Base Transceiver Station for W-CDMA System

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In January 2001, Fujitsu started commercial delivery of a W-CDMA base transceiver station (BTS). We then dramatically increased the number of traffic channels in this BTS and reduced its power consumption. Then, in September 2002, we began mass production and delivery of the new, large-capacity BTS. This equipment conforms to the global standard specifications of the 3GPP (3rd Generation Partnership Project) and was developed using all of Fujitsu's expertise, for example, expertise in radio technology, network technology, and electronic device technology.
This paper gives an overview of this large-capacity BTS and introduces its features.

1. Introduction

Fujitsu is aggressively pursuing the development of a W-CDMA system that conforms to the third-generation mobile communications system (IMT-2000). While conventional mobile phone systems center on voice services, W-CDMA systems will center on multimedia services. In order to provide multimedia services, the base transceiver station (BTS) must realize advanced functionality and high-performance, including the simultaneous transmission of voice and a variety of high-speed data services as well as high-quality transmission on the same level as fixed telephone networks. Multimedia services require much more bandwidth than voice services, so BTSs must have greater capacities to keep up with the increase in demand. In addition, it is necessary to have flexible expandability to support different equipment environments, reduce the installation size and power consumption, and provide the flexibility to adapt to changes in service contents.

In 1997, Fujitsu supplied a BTS as test equipment for an NTT DoCoMo W-CDMA system,[1] and in January 2001 we started mass production and shipment of this BTS for commercial use. Then, by using our proprietary, high-efficiency transmitter amplification technology and high-speed baseband signal processing technology, we developed a new, high-capacity BTS. Compared to the equipment currently in use, our new BTS provides four times as much channel capacity with the same power consumption and size. Mass production and shipment of the new BTS was started in September 2002.

2. About the W-CDMA system

IMT-2000 is designed to support not only voice services, but also all manner of multimedia services, including fax, e-mail, high-speed data exchange, high-definition image transmission, motion picture transmission, and Internet services. Implementing such services requires that the BTSs can simultaneously transmit voice and a variety of high-speed data services as well as provide high-quality transmission. **Figure 1** shows the network configuration of W-CDMA.

W-CDMA is a code division multiple access (CDMA) communication system that spreads data

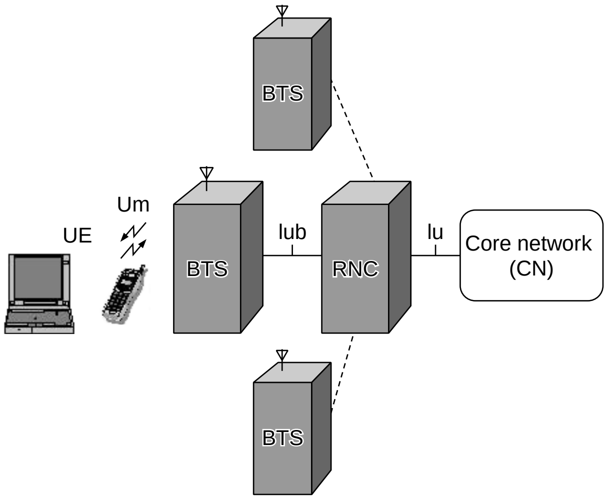

Figure 1
W-CDMA network configuration.

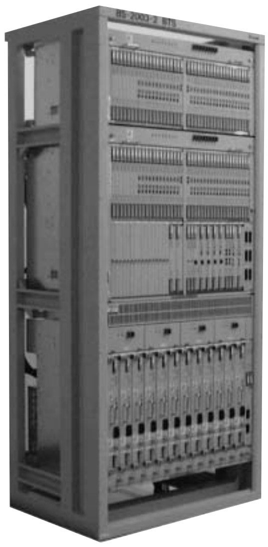

Figure 2
Large-capacity BTS.

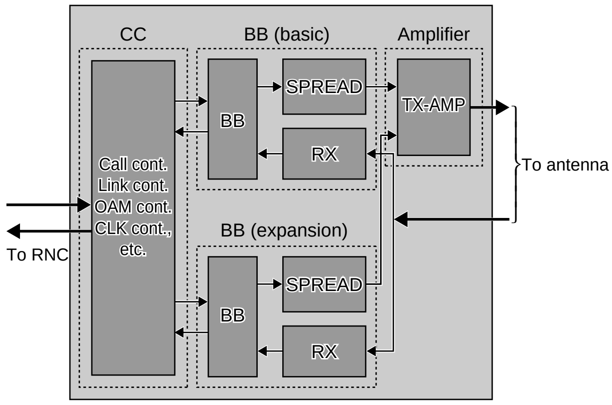

Figure 3
System configuration of large-capacity BTS.

Table 1
Main specifications of large-capacity BTS.

Item	Specification
Radio frequency band	Uplink: 1940 to 1960 MHz Downlink: 2130 to 2150 MHz
Carrier separation	5 MHz
Number of carriers	4 carriers max.
Access system	DS-CDMA/FDD
Number of sectors	6 sectors max.
Max. RF output power	80 W/sector
Channel capacity	2880 voice channels or equivalent
Transmission rate	Voice: AMR, data: 384 kb/s max.
Transmission line interface	6.3 Mb/s or 1.5 Mb/s
Equipment dimensions	800 × 600 × 1800 mm (W × D × H)

signals across a broad 5 MHz band. This system has various features not found in conventional mobile communications systems that allow it to provide multimedia services. These features are as follows:

1) The bandwidth can vary from voice bandwidth to a maximum of 384 kb/s, and multiple multimedia services are transmitted together.
2) Transmission quality is at the same level as in a fixed telephone network.
3) When a mobile station moves into another base station zone, hitless handover is performed at zone switching without any interruption of communication.

3. Technologies of the new BTS

3.1 Main hardware

3.1.1 Overview

Figure 2 shows a photograph of the large-capacity BTS, **Figure 3** shows the configuration, **Table 1** shows the main specifications, and **Figure 4** shows the shelf configuration.

The large-capacity BTS consists of the following parts.

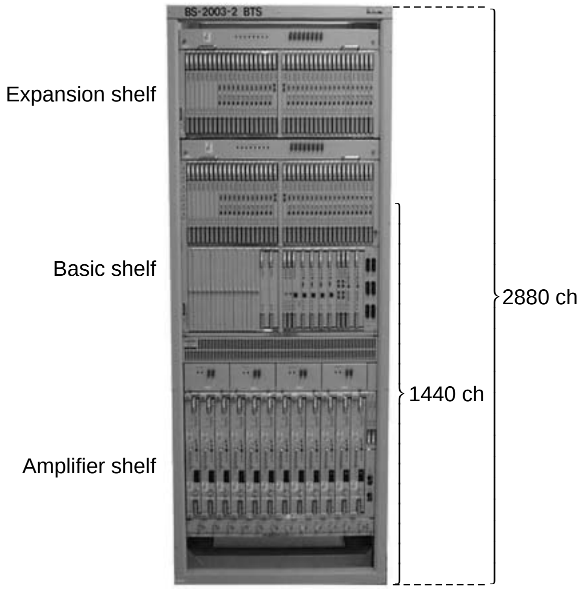

Figure 4
Shelf configuration of large-capacity BTS.

1) Radio part (TX-AMP, RX)

This part is connected to the antenna and features a transmission power amplifier and low-noise receiving amplifier for amplifying the sent/received RF signals. It performs D/A conversion of transmission signals spread on the baseband, thereby converting them to RF signals in quadrature modulation. It also performs quasi-coherent detection and A/D conversion of signals received from the receiving amplifier.

2) Baseband signal processor (BB)

This part performs error correction coding, framing, data modulation, and spreading modulation of transmitted data. For the received signal, it performs despreading, chip synchronization, error correction decoding, data demultiplexing, RAKE reception, and diversity handover between sectors.

3) Common Control (CC)

This part sends and receives control signals to and from the base station controller and controls, sets, and releases the radio links. It also performs ATM processing, ATM termination, and clock extraction from the transmission line at the transmission line interface between stations.

3.1.2 Features

Our new, large-capacity BTS provides a large channel capacity in a compact size with less power consumption and is designed for easy channel expansion and maintenance. Its main features are as follows:

1) Compared to conventional models, it provides four times as much channel capacity with the same power consumption and physical size. Using our original high-efficiency transmitter amplifier technology and advanced baseband signal processing technology, we have achieved a capacity of 2880 voice channels or their equivalent. Compared with conventional models, this is a four-fold increase in capacity, yet it has been achieved with no increase in power consumption or physical size.
2) The basic configuration accommodates 6 sectors, 2 carriers, and 1440 channels.
   In its basic configuration, which consists of the amplifier shelf and BB basic shelf, the new BTS can accommodate up to 6 sectors, 2 carriers, and 1440 channels. More capacity can be added by using the BB expansion shelf.
3) The system can be expanded while active.
   The system can be operated without an expansion shelf in low-traffic areas, and if traffic increases after system deployment, easy system expansion is possible by adding an expansion shelf while the system is running.

3.2 Common control

3.2.1 Overview

The common control has functions for call processing control, radio link control, inter-station control, maintenance monitoring control, IP over ATM, remote file transfer, file memory, shared memory, shared bus control, transmission line switching, transmission line interface, reference clock timing generation, external interface, and debugging. There are also three types of transmission line interfaces that can be used according to the type of transmission line: 1.5 Mb/s electrical, 6.3 Mb/s electrical, or ATM Megalink optical.

3.2.2 Features

1) Mounting

The common control is mounted on the right half of the MDE (Modulation and Demodulation Equipment) shelf.

We integrated the common control into six packages by rearranging the various functional sections that used to be individual packages (i.e., the shared memory, file memory, external interface, shared bus control, and inter-station control), thereby achieving a high-density mounting that occupies only 60% of the space of the previous model.

2) Improved call processing performance

In addition to achieving a more than four-fold increase in performance, we also did the following:

- Speeded up the CPU
- Speeded up the shared bus
- Added a variety of dedicated buses, and distributed the load by optimization
- Increased the ATM-SW capacity

3) Maintenance/operation

The shared bus and various dedicated bus lines within the equipment can be monitored and traced by connecting a special debugging terminal. In addition, the ATM signals corresponding to the U-Plane and the C-Plane signals of the physical line can be monitored by connecting measuring instruments to the transmission line.

The remotely controlled file transfer function distributes the load of file operations during downloads to decrease the load on the maintenance monitoring control function. In addition, hardware data can also be downloaded to allow flexible version upgrades.

3.3 Baseband signal processor (BB)

3.3.1 Overview

This function generates frames and performs error correction coding and spreading modulation for transmission data. It also performs despreading, path searches, RAKE reception, error correction decoding, and receive data demultiplex-

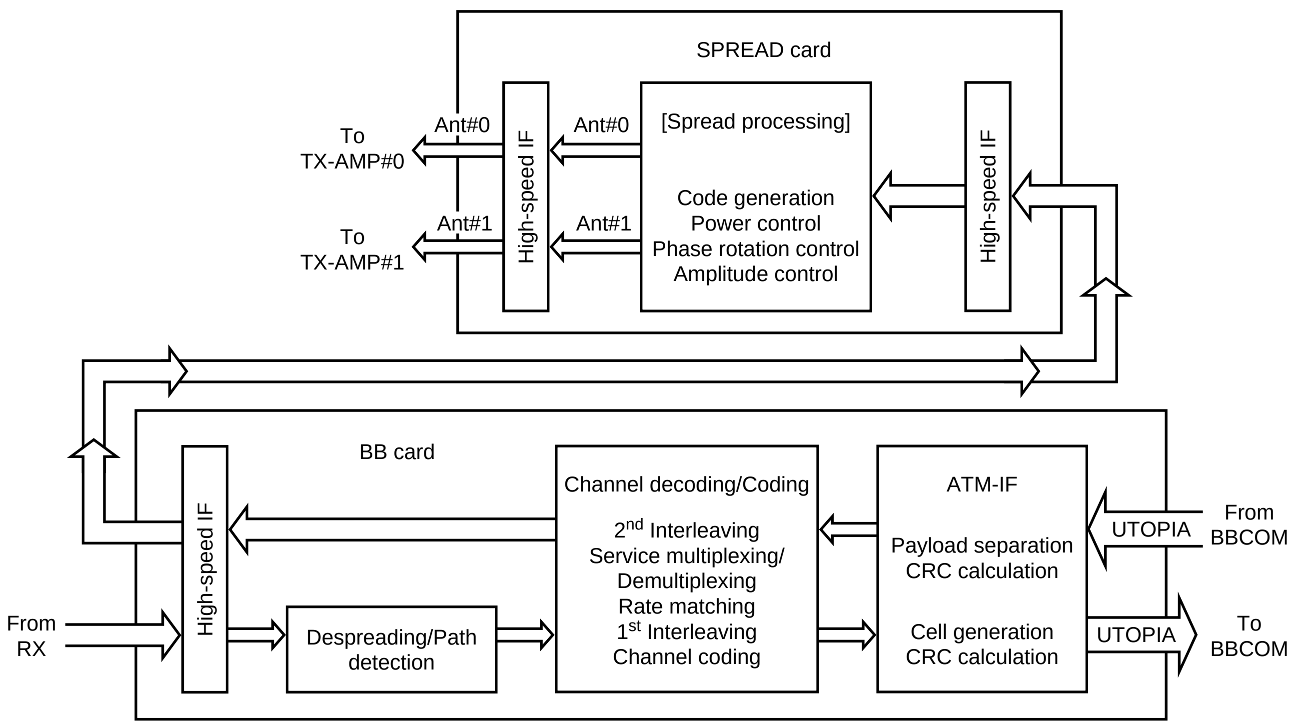

Figure 5
Functional block diagram of baseband signal processing section.

ing of the receive signal (**Figure 5**).

3.3.2 Features

1) Highly flexible and highly integrated.
   To optimize the implementation of functions, we promote a shift to firmware so we can support future enhancements to 3GPP specifications and we employ large 14 Mgate CE81-series ASICs in sections that perform large amounts of parallel processing (**Figure 6**).
   The firmware is constructed using advanced-function, high-performance DSPs (3600 MIPS).
   These features enable 64 AMR (Adaptive Multi-Rate) channels to be processed per BB card.
2) Offers improved data processing (e.g., packet transmission) performance.
   Each BB card can process 64 voice channels, and processing performance is further improved when voice is mixed with data (e.g., packet data transmission and unrestricted digital data transmission).
   The new BTS can process four 384 kb/s packet DL channels and 32 AMR channels. (This is equivalent to processing 96 voice channels.)
3) A dedicated spreading card (SPREAD) is used to optimize the functional partitioning so that the spreading section is independent (**Figure 7**).
4) Employs a common hardware card (BB card) that enables dedicated channel or common channel processing.
   The common CH (PRACH) card and dedicated CH (DTCH) card can be switched by software. The PRACH card supports a cell radius of up to 50 km (**Figure 8**).

Figure 6
14 Mgate CE81 series ASIC.

3.4 Radio part

3.4.1 Overview

The radio part is composed of a modulator/demodulator and a transmission amplifier. It provides up to 4 carriers per sector with a maximum RF output of 80 W/sector.

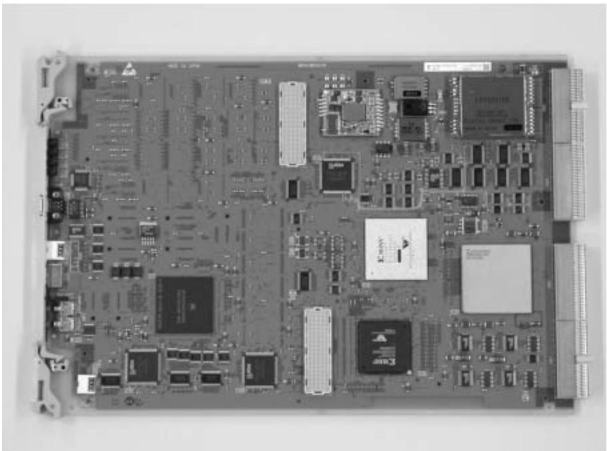

Figure 7
SPREAD card.

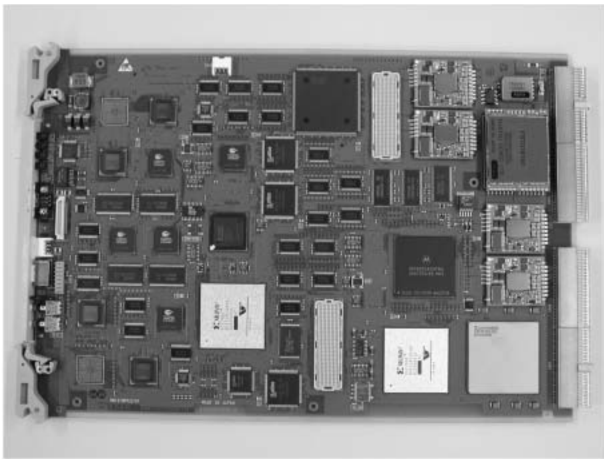

Figure 8
BB card.

Figure 9
High-efficiency TX-AMP (with digital predistorter).

3.4.2 Features

1) The radio part features a high-efficiency transmitter amplifier (TX-AMP) that performs digital predistortion (**Figure 9**).
   By introducing this new TX-AMP, we have been able to reduce the power consumption of the transmitting RF amplifier by as much as 40% compared with conventional equipment (**Figure 10**).
2) The radio part can be flexibly configured according to the number of sectors.
   Each TX-AMP can be independently configured, enabling the optimum number of cards to be mounted for the installation environment.

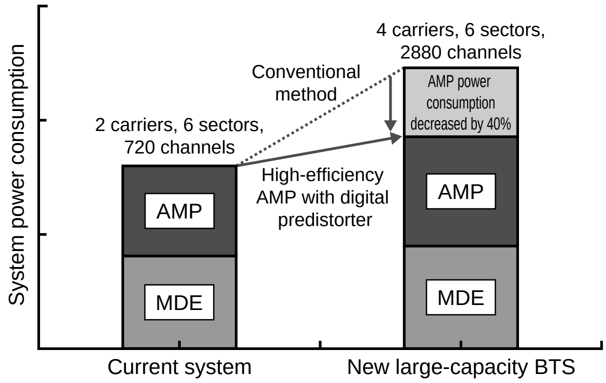

Figure 10
Dramatic reduction in power consumption.

4. Conclusion

This paper gave an overview of our new, high-capacity, low power consumption W-CDMA base transceiver station. The system's power consumption was reduced by using a high-efficiency transmitter amplifier that uses digital predistortion technology. Also, the system's high-capacity was achieved by using an optimum configuration of DSPs and ASICs.

Fujitsu is proceeding with the development of compact base stations and other equipment that will further accelerate high-speed data communication services and enable fine-tuned area expansion.

Reference

1) S. Maruyama, T. Yabe, and K. Mori: Base Transceiver Station for W-CDMA. (in Japanese), *FUJITSU*, **51**, 1, p.41-44 (2000).

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