Internet Access to a Radio Astronomy Observatory

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Abbreviations in this article:

CPU:	Central Processing Unit
HF:	High Frequency
IP:	Internet Protocol
PC:	Personal Computer
RSP:	Radio-SkyPipe
SID:	Sudden Ionospheric Disturbance
TCP:	Transmission Control Protocol
TS3:	TeamSpeak3
UDP:	User Datagram Protocol
USB:	Universal Serial Bus
VAD:	Voice Activation Detection
WAV:	Waveform Audio File Format

1. Introduction

This article describes a method to simultaneously connect radio receiver audio and its associated electronic strip chart to the internet using a Windows PC, in effect an internet-accessible radio astronomy observatory, thus enabling remote observers to hear and watch radio phenomena.

Not all radio astronomy observing involves listening to receiver audio or watching a chart in real-time, so the methods described here do not have universal application. However, they are suitable for observing Jupiter and solar emissions at high frequencies (HF), meteor trail reflections and other phenomena in which receiver audio is used by an observer for identification. Of course, the methods described here have non-radio astronomy applications as well. There are many ways to setup an internet accessible audio channel. The method described here provides a low-delay (< 1 s) audio channel using free software. The electronic charting portion of the setup uses the well-known Radio-SkyPipe software application.

The descriptions that follow are from the standpoint of the radio observatory, or *server*, end. I also may refer to this as the sending end. Observers who wish to hear the audio and watch the chart are referred to as *remote clients*. A block diagram shows the basic setup (figure 1).

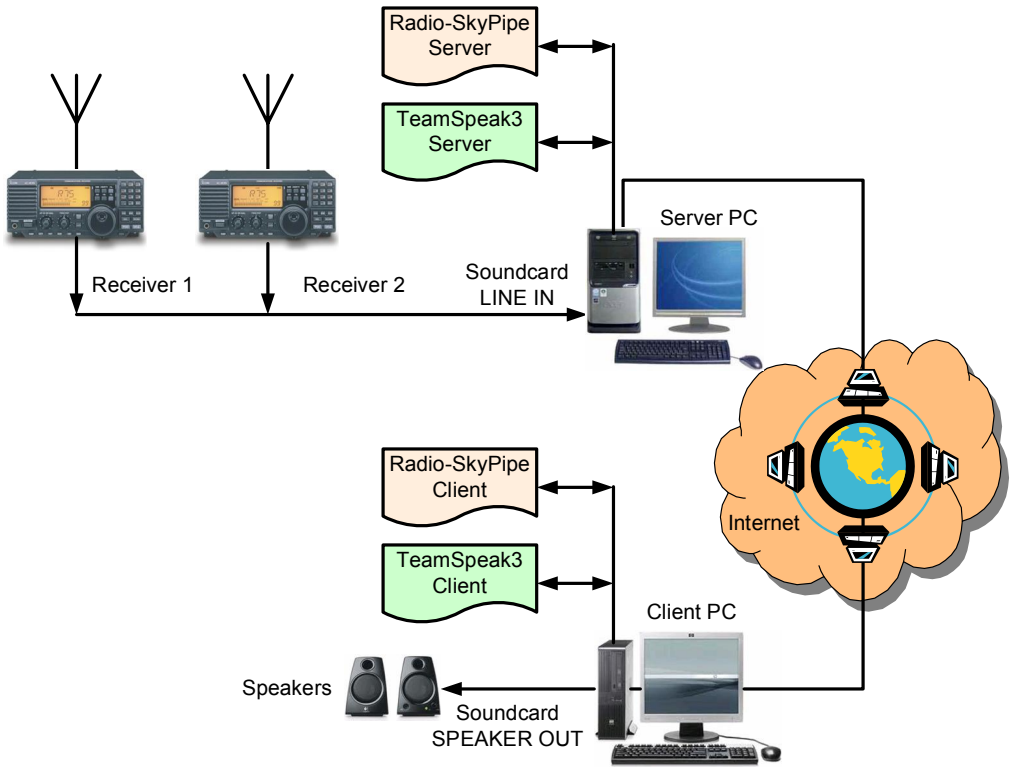


Fig. 1 ~ Remote observatory system block diagram. The observatory and associated audio and chart servers are at the top. The receivers may be general coverage HF receivers or purpose-built receivers that produce baseband audio for connection to a PC soundcard.

2. PC and internet requirements

There are no extraordinary requirements but a brief explanation of the PC hardware and internet access is in order. The system described here was tested on a 4-year old PC with 2 GB of memory and running Windows XP. It probably will work fine on any modern PC running XP or Windows 7 with at least 2 GB of memory. As for internet access, the bit-rate requirements for a single remote connection to the audio and chart servers are fairly low, perhaps less than 10-20 kb/s. However, multiple simultaneous connections will increase the bandwidth requirements. Presumably the bandwidth required at the server will increase in a linear manner but this has not been verified. Dialup internet access is unsuitable for either end.

At the sending (server) end the following are required:

- PC hardware (including soundcard) running Windows XP or 7 and powerful enough to simultaneous run the listed server software applications. See text for discussion. It is not necessary that the soundcard be built into the PC; USB soundcards can be used
- Radio-SkyPipe (RSP) Pro (as a chart server)
- TeamSpeak3 (TS3) Server (as an audio server) and TeamSpeak3 Client (to control the server)
- Radio telescope suitable for the phenomena being observed and with an audio connection to the PC soundcard
- Broadband internet access

At the listener (remote client) end the following are required:

- PC hardware (including soundcard) running Windows XP or 7 and powerful enough to simultaneous run the listed client application software
- Radio-SkyPipe (the free version is suitable)
- TeamSpeak3 Client
- Broadband internet access

3. Basic setup

The server includes one or two receivers connected to the LINE IN port of a PC soundcard. The audio is processed by the server software (TS3 and RSP) and transmitted over the internet as packets of audio and chart data. The remote client includes a set of speakers connected to the SPEAKER OUT port of a PC soundcard. The received data packets are re-processed by the client software (again, TS3 and RSP) and displayed on a chart and played on the speakers in real-time.

Besides the server software installations, attention needs to be paid to the firewalls and internet gateway routers. In particular, certain applications and ports need to be enabled in the routers and firewalls between the serving PC and the internet and between the client PC and the internet. Router and firewall setups are described below in general terms. There are too many variations to provide specific information.

4. Soundcard setup

The soundcards at the server and client ends need to be properly configured. At the server, the soundcard Recording function is set to the LINE IN port (figure 2) and, at the remote client, the soundcard Playback function is set to the Wave port (figure 3).

Fig. 2 ~ Example of soundcard driver setting at the server. The LINE IN port in the lower panel is used for the Recording function. It is shown here with a green button at bottom in this soundcard driver window. Deactivated ports are shown with red buttons.

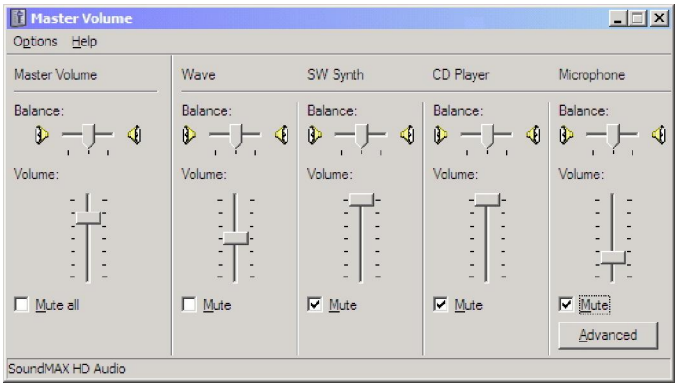


Fig. 3 ~ Example of soundcard driver setting at the remote client. The Wave port is used for the Playback function, and it is shown here with its Mute function unchecked. The Master Volume function also is unchecked. All other playback functions are muted (checked).

5. Observatory server setups

TeamSpeak3: At the observatory server, both the TeamSpeak3 Server and TeamSpeak3 Client applications must be installed. Both are free for non-commercial purposes. They may be downloaded from the TeamSpeak website (http://www.teamspeak.com).

The TeamSpeak3 Server is setup in its default mode. It does not have its own user interface and does not require setup beyond that required during installation. The server is administered through the associated TeamSpeak3 Client. This is explained in TeamSpeak's server installation video: http://www.teamspeak.com/?page=tutorials. Do not waste your time trying to install the TS3 Server and TS3 Client without first watching the installation videos or, better, following the videos as you do the installations – it requires only a few minutes.

The TeamSpeak3 Server by default uses UDP port 9987 for the audio channel and TCP port 10011 for the server queries. Setup your router firewall to forward these ports to the server PC – an example is shown in figure 4. You also need to setup *Exceptions* in Windows Firewall for the TeamSpeak3 server application as shown in figure 5.

Fig. 4 ~ Example of port forwarding for Radio-SkyPipe and TeamSpeak3 in the Cisco RVS4000 router. The red arrows indicate the settings.

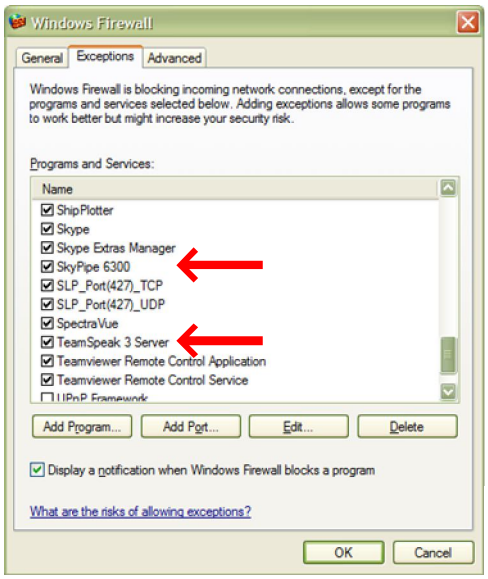
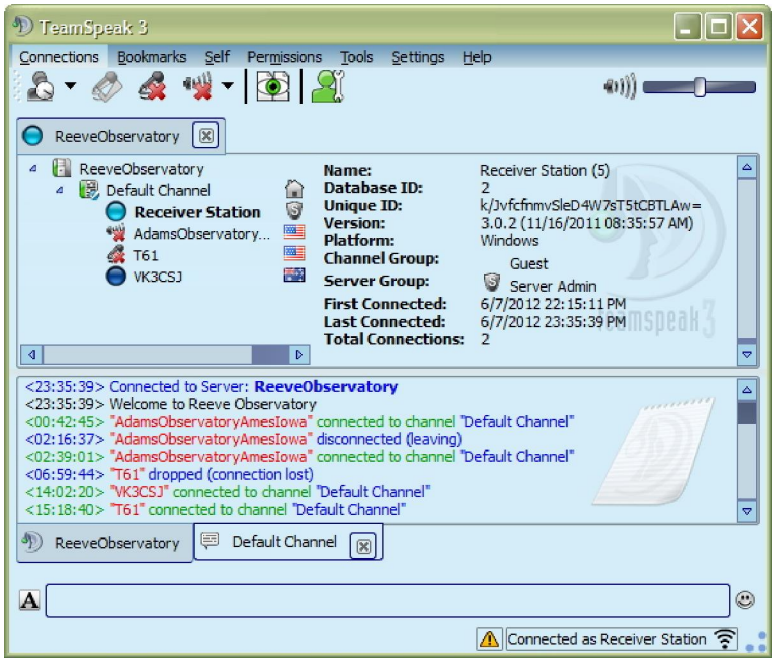
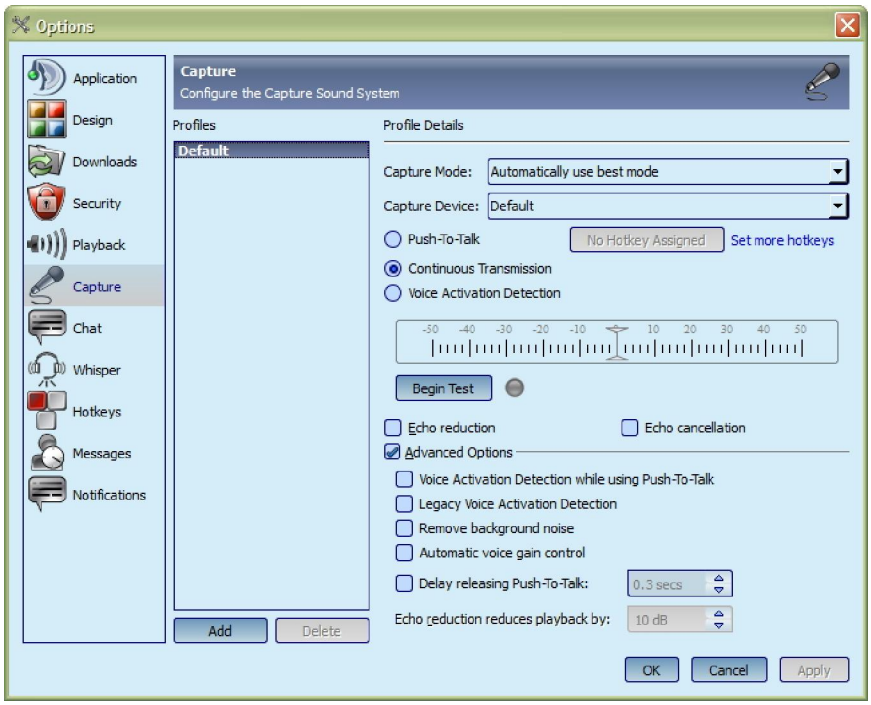


Fig. 5 ~ Example of Windows Firewall Exceptions for Radio-SkyPipe and TeamSpeak3. By default Windows Firewall blocks incoming connections to application programs. Checking the box next to the two applications (red arrows) unblocks them. If you use a 3rd party firewall program instead of Windows Firewall, you will need to unblock the programs by using your firewall's user interface.

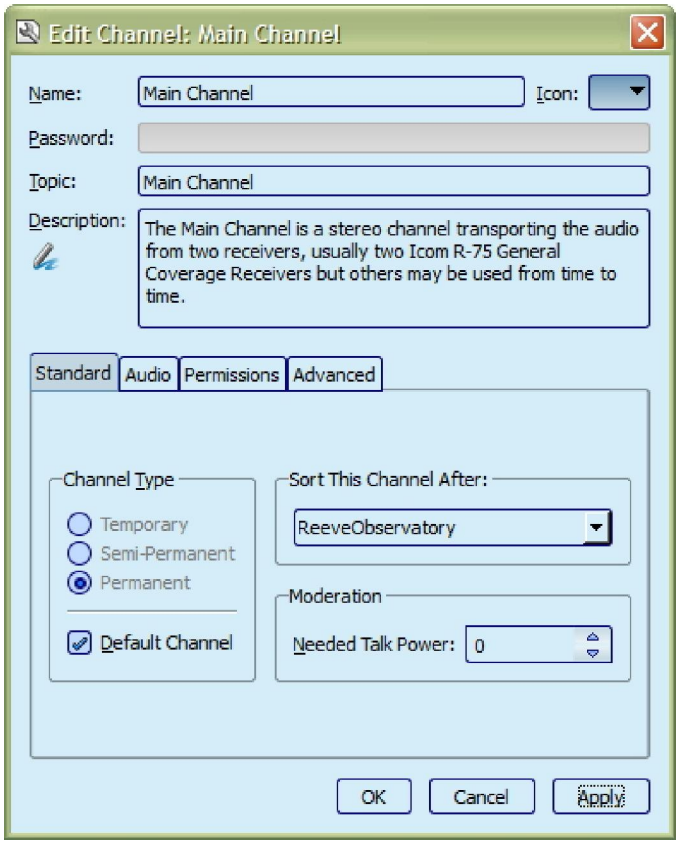
After you have installed the TS3 Server, install the TS3 Client. This is straight-forward. The client at the server end will be functional with default settings; however, some fine-tuning is required to optimize it for our purposes. A series of screenshots and captions are shown in figure 6 that can be used as a setup aid. The TS3 Client at the server initially is setup to not require password access to the TS3 Server. This can be changed as explained in section VII.



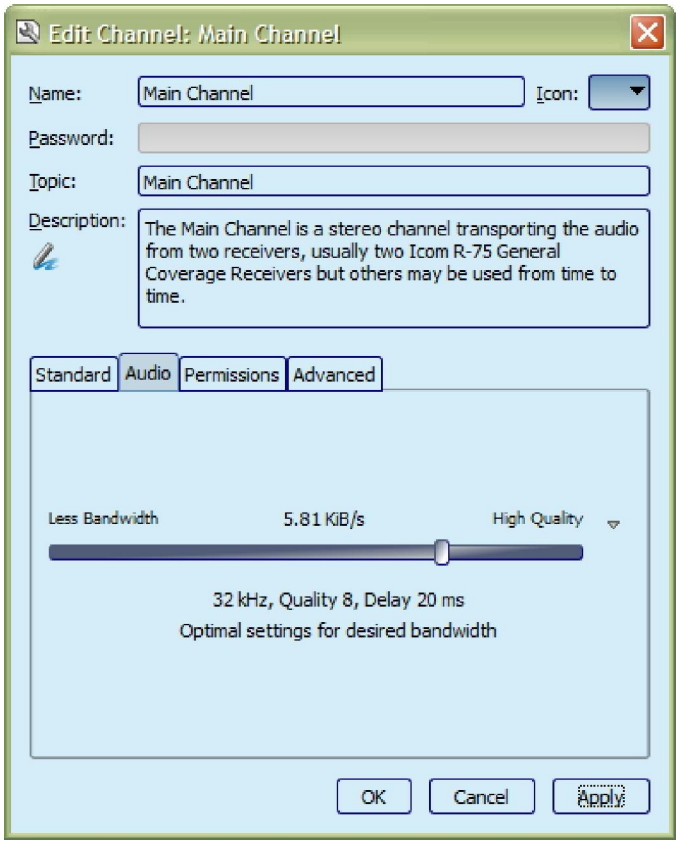
6.a ~ Server end TS3 Client main screen. The TS3 Server, here labeled "ReeveObservatory" and seen in the upper-left of the top frame, is administered through the client.



6.b ~ On the TS3 Client menu bar select Settings – Options – Capture. Change the Profile Details from Voice Activation Detection to Continuous Transmission (if you leave it at VAD, remote clients will hear intermittent audio). Also, check Advanced Options and uncheck all subsidiary settings as shown. Be sure that both echo controls are unchecked. Click OK when done.



6.c ~ On the client main screen, right-click the Default Channel. A new window will open as shown here. You can change the channel name and provide a description.



6.d ~ While editing the Default Channel (renamed Main Channel in the above screenshot), select the Audio tab. Here you can adjust the bandwidth used for the audio channel. The default uses 32 kb/s sample rate and compression to about 5.8 kb/s. You can increase this setting to about 7 kb/s, if desired, but I found that unnecessary.

Radio-SkyPipe: To setup Radio-SkyPipe (RSP) server you will need the Pro version (figure 7). It may be downloaded and purchased (about US$50) from the Radio-Sky Publishing website (http://www.radiosky.com/). Installation is straightforward and is described in the website help files. Additional helpful online information is available (http://www.typnet.net/Essays/RSPServer.htm). I use TCP ports 6300~6340 for my RSP server. The ports you decide to use will need to be enabled in your router by setting up port forwarding similar to the TeamSpeak3 ports previously described. Also, you will need to setup *Exceptions* for RSP Pro in Windows Firewall.

Note: It is possible to setup an observatory by streaming only the audio and not using a Radio-SkyPipe server. Such a setup requires a virtual audio cable at the remote client (see Virtual Audio Cable sidebar). In this case Radio-SkyPipe is operated in Standalone Mode at the remote end. The setup with a virtual audio cable is beyond the scope of this article but will be covered in the future.

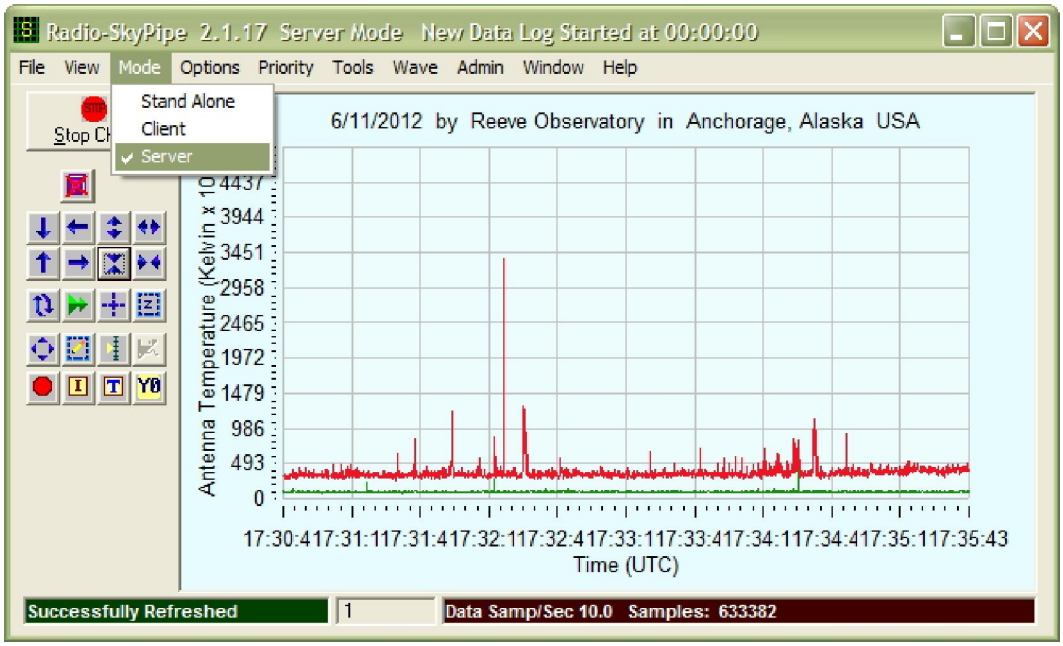


Fig. 7 ~ Radio-SkyPipe setup in Server Mode. After RSP Pro is installed and setup for your observatory, the server is activated by selecting Mode – Server on the menu bar. RSP Pro has a test tool for server connectivity, select Tools – Server Mode Connectivity Test – Test Server Connection.

6. Remote client setups

TeamSpeak3: The remote observer's TeamSpeak3 Client is setup in its default mode as described in the TeamSpeak tutorial video. It is not necessary to change the remote TS3 Client from its default settings.

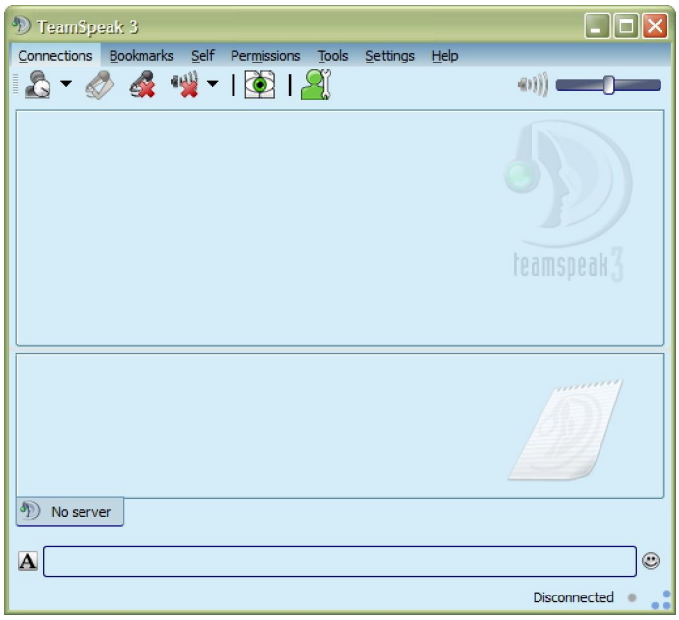
Radio-SkyPipe: Either Radio-SkyPipe or Radio-SkyPipe Pro may be used as a client and both are easy to setup in Client Mode by following the help information on the RadioSky website.

7. Operation

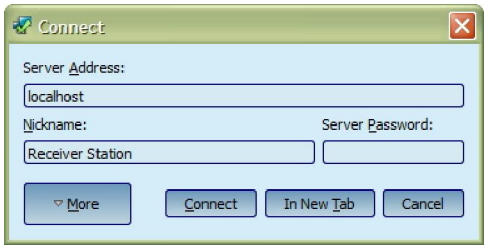
TeamSpeak3: When first installed, the TS3 Server opens and runs in the background. However, if the PC is restarted, the server will need to be re-started as well. This can be made more convenient by setting up a shortcut

on the desktop or in the Start – All Programs listing. It also can be setup to open automatically when Windows is started by putting a shortcut in the Startup folder in Start – All Programs. The server is closed by right-clicking the TS3 Server icon in the Windows Taskbar and selecting Exit.

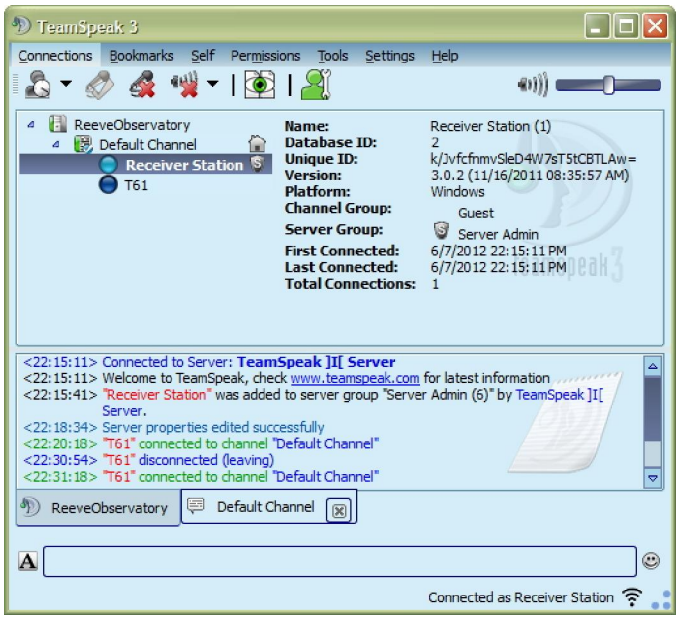
Operating the TeamSpeak3 Client at the server end is simple. See figure 8 for a series of screenshots that show how.



8.a ~TeamSpeak3 Client at server. The client must be running at the same time as the server. When first opened, the client window is blank as shown here. Click on Connections – Connect and a new window will open.

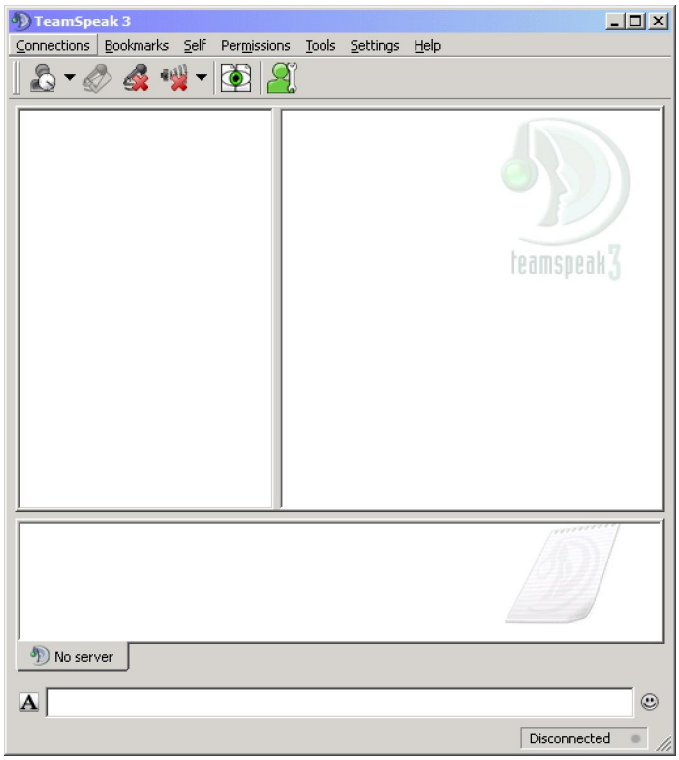


8.b ~ TS3 Client Connect window at the server. The Server Address field is set to *localhost* or the IP address 127.0.0.1. The Nickname is a user-specified name that is used by the server to identify connections. The Server Password field is needed only if the server is setup to require it. All other settings can be left at default values. Click Connect. If everything is setup properly, a client-server connection is established.

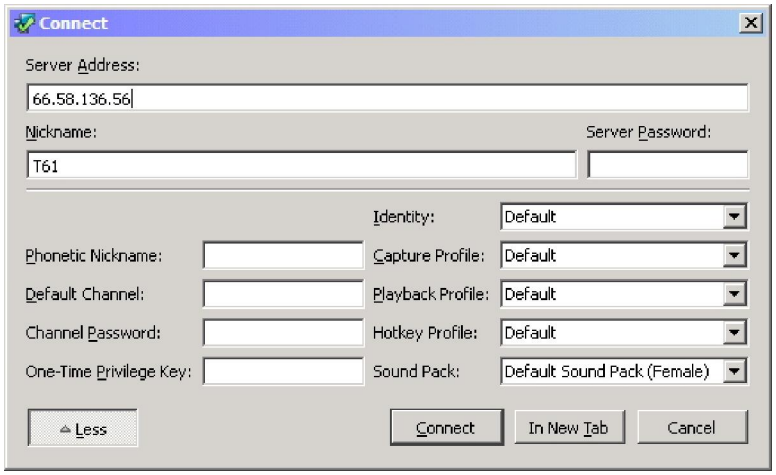


8.c ~ TeamSpeak3 Client running on the server PC with one remote incoming connection (T61) and the required local connection (Receiver Station). If there are no remote connections, only the local connection will be shown.

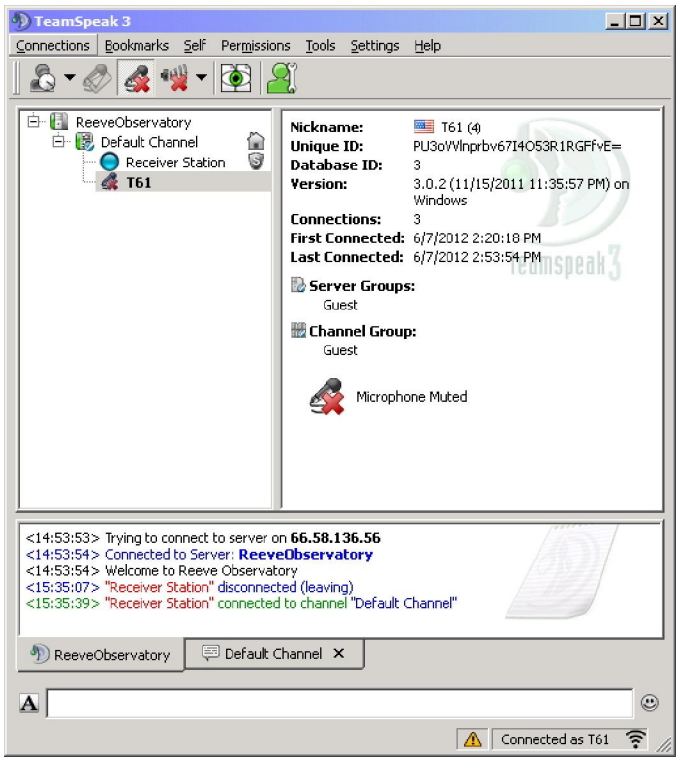
When a remote observer connects their TS3 Client through the internet to the TS3 server, it is only necessary to click on Connections – Connect on the remote TS3 Client menu bar. A new window opens where the server's IP address or domain name and a client *Nickname* are specified. The Nickname is the same as a username and is chosen by the remote observer. Once connected, the remote observer may listen to the audio and simultaneously record it if desired for later playback and analysis. The record function is found on the Tools menu. See figure 9 for a series of screenshots for the TS3 Client at the remote end.



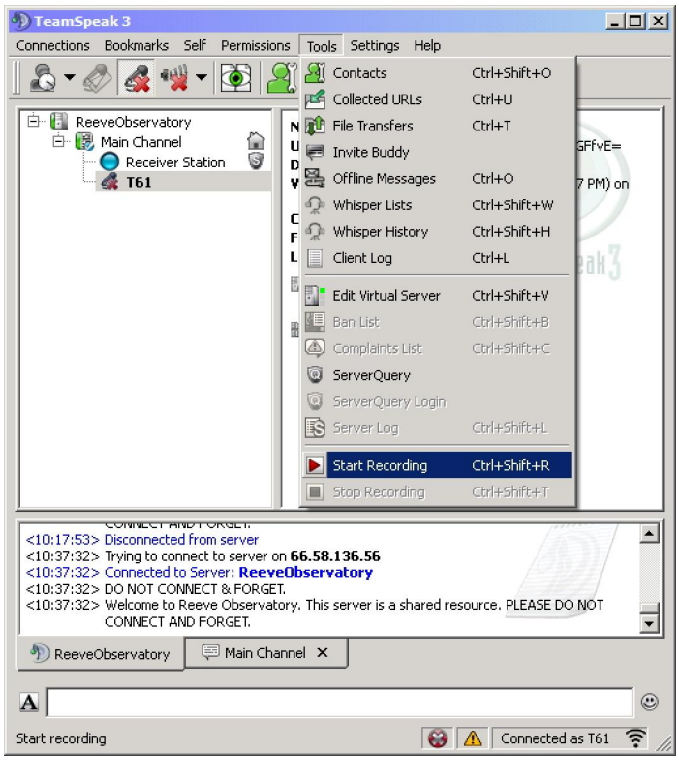
9.a. ~ TeamSpeak3 Client at a remote location ready for connection. When TS3 Client is started, this window opens. To make a connection, click on Connections – Connect.



9.b ~ TeamSpeak3 Client Connect window. Specify the domain name or IP address of the TS3 server. The Nickname field is used to identify connections; here it is *T61*. The Server Password and Channel Password fields are needed only if the server is setup to require them. After everything is entered, click Connect.



9.c ~ TeamSpeak3 Client running on the remote PC and connected to the TS3 server at the radio observatory. This screenshot shows two client connections. The first one, *Receiver Station*, is the Nickname of the client running on the TS3 server PC. The second one, *T61*, is the Nickname of a remote client.



9.d ~ Recording audio from TS3 Client at remote PC. The streaming audio from TeamSpeak3 is recorded in the WAV format, so the files can become quite large. The recording function also can be used in the TS3 Client at the server.

The Radio-SkyPipe client is connected to a remote server by selecting a server from the list at the bottom of the chart window (it is not necessary to specify an IP address). See figure 10.

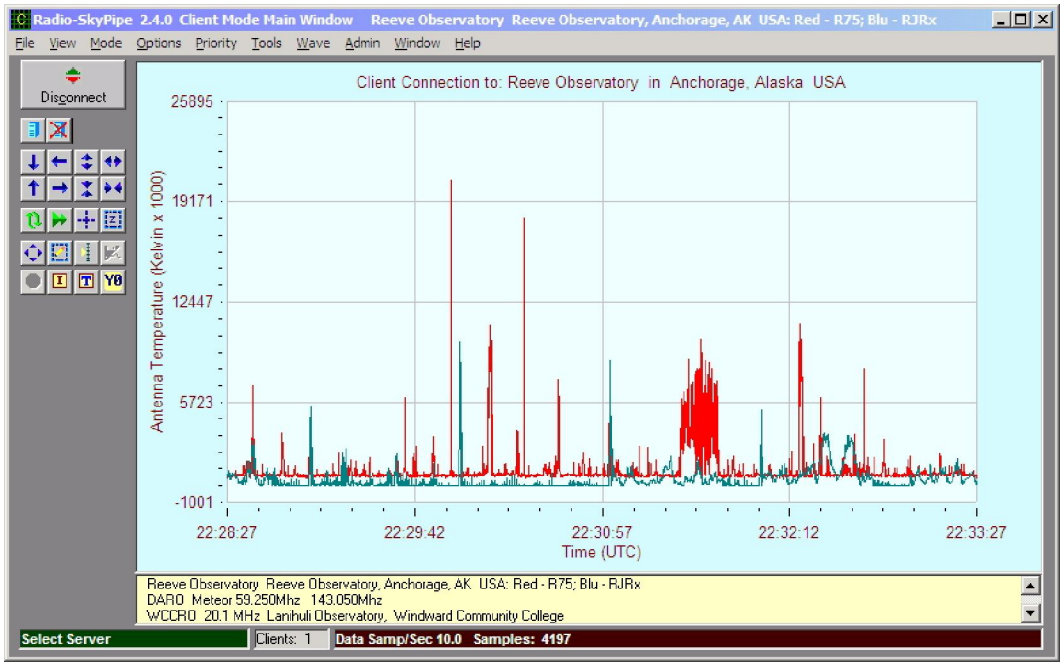


Fig. 10 ~ Radio-SkyPipe setup at the remote end in Client mode. On the menu bar, select Mode – Client, and a server list will appear just below the chart window. Click on the desired server and then click the Connect button in the upper-left corner. The client shown here is connected to Reeve Observatory as shown at the top of the chart window frame.

8. Considerations

Voice and noise transmission: The TS3 server and client applications use a proprietary voice-over-internet protocol (VoIP) and are designed for 2-way voice communications within a group of people. However, the radio astronomy observatory system described here is 1-way from a radio telescope receiver to a listener. The 2-way voice feature may come in handy in some situations, but it is better to use the text-only chat feature built-in to Radio-SkyPipe.

Distortion: Because TS3 uses digital bit stream compression methods optimized for voice service, there is some distortion when it is used for noise-like extraterrestrial emissions. The bit-rate used in the free version of TS3 is quite low – it can be set to no more than about 7 kb/s. I performed some subjective tests using Waveform Audio File Format (WAV) recordings of Jupiter L- and S-bursts and solar emissions to determine if the reduced audio quality prevented recognition of the emissions. I found that distortion was not objectionable but variations in receivers, emissions and burst strengths, soundcard hardware, TS3 audio settings and available internet bandwidth may lead to quite variable results for individual observers.

Stereo channels: The TS3 server sends independent channels if the soundcard at the server end is setup for stereo. That is, if you are using two audio channels, one from each of two different receivers, they will be sent by TS3 Server to the TS3 Client. However, limitations in the soundcard you are using for playback at the remote client may prevent you from listening to each channel separately (that is, the two channels may be mixed together).

Receiver audio: When two receivers are connected to the soundcard LINE IN port using the left and right stereo channels, it is possible for an audio ground loop to produce hum. I originally solved this problem by using isolation transformers between the receiver audio output jacks and the soundcard input jack. I later installed an audio mixer, which not only provides the needed isolation but also provides audio level control and the ability to select up to eight receivers in any combination. This setup is described here: http://www.reeve.com/RadioScience/Receivers/fixed_receiver_installations.htm.

Avoid embarrassment: If you are a remote observer and have a microphone connected to your soundcard or are using a laptop, you should mute the microphone port in the TS3 client to prevent talking and background noise from interfering with the receiver audio and to avoid embarrassment. Click on the Mute Microphone button or select Self – Mute Microphone on the TS3 client menu bar. However, at the server end, the TS3 client microphone port must be activated even though it is not being used, but be sure that a microphone is not plugged into the soundcard microphone port.

Server and client PC CPU load: When running, the TS3 Server imposes no apparent load on the server PC's central processing unit (CPU); however, the accompanying TS3 Client imposes a small variable load. On my server PC I also run RSP, a software defined radio receiver with SpectraVue software, rotator control software in the Sun-tracking mode, and aircraft tracking software and hardware. The additional load from the TS3 Client at the server end is about 5% in this setup. The additional load from the TS3 Client at the remote end is about the same.

Bandwidth usage: Users (remote clients) have a tendency to connect to an audio server and then forget about it. Over time this leads to enormous bandwidth usage at the server. If your internet service provider has bandwidth limitations on your account, you may end up paying more. Many service providers have an online method to check bandwidth usage, and you probably should monitor it. The TS3 Server (Virtual Server), accessible through the TS3 Client at the server end, can be setup to limit the number of clients and using it will help limit bandwidth usage. Right-click on the server in the Main window and select Edit Virtual Server and then adjust the Maximum Clients field as shown in figure 11. Most server traffic will be in the upload direction and, due to the asymmetric nature of most internet services, will be more taxing than at the client end where the traffic is in the download direction.

Fig. 11 ~ Manage Virtual Server screen. The maximum number of simultaneous connections, or clients, can be set here along with the Server Name, Password (if desired) and a Welcome Message.

Permissions: The TS3 server initially can be setup to not require a password, in which case any remote TS3 client will have permission to access it. I found there would be one or two somewhat random connections a day from non-observing users, occasionally during observations, and all left their microphones open. This problem can be eliminated by using password access. It is easy to setup channel and server permissions groups, password protection and even temporary passwords. Also, selected remote clients may be permitted to administer the server. The permissions setups are well covered in the TeamSpeak3 video tutorials at: http://www.teamspeak.com/?page=tutorials.

9. Conclusions

A radio telescope server for monitoring Jupiter and solar emissions and other radio phenomena may be setup for a modest cost (about US$50), allowing remote users to observe a strip chart and listen to receiver audio over the internet. The remote radio telescope described here is limited to a setup using a soundcard for receiver audio and charting.

Sidebar ~ Virtual Audio Cable

A virtual audio cable is a software device driver that allows the audio output from a software program to be connected to the audio input of another program. The connection is in the digital domain and does not require a hardware cable or wires. Since the connection is digital, the output from one program can be connected to the input of any number of other programs. An example of a virtual audio cable application is connecting the digitized audio from a remote TeamSpeak3 Client to Radio-SkyPipe. The TeamSpeak3 Client Capture Device (Settings – Options – Capture menu) is set to one of the installed virtual audio cables and the Radio-SkyPipe input Sound Device (Options – Sound tab – Device) is set to the same virtual audio cable. The actual physical soundcard is not involved. One such virtual audio cable program can be found here: http://software.muzychenko.net/eng/vac.htm, but an internet search will reveal many others.
