Family of RBS 3000 products for WCDMA systems

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Ericsson is the first company to take WCDMA technology out of the laboratory and test it in a real environment. At the end of 1999, Ericsson had seventeen WCDMA test systems in operation in Asia, Europe and North America.

The RBS 3000 product line is a comprehensive family of macro, mini and micro radio base stations (RBS) that were designed using input from second-generation mobile systems.

In this article, the author gives an in-depth description of Ericsson's family of RBS 3000 products.

Overview of the WCDMA radio access network

Ericsson's WCDMA radio access network (RAN) consists of radio network controllers (RNC), radio base stations (RBS), RAN operation support (RANOS) and tools for radio access management (TRAM). In Third-generation Partnership Project (3GPP) specifications, the RBS corresponds to Node B (Figure 1).

RNC

The main tasks of the RNC are

- to manage radio-access bearers for transporting user data;
- to manage and optimize radio network resources;
- to control mobility (the RBS provides the actual radio resources); and
- to maintain radio links.

The RNC is connected to the core network via the *Iu* interface; user equipment (UE) is connected to the RBS via the *Uu* interface (the air interface). RNCs are interconnected within the radio access network via the *Iur* interface; and the RBSs are connected to the RNC via the *Iub* interface.

RBS

The family of RBS 3000 products consists of base stations for both indoor and outdoor installations, as well as single-sector and multiple-sector configurations. The product architecture supports several configurations and establishes a basis for future development of RBSs that support macro-, micro- and picocell structures.

The range of RBS 3000 models gives operators cost-effective solutions to capacity, coverage, power supply, space and environmental requirements in network configurations.

TRAM

The tools for radio access management aid operators in designing, testing, and optimizing the performance of radio and transport networks. Configuration data can be downloaded from TRAM to the RNCs and RBSs via RANOS.

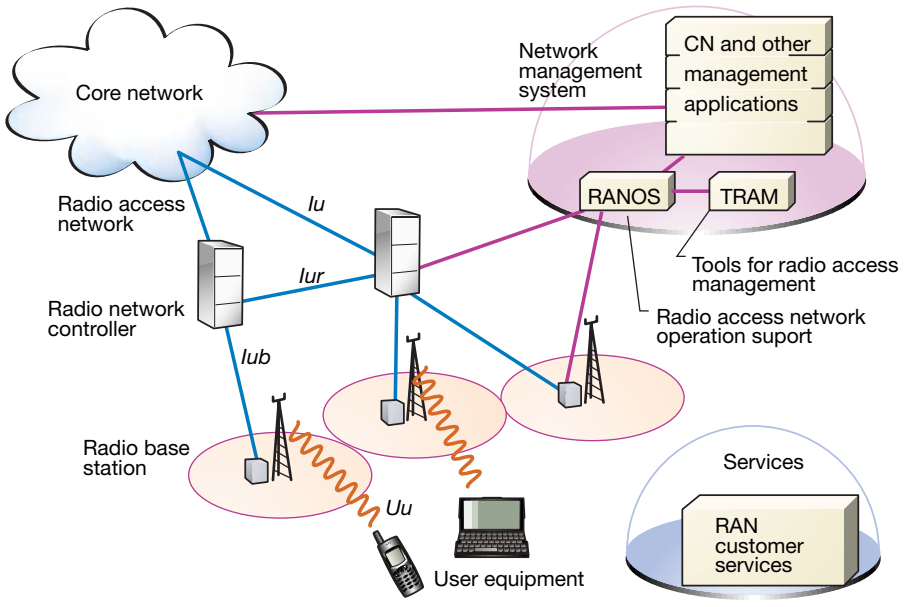


Figure 1
Overview of the radio network, logical interfaces.

RANOS

RANOS, which is the software for handling operation and maintenance tasks for the WCDMA radio-access network, gives operators a consolidated view of information on alarms, configurations, and basic performance. It also provides interfaces for easy integration into other management environments.

RBS 3000 family

The design of Ericsson's family of RBS 3000 products is based on 3GPP requirements. All RBS 3000 products are pre-tested and pre-configured before delivery to the site. They also include a built-in self-test mechanism and an equipment configuration wizard, which further reduce installation time and speed up network roll-out.

A single RBS 3000 equipment configuration handles mixes of voice, circuit-switched and packet-data services without having to be reconfigured for each different kind of traffic.

Operators can easily increase coverage, the number of simultaneous users, carriers, and sectors, by adding hardware boards or extra cabinets.

RBS 3000 macro products

All RBS 3000 macro products have been designed to handle a variety of services. The RBS hardware and software feature a modular design. The RBS hardware is flexible, meaning that the same equipment can handle most traffic situations. The architecture is scalable and thereby easy to expand. Operators can add extra carriers or more channel capacity by installing additional boards or another complete cabinet.

RBS 3202

The RBS 3202 (Figure 2) is an indoor macro radio base station. The basic configuration supports up to three sectors and two carriers (3x2). The RBS can be extended to configurations of three sectors and four carriers (3x4) or six sectors and two carriers (6x2). The output power is 20/40 W radio frequency (RF) per carrier.

All units in the cabinet are easily accessi-

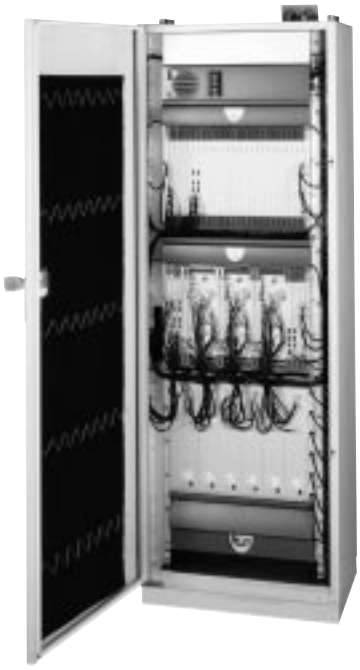


Figure 2
Description of the hardware structure in RBS 3000. Photograph of an RBS 3202.

BOX A, TERMS AND ABBREVIATIONS

3GPP	Third-generation Partnership Project
ATM	Asynchronous transfer mode
BP	Board processor
BSC	Base station controller
BTS	Base transceiver station
CBN	Common bonding network
C/I	Carrier-to-interference ratio
CORBA	Common object request broker architecture
CU	Capacity unit
dB	Decibel
dBm	Decibel relative to 1 mW
DDTMA	Dual-duplex TMA
DL	Downlink
DPX	Duplex
EACU	External alarm connection unit
EMC	Electromagnetic compatibility
ET	Exchange terminal
ETB	ET board
FDD	Frequency division duplex
HTTP	Hypertext transfer protocol
HW	Hardware
IDM	Internal distribution module
IP	Internet protocol
IPsec	IP security protocol
Java applet	Distributed embedded Java program that runs on a Web browser
MCPA	Multi-carrier power amplifier
MMI	Man-machine interface
MTBF	Mean time between failures
NMS	Network management system
O&M	Operation and maintenance
OMC	Operation and maintenance center
PBC	Power and battery cabinet
RAN	Radio access network
RANOS	RAN operation support
RBS	Radio base station
RET	Remote electrical antenna tilt
RF	Radio frequency
RNC	Radio network controller
RRU	Remote radio unit
RTOS	Real-time operating system
RX	Receiver
STM	Synchronous transfer mode [synchronous transport module]
SW	Software
TMA	Tower-mounted amplifier
TMS	Test mobile station (terminal)
TRAM	Tools for radio access management
TRX	Transceiver
TU	Timing unit
TX	Transmitter
UE	User equipment
UL	Uplink
UMTS	Universal mobile telephony system
UTRAN	UMTS terrestrial radio access network
VAC	Volts, alternating current
VDC	Volts, direct current
WCDMA	Wideband code-division multiple access
wTRU	Wideband transceiver unit

Figure 3
RBS 3101.

ble from the front of the cabinet. All cable interfaces are located at the top of the cabinet. Thus, the cabinets can be mounted side-by-side or back-to-back.

RBS 3101

The RBS 3101 (Figure 3) is an outdoor macro radio base station. It supports the same range of configurations as the RBS 3202. The output power is 20/40 W RF per carrier.

The RBS 3101 features a weatherproof cabinet for outdoor sites with high capacity and high coverage. The cabinet contains integrated power supply with backup batteries, space for transmission equipment, and a climate package. The RBS 3101 supports 50 Hz and 60 Hz systems and can be powered with single- or triple-phase AC.

RBS 3000 main-remote concept

Macrocell coverage in a microcell package

Site acquisition is an increasingly time consuming and costly problem, especially in busy urban environments. Ericsson's solution to this problem is the main-remote concept. At conventional site installations, all equipment, including digital parts, radio parts, and combiners are housed in one cabinet. However, according to Ericsson's main-remote concept, the RF and digital baseband parts are separated by an optical interface in a remote radio unit (RRU). The RF parts have been moved closer to the antenna, which means that a smaller power amplifier is used. Also, the radio parts are made smaller, which further reduces power consumption. Less power consumption means less heat, which means that the RBS can use convection cooling without any moving fans—no noise. The main unit, which contains the transmission interface to the RNC,

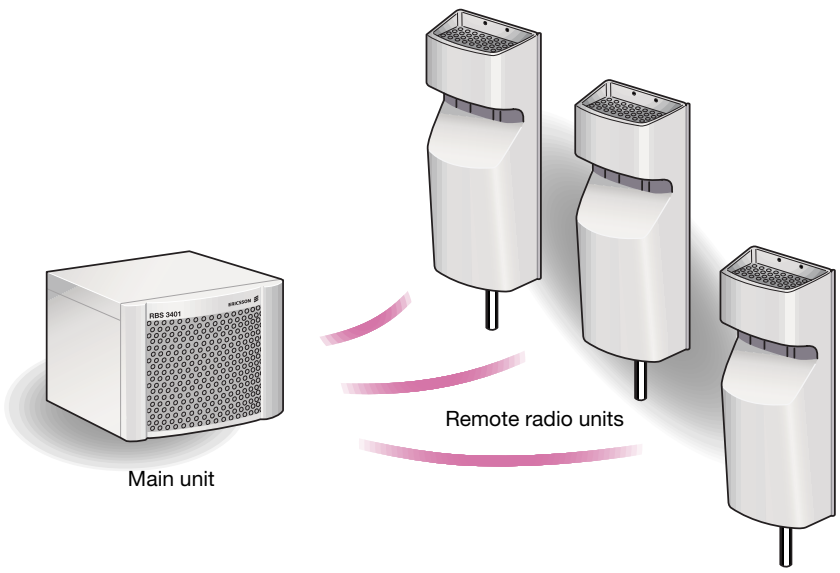
- performs all system-level diagnostics;
- provides system timing via the transmission interface source;
- controls power and processes calls, encodes and decodes WCDMA; and
- handles softer handovers.

Some advantages of the main-remote concept are

- easy and rapid installation—the main unit and remote radio unit can be placed several kilometers apart, which means that the RBS can be installed practically anywhere;
- the main units and RRU can be hand-carried to a rooftop;
- macro coverage from wideband transceiver unit (wTRU) and mini RBS solutions; and
- greatly reduced power consumption (compared to the macro RBS).

RBS 3000 main-remote products include the RBS 3401, RBS 3501, and the wTRU concept.

Figure 4
Main-remote concept RBS 3401.



RBS 3401

The RBS 3401 (Figure 4) is an indoor mini RBS. It weighs less than 30 kg and can be mounted on the wall or in a standard 19-inch rack. It can be delivered with an integrated power supply for single-phase AC, –48 VDC or +24 VDC. An optional external battery backup cabinet can be connected to provide extended backup time. When used together with remote radio units and an optional external backup battery cabinet, the RBS 3401 constitutes a compact but complete macro base station solution.

RBS 3501

The RBS 3501 (Figure 5) is an outdoor mini RBS with a complete RBS system housed in a compact convection-cooled, weatherproof cabinet. The RBS 3501 offers macrocell coverage in a microcell package and can serve as either a traditional macrocell or microcell base station.

The main unit can be mounted practically anywhere—on a wall, pole, the side of a building, or rooftop. Its compact size and low weight (with remote radio units) enable it to be hand-carried to the installation site. The RBS 3501 is powered by single-phase AC, –48 VDC or +24 VDC.

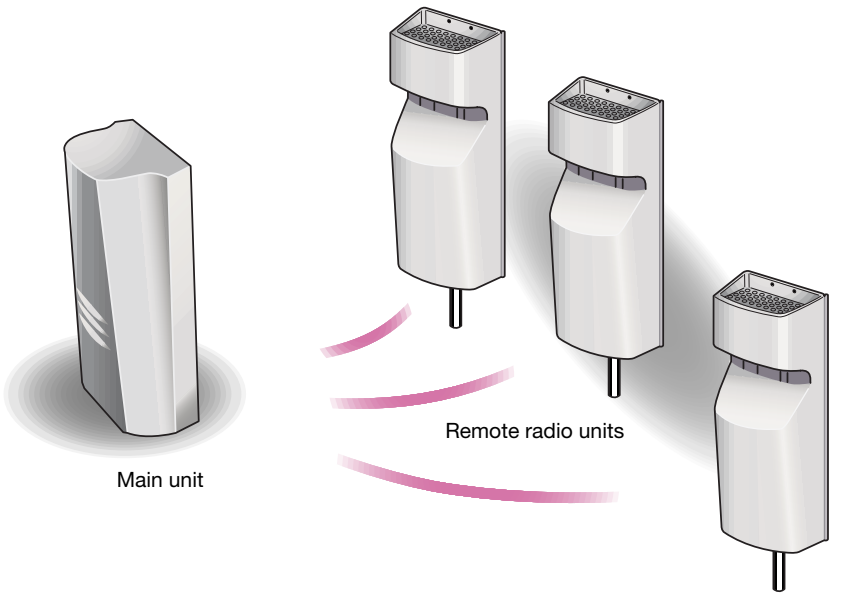


Figure 5
Main-remote concept RBS 3501.

wTRU concept

The wTRU concept (Figure 6) is a cost-effective solution for rapid roll-out of WCDMA capacity in a GSM network. The wTRU can be installed in any Ericsson RBS 2000 macro cabinet. It occupies two TRU slots and shares the GSM cabinet's power and cooling resources with other units. The wTRU supports one carrier and one to three sectors.

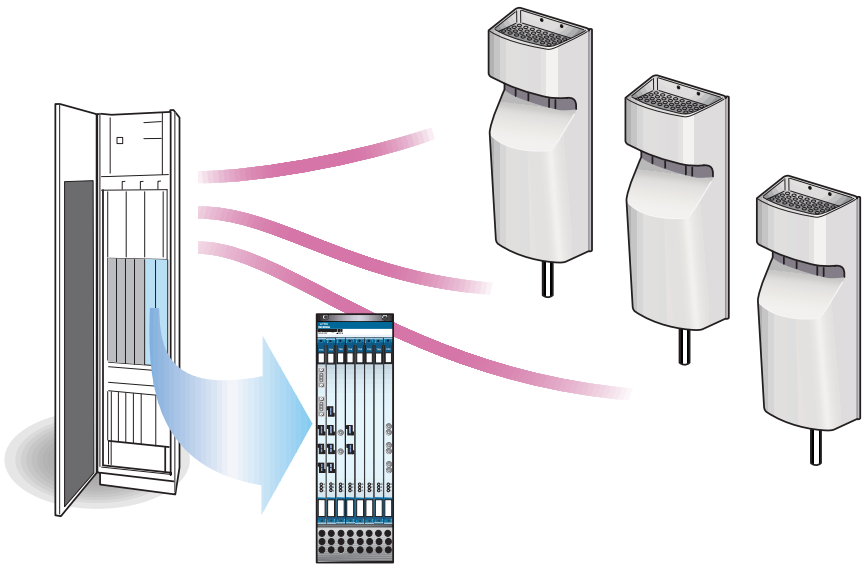


Figure 6
wTRU concept.

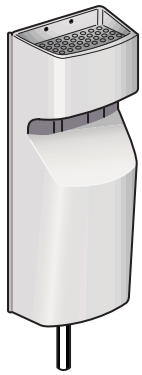


Figure 7
Remote radio unit.

Remote radio unit

The remote radio unit (Figure 7), which is a radio head with up to 10 W RF output power, is used together with the RBS 3401, RBS 3501 or wTRU. It can also be used with the micro RBS 3301 to provide extended coverage. The remote radio unit houses an RF filter, power amplifier, RX low-noise amplifier, and transceiver (TRX) for one sector carrier. It also supports RX space diversity. The unit can be placed together with the cabinet, on a rooftop, or on the tower near the antenna.

An optical digital interface connects the main unit and the remote radio unit. This ensures high performance and enables operators to place the remote radio unit up to several kilometers from the main unit. Since various different main units support the same optical digital interface, operators can reuse remote radio units when they upgrade the main unit, say, to increase capacity.

The weatherproof RRU is suitable for indoor and outdoor use. It generates no significant acoustic noise, because only conventional cooling is used. It is powered by –48 VDC, +24 VDC or single-phase AC. Power can also be supplied via the optional power and battery cabinet (PBC).

RBS 3000 micro products

Designers of the micro RBS drew heavily on experiences gained in working with micro- and picobase stations for second-generation mobile phone systems. The exterior of the micro RBS is both weatherproof and discrete. This small, light-weight RBS can easily be installed by one person.

RBS 3301

The RBS 3301 is suitable for indoor and outdoor use (Figure 8). The cabinet houses one transceiver and all necessary equipment for serving one cell. Convection cooling further contributes to a compact and weatherproof cabinet. The RBS 3301 has one carrier with omni-directional or sector-based coverage at 1 W RF output power. Optional equipment includes an external antenna, an RRU (for macro coverage), and a power and battery cabinet.

The micro RBS has the same basic functionality as the macro RBS but with less capacity and coverage. The transceiver and power amplifier have been integrated into the RBS cabinet using ASIC technology. This design yields high availability, small volume, low weight and low power consumption.

Backup power for short interruptions to the AC power supply is built-in. An extra power and battery cabinet can be connected to extend backup power. Moreover, the remote radio unit can be used with the RBS 3301 to increase coverage.

Operation and maintenance

Rapid implementation

One goal when designing the RBS 3000 was to make installation and commissioning rapid and easy. The RBS 3000 is thus pretested and pre-configured before it is delivered to the site—all hardware and software are configured at the factory. During installation, field technicians need only enter a few site-specific parameters (IP address, site name, and so on) via a Web browser on a standard laptop computer. Built-in commissioning software gives field technicians access to every function in the RBS 3000.

Live expansion

Without shutting down power or disturbing traffic, operators can increase capacity and coverage by adding boards to the RBS 3000.

BOX B, THE RBS 3000 FAMILY OF PRODUCTS

RBS 3101 outdoor macro
The RBS 3101 is an outdoor RBS with one to four carriers and one to six sectors at 20/40W RF output power per carrier. The power distribution system and battery backup have been integrated into the cabinet. External power is 230/380 VAC.

RBS 3202 indoor macro
The RBS 3202 is an indoor RBS with one to four carriers and one to six sectors at 20/40 W RF output power per carrier.

RBS 3301 micro
The RBS 3301 is a small, lightweight, weatherproof base station with no floor space requirements. It has one carrier and one sector at 2 W integrated RF output power, and can be used with an optional remote radio unit for extended coverage.

RBS 3401 indoor mini
The RBS 3401 is a compact indoor mini RBS with
- three sectors and one to two carriers per sector; or
- six sectors and one carrier per sector.

Macro coverage is achieved using remote radio units.

RBS 3501 outdoor mini
The RBS 3501 is a compact, convection-cooled, weatherproof, outdoor RBS with the same specifications as the RBS 3401. Thanks to its compact design, it can be hand-carried to the installation site.

Remote radio unit
The remote radio unit is a remote radio head with a transceiver and power amplifier. It has up to 10 W RF output power and can be connected via a digital interface to the RBS 3401/RBS 3501, RBS 3301 and wTRU.

wTRU concept
The wideband transceiver unit (wTRU) concept gives operators a rapid and smooth way of implementing WCDMA coverage. The wTRU occupies two TRU slots in a GSM RBS 2000 cabinet. When used with remote radio units, the wTRU concept yields one carrier and one to three sector coverage.

Pre-assembled site solutions
Every RBS in the family of RBS 3000 products can be delivered in pre-assembled outdoor containers which include all the equipment that is needed to build a complete site.

Hot-repair hardware maintenance

When developing the RBS 3000, designers put special emphasis on minimum system downtime and low maintenance costs. They achieved these design objectives by means of the hot-repair maintenance principle of replacing units that have been affected by faults. By hot repair we mean that a faulty unit can be replaced with minimum impact on traffic handled by the RBS 3000.

The RBS 3000 products can be accessed for the execution of management tasks from any node in the network. The RBS 3000 can locate the root cause of faults.

Power-saving mode

An optional function enables operators to order RBS 3000 nodes into power-saving mode in order to lower overall power consumption.

Support for most transmission standards

The RBS 3000 supports most transmission standards. Cascading, star, and tree transmission configurations can be combined to support different network structures.

High availability thanks to many redundancy concepts

The RBS 3000 includes several redundancy concepts (such as $n+1$ redundancy, load sharing, and processor cluster) for increased availability and reduced downtime.

Hardware architecture

Platform

Ericsson's WCDMA product portfolio is based on a new platform, which is well suited to building small-to-medium-scale telecommunications products that require low-cost support for asynchronous transfer mode (ATM) and IP transport.[1] Both the RNC and RBS are based on this platform, which includes all the physical equipment and associated software needed to create a packet-switching network node. The modular design of the platform makes it easy for operators to create nodes with different configurations, functionality, capacity and reliability. Transport can be concentrated in any node, since every node has ATM switching capabilities.

Hardware structure

The family of RBS 3000 products features a modular design: several subsystems facilitate easy expansion and evolution. The interfaces between hardware units have been clearly defined, and most will be maintained throughout product evolution. This flexible design means that new releases of hardware units and boards based on advanced ASIC technology can easily replace or be added to older units, enabling an increase in channel capacity, for example.

Redundancy

Depending on the operator's needs, the RBS can be equipped for minimum hardware configuration or high redundancy. Redundancy is based on the $n+1$ principle—that is, if one unit fails, another unit takes over, thereby guaranteeing full capacity in the RBS. In terms of load sharing, if a unit fails, the functionality is maintained but capacity abates.

Architecture of the hardware units

The RBS 3000 macro products are made up of a baseband subrack, radio subrack, multicarrier power amplifier (MCPA) subrack, power-distribution equipment, tower-mounted amplifier (TMA), and a remote electrical antenna tilt (RET).

Baseband subrack

The baseband subrack is composed of exchange terminal boards (ETB), a timing unit board and an ATM switch board. The baseband subrack also contains boards for uplink/downlink functions for coding, interleaving, and modulation. The built-in ATM switch board distributes incoming information from the transport link to radiochannel hardware.

Radio subrack

The radio subrack contains the main processor of the RBS, an antenna interface unit (AIU), and boards with radio functionality. It also contains boards for handling digital-to-analog (D/A) signal conversion, modulation and demodulation, analog-to-digital (A/D) signal conversion and filtering for the RX path for each cell carrier. The AIU is composed of radio frequency (RF) parts, such as RF filters, a low-noise amplifier, and splitters. Duplex filters minimize the number of feeders and antennas by allowing receiver and transmitter path connections to be made to a common antenna.

MCPA subrack

The MCPA unit, which is a wideband linear power amplifier, amplifies the carriers to be transmitted in a cell.

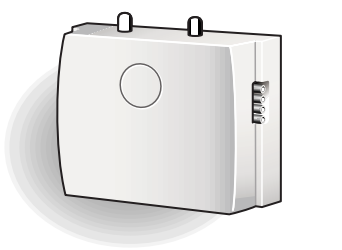


Figure 8
RBS 3301.

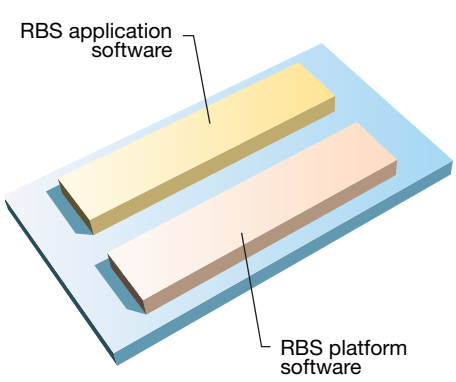


Figure 9
RBS software structure.

Power distribution equipment

The RBS is equipped with a capacitor unit (CU) that keeps the RBS in operation during short drops in –48V power. An external alarm connection unit (EACU) can also be connected to the RBS 3000. Operators can define up to 32 external alarms and two output control ports. The alarms are galvanically separated from the RBS.

Tower-mounted amplifier

The low-noise amplifier, which is mounted on the antenna tower near the antenna, is used on receiving paths in order to lower the overall receiver noise figure. It is a dual-duplex TMA (DDTMA), which means it includes two duplex filters per branch. This design uses the same feeder for receiving and transmitting signals.

The TMA embodies two transmitter (TX) and receiver (RX) branches in one unit. Thus, only one TMA is needed per sector. Power is supplied via the RF feeder from the AIU in the RBS.

Remote electrical antenna tilt

The remote electrical antenna tilt controls the vertical tilt angle of the antenna lobe. The tilt angle ranges from 0 to X degrees downtilt, where X is the vertical beamwidth of the antenna. The maximum downtilt angle approximately corresponds to the first upper null in the vertical radiation pattern. If a TMA is used, the RET is powered by the AIU via the TMA; otherwise, the RET is powered directly from the AIU.

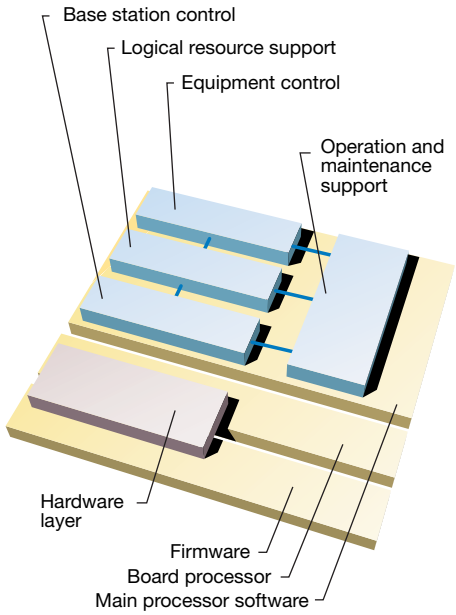


Figure 10
RBS application software structure.

Software architecture

General

All software can be downloaded to the RBS 3000 before it is shipped and installed. The software is stored in non-volatile program store in the main processor. Besides simplifying and accelerating installation, this design also speeds up recovery after power failures, since it eliminates the need for reloading software from other nodes.

The RBS 3000 software is composed of several subsystems in a layered architecture. The software platform, which provides basic support for application software, includes an execution platform with operating system, ATM transport, and operation and maintenance (O&M) infrastructure. The RBS application software is built on the platform software and handles the RBS hardware (Figure 9).

RBS application software

The application software is divided into several subsystems in a layered structure (Figure 10).

Base station controller

The base station controller (BSC) subsystem is a service layer that interprets and executes the application procedures initiated from the RNC.

Logical resource support

Logical resource support provides the service layer with control over RBS logical re-

sources, such as radio links, cell carriers, ATM connections, and so on.

Equipment control

The main purpose of the equipment control subsystem is to isolate the hardware implementation from higher layers. It contains device board control functions, hardware resource-allocation algorithms and a control-signal transport-routing function.

Hardware layer

The hardware layer is divided into several device-specific subsystems that contain hardware and software. Each subsystem has a software component in the board processor of individual device boards. The associated software is generally divided into three parts (Figure 11):

- a device-specific component, which is unique to different types of hardware;
- a board control component, which handles O&M functionality (for instance, starting and loading) for the board—this component is common to all RBS device boards; and
- a low-level communication component—this component is also common to all RBS device boards.

RBS software platform

The RBS software platform provides services for the application software. These services are an ATM platform, a distributed real-time system, basic O&M, management interfaces, and transport services (Figure 12).

The RBS application software is distributed over several processors using the interprocessor communication offered by the platform. The main processors of the RBS 3000 cooperate to form a main processor cluster (MPC) that executes most of the control software. The processors that make up the MPC are equal in terms of control—that is, there are no master-slave relationships between them. However, if one of the processors fails, the program execution is moved to another main processor in the MPC. For control, most boards are equipped with a board processor (BP). Those units that do not contain a board processor are monitored by other units.

Conclusion

Ericsson's family of RBS 3000 products for WCDMA includes indoor and outdoor versions of macro-, mini- and microbase stations. The design is based on 3GPP requirements.

The macro models consist of a weatherproof outdoor model and an indoor model. Mini- and microbase stations can be mounted on walls or poles, saving floor space. Remote radio units can be located near the antenna apart from the rest of the base station equipment. This design reduces feeder losses and increases the capacity of the base station.

For the migration from GSM to WCDMA, an individual WCDMA transceiver (wTRU) can be plugged into empty slots in existing GSM RBS 2000 macrobase stations to provide the fastest possible roll-out of WCDMA coverage and capacity.

The RBS 3000 products can be accessed for the execution of management tasks from any node in the network. The RBS 3000 has been designed to accept software corrections and upgrades while it is in service. Similarly, the RBS plug-in units can be replaced in accordance with the hot-repair principle, and RBS hardware can be installed while the RBS 3000 is in operation.

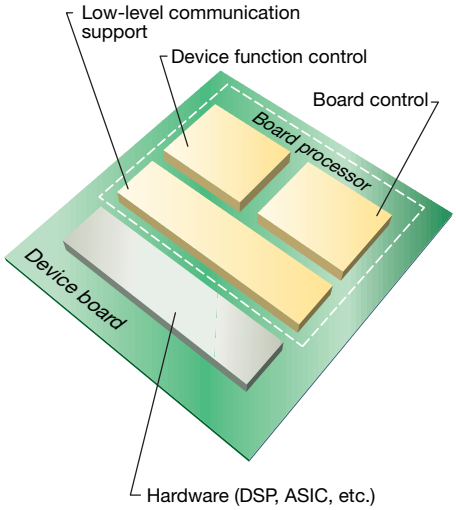


Figure 11
Application structure of the device board.

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1 Reinius, J.: Cello—An ATM transport and control platform. Ericsson Review Vol. 76(1999):2, pp. 48-55.

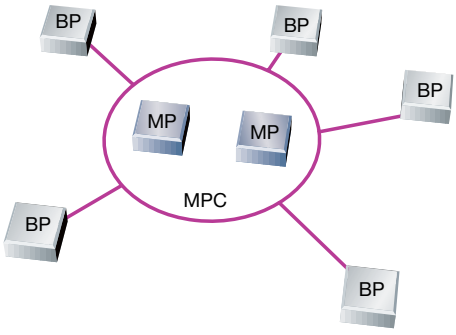

Figure12
Processor cluster.