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

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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 F. Land, London School of Economics; Joseph T. Mahoney and Matthew L. Nelson, University of Illinois at Urbana-Champaign; and Gordon B. Davis and Robert J. Kauffman, University of Minnesota. In addition, we thankfully acknowledge input received at research seminars at the University of Illinois at Urbana-Champaign (National Laboratory for Tourism and eCommerce), and at the University of Minnesota (Carlsson School of Business). We thank Dean Haacker, Motorola, Inc. for his continuous support, as well as the study participants for their time and effort.
1. 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 technologies in consumer settings 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). In organizational settings, relevant questions include: How are mobile applications different from other IT applications? What benefits can be expected and how can organizations achieve these benefits? 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 traditional IS support for 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.
2. Organizational Tasks and IS support

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) 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. Before we discuss mobile technologies and their applications, however, we identify three types of organizational tasks and relate them with traditional IS-applications.

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).

IS research provides examples and suggestions for IS support of the different tasks. Davis and Olson’s (1985) classic understanding of management information systems (MIS) mentions three forms of tasks (functions) to be supported by an MIS: 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). We use this concept as a basis to distinguish between three types of tasks (operational, informational, and management tasks) and the information systems that typically support them.

### 2.1 IS Support for Operational Tasks

A common distinction is made between simple and complex tasks. Typically, simple tasks (also known as operational or administrative tasks) have received limited discussion and are primarily used to distinguish and discuss more complex processes. In this sense, simple tasks have been 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, perform 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.

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. Table 1 provides a summarizing overview of IS support for operational tasks.

Table 1- IS Support for Operational Tasks

<table>
<thead>
<tr>
<th>Task description</th>
<th>Generic activities</th>
<th>Typical IS support: Data processing and transactional systems</th>
<th>Benefits from IS support</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Simple</td>
<td>- Familiarize with procedures</td>
<td>- Support or automate data input and processing (batch)</td>
<td>Improve productivity, avoid double data entries, reduce errors, increase speed and improve visibility of enterprise data</td>
</tr>
<tr>
<td>- Structured</td>
<td>- Process forms</td>
<td>- Predefined menus and routines (structure!)</td>
<td></td>
</tr>
<tr>
<td>- Repetitive</td>
<td>- Obtain authorizations (if required)</td>
<td>- Workflow support (integrate organization internal reporting structure)</td>
<td></td>
</tr>
<tr>
<td>- Predictable outcome</td>
<td>- Follow prescribed workflow</td>
<td>- Access to procedural information and guidelines</td>
<td></td>
</tr>
<tr>
<td>- Frequent, routine</td>
<td>- Trigger: notification, event related, e.g., travel, predefined periods</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.2 IS Support for Informational Tasks

Informational tasks are less structured than operational tasks, less repetitive, and their output is less well defined.

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.

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). Our notion of informational tasks best corresponds with Campbell’s problem and decision tasks, whereas judgment and fuzzy tasks would be most similar to our understanding of management tasks (see below).
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).

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). Table 2 provides a summarizing overview of IS support for informational tasks.

Table 2 - IS Support for Informational Tasks

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>- Complex</td>
<td>- Identify problem or task (possibly together with client)</td>
<td>- Provide toolbox and flexible access to data, information, and best practices</td>
<td>Improve quality and speed of cognitive processes, e.g., problem identification and analysis, decisions; capture and preserve knowledge</td>
</tr>
<tr>
<td>- Semi-structured</td>
<td>- Locate and retrieve information to solve problem</td>
<td>- Aggregate data from different sources</td>
<td></td>
</tr>
<tr>
<td>- Problem solving</td>
<td>- Interact with other experts to find solution</td>
<td>- Support for data analysis and interpretation, and selection of solutions</td>
<td></td>
</tr>
<tr>
<td>- Interaction with client (patient, customer, student etc.) and other experts</td>
<td>- Analyze results</td>
<td>- Support for report generation, presentation of results.</td>
<td></td>
</tr>
<tr>
<td>- Expert knowledge</td>
<td>- Present solution to client</td>
<td>- Support calendaring, scheduling and communication</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Select treatment or methods to solve problem</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Apply treatment, execute solution</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Monitor, control and document process, create reports</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Trigger: task often assigned by a customer (internal or external)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.3 IS Support for Management Tasks

In a continuum, management tasks may be placed opposite from operational tasks; informational tasks would take a place in the middle. Compared to simple operational activities, repetition of the same instance rarely occurs and simple rules cannot be implemented. In Campbell’s (1988) complexity framework, judgment and fuzzy tasks correspond best with management 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.

Applying Daft and Lengel’s (1986) concept we can state that management and leadership tasks often involve situations of equivocality, that is situations that are ill-defined and lack a clear answer, even in the future. Equivocality is more difficult to resolve than uncertainty. 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 all 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, often 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 and vice versa (Table 3). 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.

Table 3 - IS Support for Management Tasks

<table>
<thead>
<tr>
<th>Task description</th>
<th>Generic activities</th>
<th>Typical IS support: Communication and productivity support</th>
<th>Benefits of IS support</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Complex and equivocal</td>
<td>- Assign budgets and tasks, delegate, authorize</td>
<td>- IS support to ensure and manage reachability</td>
<td>Improve agility (ability to handle unforeseen situations), ensure control, improve coordination by supporting internal and external links</td>
</tr>
<tr>
<td>- Unstructured</td>
<td>- Judgment, decisions, planning activities</td>
<td>- Support for communication, calendar and scheduling</td>
<td></td>
</tr>
<tr>
<td>- Non-repetitive, non-routine</td>
<td>- Negotiations (internal, external)</td>
<td>- Productivity tools</td>
<td></td>
</tr>
<tr>
<td>- High uncertainties</td>
<td>- Monitor internal and external events, receive input and information from staff</td>
<td>Emphasis is on flexible support to ensure reachability and to support communication, rather than on automation or complete coverage of the cognitive processes</td>
<td></td>
</tr>
<tr>
<td>- Organizational knowledge</td>
<td>- Establish and maintain external and internal relationships</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Represent and motivate</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Initiate change, resolve conflicts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Handle emergencies</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.4 Conclusions

The review of typical IS support for organizational tasks shows several patterns. Tasks can be grouped according to the cognitive processes required for their performance, with complexity ranging from simple to high. Benefits vary and include benefits from automation (data processing), improved decision quality (information systems), and improved agility and productivity (management support). Computing power provided by
the systems range from low to high with functionality covering communication processes, including simple messaging; structured data processing; and information access and analysis. Table 4 positions typical IS applications with respect to the complexity of the cognitive processes that they support and the computing power that they provide.

**Table 4 – Positioning typical IS with respect to cognitive processing requirements and available computing power**

<table>
<thead>
<tr>
<th>Cognitive processing requirements, task complexity</th>
<th>Computing power provided by information system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest</td>
<td>Lowest</td>
</tr>
<tr>
<td></td>
<td>Productivity and communication tools to support management tasks</td>
</tr>
<tr>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td></td>
<td>Analysis and decision support systems to support informational tasks</td>
</tr>
<tr>
<td>Highest</td>
<td>Highest</td>
</tr>
<tr>
<td></td>
<td>Data processing and transactional systems to support operational tasks</td>
</tr>
</tbody>
</table>

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, partial 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 system has to be.

One additional point is worth mentioning, namely the overlap between the tasks and the organizational jobs functions and their owners. While it is usually possible to determine clear focus points for a particular job function, it is also safe to assume that most job functions encompass all three types of tasks (operational, informational, and managerial). Managers perform administrative and informational tasks when filing travel expense reports or conducting basics data analyses to prepare for a presentation. Accounting clerks need to obtain information to handle exceptions that are not covered by standard
procedures, as well as communicate with their peers or superiors regarding how to resolve the matter. Information workers oversee and manage research specialists and support staff collecting data and providing administrative services.

Despite the diversity of most job functions regarding a mix of different tasks, we assume, somewhat simplifying, that the main emphasis is also the primary factor to determine IS usage. This means that managers rely in fact most on communication tools, while information workers utilize information access and analysis tools, and operational staff members are most familiar with data processing and operational systems. We also assume that individual members of an organization typically use IS less for tasks outside the “regular” scope of their job function, either because such systems are not available to the individual or because of poor training or knowledge about the system functionality and usage.

3. 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. Mobile technologies can thus help extend IS-related benefits in terms of time and place. Besides benefits from automation (less double data entries, improved productivity) for situations where this was not economically or technically feasible before, we expect mobile applications to improve decision quality by providing easier access to information, and greater organizational flexibility.

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, and vice versa. 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.

### 3.1 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.\(^2\) These devices

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\(^2\) Combinations provide an interesting case, where parts of an otherwise stationary device become portable, such as USB drives.
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.

### 3.2 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).³

³ Although network connections can be wireless, they don’t 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 the following Table, providing examples for the connectivity and mobility of devices.

<table>
<thead>
<tr>
<th></th>
<th>Stationary (does not move)</th>
<th>Portable (can move)</th>
<th>Mobile (constantly moves)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No connection (stand alone)</td>
<td>PC without network connection</td>
<td>Laptop without network connection</td>
<td>PDA without network connection</td>
</tr>
<tr>
<td>Wired network access</td>
<td>PC with network connection (Ethernet or modem)</td>
<td>Laptop w/ network connection (Ethernet, modem)</td>
<td>PDA connected to wired PC (with cradle)</td>
</tr>
<tr>
<td>(network cards or modems)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wireless</td>
<td>PC connected with radio modem</td>
<td>Laptop connected with wireless modem/LAN card</td>
<td>PDA with wireless modem Web-enabled Cell phone</td>
</tr>
</tbody>
</table>
Network availability, including incompatibilities between different network providers, and high connection and communication fees might be the most important inhibitors of “always-on” connectivity, in particular for a traveling workforce.

### 3.3 Functionality

In terms of functionality, mobile applications tend to resemble traditional information systems, emphasizing their character as an infrastructure technology. In principle, the entire application spectrum 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). Below, we list 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.

### 3.4 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. Today, most cell phones allow for the transmission of both data and voice, as text and email messaging has been added 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. Similar developments can be stated for two-way pagers and handheld devices. 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 laptop PCs, currently offer the broadest functionality (Varshney and Vetter 2001, see also Durlacher 1999).

The following Table 5 summarizes a number of representative examples of mobile applications:

**Table 5 - Mobile Applications (roughly listed by device and according to inherent computing power)**

<table>
<thead>
<tr>
<th>Example</th>
<th>Functionality (n=notification, alerts, c=communication, dp=data processing, field force automation, ir=ad hoc information retrieval and analysis, document creation)</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Notification with pager- or cell-phones</strong> (exchange numeric/text messages)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Alert systems</td>
<td>Alert medical and technical staff about events or emergencies requiring response (n, c)</td>
<td>Ensure reachability</td>
</tr>
<tr>
<td><strong>Cell phone for communication purposes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. “Typical” use</td>
<td>Alerts, synchronous (voice) and</td>
<td>Ensure reachability, enable</td>
</tr>
</tbody>
</table>
of a cell phone asynchronous (voice mail, text messages) communication (n, c) communication to support decisions, shorten process cycle times, improve flexibility (react to emergency situations)

| Data processing with handhelds, tablet PCs, notebook PCs, often special purpose, including barcode scanners, printers, periodic updates (synchronization), link to wireless LANs, or GPS |
|---|---|---|
| 3. Courier services, deliveries (UPS, FedEx, Frito-Lay)<sup>4</sup> | Provide information on delivery schedules and routes, log data on location (dp) | Reduce paper work and double data entries, improve accuracy of databases, allow real-time tracking |
| 4. Store management system (Armani)<sup>5</sup> | Stockroom workers keep track of incoming merchandise (dp) | Eliminate double data entries, increase supply chain transparency, real-time updates of inventory databases |
| 5. Farming support<sup>6</sup> | Farmers monitor growth of crops and pests, log harvest data (dp) | Eliminate double data entries reduce errors, improve accuracy of databases |
| 6. Plant maintenance (utility plant in Germany)<sup>7</sup> | Plant maintenance engineers: download job information to laptop and PDA (including information about required tools), log job data on site with PDA (dp) | Eliminate double data entries, no need to pick up job orders in office or to drop expense reports, faster updates of plant maintenance databases |
| 7. Ordering system in restaurant (Skyline Chili)<sup>8</sup> | Waiters use tablet PCs to send orders to kitchen directly from guest table, using wireless LAN (dp) | 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, use of satellite technologies, feed data into Windows based system, accessible over the Internet (dp) | Instant visibility of truck positions, improve dispatching and customer service |

**Multi-purpose applications (combining different mobile devices, including cell phones, notebook PCs and PDAs and/or covering different tasks)**

| 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 using notebook PCs and wireless modems (c, dp, ir) | Ensure reachability, reduce double data entries, improve information processes and communication |

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<sup>6</sup> Thomas, Owen (2002) “Farmer on a Dell (and an iPac, and…)?”, Business 2.0 (July), 29.


10. Electronic patient medication system (hospital group in Denmark)\(^9\)

Doctors enter prescriptions electronically while visiting patients (portable computers), nurses identify patients before administering medicine (PDAs with barcode scanners, connected to wireless LAN (dp))

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)

Improve reachability (notification), increase productivity, speed up processes

**Laptop PCs for data processing and information management**

12. Police support (Lonson Police Services, Ontario) (Smith et al. 2002)

Support communication of police officers with headquarters, allow laptop access to information on police radio system directly from police cars, enable report uploading (dp, ir)

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

Use laptops with constant of periodic connectivity to issue quotes at customer sites (dp, ir)

Informational: support sales and customer service

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4. **A Theory of Task/Technology Fit for Mobile Applications**

Based on the review of organizational tasks and mobile technologies to support them, we now discuss a set of three propositions towards a theory of task/technology fit that can be used to advance mobile applications. The three propositions are as follows:

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.

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

**4.1 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, represented 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.

All other factors equal, the proposition suggests that improving the functionality of an application requires 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 diagonal 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.
More research needs to be conducted to further verify the proposed relationship and to investigate it in more detail.

### 4.2 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. As has been pointed out earlier, 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 its 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 regarding usage (user adoption) and the subsequent achievement of expected benefits. 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 it might be difficult to achieve user 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.

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.

4.3 Targeted Task-Support to Advance Mobile Applications

With our third proposition, we effectively address the trade-off between mobility and functionality and focus on the question of how mobile applications can be advanced to provide IS functionality in 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, is 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).

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).
With our third proposition, we suggest an alternative solution 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.

Again, 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.
4.4 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).

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

According to our first proposition, a trade-off exists between functionality and mobility 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 5 – Expected Benefits From Mobile Support for Procurement Approval Processes
(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).

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). This finding is in line with our theory and the assumption that specific user groups tend to utilize IT-systems that are most in sync with their main job-specific task. 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.

5. 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.

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


