The Design of Mobile Commerce Applications: What's Context Got to Do With It?

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A usable interface to any application is critical. For example, properly designed websites help ensure that users find what they are looking for and successfully perform online transactions. Given the uniqueness of the mobile commerce (m-commerce) environment [11], good interface design is especially difficult to achieve [10]. Mobile devices are typically smaller than their desktop counterparts, have lower processing power, and communicate in low-bandwidth environments. Mobile applications must be carefully designed to account for these limitations. But an even greater challenge to designing successful m-commerce applications, and their interfaces, is dealing with context. People can now conceivably be anywhere at anytime and use a mobile application, unlike the traditional (wired) Web where a physical Internet connection is needed. Applications designed for a relatively stable office or home environment may not work well on a loading dock or in a moving automobile.

What is Context?

Before mobile devices, computer applications only had to consider a fairly limited set of contextual concerns. These might include organizational culture, user characteristics (e.g., skills, education), system goals, and the working environment (e.g., lighting, noise). But users performed tasks on computers that remained stationary. Context concerns could be concretely taken into account during the design process and changed slowly (if at all) after system completion. With the advent of mobile and wireless devices, context is a less predictable influence on the actual design and use of computer systems. People are using applications in environments that are relatively unstable from one moment to the next.

In mobile and ubiquitous computing, the notion of context is often equated simply with location, but is actually more complex. Mobile application use can vary continuously because of changing circumstances and differing user needs. A context model (Figure 1) can be created using three broad categories of context - environment, participants, and activities. The “environment” category is concerned with the properties of objects in the physical environment. “Participants” includes the status of the user(s) and other participants in the environment. “Activities” covers user, participant, and environmental activities. Additionally, the model includes any interactions or relationships that may exist between participants, activities, and the environment. Table 1 summarizes several context characteristics for each category. Time is also incorporated into this model, allowing for a context history that can be used for predicting future context. This context model builds on the strengths of previously proposed models ([1], [7], [8]). The remainder of this article first discusses several challenges (summarized in Table 2) that arise when designing m-commerce applications within the boundaries of this context model, then presents ways to address these challenges.

How Context Affects M-Commerce

Many activities compete for a user’s attention on the Web. There are services sending news stories, alerts about stock prices, and notifications of email messages. But at least with wired e-commerce, the environment *outside* of the Web is fairly stable from day to day. Most offices and homes function with a good amount of predictability,

even if they do experience a great amount of activity. Relatively consistent amounts of attention can be devoted to performing tasks on the computer.

On the other hand, with m-commerce, there can be a significant number of additional people, objects, and activities vying for a user's attention aside from the application itself. Furthermore, since devices are completely mobile, this outside environment can change rapidly from moment to moment. An m-commerce application may not be the focal point of the user's current activities, as the user may be trying to juggle interaction with a mobile device along with other elements in the environment (e.g., riding a bicycle with friends on a busy street while receiving directions from a navigation system). The amount of attention that a user can give to a mobile application will vary over time, and a user's priorities can also change unpredictably. Thus, the circumstances under which m-commerce applications are used can be significantly different than those for their desktop e-commerce counterparts.

Furthermore, in the m-commerce environment, users and applications have to deal with a large diversity of devices (phones, handhelds, telematics) that continue to shrink in size and weight. While this achieves high device portability, usability of the devices can suffer. Mice and keyboards are being replaced with buttons and keypads. Smaller screens can be harder to read. Devices can be difficult to use with fewer than two hands. Changing environmental conditions (e.g., brightness, noise levels, weather) can also affect the use of mobile devices. Difficulty using devices can translate into wasted time, errors, and user frustration.

Security is another significant challenge in the dynamic m-commerce environment [3]. There are potential benefits in storing sensitive data, including medical,

personal, and financial information, on mobile devices for use by m-commerce applications. But the mobility of devices increases the risk of losing the device and its data. Furthermore, the risk of data access by unauthorized parties makes positive user identification a priority.

Potential safety issues also appear when the location and activities of the user can vary widely. For example, when designing m-commerce systems for automobiles, serious consequences can result if the application diverts too much attention from the primary task of driving. Web access in cars creates potential problems associated with "browsing while driving."

Finally, m-commerce and its technologies bring new social concerns to the spotlight. Ringing mobile phones and key tapping users are already unappreciated by many people in public locations such as theaters and restaurants. Mobility of devices and applications raises the issue of their appropriateness of use under certain circumstances.

Addressing the Challenges of Context

The problems and difficulties that arise when factoring context into the design and use of m-commerce applications can be tackled in various ways. Increased demands on users' attention in dynamic environments can be addressed through interfaces that require less attention. Pascoe, Ryan, and Morse [6] formulated the concept of Minimal Attention User Interfaces, which seek to minimize the amount of attention required to operate a device. They developed a personal digital assistant (PDA) application, used by field workers studying giraffes in Kenya, which allowed the

user to count the number of bites taken from tree leaves without looking away from the animal (which was observed through a telescope). The application used two existing PDA buttons (for incrementing and decrementing the count), and could be operated with one hand.

Devices and applications can also adapt themselves automatically to changing contexts. *Context-aware* systems [2] assist the user based on knowledge of the environment. As an example, messages typed on a mobile device are virtually attached to their current location when using a context-aware application called “stick-e notes” [6]. The notes reappear if the user approaches the same location again. Other context characteristics, such as time of day and temperature, can be used in addition to location.

New or modified interaction techniques may be necessary to overcome the physical limitations of mobile devices. In addition, flexibility of input and output modalities can allow adaptation to changing contexts and user needs. For example, text entry using a stylus or miniature keyboard on a PDA might be most efficient when both hands are free, but one-handed text entry using a thumbwheel [9] might be better when the other hand is occupied. Speech input is a viable alternative for devices too small for buttons or for those without a screen, but may not be appropriate for noisy environments or where noise is restricted (e.g., libraries). Sound can also be used for output, taking the place of text or graphics. Holland and Morse [4] investigated an audio interface for a navigation system that leaves a user’s eyes and hands free for other purposes. The application used tones projected through headphones at locations relative to the user (e.g., left, right, forward) to indicate direction.

Security of mobile commerce applications can be increased through the use of biometrics. Future wireless devices may include thumbprint identification or use smart cards for user authentication. Safety concerns can hopefully be resolved through the common sense of users and designers, but legislation may be needed to enforce the safe use of m-commerce devices and applications. Several states already have laws regulating cell phone use in vehicles. Likewise, appropriate use of m-commerce applications will be dictated through written laws and societal norms. Technology (e.g., cell phone jammers) can also be used to enforce “proper behavior.”

Implications for M-Commerce Design

Taking the complexities of context into account during the design and use of m-commerce applications is a challenging task, but one that must be undertaken seriously to achieve long-term success. Design guidelines and usability methods that work with wired systems will not necessarily work with mobile systems. Systems must function well even as environmental conditions, circumstances, and user priorities change. Developers need to understand people and how they interact with their surroundings. Realistically, all context characteristics presented in our model will not be relevant (or important) to an m-commerce application or its user at a given time. But applications that do account for those context characteristics that are relevant will benefit from increased functionality and usability.

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Table 1: Representative Characteristics for the Context Model

Category	**Representative Characteristics**
Environment	Location, Orientation (of objects) Physical properties Brightness and noise levels Availability, quality (of devices and communications)
Participants	Location, Orientation Personal properties (e.g., age, gender, education, preferences) Mental state Physical health Expectations
Activities	Tasks and goals (of participants) Events in the environment (e.g., weather)
Interactions	Co-location Group dynamics Social situations Participant/environment relationships (e.g., worker/workplace) Season, time-of-day, day-of-the-week

Table 2: M-Commerce Challenges and Potential Solutions

Challenges	**Potential Solutions**
Increased demands on attention	Minimal attention interfaces
Dynamic environment	Context-awareness
Mobile device limitations and usability	New and flexible I/O modalities
Security	Biometrics
Safety	Common-sense design and legislation
Social concerns	Societal norms and written laws

Figure 1 – Graphical Representation of Context Model