CURRENT RESEARCH ACTIVITIES ON COGNITIVE RADIO FOR u-Japan

Hiroshi Harada† and Yukitoshi Sanada‡

†National Institute of Information and Communications Technology (NICT)
3-4 Hikarino-oka, Yokosuka, Kanagawa, 239-0847 Japan
E-mail: harada@nict.go.jp
‡Dept. of Electronics and Electrical Engineering, Keio University
3-14-1 Hiyoshi, Kohoku, Yokohama, 223-8522 Japan
E-mail: sanada@elec.keio.ac.jp

Abstract

In 2004, Ministry of Internal Affairs and Communications (MIC) in Japan announced a new IT strategy called "u-Japan". This strategy is aiming to realize a ubiquitous network society by 2010. Based on the previous strategy called "e-Japan", started in 2001, broadband network has been popularized all over Japan. The object of next stage is to realize a comfortable network environment with Information & Communication Technology (ICT). In this environment everyone and everything are connected to the network anytime and anywhere.

Following u-Japan strategy, MIC has been promoting research and development of ICT. One of the key issues is the development of seamless connectivity between various networks including wire and wireless.

In this paper many research efforts of SDR towards u-Japan are introduced. In 1999, Software Defined Radio study group was formed under Communication Society of IEICE. In this study group, many research results of SDR have been presented and discussed, which include antenna, circuits, signal processing, operating system, security and so on.

1. From e-Japan to u-Japan

In 2004, Japanese ministry of internal affairs and communications (MIC) announced a new IT strategy called "u-Japan"[1]. This strategy is aiming to realize a ubiquitous network society by 2010. Based on the previous strategy called "e-Japan", started in 2001, broadband network has been popularised all over Japan.

Fig. 1 shows the achievements of u-Japan strategy from the aspects of infrastructure[2]. The population coverage of Internet users increases rapidly and especially the number of high-speed Internet users grows more than 20 times. Japanese government promoted online procedures for filing electric applications/notifications and the ratio of online transactions of stock exchange increases about 4 times.

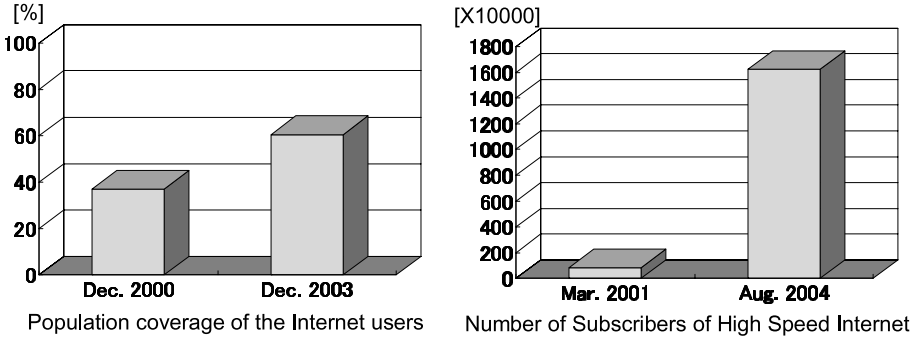

Figure 1: Achievements of e-Japan strategy.

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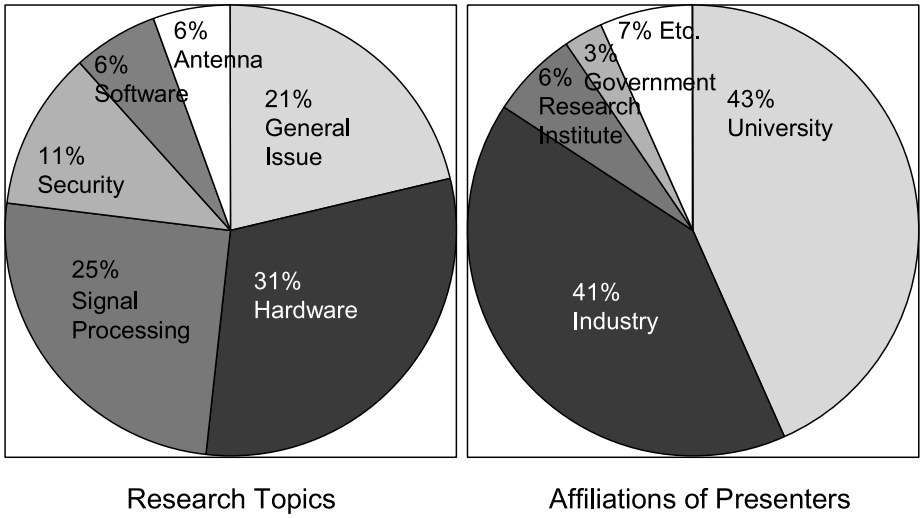


Figure 2: Presented research topics and affiliations of presenter at IEICE SDR Study Group.

The object of next stage is to realize a comfortable network environment with Information & Communication Technology (ICT). In this environment everyone and everything are connected to the network anytime and anywhere. "Universal," "user-oriented" and "unique" services will be brought about as an expected result of such ubiquitous ICT infrastructure.

2. ICT Policy Principles and Cognitive Radio

Following u-Japan strategy, MIC has been promoting research and development of ICT. In the FY2005 policy principles, one of the pillars is "Realization of a society in which networks are comfortably used anytime, anywhere". Especially, realization of confortable wireless and seampless conectivity is one of the key issues. On the other hand, radio spectrum is the limited and scarce resource, and the efficient use of spectrum is desireble.

In Oct. 2004, the final report of the Study Group on Policies Concerning the Effective Radio Spectrum Use was released [3]. Main pillars of the concepts are

- To consider economic values of radio spectrums upon calculation of the Spectrum User Fee for encouraging the effective radio spectrum use; and
- By utilising the Spectrum User Fee in addition to the general account budget;
  - To double available frequencies through intensive and strengthened R&D for supporting a foundation of the development of the wireless industry; as well as
  - To narrow the digital divide in cellular telephones, etc. so as to help the people in Japan benefit from the use of radio spectrums as common resources of the Japanese nationals.

In this report, cognitive radio and software defined radio (SDR) as its realization technology are addressed as one of the key R&D topics [4]. Cognitive radio has been investigated in order to double the spectrum efficiency especially in the frequency of less than 6 GHz.

3. R&D Activities of SDR in Japan

There are many researches on SDR towards u-Japan have been carried out. In 1999, Software Defined Radio study group was formed under Communication Society of IEICE. In this study group, many research results of SDR have been presented, which include antenna, circuits, signal processing, operating system, security and so on. Figure 2 shows the ratio of research topics and affiliations of presenter at IEICE SDR study group. There are 178 presentations in 6 years. In the figure, "General Issue" means the issues about the research or market trends, and so on. From the figure, it is clear that the large part of the researches is focusing on hardware issues, including

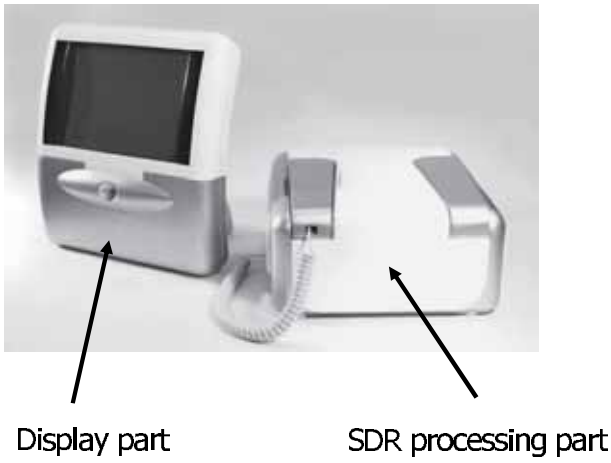


Figure 3: SDR Prototype for W-CDMA and IEEE802.11a WLAN.

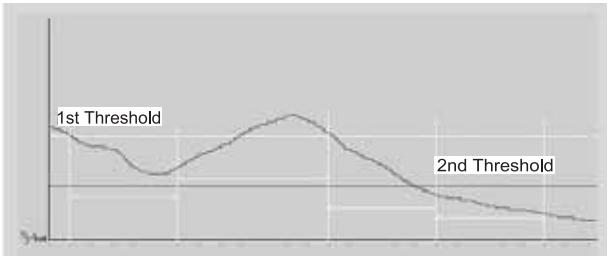


Figure 4: Double Threshold for Software Switching.

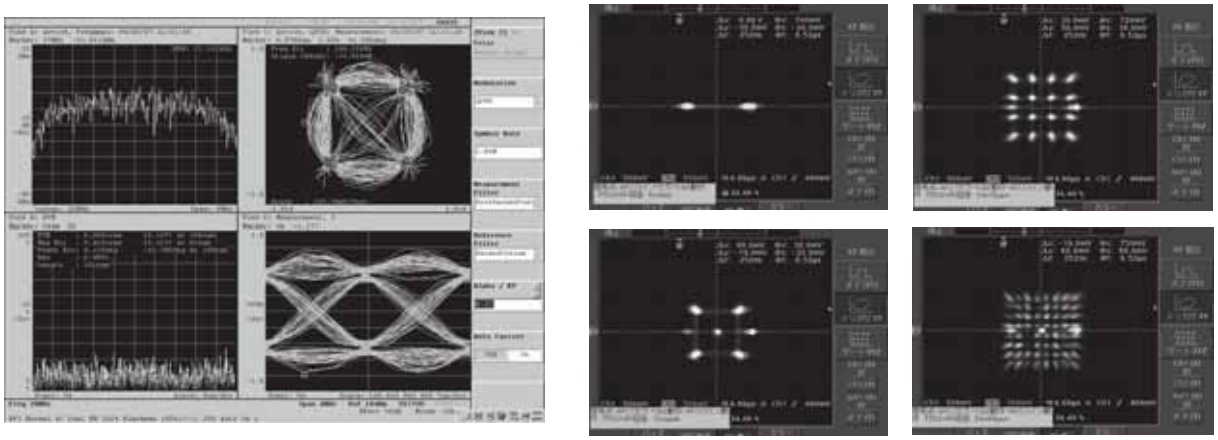
A/D conversion, processing unit, hardware architecture, and so on. The second largest part of the research topics are about signal processing, including modulation and demodulation, coding, filtering, and so on. It is clear that the research about software languages or operating systems for SDR have not been actively investigated in this study group. it is aslo clear that about 40% of the research results are presented from universities and almost the same amount of research results are from industry.

4. Prototype for W-CDMA and IEEE802.11a

As an example of the research and development on SDR, a prototype for W-CDMA and IEEE802.11a Wireless LAN is presented in this section. Fig. 4 shows the configuration of the prototype. National Institute of Information and Communications Technology (NICT) has researched SDR-based radio terminal since 1997 and this is the third prototype terminal. This prototype is for the new generation mobile communications system which is functional integration of mobile communications systems including cellular and high-speed mobile wireless access systems, non-wireless systems, and broadcast communication systems to enhance inter-system compatibility. The prototype consists of general purpose FPGA, CPU, and RF boards. It is possible to communicate with W-CDMA BST and access point for wireless LAN.

Software modules for W-CDMA and IEEE802.11a are prepared. The software package for W-CDMA consists of software for two FPGAs and software for CPU. In PFGA1 coding and decoding software is installed and in FPGA2 modulation and demodulation software is installed. The rest of the functions for W-CDMA is implemented in CPU. The software package for IEEE802.11a also consists of softwares for two FPGAs and CPU. In FPGA1 CPU interface software is installed and in FPGA2 modulation and demodulation software is installed. The rest of the functions are also realized by the CPU.

The software can be switched manually or automatically. In the automatic selection mode, the prototype terminal observes the strength of the received signal, bit error rate (BER), frame error rate (FER), and so on.



Waveform of W-CDMA

Waveform of IEEE802.11a

Figure 5: Transmission Waveform.

When each/all/some of these parameters crosses the first threshold, the terminal starts to prepare for the software switching. When these parameters crosses the second threshold, the terminal changes communication system by changing software. To change the system, the systems are prioritised based on the information set up. Fig 5 shows transmission waveforms of W-CDMA and IEEE802.11a.

5. Conclusions

This paper introduces the current status of promotion policies on ICT in Japan and the position of SDR and cognitive radio technologies. Also the brief history and current situation of reseach activities on SDR in Japan is explained. As an example of the SDR protptypes, the prototype terminal for W-CDMA and IEEE802.11a WLAN developed in NICT is presented.

References

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