NEWS RELEASE

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Press Release

NTT Developed Software Defined Radio Usable for Various Wireless Systems Including PHS and Wireless LAN

--- Seamless communications will be realized by downloading software to match the locale and user requirement ---

Nippon Telegraph and Telephone Corporation (NTT) announces the successful development of a software defined radio (SDR) prototype that supports both low-speed PHS (Personal Handy phone System) and a high-speed and broadband wireless LAN. SDR is a new technology that can handle various kinds of wireless systems with single terminal by changing software to reconfigure the functions of the terminal. Conventional SDR prototypes support only narrow bandwidth (up to few 100 kHz) systems such as PHS, which uses the TDMA (Time Division Multiple Access) scheme. They can not handle wireless LAN systems that use the direct sequence spread spectrum (DSSS) scheme since their architectures fail to achieve the required bandwidths of more than 20 MHz. However, this prototype, developed by NTT Network Innovation Laboratories, can support both PHS and wireless LANs because it uses novel wideband flexible-rate pre-/post-processors (FR-PPP) (Fig. 1). These latest results show that SDR will allow a single terminal to cover second and third generation mobile systems, as well as higher-speed and broader-bandwidth wireless systems such as wireless LANs. In addition, an over-the-air download function has been implemented. This new function allows users to update and/or bug-fix the terminals even when they are at home.

Development Background

Japan currently uses second generation (2G) mobile systems such as PDC and PHS, and a third generation (3G) mobile system, W-CDMA, which started commercial service this October. In addition, next generation mobile systems that can offer higher data-rates from several tens of Mbit/s to 100 Mbit/s, are being developed. This complex situation is mirrored overseas where many kinds of mobile systems, GSM ,AMPS, etc., are in use. In addition to these public mobile services, many private systems such as IEEE802.11x wireless LANs and Bluetooth have become popular used. The users need to buy a dedicated terminal for each system because these systems have their own specification: frequency, modulation and demodulation schemes, and communication protocol. Also the coverage of these systems is restricted to specific areas. SDR is seen as the best technology with which to achieve seamless mobile communication. Figure 2 shows an image of the future as realized by the SDR technology.

Technical Features

General radio sets consist of three stages: radio frequency (RF), intermediate frequency

(IF), and baseband (BB) stages. In our SDR prototype, the IF and BB stages were completely constructed as programmable devices (Fig. 3).

1) The programmable IF stage ("FR-PPP")
The RF signal received by the antenna is down-converted by analog circuits to an IF signal, and then analog-to-digital converted. The digital IF signal has too high a data-rate to be processed by BB processors, so pre-/post-processors (PPP's) are used to realize the high-speed real-time digital processes, which include filtering, waveform-shaping, and spectrum de-spreading, required.
The newly proposed flexible-rate pre-/post-processor (FR-PPP) consists of field programmable gate arrays (FPGA's) and direct digital synthesizer (DDS). An FPGA is a programmable device that can be reconfigured by rewriting its configuration data. Conventional PPP's are composed of preset parameter hard-wired circuits including various kinds of filters to support the wireless systems targeted. Therefore, their circuit scale is excessive. On the other hand, the FR-PPP is much smaller because the FPGA can flexibly act as the filters needed for each system. In addition, while conventional PPP's use complicated interpolation circuits to support the various clock-rates of the targeted wireless systems, the DDS in the FR-PPP directly generates the clock-rates demanded in an arbitrary manner. This also reduces the circuit scale and offers high-speed operation. These breakthroughs realize a wide-bandwidth and very flexible SDR that can support wireless LANs as well as 2G systems such as the PHS.

2) Realizing the programmable BB stage
We use a microprocessor (MPU) and digital signal processors (DSP's) to implement baseband (BB) processing and control. The MPU, a 400 MHz PowerPC, can handle high-layer protocols including PHS call control and medium access control (MAC) for the wireless LAN. Physical layer processes such as modulation, demodulation, etc., are handled by the DSP's. Each DSP offers the computational power of 1,600 MIPS, and transmitting and receiving processes are each performed by one DSP.
The SDR prototype operates as the terminal of a specific wireless system after downloading the software of the system into these processors. The programs were written in the C programming language and the Verilog hardware definition language. The programs written for the prototype reproduce all of the key operating functions offered by the regular commercial terminals.
An over-the-air download function was successfully implemented. Its protocol is very general and compact because it is based on TCP/IP and uses the physical layer of the operating wireless system. To ensure secure downloads, the 128-bit next-generation block cipher "Camellia," which was co-developed by NTT and Mitsubishi Electric Corporation, was implemented in the protocol.

Future Developments

When realizing SDR mobile terminals, hardware and software overheads should be minimized because the market requires small and low power-consumption equipment. The processing power and power-consumption of programmable processors must be improved. NTT research and development will realize an SDR mobile terminal whose size, cost, and power-consumption rival those of current mobile terminals.

Terminology

GSM: Global System for Mobile communications. A European standard, it has become the most popular digital mobile phone system in the world. The service started

in 1992, and is currently being used by more than 200 cellular operators in about 130 countries.

AMPS: Advanced Mobile Phone Service. An analog mobile phone system that was standardized in the U.S. It is widely used in Canada, South America, and Asia, as well as the U.S. The system uses the 800 MHz frequency band.

PPP: Pre-/Post-Processors. They lie between analog-to-digital/digital-to-analog converters and baseband processors to pre-process and post-process the high-speed real-time signals. The high-speed processes include channeling, filtering, rate-conversion, and so on.

DDS: Direct Digital Synthesizer. A kind of oscillator whose frequency is directly controlled by a digital signal.

Filtering: The use of filters to extract only the desired spectrum from a wide-band spectrum.

Waveform shaping: An operation to shape a signal spectrum to the desired form by using filters. In digital wireless communications, in order to suppress inter-symbol interference and improve bit-error rate, waveform shaping is performed by cosine roll-off filters.

Spread spectrum: The direct sequence spread spectrum (DSSS) scheme widens the data spectrum to be transmitted by directly multiplying it by another wider spectrum. The frequency hopping spread spectrum (FHSS) scheme randomly switches the frequency of the data spectrum in a given bandwidth. The operation of extracting the data spectrum from the spread spectrum is called spectrum de-spreading. These SS technologies are used in wireless LANs and CDMA systems.

- Fig. 1 Points of interest
- Fig. 2 The future as realized by SDR technology
- Fig. 3 Block diagram of prototype

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