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Mobility label based network: Hierarchical mobility management and packet forwarding architecture

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ABSTRACT

Scalability of the network layer mobility management solution is one of the most important requirements for the mobility control plane. Mobility Label Based Network (MLBN) is a new approach to the network layer mobility management problem that relies solely on MPLS to provide both macro- and micro-mobility for IPv4 and IPv6 mobile hosts and routers. This new approach does not rely on the existing IP mobility management protocols such as Mobile IP and is based on the combination of Multi-Protocol BGP (MP-BGP) and MPLS. In the context of the MLBN the scalable control plane should be capable of efficient Mobility Label distribution while allowing the MPLS-based forwarding plane to deliver mobile traffic in an optimal manner. This paper presents a hierarchical mobility management system capable of both macro- and micro-mobility support without the use of Mobile IP and its derivatives and allows scalable Mobility Label distribution and MPLS label stack based packet forwarding in support of optimal traffic delivery between the communicating mobile users.

1. Introduction

The Mobility Label Based Network (MLBN) introduced in [1] is the network layer mobility management system that is independent from Mobile IP [3,10] and is based on MPLS [9] and Multi-Protocol BGP [6,7]. It does not require Home Agents, Care-of-Addresses and layer 3 based traffic tunneling to enable communications with and between the mobile nodes equipped with fixed IP addresses and residing outside of their home networks. As a matter of fact MLBN architecture does not have a concept of a home network and always treats the registered hosts or routers as mobile nodes.

The main goal of MLBN is to integrate the layer 3 mobility control plane and the MPLS forwarding plane in order to achieve optimal traffic delivery and thus avoid user and network facing performance penalties associated with inefficiencies of the Mobile IP based solutions. This is achieved by using Mobility Labels (overlay MPLS labels) to represent the current location of a mobile user in the network. Mobility Labels are associated with the IP addresses of mobile hosts or IP prefixes served by mobile routers to form Mobility Bindings. Mobility Bindings in turn are distributed using MP-BGP to other network nodes (MPLS LERs) to identify the current location of the mobile user. The traffic delivery is then based on MPLS label stack and follows the optimal network path.

The benefits of MLBN can be summarized as follows:

1. *Elimination of Mobile IP and its physical and logical components* such as Foreign Agent (FA), Home Agent (HA), Care-of-Address (CoA), Collocated-Care-of-Address (CCoA) resulting in the natural integration of the mobile and MPLS transport networks.
2. *Elimination of user and network facing penalties*. For Mobile IPv4 and Mobile IPv6 in bi-directional tunneling mode: elimination of suboptimal routing due to triangular routing and reverse tunneling. For Mobile IPv4 and Mobile IPv6: elimination of HA scalability issues

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(tunnel management performance, home link congestion, capacity, home agent failures), natural support for mobile node multi-homing and processing load distribution.
3. *Integration of Mobility Control and Forwarding Planes* under the MPLS framework resulting in optimal traffic management.
4. *No requirement for explicit per-mobile prefix Mobility Label Switched Path (LSP) setup, teardown or redirection.* All Mobility LSP's are pre-configured by means of the Label Distribution Protocol (LDP) and exist at the time of network creation providing fully meshed logical connectivity among the nodes of MLBN. To achieve mobility management, only the mapping of mobile prefixes to existing LSPs is required on the sub-set of MPLS nodes (LERs) and is accomplished by means of Mobility Binding distribution using MP-BGP.
5. *Optimal traffic delivery* for Mobile-to-Mobile and Mobile-to-Fixed communications without additional requirements on the fixed nodes.
6. *Support for both IPv4 and IPv6* under common MPLS-based Control and Forwarding planes.
7. *Support for Mobile Hosts and Mobile Routers.*
8. *Support for Private Mobile Networks* by means of MPLS and MP-BGP.
9. *Ability to leverage Quality-of-Service (QoS) and Traffic Engineering (TE) capabilities of MPLS* for mobile traffic.

This paper is a continuation of work presented in [1]. It specifically addresses the scalability aspects of MLBN related to Mobility Binding distribution and the associated network update process, and introduces support for both macro- and micro-mobility under the same architecture. The increased scalability is achieved by the introduction of the network hierarchy with distinct mobility control and forwarding functions. This paper introduces the following new elements to MLBN as compared to [1]:

1. *Hierarchical network structure, regionalized architecture and corresponding network elements:* Mobility Regions and Areas, Area Label Edge Routers (ALER) and Area Mobility Route Reflectors (AMRR).
2. *New network update procedures* resulting in the scoping of the network update messaging and minimization of the amount of visitor information state changes that need to be maintained by MLBN nodes.
3. *Use of segmented Mobility LSPs* allowing support for micro-mobility while preserving optimal traffic delivery.
4. *New capabilities* such as: survivability and load distribution, mobile node multi-homing and traffic continuity during hand-offs, virtualization for private networking and inter-carrier roaming.

The set of MLBN control plane processes executing in the MPLS LER is referred to as the Mobility Support Function (MSF). A high level operation of MSF is shown in Fig. 1, where upon the MSF Discovery and Registration procedures a Mobility Label is associated with the IP addresses of mobile nodes and distributed throughout the network in the form of Mobility Bindings by using MP-BGP as the control plane signaling protocol. Mobility Label is a second (inner) label in the MPLS stack. It is followed by the infrastructure or top label that is used for the LSP to reach the MLBN node. The MLBN node terminating the LSP identified by the top label will pop this label and read the inner Mobility Label to identify a mobile device or the next LSP to reach the new location of the mobile device. The use of MPLS label stack allows to implement a scalable mobility management hierarchy.

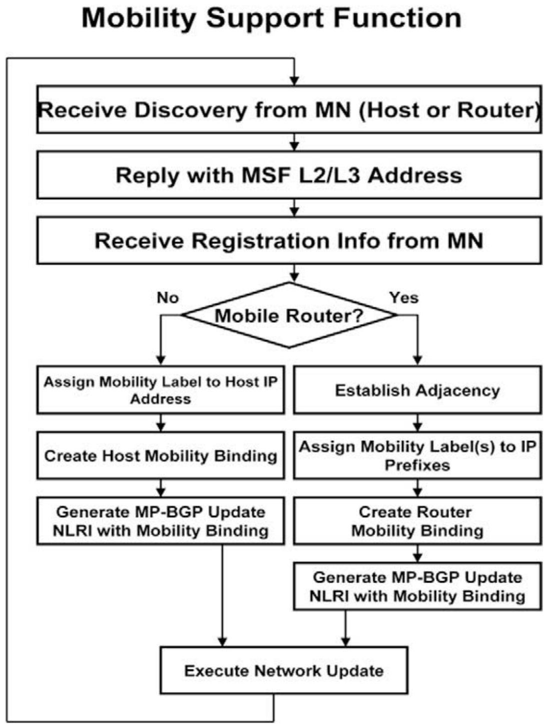

Fig. 1. High level operation of the Mobility Support Function (MSF) in the MPLS LER supporting MLBN.

From the architectural perspective MLBN follows the classic MPLS architecture in which the edge LER nodes interface with the Radio Access Network (RAN) by means of the layer 2 grooming network. The network is structured as a collection of the Mobility Regions. Each Mobility Region covers a number of RAN clusters. The mobile nodes register with the serving MSF in the MPLS LER node (see Fig. 2). As mobiles move from one Mobility Region to another different types of hand-offs may be considered.

The hand-offs between the different RANs in the same Mobility Region are referred to as MSF-Local hand-offs and do not result in either the new discovery and registration procedures or the network update with the new Mobility Label information. This type of the mobile user movement is also referred to as micro-mobility. When a mobile node moves from one radio cluster to another the MSF tracks this movement and updates the local associations with the new logical layer 3 interface identifier.

The hand-offs between the Mobility Regions are referred to as the Inter-MSF hand-offs. In the hierarchical MLBN Mobility Regions are grouped into Mobility Areas. The hand-off between Mobility Regions within the same