Wearable computing : the future mobile «phone»?

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Wearable Computing – The Future Mobile «Phone»?

Within the next 10 years computers and end-devices will become so small that they can be carried in clothes or on the body. This will result in a new type of mobile applications which automatically collect data from the user context and provide responses with no or little explicit interaction needed. Swisscom Innovations explored the above concept with a demonstrator of a smart assistant helping a user on the move. Having both hands free all the time, he/she requests information with short voice commands and sees the responses immediately on a head-mounted display.
Possible application scenarios and a demonstrator have been built and discussed with experts and others. Feedbacks and responses to questionnaires led to business considerations and proposals for follow-ups.

The programme "Integrated Communication Services" explores and develops person-to-person and person-to-content communication services that integrate a wide range of networks, applications and devices. The programme "Software Technologies for Advanced Internet Services" explores new opportunities arising from current software technology trends and assesses their impact.
With its Innovation Programmes, Swisscom Innovations follows the objective of recognising early on the impact of technological developments, finding new business opportunities, promoting technical synergies, and developing concrete innovation proposals. Further, the expertise built up enables active engineering support of business innovation projects.

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Future mobile users will carry very small computing and networked devices on their body or in their clothes. They will have their hands free and get immediate responses from smart services. This will significantly enhance the value of information and services available over the net and imply an important business opportunity.

Devices have become so small that today's users can carry them all the time when on the move. This implies that telecom operators nowadays add substantial value by making data and telephony services mobile. As devices will continue to become smaller and more integrated, they will be carried effortlessly in clothes or on the body (fig. 1). Users will have both hands free. Data will be collected implicitly from the user context and users will get immediate responses.
What does this mean for future applications? And how can telecom operators add value?

Wearable computing has long been considered a topic limited to vertical applications for special professions. However, with the use of increasingly powerful mobile phones and all kinds of electronic accessories this will likely change and become important for telecom applications.

Fig. 1. A scenario for wearable computing. The pictured user has her hands free. With voice commands she can interact easily in every situation.

This article sketches a scenario for using wearable technology on a daily basis. On the basis of two prototype systems, state-of-the-art technology and future trends are described. One prototype is built with a downsized PC and wearable end-devices, whereas the other runs on a current smartphone combined with a server application on the net. Both prototypes run context-aware software, enabling users to get context relevant information with little explicit interaction. The article also presents and analyses user feedback and closes with considerations for developing new business and exploring further topics.

Projects at Swisscom Innovations

Within the project "Wearable Computing" we first studied device technology and future usage scenarios by testing innovative devices from several suppliers, having a joint workshop with the wearable computing lab at the ETH Zurich [1] and contributing with an exhibit to a public exhibition on wearable computing [2]. In a second phase, two prototypes of a smart assistant were built in collaboration with the project SMASH-IT. They were demonstrated on different occasions to collect and evaluate user feedback and expectations.

Scenario for Wearable Computing Applications

A way for describing future applications is to think about hypothetical persons and typical usage situations. An example is given below:
Daniela (fig. 1) is travelling frequently using public transport. She recently acquired a wearable computer with a small display she can attach to her glasses. She can now read news or watch videos on the move. Sometimes she also lets the system read articles or e-mails to her, as she finds this more relaxing. Before that, she frequently disturbed her neighbours with large newspapers or searching and navigating on her notebook. Now, they rather shake their heads. As an early adopter, she does not mind. She also appreciates that other people cannot share what she sees on the small display. At every location the systems helps her with smart information to find her way.

Prototype of a Smart Assistant "SMASH-IT"

Figure 2 shows the hardware needed for building a prototype similar to the one

Fig. 2. Prototype of a smart assistant on a small PC with wearable end-devices.

sketched in the scenario above. The system consists of a standard small-form-factor PC running Windows XP and smart assistant software. Internet connection is realised respectively over a Bluetooth access point and a GPRS phone on the move. A GPS [3] receiver transmits position information over Bluetooth to the wearable PC. A standard microphone captures the audio data which is then processed by a speech recognition engine [4]. Data output is realised by a wearable display [5].

The smart assistant software was built in the project "SMASH-IT". The key goals were

- to show how context information collected from wearable devices helps to increase the quality of search results and service selection;
- to transform current Web content in order to optimise it for small screens;
- to keep navigation to a minimum.

For the prototype, the following context information is extracted: location, time and voice. In order to limit navigation, an extensible set of services was preconfigured. Currently the application allows for location-based map display, five-day weather forecast, Swiss railway time table, as well as location-based hotel, taxi, and bar lists. With the exception of the Swiss railway timetable, all services are available worldwide and presented in the same way. Navigation among the services is realised by speaker dependent voice recognition enabling hands-free operation.

Figure 3 illustrates the operation of the SMASH-IT application. Raw data is captured from the context (location, sound, time). This raw data is then enriched with information from a geographical information system (GIS) as well as a small knowledge base (KB). This transformation yields, for example, location names, E.164 area and country codes, recognised voice commands etc. From this information, queries are formulated for the various Internet services (Google, MapQuest, Wetter.com, SBB). The results of these queries are then filtered and aggregated by taking into account the current context and are finally presented to the user. It is important to note that the above process runs continuously in the background. Thanks to this information prefetching, the user always has up-to-date information available.

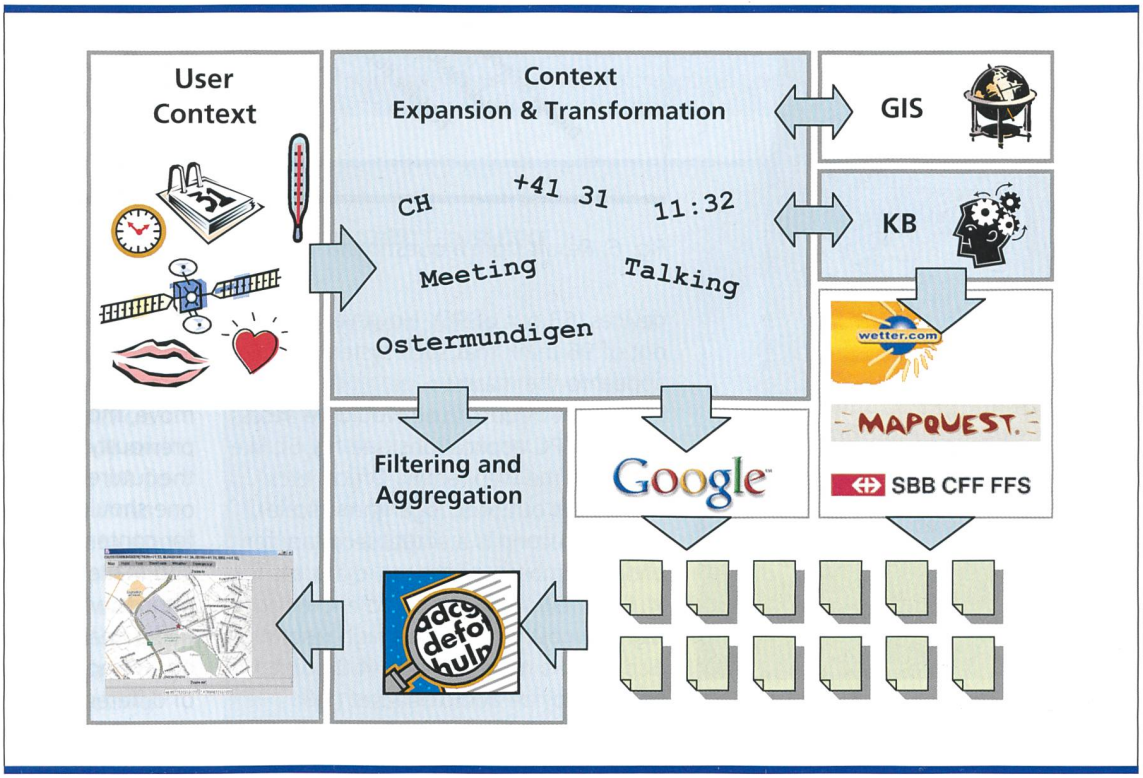

Fig. 3. Software architecture for smart assistants.

Network Versus Device-Based Services

During the SMASH-IT project an implementation for the Sony Ericsson P800 smartphone (fig. 4) was realised, too. Due to the limited resources on the smartphone, most of the application was placed on a server running in the network. The smartphone itself is only concerned with context acquisition, presentation and navigation. The raw context information is forwarded to the server software where all information processing and web interaction occurs. The aggregated and filtered information is then sent back to the mobile device. The two implementations, entirely device-based (on a wearable PC) or mostly network-based (smartphone prototype) show how current applications can be structured to adjust to various (sometimes conflicting goals) such as size of devices, battery problems, bandwidth, memory, display, privacy, network infrastructure, etc.

Questionnaire about Future Usage

In order to get feedback the prototype was shown at different occasions within and outside Swisscom. From a group of 96 students questioned, a clear majority answered that they would use a small wearable computing assistant and end-devices (63 out of 96). However, only 20 out of 96 think that such systems would appeal to the masses.

Fig. 4. Smart assistant implemented on a current smartphone.

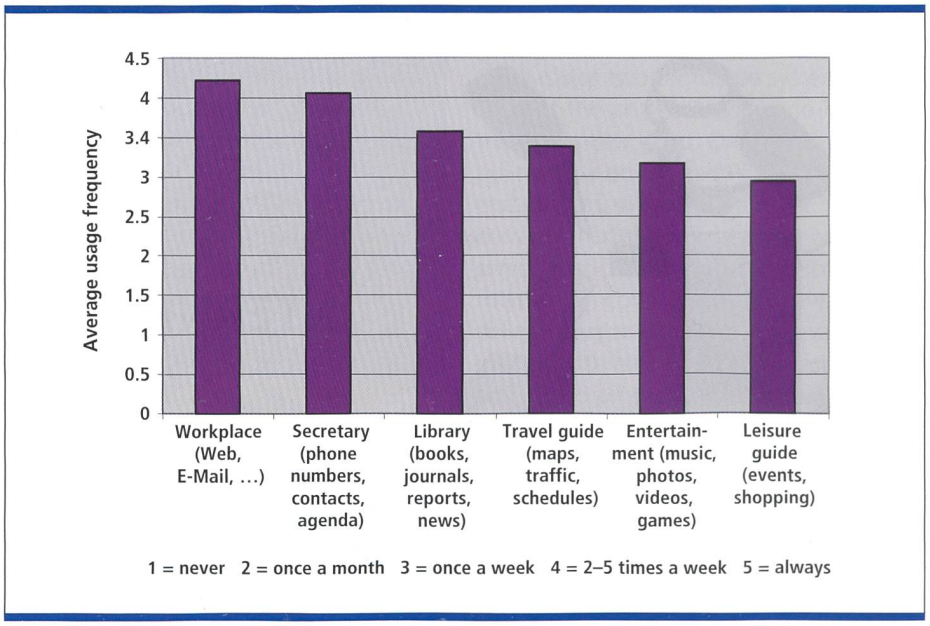

Fig. 5. Result from a questionnaire about user acceptance and content desired on the move.

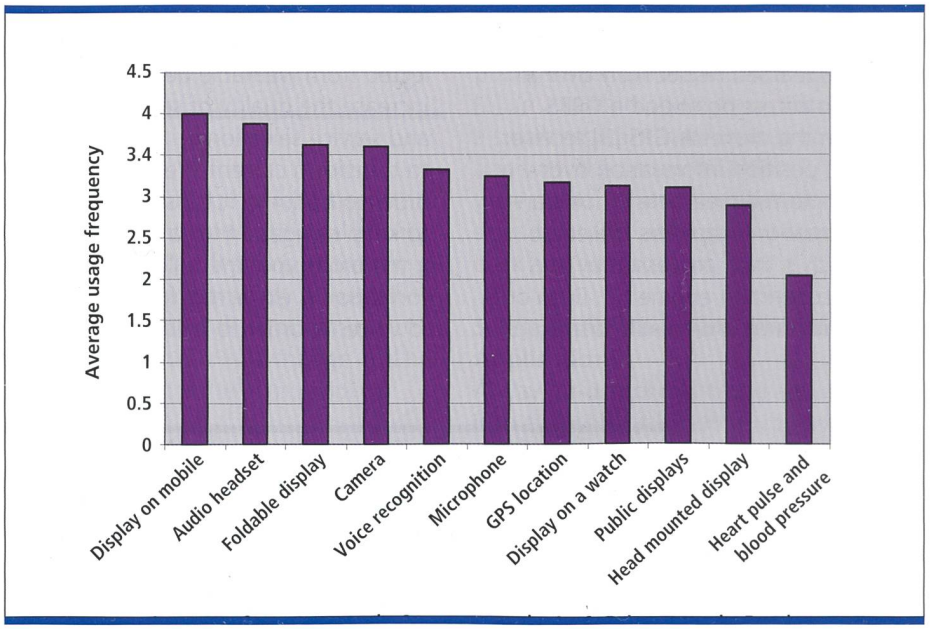

Fig. 6. Result from a questionnaire about desired end-devices.

Their most frequent use would be access to typical PC applications (see fig. 5), like browsing the web, email, Office, etc. (4.2 points out of 5, logarithmic scale). Ranking second is a virtual secretary for phone numbers, addresses, diary, etc. (4.1 points). With respect to end-devices (fig. 6), most would like a high resolution display on a mobile phone (4.0 points) followed by an audio headset (3.9 points). Many are sceptical about using a head-mounted display (only 2.9 points).

Business Considerations

Since computers and end-devices become smaller and easier to wear on the move, mobile applications which were previously impossible will be a reality in the future. Based on our user feedbacks one should first build wearable systems for content known from PC and PDA and make it easily accessible on smartphones with high resolution screens and audio headsets. With development going on, we however expect that a multitude of different applications and devices will appear on the market. Therefore a key issue will be to integrate and manage

Abbreviations

Bluetooth	Short-range radio technology for interconnecting mobile phones with personal devices
GPRS	General Packet Radio Services
GPS	Global Positioning System

services and devices for different market segments like mobile office, personal assistance, leisure, health, etc.
With mobile phones and user devices becoming smarter, network operators have to carefully decide where to run a service. Most services can be realised entirely network-based (like in the smartphone prototype) or entirely end-device based (like in the wearable PC based prototype). Both positions have their advantages and disadvantages for the user as well as the operator with respect to ease of use, cost, performance, ease of management, privacy for personal data, etc. The conclusion is again that the design of future applications should be able to adjust to various conditions in user preferences, device capabilities and business constraints.

Conclusions

The scenario study and the SMASH-IT prototype show that wearable computing devices will enable mobile applications previously not possible. The user has both hands free and gets responses immediately and with little interaction. Smart applications will extract context information and continuously prepare output using various Internet services plus application specific and personal knowledge bases. All this will add significant value for mobile users accessing services over the network. User feedback showed that a majority is expected to be sceptical about using smart applications with wearable devices. This holds specifically for obstructive devices like head-mounted displays or body sensors. But when early adopters see the potentials and are asked, they get curious and they say that they would like to regularly use a smart assistant with small and wearable devices. Their preferred devices would be mobile phones with a high resolution display and audio headset and they would primarily use them for accessing content otherwise accessed on a PC or PDA.

Outlook

As explained in this article, wearable computing will allow to get much more use and value from services and information available over the network. In the future, this business opportunity should be addressed by a telecom operator like Swisscom. Applications, however, have to be tailored to various user preferences and device capabilities. This implies that more work on understanding the applications, improving the specific technologies and finding common platforms will be needed.
For further work on this subject it is reasonable to select a few significant market segments. Based on the user questionnaire, accessing content from PC or PDA applications with wearable devices is the most likely application. In order to prepare for future steps, however, the authors propose to consider market segments where the margin for added value is higher and where more innovations are likely to appear. As an example, they have worked out proposals for the telehealth sector, in one case jointly with partners already developing services and technologies for this sector. 10,3

Simon Schubiger *received his PhD degree in computer science from the University of Fribourg and has been working for Swisscom Innovations since 2001. As a senior engineer, he is mainly involved in projects related to knowledge management and representation in combination with current Internet technologies. Context awareness of mobile devices as well as information presentation with limited resources are other key areas of his work.*

Edwin Wiedmer *received his PhD degree in mathematics at the ETH Zurich, worked in the telecom industry and since 1995 has been senior engineer at Swisscom Innovations. There he guides projects and works as an expert in multimedia services over broadband networks. In the last two years he has studied and set up prototypes for future telecom applications on novel end-devices for the home and for mobile users including wearable devices.*

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Zusammenfassung

Wearable Computing

In den nächsten zehn Jahren werden Computer und Endgeräte so klein werden, dass sie einfach in Kleidern oder auf dem Körper getragen werden können. Wird also «Wearable Computing» das zukünftige mobile Telefon sein?
Dieser Artikel zeigt mögliche Szenarien und stellt Anwendungsprototypen vor. Der Vorteil für mobile Benutzer ist, dass sie mit nur wenigen Interaktionen und ohne die Hände benutzen zu müssen zu den gewünschten Informationen und Diensten gelangen. Dies wird den Nutzungswert für Informationen und Dienste auf dem Netz erheblich steigern. Damit ist auch ein wichtiges Business-Potenzial für einen Telecom-Operator wie Swisscom oder einen ISP zu erwarten. Die weitere Entwicklung und Exploration sollte sich an den erfragten Benutzerbedürfnissen und den vorgezogenen Endgeräten orientieren.