Paving the way for new business

Innovative architecture

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User experience rules!

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Abbreviations

BFA: Business Focus Area
CAPNET: Context-Aware Pervasive Networking program funded by Tekes
HCI: Human-Computer Interaction
GPRS: General Packet Radio Service
GUI: Graphical User Interface
IPv6: Internet Protocol Version 6
MySQL: The world’s most popular open source database
PDA: Personal Digital Assistant
SMIL: Synchronized Multimedia Integration Language
SQL: Structured Query Language
UI: User Interface
WLAN: Wireless Local Area Network
XML: Extensible Markup Language
XML-RPC: XML-based Remote Procedure Calls
XUL: XML-based User Interface Language
Paving the way for new business

CAPNET (Context-Aware Pervasive Networking) research program creates a foundation for new information and communication technologies and for new business possibilities in the mobile service field. The research focus is on context-aware mobile technologies utilising ubiquitous computing. The technology base and mobile services together form one of the most promising business fields in sight: It offers great possibilities to open up totally new service concepts and uptuning existing business processes, as well.

The CAPNET program consists of four major segments, which are the basis for developing new services.

- processing of context information in profiling services for mobile user
- creating necessary software technologies for mobile pervasive services
- using rich content in the most efficient way in new technical environments
- adapting user interfaces to various terminals and environments.

The research work has a solid base in the innovatively structured CAPNET architecture which forms a foundation also for testing of ubiquitous computing applications. These applications are tested in selected prototypes. The successful prototypes are then modified to future applications with CAPNET partners. The purpose of future applications is to create business oriented value-adding services that have a strong base in CAPNET research. The prototypes and applications produce valuable feedback for iterative development of CAPNET architecture.

The work in CAPNET is not only technological. Also actual user needs and behaviour are studied, and several use case scenarios have already been developed. These use cases are implemented in CAPNET prototypes. It is important that these use cases reflect everyday situations and answer to users’ real needs. These needs are then transformed to technology research.

During the first year, one of the focal points of the first CAPNET prototype was routine learning, i.e. the pervasive network is set to learn the situations of the mobile user employing the terminal. When the device learns the habits of the user, it knows for example that in meetings the user has his/her mobile phone on silent mode and also acts accordingly. The first prototype can also facilitate a context-aware reminder service, for example location bound-electronic notes.

CAPNET pushes the limits of an increasingly ubiquitous service environment. The second prototype application is called business meeting, which will facilitate ad-hoc networking and instant messaging.

CAPNET is funded by the National Technology Agency (TEKES) and financially supported by participating industrial partners.

The researchers taking part in the program work in different research groups at the University of Oulu: MediaTeam, Intelligent Systems Group (Computer Engineering Laboratory) and INTERACT (Department of Information Processing Science). Also two other research institutes participate in the research: Institute for Advanced Computer Studies, University of Maryland (USA), and University of Linköping (Sweden).
Innovative architecture

The CAPNET architecture forms the basis for implementing context-aware and pervasive systems. It will be utilized in the CAPNET program in integrating research results into applications.

The CAPNET application area sets demanding requirements for the architecture. The applications will utilize a large network; a variety of devices and software scattered in the environment and communicating with each other via different communication methods. The user will interact with the applications mainly through his/her mobile terminal. Hence, the application has to be decomposed between the networked devices and the terminal.

Furthermore, to guarantee wide application area and interoperability, the architecture has to be platform independent. Finally, the user is mobile, which causes the local resources, the user’s context and hence his/her needs to change in a continuous fashion. To cope with this dynamics, the architecture needs to support removing parts of the application and adding others as the situation changes.

A system based on the architecture is distributed in the network. The architecture is decomposed into CAPNET Engines. Each engine contains a number of components. Components are the basic entities of a CAPNET system, and each component is specialized in producing functionality from one domain area.

The domain areas are organized into three levels: enabling, value adding, and application level.

The enabling level contains the domain areas for realizing the basic and essential functionalities for context-aware pervasive applications.

- Component Management is used to control all the local and remote components and to process the requests of component access.
- Connectivity Management is responsible for monitoring the changes of network resource and control communication channels.
- Service Discovery is used to locate resources and services, as well as other engines and components.

Components from the domain areas at the value adding level are optional to provide various supports according to the diverse requirements of ubiquitous applications. Media Domain Area provides multimedia applications with effective ways to capture and transmit images, audio and video as well as the ability to store and manipulate them either locally or remotely. Context Management offers situational awareness related services to ubiquitous applications through context information delivery and processing, history storing, routine learning, and service triggering. Context-Based Storage acts as a ubiquitous hard disk to remotely store user data, synchronize data updates and load data to local devices. Special emphasis is put on managing contextual data. UI components are used to create and manage application specific GUIs on the basics of UI descriptions provided by the applications, as well as to control the appearance and feel of the UI to adapt it to the situation.
The CAPNET Universe covers the network that contains subsystems of the CAPNET system. It is a pervasive networked environment where numerous engines operate. As the CAPNET Universe is planned to globally cover a wide network of devices, a wide continuum of different applications are possible. An application is composed of application logic and components producing the required functionality. The application logic achieves the required functionality by utilizing the services offered by the components. The components are located in engines in mobile terminals and other networked devices.

A simple application consists of application logic and a single engine, both in the mobile terminal. At the other end of the continuum, engines in the terminal and the network form a hierarchy, the application requesting services from some engines, which in turn request services from other engines.
Experimenting adaptive applications

CAPNET prototype demonstrates the work done in the CAPNET program. The first prototype implements an early version of the CAPNET architecture and provides a basis for testing and future development. Moreover, issues found in the concrete implementation can be taken into account when creating new versions of the architecture and developing prototypes. Prototype implementation also contributes to basic research and validates it.

CAPNET research is divided into different Domain Areas. The research done within each domain area contributes to CAPNET components, which provide the functionality of that particular domain area. XML-based remote procedure calls (XML-RPC) are used for communication between components.

- Component Management component is responsible for starting and initialising other components and handling the CAPNET engine. Component Management is a core process running in each device utilising CAPNET. In the first prototype, Component Management is able to run local and remote components and also load new components from the network. Dynamic component handling and adaptation are studied for the next versions.

- Connectivity Management component handles messaging between the CAPNET components. All XML-RPC activity between different CAPNET components is carried out through so-called channels. The idea is that a channel hides the actual connectivity methods from its user. Future work includes enabling changing the connections on the fly by utilising the channel functionality. In this case, the client only sends messages and data to the channel and does not need to worry about the actual connections. For example GPRS might be used first, and then the connection could be changed into a WLAN.

- Components and applications can be found via Service Discovery component. In the first version, Jini-based service discovery solution is used. Service queries are formulated with XML-based query language and the services are also described with XML. In the next phase, more context awareness and automation will be added to the service discovery system. Also methods for remote service discovery are studied.

- Context Domain Area component is responsible for providing the context information. Context Domain Area includes a Routine Learning component, which recognises important places and learns device profiles corresponding to them. In the future, routine learning is improved. The aim is for example to recognise a user’s routes and anticipate the user’s movements.

- Context-based Storage utilises a relational MySQL database and provides an interface for storing the user’s content and context. Research topics include
the creation of a general structure to organise contextual information, which can handle both user data and context information efficiently.

In the CAPNET prototype, UI and application are separate software components. Communication between the UI and application is carried out through CAPNET messaging system. The UI is described in XML-based User Interface Language (XUL).

User Interface component renders the graphical UI according to the XML description. It also captures user actions and sends events to the application. The application may send responses to the User Interface component. Separation of application and UI enables easy adaptation of the UI for different devices and usage situations.

Research and some early implementations have also been done on Media Domain Area, which will be part of the next CAPNET prototypes. Media Domain Area component processes media objects before they are sent e.g. via CAPNET channel functionality to small terminals. Some features include brightness adjustment and text detection. SMIL-based authoring tools and automatic metadata generation from media objects will be studied.
Prototypes test business scenarios

The first CAPNET prototype consisted of Personal Assistant and Context-Aware Reminder applications. The personal assistant recognizes the places the user visits most often. The Reminder application can be used to make location-based reminders for these places. The user can, for example, make a reminder that notifies the user and provides a shopping list when the user is leaving the workplace. The Personal Assistant also recognizes the device profiles that the user employs in different places. These profile changes can then be automated.

The second CAPNET prototype is based on two application scenarios that have been defined in co-operation with industrial partners. The scenarios are illustrated in the visualizations on this page. The first scenario involves ad-hoc networking of devices that are located near each other. This helps the user in taking into use the services available in a certain space, such as a meeting room. The CAPNET environment takes care of identifying services available, configuring them and adapting them to the needs of the user. Another scenario deals with sharing context information in messaging. This allows instant messaging type of communication between individuals.
Ubiquitous computing aims at embedding and diminishing technology to the environment. This means that technology becomes part of our everyday environment and will play an increasing role in our life. Therefore, when planning and testing ubiquitous computing environments, we need not only to consider the traditional usability of the system, but also the total user experience that will form itself in a dialogue of the technology, user and the context.

The user experience consists, for instance, of users’ emotions, expectations and relationships to other people and the context of use. Humans experience all the time, because they live in interaction with the prevailing environment and other people. Basically, humans experience always when they are interacting with technology. The aim of user experience research within HCI is to study user experience from the viewpoint of how the user can use a product better. The aim is to improve the interaction between a product and the user, not only make the product offer experiences. The challenge of user experience design and evaluation is that the user experience is an individual and unique experience in a particular interaction. Experience is an individual’s reaction that relates to contextual and social aspects.

User experience depends not only on the technology that is used. For instance, the context of use influences what kind of user experience a product generates. These aspects lead to an important problem area. First, how researchers or designers know which features of technology will result in a good or bad interaction experience. Secondly, what the context of use should be so that it would create positive experiences. Examples of experiences that can be designed and evaluated are: how the product feels in the user’s hand, how well users understand how to use the product, how users feel about the product while they are using it, how well the product serves their purposes, and how well the product fits into the whole context in which users are using it.

The user experience needs to be considered mainly in two phases of technology development: design and evaluation. User experience design methods aim at early involvement of experience factors in design choices. As the experience is always created in a dialogue of the technology, user and context, user experience design methods usually have a strong emphasis on prototyping and iterative design cycles. It is very difficult to design for user experience in a vacuum. Another area of user experience methods deal with the evaluation of a user experience. These methods aim at evaluating what kind of user experiences a completed product will evoke.

In CAPNET, we are exploring the evaluation of user experience evoked by technology utilizing ubiquitous computing. We are developing methods for capturing and interpreting user experiences, and translating them into design decisions. One part of this research is the user experience evaluation of the CAPNET prototypes.
Valuable fundamental research

Use of location information in mobile services increases

Location-based services are value-added services that utilise location information. Typical location-based services present the user for example with information about the nearest restaurants. Location-aware services, on the other hand, are location-based services that can change in form or content according to user location.

Location information is a central part of contextual information used in mobile services, and so also the CAPNET program has paid attention to it. In his diploma thesis, researcher Markus Aittola has discussed the concepts linked with location information and surveyed how location information in general is used and can be used in context-aware services.

On the basis of his surveys, Aittola has defined the four most important purposes of location information. Location information and location-based services can be presented to the user. Services can also be carried out automatically. In addition, location information can be combined with other data for later queries and used in deducing other context-related entities.

Location information is a vast concept, and there is no simple rule as to how and when it should be utilised. Once a suitable positioning method has been selected, the information has to be modelled in order to know what kind of coordinates will be used. The memory and engine capacities of mobile devices are limited, and sometimes the network connection is slow or none is available. Also small screen sizes cause problems. The choice of the positioning method is affected also by user context as well as means and speed of movement.

Use of location information is constantly increasing, and its role also in the CAPNET program is integral. Users of context-aware mobile services feel that the information really benefits them. However, restrictions related to protection of intimacy have to be remembered when utilising location information: a single database must not include location and identification data so that someone could be traced with them. Protection of privacy is honoured also in the research: the identity of test users must be unrecognisable.

“Development of context-aware mobile services requires careful selection of the technologies used as well as specific knowledge of their benefits, drawbacks and special features”, says Markus Aittola.
Application adapts to the user

Marika Tähti is a researcher in the INTERACT group in the Department of Information Processing Science at the University of Oulu. Her thesis was based on user interfaces adapting to user and user context. In the thesis, adaptive interfaces refer to interfaces that optimise their interaction with the user by utilising adaptivity models and user information.

Tähti studied prototypes and applications that already exist. She divided the UIs into three categories. Some interfaces allow the user to choose how the device will function. Alternatively, a device itself may suggest certain functions, but it is the user who finally decides how to work. The third type includes interfaces that evaluate the situation themselves and make decisions concerning operations.

Tähti used five criteria to investigate the UIs. Central aspects are whether the application can learn and what activates adaptability: if there are sensors, user modules or personalisation and profiling features being used. What also matters is what information the application is using, what the adaptation aims at and how the adaptivity is timed.

The thesis presents an adaptivity process in three phases: activation, analysis and actual adaptation. Tähti created a framework with which the dimensions and levels of adaptivity can be evaluated. Attention must be paid to whether the initiative comes from the user or the application, whether the application learns or not, what user information is gathered, and when the adaptation takes place.

The higher an application is placed in the framework, the more likely it is that the adaptation functions have been pre-programmed and the more information there is to be used. An application situated at the lowest level adapts only through user initiative. A learning device can automatically utilise information about the user and the context.

The framework has been used in the thesis to analyse one of CAPNET’s application scenarios (Ad hoc Networking), which, together with Instant Messaging, constitutes an entity called Business Meeting. The new prototype is based expressly on this entity.

The adaptivity level of the Ad hoc Networking scenario proved relatively high. More attention should be paid to whether the application could operate even more automatically and whether more information should be gathered. The basis of the CAPNET program is that context-aware services should be as adaptive as possible.

The framework created by Tähti is well applicable for designing application scenarios and improving existing applications. According to her, it is hard to tell whether adaptation is done in the application or in the UI. However, the user sees only the UI and what takes place there. Some visions of future ubiquitous environments do not necessarily contain any concrete UIs at all.
Visions for tomorrow

Pervasive, also called ubiquitous, computing is a mobile computing paradigm, which is based on the vision of environments saturated with computing and communication capability, yet gracefully integrated with human users. Computing power should be as invisible to the user as possible. Computing capabilities should not distract users but aid them in a kind of transparent manner.

As the last few decades have shown, technologies are evolving at an enormous speed. Computing visions from a couple of decades ago are nowadays viable commercial products: mobile phones, handheld computers, WLANs, etc., not to mention the appearance of Internet.

In the future, even more sophisticated technologies will exist. Network technologies will evolve, and mobile IPv6 will emerge. There will be new ad hoc routing algorithms. Software agent technologies and new protocols will enhance the cooperation and information sharing between different services. Efforts to make information in World Wide Web more machine-understandable are examined under a concept called Semantic Web.

There will be new terminal devices such as roll screens and displays that are integrated to eyeglasses. Methods for analysing multimedia are getting better. Digital money together with digital signatures and authentication will enable a new breed of services. Hence, in the future we will witness a yet new era of computing. Together all the new technologies will make more sophisticated, ubiquitous services. Some characteristics of future services are context awareness, proactiveness, availability, the ability to mask the variability of available computing resources in the environment from the user, and foremost: ease of use.

Pervasive computing will affect all parts of human life. New technologies will merge into our everyday life, not in one big step but gradually.

Context awareness is one of the key issues in pervasive computing, as computing capabilities should be used efficiently and in a non-distractive manner. Currently, most of the so-called context-aware services are usually only location-aware, but in the future services will start to utilise also other elements of context. Context information can contain almost anything from users’ emotional states to factors of their physical environment.

The basic context information that we observe in real life can be for example temperature, weather, time, location, identity of nearby people and objects as well as changes to these variables. When a friend of ours is smiling, we may come to the conclusion that he/she is happy. In this case, visual information is used in the creation of new, higher level information as emotions are concluded. Furthermore, both combined information of contexts and context history will be used.

Context information can be used for automatic contextual reconfiguration, a process of adding new components, removing existing components, or altering the connections between components due to context changes. Furthermore, contextual information can have an effect on the user’s commands, which can produce different results.
Location-aware services, which use also other context-elements.Notifications & warnings.

All in all, in the future, environments and devices will learn and adapt to user behaviour. For in any case it is the user who controls everything, initialising the learning algorithms and profiling the functionality of the system.

The use of PDAs is also increasing. The next step might be that people have one trusted personal device, which might be a kind of convergence of computer and mobile phone. This device would be the major method for interacting with networked services and the surrounding environment, smart spaces and such.

Wearable computers, i.e. computing capabilities embedded to clothes and such, will probably also be more common in the future. But one of the ultimate visions is that the user does not need to carry any terminal device at all, but he/she might directly communicate with the environment, for example via gestures and voice.

Some ideas of future services in computing environments might include: automatic updates to shopping list when needs arise or when food is taken from the fridge, automatic queries to shops, reservations to parking lots, concluding routes to shops, updating routes according to traffic jams or accidents, reminders about birthdays together with some gift ideas, automatic context-aware profiled marketing, and during cold weather a person spending time downtown might get an advertisement for a hot chocolate drink.

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<tr>
<th>Location-aware services</th>
<th>Context-aware services, which use also other context-elements. Notifications &amp; warnings.</th>
<th>Services, which use combinations of contexts and context history.</th>
<th>Truly proactive &amp; context-aware services with autonomic decision making.</th>
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<td>Key Application</td>
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<td>PC, PDA, Mobile Phones</td>
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<td>Interaction mode</td>
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<td>GPS, WLAN, GPRS, Internet</td>
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<td>Enabling technology</td>
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<td>Advanced routine learning, Protocols for sharing user information between services.</td>
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<td>Main Driver</td>
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<td>consuming time efficiently, ease the use of services</td>
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<td>Efficient use of ubiquitous computing environment</td>
<td>People are lazy.</td>
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Context-awareness: Visionary UBI Roadmap
How to join

Research in the CAPNET program is done on complementary levels: the results of long-term visionary scientific basic research are utilised in applied research done in cooperation with companies of the field. The aim is to transfer research results quickly into the industry and practical applications. The research is planned taking into account the business trends and the viewpoint of technology companies, while the enterprises can reflect their own operation with the research in the field along with the latest scientific trends.

It is worthwhile for companies to participate in research projects: in the scientific world, many different innovations can be experimented with, contrary to businesses where the activity is bound more to short-term results.

Enterprises now have the opportunity to use the CAPNET program for conducting company-specific projects that utilise the expertise created in the program. Company-specific projects meet the needs of the subcontracting company, with a potentially significant proportion of concrete product development. These so-called Future Application projects are short-term, three-to-nine-month projects for innovating new, promising applications as well as making concept plans and demonstrations. In a Future Application project, a company has the opportunity to learn about different application alternatives in the research stage and use this foundation of knowledge to develop its own products and services. Concrete, customer-based projects give the researchers knowledge and experience of the practical challenges in future applications.

In the CAPNET program, the business perspective is taken into account also in the Business Focus Area (BFA) model. One of the tasks of the BFA task force, established by CAPNET researchers and industrial partners, is to recognise promising application scenarios and technology modules. Participating companies can use some of the results directly in their own operation, while other results cannot be efficiently utilised by an individual enterprise. This is why the network provided by the CAPNET program is extremely important to many companies.

The basis of the BFA is to exploit the ideas created with the companies in the program to construct development initiatives from the business perspective and to appoint a body that will pursue them further. This may result in concrete multi-corporate cooperation in some application area, or a start-up company utilising a product or application idea based on the research, with involvement by the industrial partners in CAPNET. The cooperative projects and especially the start-up enterprise are supported also by the strong Mobile Forum network and the expertise of Technopolis.

The CAPNET Program Manager is looking forward to conferring with you about a CAPNET Future Application project for your own company or your participation in the CAPNET program in some other way (see contact information on the back cover).
The CAPNET program utilizes the expertise of researchers from various groups of the University of Oulu.
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