LifeLine Station: A Quickly Deployable Package for Post Disaster Communications

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Abstract This paper describes a quickly deployable package for post disaster communications called ”Lifeline Station” (LLS). In disaster situations, communication inside and outside the disaster site is an important factor as much as watering or electricity. However, if the existing infrastructure is damaged, such communication will not be available or effective. Expecting a major earthquake that may seriously damage the existing facility and infrastructure such as power supply, telephony, Internet access and broadcasting, this research designs LLS and implements its prototype. The prototype was tested in March and July of 2009 in Kurihara city, which was struck by a serious earthquake in June of 2008.

1 Introduction

In disaster situations, communication inside and outside the disaster site is important. Expecting victims of a disaster, government staffs or assigned volunteers as users, Table 1 shows services that will be necessary for rescue, recovery or second disaster prevention. However, if the existing communication infrastructure is damaged, such services may not be available or effective.

Table 1: Demanded Services

Service Name
Audio or video communication
Safety information
Hazardous area information
Emergency radio
Rescue supply logistics
Staff and volunteer assignment
Telemedicine

For the quick recovery from such a disconnected or restricted situation, we introduce a quickly deployable package for post disaster communications: *LifeLine Station (LLS)*. LLS is a portable package of IP-based communication facility, that can be kept in small packages and mobilized to deploy network in a disaster site to enable: (1) communication within the disaster site, (2) Internet access from the disaster site, and (3) various ICT services for rescue, recovery or second disaster prevention. Disaster that we expect is an earthquake that may seriously damage the existing facility and infrastructure: power supply, emergency alerting systems, fixed or cellular phone, telephony, Internet access, TV and radio broadcasting.

The prototype of LLS has been developed since 2008, and it was tested in March and July of 2009 in Kurihara city, which was struck by a serious earthquake in June of 2008.

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2 LifeLine Station

This section describes the design of LLS including the network to provide, and the system components based on the following concepts.

Self-contained
LLS provides reachability to the Internet from a disaster site, even if the existing facility or ICT infrastructure may not be available in the disaster site.

Lightweight and Small
Two people are enough to carry and settle LLS. Also, because LLS is packed into small portions, each package can be transported, for example, by car.

Easy and Simple
The equipment of LLS is pre-configured. Expecting average people as users, the installation procedure is simplified as much as possible. Expert operators will not be mandatory.

Utilization of available resources
If power supply, computers or devices are available in the disaster site, they will be the

resource that may sustain and enhance services on LLS.

Flexibility as ICT infrastructure
LLS enables an ICT infrastructure where various information devices are available in the disaster site.

2.1 Internet Access in Disaster Site

The network enabled by LLS provides wireless access to the Internet with devices in a disaster site as shown in Figure 1.

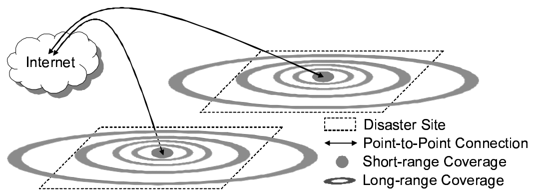


Figure 1: Disaster Sites Covered by LLS

Basically LLS has one or more point-to-point connectivities to the Internet, and wireless LAN or MAN technologies work to expand the coverage where access to the Internet is available. When there are multiple disaster sites concurrently, they can be interconnected once each acquires connectivity to the Internet.

2.2 System Overview

Functionality of LLS is classified into 6 classes as shown in Table 2. Each class is packed in one or a few transportable portions so that requisite functionalities can be selected and then deployed to work. For example, if the in-house power supply is still operational, Power Supply package may not be required to mobilize.

2.3 Class 0: Power Supply Package

Power supply package provides electricity to LLS facilities and devices that will connect to LLS. It is desirable that the power supply is stabilized and sustained as long as possible. As shown in Figure 2, this package functions as stabilized power supply. The power input from a power source charges the battery of an uninterruptible power system (UPS). Then the UPS provides the electricity with devices.

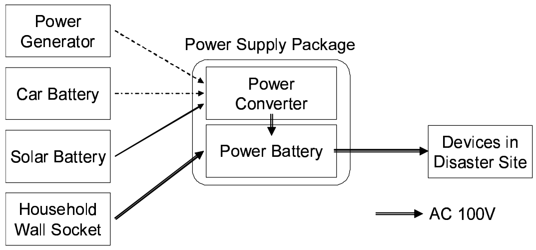


Figure 2: Power Supply Package

The terminal shape or electric voltage may vary according to the power source installed: an in-house wall socket, a power generator, a car battery, or a solar battery. Hence this package equips power inverters to accept multiple types of power source. UPS will contribute to continue the power supply without disconnection when a power source becomes unavailable and then be replaced with another.

2.4 Class 1: Satellite Package

Satellite links function independently of terrestrial networks. Hence such links are promising to serve even in the situation that the terrestrial networks are damaged seriously. Satellite package provides LLS networks with connectivity to the Internet via satellite as shown in Figure 3.

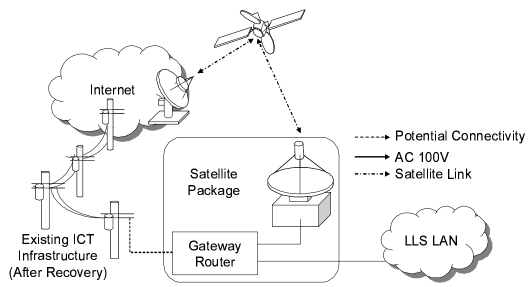


Figure 3: Satellite Package

Considering security and service management in the network, the satellite package equips a router, that can handle DHCP, firewall and QoS. Also, expecting that the existing terrestrial network may be recovered, policy-based routing will contribute to optimize the utilization of available bandwidth on both satellite and terrestrial.

Table 2: LLS Package Classification

Class	Description
0	Power Supply
1	Internet access using satellite communication
2	WiFi networking
3	Digital broadcasting
4	Internet access using wide-area wireless communication
5	Monitoring and control using sensors, robots or vehicles

2.5 Class 2: Wi-Fi Package

Wi-Fi package deploys wireless networks in LLS using a satellite-based Internet as its upstream. Expected devices that may connect to this package are smart phones, laptop computers, and other Wi-Fi enabled devices such as network cameras or sensor nodes.

A typical system component of this package is a Wi-Fi access point to work to provide high-speed network access as shown in Figure 4. Mobile nodes may also be included to extend the network coverage using mobile ad-hoc networking technologies.

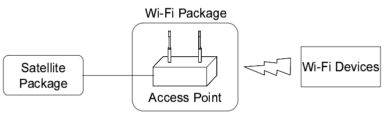


Figure 4: Wi-Fi Package

2.6 Class 3: Digital Broadcasting Package

Expecting that many victims bring their cellular phone when they evacuate a disaster, LLS installs digital broadcasting transmitter for mobile handheld devices, namely 1 segment broadcasting in Japan. The benefit of using digital broadcasting is efficient dissemination of information to a large number of victims: evacuation area, emergency supply, availability of medication, or safety information for example. Those victims can access such information even if they do not have a device to directly connect the Internet.

Figure 5 shows the overview of this package. LLS expects two types of the broadcasting approach, live and archive. Live broadcasting enables to broadcast the realtime video and audio to receiving terminals. Meanwhile, archive broadcasting contributes to broadcast contents whose source can be in the upstream Internet or in the LLS networks. The archived contents can also be TV or radio programs, that can be downloaded from the Internet as far as it is already multiplexed to be sent via 1 segment broadcasting systems.

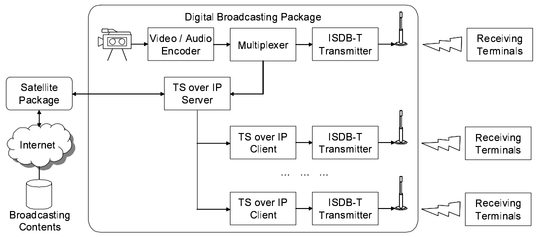


Figure 5: Digital Broadcasting Package

The requirement of digital broadcasting systems in LLS is the capability of handling MPEG-2 TS files or streams over IP communications, so that the source of contents can be either inside or outside LLS network.

2.7 Class 4: Wireless MAN Package

Wireless MAN package provides a long-range Internet access in LLS network beyond the coverage of Wi-Fi package. WiMAX is expected as the infrastructure technology. Another aspect of this package is that the long-range connectivity can be the alternative Internet connectivity that can be operated in combination with a satellite link.

2.8 Class 5: Advanced Information Services

Advanced information services are the applications that can be achieved by mobilizing sensor devices, robots or vehicles in the LLS network. Remote control of vehicles, telemedicine using vital data, and collection and dissemination of victims' safety or hazardous area will be the typical examples of services in this class.

3 System Implementation

This research developed a prototype of LLS that implements the following packages:

(1) Power Supply Package
(2) High-speed Satellite Package
(3) Lightweight Satellite + Wi-Fi Package
(4) Live Broadcasting Package, and
(5) Archive Broadcasting Package.

The equipment installed in each package is listed in Table 3. The chassis of each package is rack-mount housing that is compatible with EIA-310-D. The following sections describes their characteristics and system diagram respectively.

3.1 Power Supply Package

The prototype of power supply package is focusing on acquiring electricity from a battery of vehicles, that may be left in a disaster site. As shown in Figure 6, this package installs DC 12V and 24V power inverters to convert the power supply from a car battery to AC 100V power for injecting to the UPS.

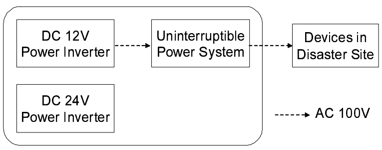


Figure 6: Power Supply Package

As long as there is a car battery available in the disaster site, the battery in UPS can be charged to supply stable electricity to devices that support AC 100V input.

3.2 High-speed Satellite Package

High-speed satellite package provides broadband access to the Internet. The system installs a VSAT terminal that can automatically perform antenna pointing using GPS receiver functionality. After assembling the earth station, the pointing procedure will be completed within 5 or 10 minutes without manual installation.

Figure 7 shows the system diagram of this package, and Figure 8 show the VSAT terminal connected to Power Supply package. This package uses SPACE-IP service that provides 10Mbps down link to and 2Mbps up link from the terminal on best effort. This package is expected to work as the primary Internet connectivity. PoE injector in the package is used to accommodate a PoE device, so far that is Wi-Fi package described in the next section.

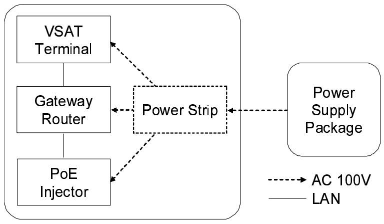


Figure 7: High-speed Satellite Package

Figure 8: VSAT Terminal

3.3 Lightweight Satellite + Wi-Fi Package

This package is a combination of a satellite earth station and a Wi-Fi access point to quickly launch a Wi-Fi hot spot in the disaster site. The system diagram of this package is shown in Figure 9.

For Internet access via satellite, BGAN service using an INMARSAT terminal is installed to enable 492kbps connectivity. Figure 10 shows the INMARSAT terminal and the Wi-Fi access point that are deployed on the rack mount housing of this package.

The benefit to use this package is that the size of equipment can be small, and the procedure of an-

Table 3: Equipment Installed in LLS

Power Supply Package		
Item	Manufacturer / Supplier	Model
DC 12V Power Inverter	Endo Scientific Instrument	AS1000-12V
DC 24V Power Inverter	Endo Scientific Instrument	AS1000-24V
Uninterruptible Power System	OMRON	BN150XR
High-speed Satellite Package		
Item	Manufacturer / Supplier	Model
VSAT Terminal	SKY Perfect JSAT	Satellite Catcher JM-75
Gateway Router	Cisco	Cisco 1812J
PoE Injector	BUFFALO	WLE2-POE-S
Wi-Fi Package		
Item	Manufacturer / Supplier	Model
Wi-Fi Access Point	BUFFALO	WLAH-HG-G54/R
Wi-Fi Skype Phone	Logitec	LAN-WSPH01WH
Lightweight Satellite + Wi-Fi Package		
Item	Manufacturer / Supplier	Model
INMARSAT Terminal	Thrane & Thrane	Explorer 5000
Gateway Router	Cisco	Cisco 1812J
Wi-Fi Access Point	Cisco	AIR-AP1242AG-P-K9
Wi-Fi Skype Phone	Logitec	LAN-WSPH01WH
Live Broadcasting Package		
Item	Manufacturer / Supplier	Model
H.264 Encoder	Envivio	4Caster
Multiplexer	Hitachi Information & Communication Engineering	UM5000
ISDB-T Transmitter	Tektronix	RTX 100A
Archive Broadcasting Package		
Item	Manufacturer / Supplier	Model
ISDB-T Transmitter	ABIT	ACS2000 (Transmitter)
Broadcasting Server	ABIT	ACS2000 (Server)
PoE Injector	BUFFALO	WLE2-POE-S

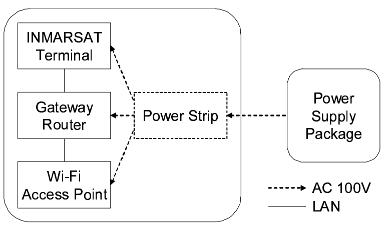


Figure 9: Lightweight Satellite + Wi-Fi Package

tenna pointing is simple compared with the high-speed satellite package. Meanwhile, the available bandwidth of this package is limited, thus the operation will require access control or QoS to optimize utilization of the bandwidth, and prioritize the certain traffic like emergency rescue communication.

3.4 Live Broadcasting Package

Live broadcasting package is the system to enable live broadcasting for 1 segment receiver terminals such as cellular phones or mobile handheld TVs.

Figure 11 shows the system diagram of this package. The video and audio from the live DV camera inputs to H.264 encoder, and then multiplexed as MPEG-2 TS. The ISDB-T transmitter re-

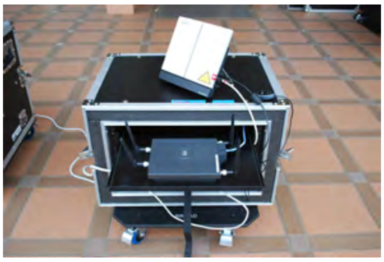


Figure 10: INMARSAT Terminal and Wi-Fi Access Point

multiplexes the MPEG-2 TS, and then transmits to the radio frequency with a very small power not to violate the legal conditions in Japan.

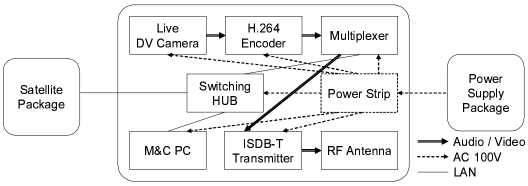
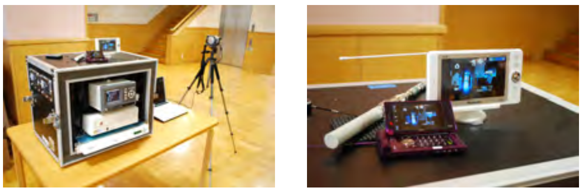


Figure 11: System Diagram of Live Broadcasting Package

Figure 12 (a) shows the overview of system, and (b) shows a mobile TV terminal and a cellular phone that receives the live contents transmitted by this package. The process of live broadcasting is done in realtime. The delay of video and audio reception is around 5 seconds mainly caused by H.264 encoding and FEC mechanism of the digital broadcasting systems.



(a) System Overview (b) Receiver Terminals

Figure 12: Prototype System

3.5 Archive Broadcasting Package

Archive broadcasting package broadcasts the archived contents that is edited as a completed MPEG-2 TS file preliminarily. Figure 13 shows the system diagram of this package. The file is downloaded from the Internet, and then kept in the broadcasting server. Based on the command from M&C PC, the broadcasting server sends the MPEG-2 TS to ISDB-T transmitter using unicast or multicast.

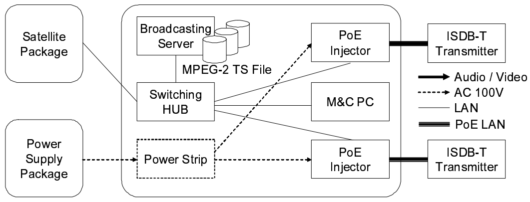
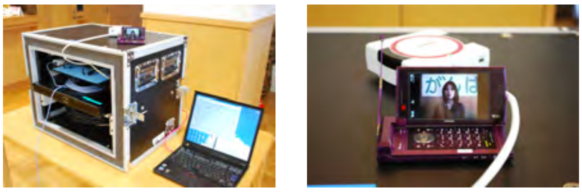


Figure 13: System Diagram of Archive Broadcasting Package



(a) System Overview (b) Transmitter and Cellular Phone

Figure 14: Prototype System

This approach indicates that once the digital data of source material can be transfered from the disaster site to the outside, the task of editing broadcasting contents can be outsourced to volunteers that are outside the disaster site through the Internet.

4 Field Trials of LLS

The prototype of LLS packages has been tested in Kurihara city of Miyagi prefecture. Kurihara city was hit by a serious earthquake in 2008, and is now in the recovery process.

The first trial was held to introduce the concept of LLS, and to perform the demonstration of the prototype in March of 2009. This trial revealed that the installation procedure of LLS can be completed within 5 minutes when using high-speed satellite package and Wi-Fi package including power supply from a car battery. A laptop computer and a Wi-Fi phone device were connected to the LLS network to enable video conferencing and telephony service through the Internet. The trial also showed that digital broadcasting package functions well to enable dissemination of information to victims. The archived contents, that were originally edited by the authors, were broadcasted to cellular phones in a tightly limited range with about 50cm diameters.

Another trial was held in July of 2009, that included a workshop for getting feedback from the potential users of LLS. In this trial, the office staffs of Kurihara city hall installed and launched LLS under the instruction of the authors. And then, the workshop was held for (1) sharing experience in the actual disaster situation of the earthquake in 2008, and (2) discussing issues raised from the LLS field trial. Analysis of the feedback from the workshop is still on-going, but this paper shows the typical issues in Section 6.

5 Related Work

Local Authorities Satellite Communications Organization (LASCOM)[1] deploys satellite-based networks where communications using audio, video and data are available. In the LASCOM network IP-based communication can also be enabled, however, this network is not basically connected to the global Internet.

Digital Ubiquitous Mobile Broadband OLSR (DUMBO) project[2] has been trying to deploy emergency response networks using mobile ad-hoc networking technology, that can be connected to the Internet expecting satellite links for the external connectivity.

ε-ARK[3] focuses enhancement of Linux-based PDA, that can be sustained using various power source including dry-cell battery, to provide adhoc wireless access to the Internet in disaster situations. This system covers network operation like DHCP, firewall and WEB cache based on the consideration of quickness and effectiveness of actual services.

6 Conclusion and Future Work

This paper discussed a quickly deployable package for post disaster communications called ”Lifeline Station”. The concept of this system is built considering the situation of disaster site hit by a big earthquake, where existing power supply or communication infrastructure can be damaged. The six classified packages are designed to be easily handled and operated accordingly with the actual situation of the disaster site. The prototype of LLS has been tested in Kurihara city since March of 2009.

The issues open for discussion are: (a) chassis protection from weather, (b) downsizing of packages, (c) legal conditions for RF usage in emergency situations, (d) access control to information collected on LLS, (e) security and scalability of LLS network, (f) maintenance cost of LLS, (g) interoperability with the on-going related work, and (h) cooperations with the local government units. This research will conduct R&D to solve those issues for future deployment.

Acknowledgement

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