

A Relay Scheme for Incapable Nodes within a CDMA Based IPv6 Network using an Ad-Hoc Mechanism

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Abstract

An Ad-Hoc Network Infrastructure for CDMA based IEEE 802.11 is proposed. In CDMA, multi-packets can be transited and received at the same time. This is an architecture that combines the Ad-Hoc and Infrastructure network in CDMA based IEEE 802.11 to transit packets more efficiently in a wireless network. Nodes that cannot make contact with base stations due to severe signal degradation and unstable wireless channels can make contact using an Ad-Hoc based routing protocol via a multi-hop path. We propose a relay mechanism called the Relay Routing Protocol for incapable nodes. It can contact the base station via a multi-hop path and communicate with other mobile hosts.

1. Introduction

When a mobile node frequently moves across networks, a mechanism is required that ensures that packets addressed to that mobile node are successfully delivered. During or immediately after a handoff, packet losses may occur due to the delayed new location information propagation. These losses should be minimized to avoid degradation in service quality as handoffs become more frequent. A packets loss situation will occur using Mobile IPv6. Hence, IP micro-mobility protocol formats [1] are proposed, such as Cellular IP [2], Hawaii [3], Hierarchical Mobile IP [4] etc... These protocols are designed to handle local mobile node movement without interaction with the Mobile IP enabled Internet. The benefit is reducing delay and packet loss during handoff and eliminating registration between mobile nodes and home agents. Eliminating registration in these protocols will also reduce the signaling load experienced by the core network that supports the mobility function. Cellular IP has the better performance in these IP micro-mobility protocols and interoperates fully with Mobile IPv6. For this reason, we selected it as our research environment.

Let us consider the following situation: when a mobile host is out of the service range of the Cellular IPv6 base station or severe signal degradation occurs, it cannot receive the beacon signal sent by the Cellular IPv6 base station. The mobile host is then called an incapable node and cannot communicate with any other mobile hosts via the base station. We propose a relay mechanism called the Relay Routing Protocol for incapable nodes. The Relay Routing Protocol is based on the Ad Hoc Network concept. Through the Relay Routing Protocol an incapable node can contact the base station via a multi-hop path and communicate with other mobile hosts.

We propose a network architecture that combines the Ad-Hoc and Infrastructure network in the CDMA based IEEE

802.11 to transit packets more efficiently. The FTP NetBEUI uses a large frequency band. The AP load will become heavy. Our proposal speeds up the transmissions to make the network more efficient. The reason of the network congested is transmissions continuity and great quantity traffic service. (1)When it speed up service can to reduce congested. (2) The Ad-Hoc mode can to reduce access point load.

In relay mechanism, we use the simulation tool, OPNET [6], to simulation the relay mechanism and analysis the result. It can find that the Relay Routing Protocol is helpful to the incapable nodes that cannot contact with the Cellular IPv6 and fully interoperates with Cellular IPv6. In other to use Netflow program to analyze to know the ratio of every protocol in the all network flow. After that we will import the analyzed data to the CDMA based IEEE 802.11 environment to simulate the transmission state. We have two-simulation environments (1) Infrastructure mode (2) Ad-Hoc Network Infrastructure mode. We will compare the transmission rate and throughputs in these two modes.

2. RELAY ROUTING PROTOCOL

A Relay Mechanism is proposed for nodes that can not make contact with a Cellular IPv6 BS because they have moved out of transmission range or have unstable channels. The purpose of this Relay Mechanism is to help nodes make contact with the BS via a multi-hop path. Because this Relay Mechanism is based on the MANET concept, it is also called the Relay Routing Protocol (RRP). The benefit of the RRP is that it helps incapable nodes and interoperates fully with Cellular IPv6.

The CDMA-based technique in [9] was applied to the nodes in this study. The benefit of the CDMA is that all users can transmit and receive at the same time. The RRP is an extra function over the Cellular IPv6. The network infrastructure, including a gateway (GW), base stations (BSs), and mobile hosts (MHs), is based on the Cellular IPv6 protocol. In normal situations, MHs operate only on Cellular IPv6. To satisfy RRP, modifications are necessary for the MHs, BSs and GWs. All have the ability to identify Cellular IPv6 and RRP packets. The Cellular IPv6 packet format is also modified. First, a bit, "R" flag is added in the route-data and the paging-update packet format to allow the BS to identify incapable nodes. The packet format is illustrated in Figure 1. If the R flag is set to 1, the route-update packet is from an incapable node via the multi-hop path.

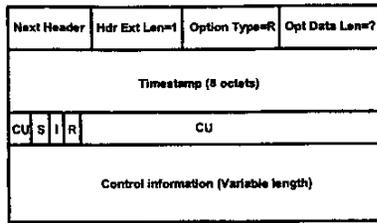


Figure 1. Modified Cellular IPv6 Route-update Packet

Second, a route record was added in the BS for incapable nodes to learn the multi-path route. The route record contains the entry number, intermediate node address, source address, destination address and expiration time. To prevent network broadcast problems, broadcast packets that contain the same BS ID are valid in the same BS service area. Packets sent by incapable nodes also contain the BS ID to be identified by MHs. MHs will drop Ad-Hoc that belong to a different BS.

3. ROUTE DISCOVERY PROCESS

An incapable node that detects that it cannot receive the BS beacon signal will initiate the Route Discovery Process. It first broadcasts a route request packet to obtain the global prefix information and uses an arbitrary global scoped address from its interface as the IPv6 source address, such as its IPv6 home address. The route request packet includes both IPv6 addresses and sequence numbers for the source and destination, the hop count, broadcast ID and BS ID. Each MH maintains two numbers to aid in route discovery, the sequence number and the broadcast ID. The broadcast ID is incremented to identify the next route request packet uniquely after broadcasting a route request packet. Each MH that receives a route request packet first checks if it knows of a route to that destination in its route table. If a route exists, it then checks its sequence number to see if it is greater than the destination sequence number. If the conditions are satisfied, the intermediate node sends a route reply message along the reverse path to the incapable node and automatically sets up a reverse path to the incapable node. Otherwise, the MH increments the hop count by one and rebroadcasts the route request packet. The BS ID is also added to the route request packet by the MHs to prevent a broadcast problem. When the BS receives the route request packets from intermediate nodes, it first checks whether the source and the destination address are the same. If the addresses are the same, this means that there is an incapable node asking for information and the R flag is set to 1 in the route-update packet. It then selects a lesser hop count for the route and replies with a route reply message to the incapable node along the reserved path that is made in its route record. The reply message will contain the global prefix information of the BS, such as the GW IPv6 address, the subnet prefix, BS ID, Paging ID, and the Cellular IP Network ID. The BS then updates its Route Cache and Paging Cache and forwards the route-update message to the GW. When the incapable node receives the reply message, the incapable node will delete the temporary address generated randomly and replace the COA with the subnet prefix and MAC address combination. We also considered the case shown in Figure 2 in which the incapable node is at the common border between two BS service areas with two established route paths. The GW also has two mappings in its caches. The

incapable node will select the smaller hop count and the most stable route path and send the route-update packet to the BS again via the selected route path. The BS forwards the packet to the GW to update the caches. When the GW receives the update packet, it deletes the other mapping in the caches. The other mapping in the caches of the other BS will also be discarded after route-timeout expires.

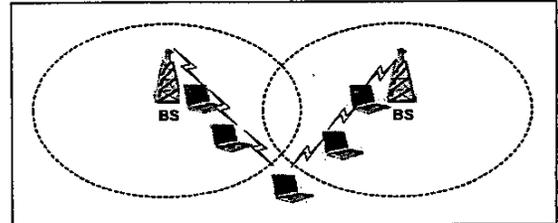


Figure 2. Two Route Path during Route Discover Process

If the incapable node wants to send packets to another MH or a CN, it will first check if the destination exists in its record. If the destination exists in its record, it will send the packet directly to the destination along the original route path. If the destination does not exist in the record, the incapable node will send a route request packet to find the destination via the BS.

When a CN or another MH wants to send packets to an incapable node, the BS that has a record of the incapable node will forward the route request message to find the incapable node. Once the intermediate nodes detect that the link is going to break, the link will be reestablished using the Route Maintenance Process to avoid interrupted transmission.

4. Ad-Hoc Network Infrastructure

There is some research involving cellular mode and Ad-Hoc mode efficiency in CDMA. In the "CDMA Ad-Hoc and Cellular networks Performance Comparison"[10], Jeffrey Q. Bao and Lang Tong set an Ad-Hoc Network model that used one hop. This is similar to our research model. They used the performance of this Ad-Hoc Network model to compare the performance of the cellular Network model. In this paper, they discussed how to calculate the throughput in Cellular Mode and Ad-Hoc Mode. The equation for calculating the throughput in Cellular Mode is as follows:

$$\beta_{cell}(n) = \frac{\sum_{k=1}^M p_k^c \sum_{l=0}^k l s_{kl}}{2}$$

$\beta_{cell}(n)$ is the throughput in Cellular Mode and p_k^c is the probability that total k packets are transmitted in the up-link time slot. l is the number of packets successfully received and s_{kl} is the probability that total k packets are transmitted in the up-link time slot and had l packets successfully received. The equation for calculating the throughput in Ad-Hoc Mode is as follows:

$$\beta_{ad}(n) = \sum_{k=1}^M p_k^a \sum_{l=0}^k l r_{kl}$$

$\beta_{ad}(n)$ is the throughput in Ad-Hoc Mode and p_k^a is the probability that total k packets are transmitted in the up-link time slot. l is the number of packets successfully received and r_{kl} is the probability that total k packets are transmitted in the up-link time slot and had l packets successfully received.

Using these equations, we can see that the transmission speed in Ad-Hoc Mode is faster than that in the Cellular Mode. This is the reason why we propose the Ad-Hoc Network Infrastructure. In CDMA based IEEE 802.11, multipackets can be transmitted at the same time. In the Infrastructure mode every node communicates with the AP directly and connects to the Internet using AP. In the Ad-Hoc mode every node is connected to all other nodes directly but cannot connect to the Internet. The transmission efficiency in the Ad-Hoc mode is better than that in the Infrastructure mode. If every node uses the Infrastructure mode, the AP load will become heavy. If the Ad-Hoc and Infrastructure modes can be used at the same time, the transmission speed can be increased and the AP load reduced. Internet connections can also be maintained. The Ad-Hoc mode can be used to transmit packets if the packet destination is in the Wireless LAN. This will provide faster transmission than the Infrastructure mode. However, the kinds of packets transmitted in the Ad-Hoc mode must be limited.

Big data flow packets, like the FTP packet, with a WLAN destination can be transmitted in the Ad-Hoc mode. Other kinds of packet will be transmitted in the Infrastructure mode. There are two reasons: (1) If the Ad-Hoc mode is used to transmit small data flow packets like Telnet or WWW packets, it must switch modes too often and waste time (2) The ratio of clients in the same WLAN with Telnet or WWW servers is few and there is low traffic. The network statistics from National Dong Hwa University and other schools show this true. The Ad-Hoc Network Infrastructure is therefore useful for big data flow traffic and allows an increase in WLAN transmission speed.

When we have big data flow packet in the Ad-Hoc Network Infrastructure architecture, the Ad-Hoc mode will be used to transmit a request packet. If no acknowledged packet is received after three request packets, the Infrastructure mode will be used to transmit data (figure 3). The Ad-Hoc mode can also be used to transmit data (figure 4). If five to ten packets are lost in transmission in the Ad-Hoc mode, the destination node is assumed moved to another WLAN and the mode will switch to the Infrastructure mode to transmit that data (figure 5). [11,12]

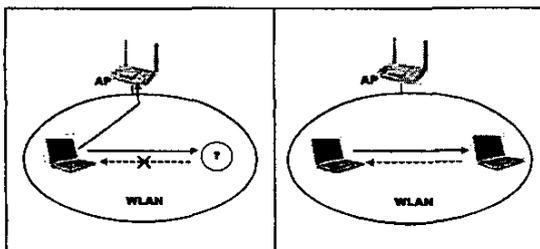


Figure 3.

Figure 4.

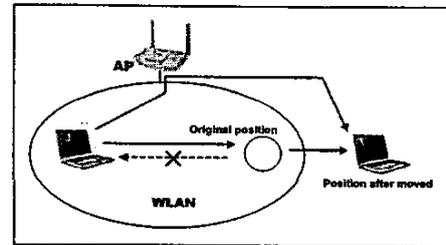


Figure 5. The destination node moves to other WLAN

If we have a node A that wants to transmit big data to node B, 4 steps must be used to switch to the Ad-Hoc mode. (1) When node A wants to start transmission, it must communicate with AP first and check if node B is in the same WLAN. (2) If node B is in the same WLAN, the AP will transit the PN code of node A to Node B and notify node B to be ready to receive the data transmitted by node A. (3) After that, the AP will transit the PN code of Node B to Node A and notify node A to start transmission in the Ad-Hoc mode. (4) When transmission starts, if node A has received an answer from node B, node A will continue transit data in the Ad-Hoc mode or continue transit data in Infrastructure mode.

5. Simulation and Results

We simulated a scenario using purely RRP in the network to observe the performance of the end-to-end throughput and delay [13]. Figure 6 shows the simulation network topology. The BS and the incapable node were fixed with the incapable node out of BS range. The other nodes moved randomly in the BS service. The mobile nodes between the incapable node and the base station are responsible for relaying packets to the base station. The traffic pattern is best-effort generated by the nodes. The physical and link layer used in the model are OPNET 802.11 model. The network layer is our proposed RRP and the upper layers are the source and the sink node. The other nodes in the node model are control the node mobility. The RRP process is divided into several parts: ack, reply, error and etc... The source is an OPNET process that generates data packet traffic. The sink destroys the packet after reception and process completion.

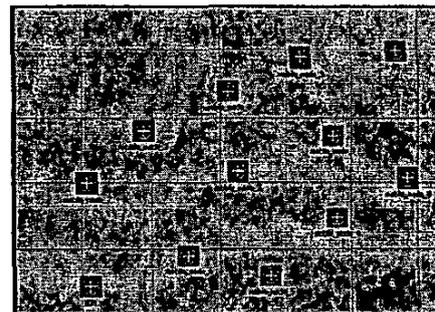


Figure 6. Network Topology of Simulation