1 Researches on New Generation Mobile Network in NICT

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R&D on new generation mobile network has attracted a growing interest over the world on the background of rapid market growth for 2nd and 3rd - generation cellular networks and wireless LANs/MANs. The National Institute of Information and Communications Technology (NICT) started the New Generation Mobile Network Project in April 2002, and has developed fundamental technologies to enable seamless and secure integration of various wireless access networks such as existing cellular networks, wireless LANs, home networks, intelligent transport systems (ITS), the Beyond-3G (B3G) cellular and other wireless access systems. This paper overviews the achievements of the project focusing on network and access technologies.

Keywords
MIRAI architecture, Seamless communications, Media handover, Mobile ring network, Mobile Ethernet, OF/TDMA, Software defined radio

1 Introduction

The past few years have seen dramatic growth in the market for second- and third-generation cellular networks and wireless LANs (WiFi). Cellular phones have become necessary devices throughout the world, and nearly all new laptop PCs are now equipped with wireless LAN modems. Moreover, in the near future we expect to see an increase in the popularity of next-generation ("Beyond 3 G," or "B3 G") cellular networks and ultra-fast wireless LANs, MANs (Metropolitan Area Networks), and WANs (Wide Area Networks). In 2005, these new systems were officially designated as "IMT-Advanced" at the study group meeting of the ITU (International Telecommunication Union)[1]. In addition to these systems, terrestrial digital broadcasting is also expected to become rapidly prevalent. We are therefore experiencing a gradual permeation of various forms of wireless network systems into our daily lives. In the future, a single user will have numerous access terminals and login IDs; as a result, when the user crosses from one network service to another, his or her devices must login from different terminals or repeat the dial-in process to continue the connection.

Guaranteeing security looms large as an issue in wireless networks. Since radio communication is basically open to all, transmissions can be received by anybody with a compatible receiver. This renders such transmissions susceptible to leakage and to malicious external interference. If the proper measures are not taken to prevent such incidents, wireless networks will remain in the realm of low reliability, unsuitable for the exchange of important communications.

If we are to find a fundamental solution to these issues, we must shift the paradigm of design from a system-centric to a human-centric (user-focused) approach. In a human-centric approach, the quality of communication will arise as a factor, to be added to the conventional strategy of simply increasing the speed and volume of transmissions. In line with this approach, our team has embarked on a research and development project on the fundamental technologies required for seamless and secure integration between different types of wireless access systems, including existing networks and future-generation networks.

The New Generation Mobile Network Project at NICT was launched in April of 2002 as a four-year project. Under the auspices of this project, we proposed a basic architecture for the integration of various wireless access networks: MIRAI (Multimedia Integrated network by Radio Access Innovation)[2]-[4]. To establish this architecture, the project focused on research and development of the following three core technologies: (1) broadband wireless transmission and software defined radio technologies, which must support transmissions at speeds exceeding 100 Mbps in mobile environments; (2) media handover technology, which will enable seamless and ubiquitous networking in mobile environments; and (3) security platform technology, which will allow for high-speed handover operations, including validation processing between heterogeneous networks. To perform validation experiments to test the effectiveness of these technologies, an outdoor testbed was constructed in the Yokosuka Research Park (YRP).

This report will describe the general outline of the project.

2 Research and development structure

The R&D efforts were conducted by three research groups: the Wireless Applications Group, the Mobile Network Group, and the Wireless Access Group. Overall planning, public relations, and event orchestration were carried out by the New Generation Mobile Project Office, and an advisory committee meeting was held once a year to solicit expert comment on the direction of the project and to report on the results of research. Additionally, a consortium was organized to promote collaboration with industry and with academia. NICT has also contracted research to telecommunication-equipment companies and telecommunication carriers in order to support research on the practical application of the system. These research groups within NICT and the external research groups conducting the contracted research work together as the “New Generation Mobile R&D Unit” and exchange information on a regular basis, as an organically connected team. Figure 1 shows the R&D organization of the unit.

We are also conducting active joint research with overseas research institutions. We have pursued joint research with, contracted research to, and exchanged researchers with the University of Aalborg (Denmark), King’s College London (Britain), the University of Surrey (Britain), Beijing University of Posts and Telecommunications (China), Tsinghua University (China), the Indian Institute of Technology (India), and Rutgers University (U.S.A). We have also held joint symposiums with Chinese and Korean counterparts, have participated and contributed to EU consortiums, and have held workshops in many Southeast Asian countries, including Thailand and Malaysia. These activities have enabled us to reconfirm, on an ongoing basis, the direction of our research with a wide perspective on global developments, and have allowed us to enhance the applicable technologies, cultivate human resources, provide technological support, and establish a foundation for international standardization.

3 System and core technologies

Figure 2 shows the concept behind the new generation mobile communication system envisioned by our project. Under this concept, cellular systems and wireless LANs of various generations, future home networks, ITS, and digital broadcasting systems will all be seamlessly and securely integrated. Our goal is to make the system available to the public by 2010. Accordingly, NICT has proposed a basic architecture to realize such a system. With this architecture, data connections and signaling connections are separated, in order to allow signaling connections to be operated

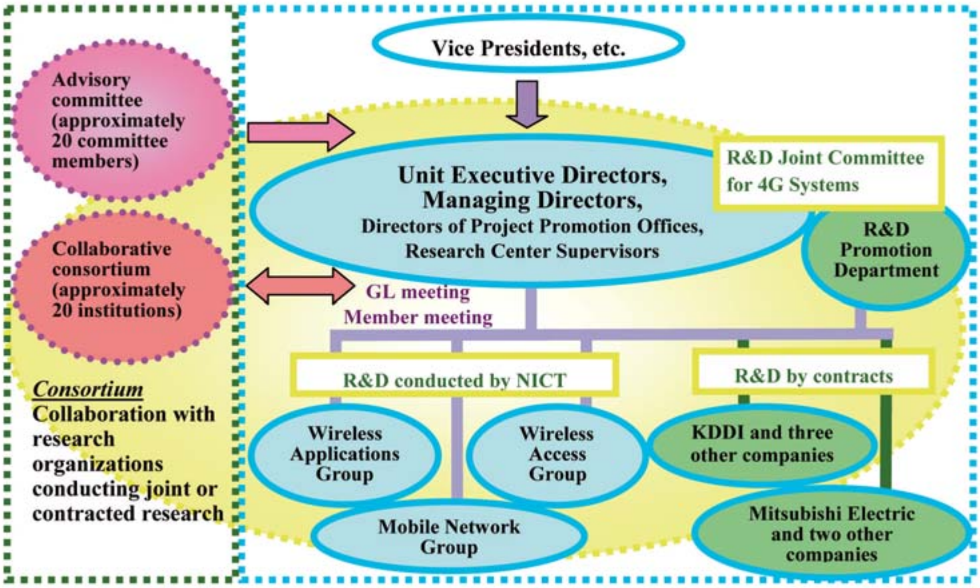

Fig.1 R&D Structure of the New Generation Mobile R&D Unit

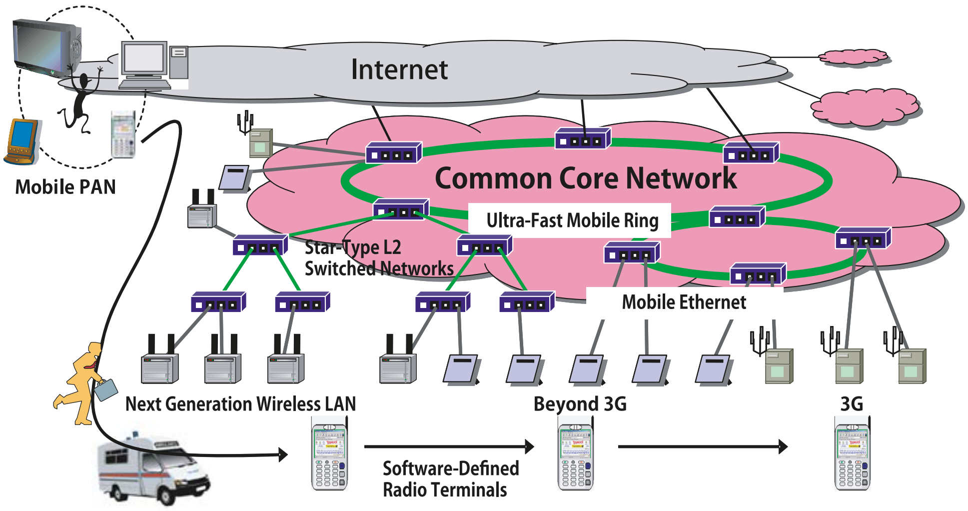

Fig.2 Concept of the New Generation Mobile Network

under communications media that differ from those of the data connection itself. This will permit us to provide a system with high QoS (Quality of Service), one that will be able to perform handover operations between heterogeneous media and adapt to changing user connections. This system has been designated "MIRAI"[2]-[4].

Interconnectivity between heterogeneous networks is realized using mobile IP technology and switching on layer 2 (L2) and layer 3 (L3)[5]. An example of a backbone suitable for such a system is seen in an ultra-fast ring network, which can cover an entire city and is capable of dispersing traffic[6]. The user terminals will require software-defined radio (SDR) technologies that will enable common hardware to be used for various communication systems simply by switching between the relevant programs[7]. This will allow users to enjoy smooth, uninterrupted communication through seamless handovers, even when crossing boundaries between different network service areas. Further, this architecture incorporates the concept of the mobile personal area network (mobile PAN) and will permit interconnections between different types of terminals, supporting handover operations between those terminals.

Below is a brief description of the core technologies on which we have focused project efforts, with the aim of realizing a new generation mobile network based on the MIRAI architecture.

(1) Wireless Security Platform Technology

This technology enables flexible and efficient security key distribution for seamless and convenient network/service authentication and privacy protection; it is to be implemented through a mobile Ethernet consisting of switching networks on L2[5]. We will work to encourage the adoption of this technology as one of the standard methods for applications such as mobile e-commerce.

(2) Media Handover Technology

This technology enables high-speed handover operations within a single network, seamless handover between heterogeneous networks, and inter-terminal handover between heterogeneous terminals—all compatible with context-aware services, which will be operated in accordance with variable user conditions (position, communication environment, terminal functions, etc.). Further, this technology will provide the QoS (Quality-of-Service) required by the respective applications[8][9].

(3) Wireless Access Technology

The goal of this technology is to allow for ultra-fast data transmission and SDR terminals. Target transmission speeds are to exceed 100 Mbps in a fast-moving environment and to surpass 1 Gbps in fixed hotspot environments[10]. The SDR terminals should enable the use of multiple communication systems on shared hardware, simply by switching between programs. On the most advanced SDR terminal prototype, third-generation cellular service using W-CDMA, IEEE802.11a wireless LAN, and terrestrial digital broadcasting are run on a single piece of hardware composed of FPGAs (Field-Programmable Gate Arrays)[7].

4 Toward standardization

One of the goals of this project is to contribute to international standardization of the relevant technologies. In 2005, NICT helped launch a new group, the IEEE802.21, aimed at the standardization of media-independent handover systems and a method for establishing interconnections between systems based on IEEE802 and all other systems, further to our successful track record in heterogeneous wireless handover technology and mobile Ethernet technology[11]. NICT will remain a regular participant as the group continues its activities until a final decision on specifications is made in 2006. Further, in the WP8F, a group that deals with B3G networks within the ITU-R, NICT has contributed to the preparation of a draft SDR technical report.

5 Comprehensive demonstration using the testbed

A testbed was constructed within the Yokosuka Research Park (YRP) for validation experiments of the developed core technologies in an outdoor environment. Figure 3 shows a bird's-eye view of the testbed. The YRP is geographically removed from urban areas and is surrounded by low mountains, thus offering a favorable environment for experiments using radio waves. The testbed consists of a network infrastructure of optical fibers, Ethernet connections, LAN switches, routers, a total of 33 poles (placed at minimum intervals of 20 m along roads and parking areas) for base stations to be affixed with wireless LAN access points, and power sources to supply electricity to the components. Further, facilities for the testing of a third-generation cellular system and a terrestrial digital UHF broadcasting system were

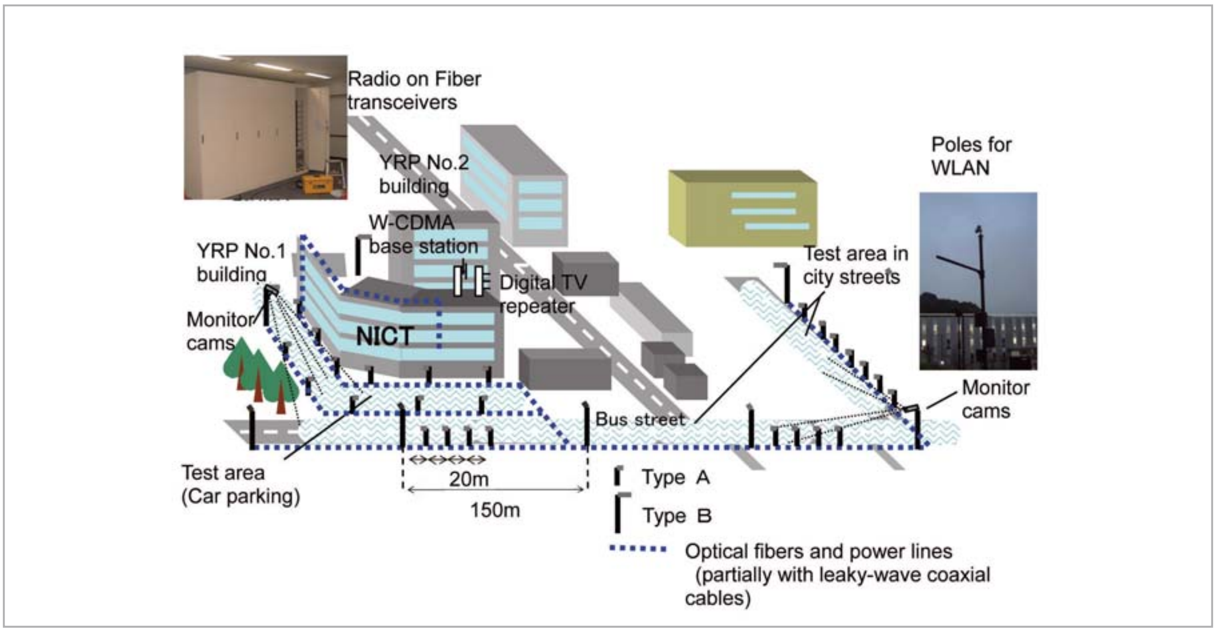

Fig.3 *Testbed constructed in the YRP*

installed on the roof of a seven-story building. These facilities were used to conduct experiments on a seamless handover technology for wireless LAN and cellular systems, as well as experiments on an SDR terminal that switches between programs for wireless LAN and broadcasting operations. The purpose of these experiments was to verify performance under conditions in which the user is riding in a vehicle.

In March 2006, in the final fiscal year of the project, we conducted a comprehensive demonstration of a prototype system using these facilities. The demonstration consisted of a tie-up project comprised of three major events—the “NICT New Generation Mobile Communications Symposium”, including a presentation of the final results of the New Generation Mobile Network Unit; “The IMT-Advanced Workshop” held by the Ministry of Internal Affairs and Communications; and the “MOCCA/WWI Workshop”, which is supported by a European Commission aimed at organizing numerous workshops around the world. The demonstration also involved a meeting of the Advisory Committee, consisting of experts outside of NICT who provided comments and advice on the project. The demonstration was well-attended, with visitors both from within Japan and from abroad (Fig. 4).

6 Conclusions

This paper presented an overview of the activities of the New Generation Mobile Network Project, which began in fiscal 2002 as a four-year project, and introduced readers to MIRAI, a basic architecture proposed for new generation mobile networks, as well as the core technologies required to put this architecture to use. We also described the testbed constructed at the YRP and summarized a comprehensive demonstration of the core technologies using this testbed.

We plan to proceed with further integration and progress in the core technologies accumulated throughout the course of this project. We will apply our results to R&D of a “cognitive wireless technology”, one that will automatically recognize the surrounding environment, perform selection and handover to the optimal media networks, and autonomously establish the required wireless connections. These technologies can be expected to contribute to an enriched and more convenient daily life, as well as providing for greater safety throughout society, through application to

Fig.4 *Scene from comprehensive demonstration and symposium*

systems for stable and uninterrupted wireless connection during disasters.

Acknowledgements

We are deeply grateful to the former director of the Yokosuka Radio Communications Research Center and to all NICT personnel involved in the project, and would additionally like to thank the members of the Advisory Committee for their valuable advice and guidance on the direction of research.

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