Combining MBMS and IEEE 802.21 for on-the-road emergency

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***Abstract*— Recent evolution of intelligent vehicles features the large scale emergence and introduction of multimode mobile terminals, with the capability to simultaneously or sequentially attach to conceptually different access networks. To cope with this, they require some abstracted framework for their management and control, especially in the case of intelligent selection between the various heterogeneous accesses. A solution to this issue, the Media Independent Handover Services, is being standardized as the IEEE 802.21. This draft standard has been studied and applied to the case of a B3G operator networks as a research topic in the EU-funded project Daidalos in order to enable seamless operation between heterogeneous technologies. This paper focuses on the seamless integration of broadcast technologies, in particular UMTS/MBMS networks, in the case when emergency information has to be delivered to a large number of mobile users. It describes an extension to the 802.21 framework which enables the dynamic selection and allocation of multicast resources and thus the efficient usage of the radio resources. The UMTS access is developed in the experimental software radio platform of EURECOM, and provides a direct inter-connection with an IPv6 Core Network, very close to the current LTE direction of the 3GPP. We describe here the additional Media Independent Handover primitives and how they are mapped to trigger the control of multicast (MBMS) resources in the UMTS network. This paper is introduced by the account of an on-the-road emergency situation, written as a showcase of the work performed in the EU FP6 research project DAIDALOS.**

***Index Terms*— MIH, UMTS, MBMS, IEEE 802.21, Heterogeneous networks.**

I. Introduction

Maria is a very famous medical doctor. She also teaches at the local university. One day, Maria and her husband Marc get into their car in front of the university. Both their terminals are connected to the university WLAN (Wireless Local Area Network). Maria starts driving the car, so she transfers all her active sessions to the car terminal, and avoid being distracted. As they leave the university, they lose the WLAN connectivity and are transferred to their mobile operator UMTS (Universal Mobile Terrestrial Service) network. After a while, the highway becomes more and more congested. Maria starts the navigation application on the car terminal. She uses the screen in the car to find a new route.

Suddenly there is a danger warning message on the car terminal screen, broadcasted about an accident in front of them. This message is sent on all the available networks, using DVB (Digital Video Broadcast), MBMS (Multicast/Broadcast Multimedia Service) and WLAN when present. It is sent only to drivers present in that zone thanks to localization systems and automatic multicast subscription to groups which identify geographical zones of the highway. A few seconds later, another broadcast message automatically pops up looking for the doctors located in this area. As Maria is a doctor, she responds to the message at the contact address, using her laptop where she has transferred back all her sessions.

This small scenario, written as a showcase of the work performed in the EU FP6 project DAIDALOS, demonstrates how heterogeneous networks can be combined to enhance safety and communications on the road. Recent years have seen the explosion of mobile communications. The trend in the mobile technologies is the conception of multimode devices, with an increasing number of interfaces, and able to remain permanently connected to the best available network. This trend implies the ability to operate these devices by abstracting the access technology diversity and complexity. To address this issue, the IEEE 802.21 work group [1] is currently standardizing a handoff process common to all the 802 media and that tentatively enables the mobility to and from 3G cellular systems. In the Daidalos-II project, this standard has been extended to include the support of multicast network operation, involving some cross-layer optimization between the Link layer and the Network layer. This paper focuses on the integration of the cellular network in this architecture, for multicast and broadcast traffic, combining the IEEE 802.21 standard with MBMS functionalities defined in the UMTS standard.

This paper is organized as follows. Section 2 presents some background information, starting with a brief description of the IEEE 802.21 standard, followed by the main characteristics of the MBMS specification and a short presentation of the "Pure-IP" UMTS platform on which this work has been performed and tested. Section 3 presents the architecture designed to enable the 802.21 standard over with the UMTS access in the case of MBMS support and finally, we draw our conclusions in section 4.

II. Related work

A. The IEEE 802.21 standard

In March 2004, the IEEE formed the 802.21 working group with the goal to develop a standard to allow a mobile terminal

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to seamlessly roam across different types of 802.x network access technologies, such as 802.11 (WiFi) and 802.16 (WiMAX). The standard was named Media Independent Handover (MIH) Services and was later extended to allow the integration of cellular networks based on 3GPP and 3GPP2 specifications. The reasons for introducing this group were mostly that 802.x standards enable handover only to the same network types and behind the same router**.** The standard was designed to facilitate mobility related operations by providing a standardized, technology-independent interface just below the network layer of the ISO/OSI stack and above technology dependent data link and physical layers. This interface is not present only at the mobile terminal, but is also deployed for signaling between the Mobile Terminal (MT) and the different network entities involved in a handover scenario (AR – or Access Routers -, AP - or Access Points - and BS – or Base Stations).

In order to help upper layer management protocols, the 802.21 defines three different Media Independent Services which offer generic triggers, information acquisition and the tools needed to perform handovers. The Event Service provides the framework needed to manage the event classification, filtering, triggering and the reporting of dynamic changes in the different links. The Command Service allows the upper layer management entities to control different link behaviors. The Information Service is responsible of distributing technology-independent, topology related information to the mobile terminals in order to allow them to choose the optimal network with the maximum of information available.

The architecture proposed by the 802.21 revolves mostly around a logical component that provides the above mentioned services to the other functions and modules running on a mobile terminal and on different network entities. This component is called the Media Independent Handover Function (MIHF). Inside the MT, a 3-layered architecture is defined and there the MIHF is acting as a relay between the media-specific Link layer entities connected by the MIH_Link_SAP (Service Access Point) and the media-agnostic MIH-Users, or upper layer entities, connected over the MIH_SAP, responsible for handling mobility protocols operation, Quality of Service (QoS) management functions or application specific requests.

A similar approach is present in the network entities, where the MIHF acts as an intermediary abstracting the technology specific functions of APs or BSs, and making them available over a technology-independent interface. This kind of deployment makes it easy for MTs to select the best Point of Attachment (PoA) since the MIHFs take care of “translating” the messages for each technology.

B. The MBMS specification

The MBMS is an enhancement of the UMTS system to provide the capability for Broadcast and Multicast Services in the network [2]. It is a point-to-multipoint service, allowing network resources to be shared. MBMS is divided into 2 parts: the User Services [3] and the Bearer services [4]. The User Services are provided by the Core Network to the mobile end user by means of the MBMS Bearer Services. The Bearer Services describe the operation of the radio link between the Radio Access Network (RAN) and the MT, and the capability to deliver IP multicast datagrams to multiple receivers using minimum network and radio resources.

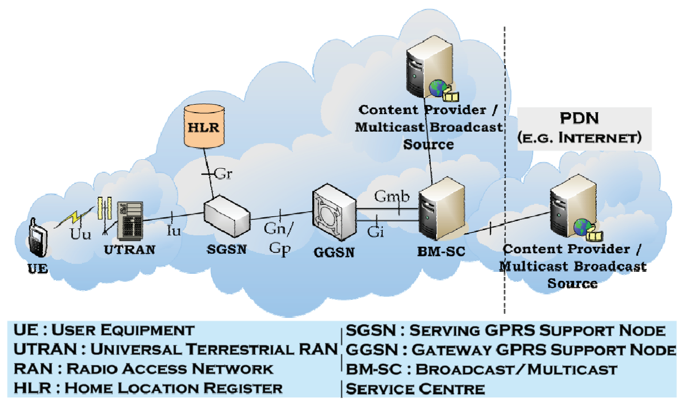

Figure 1: 3GPP reference model for MBMS

Fig. 1 shows the 3GPP reference model for MBMS. It enables the efficient usage of radio-network and core-network resources, with an emphasis on radio interface efficiency.

MBMS is achieved by the addition of new capabilities to existing functional entities and by the addition of a new entity, the Broadcast-Multicast Service Centre (BM-SC). The BM-SC provides functions for MBMS user service provisioning and delivery. It can also be used to authorize and initiate Bearer Services within the network, and to schedule and deliver MBMS transmissions.

Another important feature of the Bearer Service is its phasing model. In this model, the AR and the MT operate independently. The first phase is the MBMS user service announcement / discovery when users can request or be informed about the services available. Joining (i.e. MBMS multicast activation by the user) is the process by which a subscriber joins a multicast group, i.e. the user indicates to the network that he/she wants to receive Multicast data of a specific MBMS bearer service. Session starts when the network is ready to send multicast / broadcast data. It is the trigger for bearer resource establishment and data transfer. During Notification, the MTs are informed about current and future MBMS multicast data transfer. In the data transfer phase, MBMS data are received by the MTs. Session stops when the network determines that there will be no more data to send for some period of time – this period being long enough to justify removal of bearer resources associated with the session. Finally, leaving (i.e. MBMS multicast deactivation by the user) is the process by which a subscriber leaves a multicast group.

C. The “Pure-IP” UMTS platform

The UMTS experimental Software Radio Platform can be used in Beyond-3G (B3G) wireless network experimentations [5]. The cellular version described here implements the UMTS radio interface standard from the 3GPP [6]. The hardware architecture is based on a PC system complemented by a data acquisition and RF (Radio Frequency) module. The software portion of the platform is an extension to the Linux Operating System and makes use of a hard real-time micro-kernel.

The Layer 2+ of the radio protocol stack deviates from the 3GPP in the sense that it provides a direct interconnection with an IPv6 network in the BS / AR network node. Running IP up to the AR impacts the network architecture of the system, since it bypasses some basic 3GPP specific entities of the Core Network. An UMTS cell is considered as an IPv6 subnet, with its own prefix, under control of the AR. This allows the usage of the IPv6 stateless auto configuration and seamless network operation between various access technologies, in particular between UMTS and WLAN. The major advantage relies in the data plane, where packets are directly routed through some standard and inexpensive IPv6 routing in the AR. This architecture must be differentiated from the "all-IP" architectures, which bring the IPv6 protocol statically on top of existing protocol stacks. The benefits are the avoidance of a non optimal "IP-in-IP" encapsulation and taking full advantage of the IPv6 enhancements. Another benefit is a simplified deployment and management for the operator of a heterogeneous network offering several access technologies.

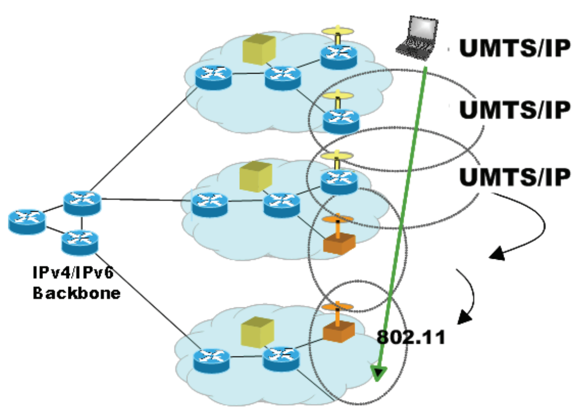

Figure 2: UMTS platform seamless operation

In the Access Router and the Mobile Terminal, the direct interconnection between UMTS air interface and IPv6 is achieved by an inter-working middleware operating below the Linux IP protocol stack, as described in [5]. The platform is completed by a 3GPP Access Stratum protocol stack, mostly compliant with the UMTS specifications [6], except for the Radio Resource Control (RRC) which has been adapted to the IPv6 direct interconnection. This platform also supports the MBMS point-to-multipoint radio channels [7], providing the capability to deliver IP multicasting simultaneously to multiple receivers in the same cell (e.g. Mobile TV), thus saving network and radio resources.

Fig. 3 shows a simplified version of the MBMS-enabled sub-system. The point-to-multipoint radio link is almost identical to its description in the standards. The cell is controlled by the UMTS AR, which establishes on request, as will be described later, an MBMS bearer; it also establishes a unicast return channel that can be used to carry bi-directional signaling. In the access network to which the AR belongs, some Service Provisioning entities provide functionalities similar to those of the BM-SC. A Content Adaptation Node is able to match the multicast flow to the reduced bandwidth provided by the UMTS physical layer.

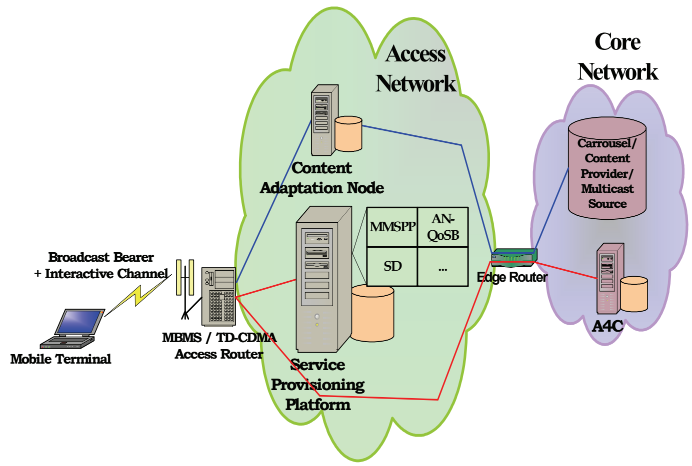

Figure 3: MBMS in a "Pure-IP" architecture

A major issue is that the UMTS is not a broadcast-dedicated technology like DVB. The MT is supposed to be able to support simultaneous services (for example the user can originate or receive a call) whilst receiving MBMS video content. This means that the MT resources (battery, processing power ...) must be shared with unicast traffic (same resources bandwidth in the cell), and so the MBMS radio bearer should be allocated only when needed. The reception at the MT must also start only when (and if) needed. Some prioritization of services must be performed based on its capabilities, between MBMS and non-MBMS bearer services. The phasing model described in section II.B has been adapted to the multicast service activation. It requires that the entities controlling the activation of the MBMS bearer exchange signaling information with the upper layer entities at the service level.

III. Using 802.21 to manage MBMS resources

One of the projects taking advantage of this study is Daidalos 2 [7], an Integrated research Project under the EU's Sixth Framework Program (FP6), dedicated to the design of advanced network infrastructures and access technologies for location-independent, personalized communication services.

As stated before, the UMTS is a connection-oriented technology. It requires that some QoS resources be allocated to enable the transfer of the user data traffic. The support of QoS in 802.21 considers the guarantee of service continuity during handovers, taking into account parameters such as the throughput or the Class of Service for example. As described in [8], the QoS support in the project is performed at Layer 3 level by QoS Decision Points, centralized, and QoS Enforcement Points, located in the Access Routers. An abstracted interface is needed to transfer requirements from the enforcement points to the Link Layer entities. This interface has been implemented in a new architecture, derived from the 802.21. This architecture is pictured in Fig. 4.

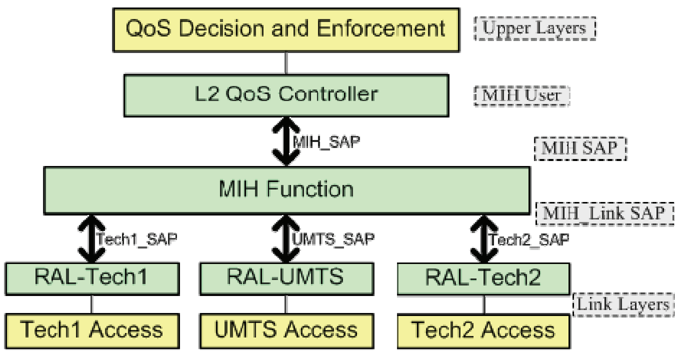

Figure 4: MIH-enabled architecture

The QoS Decision Points and Enforcement Points play here the role of upper layers. The L2 (Layer-2) QoS Controller (L2QoSC) module, acting as a MIH User, bridges the gap between L3 and L2 QoS subsystems. It keeps track of the location (current PoA) of MTs within an access network, knows the MIHF identifiers for all the PoAs and MTs, and is able to generate any number of MIH QoS reservation primitives for each L3 QoS request received from the upper layers. It interfaces the MIHF and the RALs (Radio Access Layer), which are the components responsible for the specificities of each access technologies. When resources need to be activated in the UMTS network, the RAL in the AR receives a Link Resource Activate command, carrying the QoS parameters, describing the data radio channels to allocate. Such QoS parameters are the reserved bit rate or the Layer 3 QoS class identifier. They are mapped to one of the radio QoS classes available in the UMTS platform and the resource reservation is prepared. Then the RAL triggers the physical allocation of the resources in the Access Stratum. This corresponds to a Radio Bearer Setup procedure in the RRC layer.

Since this framework is very flexible, it has been used also for the establishment and release of MBMS multicast point-to-multipoint radio channels. As described above, it is mandatory to establish them dynamically and not waste radio resources when no MT in the cell is interested in joining the multicast group. The procedure is identical to that of point-to-point resources, except that a specific identifier in the MIH command to the RAL signals that a multicast resource is concerned. The establishment of a connection in the UMTS layer triggers an MBMS context in the RAN, and sends a PIM (Protocol Independent Multicast) Join message to the service provider, requesting the respective content. In the case of establishment, the received QoS parameters are available for the downlink direction only and mapped to one of the specific MBMS QoS classes. Currently, the UMTS platform supports three of them for MBMS, based on the streaming class characteristics, with a data rate varying from 128 to 384 kbits/s. When this command is received by the RRC in the AR, the point-to-multipoint radio bearer is configured and established, and the multicast session can start. A message indicating the modified services is sent on the MCCH (MBMS Control Channel) to inform the users who previously joined the session that they can start listening.

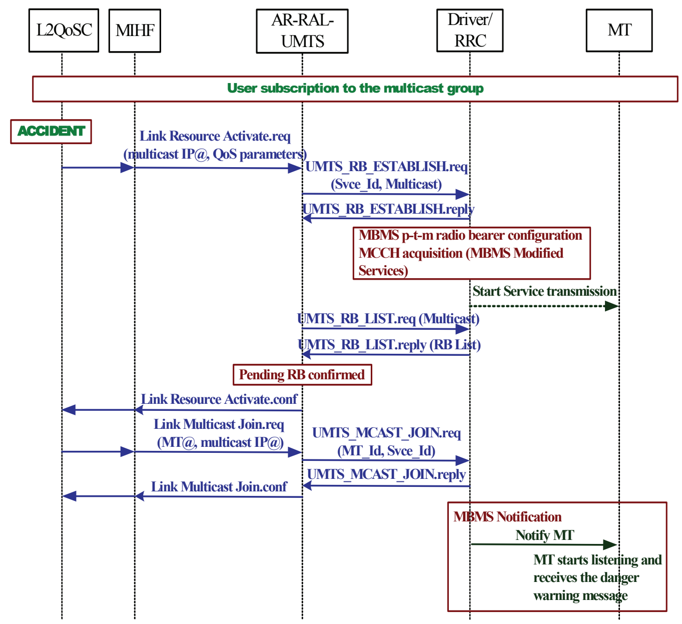

Figure 5: Activation of MBMS resources and MT notification

In the AR, the join in the multicast group of the UMTS is also triggered and a notification is sent to the MT to activate the MBMS context. MBMS notification is very important in the UMTS platform, as it triggers the multicast reception in the MT. For that, we have created two new Command Service primitives between the L2QoSC / MIHF and the RAL, Link Multicast Join and Link Multicast Leave, with a format similar to the usual 802.21 primitives, carrying the multicast flow identifier together with the MT information. In the RAL, these primitives trigger the RRC Modified Services procedure. When the MT has received the notification, it tunes to the advertised multicast flow. At this stage, it is able to properly receive the broadcast content.

This framework has been implemented and mostly integrated. Tests conducted in a local test site focusing on MBMS only demonstrate the effective ability to start the transmission and reception of multicast data less than 2 seconds after the decision to start a new session has been taken by a network entity totally independent of the technology. Figure 6 shows that data could be subsequently transferred to the MT, using the MGEN generic tool and its multicast capabilities, through the graal0 interface. Graal0 is the network interface that supports the UMTS and MBMS protocols.

The extension of the 802.21 standard presented here enables the management and control of multicast resources in the case of heterogeneous networks. It works in a very similar way with other access networks such as DVB, WLAN, or even WiMAX (IEEE 802.16). For connection-oriented technologies, it enables an efficient usage of the radio resources, even in the case of multicast or broadcast sessions, with the guarantee of an always-best-connected access to the network. Based on the dynamic measurement information provided via the Media Independent Event Service and the topology information provided via the Media Independent Information Service, the MT can choose the optimal available network and join a multicast group service that can be distributed across the heterogeneous networks of one or several operators. The network coverage, which varies according to the access technology, can be optimized by the operator against the bandwidth and network occupancy. In the case of MBMS, we can consider some future population coverage of about 90 to 100% in Europe, but with limited bandwidth capacity. It means that, in any location, using the MBMS and this architecture, vital information can be brought rapidly to a very important number of terminal users, while requisitioning a very limited amount of radio resources, because of the dynamically triggered usage of multicast or even broadcast data transmission. Future work on this topic will consider the integration of this architecture in a more global transport emergency system.

IV. Conclusion

This paper presented a scenario where some road emergency information is forwarded through all the available networks in a defined geographical area, e.g. a highway blocked by an accident. This feature is made possible by using an extension of the IEEE 802.21 standard to allocate and activate multicast resources in heterogeneous networks including DVB, MBMS… This study has been conducted as part of the integration of the UMTS in the B3G heterogeneous operator network study performed by the EU-funded research project Daidalos. It has been implemented in an experimental UMTS software radio platform which provides MBMS capability to support multicast and broadcast traffic. We have described how the 802.21 functionalities were extended and mapped to trigger UMTS and MBMS procedures, including the translation of Layer-3 quality of service into UMTS classes, the activation of multicast resources and the notification of mobile terminals when the broadcast session is available in the network. This implementation demonstrates the potentialities of including multicast traffic considerations in the IEEE 802.21 standard. Future work will be to integrate this architecture in a global intelligent transport system.

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mgen: version 4.2b4
mgen: starting now ...
14:38:37.508601 START
14:38:37.508901 LISTEN proto>UDP port>5000
14:38:37.509131 LISTEN proto>UDP port>5001
14:38:37.510010 JOIN group>ff3e:20:2001:db8::43 interface>graal0
14:39:06.763054 RECV flow>1 seq>0 src>2001:660:382:14:bfea:508:40e4:608/5001 dst>ff3e:20:2001:db8::43/
5000 sent>14:39:06.403921 size>512
14:39:07.834454 RECV flow>1 seq>1 src>2001:660:382:14:cf:ffbf:449a:608/5001 dst>ff3e:20:2001:db8::43/5000
sent>14:39:07.404745 size>512
14:39:08.769464 RECV flow>1 seq>2 src>2001:660:382:14:cf:ffbf:449a:608/5001 dst>ff3e:20:2001:db8::43/5000
sent>14:39:08.404696 size>512
14:39:09.765491 RECV flow>1 seq>3 src>2001:660:382:14:cf:ffbf:449a:608/5001 dst>ff3e:20:2001:db8::43/5000
sent>14:39:09.404643 size>512
14:39:10.771149 RECV flow>1 seq>4 src>2001:660:382:14:cf:ffbf:449a:608/5001 dst>ff3e:20:2001:db8::43/5000
sent>14:39:10.404593 size>512
14:39:11.766762 RECV flow>1 seq>5 src>2001:660:382:14:cf:ffbf:449a:608/5001 dst>ff3e:20:2001:db8::43/5000
sent>14:39:11.404534 size>512
14:39:12.867764 RECV flow>1 seq>6 src>2001:660:382:14:cf:ffbf:449a:608/5001 dst>ff3e:20:2001:db8::43/5000
sent>14:39:12.404489 size>512
14:39:13.767953 RECV flow>1 seq>7 src>2001:660:382:14:cf:ffbf:449a:608/5001 dst>ff3e:20:2001:db8::43/5000
sent>14:39:13.404437 size>512
14:39:14.868796 RECV flow>1 seq>8 src>2001:660:382:14:cf:ffbf:449a:608/5001 dst>ff3e:20:2001:db8::43/5000
sent>14:39:14.404386 size>512
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Figure 6: Transmission of multicast data through the MBMS-enabled graal0 interface