DMM: Distributed Mobility Management - Towards Efficient and Scalable Mobile Networks

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***Abstract*—Network-layer mobility management protocols have played a strategic role in the evolution of mobile networks, in which mobile nodes information and session context must be preserved as they visit foreign networks. Most of the current solutions rely on a centralized mobility anchor, which guarantee information consistency. However, they are undoubtedly the source of performance bottlenecks and single points of failure. Distributed Mobility Management (DMM) is an area of interest that intends to fill those gaps. The main objective is to enable efficient and scalable mobile networking. Alternatives to those Centralized Mobility Management (CMM) approaches are being presented and analyzed with the help of performance assessment techniques, like testbeds, analytical modeling and simulation. A special session on DMM is included in the International Conference on Networks (ICN) 2017 conference, held in Venice, Italy. Two papers describe methodologies and solutions that contributes to the state-of-the-art on DMM.**

Keywords*–*DMM; Performance; Handover.

I. Problem Statement and DMM

Network planning includes specification of access technologies, topological design, and network dimensioning, in which mobility protocols must be considered. Mobility management in the network layer makes possible for network entities to update routing tables, addresses information, and handle authentication while a mobile node (MN) moves from a network to another. The Mobile IP (MIP) protocol is one of the earliest IP-based solutions for mobility management. MIP relies on the existence of a centralized entity called Home Agent (HA), which is responsible for keeping track of the location of the MNs and forwarding data packets from the corresponding node (CN) to the MN. In case of a handover, the MN acquires a *Care-of address* in order to be still reachable from the foreign network. This solution may be well-suited for networks with a small number of MNs and low mobility. However, mobile traffic has increased around 60% between Q1 2015 and Q1 2016 [1]. MIP is not designed for large-scale scenarios, since the HA would be a performance bottleneck. Likewise, the prerequisite of implementing the protocol in the MN's operating system added to the necessary processing to accomplish handover may lead to high energy loss.

The MIP architecture demonstrates the main problems of a CMM approach. The Internet Engineering Task Force (IETF) has created the DMM workgroup to address alternatives to avoid that anchoring points, as the HA, be the main cause of high latency in the data path. In the RFC 7333 [2], a set of requirements is defined to describe a DMM solution:

- **Distributed mobility management** – i.e., to enable data traffic to avoid traversing an anchoring point far from the optimized route;
- **Bypassable network-layer mobility support for each application session** – an active application session may choose not to use the protocol if there is a situation when it is not necessary;
- **IPv6 deployment** – IPv6 must be the primary deployment;
- **Existing mobility protocols** - at first, a DMM solution must consider reusing or extending IETF standard protocols;
- **Coexistence with deployed networks/hosts and operability across different networks** – DMM solutions must be compatible with legacy systems;
- **Operation and management considerations** – DMM solutions must consider MN state and configuration for future analysis;
- **Security considerations** – the solution must support security protocols and not to introduce security issues;
- **Multicast considerations** – the DMM solution must consider multicast early in the process, to avoid performance loss after introducing multicasting support to the proposed protocol.

The recommendations from the IETF's DMM workgroup are a very appropriate way to drive original research on DMM. However, one must notice that other aspects are important do help DMM to evolve. Studies on modeling techniques to evaluate protocols for IP mobility are important to identify design gaps before a new protocol is deployed. Inter-domain handover in metropolitan networks takes DMM studies to a new level, in which mobility anchors may collaborate to increase the scale of mobile networks.

II. Approaches for DMM

The PMIPv6 protocol was proposed by the Internet Engineering Task Force (IETF) to solve issues related to energy saving and high latency found in MIP. PMIPv6 introduces two local entities: the Mobile Access Gateway (MAG), which tracks the current location of the MN; and Local Mobility Anchor (LMA), which plays a similar role as the MIP's Home Agent for its domain. Signaling between MAG and LMA is responsible for the mobile node binding update and the MN does not have to install the protocol in its operating system. However, PMIPv6 architecture limits the mobility management to a local domain, limited by the corresponding LMA. The advantage is that, in a small domain, the LMA is closer to the MN's local network than the HA in MIP, which may lead to lower latency. Nevertheless, the IETF's DMM workgroup still does not consider PMIPv6 a DMM protocol, since the LMA role is similar to the HA and thus, it may become a bottleneck in the data path performance.

Condeixa and Sargento [3] classifies DMM in two types of approaches: tunneling, where there is a mobility anchor; and host-based, in which the MN is responsible for spreading address updates to all access routers. The authors conclude that tunneling approaches are more scalable, however, host-based solutions have better data delivery performance.

Nguyen and Bonnet propose the Dynamic Multicast Mobility Support (DMMS) to add per-flow multicast routing support to mobile networks. Network operator policies and user point of view are taken into account for mobility decisions. The authors state that DMMS allows load balancing among access routers.

Ernest, Chan, Falowo, and Magagula [4] propose to split the logical functions of LMA in PMIPv6 into location management (LM), routing management (RM) and home network prefix (HNP) allocation functions. The functions LM and HNP are distributed among access routers. The authors state that this is an inter-domain solution, however, the proposal seems to describe a large domain divided into sub-domains, each one having a gateway.

In a special session on DMM, held as part of ICN 2017 conference in Venice, Italy [5], two papers are presented. A proposal of modeling handover latency in PMIPv6-based protocols using the formalism of Petri Nets [6] is presented. The paper highlights the importance of expressing parallelism and asynchronous operations in a graphical and clear fashion, which helps to identify potential performance bottlenecks in early stages of protocol design. Additionally, the proposal of the *Clustered Interdomain* PMIPv6 (CI-PMIPv6) [7] presents the collaboration among LMAs as a solution to allow inter-domain mobility in PMIPv6-based networks. The main characteristics of CI-PMIPv6 are: avoiding global entities to handle inter-domain handover; to maintain the compatibility with PMIPv6 legacy systems; and anticipation of MN information for future handovers. In comparison with several inter-domain approaches in the scenario studied, the cost, the latency, and the packet loss are lower, and the goodput is greater.

References

[1] Ericsson, "Ericsson mobility report," 2016, retrieved: mar. 2017. [Online]. Available: https://www.ericsson.com/mobility-report

[2] E. H. Chan, D. Liu, P. Seite, H. Yokota, and J. Korhonen, "Requirements for Distributed Mobility Management," RFC 7333, aug 2014.

[3] T. Condeixa and S. Sargento, "Distributed mobility management in future networks: Tunneling or host routing?" in Proc. IEEE Symposium on Computers and Communication, Messina, 2016.

[4] PetroPeshaErnest, H.AnthonyChan, OlabisiEmmanuelFalowo, and LinohA.Magagula, "Distributed Mobility Management with Distributed Routing Management at Access Routers for Network-Based Mobility Support," Wireless Personal Communications, vol. 84, no. 1, 2015, pp. 181–205.

[5] ICN 2017, The Sixteenth International Conference on Networks, April 23 - 27, 2017 - Venice, Italy, http://www.iaria.org/conferences2017/ICN17.html.

[6] N. C. Quental, "Modeling Handover Latency in PMIPv6-based Protocols with Timed Petri Nets," in Proc. of the 16th International Conference on Networks, Venice, 2017.

[7] N. C. Quental and P. A. S.Gonalves, "CI-PMIPv6: An Approach for Inter-domain Network-based Mobility Management," in Proc. of the 16th International Conference on Networks, Venice, 2017.