Ubiquitous Computing Infrastructures

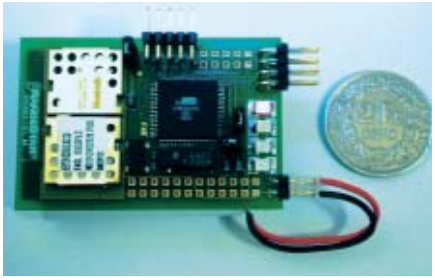
by Friedemann Mattern

Incorporation of computing power into everyday objects gives rise to 'smart things'. To enable communication and cooperation among such smart objects, new information infrastructures are required. The Distributed Systems Group at ETH Zurich addresses the challenges of designing and implementing such infrastructures.

Ubiquitous computing aims at making computers available throughout the environment, while rendering them effectively invisible. Real-world objects that contain embedded processors and sensors provide novel ways of accessing information, but they may also react to their environment and they may provide new emergent functionality when interacting with other smart things.

This vision of smart objects in particular and ubiquitous computing in general is grounded in the belief that microprocessors and advanced sensors will soon become so small and inexpensive that they can be embedded in almost everything. It is expected that billions of such objects will be interwoven and connected together by wireless networks, forming a world-wide distributed system several orders of magnitude larger than today's Internet. Infrastructures for cooperating smart objects have to cope with a highly dynamic environment and should, among other things, provide location information to mobile objects, represent context information, and enable reliable and scalable service creation.

One of the major ubiquitous computing projects at ETH Zurich is the Smart-Its project. It is one of 16 projects conducted under the European Union's Disappearing Computer initiative within the Future and Emerging Technologies programme. Its goal is to develop unobtrusive, deeply interconnected smart devices (so-called 'Smart-Its') that can be attached to everyday items in order to support new functionality, novel interaction patterns, and intelligent collaborative behavior. Eventually, Smart-Its should be as cheap and as small as state-of-the-art radio tags (RFIDs), but in addition they will also be able to communicate with peers, and they will be customizable in their behavior. In order to facilitate a meaningful integration in their environment, Smart-Its are equipped with various sensors providing context information.



One of the first Smart-Its prototypes, based on an Atmel microcontroller. Bluetooth modules allow communication between different devices.

Smart-Its only develop their inherent potential when acting in a collaborative environment together with other Smart-Its providing different sensor information and services. They require a background infrastructure in order to access distributed services, connect to remote devices, or exchange application-specific information. Among others, such services include location and security services as well as services for the propagation of context information.

The Smart-Its project is conducted in cooperation with the Perceptual

Computing and Computer Vision Group (ETH Zurich), the Cooperative Systems Engineering Group (Lancaster University, U.K.), TecO (University of Karlsruhe, Germany), PLAY (Viktoria Institute, Sweden), and VTT. The research areas being addressed include: embedded device development, perceptual computing methods for collective perception, infrastructures for smart devices, architectures for context-awareness, and evaluation of application scenarios.

At ETH Zurich, we are engaged in developing and evaluating appropriate communication schemes and adequate infrastructures for cooperating Smart-Its. However, we also interested in security and privacy issues, since this will be of prime concern in a world of highly interconnected, autonomous smart devices that will eventually permeate our everyday lives, effectively placing us under constant surveillance.

Furthermore, we cooperate with the University of St. Gallen in the M-Lab project to identify and create business applications for smart things in the area of business-to-business. The goal of the M-Lab is to build up a critical mass of highly qualified researchers and practitioners in the field of applied ubiquitous computing.

Ubiquitous computing is also part of our teaching activity. Besides teaching fundamentals of distributed systems, distributed algorithms, and Internet technology, our graduate level curriculum focuses on state-of-the-art research in ubiquitous computing. In our ubiquitous computing laboratory, students can devise and build their own smart environments using handheld devices (eg, mobile phones or pen-based computers), ID systems (eg, smart cards or RFID tags), and wireless communication equipment such as Bluetooth or WLAN.

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