Beyond 3G Demonstrator for Enhanced Service Signaling, Discovery and Management

Karim El-Khazen(1), Fabienne Lefevre(2), David Garrec(1), Michel Guiraudou(1), Omar Benali(1)
(1) *Motorola Labs (CRM), European Communications Research Lab, 91193 Gif-sur-Yvette, France*
{elkhazen,garrec,guiraudou,benali}@crm.mot.com
(2) *Motorola (PCS), Personal Communications Sector, 31023 Toulouse, France*
fabienne.lefevre@motorola.com

Abstract

The advent of the cooperating IP-enabled heterogeneous radio networks will offer, under the "Beyond 3G" vision, ubiquitous services. In this new challenging context, a novel architecture has been designed within the control plane to avoid modification of existing networks. Therefore, a new entity in the network, a complementary middleware in the terminal, and enhanced signaling protocols were introduced. In order to prove the deployment feasibility of this solution, a testbed has also been implemented to demonstrate service signaling, discovery and management concepts in such a heterogeneous environment. This paper presents different functionalities and components that have been prototyped in this "Beyond 3G" demonstrator, as well as our experience in building such a complex testbed.

1. Introduction

Today, a wide range of networks is available to the end-user. Each of these networks is satisfying certain requirements and is optimized for a given set of services. In the future, the user will require having all these services available on one integrated terminal with transparent service discovery and delivery.

The vision of Beyond Third Generation (B3G) [1] consists in an open, smooth, and flexible integration of different access technologies around an IP core network. Within this framework, the next generation services will be provided to the end-user seamlessly and in a transparent way [2] [3]. Nowadays, most of the existing services are dependent on network operators. We consider that future services will be proposed to a large variety of users based on their location, interests and terminal capabilities.

With the perspective of demonstrating service signaling, discovery and management concepts in such a heterogeneous environment, a testbed has been designed and implemented including content providers, service providers, network operator functionalities, as well as B3G terminals.

Our paper is structured as follows: Section 2 describes the overall testbed architecture. Section 3 illustrates the functional features of this testbed. The descriptions of the different components are detailed in Section 4, and the demonstrator in Section 5. Section 6 wraps up the paper with pointers to future work and conclusions.

2. Overall Testbed Architecture

The system architecture is based on a horizontal integration of the heterogeneous radio access networks (RAN), interconnected at an IP level in order to reach the following objectives:

- Ensure a mapping between the requested services, the abilities of the user terminals and the Radio Access Network (RAN) capabilities,
- Propose new services that could not be delivered by separated RAN, and enhance the current ones,
- Provide a global and unified approach of the information concerning the users.

The B3G testbed goal is to combine cellular (General Packet Radio Service, GPRS), WLAN (IEEE 802.11b) [4] [5] and broadcast (Terrestrial Digital Video Broadcasting, DVB-T) [6] networks in a relatively short-term timeframe. The architecture of the system aimed at supporting the previous combination of radio access networks was specified with the following requirements:

- The terminal information should be available in one entity and not be confined to one radio access network. This entity would have an overview of all the terminals states, the radio access networks capabilities and services availabilities and could therefore take the fairest decision for each actor,
- The architecture benefits should be localized on the control plane and shall not impact the way the data is delivered to the user. Other proposed architectures such as the ones developed within the framework of IST-DRIVE [7] [8] [1] and IST-MCP [9] projects mainly focus on inter-system handovers for insuring transport continuity. On the contrary, the presented architecture aims at enhancing the control plane to

identify the most appropriate access network for each proposed service,
- The system architecture should be independent of the supported radio access networks. The service provided by our architecture may be proposed by an independent third-party that could have bandwidth allocation agreements with RAN operators,
- No radical change shall be brought to existing radio access networks and standard protocols shall be used as far as possible.

The objectives of the system combined with the previously listed set of requirements led to the introduction a new network entity, independent of other actors and called "B3G server". This central supporting element of the whole architecture ensures the coherent inter-working between the different players (service providers, access networks, terminals…) in heterogeneous radio access networks. The responsibilities of this entity are mainly to:
- Gather the service descriptions sent by the service providers (descriptions using Extensible Markup Language (XML) [10]…),
- Decide on the most suitable announcement method to the end-users (web-based remote portal, SAP/SDP [11] [12]…),
- Collect the user subscriptions sent by the B3G terminals,
- Determine the most appropriate service access methods (based on terminal capabilities and users preferences…),
- Configure the corresponding broadcast gateways (through the use of SNMP [13]…).

On the opposite side of the network architecture, the multimode B3G terminals are, for the moment, computers that incorporates the required transceivers for the connectivity to GPRS, WLAN and DVB-T networks. In order to take advantage of the three different medias and to hide the network diversity and complexity to the end-user, the terminals have been enhanced with a middleware. By interacting with the applications, the radio access networks and with the B3G server entity, this middleware enables the terminal to start, configure, consume, stop and recover services when terminal capabilities evolve. The terminals also include a web browser where the list of available services is displayed, based on the terminal capabilities and the user preferences.

Figure 1 shows one B3G terminal with the three available network connectivities, as well as the B3G server and the service / content provider servers in the overall network. This testbed is built upon Linux and MS Windows-based platform.

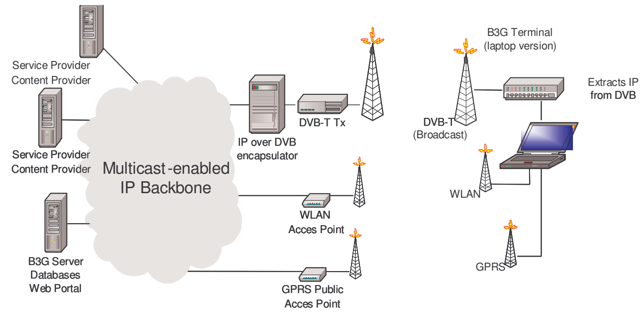

Figure 1 Overall architecture with B3G terminal

This architecture brings benefits for the users, the service providers and the network operators. Some of them are highlighted in the following items.
- Benefits for the users: The proposed services are displayed to the user according to its terminal capabilities (network interfaces, storage space…), its preferences (maximize quality or minimize cost…) and location. The user is sure that a service that is proposed to him can be run on its terminal. The service is managed for a more user-friendly use, and is remotely configured, started and stopped, in a totally transparent way for the user.
- Benefits for the Service Provider: The services target directly the users depending on the user profiles, terminal capabilities and location. The cost and the quality of the delivered service are optimized. With this architecture, the Service Provider negotiates the service transport with a unique third party.
- Benefits for the RAN Provider: By knowing the user terminal capabilities at a given moment and the proposed and subscribed services in a specific geographical area, our architecture enables the traffic load management between the different RAN. These benefits are not currently used in the testbed but the results of some other projects dealing with that, as the MONASIDRE IST project [14] [16], could be used as a basis.

3. Functional Features

The proposed end-to-end hybrid communications system has different functional features distributed between the B3G terminals, the B3G server located in the network, and the service providers. Some of the main features are described in this section: user context management, service discovery and announcement, network selection, service management.

3.1 User context management

To map the services proposed by the service managers with a targeted panel of users, the B3G server manages some information concerning these users. Thanks to a protocol between the terminals and the user manager part of the B3G server, the terminal static capabilities (hardware and software available in the terminal) and dynamic capabilities (currently available networks) are stored in a database. The status of the user towards the proposed services is also added to this information (subscribed, consuming...).

3.2 Service discovery and announcement

By the mean of a dedicated interface based on XML messages, the B3G server can discover and be aware about any IP multicast multimedia service proposed by a given service provider. The SAP (Session Announcement Protocol) server is used to announce such IP multicast services to the end users. These announcements can be sent over any IP multicast-enabled network, to the well-known SAP multicast address/port. The B3G server, taking into account the information gathered about the proposed service, the available users and their terminals capabilities, as well as some pre-defined optimization choices, decides the best way to send the service advertisements and orders the SAP server to do so. The SAP body containing an SDP (Session Description Protocol) message provides the user with a relevant service description. At minimum, this description includes the following fields corresponding to the SDP mandatory information: SDP version protocol, service owner and session id, session name, connection information, start and stop time and media information.

On the terminal side, the SAP client gathers all the SAP announcements on the different available interfaces. In addition to the sent information about a given proposed service, the user knows which interface/network is delivering its announcement.

3.3 Network selection

This feature has the role of optimizing the link on which services will be offered. The network selection decision can be made either in the B3G server or in the terminal. This selection depends on the type of service.

3.3.1 B3G Server selection. The B3G server takes into account four types of inputs: the number of users currently logged into the server, terminal characteristics, available network resources and available services. First of all, the B3G server analyses the description of service. It proposes the service with the different possible networks. With this information, the B3G server can match services parameters with terminal capabilities. It also takes into account the number of users in a specific configuration. The B3G server is able to initiate a change in the way the service is announced or consumed. It is also able to reconfigure the announcement.

3.3.2 Terminal selection. The terminal has also the possibility to "choose" the network from which a service is received, at least for services that are announced by SAP. In case the same service is available through different interfaces or under different formats, the terminal may favor one service description, by taking into account the user preferences in terms of networks and the signal levels of the radio network interfaces. This service choice can result in an interface reselection, which will be performed by the terminal, after informing the B3G server.

3.4 Service management

Existing management paradigms assume that managers and management agents are collocated on the same network with bi-directional communication, which is not suited for B3G systems. Furthermore, terminals may not offer always-on connection, and some access technologies do not allow incoming connections to terminals (such as GPRS network using NAT/firewall…). The implemented framework enables enhanced application-level management of Java-based applications, using Java Management Extensions framework (JMX) [15]. The B3G service management framework makes use of a proxy-based architecture to deliver and receive management information. It implements a "push" communication paradigm to deal with disabled-incoming-connections systems (e.g. GPRS), and relies on encoding JMX management information in HTTP to bypass firewalls.

4. Components of the Testbed

Our testbed consists of many functional entities located both in the networks and terminals. Some of the main entities are described in this section.

4.1 Network Side Elements

The Figure 2 shows the main entities of the B3G server. It shows the communication between the different entities. The database gathers all information coming from the different ingress: service, network, terminal and user. Some entity fulfills the database to allow the dynamic management.

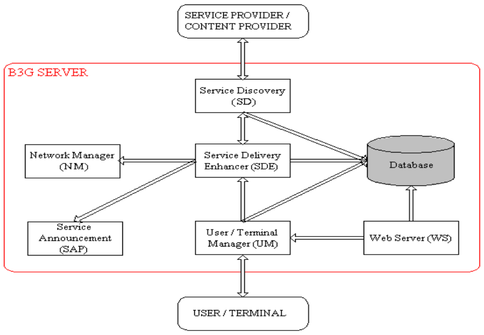

Figure 2 B3G server distributed entities

4.1.1 Service discovery (SD). The SD is the only interface between the B3G server and any service provider who wants to propose a service through this platform. The considered services are basically multicast sessions (video, audio, data or any possible combination of them). Through the SD, a service provider can ask the B3G server to start/stop announcing a given service by sending an XML message over a UDP/IP message. The "start" XML message provides the B3G server with all the mandatory information to build a complete SDP message, at least. The SD reads the XML messages and updates the B3G database as required.

4.1.2 Network Manager (NM). The NM has different roles. The first one is to negotiate resources with the different Radio Access Network (RAN). The second is to manage the start and the stop of services. The last is to indicate to the service provider when a service starts the different users that are subscribed. In the testbed, instead of negotiating with the DVB network operator (broadcaster), the Network Manager directly manages the encapsulation of the IP datagrams into the MPEG2 transport stream.

4.1.3 Service Delivery Enhancer (SDE). The main role of the SDE is to optimize the way to announce and deliver a service. It takes into account different criteria: from the service description (unicast/multicast, resources necessary), from the network description (unicast/multicast, resources available, cost), and from the users/terminals (interfaces available, users preferences). The SDE informs the SAP the way to announce the service.

4.1.4 User / Terminal Manager (UM). The UM manages completely information coming from the users and terminals. It allows to users to login in the B3G server and then access to different services of the platform, i.e.: it can subscribe and consume all services available in the platform compatible with its configuration. The UM informs the SDE when a user or terminal capability change, it allows to the SDE to update the way to announce and deliver services.

4.1.5 Web Server (WS). The platform contains a web server for two main purposes: displaying the content of the database for monitoring their content, and displaying the description of all the IP unicast services that are proposed by the platform to a given terminal. The web server has been chosen as the unique tool for displaying available unicast services to users. As above-mentioned, the SDE is responsible for selecting the services that could be proposed to a given user.

4.1.6 Java-based Management Platform. The service provider entity contains the Java-based "service manager", which is responsible for starting, configuring, and stopping applications on the terminals. This "service manager" communicates with its corresponding Java-based agent in the terminals, via our proxy. The Graphical User Interface (GUI) of the Service Provider consists in several dynamic pages displayed in a web browser, where the operator (content and service provider) can create, manage, configure, and remove services.

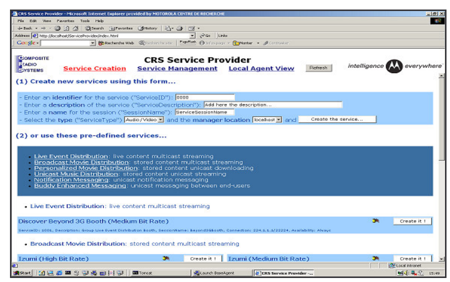

Figure 3 Service Provider GUI screenshot

4.2 Terminal Side Elements

The following Figure 4 shows an overview of the terminal functional architecture featuring the data and control plane and the internal relations between functionalities. It illustrates the communication messages with the network, which can be standard messages such as SAP or proprietary messages such as service configuration messages.

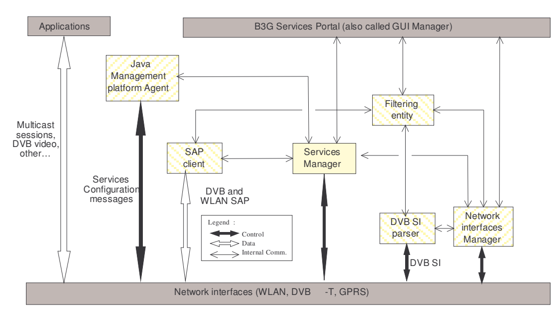

Figure 4 Terminal Architecture

4.2.1 SAP Client. The SAP client is a program that is in charge of handling all the Session Protocol Announcements (SAP) [11]. All the service descriptions, described using the Session Description Protocol format (SDP) coming from all the attached multicast capable IP networks will be sent to the collected by the Services Manager. The SAP client is required to receive all SAP announcements from both WLAN and DVB-T interfaces, and send the SAP services descriptions to the Filtering entity and to the Services Manager (when a service has been subscribed by the user).

4.2.2 Services Manager. The Service Manager is responsible for collecting the information about all services to which the user has subscribed. This information should always be up-to-date. As far as multicast services are concerned, the Services Manager especially tracks the eventual changes occurring for those services by repeated parsing of the descriptions produced by the SAP client. Upon change in any SDP description that may lead to interface reselection, the Services Manager will reconfigure the routing tables and warn the entities that will have to restart/reconfigure the service. As far as unicast services are concerned, since Mobile IP is not implemented yet in our testbed, the role of the Services Manager is to warn the B3G server in case the interface on which the service was consumed is lost.

4.2.3 Filtering Entity. The filtering entity is responsible of taking all services available from the network and selecting only those that are pertinent for the user, considering several input parameters: network information, terminal capabilities and user preferences shall lead to filter some of the proposed services. This filtering is dynamic since the parameters can evolve in time, thus the filtering is done each time it is required by the GUI manager.

4.2.4 Services Portal. The Graphical User Interface (GUI) consists in several HTML frames displayed in a web browser. The frames come either from the server in the network platform or from a local web server that displays locally stored or generated HTML frames. The interface is able to display all the services announced over the networks attached to the terminal. These services may be IP based as well as DVB native. The pushed services currently available and the service proposed by a remote portal are dynamically displayed in a page of the user web browser. The service is launched directly by hitting only a hyperlink in the page displayed in the browser. This means that the connection parameters are available in the terminal. The user is informed of the nature of the components of the service, of the schedule for subscription or consumption of the service. The user preferences may be configured through a web page. These preferences can be changed and taken into account at any moment. The displayed services are filtered according to these preferences.

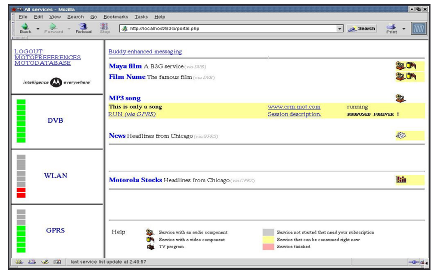

Figure 5 Terminal GUI screenshot

4.2.5 Java-based Management Agent. This Java-based management agent communicates with its corresponding agent of the service provider. It receives the management information and executes them in the terminal (launch of the right application, configuration…). It also warns the network entities when the user has stopped consuming a service.

4.2.6 Network Interfaces Manager. The Interface Manager is in charge of supervising all the different interfaces available to the terminal, keeping and maintaining all the necessary information concerning each of these interfaces. By checking the interface reception level, the Interface Manager can take the adequate measures when an interface is lost or gained. It also has to inform the other entities of all relevant piece of information that could impact them. The Network Interfaces Manager is also aware of the different routes configured in the terminal routing table(s) and is able to change them.

4.2.7 DVB SI Parser. The DVB SI parser is aimed at extracting the signaling tables form the DVB flow in order to spot the different DVB native and IP services that the user could get. The DVB service description extracted from the tables should be sent to the Services Manager.

5. The Demonstrator

Our testbed consists of many hardware and software components. The testbed demonstrator is composed of two types of terminals: desktop and laptop computers that have different hardware devices. The desktop uses a Technotrend DVB card with a PCI connector to the PC as a DVB-T receiver, the GPRS is obtained with a Motorola T280 phone and the WLAN with a Lucent Technologies Orinoco PC Cards. The laptop uses the same transceiver component except for the DVB card that cannot be plugged in due to the lack of PCI connector. The DVB card has thus been replaced by a whole DVB reception chain. The IP packet decapsulation in the terminal is obtained thanks to ViaCast IP companion component. One desktop computer running MS Windows represents the Service Provider. It uses the Java Media Framework (JMF) [15] of Sun to stream the content over the network. The SkyStream gateway is remotely managed by the Linux-based B3G server using SNMP.

Figure 6 The B3G platform

6. Conclusion and Open Issues

We have proposed in this paper an architecture that demonstrates features on how services can be discovered, subscribed, configured, and consumed by multi-mode terminals in a "Beyond 3G" environment, where different access technologies are integrated around an IP core network.

Our proposed testbed provides a building stone for the signaling, discovery and management of the services over heterogeneous infrastructures in future "Beyond 3G" networks. It includes content providers, service providers, network operator functionalities, as well as terminals, and points out the key features that should characterize the design of such a framework.

There is still future work ahead of us. It might consist, on the network side, in studying further the scalability of our system architecture, in providing some kind of network management, and enhancing the intelligence of our B3G server. On the terminal side, we are looking at the same time at adding other access technologies and getting smaller terminals.

7. References

[1] R. Walsh, L.Xu, T. Paila, "Hybrid networks – A step beyond 3G", 3rd International Symposium on Wireless Personal Multimedia Communication, Bangkok, Thailand, 12-15 Nov. 2000

[2] J. M. Pereira, "Fourth Generation: Now, it is Personal!", The 11th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC), Vol. 2, 2000

[3] B. G. Evans and K. Baughan, "Visions of 4G", IEE Electronics & Communication Engineering Journal, Vol. 12, No. 6, pp. 293-303, December 2000

[4] U. Varshney, R. Vetter, "Emerging mobile and broadband wireless networks", Comm. Of the ACM, Vol. 43, No. 6, June 2000.

[5] U. Varshney, "Recent advances in wireless networking", IEEE Computer, Vol. 33, No. 6, pp. 100-103, June 2000.

[6] Digital Video Broadcasting (DVB) – http://www.dvb.org

[7] M. Annoni, R. Hancock, T. Paila, E. Scarrone, R. Tönjes, L. Dell'Uomo, D. Wisely, R. Mort, "Radio access networks beyond 3G: A first comparison of architectures", PIMRC, San Diego, 2001

[8] T. Paila, S. Aladdin, J. Ebenhard, M. Frank, T. Göransson, W. Hansmann, T. Lohmar, L.Xu, "Flexible Network architecture for future hybrid wireless systems", Mobile Summit 2001; Barcelona; September 2001

[9] IST project MCP (Multimedia Car Platform) – http://mcp.fantastic.ch

[10] Elliott Rusty Harold, W. Scott Means. XML in a Nutshell: A Desktop Quick Reference. O'Reilly & Associates. 2001.

[11] SAP – RFC 2974 (Session Announcement Protocol)

[12] SDP – RFC 2327 (Session Description Protocol)

[13] SNMP – RFC 1157 (Simple Network Management Protocol)

[14] IST-2000-26144 Project MONASIDRE (Management of networks and services in a diversified radio environment) – http://www.monasidre.com

[15] JMX (Java Management Extensions) – http://www.sun.com

[16] K. El-Khazen, G. Martinez, V. Stavroulaki, K. Tsagkaris, A. Oikonomou, G. Koundourakis, N. Koutsouris, P. Demestichas, M. Theologou, L. Papadopoulou, "Resource Management Strategies: Software Prototype and Results" (MONASIDRE Project Deliverable), August 2002