Contents Distribution to Android Clients Using Wireless LAN Multicast for a Large Fireworks Festival

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***Abstract*— In recent years, with the spread of high performance mobile terminals, an information distribution system for them has been attracting attention in various situations. However, it is difficult to use the existing TV-based broadcasting systems for a mobile phone because a license and large-scale facilities are necessary. In this paper, we propose a new information distribution system. The proposed system broadcasts contents towards a wireless LAN interface of the mobile phone (e.g., Android terminal) by using IP multicasting. However, IP multicast packets are not retransmitted at MAC, which may result in degradation of communication quality. Therefore, we have evaluated the communication characteristics of IP multicast, and have clarified that the continuous packet loss rarely occurs, hence, the packet loss can be complemented by redundantly sending the same data several times. Based on this result, a new redundant data transmission method is proposed. We have developed the proposed system and performed the experimental evaluation in Nagaoka Fireworks Festival where about 400,000 people participate. From this experiment, it has been concluded that the proposed system has satisfactory worked for contents distribution.**

***Keywords*— Information Distribution System, Wireless LAN, IP Multicast, Android Terminal, Packet Loss Properties**

I. INTRODUCTION

In recent years, with the spread of high performance mobile terminals, an information distribution system for them has been attracting attention in various situations. For example, in a big festival such as a fireworks festival, if an organizer can provide information to participants in a limited and specific area easily, they can better offer guidance in disaster evacuations, advertising, etc.

The system can be built by using a TV-based information broadcasting system for mobile terminals (i.e., One-seg broadcasting in Japan [1]). However, such broadcasting system has several drawbacks. For example, a license of the system should be assigned by the national authority and large-scale facilities should be prepared for the system.

On the other hand, high performance mobile terminals equipped with a wireless LAN (e.g., Android smart phone) have become prevalent in recent years. Therefore, IP multicast becomes a candidate technology for simultaneously sending information toward large number of mobile terminals through a wireless LAN. However, IP multicast has a problem that packet losses are frequently occurred when IP multicast packets are transmitted on the wireless LAN.

In this paper, we propose a new information distribution system for mobile terminals using the wireless LAN multicast, and evaluate the packet loss properties of the IP multicast on the wireless LAN. Furthermore, we also propose a method of decreasing packet loss and evaluate its performance in a large-scale event.

II. RELATED WORKS AND OBJECTIVES OF THIS STUDY

A. *Related Works*

Broadcasting system for mobile terminals named One-seg broadcasting can be used to realize an information distribution system for mobile terminal in a limited area. One-seg broadcasting, started in 2006, is a special broadcast form for mobile devices in Japan. In the terrestrial digital broadcast system in Japan, each channel is divided into 13 segments. HDTV for home is broadcasted by 12 segments. The remaining one segment is used for mobile phones. However, this system requires a large facility, so cannot be easily used for building an information distribution system. Moreover, we must obtain a license from a national authority in order to use the One-seg broadcasting in the experimental examination [1].

Furthermore, an information broadcasting system (e.g., Ustream [2]) which can be provided through 3G cellular network has been widely used. However, this system is difficult to be used in a dense zone where there are many people (e.g., hundreds of thousands of people participate in the fireworks festival), and communication congestion occurs in such an area.

On the other hand, IP multicast is a candidate technology of simultaneously sending information to many terminals. The IP multicast groups users who stay in the same place can send information toward the users in the same group simultaneously. In addition, we don't need any license and special facilities to use the IP multicast. The IP multicast system becomes a good candidate because mobile terminals such as Android terminal equipped with a wireless LAN has been released.

There is an existing study which uses IP multicast over wireless LAN [3]. This study does not take packet errors fully into account. Another study proposes to complement the packet loss on the wireless LAN multicast, but needs modified functions of the access point [4].

B. *Objectives of this Study*

Considering these situations, we propose a new information distribution system which can not only broadcast any types of information towards mobile terminals but also enables the terminals to communicate each other. Furthermore, we develop the proposed system with Android terminals, particularly featuring the redundant data transmission method in order to complement the packet loss without modifying the access point.

III. Overview of the Proposed System

Figure 1 shows an overview of the proposed information distribution system. This system provides a tentative community that people in a limited and specific area can communicate each other. Some application examples to use this system are as follows:

・Information distribution and communication in a large event (e.g., fireworks festival, etc)

・Communication support in provisional housings after large disasters (e.g., earthquake, flooding, etc).

An information provider prepares 1) an access point to which users connect, and 2) a server that sends contents to mobile terminals. In order to provide information in a wide area, this system uses a long-distance wireless LAN bridge as an access point instead of a general omnidirectional wireless LAN router. In this proposed system, users utilize the services by connecting own Android terminal to the access point through wireless LAN. Users can utilize this system without any difficulty because the installation of the application in Android terminals is easily performed. We hope this system can be used even for elderly people who often suffer from digital barriers, i.e., complicated user interfaces of Windows, etc.

The first implementation of this system targets a large fireworks festival, so voice data is chosen as a distributed content. It also provides a local text chat by which users can exchange information each other. Because this system considers only voice for guidance use, it transmits the voice coded at 64 [kbps] and each voice packet is transmitted at 20 [msec] interval.

In this system, IP multicast is used as a way to send information to mobile terminals simultaneously. Users join the multicast group of the information distribution, and the server which stores the content sends it towards the multicast address corresponding to the multicast group. The access point transmits data to mobile terminals that have joined in the multicast group.

When IP multicast packets are transmitted on the wireless LAN, packet losses are frequently occurred because the lost packets are not retransmitted at a MAC layer between the access point and the mobile terminal [5]. The next section provides packet loss evaluation of wireless LAN multicast.

IV. Evaluation of Wireless LAN Error Characteristics

A. *Experimental Setup*

In order to evaluate feasibility of our proposed system, we measure a coverage area of the long-distance wireless LAN bridge and the packet loss characteristics of the IP multicast on the wireless LAN. The experimental environment is the rural zone where no other access points are deployed and there is no obstacle which blocks the radio wave.

In this experiment, Nexus One Android terminal is used as a mobile terminal and WB30031 [6] of long-distance wireless LAN bridge as an access point. Table 1 shows specifications of the Nexus One, and Table 2 shows settings of WB30031. As shown in Table 2, in order to enable communication in a wider area, the maximum communication speed and the minimum signal strength are set to be the lowest.

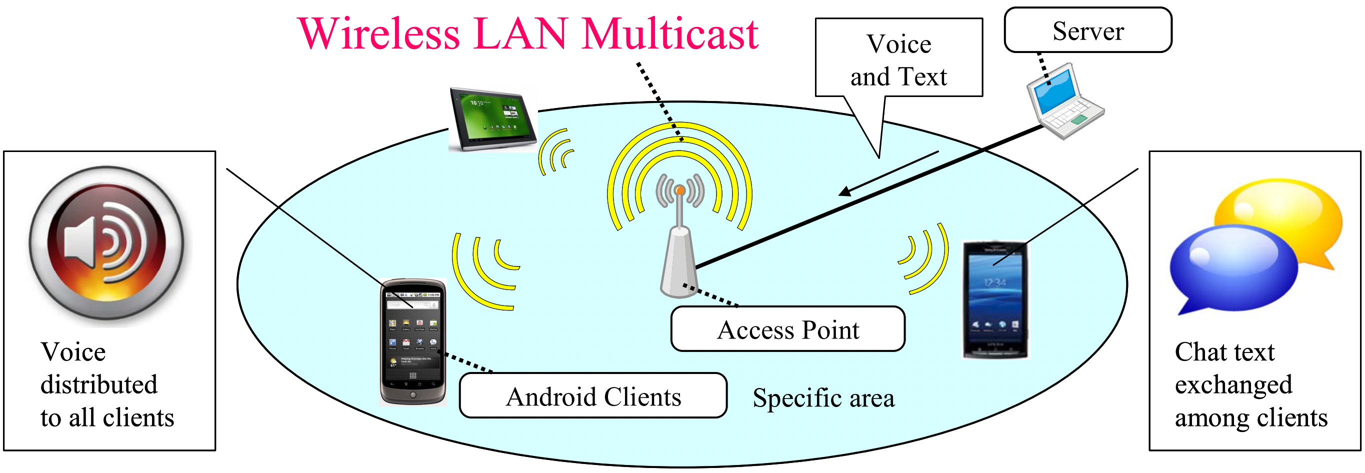

Figure 1. An overview of the proposed system

TABLE 1. SPECIFICATION OF NEXUS ONE

OS	Android 2.3.6
Kernel version	2.6.35.7-59465-g42bad32
CPU	1[GHz] (Qualcomm QSD 8250)
Memory	512[MB]

TABLE 2. SETTING OF WIRELESS LAN BRIDGE WB30031

Communication standards	802.11b
Maximum communication speed	1[Mbps]
Minimum signal strength	-96[dBm]
Channel (Communication band)	1ch (2.412[GHz])
Antenna (UHF Yagi antenna)	27-elements

B. Directivity Properties Examination

In order to evaluate whether long-distance communication is possible between a long-distance wireless LAN bridge and mobile terminals, the coverage area where the mobile terminal can establish a connection to the access point has been measured. Furthermore, the same experiment has been done by WZR-HP-G301NH/U [7] of a general wireless LAN router for comparison. Table 3 shows settings of WZR-HP-G301NH/U.

TABLE 3. SETTING OF WIRELESS LAN ROUTER WZR-HP-G301NH/U

Communication standards	802.11n
Channel (Communication band)	1ch (2.412[GHz])

Figure 2 shows the measurement results of the coverage area. Each measurement point indicates the place where a mobile terminal can barely establish a connection with the access point and an area enclosed by the line is a coverage area estimated by the measurement points. The proposed system using a long-distance wireless LAN bridge can cover about 900[m] in vertical width, and about 400[m] in horizontal width. On the other hand, the proposed system using a general wireless LAN router can cover the area of a radius of about only 190[m]. Therefore, this result indicates that the long-distance wireless LAN bridge can achieve a much wider coverage area of the information broadcasting than the general wireless LAN router.

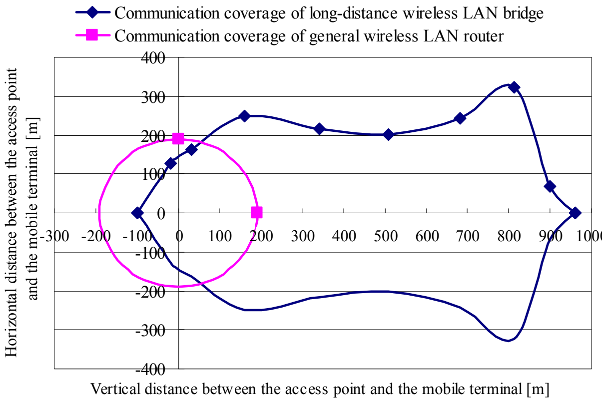

Figure 2. Communication coverage of wireless LAN multicast from the access point

C. Examination of Packet Loss Properties

We then measure the packet loss characteristics of the data transmission using IP multicast over wireless LAN.

In this experiment, the server periodically transmits packets to a multicast IP address at 20 [msec] interval for 1 minute, and the mobile terminal joining the multicast group receives the packets. This packet pattern is derived from 64 [kbps] voice transmission. The communication speed of the data transmission including headers becomes 81.2 [kbps].

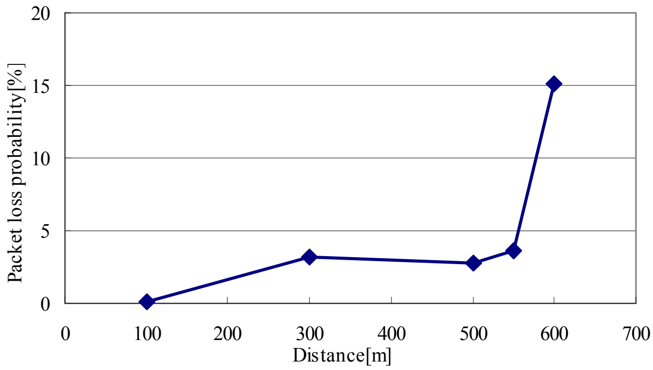

Figure 3. Distance vs. packet loss probability

Figure 3 shows the packet loss probability as a function of a distance between the access point and the mobile terminal. At the distance less than 550 [m], the probability of the packet loss is only less than 4%. However, when the distance goes to 600 [m], the probability of packet loss increases to 15% which degrades quality of data multicasting. This result shows that the proposed system can achieve about 550 [m] coverage with keeping high quality communication.

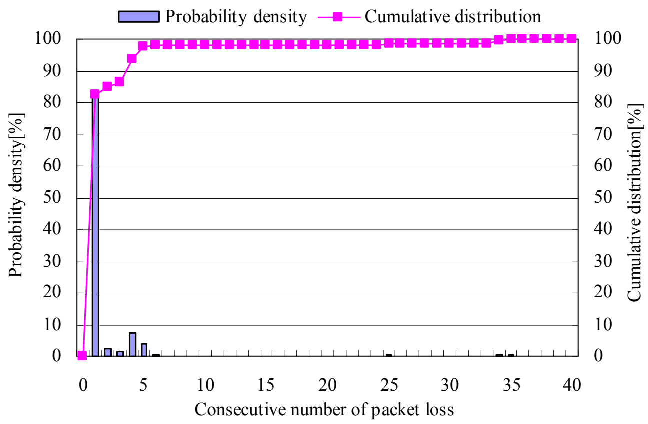

Figure 4. Characteristics of consecutive packet loss

Figure 4 shows the probability density of consecutive number of packet loss when the distance between the access point and the mobile terminal is 550 [m], where the packet loss probability is about 3.6%. As shown in this figure, probability of the single packet loss is about 80%. Therefore, this system can complement 80% of data losses by redundantly sending the same data twice.

V. PROPOSAL OF REDUNDANT TRANSMISSION

A. Proposed Methods

Based on the experiment presented in Section IV, a method of redundantly sending data is considered to effectively complement the packet loss of the proposed system. By transmitting the same data packet several times, the proposed system may complement almost all packet losses. In this section, we propose a method of the redundant transmission, and evaluate the performance of the method.

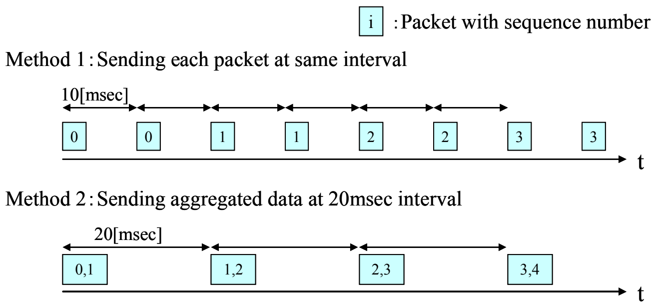

Figure 5. Two redundant transmission methods (e.g., redundancy = 2)

Figure 5 introduces a basic idea of the redundant data transmission method. As shown in Figure 5, two types of redundant transmissions are considered.

Method 1 sends data packets at the same interval. In the case of redundancy = 2, each data packet is transmitted twice, hence the packets are sent at 10 [msec] interval. If the redundancy becomes large, more packet losses can be complemented, but sending interval becomes narrow and the communication bandwidth becomes large.

On the other hand, Method 2 sends the packet which includes not only newly generated data but also redundant data at 20 [msec] interval. If the redundancy becomes large, more bandwidth is consumed for the data transition as the same as Method 1. However, the number of packets transmitted by the Method 2 is the same as that of the data distribution without redundant transmission, which may keep the packet loss probability on the wireless LAN within a small value.

B. Evaluation of Proposed Methods

In order to compare the packet loss characteristics between these two methods, we performed the experimental evaluation. In each evaluation, the server transmits the data to the predefined multicast IP address for 1 minute, and the mobile terminal receives them and derives the packet loss probability. Furthermore, a distance between the access point and the mobile terminal is set to 550 [m].

Figure 6 shows the packet loss probability as a function of the redundancy of the data transmission. The redundancy indicates how many times the server transmits each data. With the increase in the redundancy, broader bandwidth is consumed. As shown in Figure 6, the packet loss probability becomes large as the redundancy becomes large. However, the packet loss probability of Method 2 is much lower than that of the Method 1. The reason of this result is thought that Method 2 can avoid collisions of radio transmissions by sending packets at longer interval than Method 1. Therefore, we can conclude that Method 2 is suitable for complementing the packet loss occurred on the wireless LAN IP multicasting.

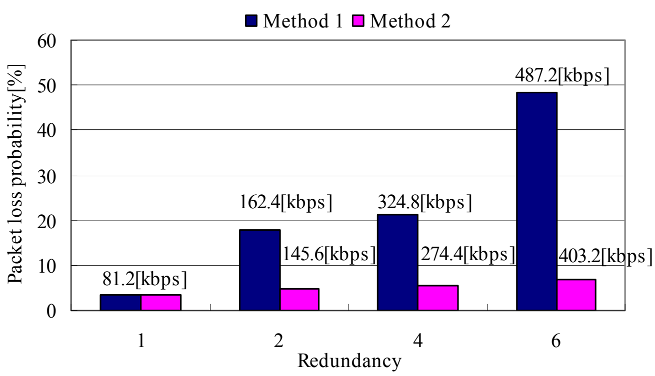

Figure 6. Packet loss probability – redundant transmission

VI. EXPERIMENTAL EVALUATION IN FIREWORKS FESTIVAL

A. Experimental Setup

In August 2 (Thu.) and 3 (Fri.), 2012, in order to evaluate feasibility of the proposed system, we have performed the experimental examination in the Nagaoka Fireworks festival where about 400,000 people participate per one day [8]. The site for this festival is Shinano riverside, Nagaoka, Niigata, Japan. Figure 7 shows the site of this festival and installation location of access points. Two access points have been installed in opposite directions each other on the roof of a building near the site. These access points can cover the whole site because the length of the site is about 700 [m]. The access points select different channels so as to avoid radio interference.

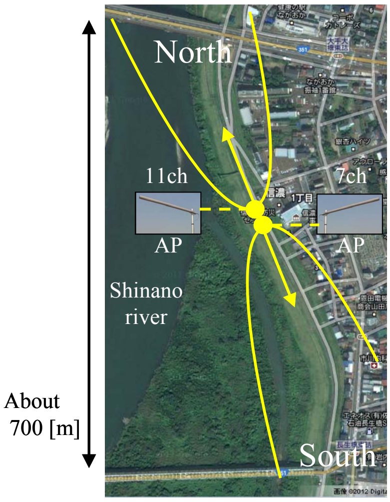

Figure 7. Site of the Nagaoka Fireworks Festival

For the participants of this festival, we have developed the user-side Android application which receives data multicasted from the access point. Figure 8 shows the GUI of the developed application. This application has been advertised in a website and leaflets of the festival, and released it from Google Play [9]. Figure 9 indicates the number of unique accesses to website. As shown in this figure, the number of unique accesses rapidly increases from the beginning of August. This result indicates that the participants have been interested in the proposed system just before the festival. In addition, Figure 10 indicates the number of terminals which have installed the application. From these figures, it seems the proposed system has been attracting attention of many people.

Figure 8. GUI of developed Android application

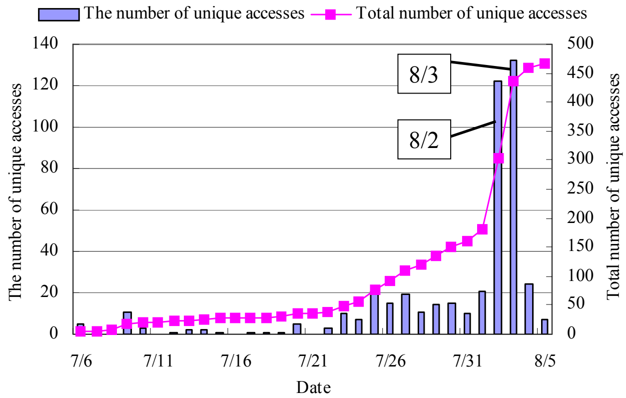

Figure 9. The number of unique accesses to website

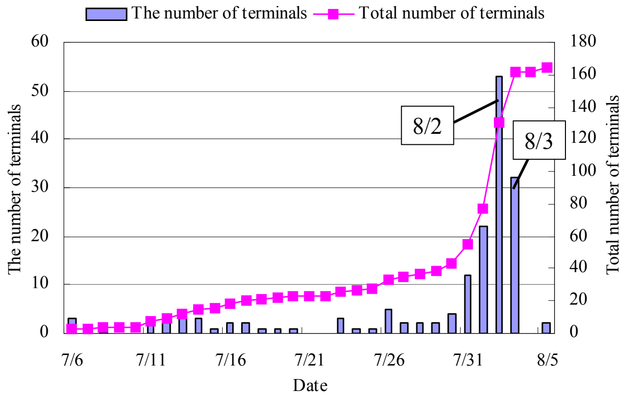

Figure 10. The number of the installation terminals of the application

B. Experimental Evaluation of Packet Losses

In the festival, Method 2 of redundant data transmission with redundancy = 2 has been used. The communication speed becomes 218 [kbps] because we broadcast not only voice data but also chat and image data. The chat is used for communication between participants of the festival, and image data includes useful information (e.g., a program of the fireworks, train timetable).

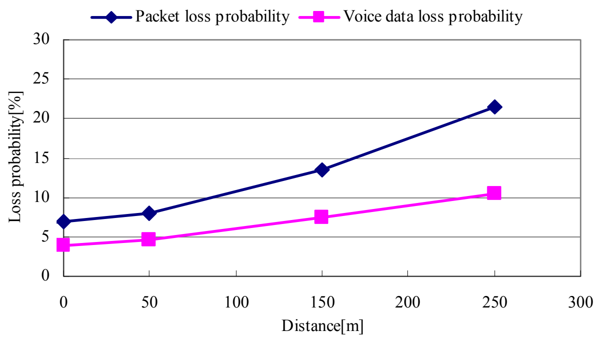

Figure 11. Distance vs. packet/voice data loss probability

Figure 11 shows packet and voice data loss probabilities as a function of a distance between the access point and the mobile terminal. From this figure, the packet loss probability becomes large when the distance goes to large. However, in each distance, about a half of voice data losses can be complemented by the proposed method. Therefore, it is concluded that Method 2 of redundant transmission can achieve efficient data broadcasting in a large-scale festival.

VII. Conclusions and Future Work

In this paper, we have proposed a new information distribution system for mobile terminals using wireless LAN IP multicasting.

From the experimental evaluation of the proposed system, we have clarified that the proposed system using a long-distance wireless LAN bridge can achieve a much wider coverage area where the mobile terminals can receive the voice and text broadcasting. It has also been clarified that the probability of the single packet loss is about 80% of all packet losses. Therefore, in order to mitigate an impact of the packet loss probability, a method of sending aggregated data which includes newly generated data and redundant data has been proposed.

Furthermore, in August 2 (Thu.) and 3 (Fri.), 2012, we have performed experimental evaluation of the proposed system in the Nagaoka Fireworks Festival where about 400,000 people participated. An Android application for the participants has been developed, and has been released from Google Play. The experiment has shown that the proposed data transmission method can halve the voice data loss probability. Furthermore, the proposed system has been attracting attention of many people.

In the future study, we will build a statistical model of packet loss pattern on the IP multicasting over wireless LAN and will use it for evaluating the effectiveness of the proposed system in various conditions.

Acknowledgment

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