A UDP-based protocol for mobile robot control over wireless Internet

Dong Kwon Cho, Sang Hun Chun, Jeong Gyun Ahn, Yong Sik Kwon, Jong Hoon Eom, and Young Il Kim *Member, IEEE*

***Abstract*—An efficient method for transmitting the robot control data over wireless Internet based on UDP protocol is proposed. The method allocates the highest priority to the robot control data and transmits them multiply from the base station. Simulation results show that very low packet delay and low packet errors can be achieved by the proposed method.**

I. Introduction

GROWTH rate of the Internet game service for wireless networked terminal seems to be steep. Tools for Internet game access can be a computer keyboard, a remote controller, a PDA, or a mobile phone. The figure 1 shows the wireless robot application environment. In the mobile robot applications, one should consider two important factors. One is the real-time operation and the other is the reliability of robot control data transmission. The reliable and real-time transmission of robot control data should be guaranteed because real robots might be dangerous for some control environments.

There are two major transport protocols in data transmission in the Internet, TCP (Transmission Control Protocol) and UDP (User Datagram Protocol). The retransmission in TCP causes the delay of transmission time [1-3]. Some improved researches for reliability of data transmission usually cause time delay problem[4-7]. The control data for moving a robot can be modeled simply. We assumed that UDP can be designed for carrying data packet not exceeding to 64 Kbytes [1, 2]. With the assumption, we can control the robot via UDP. We select the UDP protocol for robot real-time control through wireless Internet. However, there are some problems even in the UDP. It is prone to errors even though the protocol is speedy. So, we propose a scheme to complement this weakness of the UDP. In this paper, we propose a retransmission scheme and show simulation results using network simulator NS-2[8].

Dong Kwon Cho, Jeong Gyun Ahn, Yong Sik Kwon, and Jong Hoon Eom are with KT, Central R&D Laboratory, 463-1, Jeonmin-dong, Yuseong-gu, Daejeon 305-811, Korea (corresponding author to provide phone: +82-42-870-8661; fax: +82-42-870-8050; e-mail: dkcho@ kt.com).
Young Il Kim is with KT, Central R&D Laboratory, 17, Woomyeon-dong, Seocho-gu, Seoul, Korea (e-mail: yikim@kt.com).
Sang Hun Chun is with Jaenung Collegy, 8 Songrim, Donggu, Incheon, Korea (e-mail: altari@jnc.ac.kr)

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II. A scheme based on UDP for networked robot control

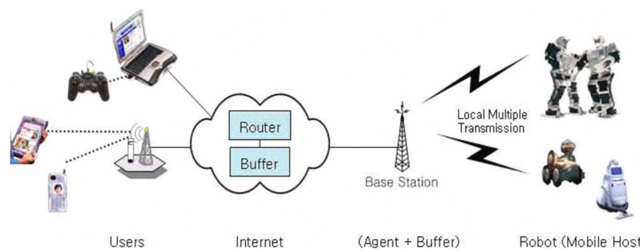


Fig. 1. Network architecture for mobile robots.

We select the UDP protocol for robot real-time control through wireless Internet. In this paper, we propose an algorithm, in which we use the fastness and overcome the error-proneness of the UDP. In transmitting robot control data, we assign priority to the data in wired links and we transmit the data multiply in wireless links to make the mobile robot respond on time. We define the robot control data and links as follows:

Robot control data : Simple commands to order the robot move or do some works. Examples of these data are key inputs to mobile phone panel or key inputs to a computer keyboard.

Wired links : To accomplish the real time transmission of the UDP packet for robot control and to overcome the congestion packet loss, set the priority field(PRI) of IP packet as 15(IPv6). The node (router) serves the arrived packet of robot control data with PRI 15 first of all.

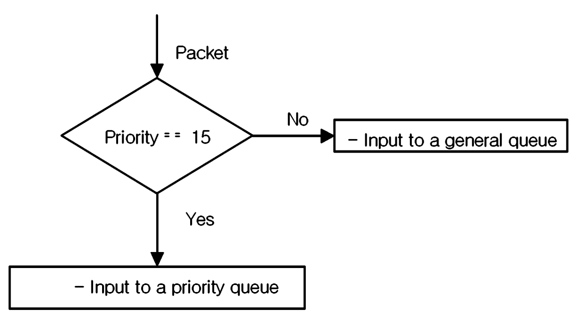


Fig. 2. Queuing mechanism using a priority(Enque).

Wireless links : To exclude the transmission congestion loss of robot control data in wireless links(which have essential difficulties), we copy the robot control UDP packet at Base Station and transmit it to robot multiply. The length of wireless link is usually shorter than wired links. So the delay time for wireless links is of short duration than the transmission time for wired links.

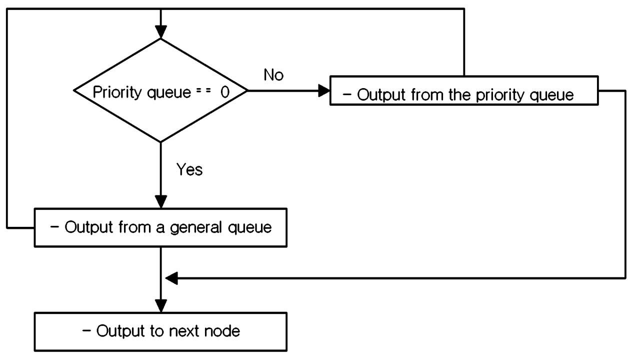
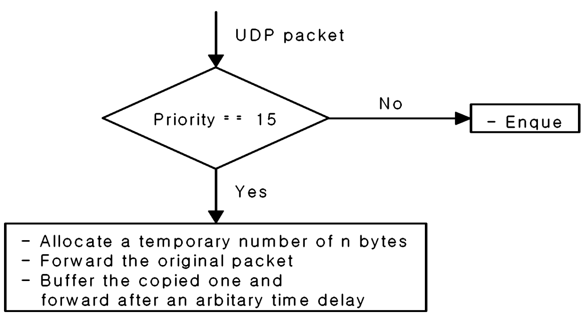
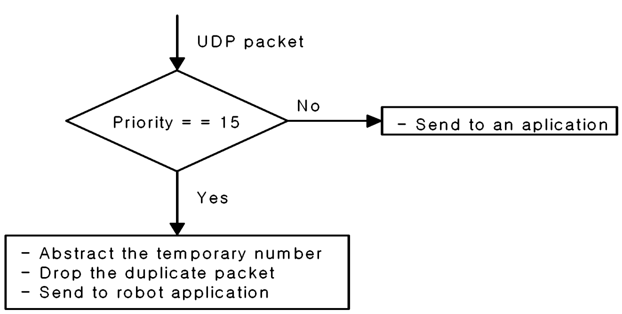


Fig. 3. Queuing mechanism using a priority(Deque).

We select the UDP protocol for robot control data transmission. If a router receives the UDP robot control packet (with PRI=15 in Ipv6), the router must immediately transmit the packet. Figure 2 shows a queuing mechanism using a priority.



(a) At the base station of wireless links.



(b) At the mobile robot.
Fig. 4. Flow chart for data processing.

In Figure 4, there might be many policies. In the wireless link base station, according to the received packet, we copies the packet and transmit it multiply if it is robot control data and we transmit it as it is if the packet is not robot control data. If there happens a packet loss at the wireless link and there is a chance that the loss is noticed by the application, one can choose the interval time.

III. Simulations

The network configuration for simulations is shown in Figure 5. Two sources S1 and S2 are connected to a router R1 through 10Mbps and 5ms delay links. Router R1 is connected to R2 through a 10Mbps and 15ms delay link. Destination D1 is connected to the router R2 via 3Mbps, 0.064ms delay link. The link between the router R2 and destination D1 is made wireless link with packet errors. A traffic to evaluate the performance is connected to the source S1, and a background traffic is connected to the source S2 and generates the bottle neck link between the router R1 and the router R2. The source S1 sends data to the destination D1, the source S2 the destination D2. The traffic connected to the source S1 is generated by a CBR (Constant Bit Rate) traffic with a packet size of 50 bytes and the time interval of 0.1 second. The background traffic connected to the source S2 is a CBR traffic with a packet size of 500 bytes and its rates are 5Mbps, 10Mbps, and 20Mbps. The packet error rate of the wireless link is varied to evaluate the performance of various methods under different loss environments. The schemes we compared include base TCP, UDP, and the duplicate transmission method considering the priority which is proposed in this paper.

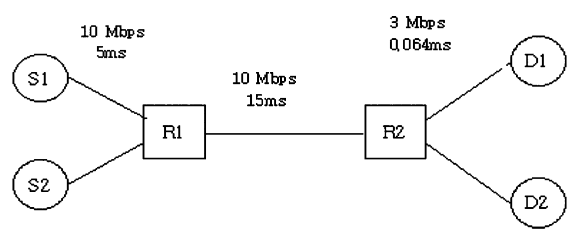


Fig. 5. Network configuration for simulations.

Simulations were performed using the ns-2 simulator from the Lawrence Berkely Laboratory. The major performance indices we used to evaluate the various schemes are a packet delay and a packet loss. The packet delay in TCP is defined as the time difference between the transmitted packet and the acknowledged packet. The packet delay in UDP is defined as the time difference between the transmitted packet and the received packet. The packet loss is defined as the packet which is not successfully received at the receiver. The performance indices of the three schemes under two packet error rates are shown in Figure 6 and Figure 7.

Figure 6 shows the results under 1 % packet error rate for the wireless link between the router R2 and the destination D1. Figure 6(a) shows the result under the transmission rate of 5 Mbps for the source S2. As we can see from the Figure 6(a) the packet delay of UDP and the proposed scheme are about 20 ms, while the packet delay of TCP is about 40 ms. We can also find that the UDP packet in sequence number 1 is lost. Figure 6(b)

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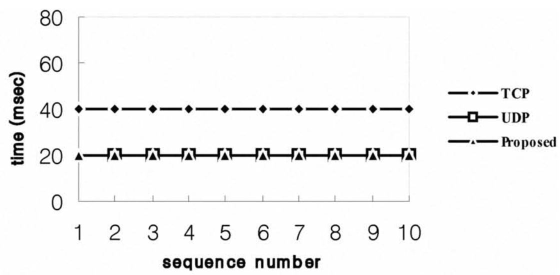
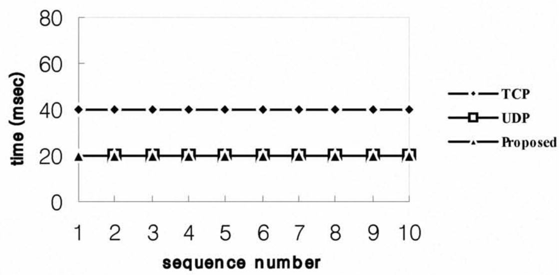
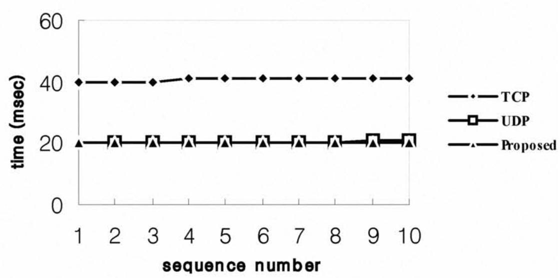
shows the result under the transmission rate of 10 Mbps for the source S2. we can see that the results follow a similar pattern to those in Figure 6(a). Figure 6(c) shows the result under the transmission rate of 20 Mbps for the source S2. Figure 6(c) shows that the packet delay of TCP is increased a bit from the sequence number 4 and the UDP packet of the sequence number 1 is lost, while the result of the proposed scheme is not changed.



(a) The transmission rate of the source S2 : 5 Mbps



(b) The transmission rate of the source S2 : 10 Mbps.



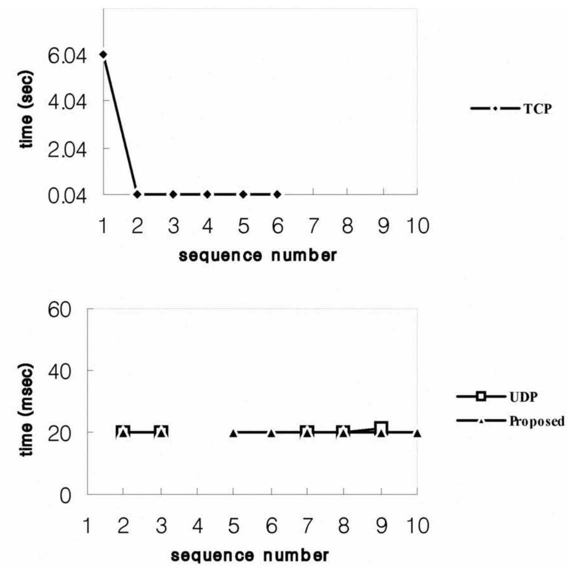
(c) The transmission rate of the source S2 : 20 Mbps.

Fig. 6 The packet delay and the packet loss under 1 % packet error rate

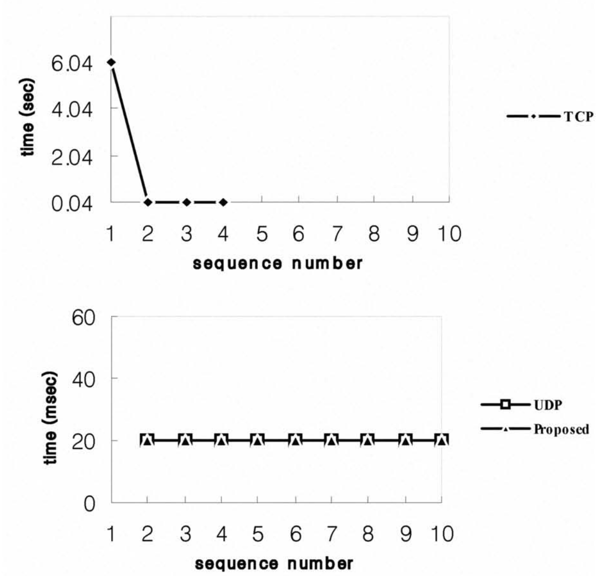
Figure 7 shows the results under 10 % packet error rate for the wireless link between the router R2 and the destination D1. Figure 7(a) shows the result under the transmission rate of 5 Mbps for the source S2. From the Figure 7(a), the packet delay of TCP packet of the sequence number 1 is 6 seconds. This result is expected from the retransmissions which are caused by the packet loss. Furthermore, after the packet of the sequence number 7, there are cases that the acknowledged packet is not arrived at the source S1. In UDP, there are packet losses for the sequence number 4, 5, 6, and 10. In the proposed method, there are packet losses only for the sequence number 1 and 4.

Figure 7(b) shows the result under the transmission rate of 10 Mbps for the source S2. From Figure 7(b) we can see that the packet delay of TCP follows a similar pattern to the results in Figure 7(a), while after the packet of the sequence number 5, there are cases that the acknowledged packet is not arrived at the source S1.The packet delays of UDP and the proposed scheme are about 20 ms, and both schemes have a packet loss in the sequence number 1.

Figure 7(c) shows the results under the transmission rate of 20 Mbps for the source S2. From the Figure 7(c) we can see that the packet delay of TCP follows a similar pattern to the results in Figure 7(a), while after the packet of the sequence number 3, there are cases that the acknowledged packet is not arrived at the source. The packet delays of UDP and the proposed scheme are about 20 ms. In UDP, there are packet losses of the sequence number 1, 2, 5, and 10. In the proposed method, there is a packet loss only for the sequence number 1.



(a) The transmission rate of 5 Mbps for the source S2.



(b) The transmission rate of 10 Mbps for the source S2.

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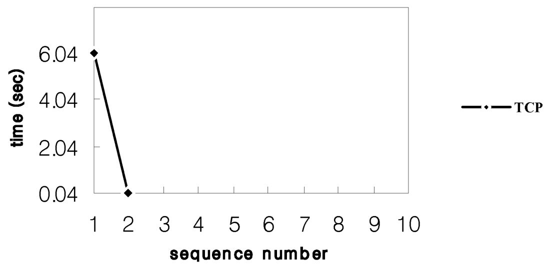

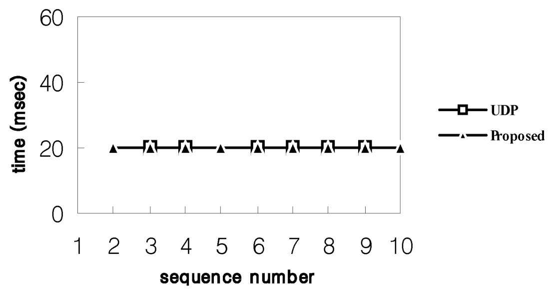

(c) The transmission rate of 20 Mbps for the source S2.
Fig. 7 The packet delay and the packet loss under the packet error rate of 10 %.

IV. Conclusions

In this paper, we proposed an efficient method for transmitting robot control data based on the UDP protocol. The method allocates the priority to the robot control data and transmits it multiply from the base station. The scheme was shown to have very low packet delay and very low packet errors by simulations using the ns-2 simulator. Especially, the packet loss and packet delay caused by the wireless link error in the the proposed scheme are both very low compared to the very long packet delay for the case of TCP.

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