A Study on QoS of Multipoint-to-Point Packet Streaming over the Wireless Ad Hoc Network Testbed

Keisuke Utsu
Graduate School of Engineering,
Tokai University
Hiratsuka, Kanagawa, Japan

Yoshimasa Sajima
OKI System Center,
OKI Electric Industry Co., LTD.
Warabi, Saitama, Japan

CheeOnn Chow
Unified Graduate School,
Tokai University
Hiratsuka, Kanagawa, Japan

Kazumasa Takami
Graduate School of Engineering
Soka University
Hachioji, Tokyo, Japan

Hiroshi Ishii
Professional Graduate School of Embedded Technology
Minato, Tokyo, Japan

Abstract - Communication over an ad-hoc network is attracting attention as an alternative to use of the existing infrastructure, in situations such as a disaster or a temporary event, where the infrastructure is not available or functioning. This paper proposes a method of maintaining the QoS of streaming data over an ad-hoc network by sending the same data from multiple points. The effectiveness of our proposal is shown through experiments on a testbed.

Keywords: Ad-Hoc Networks, Streaming, Quality.

1 Introduction

An ad-hoc network is an autonomous, distributed network that requires no fixed communication infrastructure. The growing use and shrinking size of mobile terminals, as well as progress in wireless communication technology, have been prompting studies on a wide range of applications of ad-hoc networks. In particular, the ad-hoc network is attracting interest as a means of communication in the event of a disaster or for a temporary event when it is difficult to build a large-scale fixed communication infrastructure. In an ad-hoc network mobile phones owned by individuals can exchange and pass on useful information when relaying base stations become inoperative due to an earthquake or other disaster. Also, the organizer of an event, or its participants, can send useful information to the people in the event site using an ad-hoc network.

However, there remains a concern about the reliable arrival or reassembly of data packets due to a rapid change in information propagation topology and fluctuation in the radio signal in an ad-hoc network. In particular, it is difficult to maintain sufficient quality for streaming video or audio data, which require a certain minimum bandwidth and real-time delivery. There have been many simulator-based studies regarding these aspects, but few studies have been based on experiments using devices in a real network.

This paper proposes data delivery from multiple points in an ad-hoc network as a means of improving the reachability of data streaming. We have conducted experiments of sending the same data from multiple terminals and confirmed the effectiveness of the proposed method.

Section 2 describes previous studies. Section 3 presents the proposed method and section 4 describes the experiments. Section 5 discusses the results of the measurements made in the experiments, while section 6 summarizes the conclusions.

2 Previous studies

A previous study [1] proposed a method of delivering video data to a receiving terminal with a high packet reassembly probability in a wireless ad-hoc network. This method incorporated Multiple Description Coding (MDC) and multipoint-to-point (M2P) video streaming. The effectiveness of the method was shown using a network simulator called ns2 [3].

This method aimed to improve data reachability and packet reassembly probability by using a special coding scheme to encode a set of original video into multiple sets of video, each containing sufficient video to be usable by itself, and sending the video from multiple terminals, as shown in Fig. 1. An advantage of this method is that, even if data are lost due to a link disconnection or traffic congestion during video delivery, the probability that all the data sent are lost is much lower than that of conventional coding schemes.
3 Proposed method

In order to verify the effectiveness of the proposed method, examined in the previous study using simulation, we experimented with multipoint-to-point data streaming on an ad-hoc network testbed. For simplicity, we sent data from multiple points instead of using MDC.

Specifically, we made two sending terminals send the same data to a receiving terminal. We turned the network interface cards (NIC) of a relaying terminal on and off to cause packet loss deliberately.

In building the real ad-hoc network, we chose to use IEEE802.11g mode, and OLSR [4], a proactive routing protocol, for its ease of implementation. The measurements were made indoors. Packets were generated using Lan Traffic v2 [5]. The packet size was 512 Bytes, and the mean throughput was 128kbps. UDP [6] was used at the transport protocol.

4 Streaming experiments on a real network

4.1 Outline of the experiments

Experiments were made for four different cases, designated by Experiments I, II, III and IV. In each case, we compared the probability of packet reassembly of multipoint-to-point streaming, which is the proposed method, with that of point-to-point (PP) streaming. We evaluated PP by assigning “Good” to the case where the receiving terminal successfully received packets from the sending terminal, and “Bad” to the case where the receiving terminal failed to receive the packets. In the case of M2P, if the receiving terminal receives data from both the two sending terminals, the evaluation is “Good”; if it receives data from only one of them, the evaluation is “OK”, and if it receives data from neither of them, the evaluation is “Bad”.

4.2 Experiment I

4.2.1 Configuration of Experiment I

The configuration of the real network in Experiment I is shown in Fig. 2. The network was so configured that the pairs of terminals shown connected directly with either a solid or dotted line communicate with each other in one hop, and other pairs do not.

In the case of PP, the sending terminal was Node 1, and the receiving terminal was Node 4. In the case of M2P, the sending terminals were Nodes 1 and 5, and the receiving terminal was Node 4. In the initial state, the route used for communication between Nodes 1 and 4 was through Node 2.

4.2.2 Measurement results of Experiment I

Table 1 Procedure of Experiment I

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Measurement is started.</td>
</tr>
<tr>
<td>2</td>
<td>NIC of Node 2 is turned off. (This causes OLSR to change the route from the one passing through Node 2 to the one passing through Node 3.)</td>
</tr>
<tr>
<td>3</td>
<td>The test is completed.</td>
</tr>
</tbody>
</table>

This procedure is intended to simulate how M2P can eliminate the packet loss caused when Node 2 is isolated from the network and the route is switched to an alternative one passing through Node 3, while Node 1 continues to send streaming data to Node 4.

The packet reassembly probability is evaluated by examining whether the receiving terminal received data successfully. The length of the streaming data used was 240 kB or 480 packets.

Figure 3 shows the measurement results.
4.3 Experiment II

4.3.1 Configuration of Experiment II

The configuration of Experiment II is the same as that of Experiment I (Fig. 2). However, the procedure is different, as shown in Table 2. Again, the test measurements were performed 5 times.

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Measurement is started.</td>
</tr>
<tr>
<td>2</td>
<td>NIC of Node 2 is turned off. (This causes OLSR to change the route from the one passing through Node 2 to the one passing through Node 3.)</td>
</tr>
<tr>
<td>3</td>
<td>NIC of Node 3 is turned off.</td>
</tr>
<tr>
<td>4</td>
<td>The test is completed.</td>
</tr>
</tbody>
</table>

As in Experiment I, this procedure is intended to simulate how M2P can complement the packet loss caused when Node 2 is isolated from the network and the route is switched to an alternative one passing through Node 3, while Node 1 continues to send streaming data to Node 4. In addition, it simulates how packet loss is compensated for when Node 3 is also isolated from the network.

As in Experiment I, the packet reassembly probability is evaluated by examining whether the receiving terminal received data successfully. As in Experiment I, the length of the streaming data used was 240 kB or 480 packets.

4.3.2 Measurement results of Experiment II

Figure 4 shows the measurement results.

Figure 4 shows that the proportion of “Good” and “OK” combined for M2P is higher than that of “Good” for PP in all tests, just as in Experiment I. In fact, M2P recovers lost packets, enabling the streaming video to be played without any frames loss, which is not the case for PP.

4.4 Experiment III

4.4.1 Configuration of Experiment III

The network configuration of this experiment is shown in Fig. 5. The network is so configured that each node can communicate in one hop only with the immediately adjacent nodes.

In PP, the sending and receiving terminals are Nodes 1 and 2 respectively. In M2P, the sending terminals are Nodes 1 and 5 and the receiving terminal is Node 3.

This procedure simulates the case where either Node 2 or 3 becomes inoperative for two seconds due to it, or another node, moving, or due to temporary deterioration of radio reception.

The following test sequence was repeated five times.
Table 3 Procedure of Experiment III

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Measurement is started.</td>
</tr>
<tr>
<td>2</td>
<td>NICs of Nodes 2 and 4 are turned off for 2 seconds, and then back on.</td>
</tr>
<tr>
<td>3</td>
<td>NIC of Node 2 is turned off for 2 seconds, and then back on.</td>
</tr>
<tr>
<td>4</td>
<td>NIC of Node 4 is turned off for 2 seconds, and then back on.</td>
</tr>
<tr>
<td>5</td>
<td>The test is completed.</td>
</tr>
</tbody>
</table>

Just as in Experiment III, this procedure simulates the case where either Node 2 or 3 become inoperative for two seconds due to it, or another node, moving or temporary deterioration of radio reception.

The packet reassembly probability is evaluated by examining whether the receiving terminal received data successfully. As in Experiment III, the length of the streaming data used was 300 kB or 600 packets.

4.4.2 Measurement results of Experiment III

Figure 6 shows the measurement results.

![Fig. 6 Measurement results of Experiment III](image)

Figure 6 shows that the proportion of “Good” and “OK” combined for M2P is higher than that of “Good” for PP in all tests. This means that the packet reassembly probability of M2P is higher. There are some variations in the probability between different tests. This seems to stem from the fact that there is some variation in the time interval between the time when an NIC is turned on and the time when it becomes operable.

4.5 Experiment IV

4.5.1 Configuration of Experiment IV

The configuration of Experiment IV is the same as that of Experiment III (Fig. 5). However, the procedure is different, as shown in Table 4.

Table 4 Procedure of Experiment III

<table>
<thead>
<tr>
<th>Time (seconds)</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Measurement is started.</td>
</tr>
<tr>
<td>2</td>
<td>NICs of Nodes 2 and 4 are turned off for 2 seconds, and then back on.</td>
</tr>
<tr>
<td>3</td>
<td>NIC of Node 4 is turned off for 2 seconds, and then back on.</td>
</tr>
<tr>
<td>4</td>
<td>NIC of Node 2 is turned off for 2 seconds, and then back on.</td>
</tr>
<tr>
<td>5</td>
<td>The test is completed.</td>
</tr>
</tbody>
</table>

In all Experiments (I-IV), the proportion of “Good” and “OK” combined for M2P is higher than that of
“Good” for PP in all tests, which means that the packet reassembly probability for M2P is higher. We can thus conclude that data streaming from multiple sending nodes can improve the packet reassembly probability in a wireless ad-hoc network.

5 Conclusions and future issues

We have measured the quality of streaming data sent from multiple sending nodes, a scheme conceived to improve the quality of streaming delivery of videos in a wireless ad-hoc network, and have verified the effectiveness of this scheme.

The measurements have been made in experiments using four different situations.

The packet reassembly probability of multipoint-to-point (M2P) delivery has been compared with that of point-to-point (PP) delivery, and it has been found that the probability of M2P delivery is higher in all cases. This indicates that M2P delivery allows video data to be reassembled with a higher accuracy, even though there may be some degradation in quality at the receiving terminal.

A problem with the proposed M2P delivery scheme is that, since the same packets are sent from multiple sending terminals, more packets flow across the network than in PP delivery, and as a result, more network resources are consumed.

Since we made measurements for both M2P and PP simultaneously, we chose to use a relatively low packet traffic load to prevent the receiving terminals from being affected by traffic. When we consider a practical application, it is necessary to use a higher traffic load. It will be necessary to build separate experimental environments for the two delivery schemes.

We plan to evaluate the packet reassembly probability when MDC is used for packet transmission with higher traffic loads. Specifically, we will measure the quality of data streaming from multiple sending terminals in combination with the use of MDC in a wireless ad-hoc network.

6 Acknowledgements

This research has been conducted as part of “R&D on Data-driven Networking Processors Suitable for an Ad-hoc Ubiquitous Communication Environment” under the Strategic Information and Communications R&D Promotion Program (SCOPE) of the Ministry of Internal Affairs and Communications in Japan, and also by KAKENHI(19500064).

7 References

[1] CheeOnn Chow, Hiroshi Ishii, “Study on Multi-point-to-Point Video Streaming Using Multiple Description Coding over an Ad-hoc Network,” Tokai University Bulletin, School of Information Technology and Electronics, pp.31-37, Vo5, No.2 2005