

TITLE: Xelatec XIPPR Radio Over IP Server Installation Process  
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#### PURPOSE

Our goal is to enable Push-To-Talk radio users to interconnect radio systems via IP networks and incorporate the power of Voice Over IP PBX switches. We recognize that organizations need far more than basic PTT radio communications and this package incorporates several related applications that complement Radio Over IP connectivity. This document explains an installation process for these applications recommended by the developers. This package is named the XIPPR for Xelatec Internet Protocol Professional Radio. It is an Open Source Software Project provided on an "as-is" basis. Xelatec offers professional support services for XIPPR systems.

#### DESCRIPTION

This process installs a VoIP-PBX system with radio interface and control modules. Because the full power of the VoIP-PBX enables linked radios to do much more than just communicate among themselves, we included several popular telecommunications packages and server administration tools. Most recognizable are the Asterisk IP-PBX, and the FreePBX web based configuration tool, and Webmin for system administration. Unlike most VoIP packages, this package includes the complete source code and development environment and the radio linking software. This enables developers to work with users directly on the target system instead of having to duplicate the application in the laboratory. Also this allows updates to be compiled locally on the user's specific hardware.

#### PACKAGE COMPONENTS

The following Open Source Software packages are included in the XIPPR system.

- Fedora Linux Operating System and supporting packages.
- Webmin System Administration
- Asterisk VoIP-PBX
- FreePBX Web based VoIP-PBX configuration tool.
- Shorewall Firewall
- Various system and network utilities.

The iaxRpt PTT radio dispatch client is available as a separate download from the Xelatec site. When installed on a personal computer it is used to control to radio equipment on XIPPR servers over the network and provide the user with a Speaker, Microphone and PTT interface.

#### AUDIENCE

Persons who attempt to use this document to construct a XIPPR Radio Over IP server should be well versed in private radio communications technology, Linux software, programs, tools and utilities.

These include but are not limited to:

- Open Source Software Development Practices,
- the Linux Operating System,
- the Webmin Linux server configuration tool,
- public and private IP Networking,
- Private Mobile Radio terms, practices and methods.
- the Asterisk IP-PBX and FreePBX

As this is an Open Source Software project, the documentation motto is "Read the Full Sources" (RTFS). That and the comments in the configuration files and examples are your best references.

Xelatec provides professional services to assist in the implementation and detailed documentation of specific XIPPR systems.

#### MINIMUM COMPUTER HARDWARE REQUIREMENTS

PC, Intel Pentium III 800 MHz CPU or better,  
(note that we do not recommend AMD processors for this application)  
512 MB RAM, 5 GB Hard Drive,  
Ethernet Network Interface Card (NIC),  
During the installation only:  
- CDROM Drive  
- Monitor and Keyboard

#### IP NETWORK REQUIREMENTS

This application requires an Ethernet connection to an IP network with DHCP and broadband Internet access. Incoming packets to the computer's FQDN on port number 4569 (or an alternate port number defined during installation) must be routed to the computer through any intervening routers or firewalls. For connection to external SIP VoIP services, ports 5060 TCP/UDP and 10000-20000 UDP must also be routed to this server.

#### RADIO TRANSCEIVER REQUIREMENTS

The XIPPR system's Radio Over IP modules enable it to be connected to almost any radio transceiver and network if you have the skills and patience to construct the necessary interfaces and configurations.

For the commercial private mobile radio bands there are many radio repeaters with a community repeater or trunking radio controller accessory port available.

For frequency agile remote applications, the XIPPR server can control a frequency programmable or channel steerable radio transceiver.

Several different radio makes and models are well supported by Xelatec who provides commercial interfaces and cables.

#### RADIO TRANSCEIVER TO SERVER INTERFACE

The XIPPR package supports connecting PTT radios to the server via a USB Radio Device (URD). Through the URD, Continuous Tone Coded Squelch System (CTCSS) and other signaling encoding and decoding is done in the software. And, signal level setting is also done electronically so there are no physical adjustments to make that require access to the computer and taking the covers off to reach potentiometers. Additionally, the URD can determine the received signal level in software and uses it for squelch and other features. Software modules are available that enable this interface to encode and decode several professional digital coded squelch, scrambling and trunking radio formats in addition to CTCSS.

The best and preferred radio connection is directly to a radio's unsquelched and unfiltered receiver audio signal and its flat transmitter audio modulation point. Of course a transmitter activate or PTT connection is required. In some cases a carrier or signaling tone detection point is required but usually the XIPPR software provides all carrier and coded squelch processing.

#### GENERAL INFORMATION

These instructions and the installation scripts require booting the target computer from a 20 MB CDROM boot image and then accessing various Internet sites to download and install the Fedora Linux Operating System (OS) and the VoIP and RoIP applications.

This installation will completely erase the computer's hard drive. Any information that existed on it before the installation will be irretrievably lost. Contact Xelatec for other options.

In our tests, an 800MHz Pentium III computer connected to a 6 Mb/s ADSL Internet service required slightly more than an hour and a half to execute the complete installation process.

#### PRE-INSTALLATION PLANNING

##### PRIVATE RADIO OVER IP NETWORK CONFIGURATION

Node numbers in the range of 1000 to 1999. These node numbers can be used as they are for connections or re-mapped through the VoIP server dialplan.

Xelatec provides additional server software that for a distributed private system, the various radio/node information can be entered in a manually constructed file and then regularly downloaded by the nodes.

#### INSTALLATION PROCEDURE

Before beginning the server installation you should plan your initial system so that you can properly answer the configuration options when prompted for them.

This includes the number of sites/servers, the radios attached to each server and a basic dialplan. For private systems we recommend node numbers in the range of 1000 to 1999. Node numbers can be used as they are for connections or re-mapped through the dialplan. For example:

Site	FQDN or IP ADDR	Description
1	hq.example.com	Headquarters
2	sub.example.com	Substation

Node	Site	Radio	Description
1110	1	1	Xcvr, Repeater, UHF-FM, Rx=469.500, Tx=464.500
1210	2	1	Xcvr, Simplex, UHF-FM, Tx/Rx=464.575
1220	2	2	Xcvr, Simplex, VHF-FM, Multi-Channel Remote

Node	Remote Password
1110	xxxxxxxxxxxxxx
1210	YYYYYYYYYYYYY
1220	zzzzzzzzzzzzz

The node information can then be entered during the installation process and automatically used to build some of the XIPPR configuration files.

You must obtain at least one USB radio interface for each server and it must be attached to the server during the installation process in order to be recognized and for the software to operate properly.

We recommend that you assign your computer a Fully Qualified Domain Name (FQDN). If your Internet connection has a dynamically assigned IP address, you should register for a free Dynamic DNS service at "http://www.dyndns.com" or use an equivalent service. The XIPPR installation process installs the 'inadyn' dynamic DNS client and places your DNS FQDN in the '/etc/inadyn.conf' file. If you use this service, when the automated portion of the installation is complete, edit '/etc/inadyn.conf' to add your DynDNS account username and password and then change the ENABLE option.

Because of the large number of potential IP network configurations, we cannot describe them all in this document. Therefore we will cover a common case. This is where the node is attached to a network with a router that provides a DHCP service that assigns local NAT addresses to client computers.

In that case you must set the router so that incoming packets to the system's Internet address on port number 4569 (or another port number specified in the configuration files) must be routed to the node computer's local area network address through any intervening routers or firewalls.

For example: 1) determine your node computers Ethernet MAC address, 2) set your router's DHCP server to always assign a fixed internal IP address to that MAC address, 3) set your router to forward traffic on that port the fixed internal address of the node computer.

If you have a single Internet IP Address available and several computers running on a NAT and you have a main high availability Asterisk server for telephone call processing and a separate XIPPR Server for connection to your wireless communications equipment, you should consider using a non-standard port number for IAX2 on your XIPPR Server. The software easily accommodates IAX2 (the VoIP protocol developed for Asterisk) on non-standard port numbers. Some telephony applications do not. So the wireless server gets to be the one with the non-standard port number (e.g. 4568). Configure your NAT Router to send incoming traffic on the standard IAX port number (4569) to the main

Asterisk server and traffic to the non-standard IAX port number to the XIPPR server.

Note that security issues are your responsibility, especially if you connect your server directly to the Internet or place it in a DMZ.

#### INSTALLATION PROCEDURE

Connect the USB radio interface to your computer. The interfaces do not need to be connected to radios but they must be present during the installation process so that they are recognized and the software is properly configured.

Connect your node computer to a network with DHCP and broadband Internet access.

You need an attached local video monitor and keyboard during the installation. If the computer BIOS permits it, you can remove these after the installation is complete.

Using another computer with a CDROM burner, create the CDROM with the network installation ISO image. The CDROM ISO image is available at "<http://www.xelatec.com/XIPPR/install>".

Start the computer and press the keys necessary to enter its BIOS utility.

In the BIOS, enter the correct date and time. We recommend using UTC (a.k.a. GMT or Zulu) time. Setting the proper time is important to make sure that the software builds and operates properly.

Also in the computer BIOS, select the boot or start device to first boot from the CDROM and then the Hard Drive.

Finally, disable the BIOS Automatic Power Management (APM) options. It might be possible to reenable these later but if the computer goes into standby or turns off during the installation process it will fail.

Save the BIOS settings and exit the BIOS setting menu.

Insert the installation CDROM into the computer CDROM drive.

Reboot the computer by pressing Ctl-Alt-Delete or power cycling.

The computer should boot from the CDROM and present you with an option prompt.

Select the XIPPR option and press the Enter key.

The installation then proceeds with several standard defaults.

The entire hard drive is erased, reformatted and written with operating system and applications.

The operating system "root" password is set to "madminx63". This should be changed to something more secure when the installation completes.

The system timezone is set to USA/New York.

After the Operating System is installed, the CDROM may eject. When the "Reboot" prompt appears, remove the CDROM from the drive and press the enter key.

After a half hour or more, the computer will prompt you for more information, reboot and then finally come to rest with a login prompt. Note that as advised in detail during the installation process, you must use the FreePBX utility to manually "Apply Changes" and reboot the computer one additional time.

After the installation is complete and confirmed to be operating properly, you may reboot the computer and enter the BIOS setup utility and change the Boot Order to only boot from the Hard Drive.

If you have an Internet connection with a dynamic external IP address, you can use the included inadyn dynamic DNS client as described at "<http://linux.die.net/man/8/inadyn>".

IMPORTANT: Almost any file in the directory "/etc/asterisk" without the keyword 'custom' in its filename is overwritten when you make changes using the FreePBX web interface.

In all other cases, the installation creates files using the naming convention 'zzz\_rpt\_custom.conf' where 'zzz' is a specific parent Asterisk .conf file name. We then add an '#include 'zzz\_rpt\_custom.conf' in the parent '.conf' file to reference our information.

The installation process will prompt you for the information necessary to configure a single primary radio interface. If you connect additional radios edit the '/etc/asterisk/' configuration files 'rpt.conf', and if you are using USB Radio Devices, edit 'urd.conf' to match your radio hardware and enable the desired operating features.

IMPORTANT: Almost any file without the keyword 'custom' in its filename is overwritten when you make changes using the FreePBX web interface. The non-FreePBX supported files of 'rpt.conf' and the 'urd.conf' files are exceptions to this guideline and the installation process modifies them directly.

In all other cases, we create files using the naming convention 'zzz\_rpt\_custom.conf' where 'zzz' is a specific parent Asterisk .conf file name. We then add an '#include 'zzz\_rpt\_custom.conf' in the parent '.conf' file to reference our information.

#### INSTALLING USB RADIO DEVICES (URD's) AND ADJUSTING SIGNAL AMPLITUDES

Though other methods are possible, this installation process requires a direct connection to the radio's unfiltered, unscelched receive audio signal and the radio's transmitter microphone input and its sub-audible tone modulation input. It also assumes that this is a narrow band FM radio with a peak modulation level of +/-5 KHz.

The best adjustment of these settings is accomplished using a properly calibrated Radio Communications Test Set or a separate radio frequency signal generator and modulation analyzer.

The '/etc/asterisk/urd.conf' file must contain valid information for your specific radio connection. Refer to the file 'urd.conf.sample' for details.

Each USB Radio Device is named by the expression [URDNAME] in the '/etc/asterisk/urd.conf' file where URDNAME is the user assigned name of the interface. The installation process automatically uses the name 'usb' for the first device. A good practice would be to name additional devices 'usb1', 'usb2' and so forth. Each interface name is logically linked to a specific USB bus address and its radio signal amplitudes are set by the information in its associated 'urd\_tune\_URDNAME.conf' file.

After they are installed, USB Radio Devices cannot be casually moved from one physical USB port to another whether those ports are on the node computer or on an attached USB hub. If you need to move one or more URD's, unplug them from their originally installed positions and then one at a time, plug them into the new port and as you plug in each moved URD, use the CLI 'radio active xxx' command where 'xxx' is the device name that you moved. Use a 'radio tune' CLI command to verify that the device is found at its new location. Then use 'radio tune save' to save the configuration information for that device with the new USB port number. Now you can plug in the next USB to its new port and use 'radio active xxx' to select the device configuration for it. Do this one at a time for each URD you move.

You may also use the CLI command "radio probe on" to see all connected URD's and their assignments. The command "radio probe off" stops this repeating report.

We now describe the command line process to set the radio transceiver signal amplitudes.

Using either an attached keyboard and monitor or a remote ssh session, login to the node computer as root.

Make sure Asterisk is not running with the command 'amportal kill'.

Start Asterisk with the Command Line Interface (CLI) using 'asterisk -c'.

Each URD must be attached in sequence during the installation process in order for it to be properly identified and match a specific radio. Attach the first URD to the computer and radio now.

Enter the CLI command 'radio tune'. The information that returns indicates the currently selected radio interface, its settings and a list of 'radio tune' command options. There is a later section in this document that describes these options in detail.

To set the URD receiver input level adjustment the radio must be running with no signal applied on the receive frequency. Because the URD is connected to the radio's unfiltered and unscelched receive signal point it is now subject to a maximum amplitude white noise signal from the radio.

Enter on the CLI 'radio tune rxnoise'. The software will now automatically adjust the URD's input sensitivity to match the radio output signal.

To set the URD receiver carrier detect squelch level, enter the CLI command 'radio tune rxsqlch'. The display will show the current no-signal strength and the current squelch setting. Enter the CLI command 'radio tune rxsqlch xxx' where xxx is the Current Signal Strength reading plus 150. You can test the squelch setting and make a final adjustment later.

To set the URD receiver voice level adjustment, apply an on-channel, strong, full-quieting RF signal modulated by a 1 KHz tone at 60% of maximum modulation. Enter the CLI command 'radio tune rxvoice'. The software will now automatically adjust level for voice modulation.

To set the URD receiver sub-audible tone (CTCSS) level adjustment, apply a strong, on-channel, full-quieting RF signal modulated by a 100 Hz tone at 650 Hz deviation. Enter the CLI command 'radio tune rxtone'. The software will now automatically adjust the level to decode the sub-audible tone modulation.

Configure the equipment used to measure the radio transmitter modulation.

If the attached radio sub-audible tone modulation is not supplied by the URD enter the CLI command 'radio tune txtone 0'. The transmitter will activate for a few seconds to enable you to observe the modulation.

If the radio sub-audible tone modulation is supplied by the URD, enter the CLI command 'radio tune txtone 100'. The transmitter will momentarily activate. Using the modulation measurement equipment note the sub-audible tone modulation level. Repeatedly issue the 'radio tune txtone xxx' command with xxx as a new relative level adjustment as necessary to properly set the sub-audible tone modulation.

Issue the CLI command 'radio tune txvoice'. The transmitter will momentarily activate. The URD applies both the sub-audible tone modulation signal and a 1 KHz tone. Repeatedly issue the 'radio tune txvoice xxx' command with xxx as a new relative level adjustment as necessary to properly set the combined voice and tone modulation to +/- 3.65 KHz of deviation.

Save the URD settings for this device using the CLI command 'radio tune save'.

You will have to enter the information for additional URD's and radios in the 'rpt.conf' and 'urd.conf' files using the first device's information and the '.sample' files as a guide.

If desired, attach an additional URD and issue the command 'radio active xxx' where 'xxx' is the assigned name for the device in the 'urd.conf' file. Then repeat the procedure above. Repeat this again to install each additional URD.

The URD installation and tuning process is now complete.

Enter 'stop now' on the CLI then 'amportal start' to start Asterisk and FreePBX as a secure and reliable service.

#### ABOUT USB RADIO DEVICE CONNECTIONS IN GENERAL

The simplest transceiver connection is just 4 (four) points consisting of ground, tx composite modulation, rx detector output and PTT input.

The radio transceiver can be either simplex (PTT) or duplex (repeater).

Connection directly to a repeater transceiver offers the best performance and allows the radio users to remain in control of the link and answer and originate telephone calls and connect to remote base nodes such as HF transceivers that usually operate in open squelch mode.

#### General Receiver Connection Options

- 1) Baseband Demodulated Signal - Unsquelled - Unfiltered
- 2) Filtered Rx Audio with separate CTCSS Decode signal.
- 3) Speaker or Earphone Audio - Voice Operated Transmit (VOX)

#### General Transmitter Connection Options

- 1) Microphone Audio
- 2) Separate Microphone Audio and Tone Modulation Inputs
- 3) Composite Modulation Post Limiter Baseband Input

The preferred method of connection is directly to the radio transceiver's baseband signals. For the receiver this is known as the discriminator, quadrature or detector output. It is unsquelled and has a flat frequency response and in some cases is DC coupled.

For the transmitter this is called the flat transmit modulation or post-limiter input.

The chan\_urd module can be set to provide either flat unprocessed audio ready for application to the transmitter's microphone input or for FM pre-emphasized, amplitude limited and low pass filtered voice suitable for direct connection to a post-limiter modulation point. The chan\_urd module also encodes CTCSS tones and can be configured to output them either mixed with the processed voice in a composite modulation signal or on an output separate from the voice band modulation.

All transmit amplitudes are software adjustable via an interactive tuning process.

The chan\_urd module performs transmit and receive radio signal processing using the host PC's CPU much like a high compression factor VoIP speech transcoder. For this reason PC CPU's offering less than 800 MHz of processor speed or non-Intel processors are not recommended. You should use the Linux 'top' command or an equivalent tool to determine how a mix of simultaneous radio and telephony calls are loading your processor to ensure that your users' call quality expectations are met.

One PC can support several USB Radio Devices and telephone connections. In our tests a 2.66 GHz Pentium 4 functioned well with simultaneous communications taking place on 7 USB Radio Devices and 4 TDM-400/ZAP based telephone calls. The developers can provide special assistance in constructing nodes with 20 or more transceivers connected to a single host computer.

#### USB RADIO DEVICE (URD) ASTERISK COMMAND LINE INTERFACE (CLI) OPTIONS:

radio active - selects by name a specific USB Radio Device for display or tuning.

radio tune - displays information about the current active radio device.

radio tune rxnoise - Automatically adjusts the USB Radio Device input sensitivity to match the maximum signal output from the connected radio. This is the signal from the radio when no signal is present on the receive frequency. If the receive signal connection point is not the unsquelled and unfiltered receive signal point, this maximum signal can be obtained by using the user controls to unmute the receiver and open the squelch.

If the USB Adapter is connected directly to an unmuted and unfiltered demodulated signal point in the radio receiver and no signal is present on the radio channel then this is the open channel reference signal.

radio tune rxsqlch - This sets the receiver noise squelch sensitivity. It provides a measurement of the current signal strength as a reference value.

radio tune txtone - This adjustment sets the modulation amplitude of the sub-audible tone or data that is transmitted simultaneously with the voice signal.

radio tune txvoice - This adjustment sets the modulation amplitude of the voice signal. The device generates a reference signal of 1000 Hz at the 60% modulation level.

radio tune save - This save the adjustments to a configuration file for a specific channel that will be automatically loaded when the server restarts.

#### ADDITIONAL INSTALLED SOFTWARE PACKAGES

FreePBX - This is a browser based Asterisk configuration and operation program. You can see the FreePBX interface on your Asterisk app\_rpt server by using a web browser to view "[http://\(your computer ip address or FQDN\)](http://(your computer ip address or FQDN))".

Webmin - The 'Webmin' Linux server administration utility is a wonderful interface to control the many complex features and services available on a Linux server. It is included in this installation. See "<http://www.webmin.com>" for full documentation. You can see the Webmin interface on your Asterisk app\_rpt server by using a web browser to view "[http://\(your computer ip address or FQDN\):10000](http://(your computer ip address or FQDN):10000)".

Upgrade - This utility should be run after updating any of the server software including FreePBX or Webmin. It is available through the web based interface at "[http://\(your computer ip address or FQDN\)](http://(your computer ip address or FQDN))" underneath the System menu tab.

#### NOTICES

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#### CONCLUSION

Thank you for your interest in this project.