# Vanu GSM Base Station System

## ADC Digivance and Telos Sonata Configuration

VANU INC

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**Revision 1**

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# 1. System Overview

The Vanu Software Radio™ GSM/GPRS base station sub-system provides radio access network functionality by implementing the BTS (Base Transceiver Station) and BSC (Base Station Controller) in software running on a general-purpose server.

For a standard network configuration, Vanu, Inc. deploys a Vanu Software Radio BTS at each tower site, and a centrally located Vanu Software Radio BSC. The Vanu BTSs and BSC run on industry-standard HP ProLiant Servers. Signal processing, protocol processing, and all other radio access network functionality is implemented as application level software running on top of the Linux operating system.

An internet connection is required to allow remote access to the system for software upgrades and administration. Figure 1 and Figure 2 shows the system with either a T1 internet connection or a local internet connection that is connected directly to the VPN router.

The Vanu BTS system uses the ADC Digivance Long Range Coverage Solution serving as the RF front end. The Vanu BSC seamlessly connects to the GSM core network circuit switch domain via the A interface and to the packet switch domain for future GPRS capabilities by means of the Gb interface.

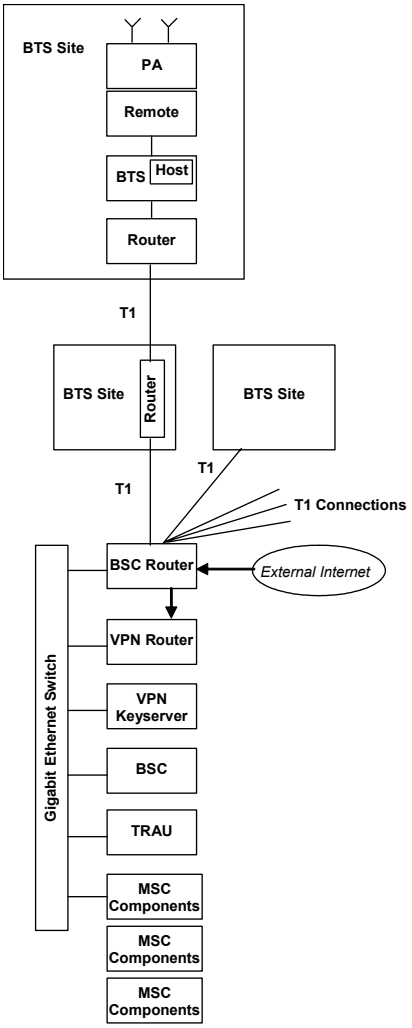

**Figure 1: System Diagram, T1 Internet Connection**

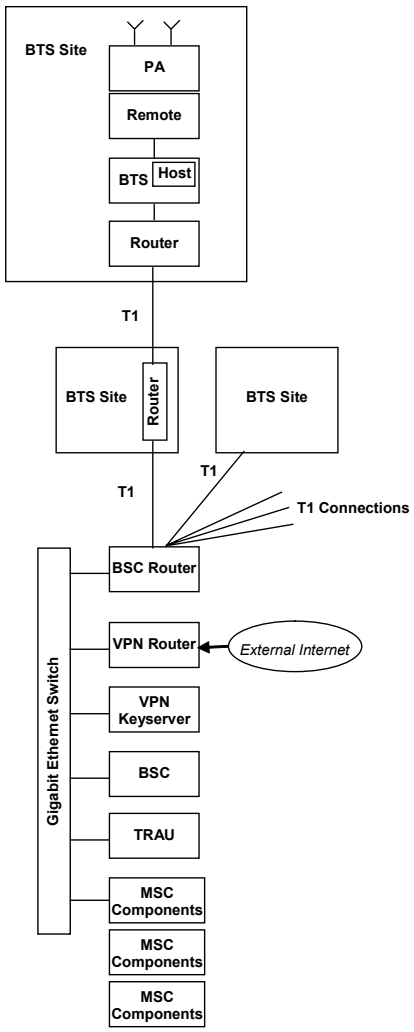


**Figure 2: System Diagram, Local Internet Connection**

The Vanu Software Radio base station is composed of four major subsystems:

- RF front end, supporting the 800MHz cellular band
- Analog-to-Digital and Digital-to-Analog conversion
- Signal Processing
- Back end network connectivity

Vanu, Inc. integrates these subsystems, running its software on top of the COTS hardware that comprises a complete radio access network, including the traditional functionality of the BTS, BSC, and Transcoder and Rate Adaptor Unit (TRAU).

# 2. BTS Sites

The Vanu Software Radio BTS implements all of the signal processing required to implement full GSM basestation functionality in software running on a server. A standard system implements the components of GSM Phase II for voice communications. It supports mobile phones operating in enciphered mode using the full-rate (GSM 6.10) vocoders.

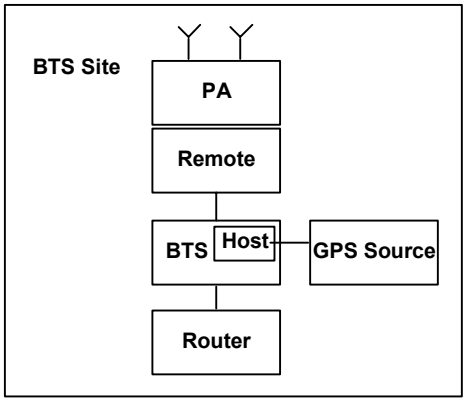


**Figure 3: BTS Site**

The Vanu BTS is complemented by an ADC Telecommunications Digivance RF subsystem. The ADC PCI Host connects the BTS to an ADC Remote using digital-over-fiber technology. A 25-MHz frequency band is digitized and transmitted between the two units.

## Routers

The BTS router is a Cisco 1760 1U router. It has two Wide Area Network Interface cards (WIC) installed. One is a dual port T1 card, and the other is a four-port ethernet switch. The ethernet switch provides a local network for the server, its iLO (integrated lights out, the HP remote management system), the ADC EMS (element management system) server, and any other diagnostic computers. The T1 card provides a connection to the BSC site. Some of the BTS sites are daisy chained together, and use both T1 ports, while some only use one. Ports are labeled:

**(slot number of the card)/(port number on the card)**

### Connections

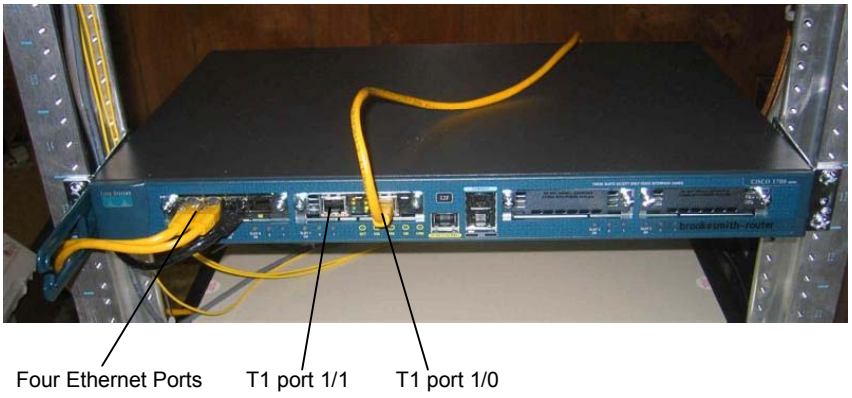

**Figure 4: BTS Router and Connections**

There are two different configurations of T1 connections, daisy-chain and endpoint.

In a daisy-chain configuration:

- T1 1/0 to BSC router
- T1 1/1 to daisy chained BTS router

On an endpoint router that is connected to only the BSC router or at the end of a daisy chained T1:

- T1 1/0 to downstream BTS router or BSC router

Common to both configurations:

| Qty | Connection |
|---|---|
| 1 | Ethernet cable to server ethernet port 1 |
| 1 | Ethernet cable to server iLO ethernet port |
| 1 | Power cable |

### Troubleshooting

The connected ethernet ports should have green LEDs.

The T1 port(s) in use should have only one green LED lit. If both an amber LED and a green LED are lit, the T1 connection is made, but there are alarms on it. An alarm indicates that there may be a problem with other equipment in the T1 link, or the line code or framing are not configured correctly. If only an amber LED is lit, the T1 connection has not been established at all.

## BTS Servers

The HP Proliant server runs the BTS software on top of a Linux operating system. The RF data enters the computer via the ADC Host Card in the PCI chassis. Messages to the rest of the system are sent from the ethernet port to the router, where they travel over the T1 to the BSC. The iLO port is used to monitor and control the server remotely.

### Connections

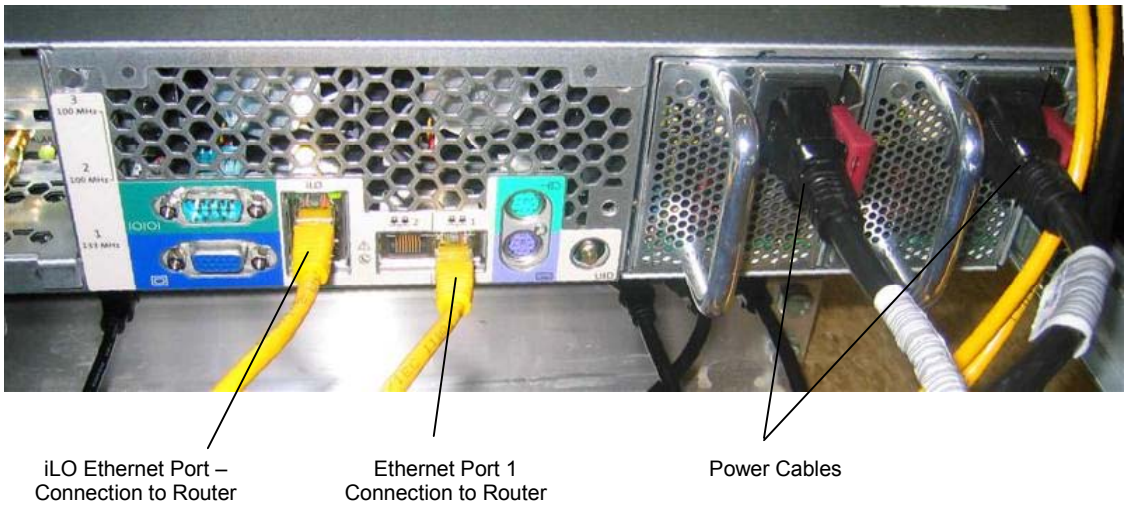


**Figure 5: BTS Server Connections**

| Qty | Connection |
|---|---|
| 2 | Power cables |
| 1 | Ethernet cable from ethernet port 1 to the router |
| 1 | Ethernet cable from iLO ethernet port to the router |
| 1 | ADC Host card installed in the PCI chassis |

### Troubleshooting

The power supplies should each show a green LED when the server is turned on. There are four LEDs on the front of the server next to the power button. If one of the power supplies is not working, the heartbeat LED (second from the top) will be amber instead of green. The bottom two LEDs are for the Ethernet ports, only the LED marked with a 1 should be green, and it will flash on and off with traffic on the interface. The hard drives each have green LEDs on them that will blink on and off as they are used. The hard drive LEDs will show red if there is an error with the hard drive.

## ADC Host Card

The ADC Host Card transmits and receives digitized data to and from the ADC Remote Unit over the fiber connection. It uses a PCI-X slot to connect to the server. It receives a 10 MHz frequency reference and 1 pulse per second timing signal from the GPS unit to ensure precision timing.

The Host Card must be configured to use the desired frequency channels for each BTS through the ADC EMS software. For more information, please refer to the ADC EMS manual.

### Connections

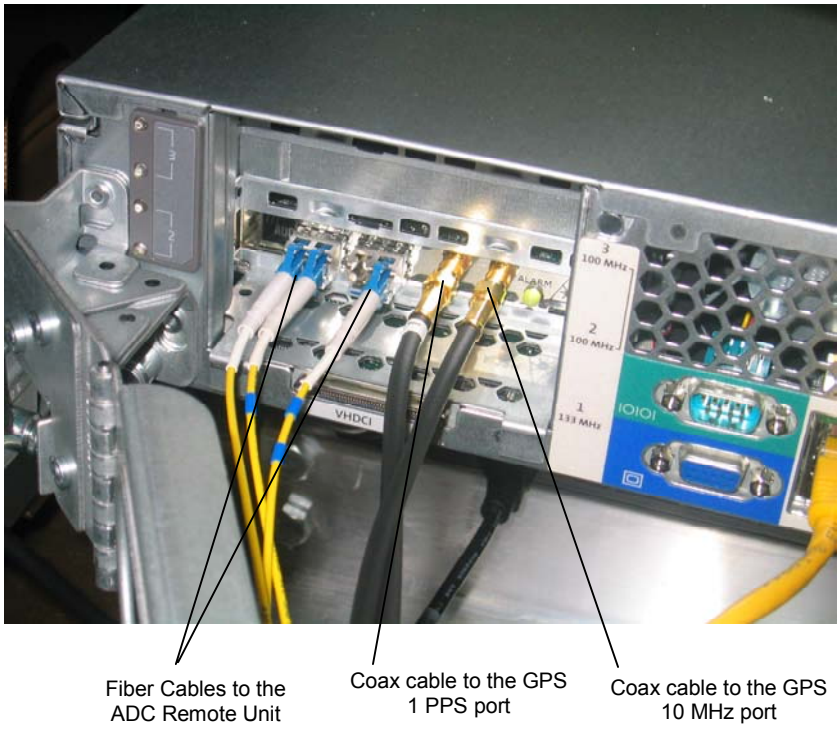


**Figure 6: ADC Card Connections**

| Qty | Connection |
|---|---|
| 3 | Fiber cables to the ADC Remote Unit (2 for non-diversity units) |
| 1 | Coax cable to the GPS 10 MHz port |
| 1 | Coax cable to the GPS 1 PPS port |

### Troubleshooting

The PCI chassis must be securely connected to the server. If it is not fully plugged in, the server will not turn on.

After turning the server on, verify that the LED next to the fiber cables is green. If the LED is red, the host card is not communicating with the remote over the fiber cables, it does not have a 10 MHz reference from the GPS unit, or there is some other internal error. If the LED is yellow, the device is in "stand-by" mode. The LEDs on the front of the remote unit can be used for further debugging to determine if there is a problem with the fiber connection. The EMS software can provide more detailed debugging information if necessary.

## ADC Remote Unit

The ADC Remote Unit converts digital IF data to an RF signal, which is amplified by the multi-carrier power amplifier that is housed in the same chassis. The remote unit transports the digital IF data over fiber patch cables to the ADC Host Unit.

## Connections

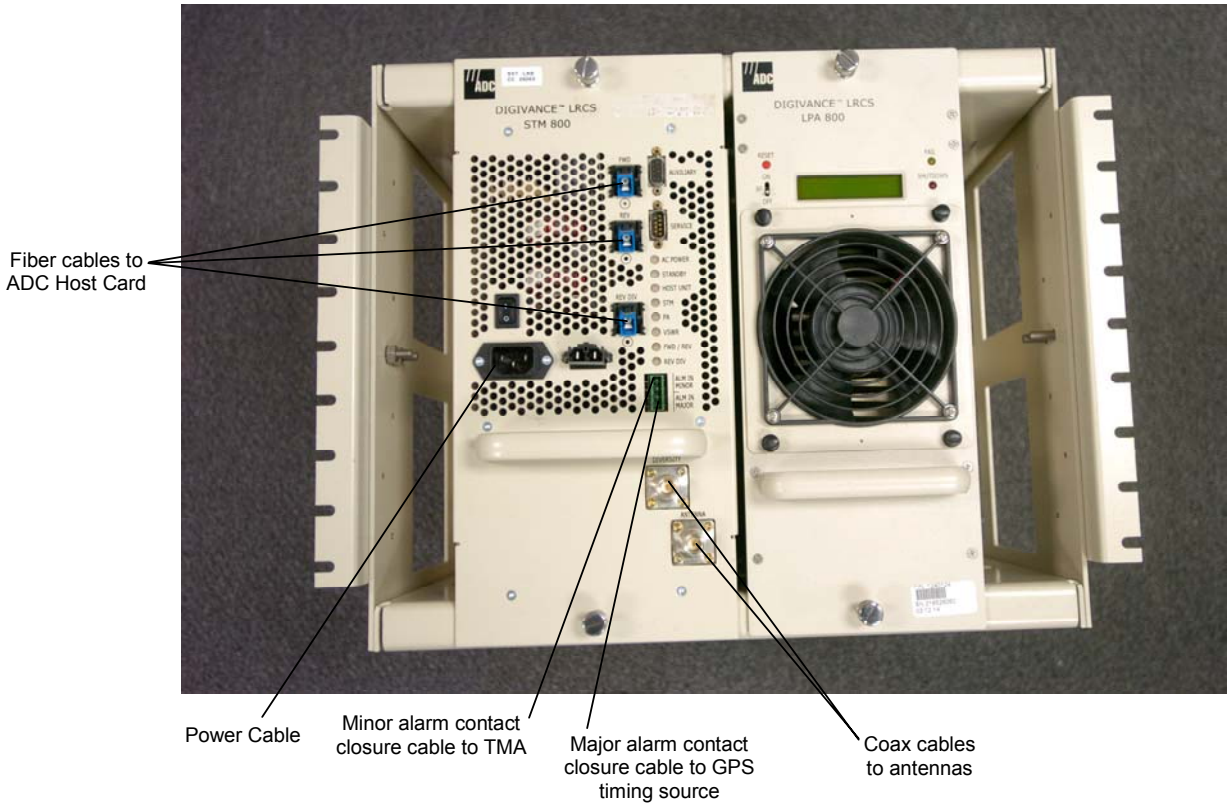


**Figure 7: ADC Remote Unit Connections**

| Qty | Connection |
|---|---|
| 3 | Fiber cables to the ADC Host Card (2 for non-diversity units) |
| 1 | Power cable |
| 2 | Coax cables to the antennas (1 for non-diversity units) |
| 1 | Major alarm contact closure cable to GPS timing source |
| 1 | Minor alarm contact closure cable to TMA (optional) |

## Troubleshooting

The LEDs on the front panel of the remote and the ADC EMS software are the best source for debugging problems with the remote. For more information, please refer to ADC's Digivance® LRCS System Indoor Remote Installation and Maintenance Manual and Element Management System for Digivance Application V 4.0 for SDR.

# GPS Timing Source

The GPS Timing Source simply provides a 10 MHz clock signal and a 1 pulse per second signal to the ADC Host Card for precision timing. It must be locked onto enough GPS satellites to operate, and it will indicate a lock with an illuminated LED on the front panel. Please note, it may take up to five minutes for the GPS unit to acquire a lock.

### Connections

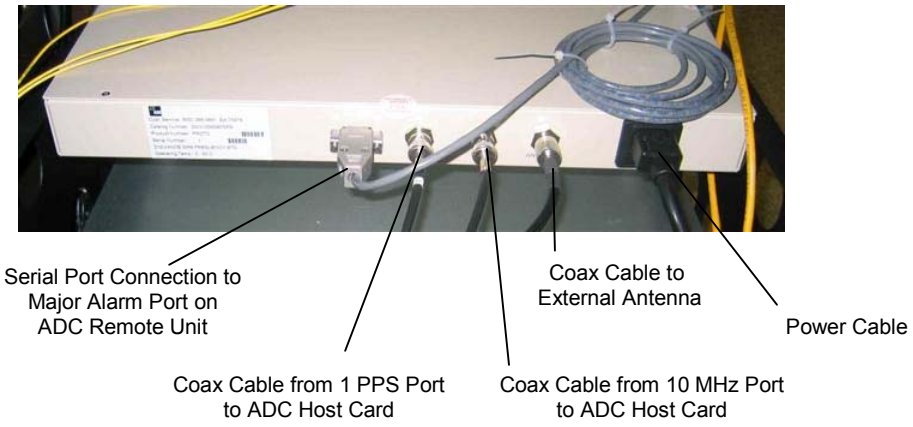


**Figure 8: GPS Timing Source Connections**

| Qty | Connection |
|---|---|
| 1 | Power cable |
| 1 | Coax cable from the 1 PPS port to the ADC Host Card |
| 1 | Coax cable from the 10 MHz port to the ADC Host Card |
| 1 | Coax cable to the external antenna |
| 1 | Cable from serial port to major alarm port on ADC Remote Unit |

### Troubleshooting

The LEDs on the front panel indicate whether a lock has been achieved. After installation, the lock and fault LEDs will both be on for a short period of time (on the order of 10-15 minutes) until the GPS clears all of the errors out of its buffer.

# 3. BSC Site

The Vanu Software Radio base station controller (BSC) is the network node that runs radio resource management and manages the connections to the GSM Core Network. The BSC and TRAU/RAU (Rate Adaptor Unit) are built on an HP Server platform, using gigabit ethernet for interconnect.

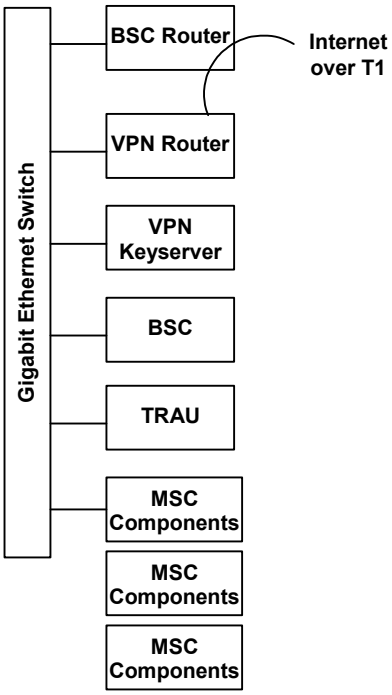


**Figure 9: BSC Site**

The BSC can handle up to 140 GSM carriers, which is equivalent to 2000 full-rate voice calls. Each RAU can support up to 300 voice calls, TRAU up to 100 voice calls, and larger call volumes can be supported by increasing the number of TRAU or RAU servers.

## Routers

The BSC router can support multiple T1 connections to connect to the BTS sites. It has two ethernet ports; one is connected to the private LAN. If there is no local internet connection, a T1 internet connection is forwarded to the second ethernet port, which is directly connected to the public interface of the VPN router.

### Connections

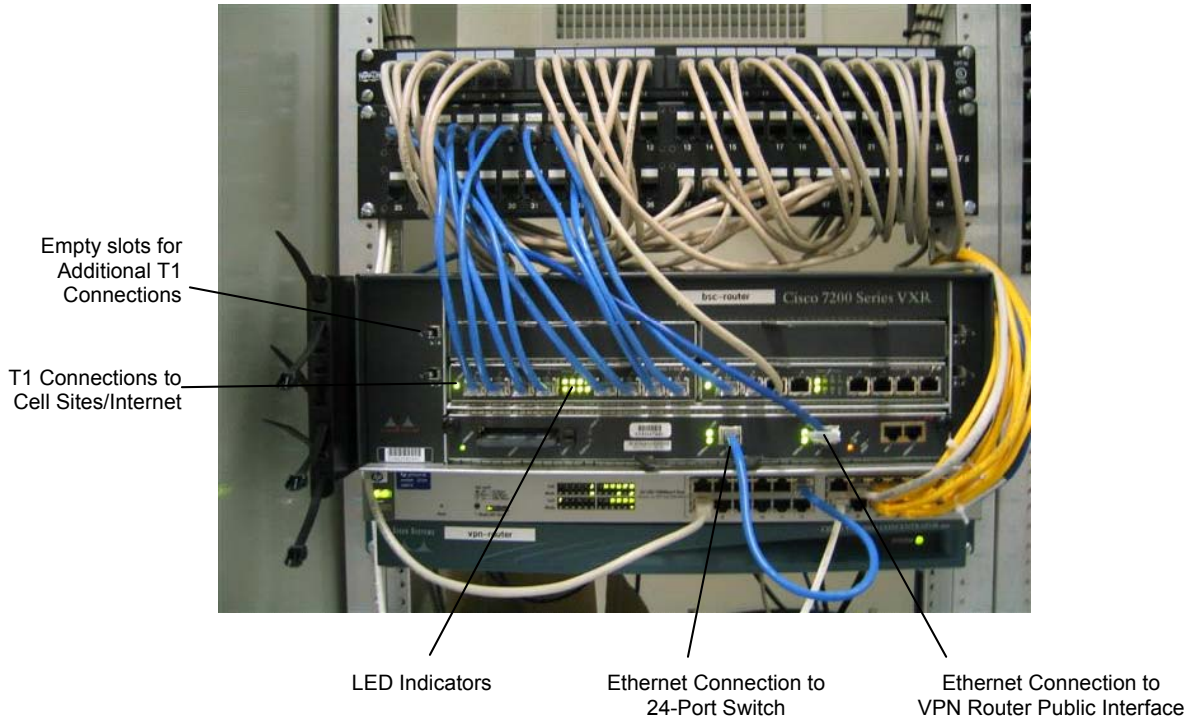


**Figure 10: Router Connections**

| Qty | Connection |
|---|---|
| | Multiple T1 connections to cell sites |
| 1 | T1 connection to the Internet (Internet over T1 option only) |
| 1 | Ethernet connection to the 24 port switch |
| 1 | Ethernet connection to the public connection on the VPN (Internet over T1 option only) |
| 1 | Power connector |

### Troubleshooting

There are banks of LEDs, with each LED corresponding to one T1 connection. If the LED is lit, the T1 connection is made. If the LED is dark, the T1 connection may be showing alarms or it may have no signal.

## BSC Servers

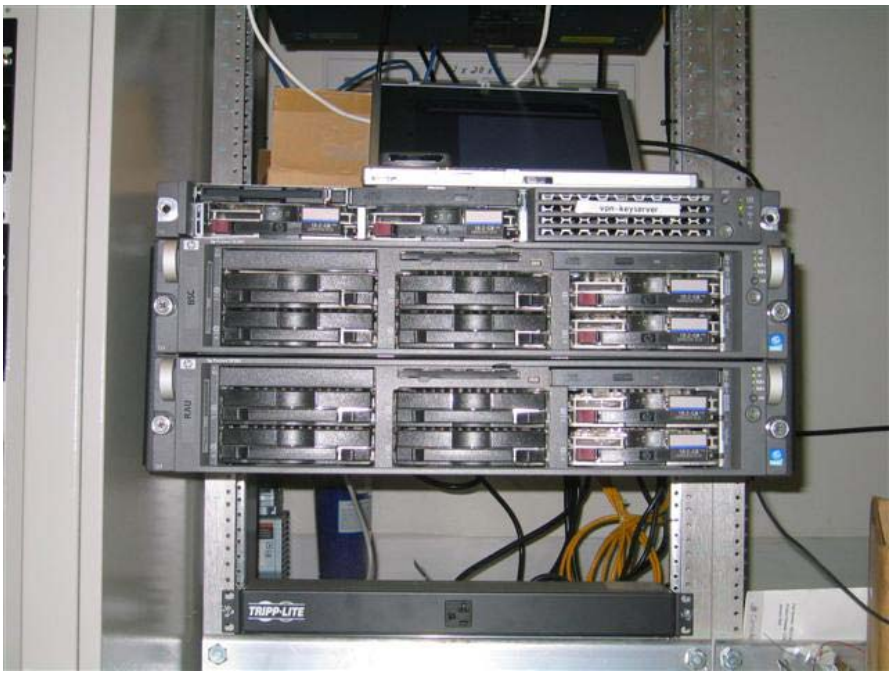


**Figure 11: Key Server, BSC and RAU Servers (top to bottom)**

The HP Proliant server runs the BSC software on top of the Linux operating system. Messages to the rest of the system are sent from the ethernet port to a LAN where the RAU and the MSC connect, or to the router where they travel over the T1 to the BTS sites. The iLO port is used to monitor and control the server remotely.

## Connections

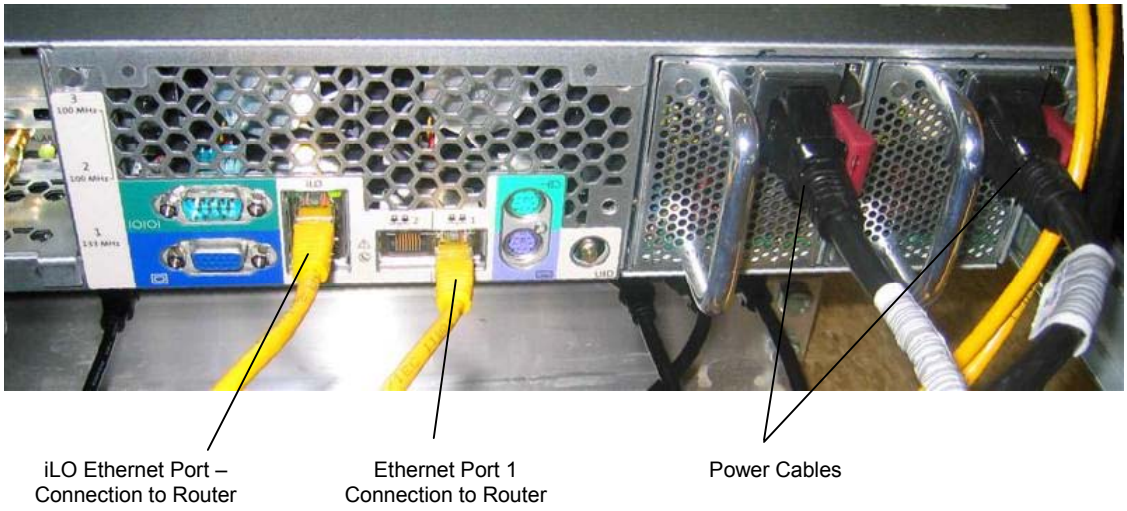


**Figure 12: BSC and RAU Server Connections**

| Qty | Connection |
|---|---|
| 2 | Power cables |
| 1 | Ethernet cable connecting ethernet port 1 to the router |
| 1 | Ethernet cable connecting the iLO ethernet port to the router |

### Troubleshooting

The power supplies should each show a green LED when the server is turned on. There are four LEDs on the front of the server next to the power button. If one of the power supplies is not working, the heartbeat LED (second from the top) will be amber instead of green. The bottom two LEDs are for the Ethernet ports, only the LED marked with a 1 should be green, and it will flash on and off with traffic on the interface. The hard drives each have green LEDs on them that will blink on and off as they are used. The hard drive LEDs will show red if there is an error with the hard drive.

## RAU Server

The HP ProLiant server runs the RAU software on top of a Linux operating system. Messages to the rest of the system are sent from the ethernet port to the LAN where the BSC and the MSC sit, or to the router where they travel over the T1 to the BTS sites. The iLO port is used to monitor and control the server remotely.

### Connections

Please refer to Figure 12 for connection locations.

| Qty | Connection |
|---|---|
| 2 | Power cables |
| 1 | Ethernet cable connecting ethernet port 1 to the router |
| 1 | Ethernet cable connecting the iLO ethernet port to the router |

### Troubleshooting

The power supplies should each show a green LED when the server is turned on. There are four LEDs on the front of the server next to the power button. If one of the power supplies is not working, the heartbeat LED (second from the top) will be amber instead of green. The bottom two LEDs are for the Ethernet ports, only the LED marked with a 1 should be green, and it will flash on and off with traffic on the interface. The hard drives each have green LEDs on them that will blink on and off as they are used. The hard drive LEDs will show red if there is an error with the hard drive.

## Gigabit Ethernet Switch

The HP ProCurve Gigabit Ethernet switch provides an ethernet LAN with 24 ports.

## Connections


**Figure 13: Switch Connections – Front**


**Figure 14: Switch Connections – Back**

| Qty | Connection |
|---|---|
| 1 | Power cable |
| | Any computer sitting on the 10.0.0.X subnet at the BSC site should be plugged in* |

*Including the BSC, the RAU, the MSC components, and the ADC StarGazer

## Troubleshooting

Make sure that the power cord is plugged in and the switch is on. There is an LED corresponding to each ethernet port. Verify that the port you are interested in is behaving as expected: a 10Mb connection will be dark, a 100Mb connection will blink, and a 1Gb connection will be solidly lit.

# VPN Key Server

## Description

The VPN Key Server is running on a 1U HP Proliant server. It serves as an authentication server for the VPN software.

## Connections

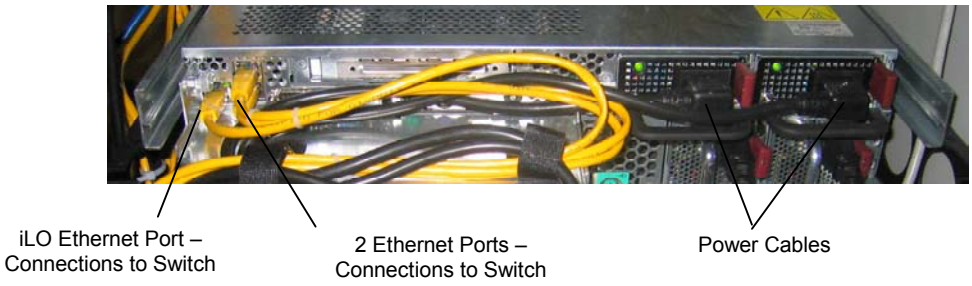

**Figure 15: VPN Key Server Connections**

| Qty | Connection |
|---|---|
| 2 | Power cables |
| 2 | Ethernet cables connecting both of the 2 ethernet ports to the switch |
| 1 | Ethernet cable connecting the iLO ethernet port to the switch |

### Troubleshooting

The power supplies should each show a green LED when the server is turned on. The four LEDs on the front of the computer should all light up when the server is turned on. The top two are steadily lit, and the bottom two will flash on and off. If either of the bottom two are not on, check the ethernet connections.

## VPN Router

The VPN router provides a secure outside connection to the Vanu, Inc. Software Radio network. It allows Vanu, Inc. engineers to monitor the system remotely, and upgrade the software when necessary. The VPN router can be connected directly to an external ethernet network. It is also possible to use network address translation in the BSC router to forward a T1 Internet connection directly to the VPN router.

### Connections


**Figure 16: VPN Router Connections**

All of the connections are on the back of the router.

| Qty | Connection |
|---|---|
| 1 | Power cable |
| 1 | Ethernet cables from the public ethernet port to the BSC router or public internet connection |
| 1 | Ethernet cable from the private ethernet port to the Gigabit Ethernet Switch |

### Troubleshooting

There is one LED labeled “SYSTEM” on the front of the VPN. This should be illuminated when the power is on. There are more LEDs on the back of the router. Each ethernet port has four LEDs. The two marked “LINK” and “100” should be lit. The one marked “TX” should blink from time to time. The one

marked “COLL” may light up, but if it is often lit, there may be a problem with the switch, as it indicates collisions occurring on the ethernet network.

# 4. System Administration

## Accounts

Every machine has multiple accounts for different users. There is an FCC account to allow FCC personnel to perform a software audit on the system, and an account for Vanu Inc. personnel to use for system administration and installing software updates. In addition, a gsm-user account is provided for the operator to use for controlling BSS applications.

Each account has a separate password that is kept on file in a secure location at Vanu Inc. The gsm-user password will be given to the operator at the time of installation, and it should be changed on a regular basis using the linux passwd command.

## Gsm-user account

Every machine in the Vanu BSS, including the BSC, (T)RAU, and BTS, has a gsm-user login for administration of the BSS applications. Under this login, it is possible to:

- Start each application.
- Check the status of the application.
- Select which version of the application is running, if multiple versions are installed.

The following executables control BSS applications. Each executable can be run by typing the executable name at the command prompt. Help messages are displayed by typing the command name followed by the “--help” flag and pressing Enter.

A brief description of the commands and their actions are listed below.

| Command | Action |
|---|---|
| gsm-start | Starts the chosen version of the BSS application. It will not restart the application if it is already running. |
| gsm-stop | Stops the BSS application that is currently running. This only stops the application from running during the current session. If the machine restarts, the selected version of the application will restart once the machine has finished booting. |
| gsm-restart | Restarts the currently selected version of the application. |
| gsm-setup-version [selected-version] | Selects “selected-version” of the application to run. After this has run, this version will automatically start, and it will also automatically start following a machine reboot.<br>gsm-setup-version can be run with "none" as the argument, so that no version is selected. In this case, any currently selected version will be stopped and no application will be automatically started when the machine reboots. |
| gsm-list-version | Lists all of the available installed versions of the application. |

| | |
|---|---|
| gsm-status | Reports the version of the application that is currently selected. It also reports the uptime or downtime of that application. |

Log files for the application are stored in: **/home/gsm-user/logs**.

The current log is **gsmbss.log**, and the logs are rotated on a regular basis from gsmbss.log to gsmbss.log.1 and on, in increasing order. The number of logs in the rotation is configurable on a per-machine and operator basis.

Configuration files for the application are stored in **/home/gsm-user/config**. There can be multiple versions of configuration files in this directory. The one in use is selected by a link from /home/gsm-user/Current.gsmbss.conf to the desired configuration file in /home/gsm-user/config/.

# 5. Acronym Glossary

| | |
|---|---|
| BSC | Base Station Controller |
| BSS | Base Station Subsystem |
| BTS | Base Station transceiver Subsystem |
| COTS | Commercial off-the-shelf |
| EMS | Element Management System |
| GPS | Global Positioning System |
| HLR | Home Location Register |
| iLO | Integrated lights out<br>HP remote management system |
| MSC | Mobile Switching Center |
| PA | Power amplifier |
| PCI | Peripheral Component Interconnect |
| PCS | Personal Communications Services |
| PPS Port | Pulse per second port |
| RAU | Rate Adaptor Unit |
| RH | Radio Head |
| SDR | Software Defined Radio |
| SMS | Short message service |

| | |
|---|---|
| TRAU | Transcoder and Rate Adaptor Unit |
| VoIP | Voice over Internet Protocol |
| VPN | Virtual Private Network |
| WIC | Wide Area Network Interface Cards |

# 6. Index