computer communications

Guest Editorial

Special Issue: Ubiquitous Computing

What happened in the decade since the phrase of Ubiquitous Computing was coined by the late Mark Weiser (1952–1999), described in 1988 as 'the calm technology, that recedes into the background of our lives'—until the late Nineties, when this vision began to spread rapidly, and gaining a momentum of reality in the young millennium? Have we all been sleeping until the ubicomp wake-up call?

Obviously not, we have been working on maturing the enabling technologies, the sensors and actuators, the wireless and ad hoc networking, the distributed and embedded systems, the power density of energy sources, the capacity of storage devices, the software architectures and middleware, the localization and positioning technology, the microelectronics, nano technology, MicroElectro-Mechanical Systems (MEMS), human-centered application design, multi-modal user interfaces, and many more.

It is the synergy, the interdisciplinarity of all these developments, that begins now to enable the increasing availability, mobility and interaction of services and applications in a large variety of areas in daily life-defining Ubiquitous Computing. Recently, we have seen major progress in developing the new off-the-desktop computing paradigm that indeed moves towards the notion of a pervasive, wearable, unobtrusive, disappearing, personalized computer.

The impact on our daily life will probably be even more revolutionary than the effects of the Internet during the previous decade, and within ten years, we will have applications we currently not even think of.

Sometimes I am questioned about the price, as people find current, preliminary solutions rather expensive. While military applications are usually well paid for, what about the consumer domain? Will this technology be affordable for all of us? Probably it will—if the appropriate business models can be established, and products enter mass production. Or, would you have believed ten years ago that there is hardly a primary school kid today in Europe that is not equipped with a 'complex, digital radio link for speech and data communication' (= mobile phone)? Today, the embedded systems in each car have magnitudes more computing power than the vehicles that carried the man to the moon.

However, we have to be aware of the social implications of our technology. As engineers, we have the tendency to enjoy playing with our toys in research and development and to think too late about issues such as the market acceptance and the impact on privacy.

Should we go with Sun's CEO Scott McNealy that 'you already have zero-privacy anyway, get over it' (1998)? We should not give up that early. We need to learn to design privacy into our systems first-hand, not as a later add-on. This inherent need for trustworthiness becomes very obvious in health care and medical monitoring based on sensors and body area networks.

The near future will bring more insights into these key issues that have already been the topic of heated discussions. Within this special issue, with a truly international coverage, seven full papers are published. They cover the whole range from the provision of energy, hardware development, context-aware technology, services, architectures and applications. The two tech notes discuss aspects of transmission technology and privacy.

The first paper by *Shad Roundy* et al. from Berkely, California/US, is a typical example for the interdisciplinary impact on Ubiquitous Computing. It provides an approach for the problem of powering small wireless computing devices over a long time period without maintenance. Assuming that a 1 cm^3 device could consist to 50% of the power source, the authors evaluate a variety of energy sources. To replace or support fixed sources like batteries, energy scavenged from the environment is discussed. While solar energy is an excellent solution for well lit places, it fails for darker environments. To provide an alternative, the authors investigate in detail the conversion of environmental vibration into electricity. Electromagnetic (inductive), electrostatic (capacitive), and piezoelectric converters are compared. The latter two have been built and optimized as capacitive MEMS and miniaturized piezoelectric prototypes, providing promising results.

The paper by *Pieter Jonker* et al. from the Netherlands treats the location, context and ambient awareness aspect of Ubiquitous Computing. They consider contextual sensing, adaptation, resource discovery, and augmentation as principal viewpoints. The state of the art of the full range of context sensors is reviewed, from inertial sensors over GPS and GSM positioning up to visual sensing and support by acoustical clues. Based on their own hardware setups for position sensing and visual tracking, an improved

recognition accuracy is obtained by synergetically combining these technologies.

Marius Portmann from Australia and *Aruna Seneviratne* from Switzerland go for efficiency aspects of fully decentralized systems. While such systems provide a high degree of robustness within highly dynamic and transient network environments, the authors identify drawbacks in communication efficiency for central information. Investigating peer-to-peer networks such as Gnutella, the difficulties of broadcasting messages are discussed. A simulation of an enhanced 'rumour mongering' protocol is presented, which exploits typical characteristics in neighbourhood relations of peer-to-peer networks and proves to achieve a significant reduction in cost.

Paul Prekop et al. again from Australia, present a theoretical study about the modelling of activity-centric context. They argue that context-aware applications capable of supporting complex, cognitive activities can be built from such a contextual model. Reasoning what separates context-aware applications from traditionally designed applications, the authors argue that they require the ability to implicitly sense and automatically derive the needs of the user, and to usefully adapt the services or information they provide according to their user's identity and environment.

Gregory O'Hare et al. are from Ireland. The idea of a context-aware tourist guide has always been pushing the concept of Ubiquitous Computing forward, and the authors follow the part of the path already paved with an evaluation what has been done in this area. They check it against the technology presently becoming available regarding context sensitivity, telecommunications, positioning and agent technologies. Their own contribution, employing multi-agent technology, focuses on caching and pre-fetching algorithms for intelligent content delivery.

The team of authors led by *Jukka Riekki* from Finland presents an agent-based service architecture, which can be used for a variety of context-aware applications. Knowledge representation, information management and event scheduling are main issues for their primary application areas, such as: a home notice and schedule board, a family calendar, and Neon Digipainting, a distributed visualization system for changing art work and information.

In Japan, *Sen Yoshida* et al. consider a framework of communication systems to support network communities in peer-to-peer environments. They provide a unified structural design approach with the goal to enable shared software components to cooperate with each other. Such communication support, utilizing mobile systems, multimedia, natural language processing and other advanced technologies is discussed as 'socialware' and aims to merge human's face-to-face communication with the computer-supported online communication.

The first of the two tech notes comes from France, written by *Thierry Val* et al. The enthusiasm about wireless radio communication has distracted our attention from the alternative physical layer, namely infrared light-although this layer is already considered in standards like IEEE-802.11. The authors have studied and simulated this technological niche and evaluate in which cases this technology can provide undeniable advantages compared to the radio solution.

Finally, *Silke Holtmanns* and *Marcin Toczydlowski* from Germany discuss a practical privacy problem, namely the confidential retrieval of e-mail with a mobile device within an untrusted domain. Because the mobile user tries to avoid to download the full bulk of encrypted e-mail from the untrusted server for bandwidth reasons, the authors demonstrate a solution for selecting priorized e-mails within such an environment.

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