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@INGate: A Distributed Intelligent Network Approach to Bridge Switching and Packet Networks

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Abstract

This paper presents the results of a joint project initiative, @INGate ([1],[2]), in the area of Computer/Telephony Network Integration (CTNI) carried out by Siemens AG and the Technical University of Berlin. We propose a distributed intelligent network architecture (DINA) that implements a Unified Media Communications Service (UMCS) providing both messaging and telephony services along with network computing and service management throughout circuit switching and packet networks. The architecure comprises a series of interconnected and locally managed intelligent Service Nodes as InterWorking Units (IWU) between heterogenous networks allowing the user access to a Unified Media Store/Bus (UMS/B) via traditional PSTN/ISDN/GSM equipment such as telephones, pagers and fax machines on the one hand and networked computers and PDAs equipped with mail readers and Web browsers on the other hand to enable both on-line and off-line communication.

The core of this architecture is the Network-Bridge Service Node (NB-SN), a distributed intelligent network element (DINE) consisting of a Channel Matrix Switch (CMS) and a Data Packet Switch (DPS) to link to fixed/mobile telephony and data networks correspondingly, several Resource Platforms (RPs) connected to Media Conversion Processors (MCPs) to perform media translation in required interchange formats, an Internet Gateway (IG) for IP telephony and data access (incl. customer service control and agent-based network computing) holding the subscribers' mailboxes and providing the Internet connectivity, and a Network-Bridge Service Node Controller (NB-SNC) to control the overall service logic and the above components. The NB-SN itself is managed along with other nodes in a distributed intelligent network (IN) by a TMN-compliant Operation, Administration and Maintenance Center (OAMC).

Keywords: *computer/telephony network integration, intelligent networks, multimedia PCS, Internet gateway .*

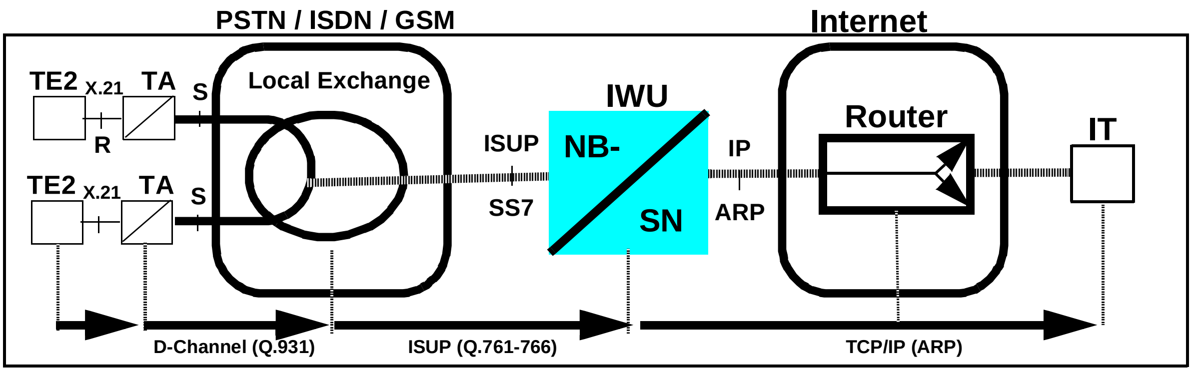

Fig. 1 : The Network-Bridge Service Node as InterWorking Unit

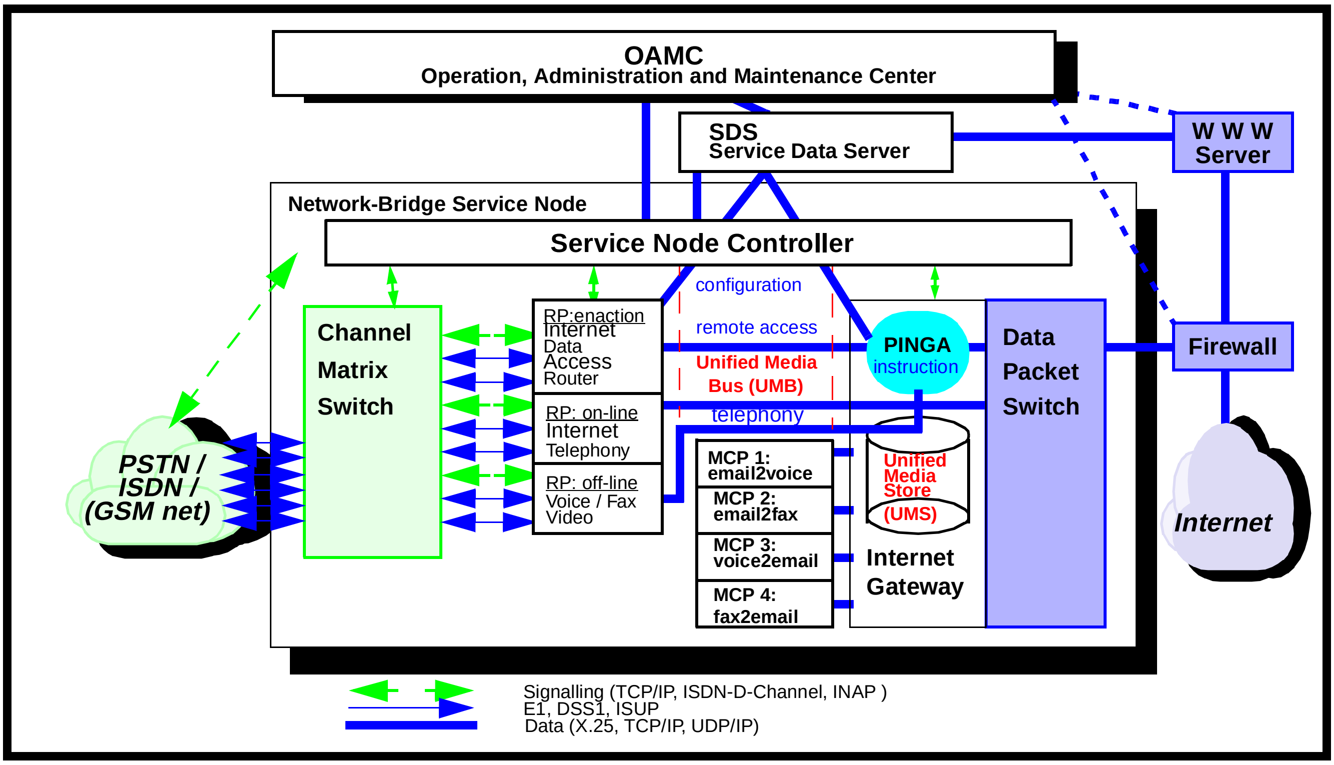

Fig 2 : The @INGate Reference Model

I. Introduction

The goal of the @INGate project is to design an Inter-Working Unit (IWU) as a mediation device between existing circuit and packet switching networks for deploying effective and value-adding personal communications by using traditional ISDN/PSTN/GSM equipment (TE2) and Internet Terminals (IT), cf. fig. 1, [3]. Our prototype hosts a generic Unified Media Communication Service (UMCS) composed of multimedia messaging (store-and-forward), telephony and agent-based network computing. This architecture addresses three basic topics in communications:

•*protected network links:* Channel Matrix Switch (CMS) and Data Packet Switch (DPS) facing PSTN/ ISDN/GSM and the Internet;

•*enhanced media contents*: Resource Platforms (RP), Media Conversion Processors (MCP);

•*reliable service and resource control:* Service Node Controller (SNC).

II. The @INGate Reference Model

The @INGate Reference Model contains the following network elements (cf. fig. 2):

•Network-Bridge Service Node (NB-SN)
•Service Data Server (SDS)
•Operation, Administration and Maintenance Center (OAMC)
•WWW Server
•Firewall

The Network-Bridge Service Node represents the core of the Interworking Unit between PSTN/ISDN/GSM and the Internet. It consists of :

•Service Node Controller (SNC)
•Resource Platforms (RPs)
•Channel Matrix Switch (CMS)
•Data Packet Switch (DPS)
•Media Conversion Processors (MCPs)
•Internet Gateway (IG) with
- Unified Media Store/Bus (UMS/B), and
- Personal IN Gateway Area (PINGA)

The Service Date Server (SDS) holds all service- and subscriber relevant information such as configuration data, user profile information and Automated Message Account (AMA) records in a database.

The Operation, Administration and Maintenance Center (OAMC) allows access to all components of the Network-Bridge Service Node via remote control sessions to UNIX hosts (NB-SNCs) or SNMP-based management.

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The WWW Server supports WWW-based management of all NB-SN components in addition to the TMN-conform OAM workstation, as well as Customer Service Control (CSC) such as configuration of service specific parameters through the Internet by using security-enhanced Web browsers.

The Firewall computer connects the NB Service Node to the Internet, whereas the UMCS logic in the SN Controller guarantees the secure service access from the telephony network.

In the following sections we describe the NB-SN components in some detail.

A Service Node Controller (SNC)

The Service Node Controller handles the allocation and deallocation of resources and the overall flow of the service. Services are implemented in the SNC by Service Logic Programs (SLPs) interfacing to their subparts and resources in the RPs directly or via the switches and the Internet Gateway.

B Resource Platforms (RPs)

The Resource Platforms implement dedicated media treatment: voice/fax reception, storage and response, as well as Specialized Resource Functions (SRF) such as collecting user input (incl. DTMF/voice recognition), playback of announcements, etc.

Appropriate RPs are assigned to incoming and outgoing calls, as well as to service logic by the SNC. There are three different RP types in @INGate: one for recording/sending of voice/fax/video messages, one for the interface to Internet Telephony, and one for Internet data access and configuration of user profiles (Customer Service Control, CSC) --- on-line via IVR/VR/DTMF/http, etc. or off-line via the PING agents, cf. F .

C Channel Matrix Switch (CMS)

The Channel Matrix Switch is controlled by the SNC and routes calls from the PSTN/ISDN or GSM net to the appropriate resource platforms via circuit and call related signalling (ISUP, TCAP, or MAP).

D Data Packet Switch (DPS)

The Data Packet Switch is controlled by the SNC and routes calls from the Internet to the appropriate Unified Media Store/Bus or to the Personal IN Gateway Area.

E Media Conversion Processors (MCP)

The Media Conversion Processors have the task to convert media messages:

1. between RP-specific and Internet formats, and
2. between two different RP-specific formats.

F Internet Gateway (IG)

The Internet Gateway basically consists of:

- a *Unified Media Bus (UMB)* enabling the on-line communication between users in both network domains along dedicated lines for configuration, remote access and telephony;
- a *Unified Media Store (UMS)* with customer disk partitions for message archivation in a Unified Media Format (UMF); and
- a *Personal IN Gateway Area (PINGA)* for network computing by programming individual agents to fulfill specific tasks such as “wake-up” calls, news delivery or database access. It is connected to the UMS and via the UMB to the resource platforms.

By default, each UMS mailbox functions as an answering machine for the corresponding customer access line (Universal Personal Number, UPN). The PING agents are called, activated and programmed also through the mailbox using a Web/IVR/VR/DTMF interface. They are designed (Service Creation), configured (Customer Service Control) and used (Service Deployment) by the customer herself, e.g. by using scripting technology to realize definite information services. Here we speak of “an *active* mailbox in the Network-Bridge Service Node”. In addition, the Internet data access RP has a newsgroup agent for threads selected via the CSC menue.

The IP telephony module currently contains a standard Internet Telephony (IT) client modified for use as a gateway along with an interface to a special resource hardware handler. Since most IT applications today support half-duplex operation, only half-duplex communication is implemented at the moment. This coincides with the fact that the selected resource hardware (voice modem) also performs only a half-duplex voice recording and playback.

III. Unified Media Communication Service (UMCS)

Another main goal of the @INGate project was to implement a generic Unified Media Communication Service (UMCS) for on-line and off-line access from both the circuit switching telephone networks and the packet-driven Internet using a Universal Personal Number (UPN) with a given email address. Currently, UMCS is composed of messaging/notification (voice/fax/email/SMS), telephony and data delivery (on demand). Its logic is located in the SNC. The service imposes several constraints on the message format to support both net worlds:

- The identity of the subscriber (i.e. owner of the message) must be verifyable.
- The UMF must accommodate both telephony (e.g. G3 fax) and Internet data format (JPEG, ASCII text, etc).

- The format must handle multi-part messages that occur in the Internet world (MIME-format emails).
- The message format must identify the type of the content data it encapsulates.

The message format must be accessible from both Internet e-mail software and telephony services residing in the RPs and the PINGA.

There are several choices for the implementation of such a Unified Message Format (UMF), especially if timing and performance of necessary conversion procedures are taken into account. The messages might be stored either in a proprietary format (e.g. involving a multimedia database or special file formats) or in a standard format (e.g. standard UNIX mailbox format). The proprietary format has the advantage that it can be implemented in a very efficient manner compared to ordinary UNIX mailboxes that store all data in one mailbox file. The drawback is, however, that standard Internet daemons such as POP3 daemons have to be rewritten to use this new format. This would also make running a POP daemon computationally more expensive. There are two strategies to solve the conversion:

- *"Lazy" Conversion* of media types on demand when a user accesses her mailbox using her Internet mail user agent (MUA) and the mailbox contains voice messages, at entering it using a telephone, the POP daemon converts these voice messages into MIME audio/basic.
- All incoming messages are converted to/from a canonical format (CF) as soon as they come in. If the CF is the standard UNIX mailbox with MIME types at least for the Internet access, no conversion on-the-fly is required.

The standard UNIX mailbox with a canonical format was chosen. In a later revision the proprietary format with lazy conversion should be favoured because of better performance.

Currently, from the PSTN/ISDN and GSM net side only the UMCS subscriber can reach Internet Telephony users from an analog telephone. She can then select the desired party using DTMF tones (either from a shortlist or by entering the IP number). The Internet side is not limited to subscribers: everyone can call a PSTN/ISDN or GSM number from the Internet, provided that she is willing to pay by credit card or using digital cash for using UMCS.

IV. Operation, Administration, and Maintenance Center (OAMC)

One main challenge of the TMN integration in Intelligent Networks is the lack of usable standards. Thus we tried to merge the TMN Functional Models of the ETSI Baseline documents [4] and the ITU-T Recommendations ([5], [6]) and map them to our physical architecture, fig. 3.

The OAM Center allows access to all components of the NB-SN as well as to SDS, the WWW Server, the Firewall and the CSC workstation. The management information is processed by distributed SNMP agents within each network element.

The implementation of the IN management platform is based on HP OpenCall. The Customer Service Control (CSC) is supported over the Internet by HP OpenView as part of the OpenCall platform, with additional modules implemented by the PRZ lab at the TU Berlin.

Some management information is accessible via a Web interface, mainly to support service subscribers to access and change their profiles using the Internet. We defined three main services:

A Service-Subscriber Administration (SSA)

This management service includes the needed functions for the administration of user profiles. The operator has total access to this data. The service subscriber can modify certain data in the user profile to get the service fitted to her needs.

B Operation and Maintenance (O&M)

This management service offers the functions for management of the service node operation. Typical functions are load-control, reachability, availability and statistics for billing and control purposes.

C Network Element Management (NEM)

This management service offers the functions needed by the SNC to control the modules of the NB-SN. The latter behaves to upper TMN instances as a single Network Element, representing the components inside it. In addition, the NEM updates the SSA databases in the single NB-SNs via the SDS.

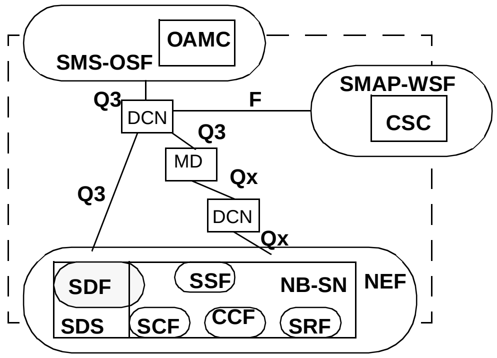
V. Service Data Server (SDS)

The Service Data Server (SDS) is a common data repository for all components of the @INGate system. It holds information about configuration of resources, services and subscriber profile data.

Resource and service configuration can be performed by the OAMC. The subscriber can change parts of her profile using the Web or telephony interfaces. The Charging and Billing component uses the billing information in the subscriber profile.

VI. WWW Server

The WWW-Server serves a dual purpose in the architecture of the @INGate system. It allows:



SMS-OSF: Service ManagementSystem - Operation System Fct.
SMAP-WSF: Service Management Access Pt. - WorkStation Fct.
DCN: Data Communication Network
MD: Mediation Device (www-Server, Firewall)
SN-NEF: Service Node - Network Element Function
SDF: Service Data Function (SDS, SNC)
SCF: Service Control Function (SNC)
SSF: Service Switching Function (CMS, DPS)
CCF: Call Control Function (CMS, DPS, RP)
SRF: Service Resource Function (RP, IG)

Fig. 3: Mapping TMN into IN in @INGate

•remote WWW-based management of @INGate services as an alternative to the centralized OAMC;
•CSC, a particular personal profile modification by the subscribers themselves in the SDS.

There are several NB-SN components to be managed using the WWW-Interface. Since not all of them support profile configuration via HTML, some database conversions were implemented:

•SNMP MIBs into HTML,
•database tables (esp. in the SDS) into HTML.

The WWW server can manage:

•a Mail Server in the Internet Gateway (native HTML-Interface)
•Service Node Controllers (MIB-to-HTML)
•Ressource Platforms (MIB-to-HTML)
•SDS (forms-based access to a subscriber profile database: self-subscibtion, CSC)

The NB-SN will distribute its services securely through an SSL-enabled server (SNC, cf. fig. 2) which requires the usage of a certificate-based authentication scheme.

VII. Charging and Billing (C&B)

The UMC service will be accessible from PSTN/ISDN/GSM and the Internet. It should be able to handle service requests from POTS subscribers and from anonymous users originating from the Internet. The introduction of a distributed IN gateway service evokes the need of automatic message accounting records and toll tickets close to the service, i.e. in the NB-SN and the related RPs (also in other SNs). The events to be recorded are no longer network events but service events. Fig. 4 shows a matrix of network usage crossovers and possible applicable billing scenarios.

The @INgate project considers a tariff concept of a gateway service including resource consumption of two different networks and a service host:

•PSTN: time tics and tariff areas;
•IP: traffic volume;
•NB-SN: CPU time, average disc space.

The costs of the service will be splitted in message entering costs billed to the service initiator, who is not nessecarily a service subscriber, and average mailbox resource consumption costs.

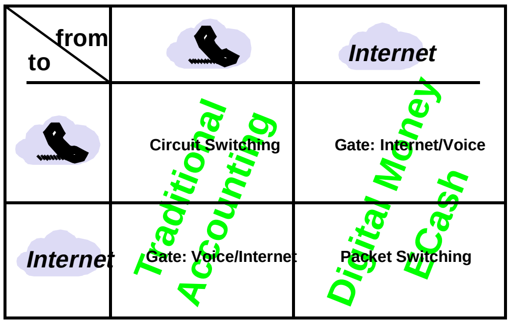


Fig. 4 : Billing Areas Internet / IN

Regarding our activities on billing for anonymous customers a close relationship exists to ecash shops [7], but our main concern in @INGate is the evolution of digital money [8] which supports the distributed NB-SN architecture.

VIII. Related Work

Our goal is to provide a distributed IN architecture and a generic communications service to bring computer and telephony networks together *now*.

Several commercial products combining both telephony and Internet mail systems has been announced recently ([9],[10],[11]). Most vendors traditionally come from the voice processing area, thus offering proprietary interfaces and media formats. Although sharing the common feature of setting the trend towards multimedia PCS, they typically provide limited Web-based service ma-nagement and some Internet enhancements to available telephony mailing systems which basically lack a common integration concept within existing network infrastructures. Other companies with know-how in the media packet coding area address real-time telephony and are entirely IP-oriented ([12]), thus fitting only computer terminals.

None of these products has the character of a complete network-wide solution or “killer application”. Yet, there are two emerging technologies claiming to *unify* telecom-

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munications in a radical way --- anyway not without the blessing of regulation and developments in traditional telephony equipment: the Inferno operating system ([13]) and the IMTC standard for Voice over IP (VoIP, [14]).

IX. Conclusions and Outlook

This paper has shown a new way to integrate two worlds that have evolved very differently - the ubiquitous plain old telephone system(POTS) on the one hand and the rapidly developing packet-data Internet on the other hand.

Personal Cordless Telephony (PCT), [15], is a service that Siemens recently implemented for one of its international customers with the Service Node architecture. The service allows the access to a distinct subscriber from a group of persons via mobile telephony while calling a known fixed network number.

This service is the first step towards a complete PSTN, ISDN, DECT and GSM integration. In this manner, PCT is a basic service towards PCS that will build up the skeleton of much more complex communications services, such as routing of multimedia data throughout diverse networks.

PCT and UMCS build up together the base for the next generation telecommunications services. Whereas the first service introduces Distributed Intelligent Network Elements (DINE), Service Nodes, in the IN routing techniques of the PCS world, the second one provide a practical approach to Enhanced Media Contents Provisioning in the CTNI area. Both services are mutually complementary and build the ground frames of a layered service model in an integrated media communications architecture.

Whereas the first frame of services will grow horizontally, thus including new network types and routing mechanisms, the second one will grow vertically in order to develop complex applications with different (possibly hierarchically structured) media types such as video-telephony, conferencing, teleworking, teleoffice, telefactory, etc.).

Both services will be developed, justified and tested in an interplay relation in order to be finally merged in a configurable CTNI service. Regarding the new developments in network technology, the evolution of the NB-SN is characterized by the following features:

- NB-SN as multimedia platform represents a mirroring (extension) of the data networks concerning news and data transfer, as well as tele-(co)operation services;
- NB-SN as network bridge (CTNI) allows the access to other networks, resources and services: radio and satellite networks, electronical and optical broadband networks, etc.;
- NB-SN as a glue element (mediation function) in access networks and thus to closed loop interactive services in the business and entertainment areas;
- NB-SN as first step towards the realisation of *truely active intellient networks* and thus towards the complete integration of autonomous data, programs, services and functions (mindware) within the global telecommunications network of all physical carriers.

Our further plans are to continue work on the @INGate architecture with respect to intelligent routing in switching and packet networks, as well as on media contents and service enhancements.

X. Acknowledgements

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