R&D Project of Multilayered Communications Network

-For disaster-resilient communications-

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***Abstract*— Learning from lessons of The Great East Japan Earthquake in March 2011, MIC (Ministry of Internal Affairs and Communications) of Japanese Government has initiated many R&D programs in order to establish new communications systems which are robust, resilient, and dependable in case of disaster and emergency. Our joint proposal "Multilayered communications network" by Tohoku University, KDDI R&D Laboratories, KDDI Corporation, and OKI Electric Industry has been accepted by MIC and the R&D project has started this March. The project is being carried out in collaboration with NICT (National Institute of Information and Communications Technology) and YRP (Yokosuka Research Park). This paper gives the concept of "Multilayered communications network" and introduces R&D subjects of the project.**

Keywords-Disaster-resilient communications

I. INTRODUCTION

The Great East Japan Earthquake [1] revealed many problems of communications networks during emergency. Major problems are listed below.

(1) Mobile communication had been disabled for several days due to traffic admission control of 70-95% as an unexpected volume of calls which is 50-60 times larger than normal situations occurred.
(2) Many base stations had been damaged and/or backhaul cables had been cut off in many places.
(3) Although base stations and backhaul cables were safe, batteries or fuel of emergency power generators ran out and could not be recharged or refueled because of blackouts and damages of roads.
(4) Many mobile phone users could not get fast and effective disaster information.

Among the above problems, our R&D project "Multilayered communications network" focuses on problems of (1), (2) and (4).

II. MULTILAYERED COMMUNICATIONS NETWORK

A. Traffic detour

In case of a disaster, communications services provided by commercial operators would become unavailable because of heavy traffic congestion, serious damage and/or power cable cutoff of base stations, backhaul cable cutoff, etc. An idea of the multilayered communications network is to establish a traffic detour through surviving local networks, as shown in Figure 1.

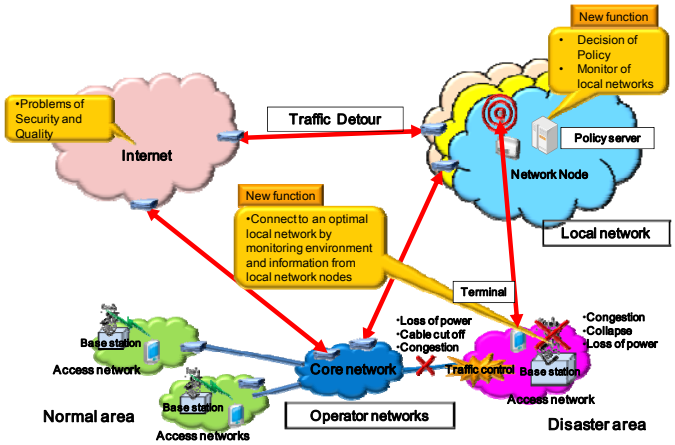

Figure 1. Traffic detour.

B. Multilayered communications network

Figure 2 illustrates a conceptual structure of the multilayered communications network consisting of four layers of (1) operator's cellular network, (2) public and private networks, (3) ITS, and (4) satellite system.

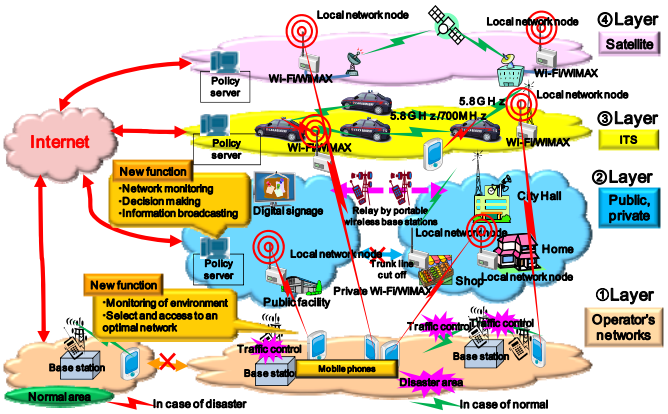

Figure 2 Conceptual structure of multilayered communications network.

In case of a disaster, the commercial operator's cellular network may fall into severe traffic congestion or is damaged. When this happens, a mobile phone will automatically connect to a surviving local network. Local networks will be private Wi-Fi, WiMAX, dedicated networks such as cable, satellite, and ITS (Intelligent Transportation Systems) networks. To enable such an autonomous network selection, a "Policy server" will be installed in each network. The policy server monitors its own network and decides whether or not the network can be open to third users based on its own network policy. Accordingly, a new function needs to be installed on mobile phones to select and access to one of the local networks. The decision is made by monitoring its surrounding radio environment and information broadcasted from the policy server of each network.

The objective of the R&D project is to establish an alternative communication route and to develop its related technologies. In this project, the commercial operator's network such as the 3G network is not considered. Security and quality of communications are also very important issues to be studied because the traffic which includes private health information, safety information, etc will detour through the Internet.

C. *Design policy*

Unfortunately, dedicated disaster communication terminals are not user friendly, since they are designed for professional staffs engaged in emergency works. On the other hand, mobile phones (recently smart phones) are widely used in daily life and can be the best "emergency terminal".

The design policy of the network is as follows.

- In case of a disaster, terminals can easily be used by almost all people to access the emergency and safety information.
- In normal situation, different networks in the multilayered network operate independently. However, in case of a disaster, each different network will become a part of the multilayered network to enable the traffic detour to the users in a damaged or over-traffic cellular network.
- For useful and effective information sharing among a group of people, the multilayered network should have functions of secure simultaneous calls and secure group calls.
- Safety-related information should be provided to a designated person such as handicapped and seniors with authentication.

III. R&D SUBJECTS

The R&D subjects can be categorized into key technologies, network technologies, and communication services. In each category, there are several sub-subjects as shown below.

A. *Network technology*

(1) Connection control of multilayered network
(2) Relay-based recovery of backhaul
(3) Ad-hoc vehicular network

B. *Key technology 1 – enhanced network protocol and routing*

(1) Network protocol optimization
(2) Routing control taking into account power supply and/or battery condition
(3) Localization of network nodes

C. *Key technology 2- dependable communication*

(1) Robust VoIP in high packet-loss environment
(2) Low-rate video transmission
(3) Quality restoration of deteriorated pictures and videos
(4) Multi-AP cooperative diversity
(5) Broadband antennas
(6) Effective intra-node data processing

D. *Communications services*

(1) Secured communications services
(2) Push type information services

IV. CONCLUSION

This paper outlined the R&D project "Multilayered communications network". This project will be carried out based on our valuable experiences of The Great East Japan Earthquake. We will develop new technologies and fruitful results which will save lives in a disaster.

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