Journal of Network and Computer Applications 57 (2015) 1–11

Contents lists available at ScienceDirect

Journal of Network and Computer Applications

journal homepage: www.elsevier.com/locate/jnca

Dynamic anchor points selection for mobility management in Software Defined Networks

Abbas Bradai [a], Abderrahim Benslimane [b,*], Kamal D. Singh [c]

[a] Grenoble Computer Science Laboratory (LIG), 38041 Grenoble, France
[b] CERI – University of Avignon, 84911 Avignon Cedex 9, France
[c] Telecom Saint Etienne/Université Jean Monnet, Saint Etienne, France

ARTICLE INFO

Article history:
Received 26 March 2015
Received in revised form
20 June 2015
Accepted 29 June 2015
Available online 21 July 2015

Keywords:
Mobility management
Handover
Latency
Software Defined Network

ABSTRACT

Today consumers want to stay connected to networking services anywhere and at anytime. Managing consumers' mobility to ensure session and service continuity in efficient and effective manner is more and more challenging due to the increasing number of mobile devices and their high mobility pattern. Different solutions have been proposed in the literature to tackle this problem. They are based on a single mobility management point, called mobility anchor. Unfortunately, most of these solutions suffer from long packets delivery delay and high overhead ratio. In this work, we propose a new mobility management called Software Defined Mobility Management (SDMM) based on the Software Defined Network (SDN) paradigm. The proposed solution is network based, where the mobility is managed by network entities. In opposite to existing approaches, the anchor point is dynamically selected for each flow by a virtual function implemented at the top of the SDN controller which has a global view of the network. The main advantages of our approach are threefold: first reducing packet delivery delay, second reducing the handover latency and third minimizing the tunneling overhead.

1. Introduction

Today people want to remain connected to network services anywhere and at anytime. This has led to explosive growth of traffic in mobile and wireless networks. Moreover, this has induced the convergence of network and services as all kinds of services VoIP, IPTV, data, etc. are expected these days from telecom as well as data networks.

Network infrastructures are evolving as well and all networks are converging towards an all-IP network. The convergence of networks to all-IP is inevitable due to several benefits of all-IP such as reduced cost, efficiency, network resilience, natural integration with Internet, etc.

The above scenarios and evolutions have also given rise to new challenges that need to be tackled by the research community. Challenges include QoS management when using all-IP for different services such as VoIP and IPTV, mobility management due to users wanting to remain connected anywhere and at anytime and increasing network complexity due to multitudes of services and growing number of network equipment.

1.1. Motivations

In this paper we focus on mobility management, improving performance in terms of packet delivery delay experienced by the consumers and tackling network complexity to ensure seamless user mobility from a network to another. Mobility management focuses on assuring service continuity and connectivity even when the user is mobile and changes networks (Fig. 1).

Many mobility management mechanisms have been proposed in the literature (Al-Surmi et al., 2012). Some mechanisms have been proposed by IETF such as Mobile IP (MIP), Mobile IPv6 (MIPv6), Proxy-Mobile IPv6 (PMIPv6), etc. These mechanisms utilize IP tunneling and mobility anchors to assure session continuity. The mobile user is able to keep its IP address as the IP packet having the original IP address, often called Home Address (HoA) is tunneled to the new IP address which is often called the Care of address (CoA). However, the use of mobility anchor means that all the traffic related to corresponding mobile consumer has to pass through same network equipment which leads to sub-optimal routing, increased delays experienced by the consumers and creation of a networking bottleneck. Moreover, the increasing

* Correspondence to: Centre d'Enseignement et de Recherche en Informatique (CERI) Agroparc - BP 91228 339, chemin des Meinajariès 84911 Avignon cedex 9, France.
E-mail addresses: abbas.bradai@imag.fr (A. Bradai), abderrahim.benslimane@univ-avignon.fr (A. Benslimane), kamal.singh@univ-st-etienne.fr (K.D. Singh).

http://dx.doi.org/10.1016/j.jnca.2015.06.018
1084-8045/

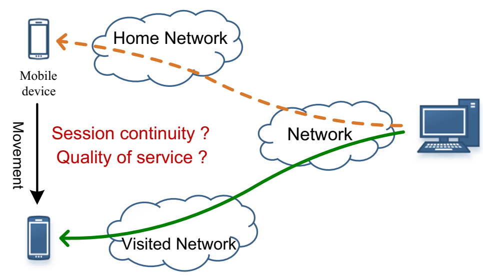

Fig. 1. Example of mobility management problem.

number of mobile devices and their increasing mobility behavior are making the management of mobility as well as management of related network devices more and more complex and challenging.

1.2. Contributions

In this work, we propose a mobility management scheme, based on Software Defined Networking (SDN), to tackle the today's mobility management protocols problems. The philosophy of Software Defined Networking is to separate the control and the data plane. The control plane is logically centralized which controls the data forwarding elements in the network using an open interface. SDN originated from the need to solve the problem of increasing complexity of today's networks which are hard to evolve and manage. The key to solve the above problem is through the virtualization of the network by hiding the detailed configuration process from the network control. SDN is one of the ways towards the network virtualization and it provides a flexible and centralized way to configure the network elements.

Our SDN based mobility management solution takes optimal decisions related to establishing tunneling points in the network. Thus, we propose Virtual Mobility Anchor (VMA) functions and we use the SDN controller for optimal creation of IP tunneling points in the network. SDN capability is used to compile the above optimal configuration decisions into network forwarding rules. The SDN controller sends these rules to SDN switches which in turn implement them.

In this work, we take advantage of the global view of the network provided by the SDN controller to optimally decide the placement of tunneling points in the network, as a function of optimal route to the mobile node and as a function of load on prospective tunneling point routers for load balancing.

Our main contributions in this paper are as follows:

1) We propose a new architecture for user mobility management. The proposed architecture relies on the SDN paradigm, where the traditional mobility management equipment, such as the mobility anchor and the Mobility Access Gateway, are virtualized. Toward this goal, we introduce a set of virtual mobility management functions implemented on top of the SDN controller. These virtual functions, combined with SDN switches, play the role of the different mobility management equipment.
2) We model the problem of mobility management in SDN based architectures as a problem of dynamic selection of a set of switches, which will play the role of anchor points, for a given set of flows. The selection of anchor points should be optimal in such a way which minimizes the packets delay and leads to load balancing between the switches. To the best of our knowledge, we are the first to introduce the dynamic anchor points' selection for mobility management.
3) We prove that the problem of assigning switches to different flows is NP hard and we propose a heuristic algorithm to resolve it.

Unlike traditional approaches, our solution avoids single bottlenecks and does not suffer from sub-optimal routing. This leads to improved packet forwarding and load balancing which results in improved performance experienced by the user. This central approach significantly reduces the effort required to configure a complex network and at the same time improves upon the performance of traditional mobility management mechanisms.

1.3. Paper organization

This paper is organized as follows. Section 2 provides the state of the art, Section 3 provides the details of the proposed SDN based mobility management solution, Section 4 uses simulation to provide the results and Section 5 concludes this paper.

2. Related works and background

Mobility management is important for ensuring session continuity when a mobile node changes its network attachment point during handover. Various mobility management mechanisms are implemented in different protocol layers to target different functionalities (Zhang et al., 2014). In the physical layer, mobility management carries out the procedures of detach and attach to different access points during handover. In the network layer, mobility support deals with the change of the sub-network. Mobility support in this layer may be based on routing (for example used in Cellular IP Berrocal-Plaza et al., 2015) or mapping (used in Mobile IP (MIP) (Bernardos, 2014) and Proxy Mobile IP (PMIP) (Gundavelli et al., 2008)). In the transport layer, mobility management focuses on keeping the on-going TCP connection, even though the IP address changes (for example used in Mobile Stream Control Transmission Protocol (M-SCTP) (Riegel and Tuexen, 2007)). In the application layer, different mobility management approaches are used which can be specific to each application type (used e.g., in the Session Initiation Protocol (SIP) (Takahara, Nakamura, 2010)), or a middle-ware may be implemented between applications of two nodes to manage mobility, such as WiSwitch (Giordano et al., 2005). The network layer based scheme is the most popular one offering transparent mobility support to all kinds of applications. MIP (3GPP Technical Specification), PMIP (Johnson et al., 2004), and 3GPP mobility management (Bertin and Bonjour Bonnin, 2009), are examples of such scheme.

In the network layer, the Internet Engineering Task Force (IETF) has defined some IP mobility support protocols. In general there are host based mobility management protocols and network based mobility management protocols.

For host based mobility protocols, Mobile IPv6 (MIPv6) (Bertin and Bonjour Bonnin, 2009; Al-Surmi et al., 2012) has been proposed for a single node mobility support. In order to support mobility of a set of nodes Network Mobility protocol (NEMO) (Jeon et al., 2013) has been proposed by extending MIPv6. With MIPv6 when a mobile node (MN) changes its network during handover, it registers its new address with a mobility anchor, home agent (HA). Then a bi-directional tunnel between the MN and the HA is established for forwarding packets to the new location of MN. However, the signaling cost between MN and HA is high, mostly has to be done over the last mile wireless link and significantly adds to the handover delay as HA can be far from MN.

To reduce the long delay of signaling messages exchanged between a MN and a HA, Hierarchical Mobile IPv6 (HMIPv6) was proposed and standardized by IETF (Pentico, 2007). HMIPv6 sets up a local HA called Mobility Anchor Point (MAP), to handle MN mobility while the MN is still in the local region. In addition, in