Effect of Experience on Communication Media Choice", *Decision Sciences* 28 (4), pp. 877-910.

March, J., and H. Simon (1958) *Organizations*, New York, NY: Wiley.

Mathieson, K., and M. Keil (1998) "Beyond the interface: Ease of use and task/technology fit", *Information & Management* 34, pp. 221-230.

McGrath, J. E. (1984) *Groups: Interaction and Performance*, Englewood Cliffs, NJ: Prentice Hall.

Mintzberg, H. (1973) *The Nature of Managerial Work*, Englewood Cliffs, NJ: Prentice Hall.

Mintzberg, H. (1989) *The Structuring of Organizations – A Synthesis of the Research*, Englewood Cliffs, NJ: Prentice Hall.

Mitleton-Kelly, E., and M.-C. Papaefthimiou (2000) "Co-evolution of Diverse Elements Interacting Within a Social Ecosystem", in P. Henderson (Ed.) *Systems Engineering for Business Process Change*, Book 2, Heidelberg, Germany: Springer Verlag, p…

Orlikowski, W., and C. S. Iacono (2001) "Research Commentary: Desperately Seeking the "IT" in IT Research – A Call to Theorizing the IT Artifact", *Information Systems Research* 12 (2), pp. 121-134.

Ovum (2002) "Defining the future: Can new generation devices and MMS revitalize the mobile industry?" Executive Briefing, July, www.ovum.com (current 8/15/02).

Perrow, C. (1986) *Complex Organizations: A Critical Essay, 3rd ed.*, New York, NY: Random House.

Scudder, R. (2002) "M-Commerce US", Presentation at 15th Bled Electronic Commerce Conference. Bled/Slovenia, June 17-19, 2002.

Simon, H. (1977) *The New Science of Management Decision*, Englewood Cliffs, NJ: Prentice Hall.

Smith, H. A., N. Kulatilaka, and N. Venkatraman (2002) "Development in IS Practice III: Riding the Wave: Extracting Value from Mobile Technology", *Communications of the AIS* 8, pp. 467-481.

Stabell, C. B., and Ø. D. Fjeldstad (1998) "Configuring Value For Competitive Advantage: On Chains, Shops, and Networks", *Strategic Management Journal* 19, pp. 413-437.

Subramaniam, C., and M. J. Shaw (2002) "Effects of Task-Technology Fit on User Perceptions of Web-based B2B Systems: An Empirical Investigation of B2B e-Procurement", Working Research Paper, University of Illinois at Urbana-Champaign.

Tarasewich, P., R. C. Nickerson, and M. Warkentin (2002) “Issues in Mobile E-Commerce”, *Communication of the AIS* 8, pp. 41-64.

Thompson, J. D. (1967) *Organizations in Action*, New York, NY: McGraw Hill.

Tornatzki, L. G. and K. Klein (1982) “Innovation Characteristics and Innovation Implementation: A Meta-analysis of Findings”, *IEEE Transactions Engineering Management* 29 (1), pp. 28-45.

Turban, E., R. K. Rainer Jr., and R. E. Potter (2001) *Introduction to Information Technology*, New York, NY: John Wiley & Sons.

Varshney, U., and R. Vetter (2000) “Emerging Mobile and Wireless Networks”, *Communications of the ACM* 43 (6), pp. 73-81.

Varshney, U., and R. Vetter (2001) “A Framework for the Emerging Mobile Commerce Applications”, Proceedings of the 34th Hawaii International Conference on System Sciences.

Zigurs, I., and B. K. Buckland (1998) “A Theory of Task-Technology Fit and Group Support System Effectiveness”, *MIS Quarterly* 22 (3), pp. 313-334.