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Enabling Pervasive Computing with Smart Phones

Although some business and practical challenges exist, mobile phones could serve as information service end points, control devices for ubiquitous systems, network hubs for personal and body area networks, and ID tokens.

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Mobile telephony's technical and market success in Europe in the early 1990s attracted researchers' interest in mobile systems. Some researchers began investigating appropriate architectures for providing information services to cellular mobile telephony users, and the quest for the "killer" third-generation (3G) mobile telephony application dominated the EU Information Society Technology research program from 1998 to 2002. Dozens of projects launched to pursue this aim, and we were intimately involved in several of them. We report here on lessons learned during our involvement in this research and suggest how pervasive computing might benefit from this experience.

3G and beyond

A common thread throughout this work is the desire to develop universal information services delivered over ubiquitous, high-speed wireless networks. While the second generation of mobile computing is largely a person-to-person voice (and increasingly short messaging) communications medium, 3G visions add data services and corresponding infrastructures to support service provision. But 3G didn't arrive as expected—today, mixed 2G, 2.5G, and 3G networks operate alongside local wireless networking systems, most based on Wi-Fi and Bluetooth protocols. Research focus has thus shifted to what's currently known as fourth-generation (4G) or beyond-3G (B3G) mobile networks, seen as an extension of the current situation. In many ways, the current assumptions of the European Information Society Technology research program (running until 2006) resemble those proposed in the US as ubiquitous or pervasive computing. Considerable differences exist, however—for example, regarding the appropriate development path for such infrastructures.

Also driving this shift in program priorities is the realization that miniaturizing sensing and computational devices allows for deeply embedded wirelessly networked systems. *Ambient intelligence*—the vision for the European Information Society Technology program's next 15 years[1]—resembles pervasive or ubiquitous computing, but it emphasizes the system infrastructure's autonomic learning capability and interaction mechanisms for users in particular social contexts. Its ultimate aim is to populate the environment with smart devices and make information services accessible everywhere.

Developing mobile telephony information services poses several ubiquitous computing challenges. The very small form factor complicates user interaction, and devices might operate in insecure or even hostile environments. Also lacking are reliable network connectivity and infra-

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Figure 1. MyGrocer uses radio frequency ID technology to tag supermarket objects and monitor consumption patterns. One of the applications developed for smart phones lets clients manage their shopping lists and place orders while on the move.

structures that support service delivery. However, currently available service delivery techniques for mobile and PDA-type smart phones' small form factor should prove useful for similar devices used in pervasive systems. Some research on mobile information services provision explores voice as the primary interaction modality. (A review of methods and results appears elsewhere.[2]) Because people frequently carry mobile phones wherever they go, distinct opportunities exist for harvesting profile and activity data and for delivering timely information services. Finally, many mobile phones currently feature wireless local networking capabilities that let them interact with other nearby devices.

Perhaps most importantly, pervasive computing and mobile telephony systems operate in significantly different environments.[3] Whereas most pervasive systems inherit the Internet's legacy of open standards and systems and end-to-end application architectures, mobile phones operate within a more restricted environment. This offers distinct security advantages because the telephony network operator has greater control over management operations, but this environment's clear separation of data transfer and control planes potentially leads to a fundamentally different service architecture.

Mobile phones as information service end points

From the pervasive computing perspective, the mobile phone's most interesting use is as an end point for an information utility or service. Indeed, ubiquitous information delivery is one of the most often discussed scenarios of pervasive systems. Popular scenarios include spatial navigational assistance and recommendations for nearby places of interest, shopping, and entertainment; task-specific cognitive assistance; access to personal messaging and schedule information; and health care monitoring and diagnosis. The pervasive computing vision dictates that such services should be accessible from any location and whenever needed, via various devices augmented with computational and communications capability.

The literature discusses several device types supporting such interaction, ranging from ambient displays to tangible interfaces and more traditional appliances. Despite their considerable advantages, such devices are expensive and not widely available. Mobile phones offer a short-term solution readily available to much of the global population at relatively low cost. Moreover, their current computational capabilities compare favorably with common mobile application requirements and also against several device types often used in pervasive computing. Finally, today's mobile phone networks provide an almost global ubiquitous wireless access network, which satisfies most requirements of pervasive computing information service delivery.

Mobile phones' advanced processing capabilities offer many opportunities for developing novel information services. Although some of these can be delivered by voice, smart phones support more advanced interactive user interfaces. Several projects we've been involved with aimed to develop such services:

- *mXpress*[4] exploits location sensing and tracking to provide navigational assistance within a trade exhibition space. The system lets preregistered users who've provided personal profiles receive targeted content, such as notifications about specific events of interest (http://mexpress.intranet.gr).
- *MyGrocer*,[5] a 2G pervasive retail system (see Figure 1), includes a shopping list management and order placement client for smart phones (www.eltrun.aueb.gr/mygrocer).
- *E-Care*[6] developed a data-harvesting system to collect patients' vital measurements and provide a care-in-the-community monitoring and alerting service for people with chronic conditions (www.e-care-ist.net).
- *TellMaris*,[7] shown in Figure 2, employs location sensing to display 3D maps, overlaid with tourist information (www.tellmaris.com).

Figure 2. The TellMaris client application interface lets users navigate a 3D model of their location and discover nearby landmarks and services.

These projects all need to provide contextualized information. In this case, context refers to both the user's cognitive context and the system's operational context (such as available wireless bandwidth). Personal context information lets us minimize the number of steps required to carry out a specific action, and this in turn depends on adapting content and application functionality.[8] Unlike desktop systems, where functionality often takes precedence over speed, mobile devices' small form factor and limited input facility (mostly a numeric keypad and in a few cases an Accupoint or pointing stick) lessen the chances that users will complete tasks requiring a long interaction sequence. More common methods to develop personal context models include extracting common patterns from demographic and historical usage data, which the system then uses to anticipate user actions or better meet user information requirements.

We can further improve the success rate of predicting what users will choose if we also consider their current situation. For example, we can use location and time-of-day information to identify specific user activities and roles, permitting faster access to specific content or appropriate application functionality configuration. Such mechanisms can be inaccurate, however, and we should use them conservatively and in addition to rather than instead of other system features that help users perform tasks efficiently. Indeed, a common pitfall is to optimize aggressively for user interaction. When the system predicts the wrong pathway or, even worse, prevents the user from accessing required functionality because it doesn't appear to be a probable alternative, the user will more likely reject the system than if he or she only had to deal with the difficulty of navigating the interface.[8]

Finally, we can also adapt services to meet system capabilities, primarily in terms of user interface features and available network bandwidth. For example, the user experience suffers if the system delivers rich content developed for a 3G network over a slower network segment that supports only GPRS, because performance will likely be inadequate.

In recent years, the priorities in personalizing mobile information services have shifted considerably. The original stated goal was to make information services available to anyone, anywhere, at any time. But in practice many have interpreted this aim as providing everyone, everywhere, all available information all the time, leading to cognitive overload and service failure. For example, with mXpress we found it relatively easy to make massive amounts of information available to exhibition visitors, but users often had difficulty making sense of this information without appropriate means to organize and track data.[4]

Today, personalization focuses on creating information services that deliver the right information at the right time, in the right place, in the right way, to the right person. Indeed, in a world saturated with mobile information services, providers compete not to distribute massive amounts of information but rather to gain the user's attention. Early attempts to develop information services for mobile phones assumed that mobile users were simply "mobile Internet" users. Services thus aimed to reproduce the desktop Internet browser experience, albeit with a more compact interface and less demanding data transfer requirements.

This view has proven erroneous—information services on the move play a fundamentally different role and cannot be developed just by trivially extending the desktop paradigm. Web navigation highlights the difference between desktop and mobile devices: desktop users can employ a search engine to retrieve several pages of relevant results and review them in turn, moving from site to site over time. This is hardly feasible for mobile users, who should be taken directly to a specific location to carry out a short, focused task.[9] Mobile information services must be designed specifically for the context of their use and meet mobile users' needs for brief, targeted sessions.

This application-layer property extends beyond the user interface and the application functionality to the service architecture itself. The requirements of browsing Web pages on a mobile phone go well beyond the need to display content in a condensed form. The content itself must be modified to meet user expectations and needs, and more importantly to match user activities. For example, we found in a recent study that the British Museum's Compass, an extensive online database for objects in its collections, wouldn't meet mobile users' needs during museum visits. Compass pages often provide lengthy background discussions of objects and exhibitions that require users to switch from the visit's physical and social context to that of information browsing on the device. This attracts attention away from the visit's main focus in a fairly disruptive way. Typically, mobile users want a concise overview of objects, and relevant pages should present the information in a less academic, more informal style better suited to the visit's discursive nature. Although automated summarization techniques might help here, a person should author or edit mobile user content to achieve the desired effect.

Likewise, TellMaris showed that the location itinerary dominates tourist visits, and a complex information service interferes with the actual experience. More appropriate and desirable is a simple but authoritative response to a location-specific query or notification of a change in environmental condition.[7]

The finding that content should be authored specifically for mobile users' activities suggests that transcoding architectures developed in various mobile computing projects are less important than initially thought. Although this functionality is clearly feasible and in fact is now readily available in commercial platforms, it addresses a problem that has minor implications for a system's success. Of course, achieving interoperability between devices of the same form factor is clearly desirable and should be accommodated whenever possible. But this finding may have design implications for some emerging pervasive computing infrastructures. Content authored for a smart phone might be inappropriate for users interacting with tangible interfaces or proactive displays, and design principles developed for mobile telephony might not transfer well to these situations.

Mobile phones as remote controllers

Pervasive computing requires the seamless interoperation of diverse devices and electronically augmented artifacts within spaces saturated with wireless communications capability. In the home environment, for example, perhaps hundreds of (mass-produced) devices must be configured and managed to operate in a way that satisfies the needs of the family occupying this space. Although the pervasive computing vision dictates that such devices adapt automatically, current techniques cannot robustly and consistently support this on a large scale. The mobile phone offers a potential solution by acting as a control device, similar to remote-control devices used in consumer electronics.[10]

This approach faces several challenges, not least the limited availability of standards that are clearly essential for its success. Yet the concept has appeal in that the mobile phone fits this role well. Smart phones' processing capability permits flexible functionality that can be adapted or extended to include control functions for particular devices. Larger-form-factor smart phones allow for the provision of more intuitive user interfaces, such as a physical space abstraction to control multiple devices simultaneously or interpret higher-level commands to device-level management functions. Instructions can be transferred locally using a wireless interface. In fact, although infrared communication is relatively low bandwidth and is often discounted in pervasive computing systems in favor of higher-power access media, we've found it well suited to this role and a potentially appropriate solution.[6] Naturally, a mobile device also offers the opportunity to manage the home environment remotely, for example, via a control applet that connects directly to an Open Services Gateway home server.[11]

We see another, more subtle advantage to using the mobile phone as a remote controller in a pervasive computing situation. Ubiquitous computing systems users often have difficulty conceptualizing the system and thus developing mental representations and appropriate strategies for interacting with it.[12] The problem is that system functionality is transparent, and unlike other computing situations, ubiquitous systems offer no specific interaction point. People are used to interacting with information systems via specific service end points, such as a personal computer, a bank teller machine, a digital television, or a mobile phone. Ubiquitous computing is, as Mark Weiser put it, "invisible, everywhere computing that does not live on a personal device of any sort, but is in the woodwork everywhere."[13] It thus has no specific physical expression. As a point of contact, the mobile phone becomes a manifestation of the pervasive service and thus much easier to conceptualize and interact with.

> Smart phones' processing capability permits flexible functionality that can be adapted or extended to include control functions for particular devices.

Mobile phones as pervasive network hubs

We find a more interesting use of mobile phones in pervasive computing when considering their functionality rather than their form, that is, as a communications device offering wide-area networking capabilities. The cellular telephone can operate as the hub of a personal or body area network: it connects to remote services and the Internet, and the local area network connects to local devices.

The Healthcare Compunetics architecture offers one incarnation of this concept.[14] It specifies a system that processes data harvested from sensors into an appropriate XML-based specification called *i*-notes. It stores them for future use and, following a predefined policy, communicates them to the appropriate consultant for analysis. Because connectivity with health care systems might not always be available, Healthcare Compunetics provides two devices that work together to offer secure storage and seamless communication within a body area network. The first component is the *i*-wand, a wearable storage and processing device with fingerprint authentication. It structures and stores personal data in *i*-note format, checks it on the fly for evidence of critical conditions locally, and encrypts it. The device employs wizards that detect the type of sensor that's transmitting data, and it currently supports many homecare monitors, flat-padded water-resistant hypoallergenic dermal patches, and certain biocompatible sensor chips in ingestible capsules. The second component, the Mobiliser, is a GUM (Global System for Mobile Communication) modem core attached to the *i*-wand that communicates with back-end servers over the cellular network. These two devices transform the mobile phone into an enabling device for typical ubiquitous information services, removing the recognizable form of the device itself.

This approach removes the mobile phone's form factor limitations and, taken to its extreme, lets us see the whole personal area network as an extended telephone. This view suggests several similarities between mobile phones and more typical pervasive computing devices. For example, Ericcson Research Labs' Phone Glove[15] introduces the idea of a fragmented telephone consisting of a basic communications core embedded in user clothing and the remaining components distributed to the points of their actual use. We already see a form of this when people use an earphone instead of the mobile phone speaker. This model would also support electrical field sensing and the finger-joint gesture keypad input paradigm to replace the traditional telephone numeric pad. Phone Glove uses the finger phalanges as the telephone keypad and the thumb as operator.

Some see smart phone cores as the basis for developing a networking model for ubiquitous computing based on user-centered concentric spheres.

Other projects take a similar approach to provide wide area connectivity for wearable systems. In some cases, the telephone core transmits data harvested from associated sensors in the body area network; in other cases, the device acts as a network router to receive information from a remote location and passes the content along for further processing or display at another network component. By accessing remote services and the Internet, these systems can employ network-based authentication and authorization processes and thus partially address the problems of secure operation and privacy protection inherent in all pervasive computing environments. In fact, some see smart phone cores as the basis for developing a networking model for ubiquitous computing based on user-centered concentric spheres—for example, the Multi-Sphere Reference Model,[16] a current proposal of the Wireless World Research Forum.

Mobile phones as ID tokens

Arguably, one of the most pressing challenges in pervasive computing is security and privacy protection.[12] Mobile phones can address this challenge by acting as a *secure personal device* that stores information used to verify user identity and determines when to disclose this information. This generalizes a function that all mobile phones carry out under normal circumstances. For example, on a GUM network, they use their embedded unique ID code and the GUM family of cryptographic algorithms to identify users to the network and verify their right to access resources and services.

The mobile phone can also store credentials associated with specific information services—for example, electronic commerce account logins and payment information using the Electronic Commerce Modeling Language, which several mobile phone manufacturers currently support.[17] These credentials serve to authenticate with remote services over the cellular network or over the local network by directly interacting with the payment facility using, for example, Bluetooth or RFID. NTT DoCoMo recently introduced the latter option as a commercially available system in Japan under the FeLiCa brand.

User ID mobility poses several other challenges.[17] Identity is mobile between devices, between locations, and between roles and contexts. Although mobile phones can support some of these modes, they are less effective with others. For example, location mobility entails coordinating authority domains, because a person moving between locations is also usually moving between areas controlled by different organizations. When a company's employees access information systems from their desks, both the access medium and the information storage are physically located within a single authority domain regulated by their employer. But when they access information via a trading partner's extranet, they cross organizational boundaries, and the trust relationship between the two organizations must be negotiated as well.

Clearly, smart phones can provide only a partial solution to this problem. Role and context mobility is even harder to address, and a mobile phone probably can't provide either the computational power or the storage resources to maintain appropriate role representations and predict suitable actions independently. Of course, the three modes of mobility are not isolated. User actions (active or passive, such as moving between rooms) typically modify them concurrently and thus create much more complex situations than what a single mode implies in isolation. Finally, a mobile phone has limited capacity to hold ID credentials because the individual elements comprising the mobile identity might be distributed between different locations, authority domains, and devices, often for regulatory or business reasons.

Business and practical implications

Mobile phone use clearly differs from that of an open system such as the Internet because mobile operators completely control their networks, including all data flows. This stems as much from historical reasons, given mobile operators' evolution from fixed telephone network operators and their tendency to follow similar models and strategies, as from differing user expectations. Mobile phone users primarily communicate by voice, and their expectations are shaped by their experiences with fixed telephony. The operators control which parties may offer services over particular networks and under what circumstances, and these parties will generally enter a profit-sharing agreement with the operator.

Service availability and infrastructures

We must consider what services might become available if pervasive computing's network access model follows that of today's cellular mobile networks. Indeed, the oft-cited *i*-mode success story hinged on the operator's ability to share in the profits of third-party providers given access to the service. Compare this to Internet users' relationship with their service providers, who have limited or no control over user choice of consumed services.

> Many mobile phone system operators, including several 3G operators, don't see information services as critical for their revenue development.

Moreover, many mobile phone system operators, including several 3G operators, don't see information services as critical for their revenue development. In our work, we've often been restricted by operators that limit data movement on their networks in favor of voice. One major European operator limits GPRS (General Packet Radio Service) users' available bandwidth to well below the technology's capacity, often to a few Kbits. Even more characteristically, the UK's first 3G operator completely prevents users from accessing information services and actively promotes a business model in which growth is based on video messaging. And despite the rapid proliferation of Wi-Fi networks, most European operators claim not to be able to support a profitable business model based on this technology and see it as merely a value-added service for business customers rather than a viable public-access alternative.

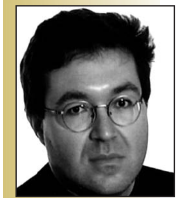
The mobile telephony experience to date provides significant lessons for market development of supporting service infrastructures. Indeed, even if the seamless interoperation envisioned in pervasive computing scenarios proves technically feasible, it might not happen because we lack successful business models to support development of the necessary infrastructure. Of course, this might just be one of the teething problems of a wireless communications industry that doesn't yet fully appreciate the opportunities pervasive computing offers.

Adapting to user needs

We've also learned that we can move much faster from one technology generation to the next than individuals and groups can adjust their habits and behaviors to make new technology part of everyday life. This proves especially true in the case of mobile telephony, compared to the development of the desktop or the server computer. Whereas previous computing generations used technology primarily for professional activities, mobile telephony offers a more personal and intimate computing environment. As we've discovered consistently across our work, a mobile phone is a truly personal device, often seen as part of an individual's identity.[17]

This personal identification makes it

the AUTHORS



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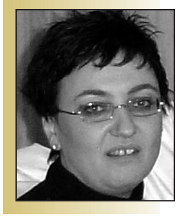

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that much harder to demand that users adopt specific behaviors to operate the technology (as is the case for desktop office productivity systems). Thus we must adapt the technology itself to meet individuals' needs and self-perceptions. This pressure to develop "calm technology" will only intensify as we introduce different pervasive computing technologies that become part of everyday life and, to some extent, invade users' personal space and intimate activities.

Respecting user privacy and diversity

Finally, ubiquitous computing systems development must focus on protecting the user's personal data. Retrofitting trust in any technology is considerably harder than building it in from the start, especially when users have already perceived it as invasive, intrusive, or dangerous. In particular, users must understand and agree to the rules of ownership and compensation for data created by user actions, a core requirement for providing context-aware services. Lack of a clear framework to protect private functions or compensate for the use of personal data will appear unfair and create negative perceptions of a service.

Developing a substrate for providing universal services poses another core challenge to pervasive computing. Systems must cater to widely varying national, cultural, and religious differences, which might result in system incompatibilities or even the failure of such infrastructures to provide the required adaptation. Even within a region with relatively uniform legislation (such as the EU), different countries might interpret common rules in incompatible ways, or in ways that prevent processing personal data lawfully across the region.[18]

Our work over the last decade has sought to make mobile information services practical. During this time, our understanding of the services mobile users might find valuable has shifted considerably. We anticipate that mobile users will find the greatest benefit not in a single or a small number of services but in connectivity itself: always being connected to activities, people, and groups that play a central role in everyday life. They will interact with services not in long continuous segments, which are best facilitated by larger-form-factor computing devices, but rather in short and targeted interactions that fulfill specific needs. Until practical ubiquitous interfaces and services emerge that allow for a greater wealth of interactions, the smart phone will remain the best available personal computing device.

REFERENCES

1. N. Shadbolt, "Ambient Intelligence," *IEEE Intelligent Systems*, vol. 18, no. 4, 2003, pp. 2–3.
2. B. Shum and P. Peterson, "A Data-Driven Methodology for Evaluating and Optimizing Call Center IVRs," *Int'l J. Speech Technology*, vol. 5, no. 1, 2002, pp. 23–37.
3. P. Asunmaa et al., "Introduction to Mobile Internet Technical Architecture," *Wireless Personal Comm.*, vol. 22, no. 2, 2002, pp. 253–259.
4. G. Giaglis et al., "On the Potential Use of Mobile Positioning Technologies in Indoor Environments," *Proc. 15th Int'l Conf. Electronic Commerce*, Univ. of Maribor Press, 2002, pp. 413–429.
5. P. Kourouthanassis and G. Roussos, "Developing Consumer-Friendly Pervasive Retail Systems," *IEEE Pervasive Computing*, vol. 2, no. 2, 2003, pp. 32–39.
6. A. Marsh, "The E-CARE Project: Removing the Wires," *Proc. Int'l Conf. Computer Science*, vol. 2, Elsevier Science Publishers, 2002, pp. 1012–1018.
7. A. Schilling et al., "Introducing 3D GIS for the Mobile Community: Technical Aspects in the Case of TellMaris," *Proc. IMC Workshop 2003*, Fraunhofer IRB Verlag, 2003, pp. 86–92.
8. B. Smyth and P. Cotter, "MP3—Mobile Portals, Profiles, and Personalization," *Web Dynamics, Adapting to Change in Content, Size, Topology, and Use*, M. Levene and A. Poulovassilis, eds., Springer SMB, 2004.

9. A. Sellen and R. Murphy, "The Future of the Mobile Internet," *Appliance Design*, no. 3, 2001, pp. 7–13.

10. A. Sanguinetti et al., "FReCon: A Fluid Remote Controller for a Freely Connected World in a Ubiquitous Environment," *Personal and Ubiquitous Computing*, vol. 7, nos. 3–4, 2003, pp. 163–168.

11. E.A. Gryazin, J.O. Tuominen, and P. Kourouthanassis, "Distributed Information Systems Development for the Consumer Market," *Proc. 2003 Int'l Conf. Artificial Intelligence Systems* (AIS 03), IEEE Press, 2003, pp. 88–95.

12. G. Roussos and T. Moussouri, "Privacy, Security and Trust in Ubiquitous Commerce," *Personal and Ubiquitous Computing*, vol. 8, no. 6, 2004, pp. 416–429.

13. M. Weiser, "The Computer of the 21st Century," *Scientific American*, vol. 265, no. 3, Sept. 1991, pp. 66–75.

14. A. Marsh, G. Roussos, and Y. Vogiazou, "Healthcare Compunetics: An End-to-End Architecture for Self-Care Service Provision," *Proc. 1st Int'l Workshop Body Sensor Networks*, 2004, www.doc.ic.ac.uk/vip/bsn/home/index.html.

15. M. Goldstein, M.G.O. Baez, and P. Danielsson, "Employing Electrical Field Sensing for Detecting Static Thumb Position Using the Finger-Joint Gesture Keypad Input Paradigm," *Proc. 4th Int'l Symp. Wearable Computers*, IEEE CS Press, 2000, pp. 173–174.

16. K. Crisler et al., "Considering the User in the Wireless World," *IEEE Comm.*, vol. 42, no. 9, 2004, pp. 56–62.

17. G. Roussos, D. Peterson, and U. Patel, "Mobile Identity Management: An Enacted View," *Int'l J. Electronic Commerce*, vol. 8, no. 1, 2003, pp. 81–100.

18. O. Pitkänen et al., "Assessing Legal Challenges on the Mobile Internet," *Int'l J. Commerce*, vol. 8, no. 1, 2003, pp. 101–120.

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