Wideband Spread Spectrum Modulation System for Ubiquitous Communication Services

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Abstract: - A wideband spread spectrum (SS) system is proposed in this paper for a radio air interface scheme of a ubiquitous network system.

Ubiquitous network system is highly reactive to provide sufficient information for anybody, anytime, and anywhere for daily lives, business, and scientific utilities.

This radio system is composed of wideband modulation, coherent demodulation, advanced synchronization based on a matched filter system, and interference canceller for enhanced capacity.

In this paper, concept of ubiquitous communication network is clarified. A wideband transmission scheme of spread spectrum (SS) modulation with code division multiple access (CDMA) scheme is proposed for radio air interface. Prototype hardware was implemented and validated for this scheme.

Key-Words: - SS modulation, coherent demodulation, reliable synchronization, digital matched filter, variable data rate

1 Introduction

The mobile communication plays important role of public communication services for business and civil life.

The government and industries are attended to the development of ubiquitous communications as the post cellular mobile phone in Japan. Seamless network technologies are subjected as the most important term for the system.

The orthogonal frequency division multiple access (OFDM) scheme and the multilevel modulation technologies are intended for data and radio frequency modulations respectively. The enhancement of communication capacity is not expected by the multilevel modem technologies under multipath radio propagation condition. This estimation was confirmed by practical field evaluation against proposed mobile phone systems by NTT DoCoMo.

In this paper, basic concept and system design are presented for the next generation ubiquitous mobile communication services followed with technical feature.

2 A Ubiquitous Communication Network System

Communication, information (IT), and broadcasting have been separated services provided to citizen conventionally. They are now expected to be unified and merged to support near future the citizen lives.

Great parts of citizen are well furnished with compact equipments for communication. Personal computers are also popular for business life in the office, but they are limited for mobile use. One of the pointed problems for IT area is the matter of digital divide among citizens in daily life. One of the problems of computers is the engineering problem to provide compact equipment with high performance and small power exemption. The other is difficulties of handling of computers. The target of this studies is to provide technologies merging the communication and the IT for public people use.

Ubiquitous communication network system is provided both of advanced communication and computer technologies.

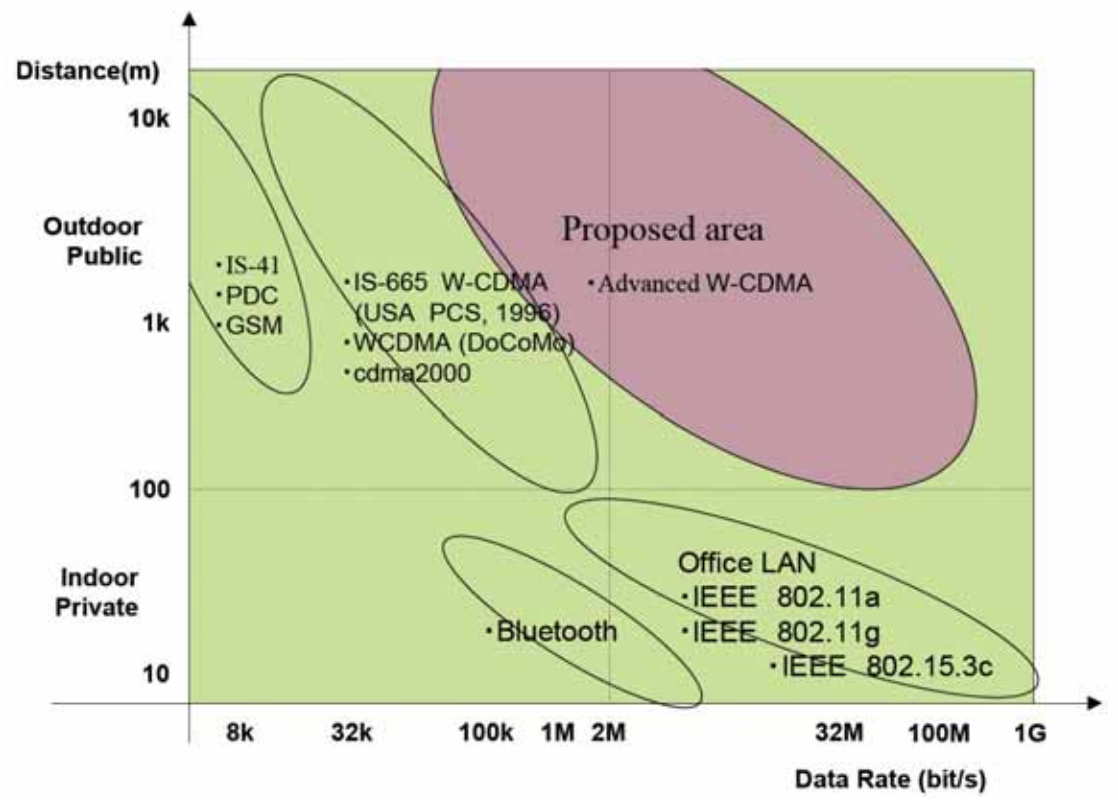


Fig. 1 Applied area of the proposed radio air interface.

2.1 Wideband Mobile Radio System

Initial video services are introduced in cellular mobile system to enhance the capability of communications. These services are limited in size of contents, which lead to reduce display size and text based internet menu etc. Scaling up of picture size degrades its quality rapidly.

Applied area of the proposed radio air interface is shown in Fig. 1. The horizontal and vertical axes are data rate (bit / s) and distance of communication (m) respectively. The low area is assumed to radio LANs. This study intends to be applied to public mobile communications drown on the upper part of Fig.1.

2.2 Embedded Computer System

Data processing capabilities are also enhanced by the progress of semi-conductor MPU. The knowledge on IT technologies including soft wares and operations should be enough to utilize these processors as general computer [1].

3 Wideband Radio System

3.1 Microwave Frequency Allocation and Bandwidth

Micro wave diffraction is essentially expected against relief of terrain and buildings, propagation distance is about 1~several kilometers for public mobile communications. The frequency band should be allocated at 1~3.5 GHz (wavelength 3~1 meters). Figure 2 illustrates transition of microwave and frequency bandwidth. In this study the suitable frequency band is 3~3.6 GHz, and the frequency bandwidth is 40 MHz, if needed up to 100MHz for download of broadband data and high quality pictures.

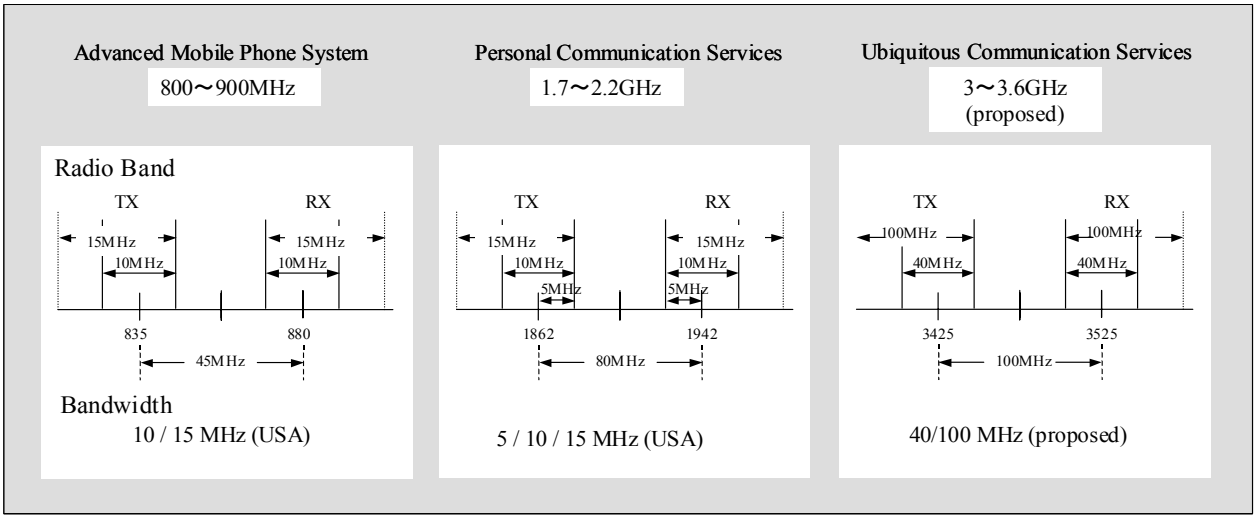
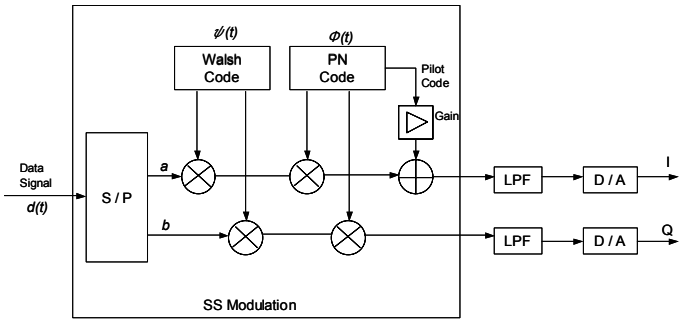
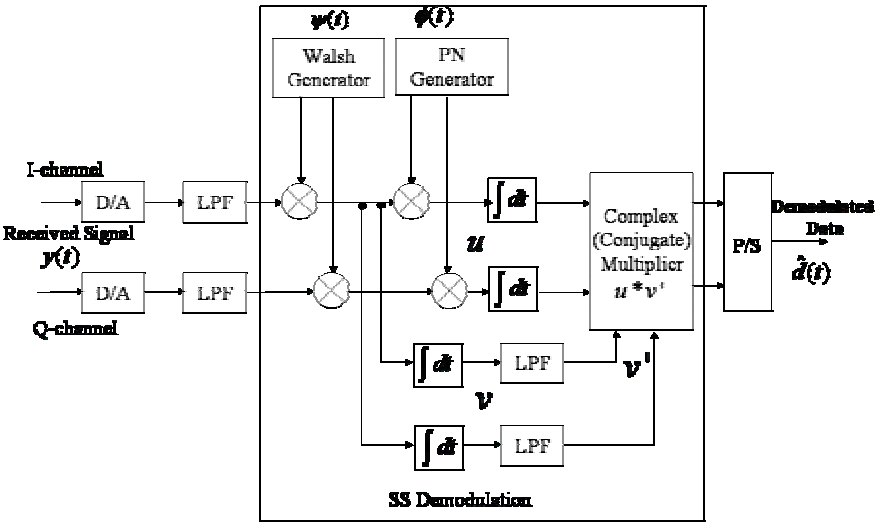


Fig.2 Microwave frequency band and bandwidth assigned for mobile communication systems.



(a) Configuration of Wideband SS modulation.



(b) Configuration of Wideband SS demodulation.

Fig. 3 Configuration of Wideband Spread Spectrum scheme.

3.2 Wideband SS Modulation and Demodulation

Basic configuration is shown in Fig.3 for the ubiquitous communication system [2][3][4][5]. Configuration of the radio system is secondly described. In this system a pilot signal is transmitted for system synchronization and coherent demodulation. Correlation of received signal and the replica of the pilot signals are calculated to generate clock signals for the later processing after this clock signal. Accuracy and resolution of this correlation output specifies the characteristics of vector combining of multipath components of radio propagation.

3.3 Matched Filter System

Extremely short time of data processing is required especially for synchronization and coherent demodulation compared to other processing and operations.

Over sampling and long timeframe are needed to extract correlation peaks with fine resolution and precise value of time.

It is found by computer simulation of synchronization, one sampling times 1024 chips is required for cell synchronization (cell site and mobile), four sampling times and 256 chips for path synchronization (radio propagate paths between cell site and mobile) are needed at least. The resolution of time of path synchronization is required for vector combining of multiple paths.

A matched filter system is developed and introduced into synchronization and demodulation in this scheme [6][7][8][9].

3.4 Synchronization and Demodulation Based on Matched Filters

A new structure has been proposed utilizing parallel matched filter for synchronization and demodulation. Due to multipath propagation and Doppler effect , it is important to establish accurate synchronization. A new scheme is provided for synchronization to improve characteristics using a delay profile with reduced steps of processing. A parallel matched filter is configured by analog MOS LSI instead of conventional digital components. The power consumption and dimension of the LSI are reduced effectively by the mixed approach of the system and the hardware. Finally, this paper describes feasibility of the high speed data transmission on the W-CDMA system.

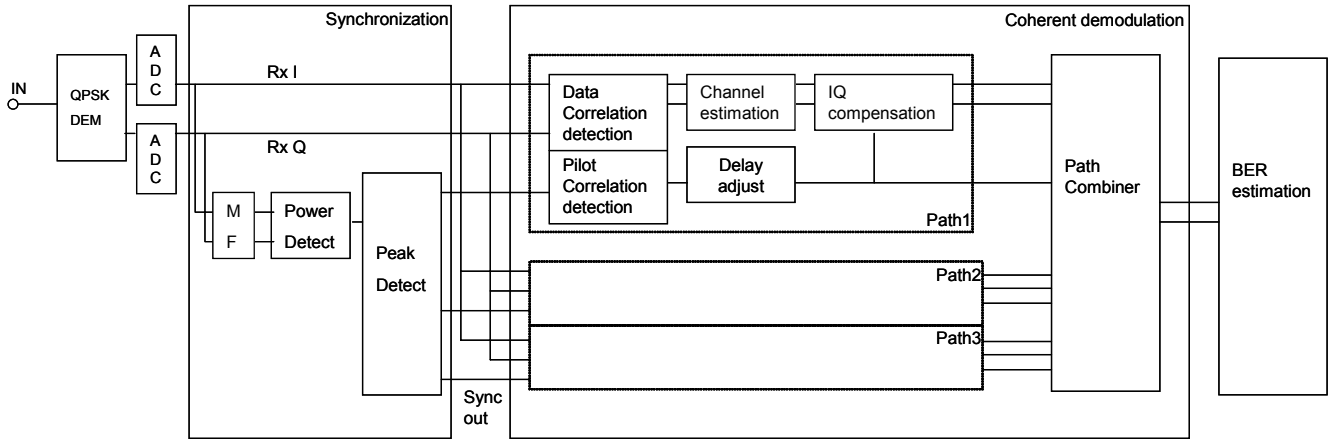


Fig. 4 Configuration of synchronization and coherent demodulation for the proposed W-CDMA.

4 Radio System Design and a Prototype Hardware

4.1 Radio System Design

The W-CDMA was first presented for the personal communication services by the authors [10][11][12][13]. This scheme is featured by spectrum spreading to radio frequency wideband, and coherent demodulation by using a pilot channel. The system configuration of the proposed W-CDMA is shown in Fig.4.

Coherent demodulation scheme is composed as follows. (i)Continuous pilot signal is transmitted through a pilot channel, (ii) the pilot channel is composed of O-QPSK and QPSK for reverse and forward links respectively, (iii) pilot signal is added in each I channel of O-QPSK and QPSK, (iv) coherent demodulation is achieved by estimation and compensation of phase rotation using the pilot channel.

Phase rotation and its linearity has been estimated for QPSK and O-QPSK data modulation methods. The constellation on the complex plane is used for the evaluation of phase rotation, and the Eye pattern for the demodulated waveforms. The bit-error-rate (BER) vs. Eb/N0 is used for the characteristics of data modulation / demodulation and SS modulation / demodulation of the proposed radio system.

Interference canceller is also studied for increased capacity in future. This also is based on the pilot channel to decide timing of each component of matrix of radio channel models with multiple transceiver.

4.2 Implementation of Prototype Model

Complex and large quantity of processing steps is actualized by field programmable gate array (FPGA), and flexible management of data and process are done by micro processor unit (MPU).

A prototype model is designed for 40 MHz and 5 MHz band width for the forward and reverse links at 3.5 GHz radio frequency band. Variable data rate is adopted at multiple times of 64 Kbit/sec. The data rate of 64 Kbit/sec ~ 32 Mbit/sec is designed to the forward link for download of broad band data of high quality video data.

Prototype hardware was implemented as shown in Fig.5. This hardware was developed by the aid of automatic characteristic monitoring system with registers fabricated in FPGA board and read and write access software fabricated in a personal computer.

Fig.5 Evaluation and operation of the prototype hardware.

5 Conclusion

For ubiquitous communication system the wideband spread spectrum (SS) scheme is proposed based on enhanced synchronization coherent demodulation technologies using matched filter system.

Not be based on political, but on technical view point, 3.4~3.6 GHz microwave frequency band and 5,40,100 MHz band width was estimated for the system.

By implementing a prototype hardware by MPU and FPGA, the advantage of the proposed scheme was proved to provide simple configuration and enough characteristics for coming ubiquitous communication societies.

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