Intelligent Handling of Communication Media

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Abstract

Personal Communication Support enhances control over reachability in telecommunication. Conversion and screening technologies of communication media, combined with QoS evaluation, allow to focus on the semantic of the information instead on carriage. A CORBA-based implementation allows scaling from Java clients to IN service nodes and TINA integration.

Keywords: Communication media, conversion, screening, QoS, IN, TINA, CORBA, Internet

1. Introduction

To deliver *"information any time, any place, in any form"* is a vision for future communication, as described in the Virtual Home Environment (VHE) concept [2] within the emerging Universal Mobile Telecommunication System (UMTS) standards [1].

Global reachability is today realized by mobile equipment, so now the user wants to manage and to control this accessibility in order to maximise or to filter it – independent of his location, the used communication medium, and the applied human communication interaction (asynchronous or synchronous). Additionally, he wants to have access to his asynchronous message store from everywhere and in any form.

In this context the concept of *"Personal Communication Support (PCS)"* [4] provides people with a new dimension in communication. In general, the concept allows users to establish their own personalized communication environment by addressing three important aspects, namely:

- *Personal Mobility*, which denotes the mobility of the user in *fixed* networks and wireless networks, allowing the user to make use of communication capabilities available at different locations, i.e. at any place and any time;
- *Service Personalization*, including personalized call / reachability management allows the user to configure his communication environment and control his reachability according to his specific individual needs, i.e. *if, when, where, for whom* he will be reachable, possibly supported by concepts of content screening.
- *Service Interoperability* in distributed multimedia environments between different types of communication services and terminals, allowing users to maximize their reachability. In this context, capabilities are required that enable dynamic/intelligent content handling and conversion of different media types and media formats in order to deliver information in any form.

When accessing his received messages remotely, the user wants to focus on the most considerable aspects and postpone ore discard unimportant material.

The research is backed by practical implementations of an *intelligent Personal Communication Support System* (iPCSS), developed jointly by TU Berlin and GMD Research Center for Open Communication Systems (FOKUS) and Deutsche Telekom Berkom.

In this paper, we discuss the aspect of sophisticated handling of communication media in the following section. In section 3, the latest implementation of the iPCSS is introduced as a practical example. Section 4 describes the integration of the concept into communication systems of various scale, ranging from personal systems over CPE solutions up to Intelligent Network (IN) [13] and TINA [5] contexts.

2. Media Handling

Each communication employs media, which can be abstracted on various levels. We distinguish transmission channels on a physical or a logical level, human perception systems, and several abstractions of presentation spaces, such as 'audio' (lower level), 'speech and sound' (higher level). Computerized multimedia already allows the inte-

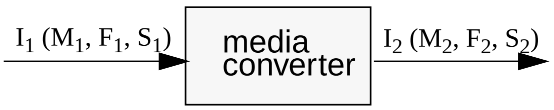

FIGURE 1 Media converter system

gration of various lower level data (audio, video, text, executables) into a single technical system. Consequently, this paper considers the integration of higher level presentation spaces by providing methods of converting such media as speech, text, image, etc. into each other.

2.1. Media Conversion

A media converter may be defined as a system entity, which input is information I_1 with the semantic S_1, carried by a specific medium M_1, using a specific form (or format) F_1. We obtain information I_2 as output in another Medium M_2 in format F_2, carrying a semantic S_2 (see Figure 1).

The quality of conversion can be measured by comparing the input and output semantic, S_1 and S_2, which should be preferred to be as close as possible, or having a predefined reduction.

Evaluating technical realizations of media converters we soon find that it is impossible to find commercial solutions for converting media (M_1,M_2) for every interesting combination of formats or technical representations (F_1,F_2). Therefore, the found solution supports different formats (F_1’,F_2’) and has to be accompanied with format converters (F_1,F_1’) and (F_2’,F_2). Consequently, we can distinguish two major classes of conversion:

- Media type conversion, and
- Media format conversion.

A deeper excursus into theoretical modelling of media conversion can be found in [8].

For specifying the model in more detail it is now necessary to consider the kinds of intended conversions. For this purpose, we need to consider that all information is intended to be perceived by human beings. However, this information could be generated by other humans as well as technical systems.

In the iPCSS approach we naturally focus on the conversion of media and technical representations already involved in classical or upcoming scenarios (Figure 2), such as telephone speech, fax images, audio announcements, multimedia e-mail, multimedia conferencing, paging services.

An example, covering some complex media conversions, is the delivery of a fax message by telephone, after converting the fax image to text (Optical Character Recognition, OCR), filtering the text for speech purposes, converting the text to speech (Text to Speech, TTS), adapting the resulting audio format (e.g. μ-law to a-law), and delivering the audio stream via an ISDN phone service gateway to the recipient.

2.2. Quality Evaluation

Brute force conversion of media would not be very satisfying for the user, as he often may realize that the chosen message was not suitable for the kind of media conversion applied.

A system can call itself intelligent only if it provides support for the user in the selection of the most appropriate media conversion and delivery method. A respective resource selection and configuration mechanism is described in the following section. Such a mechanism depends on comparable quality criteria for the conversion process as well as for the suitability of the message itself.

In the current implementation, a selection of four important QoS parameters has been made, which cover most detailed aspects. These parameters are:

- *Intelligibility*, covering problems of media synthesis, error probabilities, compression losses, channel noise, and semantic reductions, spell-check hit rates; given in percent (0...100%),
- *Bandwidth*, covering data volume and bitrate; given in bit/s,
- *Delay*; given in seconds,
- *Cost*, covering all aspects of tariffing and resource consumption (transmission and computation); given in countable units.

Quoting the example from the previous sub-section, the intelligibility of the fax message could be measured at various stages. First, the noise level of the image can be determined (number of isolated pixels). After OCR, the spell-check ratings for various languages can be compared, determining the required specific language and the worth of a following TTS in general.

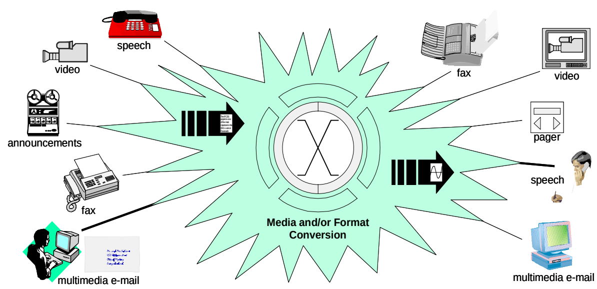

FIGURE 2 Media conversion priorized in iPCSS

2.3. Subject Screening

Due to their low cost, electronic communication is increasingly (ab)used for unsolicited or unpleasant advertising, therefore requiring methods for content evaluation and screening.

Screening mechanisms already implemented in PCS systems are based on recognition of the *originator* of a message by means of signalling, such as ISDN calling line identifier or e-mail headers.

As the iPCSS already evaluates the *content* for conversion purposes, screening rules can be implemented easily.

Naturally, content based screening can only apply for asynchronous communication, as the content of synchronous communication is not known in advance.

As it is discussed below, such screening can go far beyond searching of descriptive or grading text patterns in e-mail headers and bodies.

2.4. Content Analysis

Many tools for content analysis have been derived for purposes of indexing and content-based retrieval in multimedia databases, e.g. searching for specific audio samples, spoken text phrases, objects in images, person's faces in videos, etc.

Some of them are also suitable for screening purposes. Additionally, specific algorithms are subject of worldwide research. E.g., image analysis for screening purposes provides some new specific approaches. Beyond classical approaches of picture analysis, using histograms, colour histograms ("to much skin colour"), new approaches employ DCT based wavelet comparison with databases for classification of picture categories [11]. These algorithms have proven efficiency for e.g. suppression of pornographic advertisements in electronic documents.

3. Intelligent Personal Communication Support

This section will provide an overview of the iPCSS development and implementation.

3.1. PCS Environment

The principles of Personal Communication Support, as described in the introduction, are already realized within a four stage mapping process of communication requests (e.g., calls, messages). In the first stage, the personal preferences of the called user are considered, resulting in acceptance, redirection or rejection. Second, the user is mapped to his current location, derived from schedule, manual or automatic registration. Third, the location is mapped to the communication capabilities available at this very vicinity. Finally, an appropriate communication terminal is selected, and necessary media conversion is initiated. Details of this process, except the media handling, can be found in [4].

For means of system development, the complexity of the problem and the heterogeneous and distributed platforms to support require the application of sophisticated design methods. The Reference Model of Open Distributed Processing (RM-ODP) [12] provides a guideline to design distributed applications, hiding the impacts of distributed systems from the programmer as well as from the user. Consequently, the system has been implemented on a CORBA platform.

3.2. System Design

From the various viewpoints designed with ODP, the computational view of the system is provided and illustrated within Figure 3. The computational objects are displayed with their interfaces. The icons only support the comprehension of the interworking and can be regarded as a removable transparency layer. The usage of multiple interfaces for one objects has been solved within this project.

A central component of the system is the *Active Store* (AS). Beside storing messages for the connected users (in most cases in the incoming media format), it notifies the system of incoming messages and initiates the proper handling by questioning the *intelligent Communication Manager* (iCM, see below) for user related data about immediate delivery. Additionally, the store can be remotely browsed by the user, and the best way to deliver browsed messages can be calculated on demand.

Service Gateways connect the system to the whole world of communication outside, synchronous as well as asynchronous (SyGw, AsGw). They support phone, fax, e-mail, paging, multimedia conferencing, etc., in legacy systems (like Plain Old Telephone Systems - POTS) as well as enhanced versions (like ISDN).

*Remote Access Gateway*s (RaGw) allow the remote access to the Active Store from any terminal, anywhere in the world. They can be implemented as portable Java application, which may run in any WWW browser. Alternatively, they can use a touch-tone or speech recognizing telephone interface, fax polling, etc.

The personal preferences of a user, his current location, as well as information about the communication terminals available at this very location, are provided by a set of modular personal profile components, which can be requested by the system and edited by the user. *The Personal Call Logic* (PCL) provides rules and actions for call

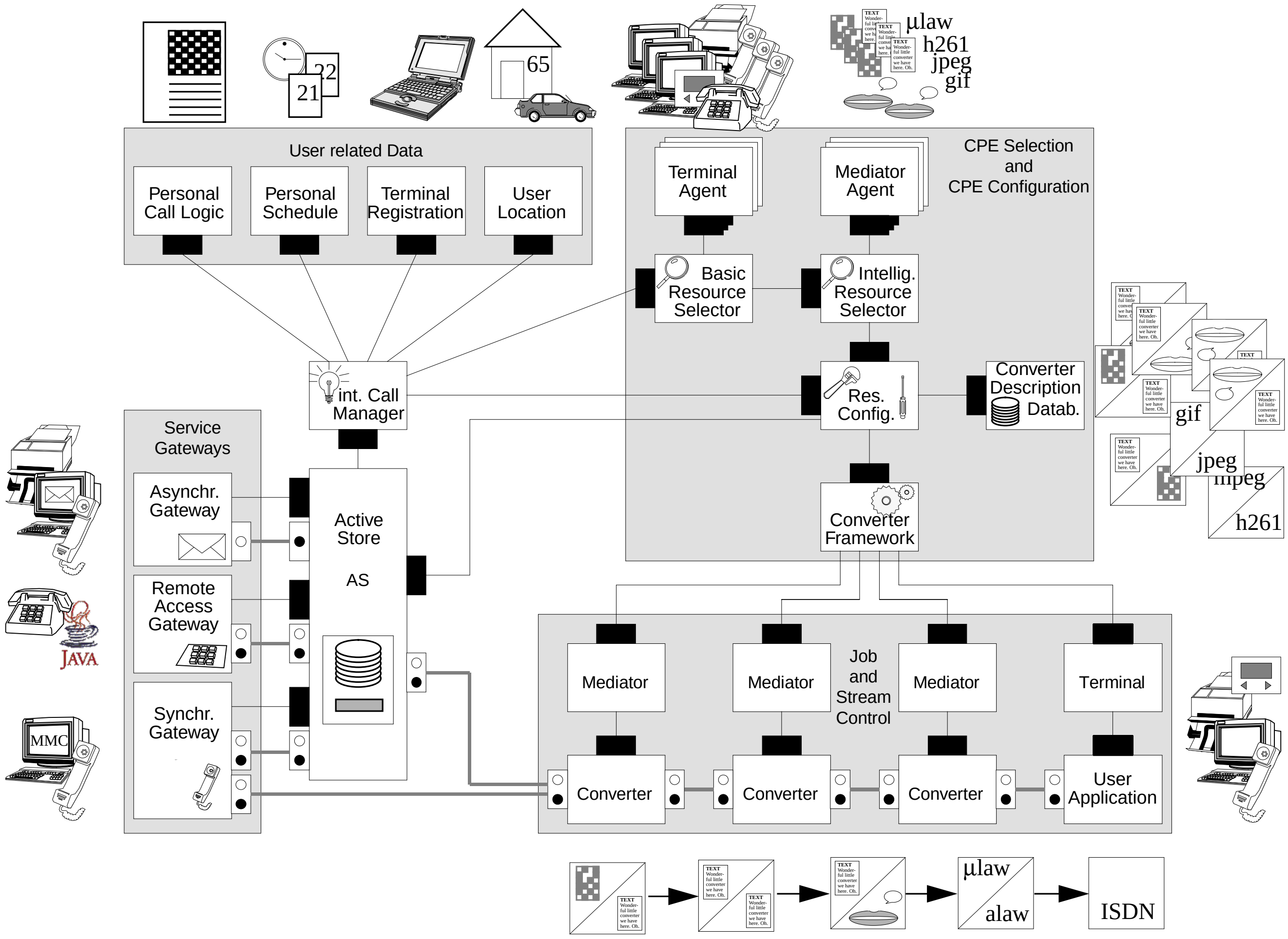

FIGURE 3 iPCSS: Illustrated Computational View

forwarding, prioritizing, screening, and specifically required conversions. The *Personal Schedule* (PSch), *User Location* (ULoc) and *Terminal Registration* (TR) describe the various aspects of reachability of a user, namely pre-planned regular locations or absences; manual or automatic registration at previously known locations; and registration at isolated or unknown communication terminals; respectively.

The *intelligent Communication Manager* negotiates between the AS and the user related data and initiates the process of selecting a terminal or conversion resources.

Therefore, the *Basic Resource Selector* (BReS) considers the selection of a terminal at the user's location appropriate for the incoming teleservice by evaluating the respective *Terminal Agent*s (TA). If no such terminal is found, the request is handed to the *Intelligent Resource Selector* (IReS), which checks the available *Mediator Agents* (MA) for possible conversions, and evaluates all possible converter chains for the incoming communication medium in relation to the terminal types available and allowed by the user.

The *Resource Configurator* (ReCo) questions the *Converter Description Database* (CDDb) for properties and parameterization of individual converters. The resource selection and configuration process is the key component providing the adaptivness of this architectural concept.

The *Converter Framework* performs the media conversion if necessary, e.g. the transfer of the semantic of a message towards another carrying medium. Most complex converters are Text-to-Speech, Speech recognition, Optical Character Recognition, accompanied by simpler media type and media format converters. The *converters* themselves, capable of streaming the communication data, are represented by *Mediators*, providing a unified interface about their properties. A sophisticated UNIX *Job and Stream Control Management* (JSCM), developed within this project, concatenates the dynamically selected converter, binds their data streams and monitors the correct execution of all processes involved.

3.3. Example

As an example, the case concluding the sub-section “Media Conversion” on page 2 should be discussed. An incoming fax communication is handled by the Asynchronous Service Gateway “Fax”. The recipient was recognized by his individual fax number, the sender is derived from the fax protocol, and the fax image is moved into the Active Store. The AS informs the intelligent Call Manager, which requests the user related data.

In the Personal Call Logic, the user has categorized faxes from this sender as highly important. While no schedule data are available for this time of the day, and the user is not registered at a specific terminal, the User Location delivers the sighting of the user’s Active Badge [10] in the library.

The iCM hands the request to the Basic Resource Selector for searching an appropriate terminal, which fails, because the library has no fax machine, just a telephone. So, the request is now passed to the Intelligent Resource Selector, which finds Mediator Agents describing various conversion capabilities.

The IRes evaluates all of possible combinations for this case and delivers the best one to the Resource Configurator. The latter questions the Converter Description Database for correct parameterization, and instructs the Converter Framework to build a specific converter chain (see the bottom of Figure 3), in this case consisting of an image/text converter (OCR), text filter, text to speech (TTS), audio format conversion, terminated at the ISDN phone-out gateway.

All these converters connected, the stream binding to the AS is established and monitored by the Job and Stream Control, the telephone in the library rings, and our happy user receives the so important fax message in spoken form.

3.4. iPCSS Media Handling

The system is not only able to convert one communication medium into another using dedicated methods, it is able to evaluate the assumed outcome of such a conversions and to automatically propose the most suitable way of conversion and delivery, based on the reachability of the user as well as the technical quality and the semantics of the communication content.

For complex kinds of media conversion the iPCSS provides a generic interface for integrating third party products such as Text-to-Speech, Speech recognition, Optical Character Recognition. This concept of easy integration of conversion and filtering tools allows further enhancements beyond the technical quality of the message for the evaluation of content semantics (*intelligent content handling*) as described in the previous section, ranging from simple keyword recognition to multimedia content evaluation.

3.5. User Interfaces

For acceptance by the user, the system needs to hide its internal complexity and to provide user interfaces that are easy to use. Adjustable levels of usage difficulties would be desirable. On the other hand, the automatic selection of the most appropriate delivery method is already a step in supporting the user to ‘do the right thing’ in a given situation.

Graphical user interfaces, implemented on various platforms, including cross-platform Java, allow the comfortable configuration of the personal communication environment and preferences, the modification of personal messages, customized for various callers, the remote registration anywhere in the world as well as the remote access to the own message store.

A prototypical user interface is presented in Figure 4. The user can authenticate and register himself at a specific location, having access to his messages in various forms, sending them in converted form to the local telephone or fax machine, or play and view them in the Java browser.

As for remote access often only the most basic method of communication can be presupposed, a remote telephone interface will become a key element for using the system. Strategies are being developed for touch-tone interfaces as well as speech command recognition.

FIGURE 4 Prototype for Remote Access Gateway

4. Scalability and Integration

The modular, scalable design of the iPCSS allows tailoring for various purposes and environments. While the first implementation is focused on the Customer Premises Equipment (CPE), the scalability in all directions, from global telecommunication architectures like TINA and IN (see below), down to a compact, individual solution, was a major aspect in the research.

The tool enabling such a wide range of scalability and independence from single/multiple host environments was the usage of a middleware platform hiding such properties, CORBA in our case.

This section discusses these impacts of scalability, providing an outlook to current or further developments this way.

4.1. Customer Premises Equipment

A CPE environment is the scope of the current reference implementation of the iPCSS. This implies the existence of a multiple host computing environment for classical communication (e-mail host, PABX control host, voice mail server, fax server) and for the additional services (media conversion, PCS control and databases, resource configuration, central storage, service gateways), communicating in a heterogeneous LAN and telecommunication network environment.

4.2. IN - Intelligent Peripherals

Intelligent Networks (IN), successful in telecommunication worldwide, [13] know the concept of Intelligent Peripherals (IP) and Service Nodes (SN) for the dialogue with the user and for enhanced service platforms.

These IP/SNs can be employed for the introduction of value-added services and features to the IN.

Traditional voice processing services have already been described for the integration into IP/SNs, such as virtual mail boxes, voice actuated dialling, virtual voice messaging, global store concepts [15].

Recently, Rieken et al. [14] have proposed to integrate innovative features and media-oriented services like voice mail, fax mail, voice recognition, voice synthesis, video services, into a service node, employing specific Resource Platforms (RPs).

The iPCSS can be adapted to operate as an IP/SN, following the trend of harmonization of TINA concepts with IN management and control aspects [16].

The iPCSS with its concept of the Active Store and the dynamic selection and configuration of individually tailored converter chains provides a powerful IP/SN. As it is already implemented on CORBA technology, the same migration strategies can apply as described for the TINA service nodes [16].

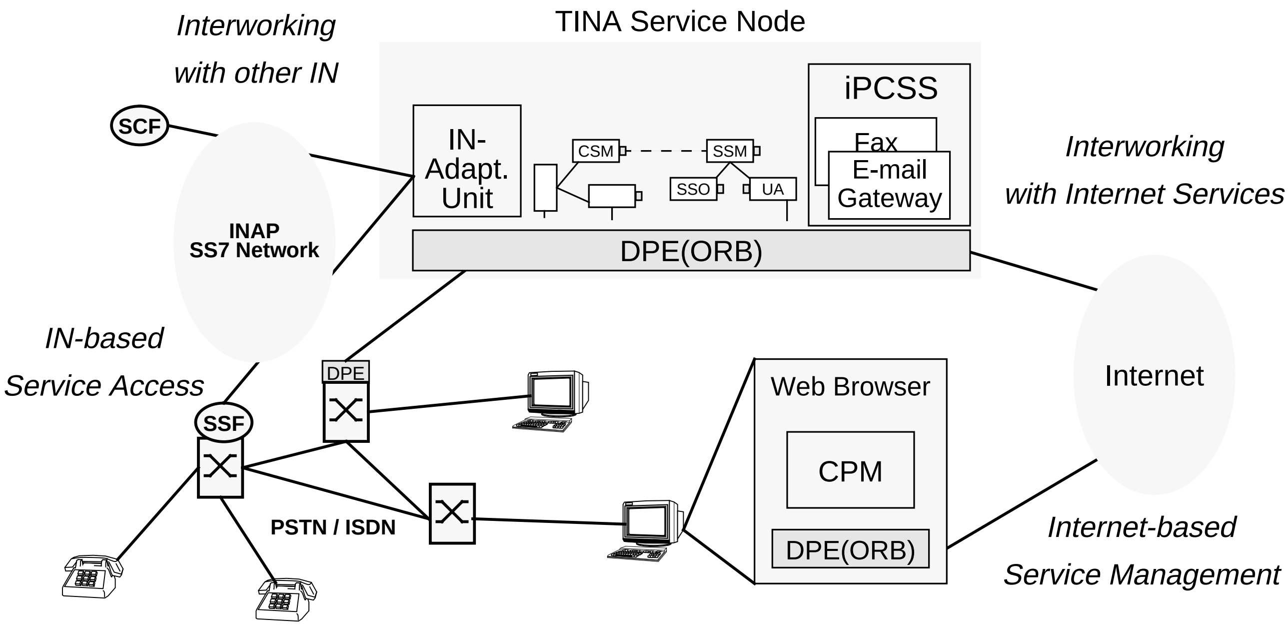

FIGURE 5 TINA Service Node integrating IN and Internet environments [16]

4.3. TINA

The Telecommunication Information Networking Architecture (TINA) represents a fundamental software architecture for Distributed Processing Environments (DPE), based on CORBA technologies, for rapid and flexible introduction of innovative services into information networking [5].

This research project is accompanied by a complementary project developing PCS in the TINA context, which proved the possibility to realize IN functionality by PCS principles, leading to a TINA Service Node [5].

As some of the concepts of the iPCSS (mostly considering content handling) are not covered by TINA principles, research is driven in both directions. However, the CORBA based approach of the iPCSS and the design of the Computational Objects follow the ideas of the TINA Service Architecture [6] closely, with the purpose of allowing an integration of dedicated aspects of the iPCSS into TINA. Further details are described in [8].

Figure 5 presents the idea of the emerging TINA Service Node concept, which provides an important step in evolution from IN based service environments toward TINA based service environments. The principal is to model service control and service management TINA conform, but still providing access to this logic from IN based switches (via the IN Adaptation Unit) and TINA end-systems (via a TINA Access Session).

Additionally, the TINA Service Node features media conversion and service gateways derived from the iPCSS, in order to integrate internet and telephony services.

In particular, the Java based Customer Profile Management (CPM) is employed to enable TINA Service Node users to configure their communication environment.

4.4. Single Host iPCSS

A specific direction of development will be the downscaling of the iPCSS to a ‘single host’ or ‘black box’ solution, allowing small companies or individual home users the exploitation of major features if intelligent media handling.

Such a system requires the integration of various hardware support for service gateways if the respective service cannot performed in software for technical or performance reasons.

It needs to be manageable in an easier way than a CPE system, as specific administration knowledge cannot be presupposed.

5. Conclusions

This paper has presented an overview of the iPCSS, representing a CORBA-based platform for the provision of PCS capabilities as an usage example of automatically configurable technology of media conversion and handling. This technology has been evaluated from the theoretical viewpoint, and tested in a prototype application.

The iPCSS provides enhanced reachability of users while the users are able to control/manage their reachability. PCS capabilities are scalable in a wide range, up to IN and TINA scenarios.

Further information about the iPCSS as well as the IN and TINA integration can be obtained electronically from “http://www.fokus.gmd.de/ice/”.

6. Acronyms

CO	Computational Object
CORBA	Common Object Request Broker Architecture
CPE	Customer Premises Equipment
CPM	Customer Profile Management
DCT	Discrete Cosine Transform
DPE	Distributed Processing Environment
IN	Intelligent Network
IP	Intelligent Peripheral
iPCSS	intelligent Personal Communication Support System
INAP	Intelligent Network Application Protocol
ISDN	Integrated Services Digital Network
JSCM	Job and Stream Control Management
LAN	Local Area Network
OCR	Optical Character Recognition
ODP	Open Distributed Processing
PABX	Private Automatic Branch Exchange
PCL	Personal Call Logic
PCS	Personal Communication Support
POTS	Plain Old Telephone Service
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RM-ODP	Reference Model of Open Distributed Processing
SN	Service Node
SS7	Signalling System No. 7
TINA	Telecommunic. Information Networking Architecture
TMN	Telecommunication Management Network
TTS	Text-To-Speech conversion
UA	User Agent
UMTS	Universal Mobile Telecommunication System
UPT	Universal Personal Telecommunication
VHE	Virtual Home Environment
WWW	World Wide Web

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