LETTER

Intelligent Handover Decision Using IEEE 802.21 in Mobile IPTV*

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SUMMARY This letter proposes a new mechanism for network configuration on a mobile device that provides Point of Attachment (PoA) specific information using IEEE 802.21 and DHCP before moving to a new PoA. This allows the mobile device to prepare for intelligent handover decision either stateless address configuration or stateful address configuration when entering an IPv6 network. It allows the mobile device to reduce time delay for IP address configuration in the new PoA. Implementation and evaluation results show that the proposed mechanism can be an acceptable network configuration mechanism for providing seamless television watching in IPv6 mobile networks, even when in motion.
key words: *IEEE 802.21, Mobile IPTV, IPv6.DHCPv6*

1. Introduction

IPTV allows users to transmit and receive multimedia traffic and provides real-time broadcasting and video on demand through IP-based networks. However, IP-based networks are not suitable for providing real-time service since the IP design principle is a best effort. To assure high-quality IPTV services, supporting key QoS factors, such as packet loss, bandwidth, delay, and packet-error ratio, is vital, and IPTV systems should be able to handle such factors through IP network.

An IPTV device must configure network information such as the IP address, Domain Name Service (DNS) server address, and other information before receiving IPTV services. In particular, those configurations should be established rapidly in order to view real-time broadcasts in mobile networks since Mobile IPTV [1] devices move and attach randomly to wireless networks (e.g., Wi-Fi, Wimax, cellular network). In the mobile environment, Mobile IPTV services frequently suffer from unreliable network connections and insufficient bandwidth. Thus, service continuity requires fast network configuration to suppress user delay.

In fact, network configuration delay is generated by several factors, for instance PoA connection, new access router discovery, IP address discovery and configuration, network information, particularly DHCP and DNS discovery and configuration, and so on.

This letter mainly focuses on the initial time delay meant for IP address configuration while connecting to the new PoA. Without the proposed mechanism by this letter, the mobile device always trigger its IP stack to configure a new IP address in stateless address configuration mode [2] when connecting to the new PoA, even the new PoA does not support stateless address configuration mechanism, but just provide stateful address configuration using Dynamic Host Configuration Protocol (DHCP) [3]. It waists time unnecessarily. To reduce address configuration delay, any alternative ways are required to provide network information of the new PoA before the handover.

This letter proposes the new mechanism for intelligent handover decision using IEEE 802.21 standard [4] in IPv6 networks and defines new supplementary methods for delivering network information to the IPv6 client via DHCP. Using the proposed mechanism, mandatory network information of the IPTV device such as IP configuration method and subnet information can be obtained before moving to the new network.

Due to new features such as IEEE 802.21 and DHCP, some protocol level modifications and extensions are required for the mobile devices to determine the easiness of the deployment of the proposed mechanism.

2. Network Configuration for IPv6

By default, the IPv6 client should trigger its IP stack to initiate IPv6 Stateless Address Autoconfiguration [2] procedure whenever connecting to a new network either fixed or mobile environment. In that procedure, Neighbor Discovery for IP Version 6 [5] is also in use. To configure a new IP address, several steps happen in a new network such as (i) waiting for IP address information including prefix and subnet information from the new network router (ii) requesting IP address information to the router unless otherwise IP address information is obtained by the router after several minutes (iii) receiving the information from the access router (iv) sending DHCPv6 message for IP address information to the DHCP server in case IP address information is not included in step (iii); for instance, no prefix support by the router, IPv6 stateful address configuration method is only available in the existing network (v) generating a new IP address automatically (vi) sending the new generated IP address to the network for the duplication check (vii) con-

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figuring the new IP address to the interface in case the duplication does not occur (viii) exchanging the application data. These steps arise whenever the new IP address is configured and takes some seconds before sending the application data as IPTV multimedia traffic. Unless the new IP address is configured successfully, Mobile IPTV service is broken, and cannot support QoE guaranteed service to the user. Note that the procedures above does not cover other network information configuration such as DNS server, and so on since it is beyond scope of the intention of the proposed mechanism in this letter.

2.1 Network Information Using MIIS before Handover

To reduce the delay on IP configuration procedure in a new network, the mobile device should obtain network information from the candidate network before the handover. So that, the mobile device can prepare intelligent handover decision either IPv6 stateless address configuration (initiating step (ii)) or IPv6 stateful address configuration (initiating step (iv)) without wasting time delay in advance. For providing PoA specific information, this letter adopts IEEE 802.21 standard which includes support for various information elements providing information that is essential for a handover module in the mobile device to make intelligent handover decision stored in information server. Also, DHCPv6 is used for delivering IEEE 802.21 information to the mobile device.

IEEE 802.21 standard is consisting of three services, Media Independent Event Service (MIES), Media Independent Command Service (MICS) and Media Independent Information Service (MIIS). MIIS provides a framework by which a MIH (Media Independent Handover) function both in the mobile node and in the network can discover and obtain homogeneous and heterogeneous network information within a geographical area to facilitate handovers. MIIS includes support for various Information Elements (IEs) stored in information server.

Figure 1 gives network information that supports intelligent handover decision on the mobile device before moving to the new network. In this letter, both IP_CFG_MTHDS and IP_PREFIX_LEN are used for the proposed mechanism. IP_CFG_MTHDS means IP configuration methods supported by the access network, and IP_PREFIX_LEN means the length of IP subnet prefix. By using this information, the mobile device is able to predict IP address configuration method that is coming soon when attaching to the new network. Depending on the type of mobility support for different types of information elements may be necessary for performing handovers.

A schema is defined by a language and may be represented in multiple ways for annotating the network information in IEEE 802.21 standard. Examples include Resource Description Framework (RDF) which is based on XML which is used in 802 MIBs, Variants or a simple TLV representation of different information elements. The MIIS schema is classified into two major categories. Basic

Data Type Name	Derived From	Description
IP_CFG_MTHDS	BITMAP(32)	A set of IP configuration methods. Bit 0: IPv4 static configuration Bit 1: IPv4 dynamic configuration (DHCPv4) Bit 2: Mobile IPv4 with foreign agent (FA) care-of address (CoA) (FA-CoA) Bit 3: Mobile IPv4 without FA (Co-located CoA) Bits 4-10: reserved for IPv4 address configurations Bit 11: IPv6 stateless address configuration Bit 12: IPv6 stateful address configuration (DHCPv6) Bit 13: IPv6 manual configuration Bits 14-31: reserved for IPv6 address configurations
IP_PREFIX_LEN	UNSIGNED_INT(1)	The length of an IP subnet prefix. Valid Range: 0-32 for IPv4 subnet 0-64, 65-127 for IPv6 subnet (IETF RFC 4291)

Fig. 1 Selected IEs for the intelligent handover decision.

<table>
<tr><td colspan="3">Original DHCP Message</td></tr>
<tr><td>IS_NETWORK_INFO</td><td>LENGTH =
Multiple of 4</td><td>IP_CFG_MTHDS (32–bits)</td></tr>
<tr><td colspan="2">IP_CFG_MTHDS</td><td>IP_PREFIX_LEN (Variable Length)</td></tr>
</table>

Fig. 2 IS Network information option.

schema that is essential for every MIH to support and extended schema that is optional and can be vendor specific. In this letter TLV representation is used for the network information representation. In particular, Type and Length field in MIH message are excluded, and only Value of the information are encoded into the IS Network Information option's Value fields. It is because our proposed mechanism is designed not to exchange MIH messages; rather DHCP carries out the network information directly.

This letter defines a new DHCPv6 option as IS Network Information Option for discovering and delivering both IP_CFG_MTHDS and IP_PREFIX_LEN, and described in the next section.

2.2 IS Network Information Option for DHCPv6

The IS Network Information option is used to signal the use of the messages exchange for obtaining network information of the new PoA. The code for the IS Network Information option has yet to be defined by the Internet Assigned Numbers Authority and its length is multiple of octet.

A client must include this option in a DHCPREQUEST and DHCPREPLY messages. Figure 2 shows the format of the IS Network Information option.

Once getting network information, the client decides the available IP address configuration method (bit-11 and 12 are in use, but bit-13 is disabled in this letter) for the targeted PoA. In the case of IPv6 stateless address configuration, the client should compare the length of IP prefix information received by the IS Network Information option with the existing prefix and distinguish among multicast prefix, anycast prefix and unicast prefix. The proposed mechanism only copes with unicast prefix comparison to prepare IPv6 stateless address configuration. The length of subnet prefix is zero in the case of IPv6 stateful address configuration, and directly goes for DHCP messages exchange. Therefore, the length of subnet prefix is vital element for intelligent handover decision in the proposed mechanism along with IP configuration method information. Practically, these elements are configured by a service and network operator manually in MIIS information server.

2.3 Information Server Discovery Using DHCP

To obtain any of necessary IEs, the mobile device has to discover at least one available information server in the existing network. In [7], the new mechanism with DHCP is proposed to discover various network information stored somewhere in an Internet. For that, the new IS Location Address Option is defined in [7] to be used to signal the use of DHCP message exchanges for IS location information configuration. After receiving the IS Location Address Option from DHCP server, the mobile device can access to the specific information server, and obtain IEs. Based on the previous DHCP-based MIHF, this letter also extends the system implementation with DHCP operation [7] to obtain the necessary IEs depicted in Fig. 2.

3. Evaluation and Experimental Results

We evaluated the performance of the proposed mechanism and compared it with the existing mechanism using *Omnet++* (Objective Modular Network Test bed in C++). In particular, our simulation evaluated the difference IPv6 address configuration delay between MIIS support before moving to the new PoA and the existing procedure without MIIS support. In addition, packet loss and data throughput were measured during the handover to verify the enhanced performance in IPTV service. It is because these parameters were closely related to the quality of service and the quality of experience on the user's IPTV device as well as perception.

In terms of user perception during the handover, several factors such as delay, jitter, and frame rate are significant. Particularly, these factors are closely related to stabilization time, and impact user's QoE. Results in [6] show that a significant reduction in frame rate does not reduce the user's understanding of the information. To ensure the transfer of information, delay should be adapted to maintain the user's level of enjoyment.

Figure 3 shows the reference model for the proposed mechanism evaluation. The simulation model consists of 3 PoAs (Wi-Fi access points, 2 PoAs are same subnet and 1 PoA is different subnet) and a corresponding Mobile IPTV device, DHCPv6 server (IS Network Information Option is supported), IPTV contents server and MIIS information server (IP_CFG_MTHDS and IP_PREFIX_LEN are supported). The specific network parameters are described in Table 1.

To perform simulation closer to conditions of realistic network environment, background traffics are generated to each wireless network area. A number of users are randomly distributed over the network area and any users get IPTV multimedia service from IPTV contents server randomly. We assume that data packets are generated from IPTV contents server with constant packet rate and are serviced to the Mobile IPTV device. Characteristic of packet rate depends on service type of IPTV. In our simulation, two types of IPTV services were supported such as High Definition TV (HDTV), Standard Definition TV (SDTV). The characteristic of each packet is described in Table 1.

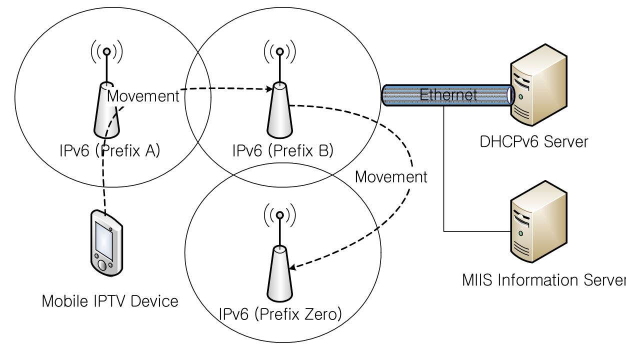

Fig. 3 Network architecture for handover scenarios using DHCP and IEEE 802.21 Information Server.

Table 1 Configuration parameters used in the evaluation.

Network Parameters			
Network Type	WLAN		LAN
Frequency	2.4 GHz		-
Data rate	54 Mbps		100 Mbps
Range	115 feet		-
IPTV Contents Server Parameters			
Content Type	Bandwidth	Period	Payload
HDTV	20 Mbps	1 ms	2,500 bytes
SDTV	4 Mbps	10 ms	4,000 bytes
Mobile IPTV Device Parameters			
Network Interface	Ethernet, 802.11g(WLAN)		
Mobility type	Linear mobility		
Mobility speed	3 ~ 6 km/h (working speed)		

The simulation scenario is as follows: the Mobile IPTV device moves to PoA (Prefix B) from PoA (Prefix A) where the Mobile IPTV device is located in PoA coverage. When the Mobile IPTV device moves to the new network, it runs IPv6 stateless address configuration for a new address. In our simulation, we observe IPv6 address configuration in the Mobile IPTV device. After some seconds, the Mobile IPTV device moves to PoA (Prefix Zero) from PoA (Prefix B) where IPv6 stateful address configuration should be used for the new address. No need to wait for prefix information from the access router in prefix zero area. We measured IPTV traffics in 50 trials, and the results are shown in Figs. 4, 5 and 6.

Firstly, we observed that IPv6 address configuration delay. Configuration delay means that wasting time until creation of stable connection with the new network. As shown in Fig. 4, configuration delay is increase linearly because the number of user in network increases. Also con-

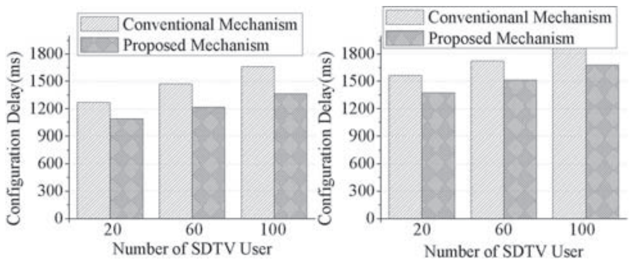

Fig. 4 IPv6 address configuration time delay (left: IPv6 stateless address configuration, right: IPv6 stateful address configuration).

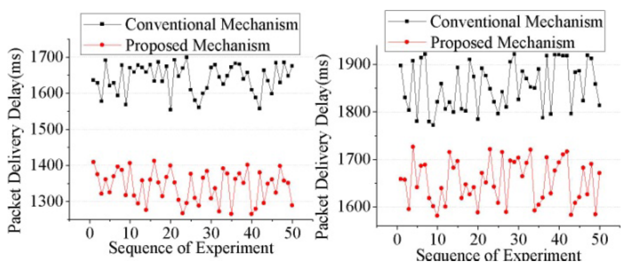

Fig. 5 Packet delay (left: IPv6 stateless address configuration, right: IPv6 stateful address configuration).

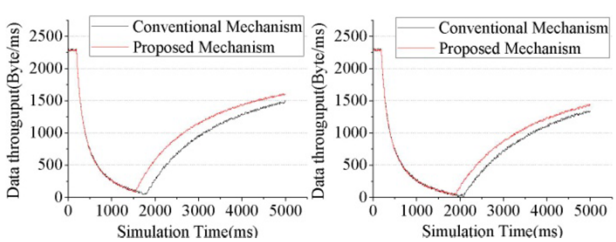

Fig. 6 Data throughput (left: IPv6 stateless address configuration, right: IPv6 stateful address configuration).

figuration delay is reduced by MIH server. IPv6 configuration delay of the proposed mechanism is short than that of the conventional mechanism. Since Configuration procedure is triggered efficiently according to network information which is provided by MIIS information server, when the Mobile IPTV device changes its point of connection.

Second, we measure serviced data packet delay from IPTV contents server to the Mobile IPTV device during IPv6 address configuration. As illustrated in Fig. 5, the simulation results show that the proposed mechanism achieve lower data packet delay during IPv6 address configuration in average than that of the conventional mechanism without MIIS information server. Since MIIS information server enables the Mobile IPTV device to have more flexible IPv6 address allocation options. As a result, the proposed mechanism offers better service quality than conventional mechanism.

Lastly, we evaluate data throughput during the operation of IPv6 address configuration. Data throughput is defined as the total packets that arrive at the Mobile IPTV device successfully from media server during specific times. Figure 6 is data throughput of the Mobile IPTV device with IPTV contents server in our simulation. Through this evaluation, we show that much improved data throughput is provided with the proposed mechanism. It is because the proposed mechanism obtains network information from MIH server prior to the handover, and uses information to consider operating IPv6 address allocation immediately or not.

Mobile IPTV device has been used for the evaluation in conjunction with IPTV application in this paper. However the proposed mechanism is a widely applicable solution for all types of mobile devices to prepare intelligent handover decision in their application environment.

4. Conclusion

This letter proposed a new mechanism for IPv6 address configuration that provides new network information before the handover operation and IEEE 802.21 standard and DHCP new option are used to pass network information to the mobile device. It allowed the mobile device to prepare intelligent handover decision for IPv6 address configuration in advance. The performance evaluation and comparison have shown that the proposed mechanism has shorter delay than the existing IPv6 address configuration, has reduced packet loss, and enhanced data throughput, and is acceptable for viewing IPv6 television seamlessly.

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