Information and Communication Technologies

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After the occurrence of the Great East Japan Earthquake on March 11, the Internet connectivity remained more robust than expected, whereas telephone services and texting on mobile phones were disrupted. This is because the Internet itself possesses robustness: Internet traffic bypasses damaged places automatically so that the Internet can be always accessed at any time. The optical undersea cables, whose north route was damaged, stayed connected to the world through the south route serving as a bypass. Social networks, such as Twitter, which are flexible and open systems, were recognized as an effective tool for public communication in the event of disaster. The government and public organizations also started to utilize social networks. In addition to the Internet connectivity, the scalability, that can address a rapid increase in the flow of information and data processing, is important to the robustness against disaster. Twitter ensures scalability by using the external cloud service and Skype by the technique referred to as super-node. There are also means such as mirror sites to ensure scalability of websites.

The TV and other mass media broadcasted prompt reports including the earthquake and tsunami warnings, and they kept showing the devastating videos of the disaster. However, they failed to transmit sufficient information necessary for disaster victims because there were a huge number of victims spread across a wide area. This weakness was compensated by the Internet and social networks supported by many volunteers. Volunteers marked the locations of evacuation shelters for stranded commuters on the map, which resulted in a real-time map (Figure) of shelters in the metropolitan area. Volunteers also helped to launch the "Person Finder" where people can search for information about safety confirmation of victims. The Internet and social networks were used as the most powerful media in the event of disaster because they have not only the robustness but also the following characteristics; the openness that allows people to touch up them quickly in order to gather and transmit the necessary information to or from victims, and the familiarity in the sense that people use them every day.

In the event of disaster, it is crucially important to gather information quickly and to transmit information after the integration in a user-friendly manner. To that end, we need to build an open information infrastructure that can attract volunteers scattered all over the nation.

(Original Japanese version: published in June 2011)

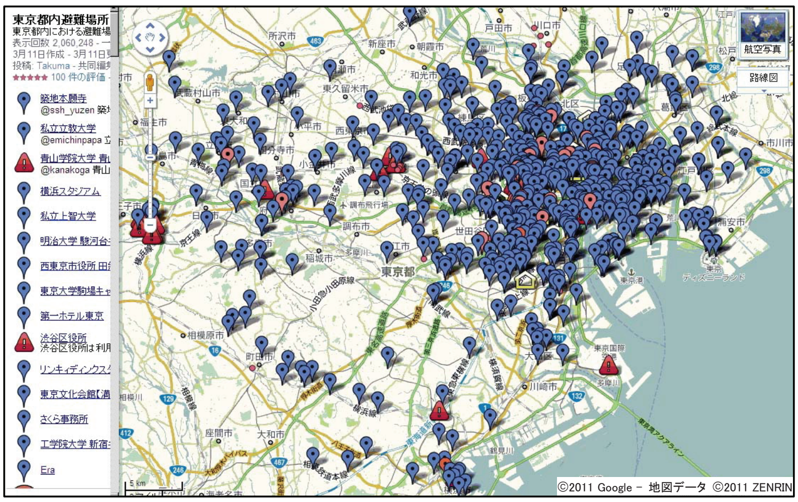

Figure : Real-time map of evacuation shelters

Source: Cited from Reference 11

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Robust and Usable Media for Communication in a Disaster

Tsuneo ICHIGUCHI
Information and Communications Research Unit

1 Introduction

In the event of a large disaster, what we need first is the right piece of information. What happened? What was the scale? What should we do? Where should we evacuate? Such information should be provided immediately without a moment's delay. It is also important to provide additional information on the event after the instant communication.

The necessary information varies over time. The next thing we need to know is information about safety confirmation of family and friends. After the Great East Japan Earthquake on March 11, TV broadcasts showed us the images of people who wandered from one shelter to another, looking for the information on their missing family members. For victims of disasters and the persons involved, information on the extent of damage and the safety of their family members or friends is much more important than infrastructure such as electricity and water, or food and heating. Of course, various types of information on the refuge life become necessary when the evacuation is prolonged.

In the past, detailed reports and suggestions about information infrastructure at the time of disasters were published after the Great Hanshin-Awaji Earthquake (1995) and Mid-Niigata Prefecture Earthquake (2004). Following the Great Hanshin-Awaji Earthquake, information volunteer activities related to the opening and management of a local FM mini-station exclusively for refuge life was reported as a new movement.[1] After the Mid-Niigata Prefecture Earthquake, it was pointed out that the problem of digital divide was being experienced, due to aging and depopulation in mountainous regions.[2]

Previous reports, however, may not be directly applicable to the Great East Japan Earthquake because the enormity and extensiveness is incomparable with the past disasters and the worst damages were caused by the tsunami. Especially, we saw new plugged-in movements to utilize social media, such as Twitter and websites, and to keep tentative collaboration between TV broadcasts and the Internet.

A number of detailed progress reports on information infrastructure in the Great Earthquake of March 11 will be released in the future. Therefore, in this paper, I would like to describe how people received information and what kind of new media were used immediately after the Great East Japan Earthquake, and then examine their characteristics and advantages.

2 With What Means People Obtained Information

2-1 Disaster radio system

We have witnessed, through TV broadcasts, speakers of the disaster radio system (formally called "Municipal Disaster Prevention Administration Radio Broadcast System") urging people to evacuate in a tense voice, while the tsunami was surging on the Pacific coast of the Tohoku district. For many people in disaster areas, who were working in fields and fishing ports, this disaster radio system was the only means to get the warning of danger. In the event of emergency, a simple and clear vocal evacuation order is effective.

After the 1960 Chilean tsunami, all of the coastal municipalities in Iwate, Miyagi, and Fukushima Prefectures were equipped with a disaster radio system. Although the system was broken down by the tsunami on March 11, there is no doubt that many lives were saved thanks to the disaster prevention personnel who used this system and kept calling for people to evacuate. The message was sent from municipal offices or fire stations, many of which were devastated by the tsunami.

Disaster radio system is now in the transition from analog to a digital wireless system.[3] However, for the sake of safety of disaster prevention personnel, it is more important to construct an automated, unmanned, and remote-controlled system for emergencies, and to create a network with neighboring municipalities.

Because the tsunami disrupted communication cables, destroyed base stations of mobile phones, and caused power outages, there were many places where the only means to receive information was battery-operated radio. It became impossible for people to send out critical messages such as a request for rescue; on TV we saw the letters "SOS" written on the ground or rooftop of shelters, trying to send messages to helicopters flying over the area the day after the earthquake.

2-2 The Internet

In the metropolitan area, power outages or damage to communication facilities did not occur, but land-line or mobile phone services and texting on mobile phones became practically unusable. Information on the earthquake and tsunami was sent through TV broadcasts and the Internet. Many office workers were not able to watch TV, but they could watch TV news simulcast on the Internet. Because Internet connection was available as usual, social networks such as Twitter, Facebook, and Skype, were utilized as means of communication, to prevent the confusion among a vast number of stranded commuters. The Internet was connected to the world through a detour path of optical undersea cables, and transmitted real-time information on the disaster toward the rest of the world.

About half of the base stations of mobile phones in disaster areas were recovered on March 14, three days after the earthquake. Temporary mobile base stations and satellite phones using communication satellites were installed in shelters as well. However, mobile phone services and text messaging continued to be unusable because of overloaded lines, so social networks still played main role in communication. By that time, safety confirmation of victims became the most important information for their family and friends. Once the number of victims reached into the tens of thousands, it was almost impossible for mass media such as TV to collect and transmit individual safety information. It was also difficult to search for safety information from lists of names tacked on the wall of shelters scattered all over the devastated areas. Then people started a new approach on the Internet: first they accumulated and integrated information on the web, processed it in a user-friendly way, and transmitted it. A number of information volunteers joined this new approach.

Thus, Internet infrastructure was both the most robust and useful at the time of disaster. In the next section, I would like to discuss more concretely why social networks using Internet connection were so robust during the disaster and what kind of new attempts were made.

3 Internet Infrastructures Robust in a Disaster

3-1 Telephone lines and Internet connections

Since the electricity did not go out in the metropolitan area, TV and the Internet became the important sources of information. However, land-line or mobile phone services and texting on mobile phones became practically unusable, although there was no substantial damage on exchange equipments of telecom companies or base stations of mobile phones. Such a condition where telephone connection is cut off or text messages cannot be sent or received is called "network congestion". Once the congestion reaches its limit, the communication system as a whole goes down, so telecom companies take measures to limit the connection. In case of telephone services, you would hear the message, saying "The number you have called is congested and is not available now," and the line won't be connected.

Network congestion at the time of disaster is caused by the concentration of phone calls or text messages to confirm someone's safety, but the congestion can happen in other occasions, too; for example, telephones can be congested at the start of ticket reservations or for "A Happy New Year Call" from around midnight to 2 a.m. on the New Year's Day. After this earthquake, 80 to 90 % of voice calls and 50% of text messages were not connected.

Compared to telephone calls and text messages between mobile phones, communication via Internet connection, such as Twitter or e-mail between a mobile phone and a personal computer, were available almost as usual in the metropolitan area. Of course, the Internet was functioning as usual. Also, means of communication that use Internet connection, such as Skype, functioned as usual, too. Thus, in the recent disaster, there was a major gap between the communication means that linked to Internet connection and those that did not.

While mobile phones are connected within a closed network inside a cellular carrier, the Internet is connected through several open lines and routers for routing information packets (See Figure 1). Even if a line is cut off somewhere or a router is broken down, the line will be connected again by bypassing the location automatically and information packets can be always sent and received. Therefore, congestion rarely happens; on the other hand, however, it is difficult to control the network traffic even if we want to.

The origin of the Internet is “ARPANET” developed by a military-related research institute in the United States. It was designed not to cut off the communication link even when telecommunication lines and bases were attacked. Thus, from the beginning, the Internet has robustness at the time of emergencies such as disasters. Renesys, an international internet intelligence company, has reported that out of 6,000 network nodes[NOTE 1] in Japan, only about 100 nodes stopped the service temporarily, but recovered within hours.[4]

The Internet’s robustness at the time of disaster seems to have been proved, but we cannot necessarily say that congestion will never happen. When a number of accesses are concentrated on a particular homepage, the access to the homepage server will become impossible or the server will go down. After the earthquake, homepages of railroad companies and Tokyo Electric Power Company could not be accessed on several occasions. Although the Internet is robust over a disaster, it also is vulnerable to malicious and intentional attacks because of its lack of perfect controllability.

3-2 Optical undersea cables

One of the characteristics of the Internet is that it is connected to the worldwide networks through optical undersea cables, so we can communicate with people in foreign countries in real time. Ibaraki and Chiba Prefectures, stricken by the recent disaster, have many landing stations of undersea cables; for example, there are landing stations in Kita-ibaraki, Ajigaura, Chikura, Maruyama, Wada, and Emi. Many undersea cables are concentrated in the offing of this area, and some of the cables go directly over the epicenter of the earthquake. Actually, undersea cables were damaged in multiple spots in this region, and it is supposed that there are three disrupted sections off the coast of Ibaraki, six off the coast of Choshi, and one off the coast of Kanagawa.

Undersea cables can be damaged not only by disasters but also by sharks and other causes, so repair work is operated by robots on a routine basis. Consequently, undersea cables as communication infrastructure do not have a point-to-point connection between Japan and foreign countries, but make a loop connection to secure a detour.

For example, the optical undersea cable, Pacific Crossing-1 (PC-1), has a loop connection between

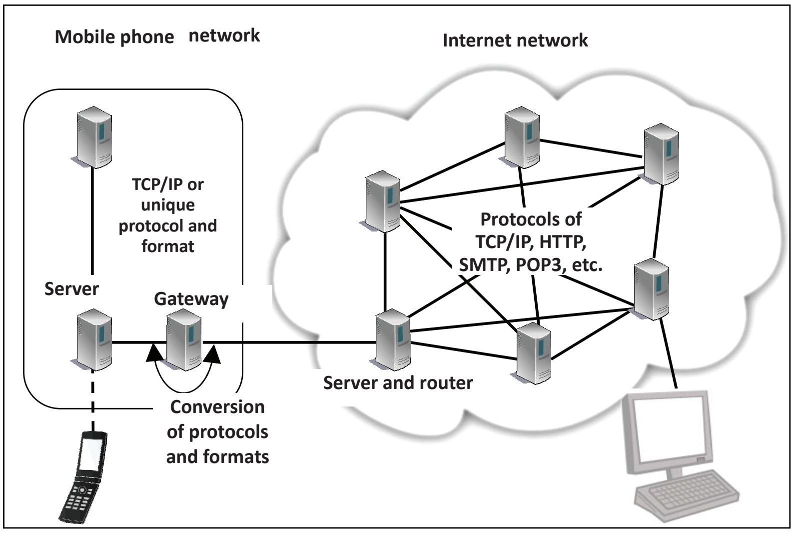

Figure 1: Difference between mobile phone network and the Internet network

Prepared by the STFC

[NOTE 1]
In accurate terms, it is “the network prefixes in the global routing table”, but the term “network node” or simply “node” is used in this report. See Ref. 4 for details.

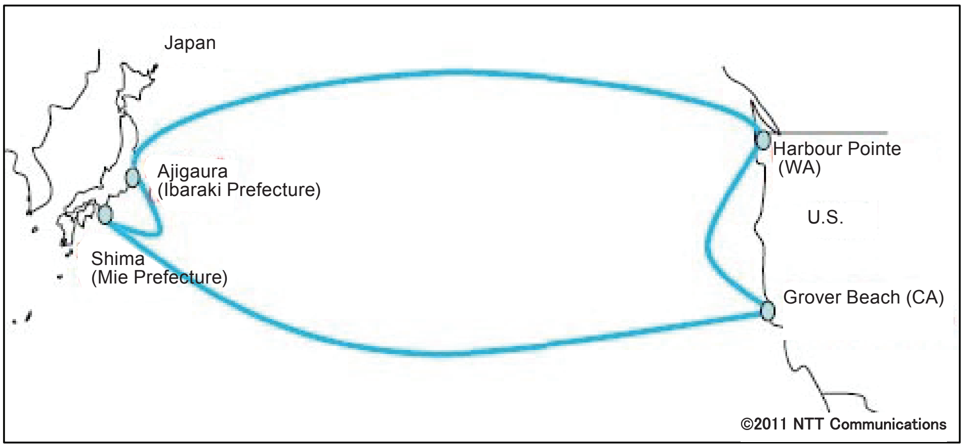

Figure 2: Route diagram of optical undersea cable Pacific Crossing-1.
Source: Cited from Reference 5

Japan and the United States with four landing points: Ajigaura (Ibaraki Pref.), Harbour Pointe (the State of Washington), Grover Beach (the State of California), and Shima (Mie Pref.), as is shown in Figure 2.[5] Also, Japan-US Cable Network connects Maruyama (Chiba Pref.), Kita-ibaraki (Ibaraki Pref.), Manchester (the State of California), Morro Bay (the State of California), Makaha (the State of Hawaii), and Minami-shima (Mie Pref.) in a loop. APCN2 (Asia-Pacific Cable Network 2) has Kita-ibaraki (Ibaraki Pref.) and Chikura (Chiba Pref.) landing stations in Japan, and connects Japan, South Korea, China, Taiwan, Hong Kong, the Philippines, Malaysia, and Singapore in a loop. There is also an undersea cable that goes around Japan along the coast.

Each loop network is mutually connected, so even if one of the networks breaks down, communication will remain possible through another network. Especially, Ibaraki and Chiba Prefectures were nodes of the loop networks connecting Asia and the United States, and had been functioning as a telecommunication hub in Japan.

At the time of earthquake and afterward, although the northbound cable was damaged, the Internet was able to connect Japan and overseas countries as usual, using the southbound detour. It is significant that the Internet could be used as usual, allowing the information on the earthquake transmitted overseas without delay. Actually, other Asian countries, such as Hong Kong and China, which had a connection to APCN2 and Japan-US Cable Network at Ibaraki and Chiba Prefectures, suffered poor connection to the United States; however, their connections were restored after being switched to another route on the next day. The Taiwan Earthquake in 2006 caused serious damage to undersea cables, and services of telecommunication carriers were stopped for a few days after the earthquake. However, each country could avoid such a situation after the earthquake on March 11.

It was an effective risk avoidance that landing stations of undersea cables were build in Western Japan as well. The robustness of Internet infrastructure in Japan was praised throughout the world because the internet kept operating and supporting the communication both at home and abroad, in spite of the scale of the disaster.[4]

3-3 Restoration activities of each mobile-phone carrier and satellite telephones

Thousands of mobile-phone base stations were damaged in disaster area, and communication with the outside became impossible for many people. The number of broken base stations was as many as 6,720 for NTT Docomo, Inc., 3,786 for Softbank Mobile, Corp., 3,680 for KDDI Corporation, and about 2,000 for UQ Communications Inc. On March 14, three days after the disaster, about half of the broken base stations of each carrier were restored. However, recovery of official municipal websites took a long time, and many municipalities used Twitter and Facebook as a means to send their residents the information on evacuation centers and delivery of relief supplies

While mobile-phone carriers hurried to restore the base stations, they also tried to ensure communication means by setting up mobile base vehicles and portable generators at affected municipal offices and evacuation shelters. For instance, NTT Docomo, Inc. provided 900 units of satellite phones, and Softbank Mobile, Corp. installed the access point combined

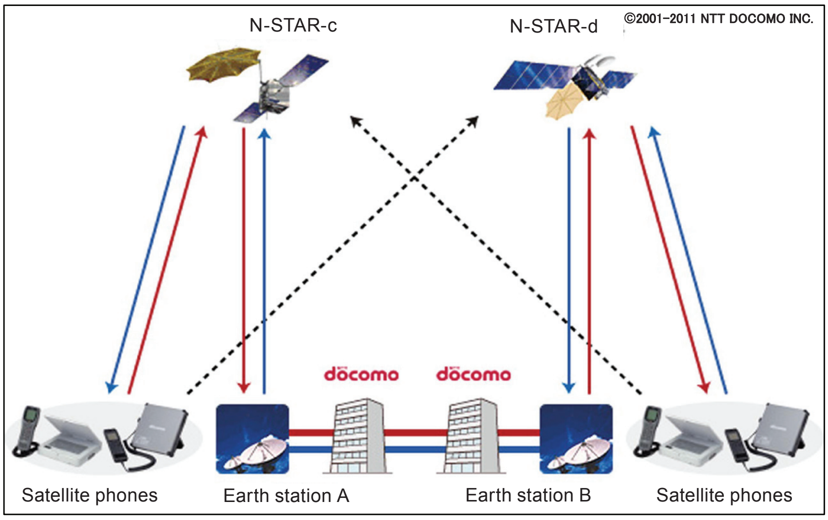

Figure 3: Outline of satellite phone service

Cited from Reference 6

with a satellite antenna so that people can use mobile phones in shelters.

The telephone service using a communication satellite covers wide areas with a few ground facilities; so we may say that it is a communication infrastructure robust in a disaster. The "Widestar" satellite phone service has been commercialized by NTT Docomo, and it covers the whole of Japan and about 200 nautical miles from its coast, providing voice and packet communications. The service started in 1996 to replace ship telephone service that used coastal base stations. The satellite phone is used at lodges in mountainous regions outside of cellular service area as well. Widestar was transferred to Widestar II in April 2010, and the speed of packet communication was accelerated from 64 kbps to 384 kbps at the maximum.

Widestar phone service is established via one of the two communication satellites, N-STAR-c (located at 136°E.) and JCSAT-5A (or called N-STAR-d by NTT Docomo: located at 132°E.); both are in a stationary orbit above the equator. The service is available anywhere in Japan and its off-shore areas, providing that the satellite is visible without obstacles. It is, however, necessary to set up an outdoor antenna in order to use the service indoors.

Satellite earth stations are located in Sayado Station (Midori, Gunma Prefecture) and Yojigata Station (Kitaibaraki, Ibaraki Prefecture), where the satellite phone connects to the telephone and Internet networks. Two satellite phones are connected to each other by making two round trips between the earth and satellites, such that satellite phone → satellite → earth station → satellite → other satellite phone. They have two earth stations and two communication satellites for risk avoidance, so that the infrastructure can be maintained even if one is damaged in a disaster.

Satellite phones are also installed in many public facilities, such as hospitals, to prepare for possible disasters. It has been reported that satellite phones were useful for affected hospital to place an order for necessary medicine. Some Widestar phones are equipped with emergency lines separated from the lines for general use, and have been introduced to some municipalities, police stations, and fire stations. There is a move for some private companies to introduce them as disaster countermeasures as well; however, since there are a limited number of lines, congestion may occur if the service becomes popular.

4 Effectiveness of Social Networks

4-1 Twitter as a means of communication

Twitter and Skype kept their robustness in a disaster by connecting them to the Internet through gateways, even if handsets of cellular carriers are used. These applications are available on smart phones that can access the Internet directly or via public Wi-Fi service at fast food restaurants, hotels, and stations.

This disaster revealed the public usefulness of Twitter, which enables us to communicate through the Internet. As a result, governments and public organizations started to use it. For example, the Prime Minister office set up an account "@Kantei_Saigai" for disaster information, and began transmitting information on March 12; the number of Tweets was 587, and the number of followers was 321,557 by April

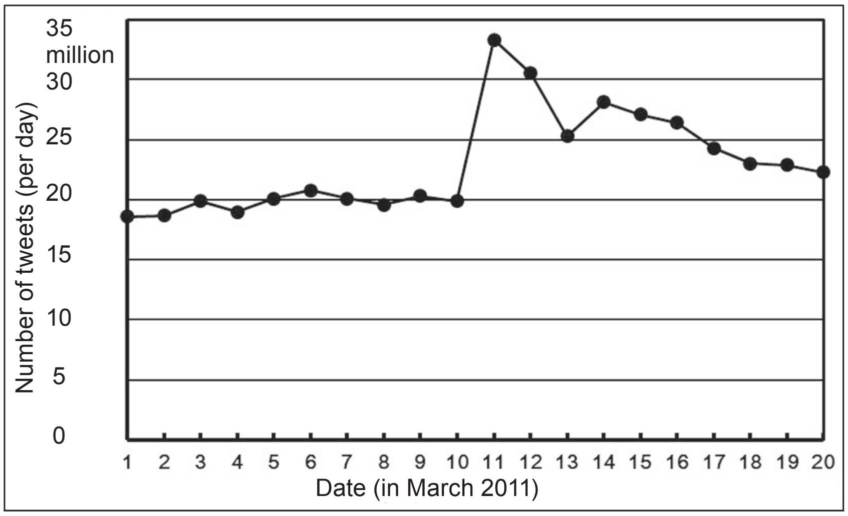

Figure 4: the number of tweets before and after the earthquake

Source: Prepared by the STFC based on Reference 7

11, a month after the earthquake. The office launched an English Tweet at "@JPN_PMO" on March 16, and started providing information to other countries through Facebook as well. The Twitter account of Fire and Disaster Management Agency "@FDMA_JAPAN" had been established in May 2010, and followers of the account increased rapidly after the disaster. The Japan Ground Self-Defense Forces also tweeted about their relief activities at @JGSDF_pr.

Unlike the traditional e-mail or blog, information through Twitter grows exponentially by means of official or unofficial re-tweeting. An enormous volume of information on the disaster has spread, and it was reported that the number of tweets on March 11 reached about 33 million in total, which was 1.8 times the average[7] (Figure 4).

When the volume of information gets so large, it becomes important to organize a lot of information or to search for information. On its official Japanese blog of March 12, Twitter, Inc. called for the use of unified hash-tags organized by topics and the use of official re-tweeting, not unofficial ones.[8] A hash-tag is a code to add at the beginning or ending of a message, in order to make classification and retrieval of information easier. Various kinds of hash-tags were provided and they could be used alone or combined; examples of such hash-tags are #jishin (information on the earthquake in general), #j_j_helpme (rescue request), #anpi (safety confirmation), #311care (information for medical staff), #311sppt (information from victims who need support), prefecture-specific information such as #save_miyagi, and life-related information such as #takidashi (provision of cooked food). Twitter provided the hash-tags needed in the metropolitan area as well, such as #318teiden (power outages on a certain date) and #318train (train schedule on a certain date).

Under these circumstances, more than 200 volunteers extracted and categorized about 4700 Tweets tagged with #anpi in four days. Since Twitter is a free service that is flexible and open to the public, information volunteers can get together easily and respond quickly and adequately to the information. Such an advantage of Twitter was fully utilized after the occurrence of the disaster.

However, the system has its demerits as well because of its openness to the public; that is, inaccurate information and false rumors can be circulated easily. This time, too, some wild rumors were circulated such as: poison gas was leaked from the oil refinery that burst into flames in Chiba Prefecture, or it is effective to take mouthwash to prevent health damage from radioactivity. Nevertheless, quick transmission of information and the power of collective intelligence led to the immediate dismissal of these false rumors. Also, linked URLs in Tweets often included the sites of NHK, the Asahi Newspaper, and the Tokyo Electric Power Co., which indicated that people had a tendency to transmit useful information by collecting various kinds of information and combining it with press reports.[7]

In the metropolitan area, no buildings collapsed after the earthquake and power outage or water outage did not happen. However, the railroad system was stopped, and almost all lines did not recover before the next morning because of the continuous aftershocks; it caused a huge number of stranded commuters. At 7 pm on March 11, 3,000 to 4,000 people were stranded around each terminal station of Shinjuku, Shibuya, Ikebukuro, or Akabane. They had to wait long time to get a bus or taxi. According to the count of the Metropolitan Police Department, the number of stranded commuters around major railway stations and Haneda Airport reached about 27,000.

At 8 pm, the government issued instructions to all government agencies to fully utilize their public facilities as shelters. The Tokyo metropolitan government also offered its community centers and schoolhouses for stranded commuters. Vice Metropolitan Governor Naoki Inose posted information on Twitter about available shelters. At 9 a.m. on the next day, he reported that about 99,000 people were accommodated in 1,023 facilities in Tokyo. Several universities and private facilities accepted stranded commuters as well, so the real number of stranded commuters is assumed to be much larger than reported. Moreover, there were tens of thousands of people who tried to walk home.

Since the earthquake caused little damage to the metropolitan area, the confusion did not grow out of control. However, if an epicentral earthquake occurs in the capital, it is estimated that the number of stranded commuters will be 3.9 million in Tokyo, and 6.5 million in Tokyo and surrounding three prefectures.[9] Therefore, it is an important issue to ensure communications means in emergency situations as well as to prepare a number of evacuation shelters quickly.

4-2 Real-time map of evacuation shelters in the metropolitan area

In the metropolitan area, as evacuation shelters for stranded commuters were announced, volunteers began to plot the physical locations of shelters on a Google map. Thus, a real-time map of evacuation shelters had been made and offered to the public. Figure 5 shows the real-time map as of 10:30 p.m. on March 11.[10] The map not only indicated the location of shelters, but also showed the detailed information of shelter about the capacity, emergency supplies such as blankets, drinking water and food, if the plotted mark was clicked. As time went on, the number of plotted marks on the map increased rapidly.[11] (See figure in page 6.)

They asked people who could use Twitter to tweet the information about evacuation shelters marked on the real-time map to as many people as possible. In this way, information discretely announced by Tokyo metropolitan government, the government of Japan, or each evacuation center was accumulated on a Google map first, and then, starting from there, transmitted through the means that people routinely used. Here again, the Internet and Twitter were naturally connected, providing a place for volunteers to establish a broad network.

For users, it is difficult to use information sent out from various sources discretely. Also, even if information about evacuation shelter is announced,

Figure 5: Real-time map of evacuation shelters (As of 10:30pm, March 11)
Source: Cited from Reference 10

those who are not familiar with the area may not know how to get there. It is noteworthy that such information was first organized and integrated on an open information infrastructure, namely Google map, and then sent out again in a user-friendly manner.

4-3 Robustness of Twitter and Skype

Social networks, such as Twitter and Skype, were robust during a disaster because they used Internet network. However, the use of Internet network alone cannot guarantee robustness at the time of disaster. Even if the Internet is connected, a rapid and large increase in the amount of information and processing bring down servers and routers. In other words, the same phenomenon as congestion with telephone service would happen.

Robustness at the time of disaster requires scalability so that the ability can be quickly altered corresponding to a rapid increase or decrease in the amount of information and data processing. Since land-line and mobile phones did not have enough scalability, communication through them had to be restricted. Twitter ensures this scalability by using the external cloud service and Skype by the technique called super-node.

Although Twitter uses self-developed software, many of its functions depend on the external cloud services. For example, it uses Amazon S3 for online storage service, and Amazon CloudFront for contents distribution service. Amazon CloudFront has distribution servers in 8 regions in the United States, 4 regions in Europe, and 2 regions (Tokyo and Hong Kong) in Asia. When making an access to a file in Amazon S3, the user will be led to the closest distribution server.[12] In other words, a tweet in Japan is processed in Japan as a rule.

However, when the amount of information increases rapidly due to a disaster or other reasons, the storage volume and processing ability increase automatically or an overseas server will be used. In this way, Twitter does not experience congestion even at the time of disaster and makes connection without fail. The most distinctive feature of cloud service is its scalability to increase or decrease its capability swiftly whenever it is needed[13,14]; Twitter, utilizing cloud service, naturally has the scalability as well.

On the other hand, Skype ensures its scalability by the technique called super-node. Skype chooses one personal computer that has higher transmission rate and higher processing ability out of every 1,000 computers accessing to Skype. The chosen computers are forced to take care of a part of the entire process of Skype (See Fig. 6). In other words, the CPU and volatile memory of the chosen computer not only perform the necessary processing for its own free video call, but also bear the functions necessary for Skype as a whole, such as list management and helping other users to call or connect to Skype. In this way, a grid of super-nodes is created for distributed processing as needed through users' personal computers. This ensures scalability, because if the number of accessing computers becomes ten times, the number of super-node computers for distributed processing also becomes ten times or more.

Skype was available as usual at the time of the disaster because its scalability was ensured in this way. It also has a charged service to make a land or cell phone call, which will be usable without

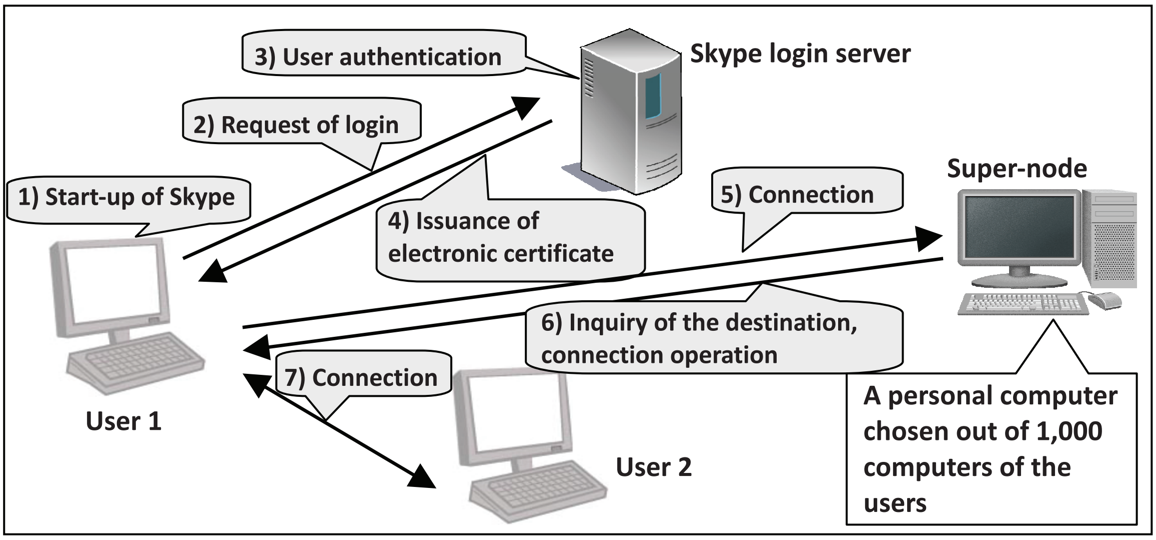

Figure 6: Connection process of Skype

Source: Prepared by the STFC based on Reference 15 congestion because it uses Internet network instead of telephone network. On May 10, 2011, as of the writing this paper, Microsoft Corporation announced the takeover of Skype Global (Luxemburg). In the future, Skype may be utilized for Xbox (a game console) teleconference system, and may be possibly useful for emergency TV conferences at the time of disaster.

4-4 Mirror sites and cloud services

In the metropolitan area, the websites of Tokyo Electric Power Company and railway companies were frequently disconnected because too many people were trying to access them to get information on planned electrical outages and train schedules. Also, in the disaster-affected areas, the websites of the municipal governments were down for a long time.

There are means to ensure scalability for websites as well. One of them is to use a mirror site. A mirror site has the exactly same format and the same contents as those of the original website, and when the original website gets updated, the mirror site is automatically updated. In order to avoid too much concentration of access, many academic paper repositories, software development and distribution sites, and various download sites have several mirror sites in different countries. In some systems, users choose a mirror site to access by themselves, and in other systems, users are automatically led to an available mirror site.

Even when the original website became unavailable due to the server down caused by a disaster, the mirror website will work as usual and ensures the robustness. Also, an alternative machine is often needed when a server experiences breakdown; in such a case, the website cannot be restored to its normal state until distribution system is recovered, if it does not have a mirror site.

Websites of municipalities and public organizations are not usually made in such a way to be able to handle heavy traffic. In fact, some websites of the disaster-stricken prefectures and municipalities caused system failures due to concentration of accesses even if the servers were not damaged. After the disaster, cloud providers voluntarily supported the affected municipalities and public organizations by constructing their mirror sites. For example, Internet Initiative Japan Inc. set up about 180 mirror websites of all the affected municipalities,[16] and SAKURA Internet Inc. set up 31 mirror websites of public organizations related to disaster prevention.[17] However, mirror sites of a few municipalities with severer damages had yet to be established as of April 13; they were Ofunato-shi, Otsuchi-cho, Okuma-machi. Nonetheless, Otuschi-cho and Okuma-machi provided information through a temporary website.[16] Cloud providers offered various IT solutions taking advantage of the swift action of Cloud service, in addition to setting up mirror sites.

Mirror sites are highly effective in terms of risk diversification. It is fair to say that a permanently-installed mirror site is critical and essential for the websites of national and municipal governments and websites related to lifelines. Since cloud service incorporates the concept of a mirror site and its actual functions, it is also recommended to use external cloud service.

5 New Partnership among Information Media

5-1 Television programs on the Internet

Radio and TV broadcasts are excellent means to quickly announce the warnings of earthquake and tsunami. Immediately after the earthquake, they informed the scales of the earthquake at various locations, too. In particular, TV broadcasts, which continuously sent shocking images from the devastated areas, played an important role as a mass medium. However, not everyone was able to watch TV at that time. Some people may have been able to watch TV through one-segment broadcasting system built in their mobile phones, but many people working in their office could not watch TV broadcast.

In this disaster, it was the mirror broadcasting (http://ustream.tv/channel/jishinsokuhou, etc.) posted by general users that responded well to the needs of those who could not watch TV. Normally, this is an act that may violate copyright laws in Japan. However, this was treated as an exception due to the emergency. At 5:40 pm on March 11, NHK's official twitter @NHK_PR tweeted as a personal opinion, "There are many regions where people cannot watch TV. Since this is a matter of life or death, if there are any means to transmit information, we would like people to utilize them."[18]

In this way, TV stations immediately realized the importance of the Internet, and set up official channels on Ustream or Niconico Live, to stream or simulcast their news programs onto the Internet. For example, NHK ran the video streaming of its news on http://

www.ustream.tv/channel/nhk-gtv and http://live.nicovideo.jp/watch/lv43018790, TBS on http://www.ustream.tv/channel/tbstv, and Fuji Television on http://live.nicovideo.jp/watch/lv43019860. These news programs were accessible not only within Japan but also from abroad.

5-2 A new trial of the Internet

TV and other mass media played a major role as news media, by sending images from the devastated areas. However, they also revealed the weakness of mass media; they could not adequately transmit the important and necessary information for disaster victims, such as information on safety of people. It would have been possible to provide sufficient information if the number of victims had been 50 or 100. However, when many evacuation shelters were set up over extensive areas and the number of victims reached tens of thousands, mass media became completely helpless for victims and all they could do was provide live broadcasts from some of the evacuation centers. Such TV programs showed people who were wandering around from one shelter to another, looking for the information on their family members and trying to find their names on the list tacked on the wall of each shelter.

The Internet and volunteers throughout the country compensated for the weakness of mass media. First, volunteers in the affected areas and evacuees themselves took pictures of the name lists displayed in shelters and posted them on the Web. Google launched a photo sharing service for the name list of evacuees using Picasa on its website. On March 14, Google called for volunteers and evacuees to post more pictures. In particular, they were asked to add the location data if GPS function was available, because this would enable links with map. Thus more than 4,600 volunteers uploaded over 9,000 photos.[19]

In this way, people could look at the name lists and messages of evacuees without going to the evacuation shelters. As a result, there were many cases where relatives and friends in remote locations were able to make contact with evacuees.

However, photo information was not very useful. It was quite difficult to search for the name of specific individual unless the photo images are converted into textual information. Therefore, Google looked for volunteers who would read out the uploaded photos and convert them into the name list in text format.[19] More than 3,300 volunteers throughout the country participated and converted nearly 90% of the pictures into text format in a short period of time, which was then compiled into a list. Thus, "Person Finder", a safety confirmation tool by searching for individual name, had been established.

"Person Finder" has the entry screen shown in Figure 7 and allows the users to input more information on people's whereabouts. By adding the name lists of evacuees offered by news media such as NHK, the number of retrievable data increased largely to 622,300. The registered data have decreased to about 14,000 as of June 10, 2011, because the data that

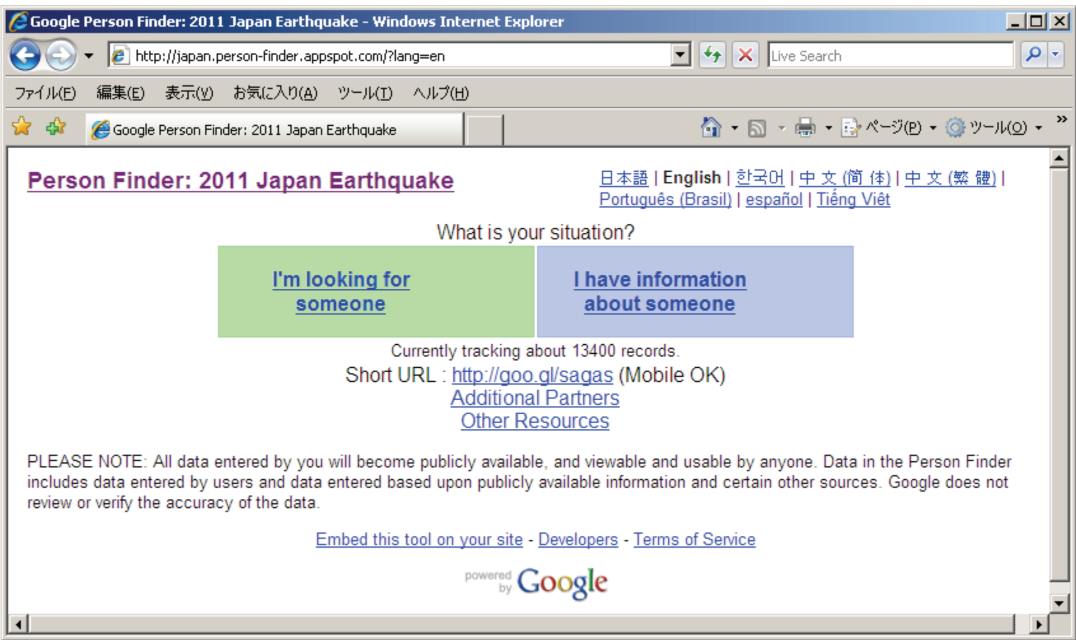

Figure 7: Entry screen of "Person Finder"

Source: Reference 20

became unnecessary was deleted.

This is not the first time Google's Person Finder was used. It started with "Katrina people Finder Project" that coordinated different formats of missing person registries on several websites which were started up after the hurricane "Katrina" hit the United States in 2005. After that, the Person Finder was also used at the time of the Haiti Earthquake in 2010. It may be said that the Person Finder was launched quickly this time thanks to these previous experiences.

If fragmented information is offered discretely, it is not useful for a recipient of the message. It is extremely important to accumulate and organize information at first, and then to quickly transmit it in a user-friendly manner, as Person Finder and the real-time map for stranded commuters did. Another important point is to have an open system that can call in many volunteers all over the country. Furthermore, it is important for each volunteer to be able to work in the system environment he or she uses routinely, without the need to use a particular machine or go to a particular place.

6 Conclusion

At the Great East Japan Earthquake, the Internet exhibited more robustness than expected, while telephone services and texting on mobile phones were disrupted. This is because the Internet itself possesses robustness such that the Internet traffic can bypass damaged places automatically to make connection. The optical undersea cables were damaged in various spots, but the Internet stayed connected to the world through the southbound cable as an alternate route. As far as the enhancement of robustness in a disaster is concerned, these facts show that it is far more important to prepare the way to compensate possible damages or breakdowns than to try to create something completely unbreakable or absolutely safe.

Another remarkable new movement was the use of Twitter and other social networks as a means of information distribution. Simple connectivity is not enough to ensure robustness at the time of disaster. Another important thing for robustness is scalability to address a rapid increase or decrease in the volume of information and processing. Telephone service experienced congestion and became unusable at this disaster due to the insufficient scalability. On the other hand, Twitter ensured scalability by using the external cloud service and Skype by super-node. As a result, both of them could keep working as usual without system failure even when the volume of information increased dramatically. There is also a means called mirror site to ensure scalability of website.

TV broadcasts played an important role as a mass medium by announcing the warnings of earthquake and tsunami quickly, and by showing the devastating videos of the disaster. However, they also revealed their weakness such that they could not provide sufficient information necessary for disaster victims when the number of victims became enormous and the disaster areas were widespread.

The Internet and social networks compensated the weakness of mass media. They were used as media not only because they had robustness and scalability; it was because, along with their swiftness, they were familiar and open to the public. These features allowed people to freely and adequately provide the information to those who needed to receive it in a user-friendly manner. Typical examples of such activities were "Real-time map of shelters for stranded commuters" and "Person Finder". Because such open information applications were offered, many information volunteers could come together in order to collect and organize information rapidly, and to send out it in a user-friendly manner

These movements can be regarded as examples of open innovation that happened voluntarily in an extremely short time. However, there were also cases where aged evacuees could not receive enough information and necessary supplies. In this respect, the role of information volunteers who transmit detailed information to and from information shortfall will increase more and more in the future.

From now on, science and technology policy is going to emphasize that "the national and local governments . . . need to properly provide information on a disaster and on evacuation to the local residents, and they should advance efforts that contribute to this."[21] I will be happy if this report can serve as a useful reference.

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Profile

Tsuneo ICHIGUCHI
Affiliated Fellow
Information and Communications Research Unit
Science and Technology Foresight Center
http://www.nistep.go.jp/index-j.html

Ph.D. in Physics. Specialized in physics of semiconductors, superconductors, and magnetism. Engaged in research, primarily on measurement using sub-millimeter waves and microwaves, at an American university and a Japanese electric appliance company. Currently engaged in research on the forecast and trends of science and technology at the STFC.

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