

Empowering IP Multicast for Multimedia Delivery over Heterogeneous Mobile Wireless Networks

Sérgio Figueiredo

Instituto de Telecomunicações,
Universidade de Aveiro
Campus Universitário de Santiago
Aveiro, Portugal
sfigueiredo@av.it.pt

Seil Jeon

Instituto de Telecomunicações
Campus Universitário de Santiago
Aveiro, Portugal
seiljeon@av.it.pt

Rui L. Aguiar

Instituto de Telecomunicações,
Universidade de Aveiro
Campus Universitário de Santiago
Aveiro, Portugal
ruilaa@ua.pt

Abstract—This paper proposes a novel multicast mobility solution aimed for mobile video, empowered by a cross-layer approach leveraging on the capabilities of Multicast Context Transfer and IEEE 802.21 Media-Independent Handover. The proposed solution was implemented and deployed in a real testbed, with results showing the significantly reduced latency for vertical handovers.

Index Terms—Media-Independent Handover Service, IP multicast, Connection Manager, Context Transfer.

I. INTRODUCTION

Two important changes are being witnessed in current mobile networking. First, heterogeneous access networks are converging in all-IP architectures; second, the hierarchically centralized nature of mobile architectures is shifting into a flatter architecture, supported by research efforts such as distributed mobility management (DMM). In such a network environment, IP multicasting persists as a key enabler for efficient multimedia delivery. Its support is problematic though, due to the lack of schemes combining fast technology-agnostic handover with fast acquisition of channel subscription of mobile users over heterogeneous mobile wireless networks.

Applications relying on IP multicast must use specific service interface calls whose listening state is both socket- and interface-specific. In inter-tech handover – also referred as vertical handover –, a different service interface must be used after handover. Thus, without “intelligence”, the application cannot invoke the subscription on the target interface and receive the multicast channel(s), even if the target multicast network has already the subscription(s) of interest.

We propose a multicast mobility solution empowered by a cross-layer design leveraging on IEEE 802.21 Media-Independent Handover (MIH) standard [1] and Context Transfer Protocol [2] for fast multicast handover over heterogeneous mobile wireless networks. IEEE 802.21 MIH is used as a main enabler of interactions between different access technologies for delivering multicast handover-related information. Context Transfer Protocol is extended for network-side transfer of multicast subscription context, significantly reducing service disruption for mobile users.

II. SOLUTION OVERVIEW

We employ a distributed mobility architecture consisting of Distributed Multicast Access Routers (DMARs), which provide access and anchoring functionalities to attached mobile users – following the concept of distributed mobility management, which aims to distribute IP mobility packets from a single anchor to multiple ones positioned at the network edges [3] – and multicast routing and context transfer functions. However, we do not use IP tunneling mechanisms for resuming multicast packet delivery after handover. The proposed solution consists of two entities (Fig. 1): the first, Video Flow Manager (VFM), is responsible for managing the network-side resources for preserving the video session during mobility (i.e. adequate mobility schemes, network selection, activation of radio resources, etc), while the other, Multicast Connection Manager (MCM), manages radio interfaces and service interfaces calls during HO. The former is located at each DMAR and handles MIH, Multicast routing and Multicast Context Transfer functions, including a Multicast Mobility Database (MMD) storing all nodes’ subscriptions. As for MCM, it is placed at each Mobile Node (MN) and acts as a MIH User responsible for updating the service interface during mobility. This solution is tailored for multicast video services but can be applied to other services based on IP multicast requiring seamless mobility.

Fig. 2 shows the signaling procedure for the proposed multicast mobility solution. The IEEE 802.21 signaling is

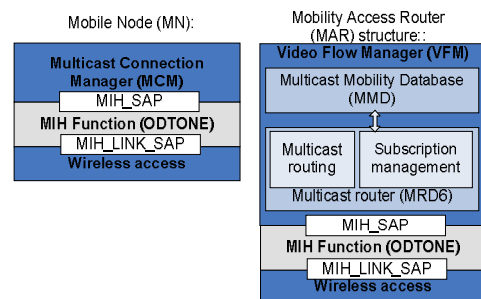


Figure 1. Functional modules in MN and DMAR

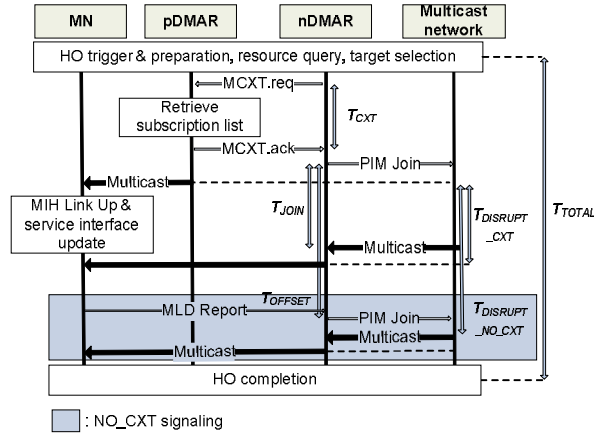


Figure 2 Proposed signaling

summarized by providing brief descriptions. In the depicted procedure, the target DMAR (nDMAR) is triggered either by the MN or the network (mobile / network-initiated handover) to activate multicast context transfer (MCXT) – a concept extended from context transfer protocol, which leads the multicast router to join the missing subscription proactively. MCM is triggered to activate and use the new interface for the subscription of the multicast session, allowing it to seamlessly receive the session packets from the new interface.

III. EXPERIMENT AND RESULTS

Fig. 3 shows the deployed experimental testbed, where a multicast receiver roams from a contention-based wireless access (WLAN) to a (emulated) coordination-based access (LTE) while playing a video received through IP multicast. For the performance comparison, we evaluated both the proposed scheme and one having no MCXT, denoted as NO_MCXT, which leverages on the MCM operation but follows standard MLD signaling procedure. The corresponding signaling is also depicted in Fig. 2. The results were achieved by averaging a 10 times run, and using the following open-source softwares:

- MRD6¹: provides multicast routing and subscription functions (PIM and MLDv2).
- ODTONE²: an open-source implementation of IEEE 802.21.
- OpenAirInterface³: an open-source software used for emulating the LTE wireless access.

We evaluated the handover latency, broken according with relevant parameters; $T_{DISRUPT_CXT}$ is the time between the reception of the last and first data packets over the previous and new links, respectively. $T_{DISRUPT_NO_CXT}$ is the equivalent to the latter but applied to NO_MCXT solution. T_{CXT} is the time spent in the multicast context transfer signaling. T_{JOIN} is the time taken for receiving the first IP multicast packet at the router after sending the PIM Join. In the scenario, the upstream multicast router from the DMARs (i.e. the nearest router

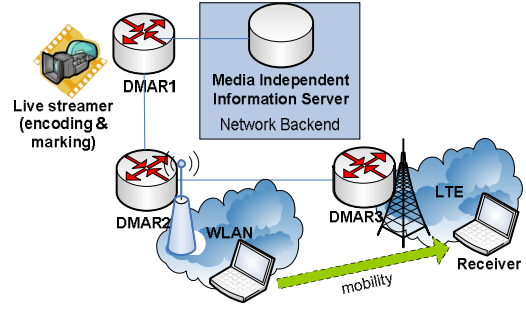


Figure 3 Experimental testbed

subscribing the multicast channel) is one hop away. T_{OFFSET} is the time between the transmission of the PIM Join in MCXT and NO_CXT. Additionally, T_{TOTAL} is defined as the total latency required for the IEEE 802.21 signaling.

Table I shows the measured latencies corresponding to all defined delay factors. $T_{DISRUPT_NO_CXT}$ was larger than 1s for all experiments and significantly larger than $T_{DISRUPT_CXT}$. The improvement of using MCXT over MLD is further shown by T_{OFFSET} , which was near 0.5s. The time that nDMAR took to join the multicast tree (T_{JOIN}) was 12.8ms

TABLE I. HANDOVER LATENCIES

Delay factor	Measured value (ms)	Std Deviation (ms)
T_{JOIN}	12.80	5.10
T_{TOTAL}	590.46	0.03
Specific to MCXT		
T_{CXT}	2.34	0.89
$T_{DISRUPT_CXT}$	127.10	2.70
Specific to NO_CXT		
$T_{DISRUPT_NO_CXT}$	553.67	570.54
T_{OFFSET}	429.22	230.01

IV. CONCLUSIONS

In this paper, we proposed a novel multicast mobility solution empowered by a cross-layer design, suited for heterogeneous mobile wireless networks. Experimental results show the benefit achieved by the proposed scheme in terms of handover latency from a Wi-Fi to a LTE access network.

ACKNOWLEDGMENT

We acknowledge financial support provided by Fundação para a Ciência e Tecnologia (FCT) through grants SFRH/BD/68507/2010 and SFRF/BPD/89736/2012.

REFERENCES

- [1] IEEE802.21 Standard, "Local and Metropolitan Area Networks — Part 21: Media Independent Handover Services," Jan. 2009
- [2] J. Loughney, W. Nakhjiri, C. Perkins, and R. Koodli, "Context Transfer Protocol (CXTTP)", IETF RFC 4067, Jul. 2005.
- [3] J. C. Zuniga, C. J. Bernardos, A. de la Oliva, T. Melia, R. Costa, A. Reznik, "Distributed mobility management: A standards landscape," Communications Magazine, IEEE, vol.51, no.3, pp.80-87, March 2013

¹ <http://fivebits.net/proj/mrd6/>

² <http://atnug.av.it.pt/odtone/>

³ <http://www.openairinterface.org/>