Satellite Base Station | Higher Data Communications Speed | VoIP Transition

Technology Reports

Special Articles on WIDESTAR II High-speed Mobile Satellite Communications Service for Diverse Satellite Communications

WIDESTAR II Satellite Base Station Equipment

New satellite base station equipment was developed for the WIDESTAR II service, which began operating nationally in April 2010. This equipment handles high-speed wireless data communications arising from increasing demand. It has been designed with consideration for economic factors and to meet requirements of voice services over IP, with full functionality to connect the satellite equipment to IMS-based core network nodes.

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1. Introduction

With the start of the new WIDESTAR II high-speed mobile satellite communications service in April 2010, we have developed new satellite base station equipment supporting the high-speed satellite system. For this system, equipment was developed to handle increasing wireless communications speeds as demand for data communications increases, to connect to IP Multimedia Subsystem (IMS) based core network nodes for voice services over IP, and with consideration for economic factors.

The satellite base station equipment consists mainly of the Satellite Transmission and Receive Equipment (STRE) [1], which amplifies and converts the frequencies of transmitted and received signals as with earlier equipment; a Satellite-Access Point (S-AP), which performs modulation, demodulation and radio control; and a Satellite-Border Gateway (S-BGW), which is the router connecting to the core node.

In this article, we describe an overview focusing on the S-AP and related technologies newly developed for WIDESTAR II.

2. Introduction

2.1 S-AP Configuration

External views of the S-AP and the STRE are shown in **Photo 1**. The

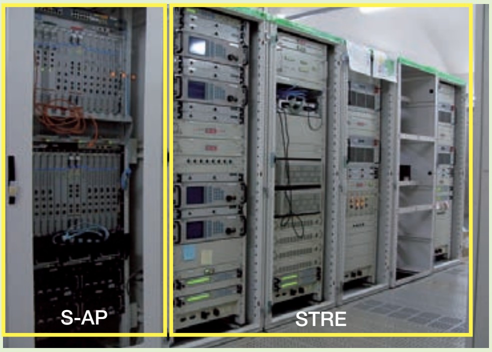

Photo 1 External view of S-AP

equipment configuration of the S-AP is shown in **Figure 1**, and the specifications of the satellite base station are shown in **Table 1**. The equipment, incorporating radio control, modulation and demodulation, is placed within a single chassis conforming to the advanced Telecom Computing Architecture (aTCA)[*1] and is considerably smaller than earlier equipment. The S-AP card configuration is shown in **Figure 2**, and the function of each card is shown in **Table 2**. The S-AP is housed in two shelves of a rack, with equipment monitoring and control and communications control cards in the upper shelf, and modulation/demodulation and communications processing cards in the lower shelf. The radio communications cards, including Baseband (BB), Transmitter and Receiver (TRX), and Radio Link Control (RLC)[*2], were newly designed. The S-AP performs communications processing for the four beam area[*3] covered by a satellite, and WIDESTAR II is operated using two S-APs each with a reserve unit, for a total of four S-APs.

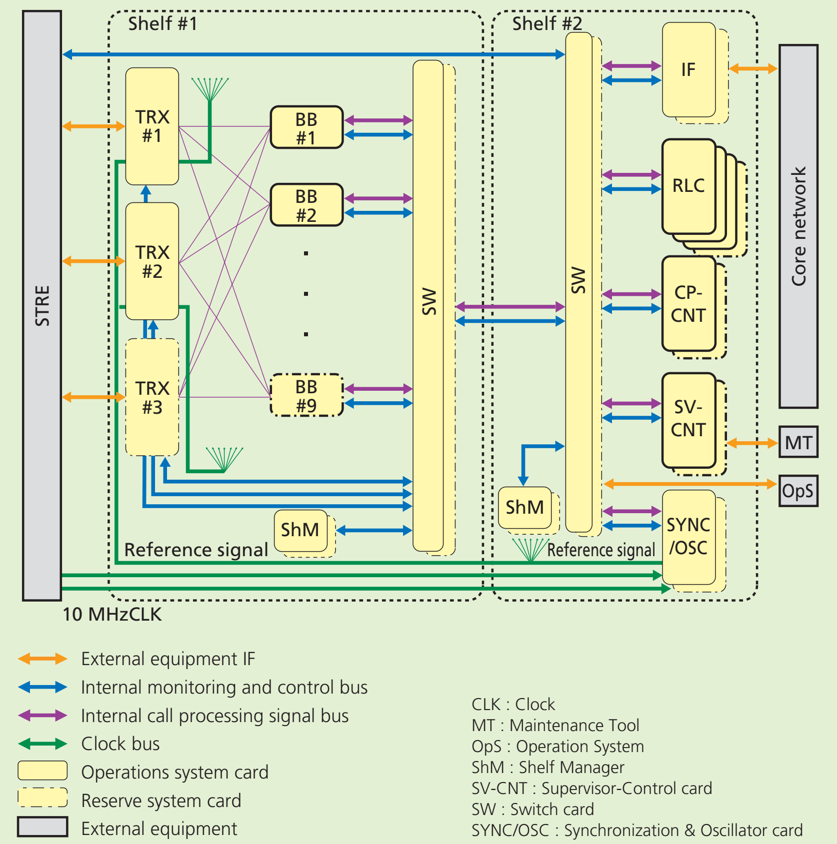

Figure 1 S-AP equipment configuration

Table 1 Satellite base station specifications

Simultaneous connections	Voice	Max. 1,000 calls
	Packet	Guaranteed : Max. 200 calls
		BE : Max. 20,000 calls
Processing capability		Max. 96,000 BHCA
Number of racks		STRE : 5 racks, S-AP : 1 rack
Weight		600 kg/m² or less
MTBF		STRE : 29,000 h, S-AP : 173,000 h
Power consumption		STRE : 5,229 VA/rack or less, S-AP : 5.0 kW or less

BHCA : Busy Hour Call Attempts
MTBF : Mean Time Between Failure

2.2 Connection to Multiple AGS

Previous WIDESTAR base station equipment had a one-to-one connection with a core node, but the S-AP is always connected to two Access Gateway for Satellite (AGS) systems and four Stream Control Transmission Protocol (SCTP)[*4] links through two Interface (IF) cards. It also supports multi-homing[*5], which guards against the unlikely event of a line disconnection.

2.3 System Maintenance Control

In preparation for circumstances when the base station cannot be used, such as the twice-yearly sun transit phe-

*1 **aTCA**: Industrial standard specifications for operator-oriented next-generation communication equipment defined by the PCI Industrial Computer Manufacturers Group (PICMG).

*2 **RLC**: Originally the W-CDMA radio layer 2 (see *12) protocol. In the S-AP, this is the name of the card performing radio layer 2 termination processing with the mobile station.

*3 **Beam area**: The unit of area dividing service areas. Users are managed in these units.

*4 **SCTP**: A transport layer protocol created to transmit telephone network protocols over IP.

*5 **Multi-homing**: A design approach with multiple SCTP links over different physical lines.

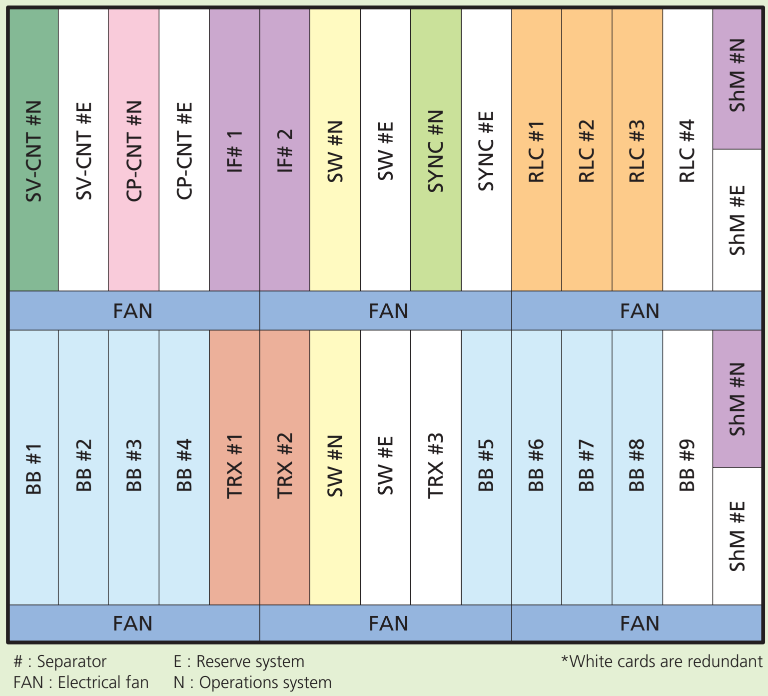

Figure 2 S-AP card configuration

Table 2 S-AP Card functionality

Name	Function overview
TRX	Transmit/Receive signal for STRE
BB	BB modulation/demodulation, BECH layer 1 control
RLC	Radio link control, voice frame processing
IF	Transmit/Receive core node and Emergency (EM) control signals
CP-CNT	Call and communications control
SV-CNT	Equipment monitoring and control
SW	Transmission of Ethernet packets between cards
ShM	Shelf management

nomenon[*6], construction, or by some chance, a disaster, S-APs have a system maintenance control function particular to the satellite system, for transferring ongoing and standby calls to other operating or reserve S-APs. The implementations for conventional WIDESTAR [2] and WIDESTAR II differ in the following points:

1) Handover of Mobile Calls between S-APs

Dropped calls are avoided by checking and securing available resources on the destination S-AP (under a different satellite) before transferring an ongoing call from the originating S-AP.

2) Enforced Preservation Control

Normally, Best Effort (BE) data calls conducted as User-Plane (U-Plane)[*7] data are transitioned to one of the following three states:

(1) Using an uplink/downlink User Packet Channel (UPCH)

(2) Using only a downlink UPCH

(3) Preservation state

A BE call is one type of data communications service sharing radio frequency bandwidth among multiple users and providing variable maximum data speeds (uplink: 144 kbit/s, downlink: 384 kbit/s) according to the radio link quality. Preservation state is a control channel standby state in which the communication channel is released.

Calls in state (3) move to the destination S-AP (another satellite) at the receipt of the broadcast information[*8], in the same way as with standby calls, but the procedure for transitioning to the destination S-AP only applies to handing over mobile calls between S-APs and to standby calls, so state (2) calls must be transferred to the destination S-AP via state (1) or (3). Uplink radio resources[*9] must be allocated to transition from (2) to (1), consuming extra radio resources, and requiring time for system maintenance control. Thus, we have added required information to the broadcast information allowing resources used inside the Satellite-Mobile Station (S-MS) and S-AP to be released and forcing the transition from

*6 **Sun transit phenomenon**: When the satellite is eclipsed, overlapping with the sun as seen from the base station antenna, so that communication quality degrades due to noise generated by the sun. This occurs twice a year, in spring and fall, for about one week each.

*7 **U-Plane**: The protocol for transmitting user data.

*8 **Broadcast information**: The location code, which is required to decide whether location registration is needed for a mobile terminal, surrounding cell data, and call restriction information. Base stations broadcast this to surrounding cells.

state (2) to (3). This reduces use of radio resources and the time required for system maintenance control.

2.4 Online Update of System Data

Previous equipment needed to be rebooted (restarted) in order to update system data, but the WIDESTAR II S-AP is able to perform an online update without restarting the equipment.

1) Changes in Dedicated Bandwidth Resources

For the newly introduced dedicated bandwidth services, the S-AP manages the dedicated bandwidth within the system data, allowing contracted bandwidth to be used exclusively, so when the contract details for dedicated bandwidth change, the dedicated radio resource data is updated on-line.

2) Support for Increasing Voice Resources during Disaster

In order to allow data communications resources to be switched over to voice communications resources flexibly in the event of a large-scale disaster, the type of the communications units described below can be switched from data communications to voice communications, on-line and at any time.

2.5 Satellite 15 M/30 M Mode Support

The N-STAR d, supports transmitting and receiving of left and right hand circular polarized wave[*10] in the C band for communication with the satellite base station (N-STAR c only supports one polarization in the C-band), and provides a 30 M mode to process an operating bandwidth of 30 MHz, This is twice the 15-MHz operating bandwidth of the earlier WIDESTAR service. A single S-AP device is able to process a signal of 15-MHz bandwidth, and the equipment is designed so that two S-AP units can operate cooperatively to handle the 30 M satellite mode.

3. Radio Communications Card Features

The S-AP radio communications cards, including the BB card which manages modulation/ demodulation and other layer 1[*11] processing, and the RLC card, which manages layer 2[*12] processing, have been designed to allow communications units to be configured flexibly in order to support WIDESTAR II voice and data communications.

3.1 BB Card Channel Configuration

To specify communications channels, a BB card first establishes resources which are then secured by a Call Processing-Control card (CP-CNT).

The BB card is equipped with seven Digital Signal Processors (DSP) called BB units, and each BB unit supports radio resources of 300 kHz bandwidth, creating the following unit types in the system data.

- Traffic Channel (TCH) Unit: Accommodates 20 voice or control channels.
- Guaranteed (GR) Speed Unit: Accommodates four Guaranteed Channels (GRCH) for 64k data communications services.
- BE Unit: Accommodates Best Effort Channels (BECH) for packet communications services, including one 384 kbit/s downlink channel and two max. 144 kbit/s uplink channels.

1) BE Unit Scheduling

Of the channels accommodated by the BE units, the uplink BECH handle dynamic allocation of required bandwidth using layer 1 control protocols, and downlink BECH are shared by multiple mobile stations, so up and downlink channels can be used efficiently by multiple users by controlling them with different schedules.

Layer 1 control of uplink BECH is confined to the BB cards, managing assignment of bandwidth when releasing and reallocating channels. Data sent on downlink BECH is scheduled by the RLC cards, which perform layer 2 processing, and the BB cards.

2) Handover for BB Card Redundancy Switching

The BB cards hold seven BB units, so they handle a large number of communications calls. If calls are dropped when a BB card is transferring them to

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*9 **Radio resource**: General term for resources needed to allocate radio channels (frequencies). This can include radio transmission power, TRX resources, BB channels, and RLC resources.

*10 **Polarized wave**: A radio wave with the property that its component electrical and magnetic fields are oriented in particular directions. The S-BE uses left and right hand circularly polarized waves.

*11 **Layer 1**: The first layer (physical layer) in the OSI reference model.

*12 **Layer 2**: The second layer (data link layer) in the OSI reference model. In this article, it refers to the Satellite-Link Access Procedure for Digital Mobile (S-LAPDM) channel processing functionality.

a reserve BB card (redundancy switching), all of the mobile stations will begin attempting to reconnect, resulting in signal concentration and congestion. The BB card redundancy switching is designed so that call information is taken over to the reserve BB card. However, the uplink BECH allocation data for BB cards undergoing redundancy switching is not reliable and processing is complex, so it is not handed over, and these resources are released forcefully.

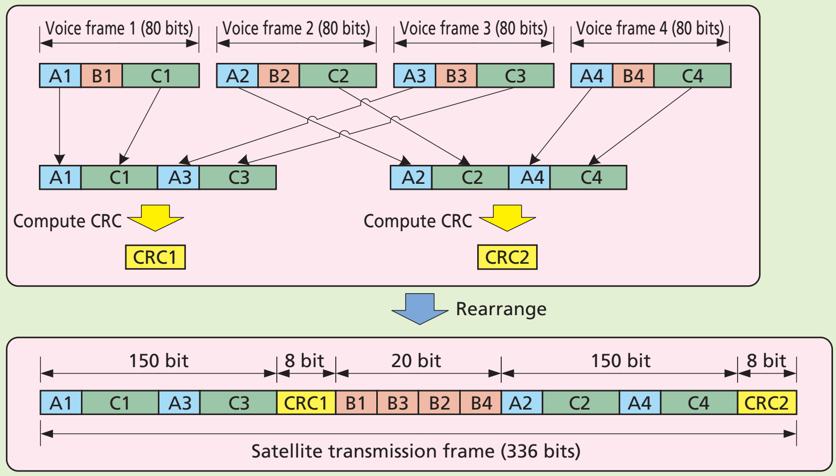

Figure 3 Assembly of satellite transmission frame

3.2 RLC Card Voice Signal Processing

For processing of voice signals, the RLC cards receive and disassemble Real-time Transport Protocol (RTP)[*13] and RTP Control Protocol (RTCP)[*14] packets, perform jitter buffer control, detect packet loss, detect silent frames, add Voice Operated Transmitter (VOX)[*15] information, detect RTP faults, assemble and disassemble satellite transmission frames, generate Cyclic Redundancy Checks (CRC)[*16], perform error detection and assemble and generate RTP packets. Among these, processes particular to the S-AP are assembly and disassembly of satellite transmission frames, and assembly and generation of RTP packets.

1) Assembly of Satellite Transmission Frames

The assembly scheme for a satellite transmission frame is shown in **Figure 3**. In response to an interrupt signal at 40 ms intervals, payload[*17] data (A, B and C) is read from the jitter buffer and reorganized into the satellite transmission frame format. One satellite transmission frame is comprised by four voice frames, but if there are three or fewer valid voice frames, an invalid frame is sent instead of voice code.

In addition to voice data, RTP packets include Silence Insertion Descriptors (SID), so SID data can be detected from the length of the RTP packet payload.

Note that when assembling a satellite transmission frame, each voice frame is fixed at 80 bits, having one of the following three patterns:

- Voice code frame: 80 bits
- SID: SID (15 bits) + SID-specific bit pattern (65 bits)
- Invalid frame: Fixed pattern (80 bits)

2) Satellite Frame Disassembly

The voice data in the received satellite transmission frame is disassembled. The transmission frame is TDM on the satellite transmission side, so there is no delay or jitter, and the voice coded data can be extracted directly from the received satellite transmission frame.

The disassembly scheme of a satellite transmission frame is shown in **Figure 4**.

The S-AP performs a CRC check, rearranges the data in the satellite transmission frame into four voice frames, and determines whether they match one of the patterns in 1).

3) Generation of RTP Packets and Dual-Tone Multi-Frequency (DTMF)[*18] Transmission

The RLC card relays the voice data, converting to a layer 2 frame for the radio side, and to an RTP packet for the core node side. For uplink DTMF trans-

*13 **RTP**: A protocol defined by the Internet Engineering Task Force (IETF) for real-time distribution of audio, video or other such media.

*14 **RTCP**: A communications protocol for tasks such as exchanging reception status of streaming server data and controlling transmission rates. Used in combination with RTP.

*15 **VOX**: Control which suspends radio power when there is no voice signal in order to reduce power consumption during transmission.

*16 **CRC**: A method for detecting errors that could occur when transmitting data.

*17 **Payload**: The part of the transmitted data that needs to be sent, excluding headers and other overhead.

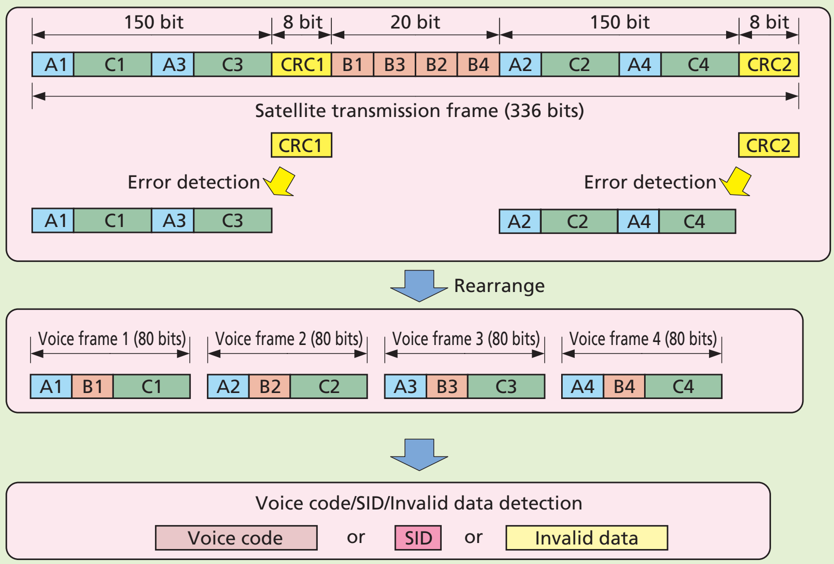

Figure 4 Disassembly of satellite transmission frame

fers, the mobile station creates a DTMF code in a layer 3[*19] signal, which is converted to an RTP packet and sent to the core node by the RLC card. Downlink DTMF transfers are relayed as voice signals from the core node, so the S-AP does not perform any particular processing.

4. Conclusion

In this article, we have described the development of new satellite base station equipment for WIDESTAR II. With the development of this equipment, we can support higher speeds for the increasing demand for data communications, and have improved functionality for connecting satellite base station equipment with IMS-based core nodes, as needed with the conversion of voice services to IP.

In the future, we will continue to study ways to use radio resources more efficiently, in line with expectations that applications of data communications services will continue to expand.

References

[1] H. Kondo et. al: "Special Articles on Satellite Mobile Communications Systems/3. Base Stations," NTT DoCoMo Technical Journal, Vol.4, No.2, pp.15-19, Jul. 1996 (in Japanese).

[2] T. Yamashita et. al: "Special Articles on Satellite Mobile Communications Systems/4. Operations System," NTT DoCoMo Technical Journal, Vol.4, No.2, pp.20-23, Jul. 1996 (in Japanese).

*18 **DTMF**: A method for transmitting telephone buttons and symbols using combinations of two out of four types of high and low pitched sounds.

*19 **Layer 3**: The third layer (IP layer) in the OSI reference model. In this article, refers to the S-RRC protocol.