RIPE | Selected Projects

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General Information about RIPE

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Pervasive Computing technologies are expected to replace the traditional personnel computers in many application domains not fully foreseen yet. For the IT oriented industry of the Upper Austria a unique chance may arise to gain international technological lead in this innovative sector.

The Research Institute for Pervasive Computing, enabled and funded by the Upper Austrian Government, acts as an applied research center involving the Institute for Pervasive Computing (formerly: Institut für Praktische Informatik) and the IT related Upper Austrian industry.

The mechanism of a transfer platform for innovative Pervasive Computing applications in the proven surrounding of the Softwarepark Hagenberg will enable the inquired and envisioned technical-industrial co-operations from an economic and organizational point of view.

Projects 2002 - 2005

This section of the report presents the projects carried out at the Research Institute for Pervasive Computing:

- Projects
- Digi Scope
- ContextComputing
- Digital Graffiti
- FutureAwareness
- Context-Framework
- GISS (Group Interaction Support System)
- SPECTACLES
- SMS Notification Service
- P2P Coordination
- PARIS
- Tangible User Interfaces
- MobiLearn
- WebWall
- INSTAR
- SmartCodes
- Smart Signs
- Digital Aura
- Smart Case

Digi Scope

With the embedding of invisible technology into everyday things and architectural spaces, these things and spaces also become the interface to “hidden” or “invisible” computational services. Embedded interactive systems allow mediating between the physical and digital (or virtual) world via natural interaction – away from the standard desktop displays and keyboards.

We believe that the utility of “invisible services” of smart appliances being better exploited when presented to the user in a more intuitive and natural way, thus raising the need for a better perception of smart environments by the user. To support people living in the real world populated with a variety of digital artefacts as created by the digital components in a smart environment, when acting, perceiving and interacting with objects in their environment, we propose a see-through based theatre experience of visual perception, seamlessly merging the artefacts of the real and the digital world.

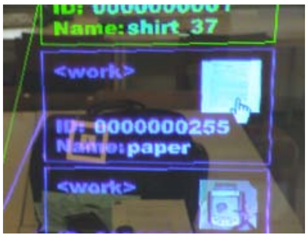
We provide now a seamless interface between real and digital world, the Digi Scope.

Key Issues

- Support an intuitive „invisible service“ inspection (see-through tablet)
- “Context-aware” smart appliances and smart spaces
- Provide services accessible via natural interaction
- Embodied into real world objects like furniture, clothing, crafts, rooms, etc.
- Building a „virtual world“ – out of the „physical world“

Approach

Towards a seamless visual perception of the coexistence of a real world and its virtual augmentation, we exploit the metaphor of digital annotations for real world objects, and display these annotations along the line of sight to real world objects that are seen through the tablet.



The challenge for digital annotation visualization via a see-through display is to cope with the changes and interactions among physical and virtual world objects in a certain environment or scene in real-time.

With DigiScope, the user is handling a holographic display tablet just like a window with six degrees of freedom opening a view into the virtual world. The tablet is an optical see-through display which allows a very natural viewing and scene inspection. To implement correct views into the scene, the angle and perspective of the DigiScope is being tracked, instead of tracking the position and orientation of the user. Thus the user is freed from all obstacles in the form of system hardware like head mounted displays (HMDs), stereoscopic glasses, trackers, sensors, markers, tags, pointers and so on. DigiScope builds on hologram technology manufactured in a thin film and laminated to a transparent acrylic plate.

Publications

- A. Ferscha: “Embedded interactive systems: back to the real world”, e & i elektrotechnik und informationstechnik, Springer Verlag, nu. 120/9, nu. 120/9, ISBN: ISSN 0932-383X, pages: 284 - 289, 2003.

- A. Ferscha, M. Keller: DigiScope: “An Invisible Worlds Window”, Adjunct Proceedings, The Fifth International Conference on Ubiquitous Computing, Seattle, Washington USA, pages: 261-264, October 2003.

ContextComputing

In recent years we have witnessed the occurrence of more and more technological developments regarding sensors and wireless communication. At the same time, the computational and sensing capabilities of portable devices are increasing, and these devices are becoming ubiquitous in our environment. This makes them ideal candidates for acquiring and providing context. On the other hand, various software and middleware frameworks have been proposed for supporting development and deployment of context-aware applications.

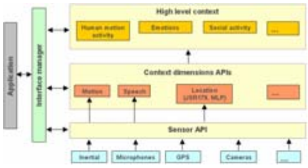
Under these circumstances, developers in context-aware computing have to deal with various technological constraints and with the important issue of interoperability. Thus, the need for standard specifications in this area is dire.

Motivated by the above considerations, we are currently developing a Java API and reference implementation for providing context services to applications that target mobile devices (e.g., mobile phones). Regarding context-enabling technologies, we consider wireless sensors, with emphasis on accelerometers. We are investigating the use of accelerometers as means for explicit and implicit interaction within context systems. In this respect, the main areas of applications are gesture recognition, human activity tracking and activity tracking of artefacts. This will highlight the potential of mobile phones as context systems.

Key Issues

- Context description, software abstractions for context
- Context representation
- Context acquisition
- Context tracking and prediction
- Wireless sensors
- Gesture taxonomy
- Gesture alphabet and interface

Approach



With regard to the Context API, we propose a three-layer architecture that consists of a Sensor API, a set of context dimensions APIs and a set of high level context APIs. An interface module is responsible for gathering the various types of context information made available by individual APIs, and for offering this information to applications in a unified manner.

Our Context API accommodates implementations on container frameworks, where various modules at all layers can be instantiated or dismissed dynamically. In particular, our reference implementation will use an OSGi compliant platform, in view of the potential of the OSGi specification to be adopted as a successor of MIDP in mobile phones.

The Context API is being built on top of a Motion tracking API, which has already been defined. As a substantial argument towards using accelerometers for explicit and implicit interaction in context systems, a gesture library was created. The gestures of this library are application independent, and they are offered through the Motion Tracking API.

We distinguish three types of gestures:

- Hand gestures, where the inertial sensors are attached to the hand. In this case, gestures are generally used for explicit interaction, and in some cases for recognition of human activity.
- Artefact gestures, which are movements of artefacts graspable by the human hand (e.g. mobile phones). Such movements can be performed intentionally (e.g., when the phone is in the hand), or unintentionally (e.g., when the phone is in the pocket).
- Gestures or movements of objects which are manipulated occasionally. As opposed to the previous two categories, these gestures are more likely to be used for human activity tracking and for implicit interaction.

Our proposed approach of employing the mobile phone as a Context Hub between sensors and back-end systems will enable the usage of gestures in the

first two categories, thus highlighting the potential of the mobile phones as context systems.

Publications

- A. Ferscha: “Pervasive Computing”, Datenbank Spektrum, Vol. 3, No. 7, 1618-2162, pp 48-51, October 2003.

- A. Ferscha, S. Vogl, W. Beer: “Context Sensing, Aggregation, Representation and Exploitation” in Wireless Networks, Future Generation Computing Systems, North Holland, 2003.

- V. Christian. “Pervasive Computing: Towards Self-Aware Systems”; The proceedings of the 2nd Workshop on Applications of Wireless Communications, Acta Universitatis Lappeenrantaensis, Lappeenranta University of Technology, ISBN: ISBN: 951-764-915-0, pages: 12-18, August 2004.

- M. Reichör: “TangibleControl: Universelle TUIs mittels Accelerometer”. Master Thesis, JKU Linz, 2004.

Digital Graffiti

Digital Graffiti are messages that can be placed at any location in the real world and addressed to any recipients who are not only identified by (phone) numbers. They specify their visibility by time and are only perceivable in a given context. The content of a Digital Graffito can be smart.

Smartness within a Digital Graffito has different forms:

- Dynamic content: Messages contain changeable elements, like a timer showing the remaining lifetime of a message.
- Influenced content: The recipient himself can influence the content of a message, like in a poll where he changes the statistical results by his vote.
- Executable content: Users are able to trigger actions through interactive elements or the Digital Graffito itself executes code when it is received.

The project "Digital Graffiti" is being developed in cooperation with Siemens AG Corporate Technology in Munich, Germany, and the Ars Electronica Futurelab in Linz.

Key Issues

- Pervasive Computing Techniques
- Localization and Wireless Communication Techniques
- Component-oriented software development
- Innovative Concepts for User Interaction
- Limited resources in embedded information appliances

Approach

The software architecture for smart elements within a Digital Graffito considers three fundamental aspects:

Conventional elements (e.g., text, pictures, video, music etc.) and smart elements can be arbitrarily combined within one message. No restrictions prevent the user from creating powerful messages.

The architecture enables third-party developers to easily design their own (smart) elements. As a consequence, the architecture provides an extensible framework structure which is prepared for deriving new elements from given templates.

Self-developed elements can be made accessible to all users without forcing them to download new versions of the client software or to restart their system. The users do not even recognize if an element has just recently been developed by a third party or if it is a basic element like plain text.

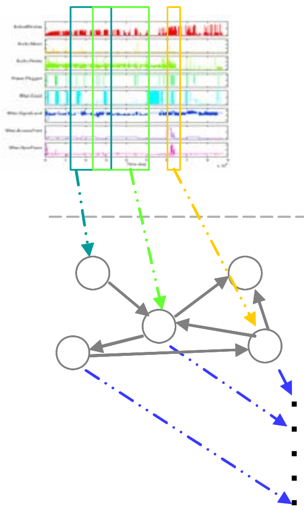
Publications

- W. Narzt, G. Pomberger, A. Ferscha, D. Kolb, R. Müller, J. Wieghardt, H. Hörtner, R. Haring, C. Lindinger, “Smart Components in a Pervasive Messaging Service”, Submitted to the 2nd International ACM/IEEE Conference on Mobile and Ubiquitous Computing (MobiQuitous), San Diego, CA, USA, July 2005.

- V. Christian, A. Ferscha, W. Narzt, G. Pomberger, D. Kolb, R. Müller, J. Wieghardt, R. Bidner, H. Hörtner, C. Lindinger, “Smart Roads in the Pervasive Computing Landscape”, 2nd International Conference on Pervasive Computing, Published in: Advances in Pervasive Computing, Austrian Computer Society (OCG) (Hrsg.), Vienna, ISBN: 3-85403-176-9, pages: 393-396, April 2004.

- TV Presentation at ORF2, “Treffpunkt Wissenschaft”, ORF-Center Linz, Europaplatz, 17.02.2005

FutureAwareness



Current mobile devices like mobile phones or personal digital assistants have become more and more powerful; they already offer features that only few users are able to exploit to their whole extent. One way to improve usability is to make devices aware of the user's context, allowing them to adapt to the user instead of forcing the user to adapt to the device.

The **FutureAware** project is taking this approach one step further by not only reacting to the current context, but also predicting future context, hence making the devices proactive. Mobile devices are generally suited well for this task because they are typically close to the user even when not actively in use. This allows such devices to monitor the user context and act accordingly, like automatically muting ring or signal tones when the user is in a meeting or selecting audio, video or text communication depending on the user's current occupation.

The **FutureAware** project uses an architecture that allows mobile devices to continuously recognize current and anticipate future user context. The major challenges are that context recognition and prediction should be embedded in mobile devices with limited resources.

Key Issues

- Predicting future context
- Continuous, unsupervised learning of user behavior with life-long adaptation to changing environments
- Use of nominal and ordinal features in addition to numerical
- Unobtrusive user interfaces for labeling context classes
- Limited resources in embedded information appliances

Approach

The main idea is to provide software applications not only with information about the current user context, but also with predictions of future user context. Typically, sensor readings will show common patterns because of user’s habits.

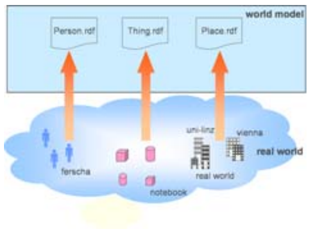
When equipped with various sensors, an information appliance could classify current situations and, based on those classes, learn the user's behaviours and habits by deriving knowledge from historical data. The automatically recognized classes of sensor readings can be regarded as states of an abstract state machine; context changes are then similar to state transitions. Our current research focus is to forecast future user context by extrapolating the past.

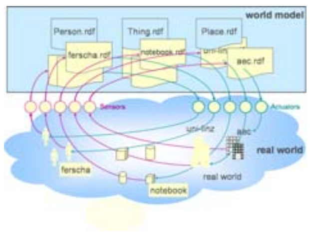
Context awareness is currently a highly active research topic, but most publications assume few but powerful sensors like video or infrastructure based location-tracking. The FutureAware project takes a different approach to context detection by using multiple diverse sensors, and extends it to also exploit qualitative, non-numerical features. The variety of different sensor types results in a better representation of the user context than a single generic sensor.

Publications

- A. Ferscha: "Pervasive Computing", Datenbank Spektrum, Vol. 3, No. 7, 1618-2162, pp 48-51, October 2003.
- R. Mayrhofer, H. Radi, A. Ferscha: "Feature Extraction in Wireless Personal and Local Area Networks". Proceedings of MWCN 2003, pp. 195-198, October 2003.
- R. Mayrhofer, H. Radi, and A. Ferscha: "A context prediction code and data base", Proceedings of the Benchmarks and a Database for Context Recognition Workshop, pp. 20-26, April 2004
- R. Mayrhofer, H. Radi, A. Ferscha: "Recognizing and Predicting Context by Learning from User Behavior". Radiomatics: Journal of Communication Engineering Vol. 1, No. 1, pp. 30-42, May 2004.
- R. Mayrhofer: "An Architecture for Context Prediction", PhD Thesis, Johannes Kepler University Linz, October 2004.

Context-Framework





The interaction with smart environments where everything is connected to everything is of fundamental importance. It is obvious that the established interaction technologies like keyboard, mouse, and display are not appropriate for pervasive computing systems. These interfaces are replaced by a potpourri of diverse sensors and modern technologies like RFID tags, GPS, temperature sensors, cameras, microphones, acceleration and rotation sensors, to note only some of them.

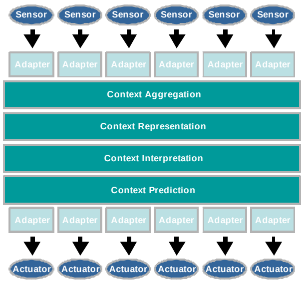
It is a fundamental must for such systems, which are based on those new interfaces that some kind of computational perceptional is integrated into them. Autonomous cognition, localization, perception, and prediction of future situations would be essential and necessary abilities of software components for pervasive systems.

The goal is to develop a pervasive computing environment (**Context-Framework**) which could collect information about its associated physical environment by use of all those different sensors and which could generate a representation of the direct and indirect context out of that sensory information, interpret this context representation and act back into the real world controlled by an automatically generated context prediction.

Key Issues

- Collecting Context-Information
- Event-Driven Programming
- Interpreted Event-Condition-Action(ECA)-Rules
- Modular Distributed Environment
- Sensors and Actuators
- Limited resources in embedded information appliances

Approach



By formalizing the whole process of context-processing, six different layers could be identified and specified.

- Context Sensing
- Context Aggregation
- Context Representation
- Context Interpretation
- Context Prediction
- Context Controlled Acting

The first layer, Context Sensing, is responsible for collecting as much information as possible about the context of the physical environment, to transform this information into a consistent collective data format, and to forward this data to the next layer. During Context Aggregation, all data coming from the Context Sensing layer are collected and combined in a way, that the Context Representation could generate a unified abstraction of the real world. The Context Interpreter together with the Context Prediction takes this abstraction and performs some application specific transformations to provide control values to perform Context Controlled Acting.

The challenge in developing context-applications following this architecture is the modeling of the interpretation of the context representation in terms of the semantics of the application. While earlier approaches have modeled context by some sort of key values, new approaches are using meta-data, object orientation models, or logic orientated systems where context are facts in rule based compositions.

Demonstrator “Munich Emergency Scenario”

By modeling a complex emergency scenario, the flexibility of the developed Context-Framework has been shown.

- **RFID:** To resolve the position of the Patients, Doctors, and the Ambulance and to identify all involved Entities

- **WLAN in Ad-Hoc configuration:** To be completely independent from an preconfigured WLAN-infrastructure and to facilitate the p2p nature of the framework
- **PDAs (iPAQ, Loox):** As lightweight devices

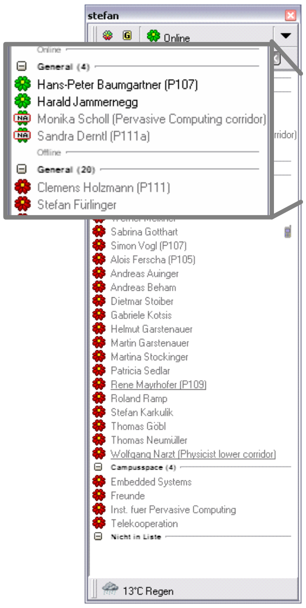
Publications

- Ferscha, A.; Vogl, S.; Beer, W.: Context Sensing, Aggregation, Representation and Exploitation in Wireless Networks, Future Generation Computing Systems, North Holland, 2003

- Beer, W; Christian, V; Ferscha, A; Mehrmann, L.: Modeling Context-Aware Behavior by Interpreted ECA Rules, Euro-Par 2003, Springer Verlag, LNCS 2790, pp. 1064-1073, 2003.

- V. Christian; Pervasive Computing: Towards Self-Aware Systems; The proceedings of the 2nd Workshop on Applications of Wireless Communications, Acta Universitatis Lappeenrantaensis, Lappeenranta University of Technology, ISBN: ISBN: 951-764-915-0, pages: 12-18, August 2004

GISS (Group Interaction Support System)



Today's computing environments are characterized by an increasing number of powerful, wirelessly connected mobile devices. Users can move throughout an environment while carrying their computers with them and having remote access to information and services, anytime and anywhere. New situations appear where the user's context – for example the current location or nearby people – is more dynamic; computation does not occur at a single location and in a single context any longer, but comprises a multitude of situations and locations. This development leads to a new class of applications, which are aware of the context in which they run in and thus bring virtual and real worlds together.

Motivated by this and the fact, that only a few studies have been done for supporting group communication in such computing environments, we developed a system, which we refer to as **Group Interaction Support System (GISS)**, that supports group interaction in mobile distributed computing environments in a way that group members need not be at the same place any longer in order to interact with each other or just to be aware of the others situation.

A similar approach is **Active Campus**; however, it does not support group formation and interaction, utilizes location as the only context information and it has a monolithic, inextensible architecture.

Key Issues

- Actively support interaction in groups within spatially bounded areas
- Cover synchronous and asynchronous communication
- Use context-dimensions location, identity, time and activity
- Take into account the context of the group members and those of the group itself
- Integrate a subsystem for automated acquisition of location and proximity information acquired by multiple sensors and their sensor-independent provision at application level
- Keep the client side as simple as possible and the user interface minimally intrusive

- Focus design on modularity, flexibility and extensibility

Approach

GISS has a flexible and extensible architecture for supporting group interaction in spatially bounded areas which is based upon a client/server architecture. It consists of a subsystem for location sensing, which acquires information about the location of users as well as spatial proximities between them, and one for providing context-aware services. In order to achieve modularity, flexibility and extensibility of the architecture, the whole system is built upon a Context Framework, which is a distributed Java-based middleware for developing context-sensitive applications.

In order to take advantage of location and proximity information, each client may have various location and/or proximity sensors attached, which are based on WLAN, Bluetooth or RFID for example. On the server side, abstraction and fusion of the sensor-dependent data is performed. The whole system is controlled by a core module, which serves as an interface to the location-sensing subsystem, collects additional context information (like time, identity and activity of a particular user) and triggers context-aware events.

The user interface is built upon a common instant messenger client, which can be integrated in the messenger interface and allows users to reuse their existing accounts. It provides a set of services which enhance group interaction by taking into account the current context of individual users as well as the context of a group itself. Location information is visualized in a two-dimensional map as well as unobtrusively integrated in a fully functional, ICQ-compliant instant messenger. Furthermore, context-aware reminders as well as the possibility to define rules for adapting the availability to the current context are provided, and virtual post-its as well as instant group messaging provide means of communication that go beyond the possibilities of e-mail or forums and conventional instant messengers respectively.

Publications

- A. Ferscha, C. Holzmann, S.Oppl: “Context-Awareness for Group Interaction Support”. Proceedings of ACM MobiWac’04, September 2004.

- A. Ferscha, C. Holzmann, S. Oppl: “Team Awareness in Personalized Learning Environments”. Proceedings of MLEARN’04, July 2004.

SPECTACLES

Autonomous Wearable Displays

Wearable see-through displays overlaying the user's real view with computer-generated display output have gained as a potentially effective means for a variety of mixed reality applications (e.g. in medicine, industrial maintenance, mobile information systems or even tourism and sports).

Such multimedia, wearable see-through spectacle systems allow to create a visual perception of the real world visually merged with a virtual world by annotating real life objects with computer-generated data to real world objects. The user is enabled to access any kind of information, unobtrusively adapted to his current situation, while not having to give up paying attention to his environment or conducting his tasks.

Key Issues

- Flexible toolkit for different application domains
- Component-oriented design for design-time and run-time adaptation
- Supports different media classes
- Custom hardware component integration

Approach

The project SPECTACLES attempts for a modular, autonomous, lightweight, wirelessly communicating wearable display device, that can be integrated into the physical structure of an eyeglasses frame. A modular and reconfigurable system design approach is followed both in hardware and in software, supporting a plug-and-play configuration of SPSs (“Special Purpose Spectacles") that meet the individual requirements of a specific use case scenario.

An SPS as an autonomous, wearable display system is enabled to communicate with its environment wirelessly (technologies like GPRS, BT and WiFi are being addressed), sense different environmental parameters, and display different kinds of media (video, audio, image, text). Besides the output facilities, the computational platform of SPECTACLES is designed to be flexible enough to allow integration of additional input devices like cameras, accelerometers and other sensor units that can act as a means for natural human-computer-interaction and as a source for recognizing the user's context and focus of attention.

SMS Notification Service

SMS notification services commonly follow a similar pattern: A user sends an SMS requesting to take part in a notification service. The request is immediately confirmed to the user. A special event finally triggers the actual notification procedure when the user is automatically informed about concerns of interest.

We have developed a generic **SMS framework for real-time notification**, co-operating with major mobile network operators in Austria and Switzerland. The main focus in this framework concentrates on real-time systems, database management and fault tolerance.

The SMS notification service has been successfully utilized in several mass SMS games and running competitions within the last years. The real-time SMS result service at the **Vienna City Marathon** and the **real,- Berlin Marathon** can be regarded as the most prominent showcases since 2000.

Key Issues

- Real-time notification
- Pervasive Computing techniques
- Database Management
- Fault Tolerance

Approach

The framework for SMS real-time notification establishes bi-directional, multi-threaded and asynchronous connections via SMPP to mobile network operators, which route all arriving Short Messages destined to an MSISDN to the framework kernel. After parsing, evaluating and logging the incoming SMS, an automatic reply to the origin MSISDN takes the same way back via the provider to the final destination.

For running competitions the initial registration process can also be accomplished via the internet. The triggering event for starting the notification process is activated through an RFID tag every runner carries on one of his shoes.

In cooperation with international time measurement companies the corresponding result records to an RFID tag could be transformed to a textual notification and sent to the subscribers in real-time.

Showcases

- Vienna City Marathon (2000-2005)
- real,- Berlin Marathon (2000-2004)
- Nestle (2003)
- Ironman (2003)
- Otto (2003)
- SurfWM Podersdorf (2003)
- Forum ONE (2002-2003)
- Grazer Altstadtkriterium (2002)
- Ski-Opening Arlberg (2002)
- Eskimo (2002)
- One-Roaming (2002)
- Life-Ball (2001)
- BMW Mini Promotion (2001)

P2P Coordination

Person-to-Person

Person-to-Object

Object-to-Object

A mobile society where the mobility is gaining more and more importance and the unplanned encountering of other previously unknown people or objects require new ways for supporting the interaction between such entities in ad-hoc scenarios.

Within this project we aim to provide support for the situated ad-hoc interaction among people as well as between people and everyday-life objects. Interaction is situated, which means that it is influenced by environmental parameters (the current context) of an interaction entity. It is moreover personalized regarding the interaction partners and is achieved autonomously as well as decentralized; each person (or object) acts on its own and an intermediary "interaction coordinator" is usually not required.

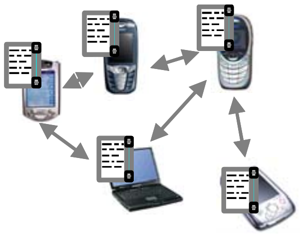
The **Peer-to-Peer Coordination** project is a comprehensive basis for the situated coordination and interaction of mobile devices in ad-hoc scenarios. It is operating fully decentralized; hence it does not rely on any kind of infrastructure and pays attention to the current environmental situation.

Key Issues

- Fully decentralized, "shared nothing" architecture
- Situated interaction, considering interaction partners, proximity and environmental situations (context)
- Self-description using profiles with capabilities, intentions and interests
- Matching of capabilities, intentions and interests
- Transparent interaction with resource-constraint devices
- OSGi industry standard compatible
- Means for ad-hoc code mobility

Approach

Within this project xml profiles, which are stored decentralized at each device, are used for the self-description of capabilities, intentions and requirements of



the corresponding entity. Upon two entities reach spatial proximity, a communication channel is established and the capabilities and intentions stored in the profiles of each entity are exchanged, whereas the current interaction partner(s) as well as the current context influence the amount of information provided, i.e. different opponents may receive different information, depending on “roles” entities are participating. The content of the transferred profile is matched against the requirements defined by the corresponding other device (“Profile Matching”) and if an adjustable amount of similarity is detected, applications on top of the framework are notified.

Considering the current interaction partner together with the adjustable degree of similarity provides essential means for privacy, called active and passive shielding which can be used to adjust the amount of information one is willing to provide as well as the importance that an interaction partner must have in order to get notified. Since different situations often imply different capabilities and also different requirements, profiles may additionally contain context-definitions, leading to a context-aware and situated coordination and interaction process.

The Peer-to-Peer Coordination Framework consists out of several OSGi compatible components which are organized layer oriented. The transport layer is responsible for actual communication with other devices, the proximity detector determines if a device is within a definable proximity range, the object identification component utilizes various components for identification of everyday-life objects. The P2P Service generally handles the availability and communication between peers as well as between peers and objects. The Ports-Service is used for transparent remote method invocation and code-mobility. The Profile Service is used to transfer and match personalized and contextualized profiles between peers. Applications, Profiles and Peers may use the Security Support module for encryption, decryption and authentication in mobile ad-hoc scenarios

Publications

- A. Ferscha, M. Hechinger, R. Mayrhofer, R. Oberhauser: “A Light-Weight Component Model for Peer-to-Peer Applications”, Proceedings of the 24th International Conference on Distributed Computing Systems, IEEE Computer Society Press, pages: 520-527, March 2004

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- M. Armbruckner: “Multi-User Interaktion in ad-hoc Netzen”, Master-Thesis, University of Linz, Austria, October 2002

- M. Hechinger: “A Peer-to-Peer Framework for mobile ad-hoc scenarios”, Master-Thesis, University of Linz, Austria, to appear

PARIS

Personal Augmented Reality Information System

Users of state-of-the-art navigation systems are supposed to understand an abstract representation of navigational information and translate it into their surrounding environment. In order to ease the perception of routing information we propose a **see-through-based** theatre experience of visual perception, merging digital elements with the panorama of the real world.

Showing a live-stream video of the scene in front of a mobile device makes the device itself a quasi transparent instrument with the advantage that the alignment of the virtual objects need not be calibrated for every individual user's eye position. There is only one constant observer — the camera position at the back of the device — enabling one **augmented reality** view that can be perceived by multiple users simultaneously from the same perspective.

The pedestrian navigation system has been completed within **cooperative work** with Siemens AG Corporate Technology in Munich, Germany and the Ars Electronica Futurelab in Linz.

Key Issues

- Augmented Reality
- Component-oriented software development
- Innovative Concepts for User Interaction
- Limited resources in embedded information appliances

Approach

For determining the current position of the device, a GPS receiver is used. A local pedestrian navigation system wirelessly transmits routing information to the mobile device or Smartphone via WLAN or GPRS. The supplementary use of an orientation tracker is necessary because the device with its camera can arbitrarily be moved in any direction.

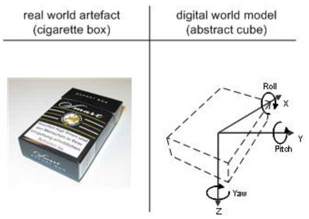
The route from the navigation system is provided by a dynamically changing sequence of geographical points in the 3D space. The concatenation of these points (e.g., through a cubic spline or by nurbs) results in the desired virtual path.

Corresponding matrix transformations rotate, shift, and zoom this model relative to the current position and orientation so that the spline finally resembles a colored part of the street viewed from the user's perspective.

Publications

- W. Narzt, G. Pomberger, A. Ferscha, D. Kolb, R. Müller, J. Wieghardt, H. Hörtner, C. Lindinger, “Applied Commercial Augmented Reality Applications”, Accepted for Publication in the Springer Journal: User-Centered Interaction Paradigms for Universal Access in the Information Society, 2005.
- W. Narzt, G. Pomberger, A. Ferscha, D. Kolb, R. Müller, J. Wieghardt, R. Bidner, H. Hörtner, C. Lindinger, “PARIS - Personal Augmented Reality Information System”, 2nd ACM International Conference on Mobile Systems, Applications and Services. MobiSys, Boston, Massachusetts, June 2004.
- W. Narzt, G. Pomberger, A. Ferscha, D. Kolb, R. Müller, J. Wieghardt, H. Hörtner, C. Lindinger, “A New Visualization Concept for Navigation Systems”, 8th ERCIM Workshop: User Interfaces for All (UI4All), Vienna., Published in the Springer LNCS Proceedings: User-Centered Interaction Paradigms for Universal Access in the Information Society, Vol. 3196 / 2004, ISBN: 3-540-23375-X, pages: 440-451, June 2004.
- G. Pomberger, W. Narzt, “Augmented Reality basierte Informationssysteme”, In: René Riedl, Thomas Auinger (Hrsg.): Herausforderungen der Wirtschaftsinformatik, Deutscher Universitätsverlag/GWV Fachverlage GmbH, Wiesbaden, ISBN: 3-8244-2179-8, pages: 193-206, June 2004.
- W. Narzt, G. Pomberger, A. Ferscha, D. Kolb, R. Müller, J. Wieghardt, H. Hörtner, C. Lindinger, “Pervasive Information Acquisition for Mobile AR-Navigation Systems”, 5th IEEE Workshop on Mobile Computing Systems & Applications, Monterey, California, USA, ISBN: 0-7695-1995-4/03, pages: 13-20, October 2003.

Tangible User Interfaces



The term tangible user interface (TUI) was introduced by Ullmer and Ishii. TUIs couple physical representations (e.g., spatially manipulable physical artefacts) with digital representations (e.g., graphics and sound), making bits directly manipulable and perceivable by people.

Tangible Interfaces make bits accessible (tangible bits) through augmented physical surfaces (e.g. walls and desktops), graspable objects (e.g. building blocks and instruments) and ambient media (e.g. light, sound and water-flow) within physical environments.

Generally speaking, tangible interfaces are systems relating to the use of physical artefacts as representations and controls for digital information. A central characteristic is the seamless integration of representation and control whereas input and output devices fall together.

This project is based upon the vision of universal, non-verbal, physical interface for everyday objects (e.g. a cigarette box), which has little weight and operates autonomously, can be integrated in existing applications easily and is capable of communicating wirelessly.

Key Issues

- development of a Tangible User Interface (TUI) for recognizing hand gestures
- easy integration in existing applications and possibility to define additional gestures
- independence of the form of artefacts as well as the underlying sensor technology
- autonomous operation and little weight of the sensor hardware

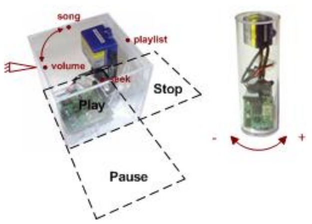
Approach

A **tangible user interface** has been developed which consists of an inertial sensor (InertiaCube2), a RS232-to-Bluetooth-converter as well as a battery pack for autonomous operation. The server-side software consists of a well defined interface so that the software is independent of particular sensor hardware.

Gestures can be recognized by three different characteristics, namely the state of the artefact (i.e. a certain orientation), a state transition (i.e. a particular sequence of states) or the way it is being moved, whereby a trajectory in the three-dimensional space defines the gesture. The starting point can be chosen arbitrarily.

The Java-based **software architecture** is based upon an event-model and supports different sensors. Dynamic adding and removing of gestures is supported.

Six **artefacts with different geometric forms** (cone, pyramid, cuboid, cube and two cylinders) have been equipped with the hardware described above and evaluated with respect to their suitability for interaction. For short, artefacts with edges are suited for changing discrete states, whereas the number of surfaces represents the number of states. On the other hand, artefacts with roundings are better suited for continuous control.



Based on this system, a **mediaplayer-control** has been implemented. The player is operated by the help of multiple tangible objects at the same time, whereas each artefact controls a certain function (e.g., stop, play, pause with a cube- and volume control with a cylinder-based artefact). In another scenario, the system has also been evaluated with respect to **controlling a robot arm**.

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- A. Ferscha: “Pervasive Computing”, Datenbank Spektrum, Vol. 3, No. 7, 1618-2162, pp 48-51, October 2003.

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- M. Reichör: “TangibleControl: Universelle TUIs mittels Accelerometer”. Master Thesis, 2004.

MobiLearn

Mobile Learning

Recent developments in **mobile learning** (mLearning) indicate that mobile devices have to be considered not only as an enhancement of existing transfer platforms, but rather as tools to provide universally accessible services for all those involved in transfer processes. This kind of transfer of public into learn spaces does not only require a platform where learners access learning material suitable for the device they use, but also content that is closely linked to discussions, communities of practice, and interaction media of coaches.

The material has to enable learning **at any time** (it requires an infrastructure and access devices that are commonly available for 24 hours every day), **at any place** (this requires to rethink the forms content can be provided for stationary and mobile use), and **in any situation** (it has the consequence of providing content elements that encode didactic quality) **for each learner** (it requires the possibility of dynamically selecting content elements according to the type of learner and his/her needs) This type of independency requires content providers to revisit their material and to reflect the situations of use. Far more than in stationary transfer, selective content consumption as well as a high degree of flexibility when tuning devices, content elements, and communication features seem to be crucial.

Key Issues

- Creation of a mobile learning environment for synchronous and asynchronous communication
- Independence of time, place and learning device
- Adaption to learning situation
- Embedding of awareness features for facilitating team learning
- Modular reuse of learning content
- Creation of 12 learning modules for the media informatics domain

Approach

The MobiLearn approach avoids creation of preorchestrated content, but allows to come up with highly modular content that can be combined as needed by teachers as well as by students and that can be made available in proper form for the various output channels like online PC/notebooks, online or offline PDAs or Smartphones as well as for offline print products. MobiLearn content is not available in terms of single, downloadable files, but is accessible by means of different views.

It is quite obvious that content needs to be structured such that it can be used for the various purposes of an any-time any-where scenario, whereas the concept of learning units, which can be composed to bigger modules, is used. Learning units are coded in **XML** and valid regarding a certain DTD. This approach allows the definition of transformation processes and guarantees interoperability between different learning systems. Transformation processes enable delivery on the fly as well as delivery of offline content. Moreover, they are aggregated to modules via IMS Content Packaging and they can be annotated via the IEEE Learning Object Metadata (LOM) standard. For assessments, IMS Question & Test is used.

The MobiLearn project considers **three categories of devices** – Notebook and Personal Computer, PDA, and Smartphone – with different capabilities and limited resources related to display size, processing power and communication bandwidth. Thus the presentation of the content has to be adapted to the learning device on the fly. Automated transformations from XML-coded base content into device-specific presentation are supported.

Learning units are sequential compositions of presentation units. A presentation unit is composed of one or more content blocks presenting given subject at the same level of granularity, encoded by means of **Level of Detail (LOD)**. The MobiLearn project considers the three Levels of Detail LOD 1 (highly structured text similar to slides), LOD 2 (detailed text similar to a script) and LOD 3 (additional materials like interactive elements). Furthermore the three Levels of Detail are synchronized among each other, i.e. each presentation unit may have one or more corresponding presentation units at the other levels of detail.

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- A. Ferscha, C. Holzmann, S. Oppl: “Team Awareness in Personalized Learning Environments”. Proceedings of MLEARN’04, July 2004.

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- M. Pohl: “Guidelines for E-Learning – Advantages and Disadvantages”. Proceedings of ED-MEDIA’04, June 2004.

WebWall

Public n:n Communication

The WebWall project addresses the potentials of ad-hoc multi-user communication in the **public** using a **wall metaphor**. Public wall displays provide an area for presenting information to a potentially anonymous audience as a stationary artefact. People encountering a wall may interact with it informally at different degrees of involvement, depending on their awareness and interest in the activities prevalent on a given display.

Multi-user communication and interaction via public displays together with the pervasive and seamless access to the WWW in public areas via mobile phones or handheld devices is enabled via the WebWall system. A software framework for the operation of WebWalls has been developed, strictly separating WebWall access technologies (like HTTP, email, SMS, WAP, EMS, MMS or voice based control) from the physical display technologies used and the presentation logic involved. The architecture integrates ubiquitous wireless networks (GSM, IEEE802.11b), allowing a vast community of mobile users to access the WWW via public communication displays in an ad-hoc mode. A centralized backend infrastructure hosting content posted by users in a display independent format has been developed together with rendering engines exploiting the particular features of the respective physical output devices installed in public areas like airports, train stations, public buildings, lecture halls, fun and leisure centres and even car navigation systems. A variety of modular service classes has been developed to support the posting or pulling of WWW media elements ranging from simple sticky notes, opinion polls, auctions, image and video galleries to mobile phone controlled web browsing.

Approach

The WebWall framework enables flexible, public access to a number of service classes using different input devices.

To enable high degree flexibility, the framework strictly separates access technologies and display devices from the application logic itself by providing a standardised XML-based interface: Requests to the system as well as events for the display clients are defined in DTDs.

The backend collects requests from different access technologies like SMS, MMS, eMail or Bluetooth OBEX (among others) and routes these requests to the addressed Virtual WebWall, where service interaction takes place: Users can create new services, delete their own items or interact with on-screen content using a powerful yet intuitive command language.

Whenever the contents of a WebWall changes an event is created and sent to the physical WebWall, were the visual state is updated accordingly.

Publications

- A. Ferscha, G. Kathan, S. Vogl WebWall - An Architecture for Public Display WWW Services WWW2002: Middleware and Applications, Honolulu, Hawaii, USA, May 2002.

- A. Ferscha, S. Vogl Pervasive Web Access via Public Communication Walls Pervasive Computing, Springer LNCS 2414, (Best Paper Award), Zurich, Switzerland, pages: 84-97, August 2002.

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INSTAR

Information and Navigation Systems Through Augmented Reality

Various types of car navigation systems are currently entering the market. Although, the depiction of the geo-graphical information has increasingly improved during the past years, users are still handicapped having to interpret an abstract metaphor on the navigation display and translate it to their real world.

INSTAR introduces a new visualization paradigm which reduces the abstraction gap between navigation system and real world perception by using augmented reality concepts in the graphical display of the navigation device.

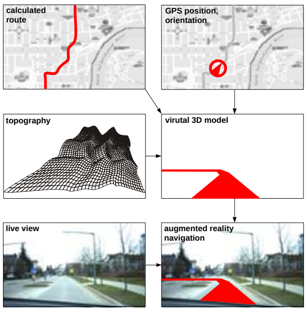
The Pervasive Computing group is responsible for the development of the software framework integrating real time imaging, pattern recognition, tracing, global position sensing (GPS), the on-car accelerometer, speed and orientation sensing, and display control.

The augmented reality car navigation system has been completed within the cooperative work of Siemens AG Corporate Technology in Munich, Germany, the University of Linz in Austria and the Ars Electronica Futurelab, also in Linz, and will (most likely) be rolled out by a major European automotive manufacturer within the next years.

Key Issues

- Augmented Reality
- Component-oriented software development
- Innovative Concepts for User Interaction
- Limited resources in embedded information appliances

Approach



A virtual road model is computed by processing the data coming from a conventional navigation system, its maps, and the received GPS signal. A combination of the current position, the orientation, topographical data and the calculated route enables the computation of a three-dimensional depiction of the route as it may look from the driver's perspective, which is then superimposed on a live stream video of the road ahead and shown on the navigation display. Current head-up displays using the windshield are not yet conceived to be used as a see-though window as originally intended.

Publications

- W. Narzt, G. Pomberger, A. Ferscha, D. Kolb, R. Müller, J. Wieghardt, H. Hörtner, C. Lindinger, “Applied Commercial Augmented Reality Applications”, Accepted for Publication in the Springer Journal: User-Centered Interaction Paradigms for Universal Access in the Information Society, 2005.
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- W. Narzt, G. Pomberger, A. Ferscha, D. Kolb, R. Müller, J. Wieghardt, H. Hörtner, C. Lindinger, "Pervasive Information Acquisition for Mobile AR-Navigation Systems", 5th IEEE Workshop on Mobile Computing Systems & Applications, Monterey, California, USA, ISBN: 0-7695-1995-4/03, pages: 13-20, October 2003.

SmartCodes

With the integration of **cameras**, mobile phones have evolved into networked personal image capture devices. Camera-phones can perform image processing tasks on the device itself and use the result as an additional means of user input and a source of context data.

With the **SmartCodes** project, we present a system that turns such phones into mobile scanners for 2-dimensional visual codes. These codes enable local interaction with physical objects, printed documents, as well as virtual objects displayed on electronic screens in the user's vicinity.

Mobile phones are in reach of their users most of the time and are thus available in many everyday situations. They are therefore ideal devices for bridging the real world and associated entities in the virtual world. The visual codes provide visible "entry points" into the virtual world, starting from the local surroundings. This offers a natural way of local interaction and strengthens the role of mobile phones in a large number of usage scenarios. The smartCode-system also provides the basis for superimposing textual or graphical information over the camera image in close real-time in the sense of "augmented reality". This entails a manifold of application possibilities in situations where information is to be closely linked to physical objects.

Key Issues

- Recognize 2D-codes with every camera-enabled phone
- Provide time- and location-adaptive services based on code-recognition
- Usable on every MMS- and camera-enabled mobile phone without additional software requirements (server-sided recognition)
- Alternatively real-time client-sided code-recognition with additional software on the phone
- Content delivery via MMS, vCard, vCal or WAP-push

Approach

smartCodes are printable and can easily be attached to every object which should be augmented with additional information or services. The main idea is to provide users with up-to-the-minute information optionally adapted to his current location.

Basically it is possible to perform real-time recognition of smartCodes directly on the phone. Because of different maturity of available mobile software platforms and more advanced recognition possibilities on server side, recognition now is performed on a server which takes MMS-Messages including a picture of the code and delivers the associated content.

Candidates for smartCode-augmented applications are those, which are either highly variable in time (like e.g. stock quotes or weather forecasts) or significantly strengthen the link between the digital and the real world (e.g. business cards with coded digital vCard for seamless import of contact data into phones).

Smart Signs

Conventional **Posters, Signs and Shop Windows** are rather static today. Although modern systems allow dynamic content, they do not interact with users, instead they are “broadcasting” information to everyone, not considering if a user is interested in the corresponding information or not. Moreover, current posters do not allow to interact with them; for the interested user it is not possible to get additional information about the content of a “sign” nor is it possible to use interactive functionality, for example to submit a quote for an offer.

Smart Signs allow a personalized presentation of arbitrary content as well as interaction with signs. Users can “pickup” information by simply passing by the poster, whereas user preferences and interests are considered to prevent annoying users with unwanted information. Depending on the application, Smart Signs moreover allow the direct interaction with them. Our generalized approach allows to “stick-on” information to everyday-life objects, whereat such objects do not need to be full featured computers. A Smart Sign can actually be implemented using a conventional sign together with an identification technology such as RFID, Barcode or Visual Codes; a more sophisticated “display technology” however provides the advantage of a highly dynamic and personalized content.

Key Issues

- Information “stick-on” and unobtrusive, contextualized “pick-up”
- Interaction with everyday-life objects
- Considering user preferences to prevent annoying
- Immediate or delayed interaction with signs
- Transfer of active code from/to physical objects

Approach

The Smart Signs project demonstrates the functionality of interacting with resource-less devices introduced by the Peer-to-Peer Coordination Project. The end-user device is equipped with an appropriate identification technology like

RFID, Barcode or a Camera for identification of Visual Codes and a communication technology to reach other devices (for example Bluetooth, IrDA or WLAN). Each Smart Poster is assigned to one or more proxies which interact on behalf of the object and publish the responsibility periodically. Upon “detecting” a Smart Sign, the end-user devices remember the corresponding ID of the poster. As soon as a proxy for the Smart Sign is available, a communication channel between the user device and the proxy (interacting on behalf of the sign) is established and the contextualized interest-profile of the user is matched against the content provided by the Smart Sign. If both, interests and Sign content match, the content of the Smart Sign is presented to the user and stored on the user-device for later review (“contextualized information pick-up”). A Smart Sign may not only contain static data, but also active code, which can be transferred to the user-device in order to allow using a Sign specific interaction GUI and application logic.

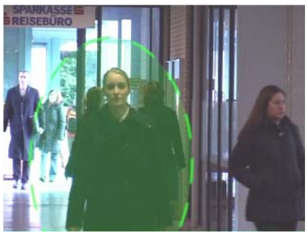
Interaction with a Smart Sign can either be accomplished immediately or delayed. Immediate interaction requires that a proxy is available as soon as the Smart Sign itself is detected, for example by utilizing an communication infrastructure such as WLAN or UMTS or having the proxy in place of (a collection of) Smart Signs. Immediate interaction therefore requires both, spatial and temporal proximity of Smart Poster and user. Delayed interaction does not require an immediately reachable proxy (interaction is accomplished later), thus interaction is achieved without spatial or temporal proximity between user and Sign itself.

Publications

- A. Ferscha, M. Hechinger, R. Mayrhofer, M. dos Santos Rocha, M. Franz, R. Oberhauser: Digital Aura, Advances in Pervasive Computing, Pervasive 2004, Austrian Computer Society (OCG), Vol. 176, ISBN:3-85403-176-9, pp. 405-410, April 2004

Digital Aura

In a world, where literally everything is connected to everything with invisible, wireless data links, we need new styles on how humans and things can interact.



"Digital Aura" proposes a "spontaneous interaction" thought model, in which things start to interact once they reach physical proximity to each other: Explained using the metaphor of an "aura", which like a subtle invisible emanation or exhalation radiates from the center of an object into its surrounding, a "Digital Aura" is built on technologies like Bluetooth radio, RFID or IrDA together with an XML based profile description, such that if an object detects the proximity (e.g. radio signal strength) of another object, it starts exchanging and comparing profile data, and, upon sufficient "similarity" of the two profiles, starts to interact with that object.

Key Issues

- Spontaneous interaction among everyday objects
- People and environments are mediated by various invisible computers in an ad-hoc style
- Self-explaining, self-aware autonomous computing devices

Approach

- interest and preference profile (XML)
- proximity sensing (BT, IrDA, WiFi, ..)
- "en-passant" profile exchange
- profile matching / similarity analysis
- active / passive privacy control

The Digital Aura

The vision of pervasive computing tells us that the future landscape of smart appliances and smart spaces will be one in which literally “everything” is connected to “everything”, interacting in a collaborative and coordinated way. A whole new class of problems related to the interaction among humans and machines comes along with this prospect, possibly better approached based on new thought models of “interaction”, than based on the classical understanding of computing.

In esotericism, the aura of a person (or a thing) is “an oval shaped, etheric, subtle, invisible emanation or exhalation” that radiates from the body in a spatially limited range, dense and thick in the portion nearest to the body, and thins out as the distance from the body increases.

The individual “auras” of persons or things can be built on the proximity area of a wireless sensor node, determined from the received radio signal strength (or the signal to noise ratio, SNR), as available from many wireless MAC layers for technologies like Bluetooth, RFID or IrDA. In our approach, a self describing interest profile, encoded in XML, is being attached to each individual object, and exchanged among objects that have approached physical proximity to each other. This whole concept of spontaneous interaction based on the metaphor of a “digital aura” has been implemented in the SILICON P2Pcomp software framework.

Publications

- A. Ferscha, M. Hechinger, R. Mayrhofer, M. dos Santos Rocha, M. Franz, R. Oberhauser: Advances in Pervasive Computing 2004, Austrian Computer Society (OCG), Vol. 176, pp. 405-410, April 2004.

Smart Case

A context aware smart suitcase, SmartCase, has been developed to illustrate a context aware software framework. The suitcase tag real world objects like shirts, keys, PDAs or even printed paper which are potentially carried. The suitcase itself is tagged and possibly sensed by readers integrated into home furniture, car or airplane trunks, conveyor belts etc., so as to allow for an identification and localization at any meaningful point in space of the application.

Key Issues

- Event triggered acquisition of context information
- Interpretation of context information
- Representing context information
- Control the environment
- Demonstration Scenario

A context-aware suitcase has been developed

The hardware for the suitcase demonstration prototype uses an embedded single board computer integrated into an off-the-shelf suitcase which executes a standard TCP/IP stack and HTTP server, accepting requests wirelessly over an integrated IEEE802.11b WLAN adaptor. A miniaturized RFID reader is connected to the serial port of the server machine, an RFID antenna is integrated in the frame of the suitcase so as to enable the server to sense RFID tags contained in the suitcase. A vast number of 125 kHz and 13,56 MHz magnetic coupled transponders are used to tag real world objects (like shirts, keys, PDAs or even printed paper) to be potentially carried (and sensed) by the suitcase. The suitcase itself is tagged and possibly sensed by readers integrated into home furniture, car or airplane trunks, conveyor belts etc., so as to allow for an identification and localization at any meaningful point in space of the application.

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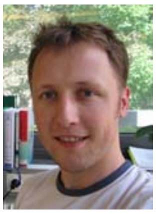

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