Overview of Japanese Activities in Software Defined Radio

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Abstract: In this paper we will present an overview of the Japanese IEICE Software Radio study group activities since it was established in December 1998. An overview of prototype Software Radio Demodulators developed in Japan will be presented. Details of some papers presented at the most recent IEICE Software Radio are outlined, and the paper will be concluded by summarizing the work being undertaken in the SDR field in Japan.

1. IEICE Software Radio Study Group

In the last few years there has been considerable interest worldwide in the field of Software Radio [1, 2, 3]. There has been great interest in Japan as well, and therefore the IEICE Software Radio Study Group was established in December, 1998 as part of the Communication Society within the IEICE.

The purpose of the IEICE software radio study group is to promote research and development in the field of Software Defined or Reconfigurable Radio, to allow protocol software and hardware to be easily integrated along with future digital radio transceiver, to foster cross-organization collaboration between protocol and hardware developers, and to organize national and international workshops on Software Defined Radio.

The subjects covered by IEICE Software Radio Study Group include but are not limited to the following:

- Theory of software radio
- Software and hardware technology for use in software radio
- Applications to communications, broadcasting, ITS etc.
- Research of API (Application Programming Interface)
- Standardization of software radio
- Information exchange and cooperation with active organizations in other countries

At present the main committee members of the IEICE Software Radio Study Group are as shown in Table 1. below.

Table 1. Main committee members of the IEICE Software Radio Study Group in Japan for 2000

Position	Name	Organization
Chair	Ryuji Kohno	Yokohama National University
Secretaries	Shinichiro Haruyama	Sony Computer Science Lab.
	Ryu Miura	MPT Communications Research Lab.
Assistant Secretaries	Hiroshi Harada	MPT Communications Research Lab.
	Yukitoshi Sanada	Sony Computer Science Lab.

1.1 Schedule of IEICE Software Radio Study Group in 1999

After the IEICE Software Radio Study Group was formed in December 1998, the first technical committee meeting took place on January 27, 1999. Following that, three technical meetings were held during the year, and one panel session was organized during PIMRC'99 in Osaka.

Jan. 27 The first technical committee meeting (Tokyo)
Mar. 11 The first technical meeting and Workshop (Yokosuka Research Park) together with the SDR Forum (March 9-11).
June 30 The second technical meeting (Nagoya)
Sept. Panel session (Osaka) : It was done as a session in the PIMRC'99 conference (10th International Symposium on Personal, Indoor and Mobile Radio Communications).
Nov. 17 The third technical meeting (Nagoya)

1.2 Schedule of IEICE Software Radio Study Group in 2000

The activities already undertaken in 2000 include two technical meetings and a panel session within the VTC 2000 (Spring) conference held in Tokyo. A panel session and symposium in Nagoya and a technical meeting in Tokyo are planned for the latter part of the year.

April 17 4th technical meeting and Workshop (Yokosuka Research Park) together with the SDR Forum.
May Panel session at VTC (Vehicular Technology Conference) 2000 in Shinagawa (Tokyo)
July 21 5th technical meeting (Yokohama)
Sept. 30 Panel session and symposium (Nagoya)
Oct. 20 6th technical meeting (Tokyo)

So far, there have been 36 regular technical papers, 12 invited presentations and 1 panel session organized in the 5 technical meetings held since the study groups inception.

Table 2, following, is a list of the issues to be discussed at the technical meetings.

Table 2. A list of the issues to be discussed at the IEICE Software Radio Study Group in Japan

General	Applications of SDR which are suitable for Japanese wireless communication environment
	Harmonization between SDR Forum and Japanese SR activities
	Introduction of SDR to Japanese researchers and industry
	Backward compatibility between the generations of the cellular standards
	Contribution to the Forum standard (Prototypes)
	Contribution to the regulatory issues in MPT
	Multiple wireless services for ITS application
	Definition of wireless systems
	Authentication and encryption
	Stratospheric platform
	Observation of illegal radio wave emission
	Intellectual property aspects
	Promotion of the SDR activities in Japan
Protocols	Software download protocols
	Reconfigurable protocols
Architecture	Hardware architecture
	Software architecture (APIs)
Devices	Antenna
	RF, IF filter
	A/D, D/A converter
	DSP, FPGA
	Battery

2. Overview of the Prototype Software Radio Demodulators Developed in Japan

The software radio described in Table 3 was developed by NTT (Nippon Telegraph and Telephone). It has a software base station and a personal station system using a system with the Japanese standard PHS (Personal Handyphone System). They implemented an over-the-air software download function [4].

The software radio prototype described in Table 4was developed by CRL

Table 3. Prototype Software Radio Demodulators developed by NTT

RF frequency	2.45 GHz Band
Bandwidth	13 MHz
Down conversion	Double super heterodyne
IF frequency(First/Second)	215/39 MHz
IF input frequency	100 MHz Max.
Access type	TDD
Sampling method	IF sampling (Under sampling)
DSP	6400 MIPS
Features	3 RF inputs for an array antenna, Multi-mode operation, PHS-like protocol, Modulation recognition capability

Table 4. Prototype Software Radio Demodulator developed by CRL

RF Frequency:	1.6/1.9/5.8 GHz band
Bandwidth:	8 MHz
Modulation scheme:	BPSK, QPSK, π/4-QPSK, GMSK, ASK
Symbol rate:	192 ksps (BPSK, QPSK, π/4-QPSK) 270.833 ksps (GMSK) 1024 ksps ETC (ASK)
A/D Converter:	10 bit / 60 MHz
D/A Converter:	14 bit /50 MHz
DSP:	200 MHz $\times$ 4
Features:	Triple mode (PHS/GPS/ETC), Parameter Controlled Software Radio (Filter,Equalizer,Detector,Decoder)

Table 5. Prototype Software Radio Demodulator developed by Toshiba

RF Frequency:	1.5/1.9 GHz band
Bandwidth:	10 MHz
Down conversion:	Direct conversion
Modulation scheme:	n-PSK, π/4-QPSK, GMSK, MSK
Symbol rate:	384 ksps (π/4-QPSK) 270.833 ksps (GMSK)
A/D Converter:	10 bit / 64 MHz
DSP:	166 MHz
Features:	Direct Conversion

Table 6. Prototype Software Radio Demodulators developed by CRL and Sony/Tektronix.

Modulation schemes:	QPSK, 16QAM-OFDM
Number of carriers:	108
Carrier interval:	4 kHz
IFFT size:	2048
Symbol length:	250μsec
Frame length:	4.5 msec (16 symbol/Frame)
Guard interval:	1/8 (31.25μsec)
Features:	Digital TV test bed, Channel measurement

Table 7. Prototype Software Radio Demodulator developed by Toyo Communication Equipment Co. and Tohoku Elect. Power Co.

Modulation schemes:	FM, FSK, BPSK, QPSK, π/4-QPSK
RF frequency:	370-380 MHz
IF frequency (Tx/Rx):	10-20 MHz / 65-75 MHz (BW 10 MHz)
A/D Converter:	12 bits / 40 MHz
D/A Converter:	12 bits / 40 MHz
Sampling method:	IF sampling
DSP:	320 Mflops/board
Features:	For an intelligent base station, Software download capability

Table 8. Prototype Software Radio Demodulator developed by Anritsu Co. and NEC Co.

Modulation schemes	AM, FM, FSK, MSK, GMSK, BPSK, QPSK, π/4-QPSK, 8-PSK, 16QAM
Access type	TDMA, SCPC
Symbol rate	10 M symbol/sec Max.
Speech codec	32 kbit/sec ADPCM, CVSD-DM
Communication protocol	RCR-STD-28(PHS)
Sampling method	IF sampling (Under sampling)
IF input frequency	100MHz Max.
Software Download	via LAN
Features	Modulation recognition capability, Envelope analysis

with the purpose of multiple mode (PHS, GPS and ETC: Electronic Toll Collection) communications targeted at vehicles [5].

A software radio using down conversion outlined in Table 5 was developed by Toshiba using the near-IF method [6].

The programmable real-time system [7]shown in Table 2. was developed to test various OFDM scenarios for the DTTB (Digital Television Terrestrial Broadcast) which is expected to start in Japan soon.

The prototype software radio demodulator shown in Table 2. was first developed in 1998, and now being used to test automatic extraction and demodulation of unknown communication signals [9].

3. Details of Technical Meeting of IEICE

3.1 Software Radio Study Group, July 21, 2000

The following are short summaries of some of the papers presented at the most recent software radio study group held at Keio University, Yokohama, Japan in July 2000.

H. Yoshioka et al (NTT) presented research about automatic modulation recognition for software radio. They propose a recognition method based on the nearest neighbor rule. They changed the boundaries between different modulation methods when they added AWGN to the modulation prototype to improve recognition. By computer simulation they showed the effectiveness of their proposal [11].

S. Ishii (YNU) et al proposed a space hopping scheme which can realize a low cost smart antenna, since it requires only one RF circuit. In this paper they discuss DOA estimation for their circuit and ways to overcome degradation of estimation accuracy [12].

K. Ikemoto (YNU) et al proposed adaptive block coding and decoding for software defined radio. Their system improves the transmission efficiency. They achieve reduction in the number of control symbols by using encoder information. In order to reduce the DSE (Detection Selection Error) they propose a decoder scheme which estimates the encoder considering the encoder transition from the transmitter [13].

K. Umebayashi (YNU) et al investigated blind modulation estimation with carrier frequency offset. Generally perfect carrier and symbol synchronization is assumed, but in this paper they assume perfect symbol synchronization but have examined carrier offset. Using each symbol's phase difference it was possible to show that improvement on modulation estimation accuracy is achievable. Several algorithms are evaluated by computer simulation [14].

4. Summary

– Since starting in 1999, 36 regular technical presentations and 12 invited talks have been made at 5 IEICE Software Radio Study Group technical meetings

– Various prototypes of software radios have been developed by companies such as NTT, Toshiba, CRL, Sony/Textronix, Toyo Communication and Anritsu
– Theoretical research has been ongoing, particularly at Yokohama National University
– Many invited speakers from the SDR forum and leading software radio companies from overseas have made presentations.

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