Reconstructing a Communication Infrastructure in a Time of Disaster

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***Abstract*-When a disaster occurs, as so many people try to confirm the safety of disaster victims, network sometimes becomes congestion state. Also, at the time of calamity, network infrastructure may break down. To cope with the situation, we propose a disaster communication system, which can rapidly reconstruct the network infrastructure, and dose not force disaster victims unusual operations. We adopt WAPL (Wireless Access Point Link), that is an original mesh network, and QMS (Quasi-Mail Server) that works as a mail server. Disaster victims do not need to be aware of the existence of WAPL and QMS. We have implemented the basis of the system, and confirmed the operations.**

I. INTRODUCTION

When a disaster occurs, network congestion usually rises because so many people use networks to confirm the safety of others. Moreover, a communication environment sometimes breaks down due to destruction of cables and base stations. Therefore, disaster victims will never be able to communicate with others. Current disaster communication services have two problems. First, they have to do unusual operations to use the services. Second, if they do not know their existence of the systems, they will never use them. To solve the problems, we suggest how to reconstruct a communication infrastructure rapidly when a disaster occurs, and provide a simple mail system for disaster victims. For reconstruction of the communication environment, we use our original mesh network, called WAPL (Wireless Access Point Link) [1] [2] [3]. It is assumed that wireless LAN technologies are widely spread, and wireless LAN interfaces are equipped in many personal mobile terminals.

II. PROBLEMS OF EXISTING SYSTEMS

In Japan, there are two practical communication services for the time of disaster, those are, NTT Disaster Message Exchange [4], and IAA (I am alive) System [5]. The former system uses telephone networks to provide a voice-mail system, the network congestion easily occurs at a time of disaster. The latter system forces users register many entries to utilize the service. Both systems will not be used if disaster victims do not know the existence of the system.

III. A PROPOSED SYSTEM

To solve the above issues, we set up targets as follows. A proposed system meets these targets with WAPL and QMS (Quasi-Mail Server).

1) The network infrastructure can be built swiftly.
2) The system can provide usual communication services, and it does not force disaster victims to do difficult procedure.
3) Connectivity with the Internet can always be established, and network congestion rarely occurs.

A. WAPL

Fig. 1 shows an example of WAPL structure. WAPL is a kind of mesh networks that have been discussed in IEEE 802.11 committee. WAPL is our original system, so that we can add several functions in the network. Here, AP in WAPL is called WAP (Wireless Access Point). In WAPL, WAP and end terminals are connected with infrastructure mode, and WAPs are connected with ad-hoc mode. An WAP has 2 wireless interfaces. One is set for an AP mode and makes connections with terminals in an infrastructure mode. The other one is set for an ad-hoc mode and makes connections with other WAPs. For the connections among WAPs, MANET (Mobile Ad-hoc Network) routing protocol is used that can make multi-hop communications.

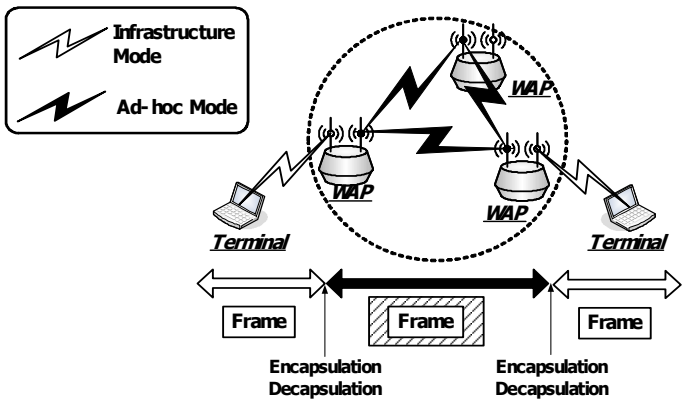

Figure 1. An example of WAPL structure.

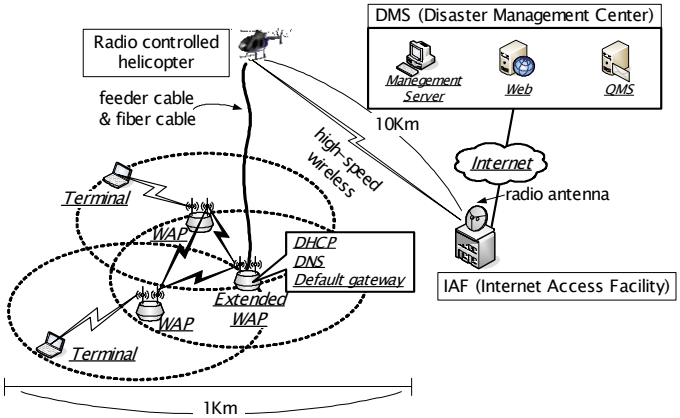

Figure 2. A proposed system.

B. Reconstructing a network infrastructure

Fig. 2 shows the proposed system. It is assumed that a disaster area is within 1 kilometer square, and IAF (Internet Access Facility) is located about 10 kilometers away from the disaster area. When disaster occurs, rescue workers first set up a number of WAPs to reconstruct a communication infrastructure. They also set up EWAP (Extended WAP), that is needed to access to the Internet. EWAP consists of a DNS server, a DHCP server, and a default gateway. A radio antenna is set near IAF. A radio controlled helicopter is used for relaying wireless signals between EWAP and IAF. The power of helicopter is supplied via a feeder cable from the ground.

DMS (Disaster Management Center) consists of a management server, an Web server for disasters and QMS, and is located at an appropriate place on the Internet. The management server manages location information of all WAPs. The web server, which is a character-based website, shares common information among disaster victims and people outside the area. QMS offers a quasi-mail system, which is described in section 4.

IV. QUASI-MAIL SERVER

Disaster victims may use e-mail services to contact others. If regular mail servers are down due to a disaster, they can use QMS. To use QMS, they need to make a mailbox in QMS, so exchanges of e-mail have to be started from disaster victim's side. Fig. 3 shows a sequence of e-mail using QMS.

When a disaster victim's terminal is powered on, it requests an IP address to the DHCP server in EWAP. Then, it gets its own IP address and addresses of the DNS server and the default gateway in EWAP. By this operation, all terminals in the disaster area necessarily send queries to the DNS server in EWAP. Next, to send e-mail, the terminal requests the IP address of a regular SMTP server, that is registered in the terminal, to the DNS server. The DNS server checks whether the server works or not using TELNET (port 25). If the regular SMTP server works, the DNS server responds with an IP address of QMS. In this case, disaster victims exchange mail messages via QMS. Disaster victims do not need to be aware of existence of QMS.

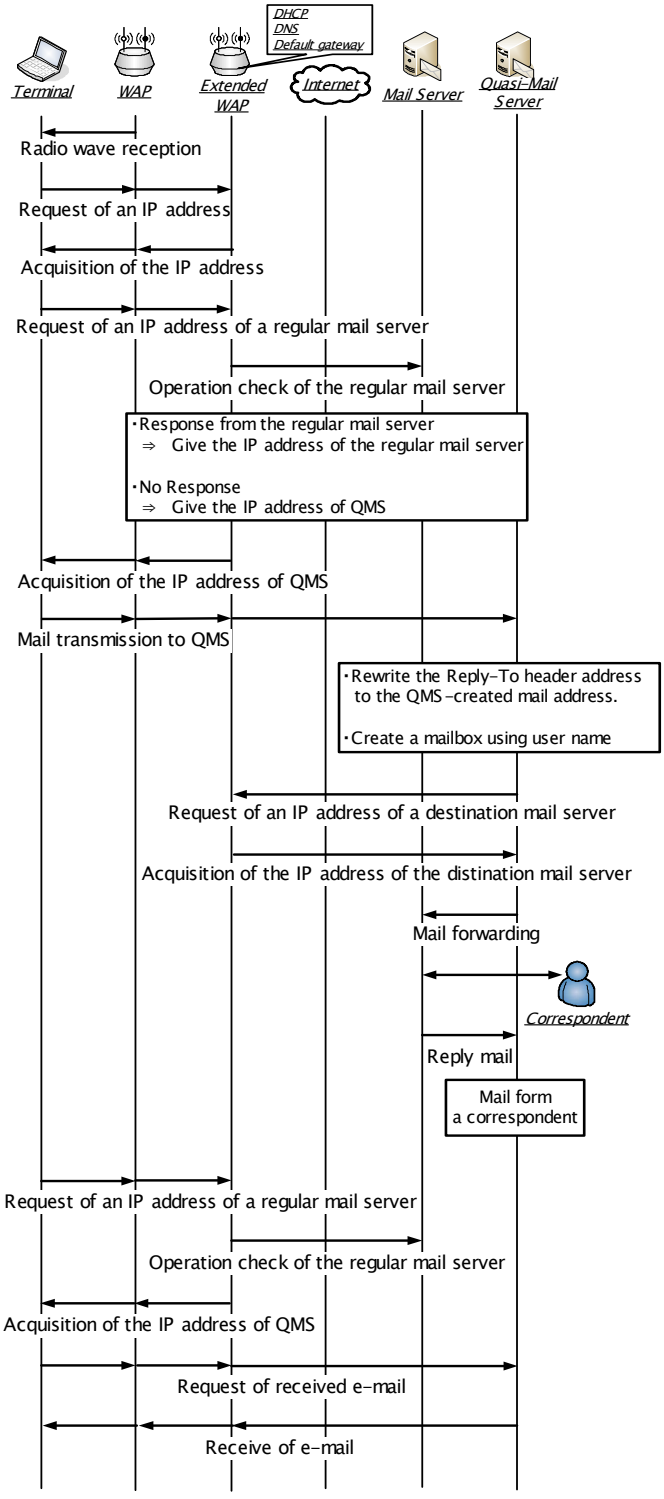

Figure 3. Sequence of e-mail using QMS.

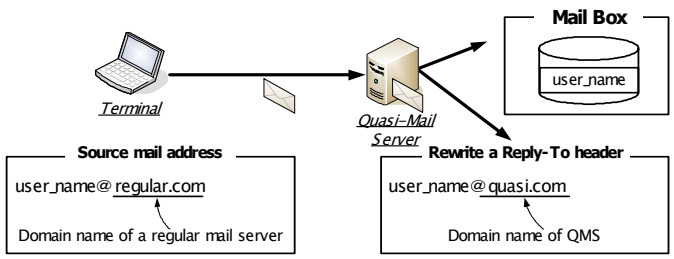

Figure 4. Sequence of a mailbox creation in QMS.

As it is thought that the receivers out of the disaster area usually reply to the mails from the disaster victims, it is desired that the disaster victims can receive the reply mail. To realize the above function, when QMS receives a new e-mail from a disaster victim, it creates a mailbox in QMS using a user name. In addition, QMS changes a Reply-To header address in the mail into the QMS-created mail address (Fig. 4). By this way, QMS can receive a reply mail from the receiver. A password is not set up at the time of the mailbox creation.

To read the reply mail, disaster victims request the DNS server to get an IP address of a regular POP server. The DNS server checks whether the POP server works or not using TELNET (port 110). If the SMTP server has been down, it judges that the POP server is also down. When the disaster victim receives the reply mail, QMS recognizes the user based on only an user name, and a password is ignored. If disaster victims use the same user name by accident, the mail address created by QMS will be duplicated. In that case, they share the same mailbox. Since it is at an emergency, we precede safety communications than privacy.

V. IMPLEMENTATION

To implement the proposed system, we have to add several functions to QMS and the DNS server. We have implemented the basis of QMS system, and confirmed the function. We have added in the SMTP server the function of changing a Reply-To header and making a mailbox in it. Also, we are going to add in the POP server the function of mailbox sharing. We are going to add in the DNS server the function of checking the life of regular mail servers. Sendmail is used for the SMTP server. Qpopper is used for the POP server. BIND is used for the DNS server. Modification of functions is described below.

A. SMTP server (Sendmail-8.13.4)

Fig. 5 shows a processing flow of modified functions. To reduce network congestions, the data size of a mail is restricted to 10KB.

1) A modification of Reply-To header: As shown in Fig. 4, when e-mail is transmitted from the disaster area, QMS extracts the user name of the disaster victim, and memorize the name as [user_name @ domain name of QMS]. Then, QMS rewrites a Reply-To header using the QMS-created mail address.

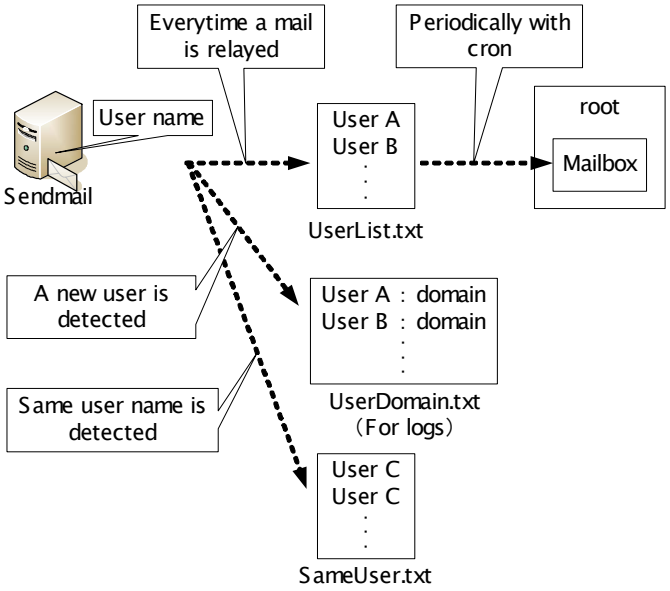

Figure 5. A processing flow of modified functions.

2) Creating a mailbox: A user name is memorized in UserList.txt whenever a mail from the disaster area passes through the SMTP server. These contents are not deleted. This operation also plays a role of logs. UserList.txt is referred to periodically, and whenever a new user name is detected, a new mailbox is created. A mailbox becomes the same when there are disaster victims having the same user name, although original domain names are different. In such cases, the user name is recorded in SameUser.txt.

B. POP server (Qpopper-4.0.8)

Fig. 6 shows a sequence of a POP server. Since a password is not set up, it is ignored at the POP server.

1) Mailbox sharing: When a terminal receives an e-mail, it transmits a DELE command to delete the mail in the POP server. However, if more than two users are sharing the same mailbox, it is needed not to delete the mail in the mailbox after one user read it. Therefore, when the POP server receives a DELE, it refers to SameUser.txt, and checks the duplication of the mailbox.

C. DNS server (BIND-9.3.1)

1) Check of a regular Mail server: A DNS server checks whether a regular mail server works or not using TELNET. If the server is working, the DNS Server responds with the IP address of the regular server. If the server is not working, the DNS server responds with the QMS IP address.

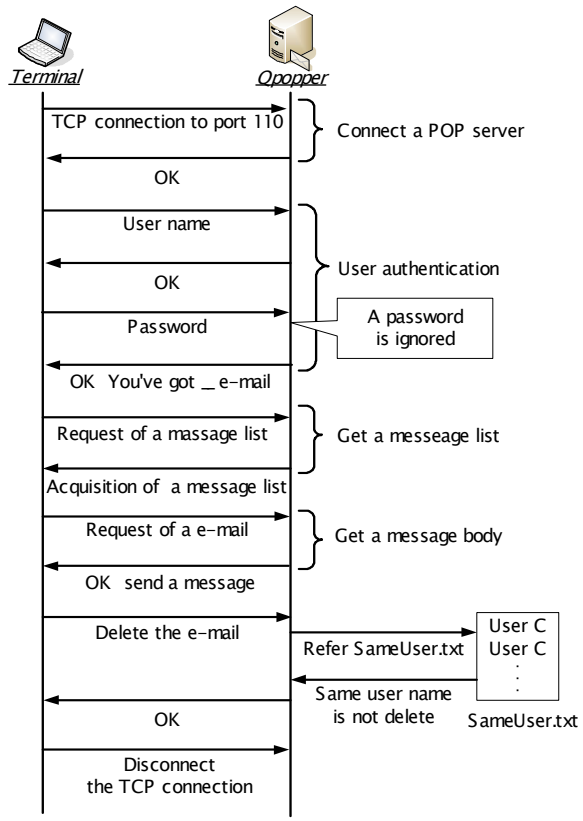

Figure 6. Sequence of a POP server.

VI. EVALUATION

A comparison with the proposed system and existing systems is shown in Table 1. A voice-mail service of NTT Disaster Message Exchange and IAA system can not be used in the situation when a communication infrastructure breaks down. A proposed system can reconstruct a communication infrastructure rapidly with WAPL. In NTT Disaster Message Exchange, traffic congestion easily occurs at a time of disaster because it uses telephone networks. Moreover, it sometimes falls into the restriction of communication taken by carriers.

TABLE I
A COMPARISON OF THE SYSTEMS

	NTT Disaster Message Exchange	IAA System	Proposed System
Broken Infrastructure	×	×	○
Traffic Congestion	×	○	○
Normal operations	×	×	○
System set up	○	○	×

Traffic congestion rarely occurs in IAA system and the proposed system, because it is limited to character-based communications. NTT Disaster Message Exchange and IAA system are never be used if disaster victims do not know the existence of the system. In the case of the proposed system, disaster victims do not need to be aware of the system, and they can do the normal operations such as mailing and browsing. A fault point of the proposed system is that we have to set up WAPs in the disaster area if the network can not be used.

VII. CONCLUSIONS

We have proposed the system using WAPL, and how to reconstruct a communication infrastructure rapidly when a disaster occurs. Also we have provided a simple mail system for disaster victims. As a future study, we will implement the whole system and confirm the operations.

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[4] http://www.ntt-east.co.jp/saigai/
[5] http://www.iaa-alliance.net/

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Background

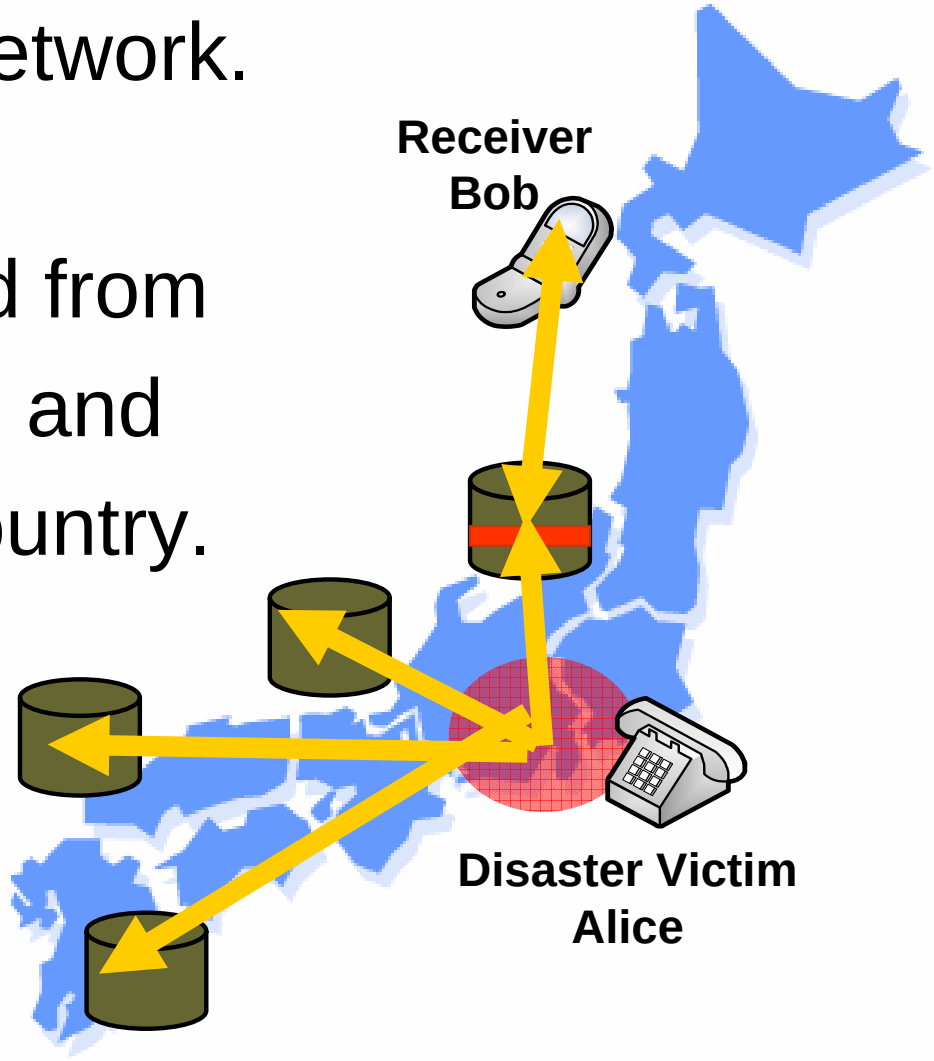
- When disasters (tsunamis and earthquakes) occur
  - Network traffic always becomes a congestion state.
  - Sometimes communication infrastructure is destroyed.

- It is very important to reconstruct the communication infrastructure.
  - We propose the method how to build a wireless LAN environment.
  - We provide a proxy mail service that victims can use the service with usual procedures.

NTT Disaster Message Exchange

Existing system

- This system provides victims a voice mail service using a telephone network.
- Voice mailboxes are created from victims' telephone numbers, and they are distributed in the country.
- It is still difficult to avoid the congestion state completely.



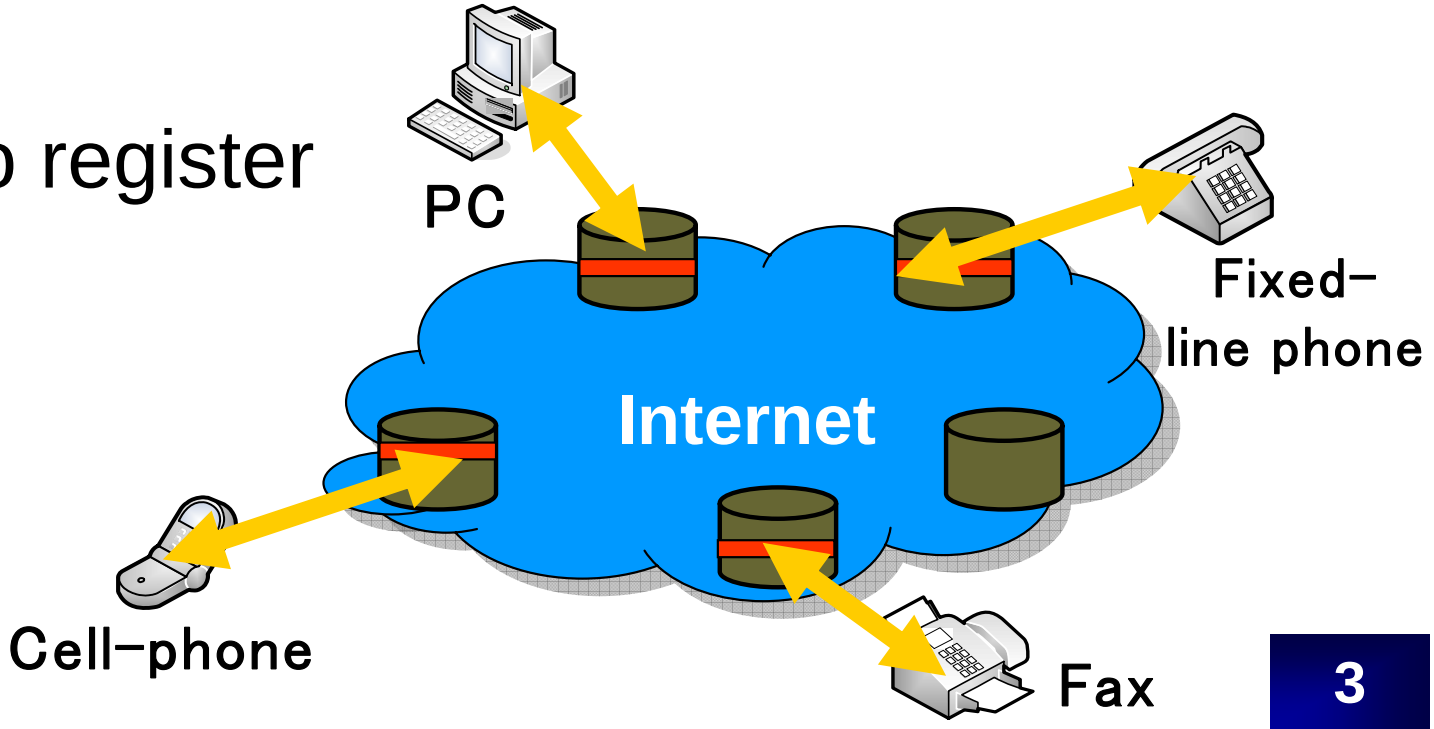
I Am Alive System (IAA System)

Existing system

- In IAA system, victims' safety information is registered and accumulated in the Internet, and it provides some searching functions for users.

- Several kinds of terminals can be used.

- Victims have to register some entries.



Issues of the existing systems

- NTT Disaster Message Exchange
  - This system uses a telephone network, so network congestion easily occurs.
- IAA System
  - It forces victims to register many entries.
- Common issues
  - Both systems force victims unusual operations.
  - If Victims do not know the existence of the system, they will never be used.
  - If network infrastructure is physically broken, the systems will become worthless.

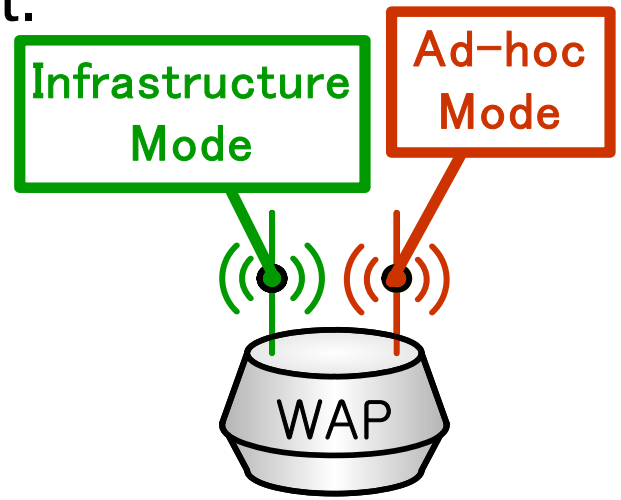
Targets of the proposed system

1. We build a wireless LAN environment immediately in a disaster area.

2. We provide some communication services.
   - We provide a unique mail service.
   - Victims can use the service with usual mailing procedures.

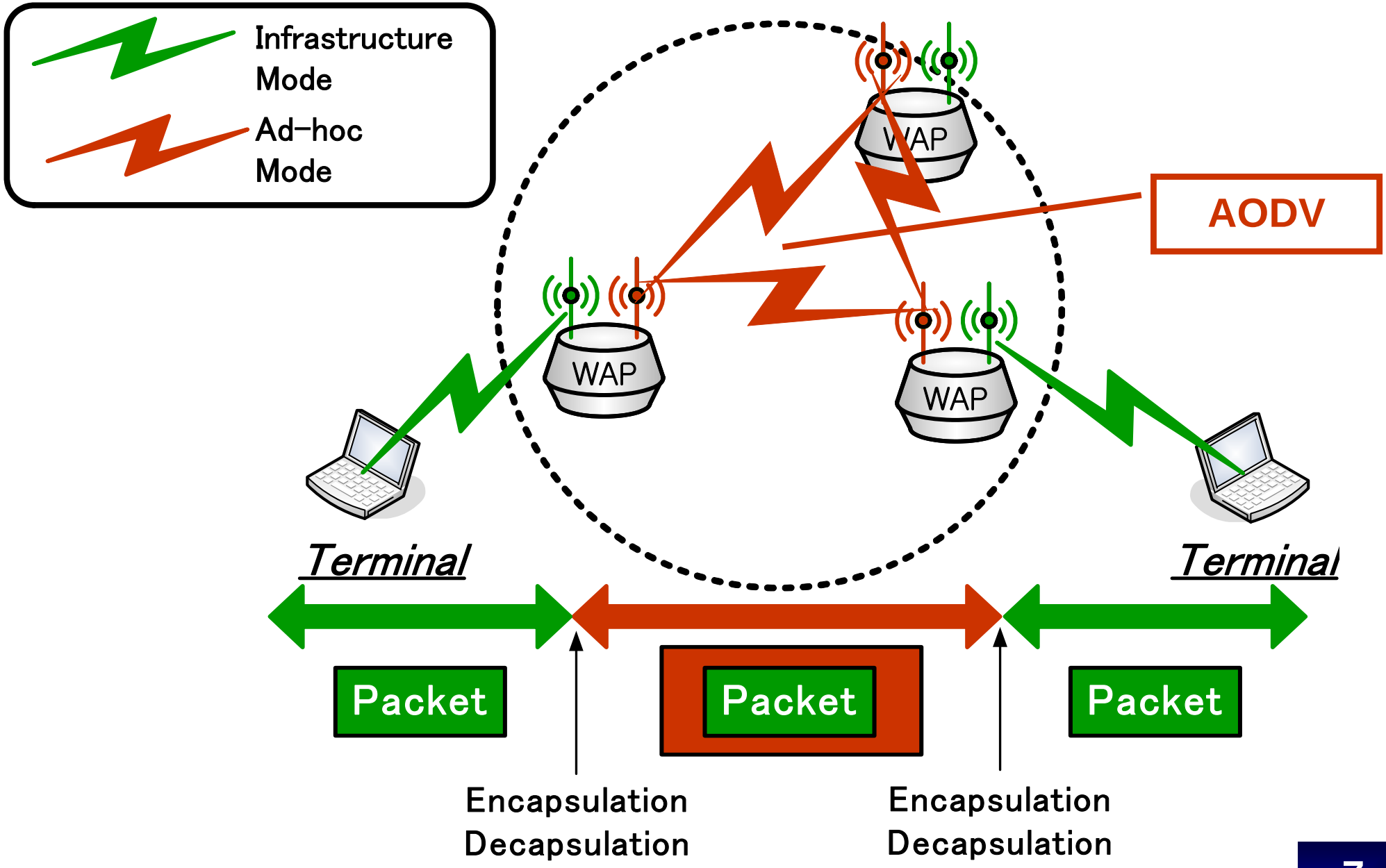
Summary of the Proposed system

- WAPL (Wireless Access Point Link)
  - Our original wireless mesh network system
  - This system is now under development.
  - WAP (Wireless Access Point)

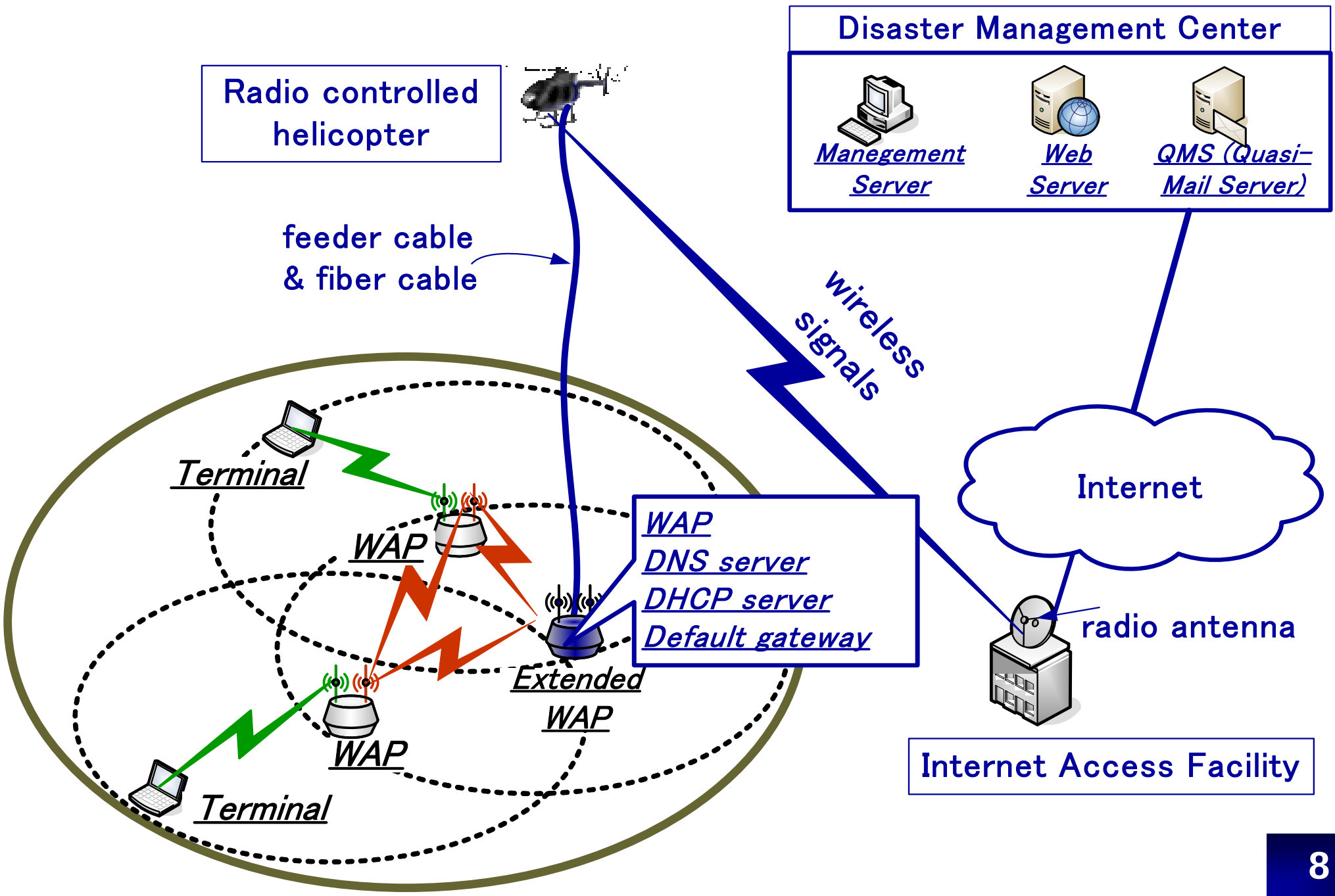


- QMS (Quasi-Mail Server)
  - It works when regular mail servers are down.
  - QMS provides victims a proxy mail service and they can send and receive e-mails with usual procedures.

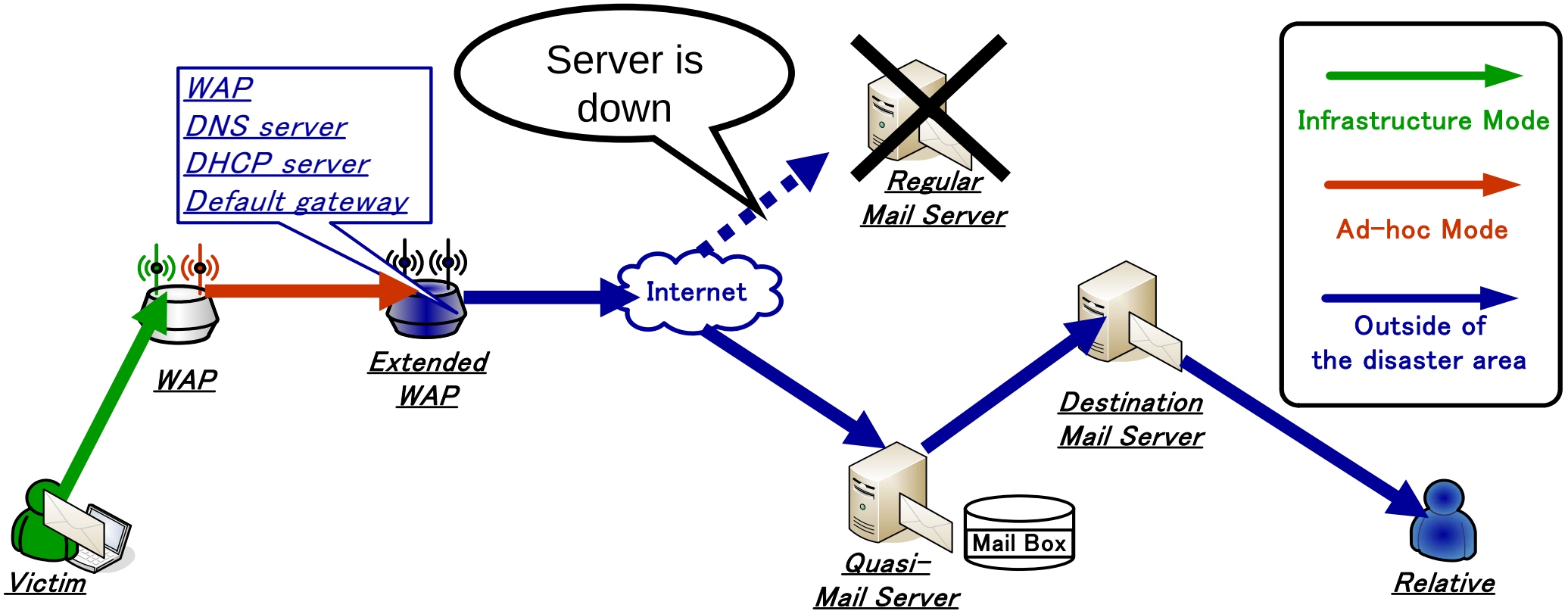
WAPL (Wireless Access Point Link)



The Proposed system



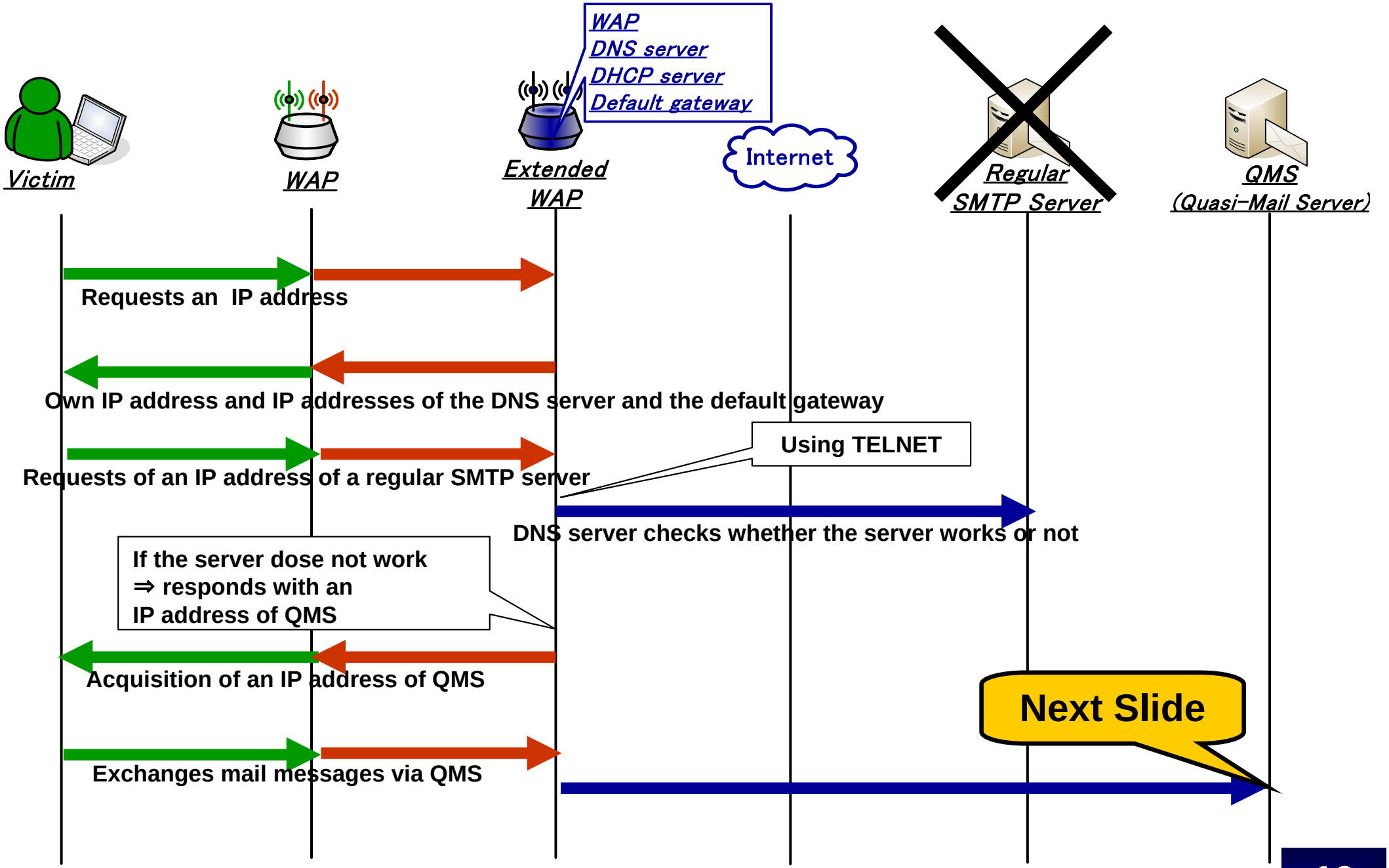
QMS (Quasi-Mail Server)



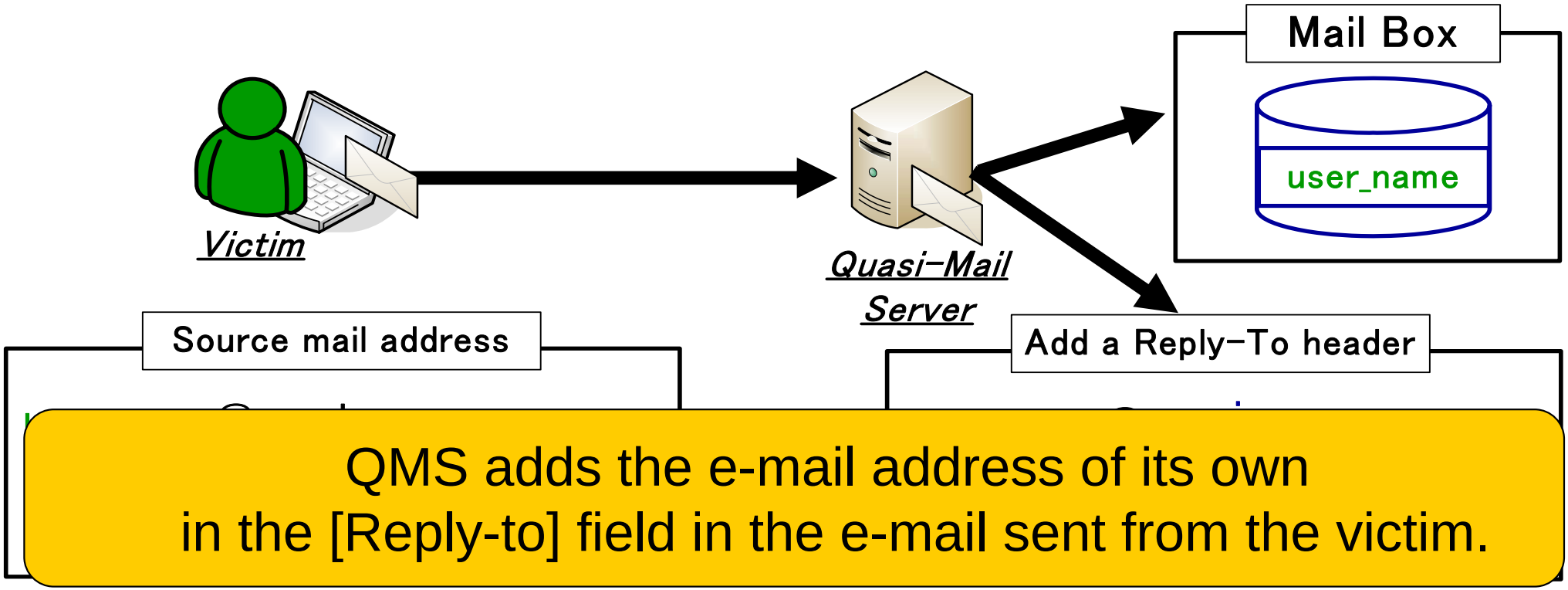
If regular mail servers are down, victims can use QMS.

- When QMS receives a mail from a victim, a new mail-box is made in QMS.
- Exchanges of e-mails have to be started from victim's side.
- Victims can use an e-mail system as usual without knowing the existence of QMS.

The sending mechanism of QMS



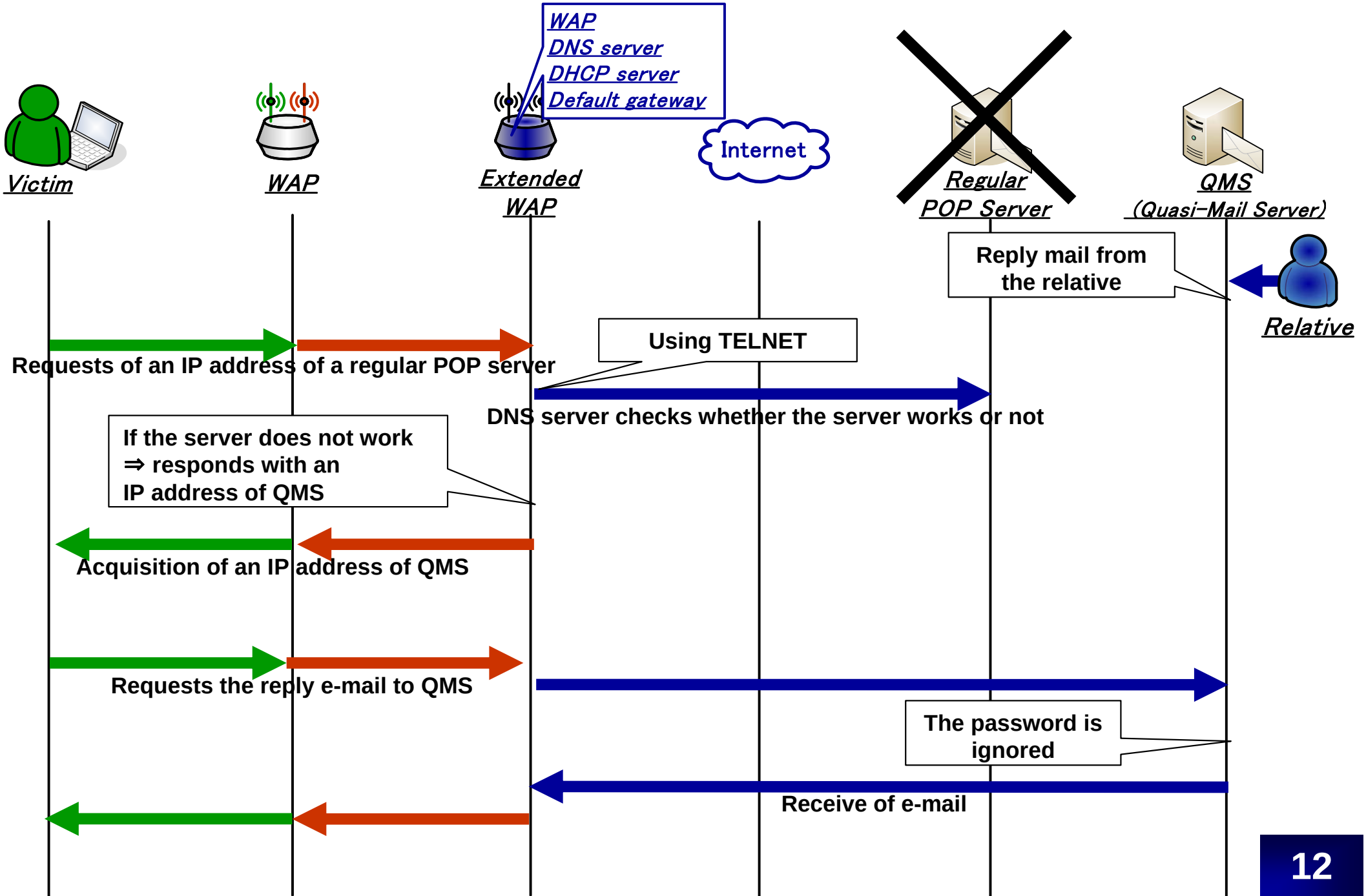
Operation of QMS after receiving an e-mail



When QMS receives a new e-mail from a victim

- A mailbox is created in QMS from victim's user name.
- An e-mail address is created from a domain name of QMS and victim's user name.
- QMS adds new information in the e-mail.

The receiving mechanism of QMS



Implementation of QMS

- To realize QMS, we have to add four functions to the mail server and the DNS server.
  - Colored portions of the figure have been completed and other functions are now under development.

Server		*function*
Mail Server	SMTP Server	Modification of Reply-To header function
		Creating a mailbox function
	POP server	Mailbox sharing function
DNS Server		Check of a regular mail server function

Summary and future plans

- We have proposed
  - the method how to reconstruct a communication infrastructure in a time of disaster.
  - WAPL, our original technology, can be utilize for the reconstruction of the network infrastructure.
  - the proxy mail service with QMS.

- As future plans
  - We will implement the whole system and confirm the operations.