Demo: NTMobile: New End-to-End Communication Architecture in IPv4 and IPv6 Networks

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ABSTRACT

With the spread of mobile devices, there is a growing demand for direct communication between users. However, under recent complex IP networks, it is extremely hard to establish a direct connection between devices. In order to solve the problem, authors have been proposing a new end-to-end communication architecture called "Network Traversal with Mobility" (NTMobile). In NTMobile, applications in the mobile device establish an end-to-end connection by using virtual IPv4/IPv6 addresses in the NTMobile network independent from real IP networks.

In this demo, we will show that Android smartphones can make free communication with each other without any constraint such as an NAT traversal problem in IPv4 networks and incompatibility between IPv4 and IPv6 architectures.

Categories and Subject Descriptors

C.2.5 [**Computer-Communication Networks**]: Local and Wide-Area Networks—*Internet*; C.5.3 [**Computer System Implementation**]: Microcomputers—*Portable devices*

General Terms

Design, Experimentation, Performance, Verification

Keywords

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1. INTRODUCTION

In recent years, high performance mobile devices such as smartphones and tablet computers are rapidly spreading all over the world. Users can get access to the Internet at any time and from anywhere by using 3G/LTE and Wi-Fi technologies. Global mobile data traffic has been growing explosively, therefore, it is desired that the traffic will be offloaded onto the fixed network through Wi-Fi [1]. In the Internet, the network changes when the mobile device switches to a different communication interface or to another Wi-Fi access point.

Most of today's network services are built on the IPv4 network. However, IPv4 architecture has a serious problem caused by IPv4 global address exhaustion. Private address networks are generally constructed using Network Address Translation (NAT) routers. Recently, Career Grade NAT (CGN) technology [2] is being introduced in ISP networks, and transition to IPv6 has been gradually progressing. However, since IPv6 architecture does not have compatibility with IPv4, it is not possible to communicate between these networks directly. Thus, it is thought that a situation of IPv4 and IPv6 coexisting networks lasts for a fairly long period of time.

In such a complex network, it is necessary to securely establish reliable connection between mobile devices directly as much as possible wherever these devices are. In addition, it is also important to achieve IP mobility in order to maintain the established connection even if the mobile devices move to another network during communication.

We have been proposing a new End-to-End communication architecture, called "Network Traversal with Mobility" (NTMobile) that can achieve connectivity and mobility simultaneously in IPv4 and IPv6 networks [3, 4, 5]. This paper describes the overview of NTMobile architecture and how to establish an end-to-end connection in the today's complex network. In this demo, we will show that Android smartphones and tablets implemented with NTMobile functions can start communication (by using a network

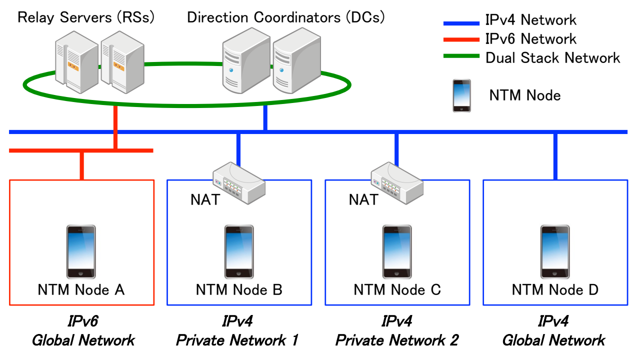

Figure 1: System configuration.

camera application) between various network environment, those are IPv4 global network, IPv4 private network, IPv6 global network and dual stack network. Moreover the video streaming is maintained even if these devices move to another network.

2. NTMOBILE

In the NTMobile architecture, mobile devices establish a connection by their virtual IP addresses which are not existed in real networks. By performing NTMobile operation, applications can make communication without being affected by switching of networks, existence of NAT on the communication route, and even by the difference between IPv4 and IPv6 networks. On the other hand, all packets based on virtual IP addresses are sent through a UDP tunnel between mobile devices. As the UDP tunnel is established in a direct route, except in certain specific situations, mobile devices always make tunnel communication through the optimal route.

2.1 System Configuration

The overview of NTMobile system configuration is shown in Figure 1. NTMobile consists of NTM nodes, Direction Coordinators (DCs), and Relay Servers (RSs).

An NTM node is a mobile device and has two kinds of addresses, those are, a real IP address assigned by the connected network and a virtual IP address assigned by DC. The virtual IP address is a permanent IP address in the NTMobile network and is not exited in the real network. Both of virtual IPv4 and IPv6 addresses are assigned in NTM nodes.

DC is a coordinator to manage the assignment of virtual IP addresses and direct NTM nodes to establish tunnels. DC stores information of NTM nodes such as Fully Qualified Domain Name (FQDN), real IPv4 and IPv6 addresses, virtual IPv4 and IPv6 addresses, and IPv4 global address of NAT router when the NTM node is behind the NAT router.

RS is a server to relay packets between NTM nodes under certain circumstances; e.g., when both of communicating NTM nodes are located behind different NAT routers, when an NTM node communicate with a general node which does not have NTMobile functions, and when NTM nodes are located in different address families, that is, IPv4 network and IPv6 network like the case of NTM node A and NTM node B as shown in Figure 1. In these cases, tunnels are

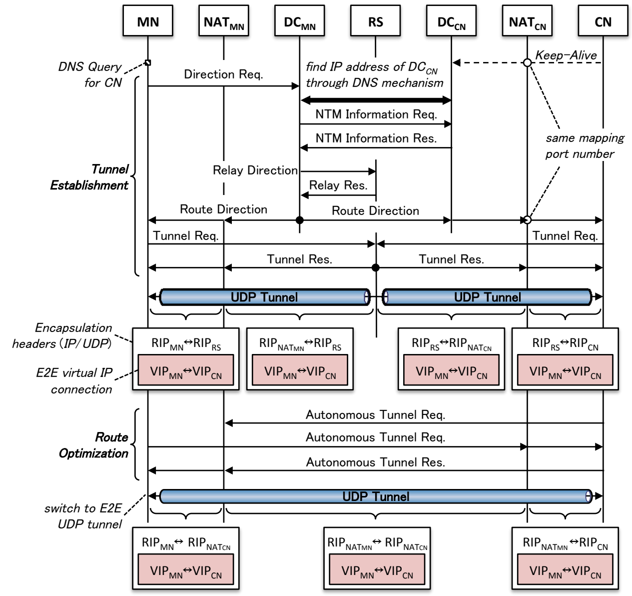

Figure 2: Signaling for creating tunnel between different IPv4 private networks and switching to direct communication route by a route optimization procedure.

established with RS which is set in the dual stack network, and communication between NTM nodes is made via RS.

DC and RS are placed in the dual stack network, and they can be multiplexed depending on the size of networks and the number of NTM nodes. Therefore, NTMobile system has scalability and can be applied to quite large scale networks.

2.2 Signaling for Creating Tunnel

Figure 2 shows the signaling for creating tunnel between NTM nodes, and the relationship between a virtual IP connection and a UDP tunnel of real IP addresses. It is assumed that an NTM node N completed a registration process, and IP address information of NTM node N is stored in DC_N. Unique virtual IPv4 and IPv6 addresses are assigned to each of NTM nodes. When an NTM node N is located behind a NAT router, the NTM node periodically sends keep-alive messages to DC_N in order to maintain a mapping in NAT_N for receiving the signaling from DC_N.

NTM node "MN" initiates the following NTMobile signaling when a DNS query from a DNS resolver is detected. First, MN sends a Direction Request message to $\mathrm{DC}_{\mathrm{MN}}$ for requesting a tunnel creation between MN and CN. $\mathrm{DC}_{\mathrm{MN}}$ finds the IP address of $\mathrm{DC}_{\mathrm{CN}}$ with the DNS name resolution mechanism. Then, $\mathrm{DC}_{\mathrm{MN}}$ obtains the address information of CN from $\mathrm{DC}_{\mathrm{CN}}$ by exchanging of NTM Information Request and Response messages. After that, $\mathrm{DC}_{\mathrm{MN}}$ determines how to create a tunnel based on IP address information of MN and CN, and directs MN and CN by Route Direction messages (including both of IP address information) to create a tunnel between them.

In the case shown in Figure 2, the Route Direction message for CN located behind $\mathrm{NAT}_{\mathrm{CN}}$ can be transmitted via $\mathrm{DC}_{\mathrm{CN}}$ because the mapping for this signaling in $\mathrm{NAT}_{\mathrm{CN}}$ is maintained by the keep alive between $\mathrm{DC}_{\mathrm{CN}}$ and CN. MN

Table 1: Communication patterns and their communication route in NTMobile system.

Location of an initiator's NTM node	Location of a correspondent NTM node			
	IPv4 Global	IPv4 Private 1	IPv4 Private 2	IPv6 Global
IPv4 Global	◎	◎	◎	○
IPv4 Private 1	◎	◎	◎	○
IPv4 Private 2	◎	◎	◎	○
IPv6 Global	○	○	○	◎

◎: Optimal route
○: Communication route via RS

and CN exchange Tunnel Request and Response messages directly with each other to create a direct tunnel between them. In the particular cases, both of MN and CN create tunnels with RS.

After the above signaling, the DNS resolver in MN reports the virtual IPv4 and IPv6 addresses of CN to its application. In this way, an MN's application recognizes that the CN is located in the NTMobile network.

2.3 End-to-End Communication

When MN establishes an End-to-End connection with CN by using their virtual IP addresses, packets are encapsulated by UDP packets with real IP addresses and are transmitted to the destination using the created tunnel. Therefore, the virtual IP connection in the NTMobile network is established through the UDP tunnel in the real network.

In the case when an MN and a CN are located in different IPv4 private networks, it is possible to switch from the communication route via RS to the direct tunnel communication route by conducting a route optimization procedure [6]. In the NTMobile system, NTM nodes can freely communicate with each other without any constraint, as shown in Table 1.

2.4 Handover

When an NTM node moves to another network during the communication and its real IP address is consequently changed, a UDP tunnel is recreated in the same way as at the beginning of the communication. For example, if the MN moves from IPv4 private network to IPv6 global network, the UDP tunnel changes from the direct route to the route via RS. However, even the tunnel route is changed, mobility is realized because the connection between MN and CN established by their virtual IP addresses is surely maintained.

3. DEMONSTRATION

We will demonstrate the NTMobile system with Android smartphones and tablets. Figure 3 shows the configuration of demonstration. As NTM nodes, we will use Samsung Galaxy Nexus and SONY Xperia Tablet Z in which our NTMobile function is implemented. DC and RS will run as virtual machines on Apple MacBook Pro. We will construct an IPv4 global network, two IPv4 private networks, an IPv6 network, and a dual stack network with YAMAHA RTX1200 router and four Wi-Fi routers. These Wi-Fi routers provide network connections for Android smartphones and tablets.

In this demo, we will show the following:

(1) Android devices can start communication with each other in any case by using network camera application.

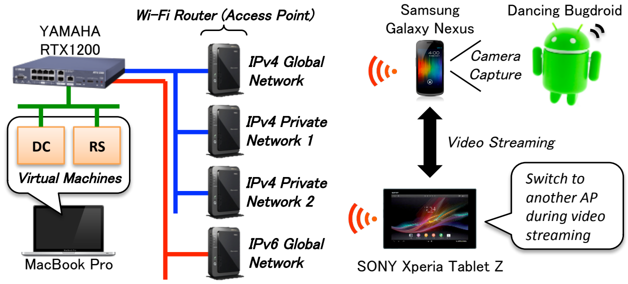

Figure 3: Configuration of demonstration.

(2) The video streaming is maintained even if the Android devices move to another network.

Our demonstration requirements are as follows:

(i) One table (W1500×D500) is needed.

(ii) We can complete the setup within an hour.

(iii) Total power consumption of 500W is needed.

(iv) No Internet access.

Finally, we provide a short video clip that gives an overview of NTMobile on YouTube[1], and also explain NTMobile in detail on our website [7].

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