Emergency Mobile Radio Network based on Software-Defined Radio

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Abstract

With growing awareness of natural disasters, border intrusions, and other crises, the demand for on-site information sharing has increased. However, conventional network systems entail some serious issues such as a variety of frequency bands, waveforms and protocols, and the use of base stations. These problems make it hard to communicate with each other when an emergency situation arises. NEC is rising to the challenge through improvements in on-site information sharing by virtue of development in Software-Defined Radio (SDR) and Ad-hoc network. This paper introduces Emergency Mobile Radio based on SDR and other SDR-based products.

KeyWords

Information sharing, Software-Defined Radio, Ad-hoc network, Disaster management, Licensed Mobile Radio

1. Introduction

With increasing risks of natural disasters, terrorism, border incidents, and other emergency situations, the importance of information sharing among organizations is growing. However, one conventional hardware-based wireless system is basically limited to support one network. The organizations have their own networks, on which different frequency bands, waveforms and protocols are utilized. Therefore, it's hard to share information among organizations.

NEC is meeting the challenges of these technical difficulties with Software-Defined Radio (SDR), which is a radio communication technology.

SDR, generally explained as a radio signal received and transmitted through an antenna, is processed into and from voices and data by loadable software. The standards for SDR include a Software Communication Architecture (SCA) published by Joint Tactical Radio System (JTRS), which enables equipment compatibility.

NEC released an SCA-based radio for the first time in the world. NEC is currently providing several SDR-based products and solutions.

This paper introduces some of the SDR-based products including Emergency Mobile Radio that is a major example of NEC's SDR-based terminals.

2. Emergency Mobile Radio Network

Just after the 2011 Tohoku Earthquake (March 11, 2011), Japanese government authorities faced difficulty in communicating with other governmental agencies such as the Police Agencies, Fire Disaster Management Agencies, and Self-Defense Forces since they had been using different networks and also most base stations of telecom companies in the area were rendered unavailable at that time. Then NEC

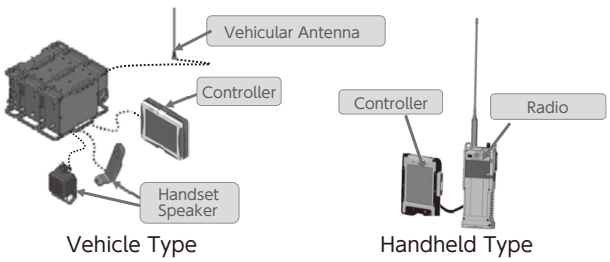


Fig. 1 Emergency Mobile Radio.

developed Emergency Mobile Radio to solve this critical situation (**Fig. 1**).

Emergency Mobile Radio has the following three key-features:

- Wideband Ad-hoc Network
- Software-Defined Radio
- Multimedia

2.1 Wideband Ad-hoc Network

While commercial mobile communication systems have base stations and other wireless infrastructure, an ad-hoc network enables communications among terminals without any wireless infrastructure.

Emergency Mobile Radio automatically builds up a private ad-hoc network by searching other terminals and making links with them. In the network, each terminal acts as a router, and relays data packets, i.e. Multi-hop (**Fig. 2**). When a link is lost, the terminal automatically reroutes with another link or creates a new link, thereby recovering the network.

To provide multimedia services on the ad-hoc network, Emergency Mobile Radio organizes a wideband ad-hoc network whose throughput is up to 640kbps and the latency is low enough to provide voice service over the network.

2.2 Software-Defined Radio

Although conventional radios have dedicated hardware to support each air-interface, SDR can support multiple air-interfaces by changing its communication software (**Fig. 3**). Emergency Mobile Radio can switch the ad-hoc network mode described above and the infrastructure-based trunked radio network in accordance with the user's operation.

2.3 Multimedia

As for traditional radio, voice service has been the dominant form of use, but recently the demand for data services is increasing, due to the expansion of commercial telecom networks, such as video phone, photo sharing, email, and position location information (PLI) sharing.

To catch up with those demands, Emergency Mobile Radio incorporates a tough tablet as a data terminal, which also works as a controller. Media-rich applications can be installed onto this data terminal.

Real-time PLI sharing system is one of the applications (**Fig. 4**). This application enables situational awareness of the individual PLI in real time. Using this application, significant places are also shared with symbols on the map.

2.4 Operation Scenario

Emergency Mobile Radio is useful for various types of

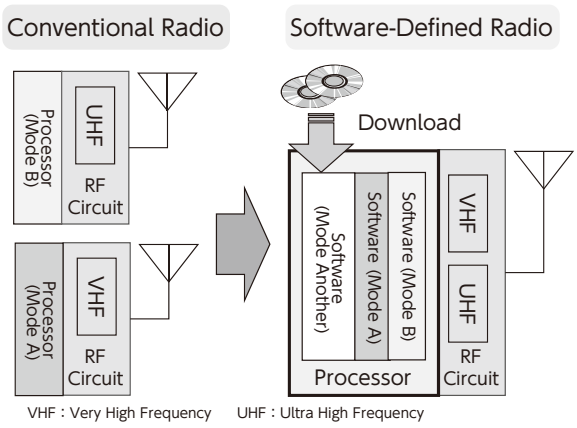


Fig. 3 Conventional radio vs. SDR.

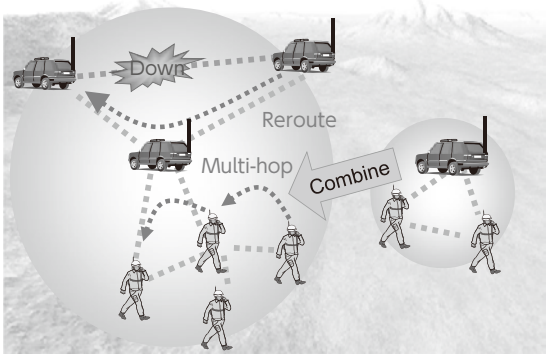


Fig. 2 Ad-hoc network.

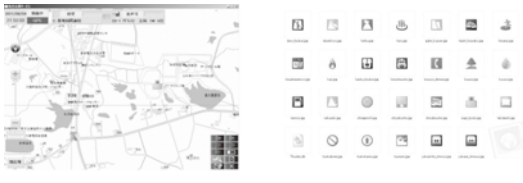


Fig. 4 Real-time PLI sharing system.

critical situations where on-site information sharing is needed and where there is no operational wireless infrastructure because it was lost due to natural disasters (**Fig. 5**). Immediately after an earthquake, the wireless infrastructure may not be available because of collapse, fire, tsunamis or blackouts, and it is difficult to transport temporary base stations because the earthquake cuts off traffic in many places. Emergency Mobile Radio is portable, so a rescue team can carry them even if they go into a disaster site on foot or by driving a small vehicle. At a disaster site, rescue teams communicate with each other through the ad-hoc network. The vehicle-mount type Emergency Mobile Radio can connect with another network's equipment via an Ethernet port, thereby connecting with an earth station of a satellite communication network, so on-site members and disaster headquarters located far from the site can share information. NEC can also provide the web-based IT system managing terminals for headquarters. In shelters, by connecting the vehicle-mount type Emergency Mobile Radio with an ordinal Wi-Fi access point, residents can receive data delivery service through Wi-Fi.

Compared to other communication equipment, Emergency Mobile Radio is quite useful during the initial phase of disaster recovery (**Fig. 6**).

In general, satellite communication stations and temporary telecom base stations are also used as communication equipment at a disaster site. However, the size of this equipment is larger than Emergency Mobile Radio, so it is hard for the rescue team to carry them by hand, and it takes longer to setup.

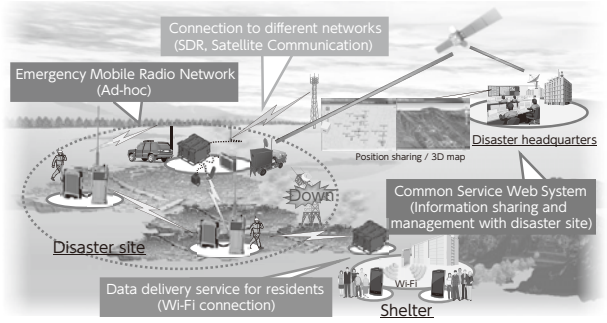
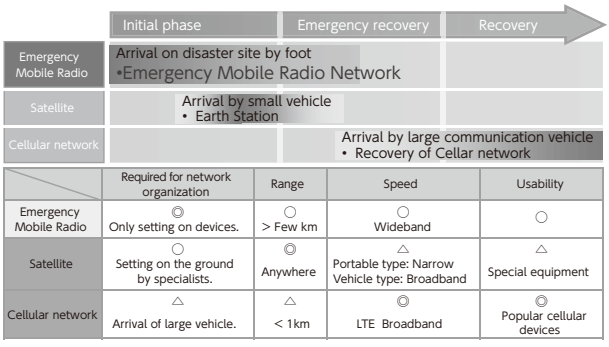


Fig. 5 Operation scenario.



	Required for network organization	Range	Speed	Usability
Emergency Mobile Radio	◎ Only setting on devices.	○ > Few km	○ Wideband	○
Satellite	○ Setting on the ground by specialists.	◎ Anywhere	△ Portable type: Narrow Vehicle type: Broadband	△ Special equipment
Cellular network	△ Arrival of large vehicle.	△ < 1km	◎ LTE Broadband	◎ Popular cellular devices

Fig. 6 Comparison to other communication equipment.

3. Other Use Cases of SDR

3.1 Digital Radio for Fire and Rescue Service

The network of Japanese fire and rescue service has migrated from analogue to digital. While analogue networks are still active in some areas, digital radio services have started in other areas. In some cases, fire fighter teams have to work in both areas, which means they need to get their equipment connected to both networks.

The SDR-based radio can solve this issue, so that rescue teams do not need to carry two kinds of radio terminals (**Fig. 7**).

3.2 Digital Railway Radio

There are more than one hundred railway companies in Japan. Some of these companies conduct so-called "mutual direct operation"; a partnership business form that shares railways so that trains of both companies can run on railways of each other's. Nevertheless, even in sections where "mutual direct operation" is conducted, each company has their own wireless network which is different from the other company's[1]. Moreover, companies have their own analogue to digital migration plan for their network. Therefore, for example, there could be a case in which one company has already migrated to a digital system, but the other is still

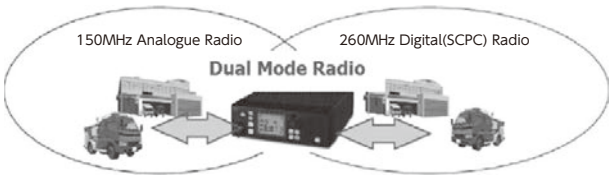


Fig. 7 Fire and rescue radio network.

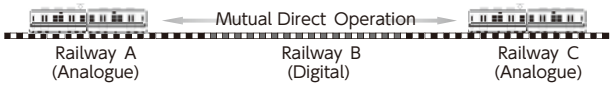


Fig. 8 Mutual direct operation.

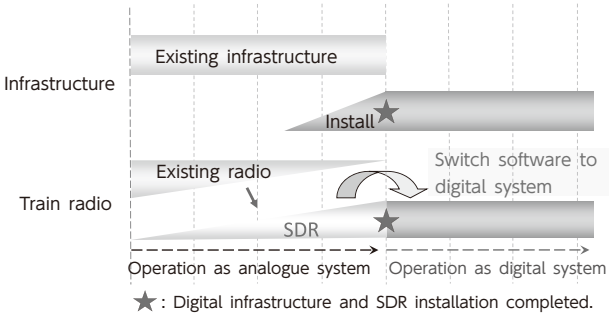


Fig. 9 Railway radio network based on SDR.

using an analog system on the same track (**Fig. 8**).

NEC proposes the SDR-based train radio to avoid maintaining two or more radios. It offers the following advantages;

- The SDR-based radio can be connected to several networks with single hardware, even in a section where "mutual direct operation" is conducted.
- The SDR-based radio can provide the same service and operability of the conventional system until a new system including base stations is completely installed (**Fig. 9**).

4. SDR Platform

NEC is going to expand the SDR business to the global market and has developed an SDR platform to respond to our customers' requests in the short term (**Fig. 10**). The SDR platform is supposed to support some globally-widespread narrowband wireless standards including TETRA and APCO P25, and to cover daily communication of public safety, transportation and other licensed mobile radio users.

5. Conclusion

There are various new demands for radio equipment

Fig. 10 SDR platform.

while increasing emphasis is placed on the importance of communication in crisis situations.

To accommodate them, NEC provides Emergency Mobile Radio that is one of the SDR-based products. This radio can form a self-organized autonomous network without any wireless infrastructure, and interoperate with other wireless networks by reloading software so that it could assist on-site information sharing with multimedia applications.

NEC is also applying the SDR technology to our radio products in ways that conform to global standards for public safety, transportation and other applications.

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* Wi-Fi is a registered trademark of Wi-Fi Alliance.

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インバリアント解析技術(SIAT)を用いたプラント故障予兆監視システム
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Vol.67 No.1
(2014年11月)

特集TOP