

Media-Independent Multicast Signalling for Enhanced Video Performance in the MEDIEVAL Project

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Abstract: With the foreseen major increase in video traffic over the coming years, the current Internet's design is being perceived as inefficient for handling the demanding flow of video over wireless access networks, populated by an ever increasing number of mobile terminals. The MEDIEVAL project aims to evolve the current Internet architecture to provide an optimized video support in all layers of the protocol stack. With its cross-layer approach, abstraction mechanisms such as IEEE802.21 will work as enablers between the different architecture modules. With the widespread diffusion of video being realized over multicast and broadcast channels for resource optimization, using 802.21 signalling to optimize handovers affecting groups of users will generate multiple messages to each individual terminal. In this article, we extend 802.21 to support multicast transport of its signalling, enabling more efficient group handover scenarios.

Keywords: MEDIEVAL, video services, IEEE802.21, MIH, multicast.

The proliferation of mobile terminals provided with different kinds of mobile wireless accesses, such as WiFi and 3G, are placing an increasing demand on network operators which now have to provide multimedia services and applications to users on the move. According to recent studies [1], it is foreseen that P2P will be surpassed by video traffic in 2011, reaching volumes close to 90% of consumer traffic by 2012. Considering this, the provision of real-time video services over wireless access to mobile users places stringent requirements over the Internet, whose architecture was not conceived considering such demanding operations. Under this setting, the EU project MultimEDIA transport for mobile Video AppLIcations (MEDIEVAL) is researching the architecture and inherent mechanisms for evolving today's Internet towards the efficient support of video services over wireless access networks with mobility support, commercially deployable by operators. Providing a cross-layer approach, it relies on the IEEE802.21 Media Independent Handover standard [2] as an enabler of interactions between the different access technologies and high-level decision modules, under a common and abstract set of services. With multicast and broadcast transport mechanisms being used in MEDIEVAL to optimize the widespread diffusion of video services, when network conditions change and handovers are required, the effects typically affect not only a single terminal but blocks of terminals, and thus multiple handover commands need to be sent. Considering this, in MEDIEVAL we evolve the 802.21's design to have its signalling transported over multicast protocols, enabling the issue of a single command to handover users affected by the same phenomena. This article is organized as follows. In the next section we present an overview of the MEDIEVAL architecture, focusing on its main areas. This is followed by Section 2 where

we present our 802.21 design extensions to support multicast signalling. In Section 3 we provide use case scenarios and then conclude the paper in Section 4.

2. The MEDIEVAL Architecture

The project addresses key areas which compose 4 main components: Video Services, Mobility, Transport Optimization and Wireless Technologies. Besides these main blocks, multicast and IEEE 802.21 MIH are also central components that will be explored. The notion of cross-layer is the crucial concept in the project: by providing video-awareness to the whole stack, MEDIEVAL aims to optimize video in mobile environments, avoiding current problems resulting from the lack of layer interaction. This is depicted in Figure 1.

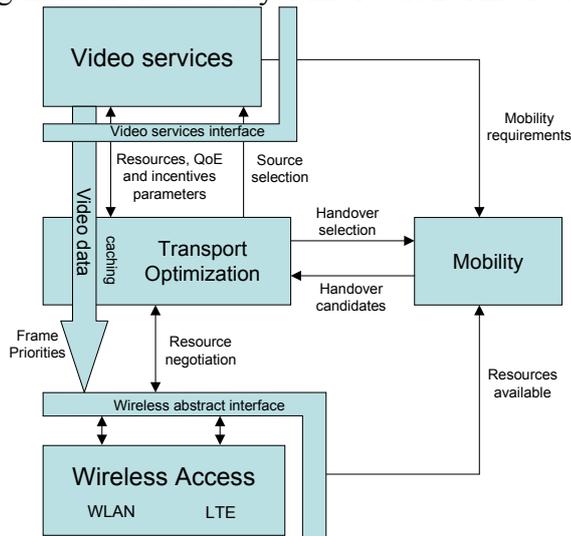


Figure 1 - MEDIEVAL main blocks

1. Video Services

The considered range of video services will be enhanced with interfaces for proper content adaptation and triggering mobility or transport related optimization. It will tackle issues such as: network dynamicity in terms of QoS requirements and network policies; session negotiation (i.e. RTSP); packet prioritization in relevant codecs (i.e. H.264) and specific link layer mechanisms for video optimization [7][8]. MEDIEVAL furthers this by specifically providing an interface for video services, enabling them to interact with network core mechanisms, providing video-specific information and requirements to the other intervening architectural blocks, and allowing them to better adapt video traffic.

2. Mobility

MEDIEVAL project uses as reference architecture 3GPP's EPC (Release 8) [18], and as reference mobility protocols PMIPv6 and DSMIPv6. Mobility mechanisms span over three areas: i) multi interfaced terminals and network mobility, ii) video-aware mobility management considering video services properties and iii) IP multicast mobility. The project considers these inputs to design a simplified and flatter mobility architecture.

3. Transport Optimizations

The project aims to provide intrinsic transport optimizations that include optimal source selection or video content adaptation based on wireless access conditions, dynamic rate-control and caching schemes, while providing the means for reliable and adaptive content

delivery [1]. Attention is paid to Content Delivery Network (CDN) architectures, which can benefit from the previously referred mechanisms, particularly in P2P video solutions [4] with optimal source selection and mobility in mind.

4. Wireless Technologies

MEDIEVAL improves service performance and reliability through the coordination of specific wireless technology properties and video services. Both contention-based (i.e. IEEE 802.11) and coordination-based (i.e. 3GPP) access methods are considered. In coordination-based ones, video traffic prioritization allows for significant QoE improvement, though constrained to specific conditions [5]. Other solutions either are based on heuristics and do not assure optimal performance [6] or are too complex, making deployment uninteresting for operators [7][8]. The introduction of cross-layer optimizations in LTE was an important step beyond previous cellular networks for data service delivery, particularly video. MEDIEVAL will support multiple wireless access technologies by taking advantage of standard IEEE 802.21, a cross-layer solution for interface abstraction for handover preparation.

5. Multicast

Although not a specific architecture item by itself, MEDIEVAL provides a common interface for allowing applications to efficiently deliver video content to user groups, leveraging multicast and broadcast context solutions, namely MBMS and eMBMS. Special focus is given to the network-based mobility multicast, as is the scope of MULTIMOB [9], tackling the non-involvement of the terminal in mobility signalling, which prevents it from participating in mobility-aware group subscription. IP multicast optimizations will consider mobility under the network perspective (i.e., due to handovers) as well as the service perspective (i.e., fast change of multicast groups, required by IPTV).

6. IEEE802.21 Media Independent Handover Services

As an important aspect shared by all areas of the MEDIEVAL architecture, 802.21 aims to facilitate and optimize handovers between different access technologies, through the introduction of a cross-layer entity, the Media Independent Handover Function (MIHF).

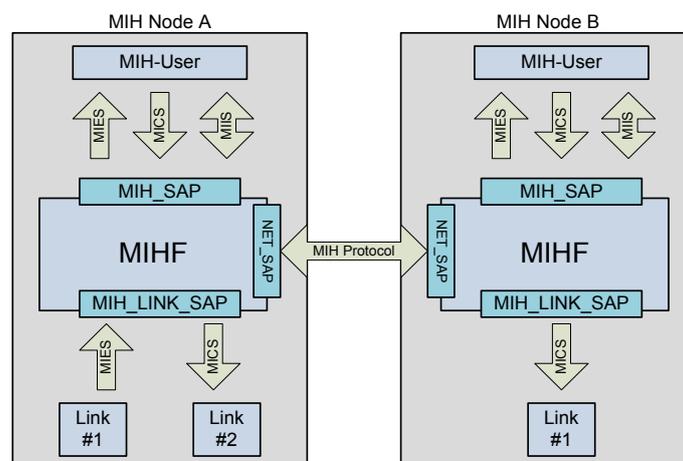


Figure 2 - The IEEE802.21 Framework

As can be seen in Figure 2, it provides an abstract interface, the MIH Service Access Point (MIH_SAP), to high-level entities, here dubbed MIH-Users. It enables MIH-Users to collect information and issue commands towards link layers of different technologies, using

standardized common primitives, without having to tackle the specificities of each independent technology. To map the generic abstract commands into specific technology commands, the MIHF interfaces with each specific link SAP. Three services are available to MIH-Users: i) the Media Independent Event Service (MIES), providing real-time events about link status, such as indication that a link is going down, or that the signal strength as crossed a pre-configured threshold, ii) the Media Independent Command Service (MICS) enabling link control for configuration, querying information and initiating handover steps and iii) the Media Independent Information Service (MIIS), which provides a set of Information Elements (IEs) stored in a database schema, supplying network information to aid in optimal network selection. These services can be accessed either locally or in a remote way, through the MIH Protocol. Remote MIH-enabled entities use specific 802.21 discovery mechanisms to gain awareness of surrounding MIH-enabled nodes. The NET_SAP is responsible for the transport services over the data plane. In the MEDIEVAL framework, these mechanisms will be employed and extended [13], in terms of new events, commands and mechanisms, to support optimized video-service access.

With the mechanisms provided by the 802.21 framework, scenarios can be conceived where a Network Decision Point (NDP) acts as a MIH-User and is able to receive remote events from the links of multiple mobile nodes. The information supplied by such events enables it to have a view of the network conditions experienced by the terminal, and use the command service to initiate handovers when required. Several scenarios involving different kinds of access technologies have been being defined for quite some time [11][12]. However, all of these scenarios use unicast signalling to transport MIH Protocol frames, and do not consider the overhead impact of sending multiple 802.21 commands in order to have groups of users handover due to the same phenomena. Particularly, in [12] the MIH signalling impact was analyzed and it was verified that it was loading the network very lightly. In this article, we evolve from this study, by providing a different perspective where increasing numbers of mobile terminals motivate stringent network management to preserve radio conditions, which are made difficult by the expected increase in bandwidth-hungry Future Internet video services. Also, the application of multicast has been applied to 802.21 in the past, but only related in supporting broadcast [14] technologies, such as DVB, or by coupling handover procedures with multicast mobility [15]. However, none of them considers the application of multicast to the MIH signalling itself. MEDIEVAL will also benefit from the inclusion of ODTONE [17], an open-source operating-system independent implementation of the 802.21 standard.

3. Multicast Transport for MIH Services

The usage of MIH signalling generates overhead due to the required information in the MIH frame. Message fields such as source and destination MIHF ID, service ID and others need to be present in every message. Also, the message exchange mechanism assumes a request/response method, further increasing the amount of data flowing in the network.

Our study considers groups of users, connected to the same or nearby access networks, accessing broadcast or multicast video services. We argue that, when network conditions change due to the same phenomena (i.e., network congestion, servicing, or environmental causes) and affect a video feed received by several users nearby, it affects not just a single user, but blocks of users. In traditional MIH signalling, each single user would be the subject of an independent MIH signalling transaction. In the MEDIEVAL framework, we aim not only to extend the core 802.21 mechanisms to support video-enhancing events and commands, but also to take advantage of the underlying multicast and broadcast framework, enabling the provision of 802.21 signalling via multicast.

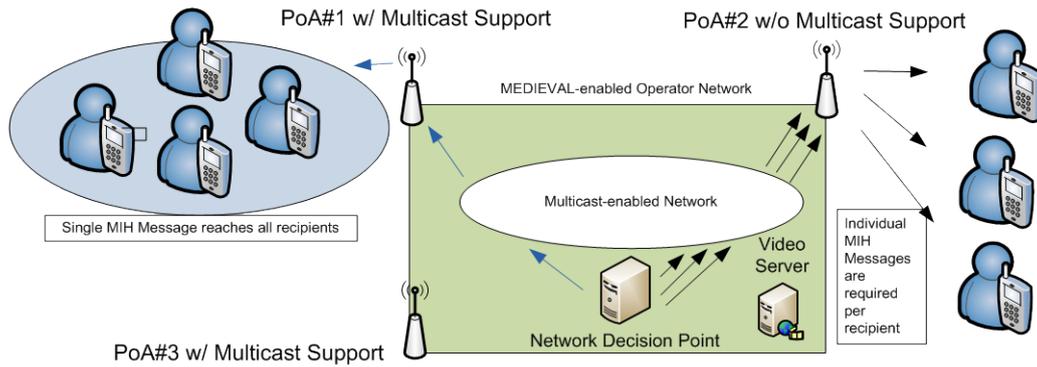


Figure 3 - IEEE802.21 Multicast Signalling

The concept is shown in Figure 3. When the NDP needs to send 802.21 messages affecting all nodes at the PoA, if it supports multicast 802.21, a single message is required. However, if there is no multicast 802.21 support, one message per terminal is required. To achieve the intended new feature over 802.21, four key interventions to the 802.21 mechanisms must be done:

1. Discovery and Capabilities Discovery

MIH-nodes are able to discover each other and exchange information regarding supported services, using a MIH_Capability_Discover.request/response exchange, in a solicited or unsolicited way. In the first case, when the address of a node is already known, the message is issued with that address as a target. In the second, the node broadcasts the message and collects responses from nodes which have received it. The message contains the parameters presented in Table 1.

Table 1 - MIH_Capability_Discover.request parameters

Name	Description
SourceIdentifier	The invoker MIHF ID
LinkAddressList	An optional list of link addresses and types supported by the node
SupportedMIHEventList	Optional list of supported events
SupportedMIHCommandList	Optional list of supported commands
SupportedISQueryTypeList	Optional list of supported MIIS query types
SupportedTransportList	Optional list of supported transport types
MBBHandoverSupport	Optional list to indicate if a make before break handover is supported

The SupportedTransportList parameter is a 16bit map, with two defined values (i.e., '0' for UDP and '1' for TCP) and the rest reserved. We added value '3' indicating "Multicast support". We have also proposed a new optional parameter, "MulticastAddress" indicating the multicast address of that operator, over which multicast signalling is sent. This address can either be in IPv4 or IPv6, and is used by terminals to subscribe to the multicast group, and to indicate to 802.21-enabled network management entities their multicast support.

2. New Information Elements for MIIS

The MIIS provides standard IEs, which can be queried by terminal or network nodes, in order to obtain information about PoAs. IEs related to PoAs are presented in Table 2:

Table 2 - PoA Information Elements

Information Element	Description
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IE_POA_LINK_ADDR	Link address of this PoA
IE_POA_LOCATION	Geo-location of the PoA
IE_POA_CHANNEL_RANGE	Supported channel range
IE_POA_SYSTEM_INFO	System information supported by the PoA
IE_POA_SUBNET_INFO	Information about supported subnets
IE_POA_IP_ADDR	IP Address of PoA
Vendor Specific PoA IE	Vendor specific IEs

In the MEDIEVAL project, we will add two new items: IE_MULTICAST_SUPPORT, which indicates if this PoA supports multicast, and IE_MULTICAST_ADDRESS, which indicates the multicast address pertaining to the group of this PoA. These two new IEs assist in identifying PoAs with multicast support, which can have impact in handover candidate decision.

3. Multicast MIHF Identifier

Issued 802.21 remote commands and events must contain the source and destination MIHF identifiers. While using multicast 802.21 signalling, a new destination identifier has to be defined, which represents not one but all the nodes involved in the multicast group. In this case, the DESTINATION MIHF ID will be replaced with the IP multicast address, identifying the destination multicast group. Upon the creation of such message, this parameter will be evaluated by the MIHF and be sent as a multicast message towards the designated multicast group.

4. NET_SAP

The NET_SAP interfaces with remote transport services on which the MIHF is running. It uses a primitive, MIH_TP_DATA.request, to designate that a MIH frame should be transported, which has the parameters presented in Table 3.

Table 3 - MIH_TP_DATA.request parameters

Name	Description
TransportType	The transport protocol to be used.
SourceAddress	The source transport protocol address
DestinationAddress	The destination transport protocol address
ReliableDeliveryFlag	Usage of message reliability
MIHProtocolPDU	The MIH PDU to be sent

For this matter the TransportType parameter was extended to support a 8 bit map, where the option 'Multicast' could be added to the other two (i.e., 'L2' and 'L3'). Upon the reception of this primitive with the 'Multicast' parameter, the transport services of the node interface with a multicast protocol to send the frame.

5. Integration with multicast group management protocol

In order to update the multicast tree, a core extension needs to be done to the MIHF. An MIH-User was created which was able to interface with a multicast group management protocol (i.e., IGMPv3 for IPv4 or MLDv2 for IPv6). Whenever a multicast 802.21-enabled node starts the discovery and capability procedures, and exchanges MIH_Capability_Discovery.request/response messages, the MIH-User interfacing with the group management protocol is fed with the multicast address provided by the capability message exchange (i.e., the new MulticastAddress parameter). With this multicast address, the MIH-User is able to initiate IGMP or MLD procedures, and thus the node is announced to the multicast router, which is now able to update the multicast tree.

4. 802.21 Multicast Signalling Scenario Use Case

To showcase the usefulness of using multicast 802.21 signalling, the following scenario is considered, based in Figure 3. In this scenario, a group of users is attending a press conference and connected to a WiFi hotspot. Using MEDIEVAL's Personal Broadcasting Service, they start broadcasting the live interview using video, which quickly stresses available resources at that hotspot. Considering this, the NDP needs to move a block of users to another hotspot, for load balancing. Using MEDIEVAL's multicast 802.21 signalling, a single signalling action is required per block of users, instead of per specific user. The signalling flow is depicted in Figure 4, showing only remote 802.21 signalling.

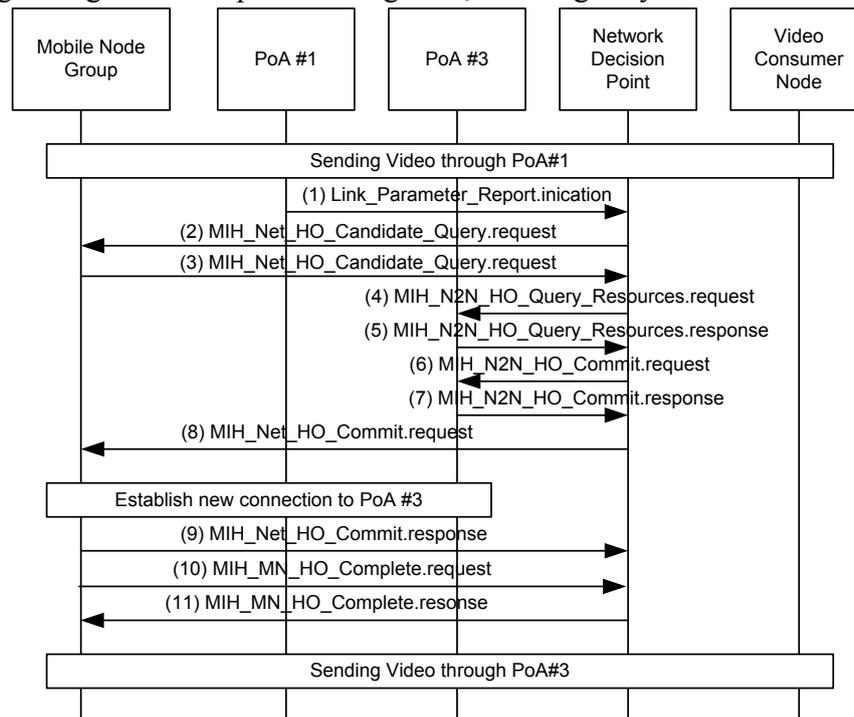


Figure 4 - MEDIEVAL multicast 802.21 handover scenario

When the PoA that is serving the Mobile Node Group (MNG) detects that network conditions are decreasing, it generates a report event (1) towards the NDP, which then sends (2) towards the MNG in order to evaluate which other PoAs are within range. Notice that the message sent by the NDP is transported in multicast, but the answers are received independently, and thus it is able to evaluate for a common PoA within range of all nodes belonging to that block. The NDP selects PoA#3 as the handover candidate and sends (4) to query resources. Upon receiving the answer and verifying that PoA#3 is able to accommodate the user block, is commits those resources via (6), and commands the MNG to start handover procedures with (8). When this message is received, nodes are able to execute the L2 attachment at PoA#3 and report its result via (9). At this point, the MNG can initiate L3 mobility procedures if required after which (10) is sent to the NDP, which can trigger other procedures such as clearing resources at the old PoA. Finishing the signalling, the terminals at the MNG are now able to send video through PoA#3.

5. Conclusion and Future Work

In this work we provide an overview of the MEDIEVAL project, which aims to enhance the current Internet's architecture to efficiently handle the increase of video traffic over wireless access networks, used by an ever increasing number of mobile terminals. We have highlighted a key innovation factor involving the abstraction layer to be used in the MEDIEVAL framework, the IEEE802.21, and detailed the required extensions that enable

it to support multicast signalling. A use case scenario was presented and described, featuring the feasibility of this new concept, showing that the number of signalling messages from the network to mobile terminals can be reduced to one per group, instead of one per terminal. On future work focusing on multicast signalling for 802.21, the project is further analysing how to tackle the dynamic creation of multicast groups, considering not only their PoA location, but also service and user profiles. The project is also analysing how to place reliable delivery mechanisms over multicast signalling, and how to further improve performance by designing the necessary mechanisms to support bi-directional multicast ability for IEEE802.21 signalling.

Acknowledgements

The research leading to these results has received funding from the European Community's Seventh Framework Programme (FP7-ICT-2009-5) under grant agreement n. 258053 (MEDIEVAL project).

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