Proposal for communication network support onboard ships in damaged areas

Kumi Sakabe, Satoshi Machida, Hidetoshi Arima, Kenji Ishida
Kobe University
Kobe, Japan

Abstract

In 1995, the Great Hanshin-Awaji earthquake occurred in Kobe. At that time, cellular phones were not generally popular. But after that, information exchange with cellular phones in disasters was recognized as necessary. Cell-phone providers divided voice communication from packet communication and set up online bulletin boards and voice mail service at disasters. Unfortunately in 2007 at the Niigataken Chuetsu-oki earthquake in Japan, communications including packet communication could not work properly because of the damage to the Base Transceiver Station, major blackout, and so on. Some parts of the city were isolated from communications. Now, we realize the importance of a supporting network of volunteer ships from the sea during a disaster. In that case, a communication exchange between networks was considered using packet communication of a cellular phone as a way of communication, since the Niigataken Chuetsu-oki earthquake. From above background, we propose a concept of communication network support onboard ships in damaged areas.

We sent a questionnaire to 47 governments of municipalities in Ishikawa, Fukui, and Toyama prefectures according to the communication method at the Noto-Hanto earthquake in 2007.

For long distance communication at the disaster, it enables the use of a vessel as a relay base, which can provide the Internet to the areas which suffered a great deal of damage and became unable to use the Internet. Some wireless LAN (WLAN) has functions as a repeater. We can communicate from an isolated area by relaying a wireless communication of the Internet with this function as a repeater. However, only function as a repeater, not only the attainment distance of WLAN is limited but also from the viewpoint that fault-resilient, it is very weak. The bridge between the WLAN environments where plurality differs, and its network is carried out securely, to reserve a long distance communication and recovery to an obstacle. This network has the advantage that ships are maneuverable and it can also provide a power supply and WLAN devices at low cost. We conceive of the construction of a coast area communication network using ships; a small-scale experiment verification was performed. It carried out the check of operation of the communication in short distance. It may become a valuable tool of serving an information-

communication function as emergency communication way at large area disasters.

1 Introduction

The Great Hanshin-Awaji earthquake occurred on January 17' 1995. Land transportation infrastructure was heavily damaged. In the disaster, measures used to send supplies to the damaged areas were over land and by air. However, in the case of Kobe, helicopter landings were not permitted due to the danger of aftershock. Also land transport faced difficulties because of destroyed roads and traffic congestion. Therefore marine transportation had to take a lead. During the Great Hanshin-Awaji earthquake ships carried both supplies and casualties, etc. Ferries moored at the quays in the harbor became accommodations for victims. Many kinds of ships played a large role throughout the recovery.[1)]

As many earthquakes occur, Japan is called *"Jishin Taikoku."* This means a country of earthquakes. In the Tokai, Nankai and Toh-Nankai areas, which face the Pacific Ocean, a big earthquake happens from between every 100 to 150 years. The Nankai and Toh-Nankai earthquakes have a possibility of occurrance of more than 80% within 50-years.[2)] When this earthquake happens, the possibility of a Tsunami is very high. Such an earthquake would create serious damage.

By organizing a support network utilizing ships as a countermeasure support would become most effective.

2 Supports by ships at disasters

2.1 Great Hanshin-Awaji earthquake

Many ships, especially small ships, were used in various ways during the immediate aftermath of the Hanshin-Awaji earthquake. These ships were used 1) for the transportation of supplies by fishing boats of the Japan Fisheries Association and other volunteers; 2) supplies and human resources carried by ships chartered by some companies; 3) emergency shuttle 'bus' for maritime transportation, 4) as commuting vessels to larger ships at anchor, 5) establishment of a sea lane by small high-speed boats; 6) transport of supplies, and as backup members of rescue crews by fireboats; 7) transportation of workforce and casualties by patrol boats and so on.

Transportation of supplies and supporting personnel using ships started from day two of the earthquake. Various ships, such as tug boats, water boats, plying boats, fishing boats and patrol boats were used. According to statistics, about 30,000 tons of supplies were brought to Kobe port from sea by the end of February.[3)]

2.2 Response of fishing ports as supporting bases

Fishing ports are scattered throughout and along the shore. They are freed up in many places to do fishing activities and many fishing boats, which have a tight turning circle, are berthed at these ports. It is believed that these ports play an important role as a supporting base to bring in supplies and human resources into the damaged area and for transportation of victims, as required there.

In order to utilize fishing ports as a supporting base, it is necessary to cooperate with neighboring fishery administrators and the fishery associations to construct a network to best deal with such disasters. Additionally, it is also necessary to create an information infrastructure for communication with such fishing ports and to inform on the post-disaster situation immediately. In order to construct a network between fisheries areas, we must look to preparing a fishing port as a disaster prevention facility and base, from the point of view of disaster prevention.

Fishing ports can handle seaborne transport supplies and evacuees immediately after disaster. They can support the transport of commodities until public facilities can be restored when a great earthquake occurred. The term 'like these ports' is used to mean here a fishing port used for disaster prevention.[4)]

At the great Hanshin-Awaji earthquake the route of transported supplies to Kobe/Awaji from the fishing ports of neighboring prefectures is shown in Figure 2.1.

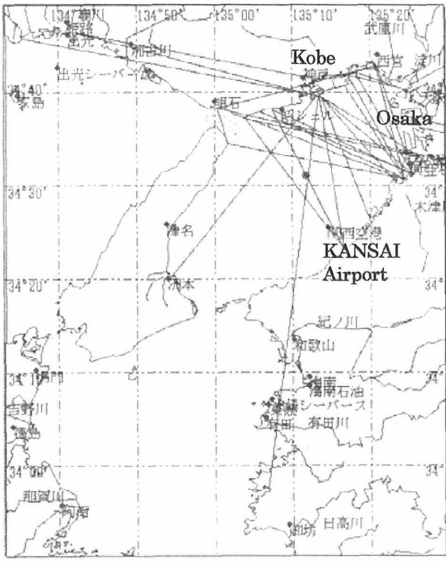


Figure 2.1 Route of supporting for Kobe by Small ships at the earthquake[1]

3 Nankai and Toh-Nankai earthquake

The Nankai and Toh-Nankai areas of the main island of Japan face the Pacific Ocean. In these areas, great earthquakes occur within a period of about 100 to 150 years. The scale is magnitude 8. The governmental "Earthquake Research Committee" announced on September 1, 2004, the possibility of Nankai and Toh-Nankai earthquakes happening at 50% within the next 30 years.[2] And 80% during the next 50 years. The next Nankai earthquake is predicted to strike near Kochi prefecture and at an intensity of 6 or more, on the Japanese scale.

Moreover, such an earthquake will cause a tsunami in all coastal areas in Kochi. This tsunami will be 3 meters to over 10 meters, which is predicted to reach coastal areas in Kochi within 3 to 30 minutes. This earthquake and tsunami will bring widespread damage to the whole of Kochi, and access to neighboring areas would be disrupted.[5]

4 Support network of volunteer ships deployed to a disaster

Well-organized support from the sea could hold the most potential for effective support systems in any kind of disaster that may happen in Japan. In order to construct an immediate, supporting network, we researched into the case of Kochi city, in Shikoku Island. Figure 4.1 is an image of the supporting network.[6)]

During ordinary times this network will spread the idea of volunteer ships, educate and train those joining the network, and create a map which will show the place where small ships can gather off shore.

1) Once a disaster happens, a volunteer ship network will collect information from on-site headquarters and others, in the damaged area.
2) Collected information will be analyzed and released by the volunteer ship network.
3) People joining the network can get information such as on how many and what kinds of supplies are required; where the safe shores and beaches are, and so forth.
4) Early after a disaster, medicines, water, food and rescue teams are placed in the highest priority.

By constructing this supporting network, information exchange will become smooth and more effective. Support from the sea by small vessels will be easily possible. It will be a center for countermeasures after the disaster has struck. This informational exchange is very important for this supporting network.

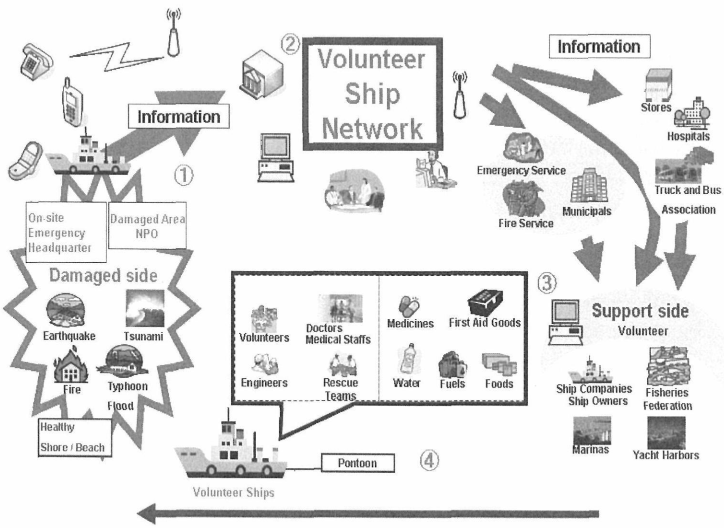


Figure 4.1 Image of the supporting network of volunteer ships from the sea

5 Communication situation at the disaster

5.1 The great Hanshin-Awaji earthquake

On January 17, 1995, the great Hanshin-Awaji earthquake, magnitude 7.3 struck Kobe. The battery and auxiliary engine for backup were installed in the telephone switchboard of the damaged area. However, electrical supply became impossible because of the fall of the battery by earthquake tremor. In addition, supplying fuel also became impossible because the light oil supply pipe to the auxiliary engine was cut by the quake. For this reason, the switchboard stopped and telephone service of about 285,000 circuits stopped. In addition, telephone communication to the damaged area was down for around five days. Telephone communication for reservation for important communications, must be regulated, being 50 times more than usual peak concentrations.[7)]

5.2 The Noto Hanto earthquake

On March 25, 2007, the Noto Hanto earthquake struck. Fixed telephone and cellular were service were seldom available until four hours after the earthquake in parts of Ishikawa and Toyama prefecture. According to Nippon Telegraph and Telephone Corporation (NTT), immediately after the earthquake, telephone service to the damaged areas was largely impossible because of telephone call concentration. However satellite telephone and e-mail could function allowing a check of the damage situation in lieu of the telephone.[8)]

5.3 Te Niigata Chuetsu oki earthquake

On July 16, 2007, the the Niigataken Chuetsu-oki earthquake hit. Cellular phone calls of 3 cellular phone providers were lost because of facility failure in parts of Niigata and Nagano prefectures were unable to use about 300 circuits in parts of Kashiwazaki city, service was restored soon after. Moreover, cell phone and fixed line were seldom available and communication became focused instead on satellite and E-mail.

Telephone call restrictions started immediately after the earthquake and lasted for at least two to three hours. In addition, a base station was downed because of the blackout. Delay here was of course prolonged.[9)]

6 Communication method

Generally, as a communication method, fixed telephone, cellular phone, the Internet, and radio (amateur radio etc.) are mentioned. Most familiar to us is certainly the phone. A fixed telephone has ISDN system and an analog by the telephone circuit of a cable formula. These communication means have both good points and bad points. If 100 calls concentrate the analog formula of a fixed telephone in 1 second, congestion will happen. However, even if electric power failure happens, minimum voice communication is securable. A cellular phone can talk over a moving phone since it is a radio formula. Moreover, by separation of a voice circuit and a packet circuit, as for regulation of a packet, it becomes loose from a sound also at the time of a calamity. However, if a base station suffers damage, use of a cellular phone will be difficult.

7 Questionnaire survey

We sent a questionnaire to 47 governments and municipalities of Ishikawa, Fukui, and Toyama prefecture concerning their communication method at the time of the Noto-Hanto earthquake of 2007 -- 32 were answered.[10] Of these 24 responses answered the question in which way communication was used and frequency of usage. Table 7.1 shows results summary.

Table 7.1 Numbers and usage & Communication way

	use	no use
fixed telephone	19	3
cellular phone	15	3
PC (Internet)	13	7
maritime radio		17
ham radio	1	17
others	3	

Usage rate of fixed telephone and cellular phone are high because they are highly popularized. In some regions, fixed telephone and cellular phone were seldom connected or disconnected. So, they were used for special communications by government or ham radio. Special communication system is the network of national and local public entities. They were installed to collect disaster information and ensure a communications means during emergency situations.

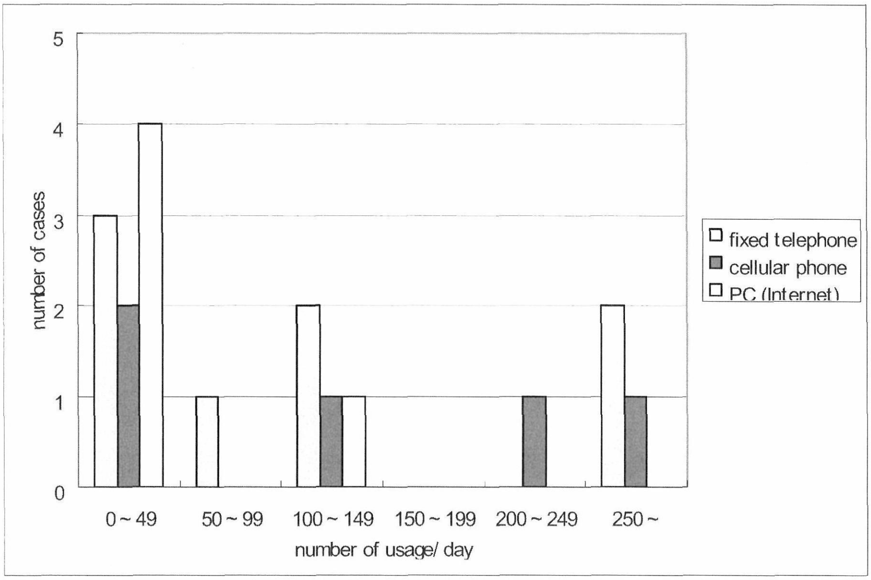


Figure 7.1 The frequency of usage by communication method, on the day

Figure 7.1 is the results of the frequency of usage by communication method on the day of the disaster. Fixed telephones were used the most frequently. Two municipalities used it more than 250 times, followed by cellular phone. PC was less frequency used.

8 Communication network support on shipboard

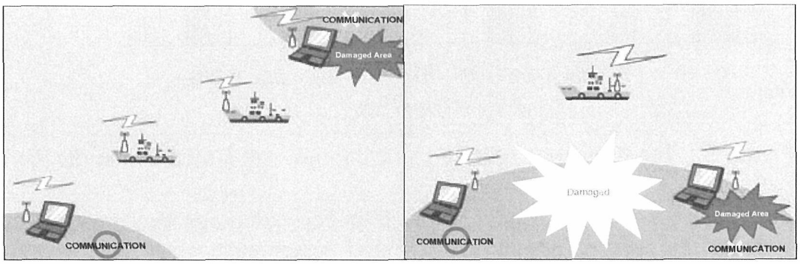
8.1 Outline of network

Informational exchange is very important at the time of disaster. At the time of the 1995 Great Hanshin-Awaji earthquake, cellular phones were not yet generally popular. However, after that, information exchange by cell-phone during disasters became more possible as cellular phones have become so popular. So, each cellular phone provider now can divide voice communication from packet communication and set up online bulletin boards and voice mail service at disasters. Unfortunately in 2007 at the Niigataken Chuetsu-oki earthquake, communications including packet communication became impossible because of the damage done to the Base Transceiver Station, major blackout, and so on. Some parts of the city were isolated from communication. Now, we realize the use of a supporting network of volunteer ships from the sea at disaster. In this case, communication exchange between networks considered to use the packet communication of a cellular phone as a way of communication. Since a problem like this has occurred, the necessity of examining communications for when not to use cellular phones came out. Using the Internet, not only for the exchange of E-mails but also for audio exchange, will be most helpful. From the above background, we propose a concept of communication network support by sea at the damage area.

According to questionnaire result, PCs had a high frequency of use, next was the fixed telephone and then cellular phone

For long distance communication, a vessel can be used as a relay base for those areas that suffered a great deal of damage and became unable to use the Internet. Furthermore, this network has the advantage that ships are maneuverable; they can also provide a power supply and wireless LAN devices at low cost.

Figure 8.1.1 Image of communication network support on ship in damaged areas



IEEE802.11 b and g which is the standard of wireless LAN can perform personal computer communications using a frequency band (2.471-2.497GHz and 2.400-2.4835GHz), respectively. IEEE802.11 b and g are can be used in the open air, and no license is necessary. In IEEE802.11 b, communication speed can reach up to 54Mbps.[11)] Some wireless LAN have functions as repeaters. We can communicate from isolated areas by relaying a wireless communication of the Internet with this function as a repeater. However, only function as repeater, not only the attainment distance of wireless LAN is limited but also from the viewpoint of fault-resilience, it is very weak. The bridge between the wireless LAN environments where plurality differs, and its network is carried out securely, to reserve long distance communication and recovery to an obstacle.

A repeater (WDS: Wireless Distribution System) is a function to relay radio wave of wireless LAN between access point and wireless LAN adapter. This function is much used to cover areas not reached by radio waves of a wireless LAN.

But this time, the function as a repeater is used to increase the transmission of wireless LAN distances. There is a mechanical limit of usage to a repeater (max 6). We connected a segment with another segment to overcome that limit.

Bridge connection is a function to connect multiple network segments in the same network. A network bridge literally works as a bridge to exchange packets from LAN to LAN.

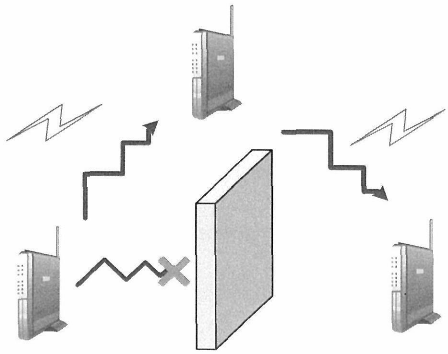


Figure 8.1.2 Image of repeater

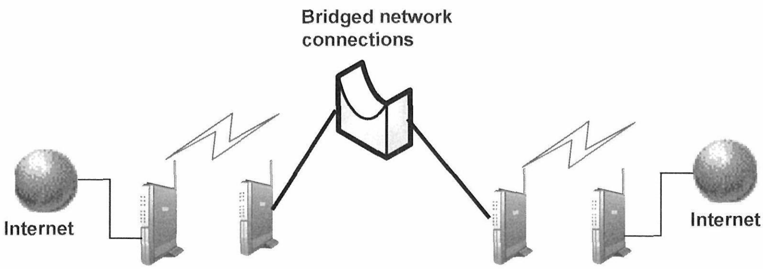


Figure 8.1.3 Image of bridge

8.2 Experiment verification of wireless LAN

In conceiving the construction of a coast area communication network using ships, a small-scale experiment verification was performed.

We built a wireless LAN network by a wireless LAN broadband router having the function as a repeater, and tried to connect a notebook computer with wireless LAN to the Internet. In general, it is said that data transmission speed is slow and communications quality is low because of radio wave interference by using wireless LAN devices. Therefore we will confirm communication environment in case of multiple devices connected.

The experiment description is shown as below.

1) Verification of function as a repeater availability
2) Time test of file downloading
3) Ping test

Ping is a program to test TCP/IP network. It works usually by sending 32 bytes of data, test whether network is connected and packet round trip time. These experiments have 2 cases. They are shown as below.

Case 1 6 wireless LAN repeaters connect in series.

Case 2 Bridge connection of 6 and 2 wireless LAN repeaters connect in series

For comparison, we will examine in case of wireline connection. Figure 8.2.1 and 8.2.2 shows repeater connection status.

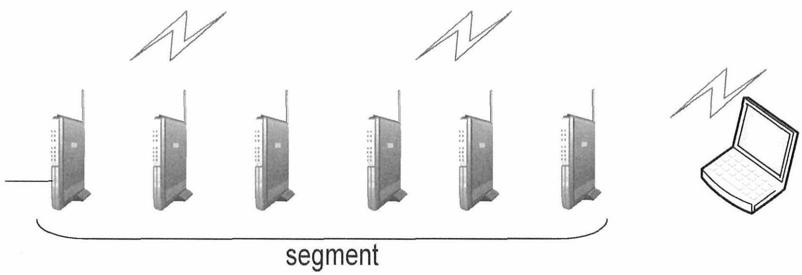


Figure 8.2.1 Image of Case 1

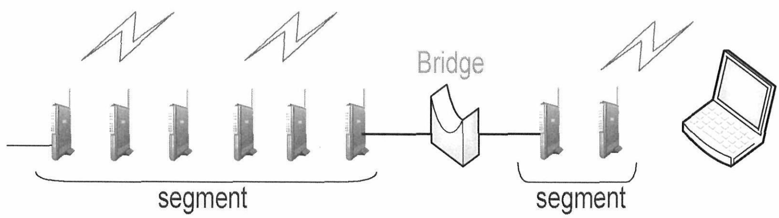


Figure 8.2.3 Image of Case 2

8.2.1 Time test of the file downloading

A notebook computer with wireless LAN connects to the Network (2 cases), and we will time file downloading with a stop watch total of 5 times. For comparison, we will examine in case of wireline connection as before. The result is shown as follows.

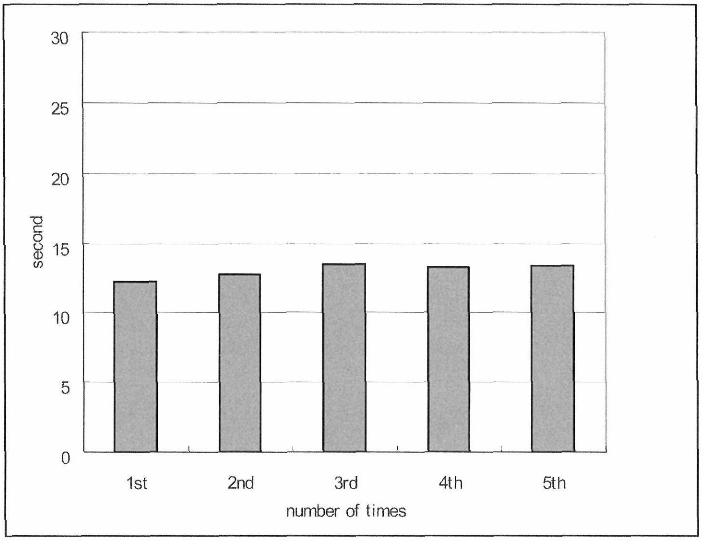


Figure 8.2.1 Result in Case 1

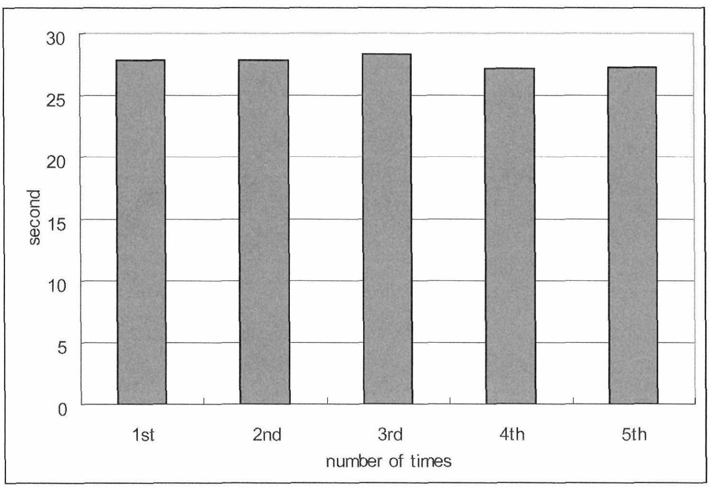


Figure 8.2.1 Result in Case 2

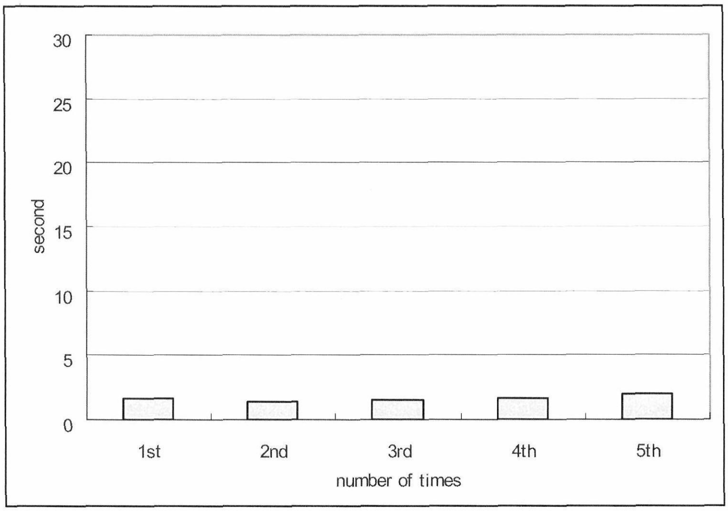


Figure 8.2.3 Result in wireline connection

According to results, it turned out that file downloading time in Case 1 is about 13 seconds, Case 2 is about 28 seconds. Compared the two cases, the result is a differences of only a few seconds. In the case of wireline connection, time was about two seconds. There will be many changes because of time zone and connection environment. Although data communication was trouble free and relatively stable, it is predicted that communication situation become worse because of radio wave interference. But it is considered that function as a repeater is effective because the wireless LAN is good performance

8.2.2 Ping test

It connects with the network in two cases, measure the round trip time to server on campus by executing Ping commands. The data of 32 bytes is transmitted 5 times by one execution, and obtain average round trip time. This procedure repeats 5 times. The result is shown as follows. The unit is "ms" (=millimeter second).

Table 8.2.1 Result in Case 1

Case 1		Case 2		Wireline	
	Average time (ms)		Average time (ms)		Average time (ms)
1st	2	1st	31	1st	0
2nd	6	2nd	42	2nd	0
3rd	2	3rd	5	3rd	0
4th	1	4th	32	4th	0
5th	4	5th	10	5th	0
Average of 5 times tests: 3ms		Average of 5 times tests: 24ms		Average of 5 times tests: 0ms	

The result of average obtained by running the test five times was three ms in Case 1, 24 ms in Case2, and 0ms in case of connection.

In Case 2, it took a little longer than Case 1 and case of wireline connection because radio wave attenuation by six wireless LAN repeaters connects in series and bridge connection.

But the Case 2 as bridge connection is affordable range even though connect up to different segment just like downloading time.

9 Conclusion

From past disasters, the problem of communication over such as fixed telephone and cellular phone became more apparent. Therefore, it turns out that we need to ensure alternate communication methods instead of them.

Here we propose to establish a communication network which makes a vessel a relay station. To apply existing materials, such as a vessel and wireless LAN has a great advantage of easy way and at low cost.

In addition, according to experiment verification, it is expected that wireless LAN method utilized widely gives a good performance. It is hoped that to enable prompt information exchange immediately after disaster strikes is useful in the transmission of safety information and getting information about a damaged area. Moreover, with a supporting network of volunteer ships from the sea, it may become a standard technique of serving an information-communication function during an emergency and as a way to get information concerning shore conditions for volunteer ships and also help the immediate needs of the shocked sufferers.

References

[1] Tabuse H. et al., Survey of supports from the sea at disasters and utility of ships for contingency plan, Review of the Faculty of Maritime Sciences Kobe University, 2004, pp. 13-18

[2] The Headquarters for Earthquake Research Promotion, Vol.1 Explanation of probabilistic seismic movement calculation map by Earthquake Research Committee, 23 March 2005, p. 61, Available at: http://www.jishin.go.jp/main/chousa/05mar_yosokuchizu/bunsatsu1.pdf, [accessed 10 July 2006].

[3] The Kansai Society of Naval Architects, Research and surveys about aspect and existence of maritime transportation system at disasters, December 1995, pp. 4-5, 21-24

[4] Fisheries Agency, Guideline for make fishery area resistant disasters, March 2006, pp. 80-82, 119-120, Available at: http://www.jfa.maff.go.jp/release/18/031301/guideline.pdf, [accessed 10 July 2006].

[5] Headquarters of Kochi prefecture for Nankai earthquake, Basic policy of prepare against Nankai earthquake, February 2005

[6] Sakabe K., Immediate countermeasure simulation supporting by ships at disasters, Thesis for a degree of Kobe University, (2006)

[7] Jichitai-kikikannri-kenkyuukai, Jissen kara manabu kiki kanri in Japanese (Learn from practice Emergency Management), pp.360-361, Toseishinposha

[8] Cabinet Office, Government of Japan, Emergency Information of Disasters, Available at: http://www.kantei.go.jp/jp/kikikanri/jisin/niigatajoutyuuetu/0707161700.pdf, [accessed 28 September]

[9] Prime Minister of Japan and His Cabinet, Emergency Information., Available at:http://www.kantei.go.jp/jp/kikikanri/jisin/niigatajoutyuuetu/0707161700.pdf, [accessed 28 September]

[10] Watanabe K, Questionnaire survey for volunteer ship network at disasters – Hokuriku Area Fishermen's cooperative and Autonomy-, Thesis for a degree of Kobe University, (2007)

[11] Ministry of International Affairs and Communications, Current Situation of Spectrum of Use in Japan., Available at:http://www.tele.soumu.go.jp/search/myuse/use/960m.pdf, [accessed 21 January 2008]