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Control and data plane separation architecture for supporting multicast listeners over distributed mobility management☆,☆☆

Truong-Xuan Do, Younghan Kim*

Department of Information and Telecommunication, Soongsil University, Seoul, Republic of Korea

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Abstract

Distributed mobility management (DMM) is currently being researched and standardized in academia and standardization development organizations for the purpose of overcoming the major issues of existing centralized mobility management. The most recent DMM protocols are being redesigned with regard to the control and data plane separation concept. However, at present, there is no solution for supporting IP multicast listeners in such new DMM environments. In this paper, we review ongoing academic research works, standardization activities and propose an IP multicast mobility design for the DMM environment using the control and data plane concept.

Keywords: Control and data plane separation; Distributed mobility management; IP multicast; PMIPv6; SDN

1. Introduction

Centralized mobility management (CMM) protocols exhibit certain major issues, such as a single point of failure, non-optimal routing, and scalability [1], which result from the nature of current hierarchical mobile network architecture. Therefore, distributed mobility management (DMM) is currently being studied and standardized in both academia and standardization development organizations (SDOs) in order to overcome these issues. In academia, the most commonly proposed DMM protocols are based on the traditional Proxy Mobile IPv6 (PMIPv6) [2,3] and the software-defined networking (SDN) concept [4,5].

IP multicast is used to provide efficient live streaming content distribution over IP-based networks. IP multicast mobility (MULMOB) management protocols offer subscribers seamless handover and the ability to keep receiving subscribed multicast traffic with low latency. Thus far, some base solutions have been standardized by the Internet Engineering Task Force (IETF) for the CMM environment [6,7] but not yet the DMM environment. In terms of DMM, several multicast mobility schemes [8–11] have been proposed in academia.

Currently, control and data plane separation is considered as a key factor in designing 5G networks. With this concept, control plane functions can be deployed as software on a cloud platform to facilitate the elastic scaling of control functions as signaling traffic increases. Furthermore, the data plane functions can be deployed on the high speed and simplified hardware networking devices, optimized for packet-forwarding tasks. Separation of the data and control planes also enables the efficient use of a common data plane and eases service provisioning by using the management and orchestration (MANO) framework of network function virtualization (NFV). This concept is not limited to SDN, with all functions placed on a centralized controller, but involves the separation of the control and data planes in both the horizontal and vertical axes. Control and data plane functions are designed as deployable and modular components. In the IETF DMM working group [12], this concept is being used to redesign the DMM protocols. Four major working items are currently being discussed, namely the mobility anchor function [13], forwarding policy configuration

* Corresponding author.
E-mail addresses: xuan@dcn.ssu.ac.kr (T.-X. Do), younghak@ssu.ac.kr (Y. Kim).

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(FPC) [14], deployment models [15], and on-demand mobility [16].

However, to the best of our knowledge, the current IETF works are restricted to unicast traffic, and multicast mobility management is still lacking in such control and data plane separation environments. Apart from our previous work, an initial idea [17] was introduced; however, this study did not include detailed architecture of the integration and protocol operation. In this paper, we review state-of-the-art research works and current standardization activities in the DMM working group and present architecture to support DMM for multicast traffic. In addition, we provide a solution for integrating our newly defined multicast mobility architecture into the current unicast DMM, including detailed protocol operation.

The remainder of this paper is organized as follows. Section 2 presents state-of-the-art and ongoing standardization of DMM and multicast mobility. Our control-data plane separation architecture for multicast mobility and protocol operations are introduced in Section 3. Section 4 discusses our qualitative evaluation, and a discussion and conclusion are provided in Section 5.

2. Related works

2.1. Distributed mobility management

(1) State-of-the-art academic research

The existing proposals for DMM rely on two major approaches: one based on traditional CMM protocols, such as PMIPv6 or MIPv6; and the other based on the SDN concept. In the first approach [2,3], the mobility management functions of the traditional PMIPv6 protocol are reused and distributed into mobility access routers (MARs) close to access networks. The second approach [4,5] applies the advantages of the SDN concept to handle mobile node mobility. In this approach, the mobility management functions are deployed on top of the SDN controller and forwarding paths are established using the controller's routing module.

(2) Standardization activities in IETF

In the IETF DMM working group, the current focus is on four major working documents, namely those of the mobility anchor function [13], forwarding path configuration [14], deployment models [15], and on-demand mobility [16]. The mobility anchor document defines the functionalities and protocol solutions for a mobility anchor and anchor switching. The deployment model document covers several possible deployment options for control and data plane functions of both the mobility anchor and access nodes. The forwarding path configuration document describes southbound protocol used by a control node to configure one or more data plane nodes. The on-demand mobility document enables the mobile nodes' capabilities to select an appropriate IP address type for their desired mobility services.

2.2. IP multicast mobility from CMM to DMM

The solutions that support IP multicast listeners in centralized mobility management are presented in [6,7]. These solutions leverage the deployment of multicast listener discovery (MLD) proxies in mobile access gateways (MAGs). The MLD proxies are responsible for collecting mobile nodes' multicast subscription and reporting to the local mobility anchor (LMA). A base solution for multicast mobility in PMIPv6 is presented in [6], while [7] provides a routing optimization solution. Furthermore, solutions for IP multicast in the DMM environment are described in [8–11]. In [8], four use cases, which combine two DMM architectures (that is, partially DMM and fully DMM) and two approaches to multicast subscription notification (that is, proactive and reactive), are analyzed. In [9], the direct routing approach for multicast traffic without a tunnel is investigated. In [10], three mobility multicast modes are analyzed, and an algorithm proposed for selecting one of the three modes based on operator requirements and user profiles. In [11], certain contexts, such as the service's characteristics, node mobility, and network context, are considered in the selection of a mobility multicast solution.

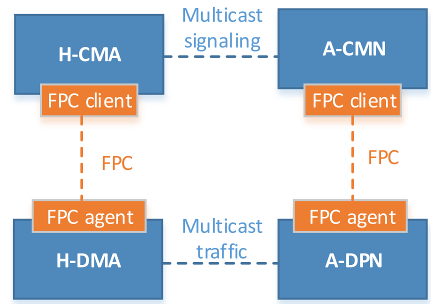

Fig. 1. Control and data plane separation architecture for IP multicast functions over DMM.

3. Proposed architecture

3.1. Control and data plane separation architecture for IP multicast listeners over DMM

In order to enable a mobile node to receive seamless multicast traffic during handover, we introduce three additional multicast functions: the home-control plane multicast anchor (H-CMA), home-data plane multicast anchor (H-DMA), and access-control plane multicast node (A-CMN). The proposed architecture is depicted in Fig. 1.

H-CMA: This function manages the life cycle of the mobile node's multicast sessions. A mobile node can participate in one or more multicast sessions, and these sessions can be anchored on the same H-DMA or different H-DMAs. The H-CMA interfaces with the H-DMA to manage the forwarding state.

H-DMA: This function is a topological anchor for multicast traffic moving towards the mobile node's subscribed multicast IP addresses or network prefixes. The H-DMA is responsible for receiving all multicast traffic heading towards the mobile node, and is selected by an H-CMA on a session basis. The H-DMA supports basic data plane functions, such as tunneling, routing, and quality of service (QoS) treatment.