KiVS'1995. - in: Franke, K.; Hüber, U.; Kalfa, W. (Eds.): Proc. der GI/ITG Fachtagung Kommunikation in Verteilten Systemen (KiVS), Chemnitz, Germany, Feb 22-24, 1995. Berlin: Springer, GI Informatik Aktuell, ISBN: 3-540-58960-0; pp. 46 - 60

On the Convergence of Distributed Computing and Telecommunications in the Field of Personal Communications

T. Eckardt•, T. Magedanz, T. Pfeifer•**

****De•Te•Berkom, •TU-Berlin**
Hardenbergplatz 2, D-10623 Berlin, Germany
Phone: +49-30-254-99-200, Fax.: +49-30-254-99-202

Abstract

This paper presents and discusses the major trends in two important areas: distributed mobile computing and personal telecommunications. The evolution in these two areas indicates a major paradigm shift towards a merging of computer and telecommunications technologies into a world of mobile, interactive computing and communications. The resulting applications comprise the handling, exchange, retrieval, and processing of data, voice, and video streams as ubiquitous services based on an integrated computing-/telecommunications supporting environment. Based on important developments in both areas, a TMN-based Personal Communications Support System (PCSS) will be introduced, which provides personal mobility and service personalization capabilities in a generic way for a broad range of telecommunication services.

1. Introduction

Both, the general field of distributed computing as well as the broad area of telecommunications are characterized by a clear trend towards the development of small, mobile, and personalized pieces of equipment. A completely new category of applications will be running on top of these mobile platforms. On the (distributed) computing field these types of applications will exhibit a characteristic "location awareness" [Harter-94] and the need for advanced wireless communications capabilities [ACM-93]. The telecommunications face of the personal communications paradigm indicates the development of new generations of service environments driven by the fast market penetration of mobile, cellular data and voice communication equipment and technology [Heilmeier-93], [RACE-94]. Both categories of technology are complementary with respect to their future requirements: The area of distributed, mobile computing requires the seamless support of a multitude of different (tele-) communication services satisfying their advanced communication demands while the world of (mobile) telecommunications builds on the advancements in the area of mobile computing hardware and location-aware applications. The environment required for an economic and open provision of these future types of services has to be based on the most advanced computing and communications technologies [Bellcore-92], [TINA-C].

2. Converging Trends in Mobile Computing and Telecommunications

Mobility in telecommunications and mobility in distributed computing are both areas of fast changing technological evolution with broad impacts on the usage paradigm of computing and communications artifacts. A common trend towards a unified world of communications and computing is a prominent issue. This target communication/computing environment will be attributed by such characteristics as *any place*, *any time*, *any form/media*, *any service*, etc. The evolution and standardization in the world of telecommunications developments commonly take place at a stage as large as possible (i.e. in ETSI, OSI, or ITU standardization bodies). Here, we see a number of standardization activities concentrating on mobile telecommunication as outlined in section 2.2.4. to section 2.2.7.: DECT, GSM, UPT, DCS1800, FPLMTS, UMTS, and IN CS-2. On the other hand, the world of mobile distributed computing is usually characterized by industrial organizations and private research labs striving for the development of de facto standards. These standards are not necessarily open. In this area, we find major research activities at Xerox PARC and the Olivetti Research Laboratory in Cambridge, England concentrating on the issues of ubiquitous computing and electronic location techniques (see section 2.1.1. and section 2.1.2.).

2.1. Trends in Mobile Distributed Computing

In a brief overview, this section provides a summary of the state-of-the-art in mobile, distributed computing. *Mobile computing* has been defined in a very general way as "a technology that enables access to digital resources at any time, from any location" [Forman-94]. This technology is intended to represent the elimination of time-and-place restrictions imposed by desktop computers and wired networks. The most important issues to be addressed in this area are location aware applications, user location technologies, highly portable hardware platforms with new usage paradigms and sophisticated wireless communication capabilities and finally new applications and (personalized) services offered to the mobile user. The most prominent work in the area of 'location aware applications' currently takes place at Xerox PARC subsumed under the title *Ubiquitous Computing* and at the Olivetti Research Laboratory (ORL) in Cambridge, England which developed the *Active Badge System* [Want-92].

2.1.1. Ubiquitous Computing

The work at the Xerox Palo Alto Research Centre (Xerox PARC) focuses on distributed computer-augmented environments commonly entitled as *ubiquitous computing, augmented reality* and *virtual reality* [ACM-93]. There is a common philosophy, the primacy of the physical world and the construction of appropriate tools that enhance our daily activities, particularly in distributed computing environments. *Ubiquitous Computing* defines a computing environment that allows people to continuously interact with a multitude of wirelessly interconnected computers distributed mainly invisibly throughout the physical world [Weiser-93].

Xerox Palo Alto Research Centre (Xerox PARC) started with the construction of different types of mobile and fixed devices for a seamless interaction in an electronic office: a wall-sized interactive surface serving as the office whiteboard or bulletin board, a note-pad or PDA to be used as an electronic artifact of the species scrap paper (termed ScratchPad, XPad, or MPad at Xerox PARC), and a tiny computer, analogous to stickers or Post-it notes which is called the ParcTab. In the daily usage of the numerous computers of these three types of computing devices, each of it is not seen as a personal computer, palmtop computer, or fixed work station, but as a pervasive part and tool of the everyday life. The tabs and pads are equipped with IR and radio communications interfaces providing the means for wireless interactions. The main goal has been defined as to achieve a technology that is essentially invisible to the user. It must be ubiquitously available throughout the personal environment and should not require any special efforts to be used. According to Xerox PARC, a possible next generation computing environment will be characterized by a scenario where:

- Each person is continually interacting with 100s of nearby wirelessly interconnected computers.
- Emphasis is not on one powerful, mobile, and personal computer but on a multitude of simultaneously active computing devices building an *augmented reality*.

2.1.2. Electronic Location Technology

Olivetti Research Ltd. (ORL) in Cambridge, UK, a company owned by Olivetti and DEC, might be seen as the first address for advanced research in the area of electronic location technology. The general term, *Electronic Location Technology* might be understood as denoting a category of systems that track your location within a network site to allow your system resources to follow you. The elementary feature of this technology is to provide information on the position of people and equipment within an organization. ORL pioneered the usage of an *active badge system* to generate and process location information [Harter-94] on people and equipment. The active badge system (their approach to electronic location technologies) depends on small transmitting devices that you pin to your clothing (i.e., the Active Badge). Sensors distributed throughout the workplace pick up the signals from these badges and relay them, via low-cost networks, to location servers. The most apparent applications of electronic location technologies such as the active badge system are:

- Automatic login on workstations while roaming
- Phone messages or E-mail following the user
- Intelligent call-forwarding on a PBX

One of the most interesting results of their research activities is that when someone is *not* available appears to be the most useful function. According to ORL, it saves countless wasted journeys and phone calls. Besides the apparent advantages, there are a number of general problems of electronic location technologies: the use of location information may potentially be abused. Unrestricted access to personal location data is an unacceptable invasion of privacy [Spreitzer-93].

2.1.3. Personal Digital Assistants

A completely different aspect of mobile distributed computing is characterized by the new developments in the area of mobile computing hardware. A new vision of computing sees the personal computers of the nineties not as miniature, mass-product versions of main-frames but rather as intelligent, highly sophisticated electronic assistants and personal communications devices [Ryan-93a]. This new generation of small, highly mobile personal computers is called *Personal Digital Assistants* (PDAs). A Personal Digital Assistant is a hand-held, battery-operated system comprising computer hardware and software. Its input device is no longer a large keyboard but an electronic pen accompanied with highly sophisticated software providing handwriting recognition capabilities. With a PDA, the user is able to carry the computer and message-oriented communications devices into her pocket. A number of important issues have been identified as key technologies in the evolution of PDAs:

- *Wireless communications:* as small, portable, and highly mobile computing devices the wireless communications capabilities of the PDAs are of uppermost importance to their success on the market.
- *Low-power processors:* strict constraints on the size of the batteries result in a very low power budget. The largest chip-producers are currently developing a new generation of low-power processors dedicated for the use in PDAs.
- *Object orientation:* new demands on the software for PDAs will be met by object oriented programming of new operating systems and applications dedicated to the use on top of the PDA hardware.
- *Advanced integration:* in a market characterized by an increasing integration of computer technologies, telecommunications technologies and the entertainment (multimedia), integration of different communications services for access by a PDA becomes more and more important.

2.1.4. Advanced Message-based Communications

The developments in the area of PDAs are the main driving force for the evolution of new service platforms specially designed for the exchange of e-mails and new active types of mail. General Magic (Mountain View, CA, USA), a start-up company that results from an alliance between some of the largest players in the computing industry and the telecommunications industry developed a software/hardware platform characterized by PDAs that exchange active messages using their build-in communications capabilities. These active or enabled mails are rather agents based on a scripting language (i.e., Telescript) than any kind of static e-mail. They represent a transition from passive (information containing) messages or mail to active, enabled mail that remotely acts as prescribed by its author. With myriads of software agents or active messages moving around the network from one network node to another, we shall see the conventional WAN transformed into a smart network that may be understood as a complex, distributed computer itself. The goal is to allow the roaming user to receive or send e-mails from any place with the help of highly mobile PDAs which have to be provided with enhanced capabilities for mobile data networking.

General Magic designed a special communication-oriented operating system (i.e. Magic Cap) with a new type of GUI to support the new way of user interaction. Magic Cap is an object-oriented operating system (called ‘platform’ by the alliance’s members) specially designed for their species of PDAs. Initially, Magic Cap has been implemented on Motorola’s 68300 “Dragon” microprocessors but it is planned to be ported to other hardware platforms. Magic Cap does not rely as heavily on handwriting recognition as the Apple Newton, instead it concentrates more on the communications aspect of a PDA.

Telescript is an agent-based, communications-oriented programming language that is used to ‘implement’ the moving objects or agents. It has been designed to let casual users create intelligent applications that actively traverse the network to perform a specific task. It is a portable, script-based language that executes atop a run-time interpreter. That is, applications can run without recompilation on any supported platform or network node. Telescript incorporates the RSA encryption algorithm for secure communications. This is an important prerequisite for applications in the realm of commercially interacting agents in virtual worlds such as the electronic market place.

2.2. State-of-the-Art in Mobile Telecommunications

Due to the society’s increasing demand for “universal connectivity” and technological progress, mobile and personal communications are becoming fundamental attributes of future telecommunication systems. The vision for future telecommunications, as promoted by TINA-C, is *“information any time, any place, in any form”* [TINA-C]. This means that service delivery has to be provided in a *ubiquitous, transparent* and *personalized* way to end users. The end user’s view of the services has to be tailored to his/her personal preferences. The services should be accessed independent of the location of the end user (including the case that the user is moving) and independent of whether the network is wired or wireless. This section provides the reader with the basic concepts and terminology in mobile and *personal communications*. In contrast to (cellular or cordless) wireless communication systems supporting terminal mobility, the concept of *personal communications* is just emerging and represents a challenging service concept in the near future. The trends for mobile and personal communications can be viewed in terms of three areas:

- mobility in fixed and wireless networks
- personalisation of communication services access and delivery, and
- interoperability of interfaces and services.

2.2.1. Mobility

Mobility deals with the physical and logical location of customers. Here, three types of mobility have to be distinguished: *terminal, personal* and *session* mobility [TINA-C]. ***Terminal mobility*** allows user's to communicate or obtain access to information services while moving. A terminal will be identified by a unique terminal identifier independent of the network point of attachment. The user binds his identity to the terminal and hence becomes continuously reachable. This requires that the network must store and maintain location information of the terminal, i.e the network keeps track of the terminal location. ***Personal mobility*** allows users to make and receive calls independent of both the network point of attachment and a specific user equipment. This means that a user can use any network access point and any terminal, while being identified through a globally unique personal number and charged to the user´s personal account. This type of mobility is a layer above terminal mobility and independent of any radio link. This implies that the services a user has subscribed to can follow that user, where service capabilities are only limited by the network and terminal capabilities. Therefore, user specific location information and services information has to be stored and maintained in a "service user profile". Functions for user registration and authentication have to be provided by the service. In addition services could be personalized be the customers. ***Session mobility*** allows a service session that an end user is currently involved in, to "follow" that user independent of the location of the user and/or the terminal the user may have access to or of the access arrangement to the network. This requires functions for the service provider to maintain session files containing information about the state and parameters of a session, which are accessible from various locations at the request of the end user. Sometimes the term *"service mobility"* is also used in this context. However, the basic aspect of this concept is that a user has global access to an individual set of services.

2.2.2. Personalisation

Personalisation describes the customer´s ability to define his own working environment and service working conditions stored in a "Personal Service Profile". This profile defines all services to which the user has access, the way in which service features are used, and all other configurable communication aspects, in accordance with the user´s needs and preferences, with respect to parameters, such as *time, space, medium, cost, integrity, security, quality, accessibility and privacy*.

2.2.3. Interoperability

Interoperability is one step beyond personalisation and describes the capacity of a communications system to support effective interworking between different (possibly unrelated) services, supported by and offered on heterogeneous networks, with the long-term aim of achieving fully interworking applications. The key prerequisite for that target is that the same sort of service interface will work across a wide range of services, e.g. call forwarding could be used for voice telephony and multi-media conferencing applications. A system concept fulfilling these above mentioned demands of personal communications is the *"Personal Service Communication Space (PSCS)"*. It is currently under definition within RACE [CFS-B230].

Looking at the above given definitions it must be recognized, that the terms *"Personal Communications"*, *"Personal Communication Network (PCN)"* and *"Personal Communication Service (PCS)"* are currently used for various quite different mobile communications systems. In the future, the term PCS will be decoupled from specific mobile communication systems and will be used in a more generic way, encompassing terminal, personal and service mobility, based on wireless and fixed network technologies. This means that *PCS* can be seen as an umbrella concept, integrating all existing and planned mobile communication services. This is illustrated in Figure 1.

Personal Communication Services

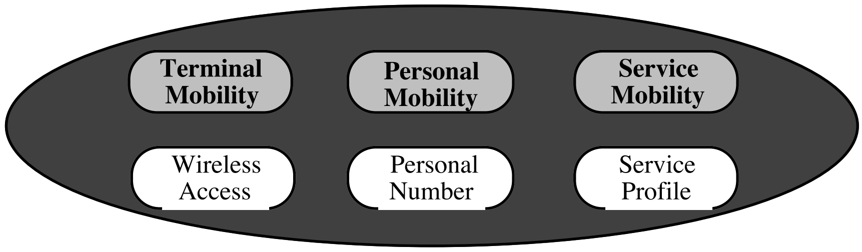

FIGURE 1 PCS as Umbrella Concept for Terminal, Personal and Service Mobility

Today, a jungle of mobile communication systems exists in the telecommunications world and it seems worth to take a look at the key systems. Therefore, we provide a short overview of the historical evolution of mobile communication systems in the following, as illustrated in Figure 2, and provide more details on the state-of-the-art systems in the following sections. In general three types of mobile communications systems can be distinguished:

- systems supporting terminal mobility, such as DECT, GSM and DCS1800/PCN;
- systems supporting personal mobility, such as UPT and PSCS; or
- integrated 3rd generation systems which are expected to start operation in the beginning of the next decade, such as UMTS and FPLMTS, supporting both terminal and personal mobility, while integrating also mobile satellite systems.

It has to be stressed that for public mobile communications systems, such as GSM, UPT and UMTS/FPLMTS, the Intelligent Network (IN) concept provides the basic architectural principles and thus can be seen as the network intelligence platform for these services.

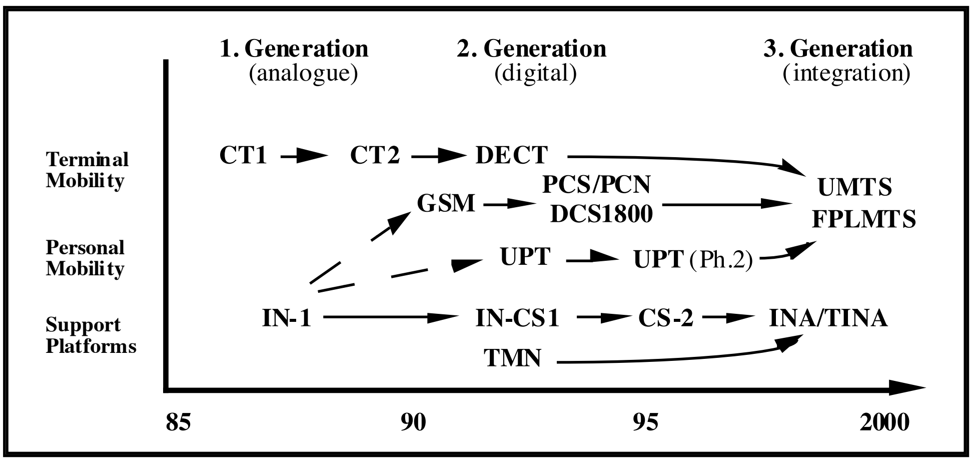

FIGURE 2 Development of Mobile Communications

2.2.4. Terminal Mobility-supporting Systems

Terminal mobility is offered by radio mobile networks, which can be categorized into *cordless* and *cellular* systems. First generation *cordless systems*, like *Cordless Telephone* (*CT1*) were based on analog technology replacing the local wire by a radio link. These systems have been followed by digital ones, such as *CT2* [CT2-89] and *Digital European Cordless Telecommunications (DECT)* [DECT-92], which have been designed with two applications in mind, namely the wireless access in private (notably office) and in public areas. DECT, operating over the 1880-1900 MHz bandwidth supports terminal mobility at walking speed and terminal driven seamless handover. DECT is the new European cordless standard, which will be used also for cordless applications in the public environment, namely for public base stations, known as

"Telepoints" (e.g. Zonephone or Phonepoint in the UK, or Pointel in France). Sometimes one can find in this context the notion of *Personal Communication Network (PCN)* for two-way telepoint (incoming and outgoing calls). Note that this term should not be mixed up with the same term introduced for GSM type cellular systems as introduced below. A good overview of cordless systems in general is given in [Tuttlebee-92]. In addition, EURESCOM, a common research institute for European PNOs, is currently investigating IN support of DECT, which has resulted in the definition of a combined terminal and personal mobility service, named *European Cordless Terminal Mobility (E-CTM)*, using UPT procedures in combination with DECT radio access [Ciancetta-94].

Looking at *cell-based systems* the first generation mobile radio systems were based on analog technology, such as the *American Mobile Phone System (AMPS)* or the *Nordic Mobile Telephone (NMT)*. Second generation radio systems are digital, such as the European *Global System for Mobile Communications (GSM)*, which has been standardized by ETSI´s GSM group in 1989 [GSM-89], formerly known as Groupe Speciale Mobile. In contrast to previous analog mobile systems, GSM represents the first pan-European mobile network, allowing users to roam throughout Europe. It was originally developed for vehicular mobile communication. In contrast to cordless systems, cellular systems are much more complex, since they comprise a *radio network* for the communication with the mobile station (i.e. mobile terminal) and a *fixed network* portion for maintaining location information of the mobile station. Hence GSM represents a complete system, comprising radio interface, infrastructure architecture, network interfaces and signalling protocols. First GSM-systems have been introduced in 1991, but it has to be stressed that GSM is only operational in Europe and will not be introduced on a global scale. (it has to be mentioned that GSM is also introduced in Australia, United Arab Emirates, Hong Kong and New Zealand.)

A global cellular system allowing global roaming will be possible with the direct successor of the GSM, the new *Digital Cellular System (DCS1800)* [Potter-92], also referred to as *Personal Communications Network (PCN)* [Liproff-94] in the United States. DCS1800/PCN, operating on 1800 MHz, defines a derivate of the GSM standard, that is designed for higher capacities in urban areas. DCS1800/PCN is a micro-cellular system, allowing for smaller cell sizes, higher frequency reuse and smaller devices and is going to be introduced in the 95/96 time frame on a global basis. This means that it can be regarded as a merger of the European and North American cellular systems [Wiygall-94].

2.2.5. Personal Mobility-supporting Systems

Universal Personal Telecommunications (UPT) is one promising service concept, which has been selected as one of the challenging applications of Intelligent Networks (IN) and is currently standardized in ITU-T [F.851] and ETSI NA7 [NA70102], [NA70201] in several phases. UPT enables access to telecommunication services by allowing personal mobility. UPT standardization and introduction should take place in so-called phases; UPT Phase 1 is only for support of telephony services over PSTN and ISDN in the 95/96 time frame, whereas UPT Phase 2 should allow for broadband services in the long term. In general UPT should enable users to participate in a user-defined set of subscribed services and to initiate and receive calls on the basis of a personal network-transparent UPT number across multiple networks (fixed or mobile) irrespective of geographic location, limited only by terminal and network capabilities. This means users have to register explicitly for incoming and outgoing calls in order to provide the system with the necessary location and authorization information. Note that UPT users can also register with a mobile terminal (i.e. a GSM terminal). As mentioned before, UPT realization is based on the IN architecture [Dang-92].

Although UPT has not yet been implemented on a European scale, RACE is already investigating the evolution of the UPT concept under the umbrella of its *Personal Service Communication Space (PSCS)* concept [CFS-B230], [CFS-C320]. Personal communications offers to end-users the ability to communicate and to organize this communication in accord with their own needs, characterized by time, space, cost, quality, accessibility, security and privacy. RACE defines in its Project MOBILISE [Gunter-93], [Gunter-94] the PSCS concept in order to support the above functionality. The PSCS can be seen as an extension of the UPT idea, while remaining backward compatible with UPT. Basic enhancements to UPT cover subscription to multiple telecommunication services, advanced services personalization and more powerful service profile management capabilities.

2.2.6. Future Integrated Mobile Systems

In the long term an integration of all mobile radio applications (cordless, cellular, and paging systems), including Mobile Satellite Systems (MSS), into one universal system is desired in order to support global roaming. The reason for integrating satellite systems into the target system is the fact, that satellite systems could complement terrestrial systems in low density areas. Therefore ETSI and ITU are working currently on the definition of 3rd generation mobile systems, which are expected to start services around the year 2000. In Europe, ETSI´s Special Mobile Group (SMG 5) looks for the definition of an *Universal Mobile Telecommunications System (UMTS)* [SMG50301], whereas parallel standardization activities on a world-wide level are undertaken within ITU-R TG8/1 under the banner of *Future Public Land Mobile Telecommunication System (FPLMTS)* [CCIR-687]. Note that FPLMTS has recently been renamed to *International Mobile Telecommunications - 2000 (IMT-2000)*. Both UMTS and FPLMTS have similar goals and both systems should provide global roaming and inter-system handover capabilities. They should provide access to a wide range of telecommunication services supported by fixed networks (e.g. PSTN, ISDN), and to other services, which are specific to mobile users. Therefore the systems are expected to be identical or largely compatible.The main aspect of both UMTS and FPLMTS, is the integration of satellite and cellular systems due to the recent advances in mobile satellite systems [Ananasso-94], [Wildey-94].

In contrast to current mobile systems, which have been designed as separate overlay networks, UMTS [Grillo-93] is targeted to be implemented using a common infrastructure with fixed networks. Full integration of UMTS with B-ISDN, where UMTS could be considered as the mobile access to B-ISDN is envisaged, in order to support a broad range of teleservices and multimedia services (voice, video, and data) [Mitts-94]. UMTS aims for a maximum user data rate of 2 Mbit/s. In order to facilitate the fast deployment of UMTS, many functions required in support of mobile systems are expected to be provided by Intelligent Networks [Broek-94]. In addition it has to be mentioned that part of the development work on UMTS takes place within a number of projects in the RACE II programme, namely the projects MONET (R2066), ATDMA (R2084) and CODIT (R2020) [CFS-D734]. RACE investigates also the area of *Mobile Broadband Systems (MBS)*, defining a high speed component of UMTS, that would support higher data rates of the order of 100 Mbit/s thus enabling mobile broadband capabilities. Good introductions to these systems are provided in [Reilly-94] and [Norp-94] respectively.

2.2.7. Intelligent Networks as Basis for Mobile Communications

The IN concept represents the architectural basis for most of the presented mobile communication systems [Hecker-92]. Since the first stage of IN standards (Capability Set 1, approved in 1992) provides only limited service functionalities for mobile services, the development of the second set of IN standards (CS-2) will be strongly influenced by new emerging mobile telecommunication services, in particular by UMTS and FPLMTS [Broek-94]. The IN standardization takes place in ITU WG XI [Q.1200] and ETSI NA6 [NA60003] since 1989.

For completeness the ongoing work within the *Telecommunications Information Networking Architecture Consortium* (TINA-C) programme has to be mentioned, where support of a *Nomadic Personal Communication (NPC)* Service is one challenging aspect for the TINA architecture. TINA can be considered as the long term successor to the IN concept. The NPC should support end user access to every kind of services in the telecommunication information network without worrying about the user´s location and motion during a service session (mobility). NPC covers the mobility aspects of transport connection services and of information services.

2.3. Summary

The current activities of research in the area of mobile computing mostly concentrate on the use of location information and on the unobtrusive enhancement of the working environments by various hardware and software technologies. These technologies are especially advanced in the area of wireless access, mobile usage of information technologies, location aware applications, and seamless integration of ubiquitous computing into the daily working life. The interrelationship and common grounds between the world of mobile computing and the vast area of mobile telecommunications are manifold: the research in the area of mobile computing exhibits a substantial demand on mobile, wireless communications systems. The emphasis is on the extension of LANs towards wireless, cellular networks. Enhancing the scope of usage of mobile computing towards larger numbers of users (in the order of several magnitudes) and towards a larger coverage area (e.g. mobile computing in WANs) leads us to a scenario where telecommunications support for mobile computing is required (cf. DECT, GSM, DCS1800, UMTS, MBS). On the other hand, a typical area where mobile computing supports the world of telecommunications are the applications developed at Xerox PARC and at ORL for the provisioning of advanced call forwarding based on location information of the users.

The intended architectural basis for most of the presented mobile communication systems, the IN concept, provides an adequate architecture for the rapid creation and provision of personal communication services [IEEE-93]. The *Specialized Data Function* (SDF) within the IN functional architecture provides the required capabilities for the handling of the various types of service-related or customer-related databases, i.e. the user profiles or service profiles. User profiles are an essential part in the concept of mobile computing and mobile communications. The user demands the global availability of his/her common set of applications usually utilized at the desktop. In order to have a mobile access to these applications (and their customizations on behalf of the user), user profiles are required containing informations on the user (e.g. user location information to support *personal mobility*) and on the used services (to support *service mobility*). The IN Capability Set 2 (CS-2) defines the usage of the X.500 *Directory Access Protocol* (DAP) for the interaction between the SDF and the service logic-containing *Service Control Function* (SCF). In the long term, the Intelligent Network concepts will be replaced by the TINA-C concepts. Currently, we investigate the thesis that IN service features may be substituted by corresponding TMN management capabilities [Maged-95]. This approach may pave the way from current IN concepts toward the long term TINA-C realization.

3. Towards an Integration of Computing and Telecommunications Technologies in the area of Personal Communications

The common trend in mobile computing and mobile, personal communications towards a unified world of communications and computing is characterized by such developments as new highly portable hardware, enhanced wireless communications capabilities, electronic market places, new types of services and (location aware) applications, and ubiquitous availability of communications capabilities and information services. Within all of these developments, the concepts of *personal mobility* and *personalization of services* are the central issues. Increased reachability of mobile users represents an important aspect within the emerging information society. The provisioning of personal mobility requires the introduction of logical names or user identifiers to be used by communication services during call setup instead of physical destination numbers or addresses. Calling users do not have to know about the current location of a desired communication partner, they only have to know a unique (logical) user number or reference. The aspect of personalization of services requires the provisioning of new categories of management services in the telecommunications management functional area (TMFA) of *Customer Query & Control* to be exclusively used by the casual user. The administration of personal service configurations and user location information in dedicated data structures, mostly referred to as *"User Profiles"* represents the most important prerequisite for supporting (personal) mobility and personalization of services. Here, a key word is the provision of location transparency. In this context, the TMN-based *Personal Communications Support System* (PCSS) has been defined to provide for personal mobility and service personalization in a uniform way to numerous communication applications.

3.1. The Personal Communications Support System (PCSS)

The *Personal Communications Support System*, currently under development at the BERKOM II project "IN/TMN Integration" performed by the Department for Open Communications Systems at the Technical University of Berlin for Deutsche Telekom Berkom (•De•Te•Berkom•), has been specially designed for providing *personal mobility*, *personalization of services* and advanced service interoperability in the area of Customer Premises Networks (CPN). It enables users to configure their communications environment according to their specific needs, with respect to parameters such as *time, location, quality, medium, cost, accessibility and privacy* [Eckardt-95], [BERKOM-94].

We applied the most important developments in the area of mobile computing and mobile telecommunications for the design of the PCSS. Various different types of communication services and location aware applications within the CPNs will be supported by the PCSS in a uniform way. The scope of the PCSS is purposely limited to the usage area of CPNs, enhanced office environments, and large in-house systems. Here, we have a closed world where specialized enabling technologies (e.g., electronic location technologies) can be ubiquitously installed [Elrod-93]. Location information, a very important issue in the context of personal mobility, can be produced with a much finer resolution and a more specific semantic than in the metropolitan, regional, or global context. Due to identical management and ownership domains in CPNs, the access to communication and computation resources is more simple than in the area of public networks. As a result, realistic demonstrators can be designed and implemented that handle the call control or routing of the various available communications media in this private area.

The central part of the PCSS is the *Core PCSS*. It is a development and runtime support environment specialized to enhance various different types of communications services in the area of personal mobility and personalization of services. The Core PCSS is designed to provide the means for a seamless integration of any locally available communication services into a customizable communications environment that virtually moves *with* the user wherever he/she goes (within the limits of the CPN). If a user within the CPN is called the system must compute a mapping of a personal number to a physical terminal address. Based on the momentarily available communication services/resources near to the mobile user, the best communication endpoint at that vicinity has to be dynamically addressed.

Technically, the Core PCSS consists of various globally accessible databases containing user-related location, configuration, and administration data. This information can be location-transparently accessed with the help of management information services. The PCSS development platform provides specialized functionality that hides the direct access to individual entries or attributes in the various PCSS databases, called 'profiles'. Being thus raised to a more abstract level, elementary functionality for the realization of personal communications is made available at the PCSS *Application Programming Interface* (API).

In a less strict usage of the term, the PCSS denotes the *PCSS infrastructure* comprising the Core PCSS and elementary management services or enabling technologies provided as specialized services (cf. Figure 3). In this category of services, we find the different registration services gathering the elementary location information of the various users to be written into the respective user profiles. An important registration service to be implemented for the PCSS, is the automatic user location service utilizing Active Badges and a sensor network as a kind of automatic registration. This *automatic registration service* currently uses the Active Badge System of Olivetti (cf. section 2.1.2. on electronic location techniques) but may be easily modified to apply any other electronic user location technology. The *user profile management service* is a third example of elementary management services comprising the PCSS infrastructure.

3.2. The Core PCSS

The individual components of the Core PCSS and the main applications interacting with those components are displayed in Figure 3. The central data structure within the PCSS profiles is the *Generic Service User Profile* containing all the information required to support personal mobility, personalization of communication services, and advanced user information services. Besides the Generic Service User Profile, the Core PCSS comprises three more types of PCSS profiles which are not display in Figure 3 for the sake of simplicity. Basically, these are different types of infrastructure-describing profiles (for the description of rooms or zones, generic communication endpoints, and individual terminals/service access points). An application programming interface specifically defined for the context of the PCSS provides various types of teleservices and location-aware information services with personal communications-related information.

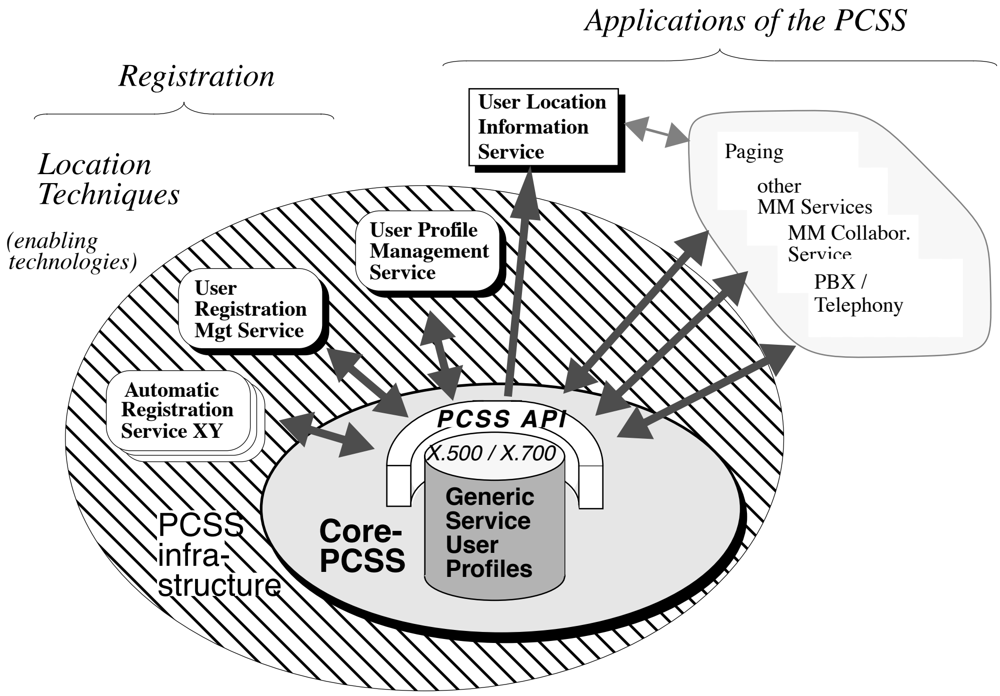

FIGURE 3 Applications of the Core PCSS

3.3. Basic Communication Model of the PCSS

One of the most prominent principles of the PCSS is the largely person-oriented and location-oriented operation of the Personal Communication Support System. This feature distinguishes the PCSS approach from traditional telecommunication approaches to service specification. Even advanced telecommunication services and IN services are primarily based on (network) numbers when specifying features such as call forwarding on busy (CFBY). For example, when comparing the concepts of Universal Personal Telecommunications (UPT) with the personal mobility-related concepts of the PCSS the most important difference between the two approaches are:

- UPT, based on IN concepts, comprises service features that are network address/number-oriented. For example, the registration procedure binds a telecommunication network number to the user who registers him/herself at a specific terminal (cf. Figure 4a). Additional IN service features which may be provided together with the UPT services are centered around network numbers (e.g. *call forwarding* routes calls directed to one network number to another network number).

- The PCSS is primarily person and location-oriented. That is, the registration procedure binds a user who registers him/herself at a specific location to a reference to that room or cell (cf. Figure 4b). The PCSS is responsible for a dynamic mapping of that reference to a suitable physical connection endpoint for a specific teleservice (e.g. physical number of a fax-machine). This process requires that the room or cell is known to the system (i.e. the room has been 'registered' with the system in an administration process prior to the use of its reference). The same is true considering the definition of service features that are supported by the PCSS. PCSS service features such as *call forwarding*, *call screening*, *time dependent routing*, etc. are person-oriented. They will be based on references to users of the PCSS instead of network addresses/numbers. Again, the PCSS is responsible for a dynamic mapping of the reference to a suitable physical connection endpoint for a specific teleservice.

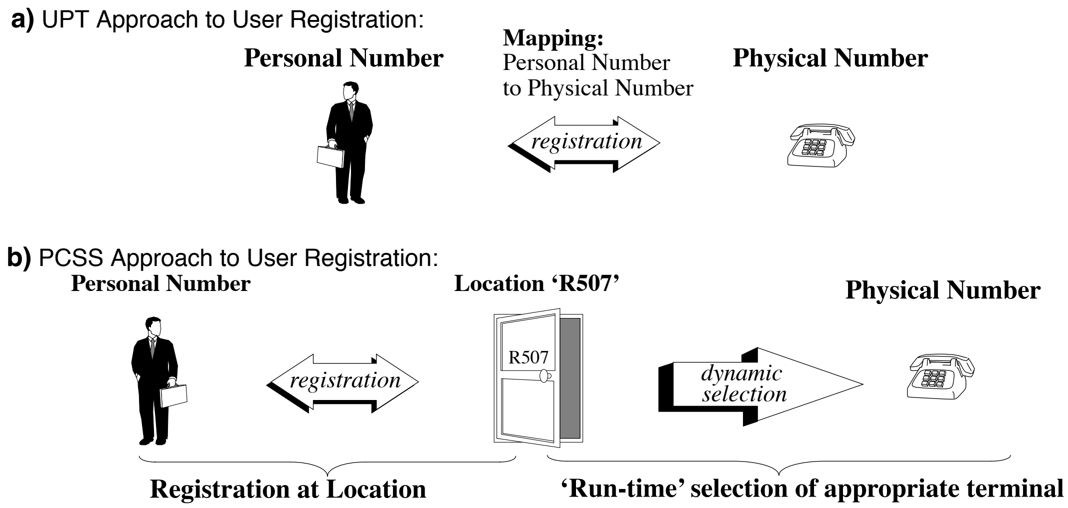

FIGURE 4 User Registration: UPT versus PCSS

Thus, to resolve a PCSS address (i.e. a personal identifier) to a physical number or terminal/application address, the PCSS must perform a multi-stage mapping leading from the personal number to the registered location and finally to an appropriate terminal. The advantage of this approach is: enhanced flexibility. With a single, simple procedure, the user can register for any type of teleservice. The system dynamically decides where to route the call depending on the type of teleservice used by the calling party and the available capabilities at the registered location.

3.4. Provided Personal Communications Capabilities

The Personal Communication Support System (PCSS) is intended to add IN service feature capabilities in the area of personal communications to a number of different, already existing or currently evolving teleservices (an application scenario for the PCSS in the context of the Multimedia Collaboration Service, MMC, can be found in [Eckardt-94]). All the capabilities provided by the PCSS are designed in a service-generic way to be applicable to an open set of teleservices. The PCSS focuses on *personal mobility* related IN service features as defined in UPT. At a clearly defined API, it provides personal communications-related primitives to allow for a user-defined intelligent call handling such as:

- Call Forwarding unconditional (CF)
- Call Forwarding On Busy / Don't Answer (CFBY), (CFDA)
- Time Dependent Routing (TDR)
- Origin Dependent Routing (ODR)
- Originating Call Screening (OCS)
- Explicit User Registration or De-registration (UREG)

3.5. Implementation Issues of the PCSS

Basically, the PCSS is implemented as a distributed environment where the communication is based on ISO/OSI communication protocols (i.e X.500 DAP and X.700 CMIS/CMIP). The current implementation of the *Generic Service User Profile* as an aggregation of distributed objects to be accessed via the *Directory Access Protocol* (DAP) or X.700 *CMIS/CMIP* applies the concepts of the *Inter-Domain Management Information Service (IDMIS)* [CFS-H430] integrating X.500 and X.700. Figure 5 shows the engineering representation of a logical instance of a PCSS User Profile in terms of X.500 Directory Entries contained in a Directory Information Tree and X.700 MOs contained in a Management Information Base (MIB). The platform used for the implementation and realization of the PCSS is the BERKOM Management Platform integrating OSIMaDE and IDMIS [BERMAN-93a|b]. On top of the IDMIS which provides a globally unique naming mechanism for management information and a location transparent access to that information for management services is an application programming interface specifically defined for the context of the PCSS. It provides higher level functionality or reusable components in the form of a library. Functions building on the internal IDMIS API to provide more abstracted, reusable capabilities in the context of the PCSS are packaged in a PCSS library to be statically bound in any location aware applications or service which has to be enhanced.

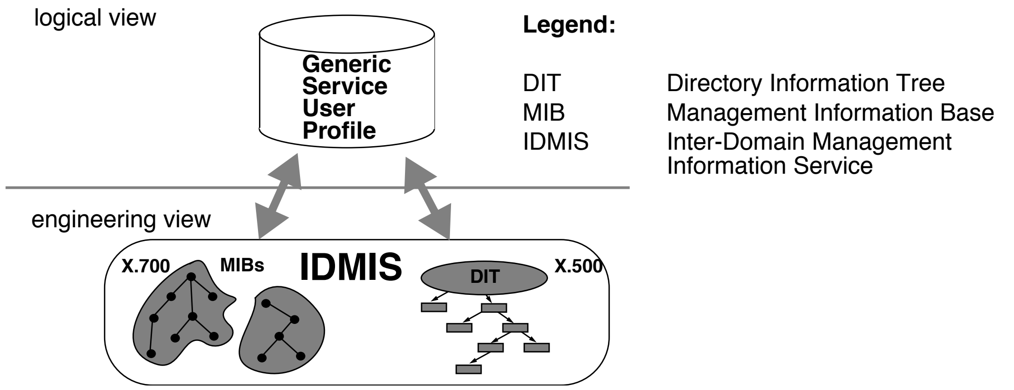

FIGURE 5 Logical vers. Engineering View of the PCSS User Profile

There are mainly two reasons for this approach: We decided to demonstrate that both, service management and service control may be realized by the means of management (cf. [Maged-95]). Second, we decided to allow for global access to any PCSS specific data which implies we need a global naming space and uniform, location transparent access mechanisms to the data contained in the various, distributed PCSS profiles. Currently, several research activities are focusing on the integration of Directory and Management Information Models, aiming for the definition of an integrated Information Model, to be accessed by an integrated protocol. The Inter-Domain Management Information Service (IDMIS) [CFS-H430], currently under development at GMD FOKUS Berlin. The IDMIS is envisaged to be included in the TMN standards.

4. Conclusion

The marriage of location aware applications in a ubiquitous computing environment with concepts for sophisticated, new teleservices such as UMTS, UPT and IN might lead to a realization of the idea of ubiquitous communications. This thesis is supported by the current trend in communication research and development that indicates a major shift towards personalized communications and personal/terminal mobility. An enabling technique for this type of personalized communication environments is the *Personal Communications Support System* (PCSS) which has been outlined in this paper. The scope of the PCSS encompasses the support of a variety of traditional and advanced telecommunication services in the area of personal mobility and personalization of services. A very crucial issue, i.e. the provision and processing of location information and service personalization information, constitutes the foundation for a broad range of services and applications.

5. Literature

[ACM-93] Communications of the ACM Journal, "Computer Augmented Environments: Back to the Real World", Vol.36, No.7, July 1993

[Ananasso-94] F. Ananasso, F.D. Priscoli: "Technology and Networking Issues in 3rd Generation Satellite Personal Communication Networks", International Conference on Universal Personal Communications (ICUPC), San Diego, California, September 1994

[Bellcore-92] Bellcore Special Report: "Cycle 1 Initial Specifications for Information Networking Architecture (INA)", SR-NWT-002268, Issue 1, June 1992

[BERKOM-94] BERKOM II Project "IN/TMN Integration", Deliverable 5: "State-of-the-Art in Personal Communications and Overview of the PCSS", Technical University of Berlin, Institure for Open Communicationssystems (OKS), November 1994

[BERMAN-93a] BERMAN, Guide to the BERKOM Directory, Version 3.0, December 1993.

[BERMAN-93b] BERMAN, Guide to the BERKOM Management Platform, Volume 1: Overview, Volume 2: User's Guide, Volume 3: Programmer's Guide for the Managing Side, Volume 4: Programmer's Guide for the Managed Side, Version 3.0, December 1993.

[Broek-94] W. van den Broek, et.al.: "Impact of UMTS on IN Development", International Conference on Intelligent Networks (ICIN), Bordeaux, France, October 1994

[CCIR-687] CCIR Recommendation 687: Future Public Land Mobile Telecommunication System (FPLMTS), Question 39/8

[CFS- B230] RACE Industrial Consortium, Common Functional Specification (CFS) B230: "General Principles of Personal Communications", Issue D, December 1993

[CFS-C320] RACE Industrial Consortium, Common Functional Specification (CFS) C320: "Advanced Service Features for Personal Telecommunications", Issue D, December 1993

[CFS-D734] RACE Industrial Consortium, Common Functional Specification (CFS) D734: "Mobile Communications: Universal Mobile Telecommunication System (UMTS) Radio Aspects", Issue D, December 1993

[CFS-H430] RACE Common Functional Specification (CFS) H430: "The Inter-Domain Management Information Service (IDMIS), Issue D, December 1993

[Ciancetta-94] M. Ciancetta, J. Isberg: "Combined personal and terminal mobility in IN environment", International Conference on Intelligent Networks (ICIN), Bordeaux, France, October 1994

[CT2-89] Department of Trade and Industry Radio Communications (DTI): "Common Air Interface Specification for CT2", MPT 1375, May 1989

[Dang-92] J.C. Dang et.al: "IN as a platform for UPT: constraints and requirements", 2nd International Conference on Intelligence in Networks, Bordeaux, France, March 1992

[DECT-92] ETSI - Radio Equipement and Systems (RES) - ETS 300 175 "Digital European Cordless Telecommunications Common Interface", 1992

[Eckardt-94] T. Eckardt, T. Magedanz: "On the Personal Communication Impacts on Multimedia Teleservices", International Workshop on Advanced Teleservices and High-Speed Communication Architectures (IWACA), Heidelberg, Germany, September 26-28, 1994

[Eckardt-95] T. Eckardt, T. Magedanz: "The Role of Personal Communications in Distributed Computing Environments", 2nd Interantional Symposium on Autonomous Decentralized Systems (ISADS), Phoenix, Arizona, USA, April, 25-26, 1995

[Elrod-93] S. Elrod et.al.: "Responsive Office Environments", Communications of the ACM, Vol. 6, No. 7, July 1993

[F.851] ITU-T Draft Recommendation F.851: "Universal Personal Telecommunications - Service Principles and Operational Provision", November 1991

[Forman-94] G. H. Forman, J. Zahorjan: "The Challenge of Mobile Computing", IEEE Computer Society, Vol. 27, No. 4, April 1994

[Grillo-93] D. Grillo et.al: "Toward third generation mobile systems: a European possible transmission path", Computer Networks and ISDN Systems, Vol. 25, 1993

[GSM-89] ETSI/GSM-PN GSM Recommendations, Geneva, September 1989

[Gunter-93] M. Guntermann et.al.: "Integration of Advanced Communication Services in the Personal Services Communication Space - A Realisation Study", Proceedings of the RACE International Conference on Intelligence in Broadband Service and Networks (IS&N), Paris, November 1994

[Gunter-94] M. Guntermann et.al.: "IN based End-user Service Management for Advanced UPT", 3rd Int. Conference on Broadband Islands: "Connecting with the End-User", Hamburg, Germany, 7-9 June, 1994

[Harter-94] A. Harter, A. Hopper: "A Distributed Location System for the Active Office", IEEE Network, Special Issue on Distributed Applications for Telecommunications, January 1994

[Hecker-92] H.P.J. Hecker et.al: "The Application of the IN-concept to provide Mobility in underlying Networks", 2nd International Conference on Intelligence in Networks (ICIN), Bordeaux, France, March, 1992

[Heilmeier-93] G.H. Heilmeier: "Strategic Technology for the Next Ten Years and Beyond", IEEE Communications Magazine, Vol. 31, No. 12, December 1993

[IEEE-93] IEEE Communications Magazine, Special Issue "Towards the Global Intelligent Network", Vol. 31, No. 3, March 1993

[Lipoff-94] S.J. Lipoff: "Personal Communications Networks Bridging the Gap Between Cellular and Cordless Phones" Proceedings of the IEEE, Vol. 82, No. 4, April 1994

[Maged-95] T. Magedanz: "On the Integration IN and TMN - Modeling IN-based Service Control Capabilites as Part of TMN-based Service Management", 6th IFIP/IEEE International Symposium on Integrated Network Management (ISINM), Santa Barbara, California, USA, May 1-5, 1995

[Mitts-94] H. Mitts: "Universal Mobile Telecommunication System - Mobile access to Broadband ISDN", 3rd Int. Conference on Broadband Islands: "Connecting with the End-User", Hamburg, Germany, 7-9 June, 1994

[NA60003] ETSI ETS MI NA-600-03: "NA6 Baseline Document", Version 1, 24 June 1994

[NA70102] ETSI ETR NA-70102: "UPT, Principles and Objectives", 1992

[NA70201] ETSI ETR NA-70201: "UPT, General Service Description", 1992

[Norp-94] T. Norp: "Aspects of Integrating Mobile and Fixed Communications", International Conference on Universal Personal Communications (ICUPC), San Diego, California, September 1994

[Potter-92] A.R. Potter: "Implementation of PCNs Using DCS1800", IEEE Communications Magazine, December 1992

[Q.1200] ITU-T Recommendations Q.1200 series: "Intelligent Network ", Geneva, March 1992

[RACE-94] Research and technology development in advanced communications technologies in Europe: "RACE 1994", Annual Technical Report of RACE, Brussels, February 1994

[Reilly-94] P. Reilly, C. Di Lapi: "MSS Architectures for 21st Century Wireless Communications", International Conference on Universal Personal Communications (ICUPC), San Diego, California, September 1994

[Ryan-93a] B. Ryan: "Communications Get Personal", p.169, Byte, Vol. 18, No. 2, February 1993

[SMG50301] ETSI DETR SMG-50301: "Framework of network architecture, interworking and integration for the Universal Mobile Telecommunications System (UMTS)", Version 0.4.0, May 1993

[Spreitzer-93] M. Spreitzer, M. Theimer: "Scalable, Secure, Mobile Computing with Location Information", Communications of the ACM, Vol. 6, No. 7, July 1993

[TINA-C] Telecommunication Information Networking Architecture - TINA Consortium, Work Program Proposal, Draft Issue 4, January 1993

[Tuttlebee-92] W. Tuttlebee: "Cordless Personal Communications", IEEE Communications Magazine, December 1992

[Want-92] R. Want, A. Hopper, V. Falcao, J. Gibbons: "The Active Badge Location System", ACM Transactions on Information Systems, Vol. 10, No. 1, Jan. 1992

[Weiser-93] Mark Weiser: "Some Computer Science Issues in Ubiquitous Computing", Communications of the ACM, Vol. 6, No. 7, July 1993

[Wildey-94] C.G. Wildey: "Satellite and Cellular Integration: A Terminal Manufacturer´s Perspective", International Conference on Universal Personal Communications (ICUPC), San Diego, California, September 1994

[Wizgall-94] M. Wizgall: "PCS Implementation - A Merger of American and European Mobile Systems", International Conference on Universal Personal Communications (ICUPC), San Diego, California, September 1994