

# Context-Aware Personal Communication for Teleliving

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**28 July 1999**

## ***Abstract***

Personal Communication with mixed voice and data can be offered as a very rich set of applications, which can be rapidly introduced at low cost. Wireless and positioning technologies in combination with Internet's demonstrated capability to integrate voice and data are further leveraged by the use of software agents. Our work clearly demonstrates the benefits of providing context-aware personal communication in terms of its potential to bringing about the rapid introduction, at low cost, of a rich communication space where artifacts, people, and non-physical entities are integral parts.

**Keywords:** context-aware, communication, multimedia, agents, teleliving

## **1. Introduction**

Telephony services have been limited by the restrictions that the user interface of a telephone imposes. The convergence of telecom and datacom networks has led to a wide range of experimentation to create new services and opportunities. In the office environment, Computer Telephony Integration (CTI) solutions use computers to provide easier-to-use user interfaces for such tasks as user status, typing messages, placing, receiving and forwarding calls. Screen Phones (for households) attempt to improve the user interface and provide easier access to supplementary services. For mobile telephony, so-called smart phones have been introduced that combine office-automation software with CTI-functions with different form factors. Yet another interesting approach is to allow data communication with dedicated servers on the Internet, by means of the Wireless Access Protocol (WAP).

Currently the scope of telephony is being extended to the Internet and other networks that run the Internet Protocol (IP-networks). There are a number of key technologies involved to accomplish this. VoIP (or Voice over IP) is a common term to refer to the different protocols that are used to transport voice and the necessary signalling by means of the Internet Protocol (IP). H.323 is an ITU-T standard for real-time voice and video communication over packet networks [13]. During the past two years it has become *the* standard on the Internet for VoIP. Another relatively recent example is SIP (Session Initiation Protocol) for establishing multimedia sessions, that has been proposed in the MMUSIC working group in the IETF [14].

We are currently seeing a proliferation of development and business efforts in this direction. System vendors (e.g., Ericsson, Cisco, and others) from the telecom and datacom industry are offering communication solutions based on IP-networks that integrate VoIP with traditional services in the telephony networks. A strong trend is to move this functionality to IP-networks. Network operators and ISP's (e.g., Telia, Telenor, and others) are currently making extensive field trials in the market place. With the availability of VoIP-technologies on the Internet they are in the position to build applications that do everything that is possible in switched telephony networks and combine this with what is possible on the Internet thus giving these applications expanded functionality. However, to a large extent the industry is occupied with looking into ways of using this technology to rationalize this infrastructure and transfer familiar services, along with their existing business model, to these new networks.

A more productive way of looking at things would be to recognize that the Internet Protocol (IP) removes a number of limitations that previously restricted the type of applications that we were able to create in telephony networks. IP allows us to have multiple applications and services that access the transport medium at the same time, where hosts have equal roles. Services may be triggered by any event, not just calls [1]. In particular, advances in mobile computing research have shown that personal communication can greatly benefit from what has become known as context- and location-aware computing. Such applications take into account aspects such as:

- who is communicating, with whom or what,
- the context which that person or object is in, and
- the location or position of the person or object<sup>1</sup>.

These services utilize devices such as active badges, sensors (direction, speed, temperature), position receivers (both relative and absolute), and more. This awareness has been shown to be highly relevant to achieve more meaningful communication:

ParcTab was the first mobile computing system built to explore and exploit context-aware software [4], that allowed software to react to a person's changing context. Active Badges developed at Olivetti Research Laboratory (ORL) [5] facilitated the development of a "telephone receptionist aid" that gave advice on how to react to telephone calls in an optimal way, based on user context information. A second example is the SmartBadge [2], which included not only a tag but also numerous sensors and substantial computing capability. Examples of context-aware information systems are the Cyberguide [8], Mobisaic [10], and the "Forget-me-not" system [6,7] - the latter of which provides a human memory prosthesis, that shows relevant slices of an information base that is collected by the user and tagged with contextual information. Other examples are the Stick-e system [9], which allowed users to attach context-carrying information to the environment and respond to it in a relevant way.

We have come to recognize this datacom-centric approach to communication as central to the creation of new classes of personal communication services, that are not possible if voice services are delivered by means of a traditional switched access. We argue that VoIP is a key element of this new service model. If users are allowed access to communication services where no distinction is made between voice and data, then we

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<sup>1</sup>Since it could be an intelligent object.

are able to build services and communication artefacts where the user is not external to a network, but a participant in a communication space. By adding VoIP to a context-aware communication infrastructure we are able to create adaptive applications where voice is not external and where the user is immersed, as it were, in a communication space of Ubiquitous Computing [11]. As we move through this space logically and change our context, we may receive audio from different sources that is modulated in strength and direction accordingly. In addition, when we move physically, we may encounter devices that may participate in this communication.

## 2. Scenarios

In our model for personal communication, the services of the past will migrate and become an integral part of a communication space on the Internet. We may then cease to perceive them as services. This communication space will interact with the physical world by means context & location-aware technology. In fact the physical world can be represented and visualized, and this allows us to interact with each other and the things that we know, within this communication space. At the same time, we will interact with things in this communication space that have no existence in the physical world.

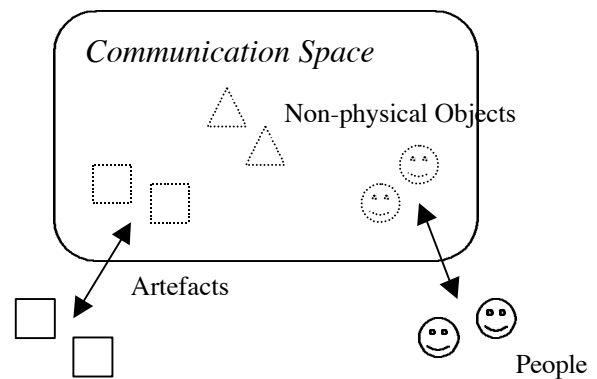


Figure 1 Communication Space Scenario

Consider for instance an office environment where people are highly mobile. A quick glance at a public presence-display will tell employees where a person is and make it easier to contact that person *only* if the information is kept up-to-date. Furthermore, it would be advantageous if this person can be contacted instantly by turning the display into a personal display for as long as needed to contact the person in question. Further improvements on this theme are if such a display or any other public display would be able to identify passers-by and respond by showing personal information, e.g., new unread messages. This differs from the active walls at MIT Medialab [3] in its emphasis in being a personalized public access medium to the communication space, rather than being a mediator between a person and media. Other examples might be that an employee is on-line and requests to be notified when a colleague arrives at a certain location. Employees in meetings could be awaiting some very important message. When your context is taken into account, there is no need to turn off the personal communicator as ordinary messages are presented in a non-disturbing way or just redirected to voice-mail, except for the ones with the required priority.

Our hypothesis is that a system as described above enhances personal communication within groups significantly. We have tested this hypothesis by letting staff members use the prototype application and infrastructure, that is described below. The second point is that it is possible to build these rich applications at low cost and to rapidly introduce them (as compared with traditional telephony services).

### 3. Prototype

In order to verify our hypothesis, we prototyped location & context awareness functionality and personal communication applications for mobile users in our communication network. We added location- and context awareness such that the basic services respond to who is using them and where they are being used from.

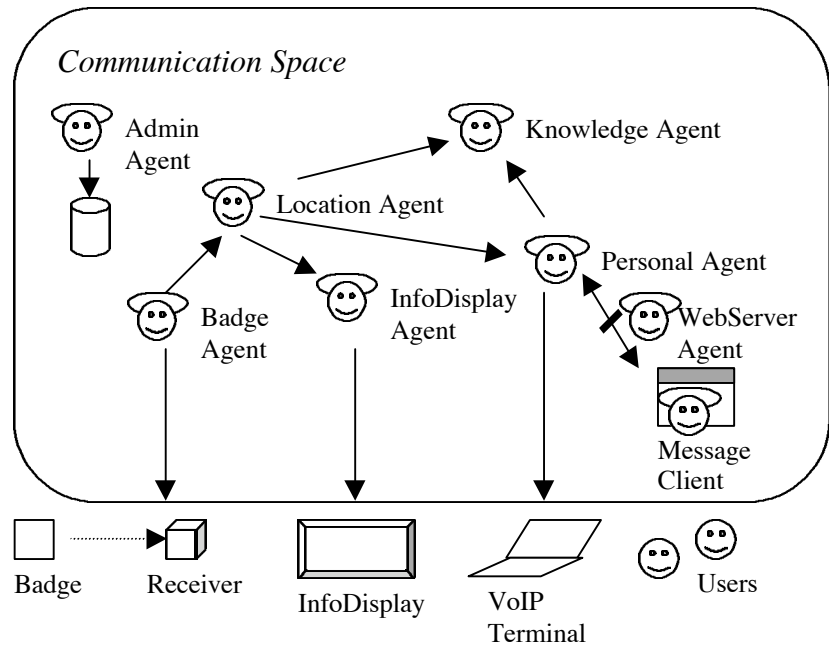


Figure 2 Prototype Overview

The basic communication services, that we have focused on, are messaging and voice services. An overview of our prototype is given in Figure 2. The role and meaning of the different components is explained in Section 4.

The system that is described here has been used to improve communications in an office environment. Staff members equipped with a badge were not only easy to locate and decide whether they were in or out of the office as was the case with the Active Badge system at ORL [5], but communication would also be routed automatically to the user's VoIP terminal (running on either stationary desktops or wearable computers connected via a wireless LAN). As this was built on an IP-network, staff members located outside of the office and connected via remote access were perceived as being 'present' just as those within the office building.

Below we present a few scenarios that we have implemented and explored. These are far from the only scenarios that are possible, and we are only at the start of research regarding such new applications. This basic infrastructure enables us to investigate which applications are possible and which applications make sense and why (or perhaps equally important why not). The scenarios that are described in this paper involve the use of:

- messaging and voice communication
- presence information
- a context-aware info display

### 3.1 Messaging and Voice Communication

The user receives an account from the system administrator. The profile in the account is used to advertise a URL. Web access of this URL prompts the user for a password in order to be able to use and configure applications. At this stage the user is able to browse, read, compose, send, and receive messages, or issue a call request.



Figure 3 User Logon

### 3.2 Presence Information

Subscription to a notification service alerts the user to the presence of another user at a specified location, by means of messages.

Note that these notifications are *interpreted* and transformed into messages, but could equally well be presented as audio or visual cues.

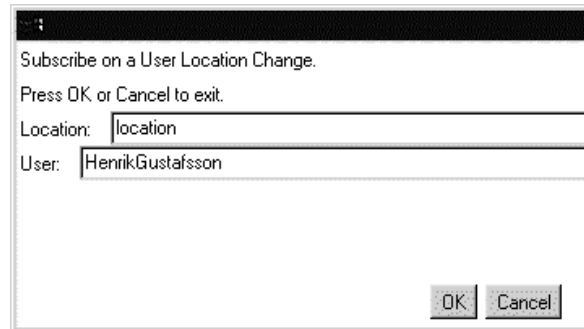


Figure 4 Subscribing to a Location Notifications Dialogue

Furthermore, the current implementation does not allow users to acknowledge subscription requests to monitor their presence in locations, nor does it allow other users to delete their subscriptions. However, a more elaborated scenario and prototype could very easily implement this functionality.

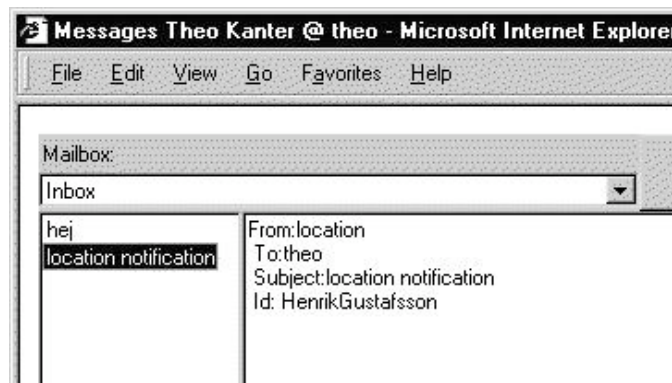


Figure 5 Receiving a Location Notifications Dialogue

Being at a desk, in front of a display or within a room: Location in our system represents a volume of space bound by proximity of a badge to (a) badge receiver(s) such that it is detected, and therefore can represent a physical location, such as a room or a building. The Location Agent that represents this volume of space is aware of the badge receivers and Info displays in its area, via their agents. Users passing by are identified by means of a badge and added to the list of users present at this location. Conversely, a user is removed from the list of those present, after having left.



Figure 6 Badge & Receiver

At present users are considered present for a certain time interval after each time they are seen. Presence information is also available on a web page associated with the location for easy access by human users.

### 3.3 Context-aware Info Display

The detection of a user's presence or absence is an event that is used as an input to determine a relevant action. In the prototype, the name of the user and the number of unread mail messages in the user's inbox is presented on the closest Info Display, accompanied by a sound cue (beep) to alert the user.



Figure 7 Context-Aware Info Display

## 4. Architecture

Figure 8 shows how the different components in the application were integrated in our service architecture. Each user is represented by an agent. Devices that a user may use are integrated via Gadget Memory [12] and are themselves represented by agents. Each of the basic services are also encapsulated by an agent per service.

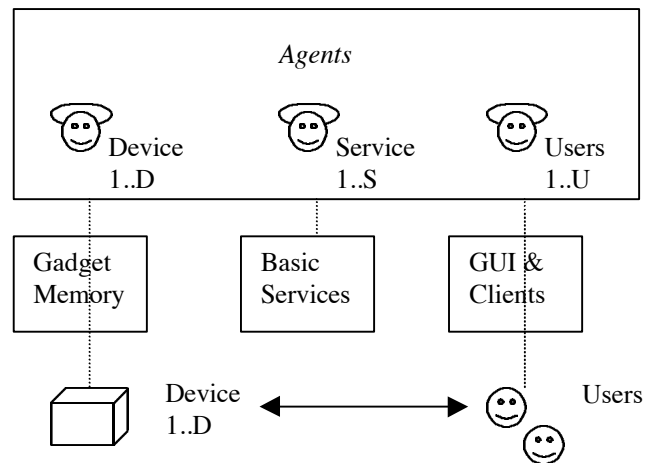


Figure 8 Architecture Overview

- **Badge, receiver & agent**  
The badge is, in this case, an active personal electronic device that has an identity which we can use to determine the identity of a user of the system. This badge's identity is detected by a Badge Receiver which can be placed virtually anywhere. The Badge Receiver passes this information on to the Badge Agent, which makes it available to the other Agents.
- **Info Display and Info Display Agent**  
The Info Display is a public information device. The display is capable of displaying information as directed by its agent.
- **Gadget Memory**  
Gadget Memory allows devices to be integrated seamlessly and represented by Agents through a distributed shared memory.
- **Location Agent**  
The Location Agent represents a physical location and communicates to other Agents when events happen at its location.

- Knowledge Agent

The Knowledge Agent is used to store knowledge about users, such as identities of their associated badges, accounts for messaging, voice mailboxes, personal devices, etc. It is used as an associative database.

- Personal-, Message-, & Message Client Agent

The Message Agent is the persistent part of the user's messaging capability. The Message Client Agent allows a user to query an agent which represents a location. The Client Agent also acts as a Personal Agent in that it incorporated behaviour to initiate Location Requests and VoIP calls.

- Agent Server, Web Server-, & Admin Agent

The Agent Server provides for the communication between Agents and is based on KQML [15]. The Webserver (not shown in the figure) provides a means for web-access to the Agents. The Admin Agent allows for administration of the Agents, such as creating a new message account.

## 5. Status

The system that has been described above has been up and running for about a year and a half in our lab network, and we have been able to evaluate the applications. Currently we have a number of badges, badge receivers, info displays, and users in the system.

We have integrated means for remote access to our agent enabled communication environment, such as Internet access, a web interface, remote dial-in (a modem pool), a voice gateway (for calls to and from the telephony network) and a wireless LAN. This has contributed to the exploration of the usefulness of the applications beyond the scope of a limited office space, where you are very much aware of the presence or non-presence of users, and thus expanded its value.

We did a redesign of our software architecture, in that the agents do not have to communicate by means of high-level KQML-messages over TCP/IP. For actions that do not involve reasoning and correspond to direct use of functionality in other software objects we use mechanisms akin to Java-RMI in Voyager™.

## 6. Conclusions

With our architecture and prototype we have shown the ease of integrating all kinds of basic services into applications *and* we can trigger on any event, not just calls - as in telephony networks. Therefore, an architecture based on the Internet for both voice and data services modelled on distributed software agents offers a framework for the rapid introduction of new applications, and subsequent seamless integration with other services (provided they make sense to a user). In summary, applications will be easier to introduce and richer in interaction. We may therefore expect that the adoption rate of new applications is much higher in this infrastructure. On the other hand, the pace of introduction and integration of these applications in the existing switched telephony networks, in particular IN<sup>2</sup>, will be dictated largely by the pace in which these existing

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<sup>2</sup>Intelligent Networks

applications will allow modifications. Our conclusion is therefore that future use of communications and applications are moving to the Internet, and this will further marginalize switched networks and traditional applications, beyond the already unfavourable position that they have in terms of cost/bandwidth utilization compared to IP-networks.

While our work offers a strong argument for new applications and moving these applications to an Internet-type infrastructure, there are a number of serious obstacles (from a user's point of view) that need to be overcome. *Security* and *privacy* issues must be addressed before more than early adopters will vest their trust in these systems. These systems must be *plug and play* in order to become popular and usable. There can be no arduous installation procedures or need for central customer administration support systems.

We find that users and artifacts, like active badges, sensors and public information displays, can be made to act as integral parts of a communication space [1]. An easy means of integrating artifacts was introduced and referred to as Gadget Memory [12]. New technologies such as JINI™ [17] and short-range radio links are other components that can be used. We lack a good understanding how to achieve a plug-and-play system, since it requires higher level intuitive mechanisms for establishing and maintaining (trusted) relationships between entities in the communication space.

Although a Society of Agents paradigm [19] is not a panacea for building these systems, we found that an Agent metaphor has some merits for implementing the applications - in particular, where high-level behaviour should be modelled. However, there is a large portion of the functionality where a more straight-forward method of using functionality in other objects is more appropriate. This second paradigm of software object technology also needs to offer automatic plug-and-play functionality. Implementing this basic behaviour in Agents is difficult. We argue that it is advantageous to rely on this second paradigm of basic software object technology and implement Agent functionality on top of it, where it is needed.

## 7. Future Work

We are currently investigating applications that will enable us to further explore the "teleliving" experience in the communication space, that we have described in this paper. These horizontal applications allow individuals to mix work and private life, possibly being members of trust groups. In particular, we may expect the combination of third generation wireless networks, short-range radio link technology and Internet to further emphasize the importance of our model.

Therefore, we are expanding our infrastructure with Presence and SIP-redirect servers, Wireless LAN access points, as well as Voice Gateways to new sites outside of Ellemtel, such as the Computer Communication System laboratory at the Royal Institute of Technology in Stockholm and we are extending this system to other universities. We will be able to communicate via this communications infrastructure using various wearable devices with mixed voice- and data- communication.

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This test bed will allow us to build and explore applications involving telepresence and local context, either at the actual location or at a location in one's virtual context. In doing so, we will research exactly what constitutes a personal mobile context and create an electronic context that:

- allows others to contact us with via 'global' identity, wherever we may be
- follows us when we move physically, with our device, on this (wireless) Internet
- is available with ubiquitous access
- is able to participate in a location context that we 'teleport' to
- allows us to discover and remember new services and devices
- facilitates ad-hoc set-up of multimedia (voice) sessions

With regarding to the device and personal mobility we will investigate optimal methods for using Mobile-IP and SIP in cases of real-time traffic and signalling. In addition we will perform user behaviour studies in order to find out what mobility and context shifting patterns need to be supported, in order to gain a better understanding how we may come to use the technology for "teleliving" purposes.

A forthcoming paper [12] will cover our investigation of requirements on the infrastructure regarding a systematic method of integrating hardware and communication devices in the communication space and services.

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