Terminal Mobility in Broadband Networks

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Abstract

The convergence of telecommunications, computing and content industries has been one of the major trends during the recent years. The convergence has lead to the creation of a wide range of multimedia services which are available in digital form through broadband networks. In this paper we consider implications of this development to the connection control of mobile multimedia services when terminal mobility is present.

1. Introduction

The development of broadband networks will provide capacity for new interactive multimedia services, which will also become available for mobile terminal users. This development will be based on new broadband network service architectures, which will support user controlled easy and rapid service creation and deployment.

The first part of the paper describes two experimental broadband multimedia service architectures: Tove architecture which is based on B-ISDN signalling and OMG CORBA based service distribution, and Calypso architecture which is based on service agent distribution over IP network nodes. Both architectures are being developed in research projects having the same names in Helsinki University of Technology, Laboratory of Telecommunications Software and Multimedia.

Two broadband services that have been piloted using the Tove and Calypso platforms are described. An ATM/UNI based music on demand service has been demonstrated in Tove, and the distribution of TV channels has been demonstrated in Calypso in the end of 1997.

Second part of the paper describes the UMTS and IMT-2000 architectures and evaluates possible terminal mobility solutions in the presented experimental broadband services. Tove architecture complies to IMT-2000 and uses an extension of OMG CORBA environment for application interfaces. Calypso architecture implements application level services by using service agents and can support both UMTS and IMT-2000. The connection control for terminal mobility is evaluated against the broadband pilot services of Tove and Calypso.

2. Multimedia pilot architectures

2.1 Tove

The main principle of the Tove architecture is separation of service control, call control and fabric control. This allows the lowest level of switching be relatively stable and simple, whereas the highest level of services provides flexible support for creation and deployment of new services. The intermediate control level may change, when for example a new signalling protocol is introduced or the call processing model needs to be updated.

The Tove prototype platform is an implementation of the layered control architecture, based on the standardised B-ISDN concepts and protocols. The service control is separated from the basic call and connection control using the IN (Intelligent Network) model [1] and CORBA technology [2]. Both access signalling across UNI (User-to-Network Interface) and network signalling across the NNI (Network-to-Network Interface) are supported using ITU-T standards (Q.2931 and B-ISUP / MTP-3). The FSR (Frame Synchronised Ring) [3] switching fabric developed by the Technical Research Centre of Finland has been used as the initial hardware platform.

2.2 Calypso

In the Calypso architecture [4, 5] the services are implemented as distributed applications consisting of the service clients in the end user terminals and service agents in the access network nodes. The service clients and agents communicate using generic network layer service that provides connectivity and data transport. TCP/IP protocol suite is suggested to be used to facilitate quick development and prototyping of the distributed service client/agent model using the existing protocols, services and applications of the IP networks. The service client/agent environment and the Calypso SEE (Service Execution Environment) will be based on Java due to the inherent support of distributed networking applications and code mobility built into the language.

2.3 Service examples

Two broadband services that have been piloted using the Tove and Calypso platforms are described below. Current implementations of the services operate only in a fixed broadband network, but it is reasonable to assume that the same services would be accessible also from mobile terminals.

2.3.1 Tove music on demand service

The Tove platform has been demonstrated using an on-demand music service. The server host is a workstation equipped with a CD player and a server application that is able to play and transmit the music to an ATM virtual channel. The server application registers an ATM SAP (Service Access Point) that is listened for incoming connections. The clients call the service through standard ATM Forum UNI 3.1 or ITU-T Q.2931 signalling procedure. Additional functionality, such as special billing schemes, can be implemented using the IN service model. Once the call has been established, the server starts transmitting the piece of music that the user requested. The service terminates and the connection is released upon user request or when the requested piece is finished.

2.3.2 Calypso TV distribution service

The Calypso TV distribution service demonstrates the concept of delivering TV programs over broadband network. The TV channels are implemented as unidirectional point-to-multipoint ATM virtual channels originating from a server host. The server creates a multicast VC for each TV channel, informs the service agent in the access node of the new channels and starts transmitting the MPEG-1 encoded video streams directly over ATM AAL5 (Figure 1.)

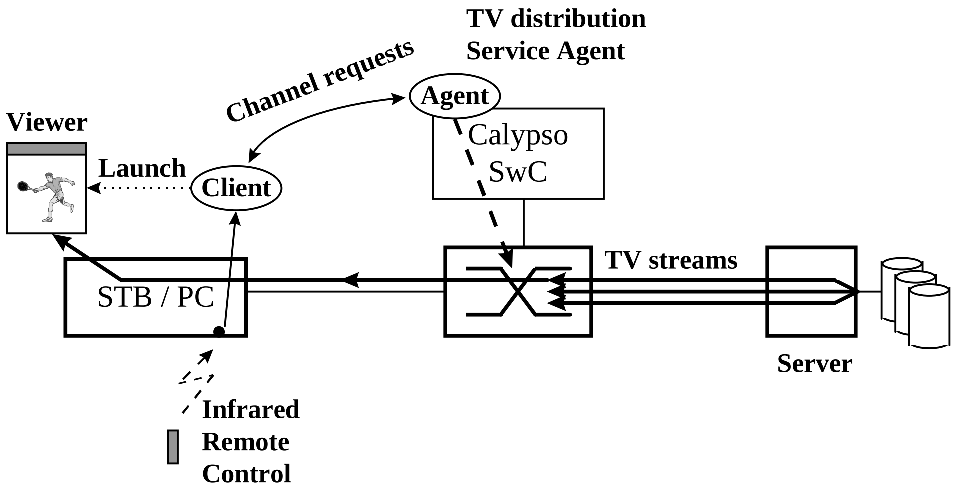

Figure 1 Calypso TV distribution service

The viewers may join and leave the channels at will. When the client application is started in the user's terminal, it connects to the service agent running in the Calypso switch controller. The service agent opens a virtual channel in the client's link and starts listening for channel requests. When the user selects a channel using an infrared remote control, the agent joins the client's VC as a leaf to the multicast tree of the selected channel. When the user changes channel, the agent prunes the client's VC from the old channel and joins it to the new one. The received program is viewed with a separate viewer application launched by the client.

The second phase of the Calypso TV service will allow operation in a network spanning over more than one ATM switch. In this mode of operation the service agent in the access node must be able to forward the channel request upstream (towards the server host) in case the requested TV channel multicast tree does not reach the access node (i.e. no other user connected to the same access node is currently viewing the channel). The request is forwarded until it reaches the multicast tree in some switch, at which point the new leaf is merged to the multicast VC. Each intermediate switch must have reserved resources upon forwarding the request. Also the channel leave requests must be forwarded upstream if the leaving user was the only receiver in the access node. The intermediate switches are responsible for releasing resources in the network branch not needing the channel any more.

3. Broadband mobile

The global standardization of third generation mobile systems is going on within the standardization bodies ITU-T and ITU-R under the name IMT-2000 (International Mobile Telecommunications 2000). In Europe the standardization is carried out by ETSI and the system is called UMTS (Universal Mobile Telecommunications System).

3.1 UMTS

The UMTS network infrastructure, as defined in ETSI [6, 7], is divided into two separate domains, the Access Network (AN) domain and the Core Network (CN) domain connected to each other via an IWU (Inter Working Unit). The interface between these domains is called I_u and it allows different instances of CNs to be connected to the Access Network. In the UMTS Phase 1 it is likely that the UMTS Access Network, i.e. UMTS Terrestrial Radio Access Network (UTRAN), will be interconnected with the GSM Phase 2+ NSS (Network Subsystem) functioning as the Core Network. The UMTS network architecture following this evolution path from GSM platform towards UMTS is illustrated in Figure 2.

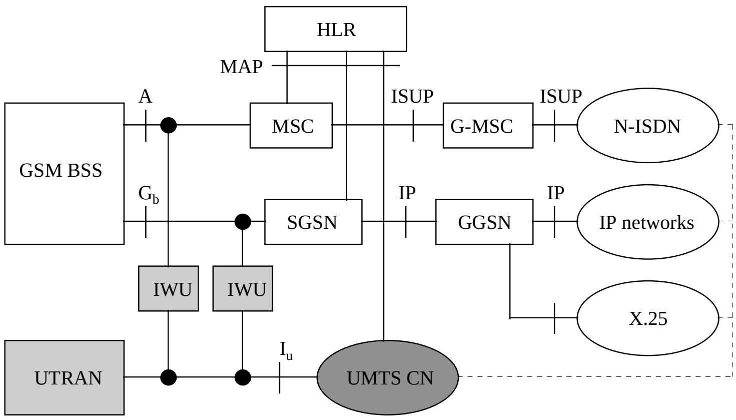

Figure 2 Evolution of GSM platform towards UMTS.

The GSM NSS in phase 2+ will be capable of handling both the conventional circuit switched transmission introduced already in GSM Phase 1 and the packet switch transmission provided by the GPRS (General Packet Radio Service). The circuit switched transmission path between the GSM BSS (Base Station Subsystem) and external networks is routed through the GSM network via the MSC (Mobile Services Switching Center) and the GMSC (Gateway MSC) while the packet switched transmission is routed via the GPRS components SGSN (Serving GPRS Support Node) and the GGSN (Gateway GPRS Support Node). The UTRAN will be interconnected to this core network via two IWUs, one between the I_u interface and the GSM A interface, and another between the I_u interface and the GPRS G_b interface. This architecture makes it possible for both GSM and UMTS customers to be connected both to circuit switched networks (e.g. PSTN and N-ISDN) and packet switched networks (e.g. the Internet and intranets). Additionally, users should also be able to roam between GSM and UMTS networks.

In order to provide real multimedia services for the UMTS customers, the UMTS Core Network (UMTS CN) is introduced later in subsequent phases of the UMTS. The UMTS CN will be connected to UTRAN directly via the I_u interface without an IWU. However, the UTRAN remain interconnected to the GSM NSS to ensure the interworking between UTRAN and GSM NSS.

3.2 IMT-2000

The IMT-2000 system, as defined in ITU-T [8], is divided into four different Functional Groups: User Identity Module (UIM) functions, Mobile Terminal (MT) functions, Radio Access Network (RAN) functions and Core Network (CN) functions. The relationships and physical interfaces between these Functional Groups are shown in Figure 3.

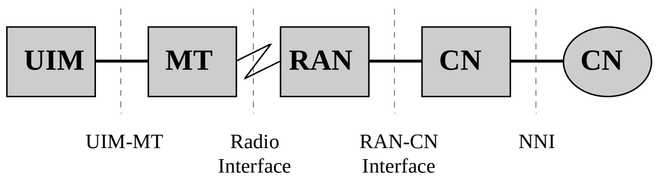

Figure 3 IMT-2000 Functional Groups

The above division to the Functional Groups is utilized when defining the functional model for the IMT-2000. The basic modelling principles for IMT-2000 functional model are the same as used for IN DFP (Distributed Functional Plane) modelling: The functions required for IMT-2000 service support have been grouped into Functional Entities (FE) and the relationships between these FEs have been indicated in Figure 4.

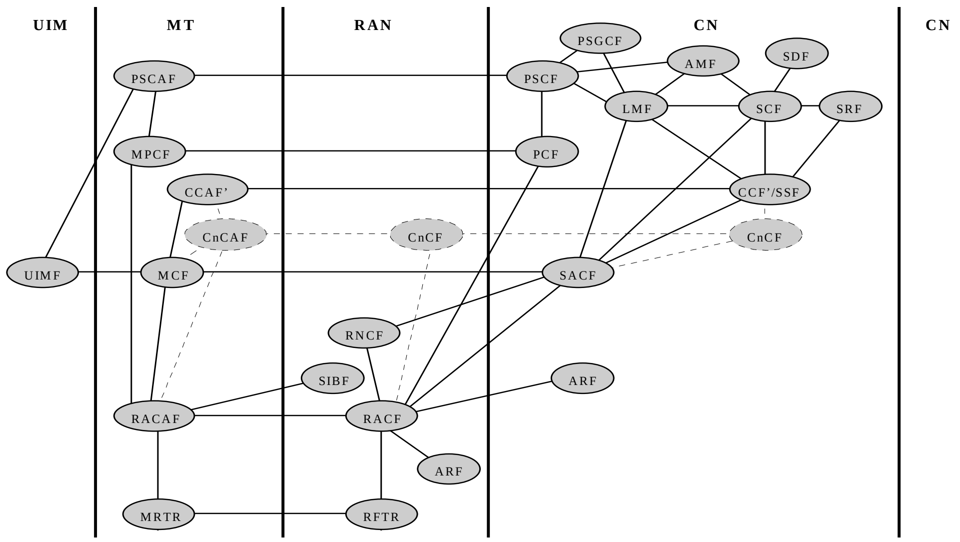

Figure 4 The IMT-2000 Functional Model; Options 1 and 2

Since two possible approaches to the allocation of call control and connection control related functionality were detected, two options for the functional model were identified correspondingly: Option 1 with integrated call control and connection control FEs and Option 2 with separated call control and connection control FEs. The functional models for both the options 1 and 2 are described Figure 4. The FEs and relationships drawn with solid lines are common to both options while FEs and relationships indicated with dashed lines, are present only in Option 2. The subsystems UIM, MT, RAN, and CN are also shown in Figure 4.

The FEs presented in Figure 4 can be grouped into three separate categories: Radio Access Control Related FEs, Communication Control Related FEs and Packet Data Services Control Related FEs. Radio Access Control Related FEs are in charge of controlling access links. These functions are distributed over the following FEs: RACF, RACAF, RFTR, MRTR, ARF, SIBF and RNCF. Communication Control Related FEs are in charge of the overall access, service call and connection control. These functions are distributed over the following FEs: SDF, SCF, SRF, SMF, SSF/CCF', CnCF, LMF, AMF, SACF, MCF, UIMF, CCAF' and CnCAF. Packet Data Services Control Related FEs are in charge of the overall context access and service control for packet services. These functions are distributed over the following FEs: PCF, PSCF, PSGCF, PSCAF, MPCF.

The functional models represented above do not fix the physical network configurations but can be mapped to physical network elements in several different ways. IMT-2000 systems may be implemented either as a standalone network with gateways and IWUs towards the supporting networks, in particular, PSTN, ISDN, Packet-Data Networks (e.g. the Internet) and B-ISDN, or integrated with the fixed networks. The first case is comparable to the current implementations of PLMNs (Public Land Mobile Networks) and is also a solution in cases where the fixed network and the radio network are operated by different operators. In the latter case, the functionality required to support specific radio network requirements, e.g. location registration, paging and handover, is an integral part of the fixed network.

4. Mobile multimedia

Until now broadband connections (2 Mbps and over) with multimedia capabilities have been mainly in business use. However, the majority of media business (70%) is created by consumer segment, so that only when broadband residential access is available the digital multimedia services over networks can grow to high volumes. The consumer behaviour will also change: Typical telephone use has been only 5 - 20 minutes per day per subscriber line. On the other hand TV is used 2 - 4 hours per day in a family, and the Internet browsing 10 - 60 minutes per day. So, the availability of low cost broadband multimedia will change the traffic behaviour and load in networks.

Future teletraffic is expected to be divided into two major types: Type 1 traffic with bursty real time streams originating from computer applications, the Internet and World Wide Web and Type 2 traffic with fixed multimedia streams from sources such as DAB radio (Digital Audio Broadcasting), DVB television (Digital Video Broadcasting) and satellite.

Both bursty and fixed streams can be delivered in point-to-point or multicast manner. There are also expectations that bursty traffic is more point-to-point oriented and optimally routing based, while fixed bandwith traffic is more multicast oriented and hence switching based. This will favor connection control with multicast capabilities. In IP switching the bursty traffic streams are routed and fixed multimedia streams are switched, which makes it possible to find a cost effective optimum between routing and switching [9]. As a result of this development new methods for network dimensioning will be needed.

The broadband mobile access is still under development. The new systems UMTS and IMT-2000 both include functions for mobile multimedia services handling and delivery to the users. The development of fixed broadband networks may be a driver for developing service controlled IP switching type solutions such as the one described in Calypso pilot (see 2.3.2).

In mobile networks the terminal mobility adds complexity in the multimedia services delivery. In terminal mobility three types of connection control will arise: Type 1 with point-to-point traffic such as ordinary calls between subscribers, Type 2 with point-to-multipoint traffic including conference calls and small number of subscribers receiving multimedia streams and Type 3 with broadcast traffic for large numbers of subscribers receiving popular multimedia streams.

In multicast traffic there arises a problem in the definition of points where multicast operation is performed. When the subscriber enters handover phase, there may be a need to introduce a new multicast leg in the core network (Figure 5). The determination of the optimal multicast point and the respective signalling needs study and should be specified.

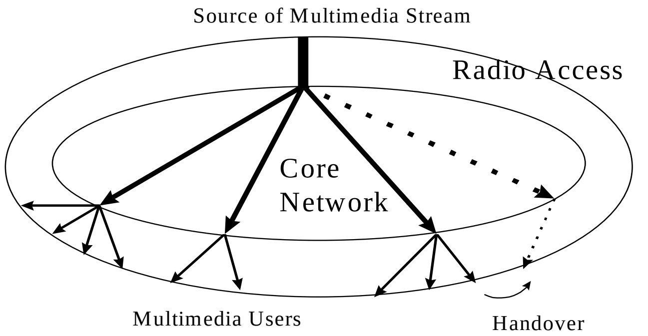

Figure 5 Multicast distribution of multimedia streams

The number of simultaneous receivers per multicast channel depends heavily on channel preference distribution [10]. In mobile case the optimal distribution strategy may be multicast or broadcast. For large receiving populations of the popular channels broadcast distribution will be the most cost effective strategy, and for small populations multicast (Figure 6). The algorithm to calculate the broadcast - multicast decision needs study and should be developed.

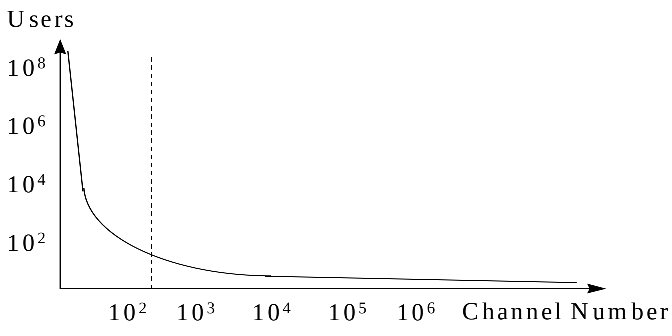

Figure 6 Channel usage (broadcast strategy is used left of the dashed line)

In broadcast traffic there will also be new demands on the radio interface. In ordinary calls, such as the Tove music on-demand service (see 2.3.1) the radio channel is available only for one mobile terminal. However, in multicast or broadcast applications like the Calypso TV distribution service (see 2.3.2) several terminals should be attached to one radio channel. This is possible e.g. in CDMA by giving the terminals same CDMA code (key) for transmission decoding.

5. Conclusions

Based on the experience of multimedia service pilots in fixed broadband networks we expect that multicast and broadcast connections will have a remarkable role. Hence, in the development work of broadband mobile networks there is a need to specify functionalities for multicast switching and for the terminal access to broadcast radio channels.

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