Bistatic Radar Hub System

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3 December 1999

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Chapter 1

System Overview

1.1 System Block Diagram

This document describes the structure and use of the bistatic radar system's hub computer. The complete bistatic radar system is comprised of a normal radar transmitter/receiver system (the radar), one or more remote bistatic receivers, and a hub computer for combining and displaying the information from all of the receivers. Figure 1.1 shows a block diagram of the system architecture. Note that the "per bistatic receiver" block consisting of the bistatic

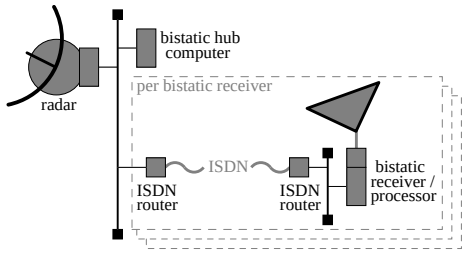

Figure 1.1: block diagram of a bistatic radar system

receiver/processor and the communications hardware for that receiver may be replicated one or more times depending on how many bistatic receivers are in the system. Also note that although the connection between the local radar network and the bistatic receivers is shown as implemented using ISDN, any TCP/IP connection between the two can be used. For example, this could be a direct network connection or a PPP connection via radio frequency modems. The type of connection can also be different for each bistatic receiver. Hence, the hardware communication architecture connecting the machines of the bistatic radar system is very flexible.

1.2 Data Paths

The data paths among the machines in the system are as follows:

radar $\xrightarrow[phases]{}$ bistatic hub $\xrightarrow[phases]{}$ bistatic receiver(s)

radar $\xrightarrow[data]{}$ bistatic hub

bistatic receiver(s) $\xrightarrow[data]{}$ bistatic hub

bistatic hub $\xrightarrow[commands]{}$ radar and bistatic receiver(s)

and all of the data are transmitted as UDP datagram packets over a TCP/IP network. The first data path shown, transmitting pulse phases from the radar to the bistatic hub and then to the receivers, is done as a two step process so that the radar need not have specific information about the number of receivers or their addresses. The second and third data paths shown simply move data from all of the receivers, including the radar, to the bistatic hub computer for merging and processing. Finally, there is a data path allowing the bistatic hub to send commands to the radar and to the bistatic receivers.

Chapter 2

The Hub Computer

2.1 Overview

The "hub" computer in the bistatic radar system merges data from each of the system's receivers, forwards phase information, performs dual-Doppler wind calculations, writes the calculated data, and provides graphical display. In addition, means are provided for sending some basic commands to any or all of the receivers. Software on the hub can also be used to look at archived data during or after normal operations. Typically the hub machine is located with the radar, but it can be placed anywhere there is sufficient reliable network bandwidth to carry the incoming data. The functions of the bistatic hub machine are implemented by two programs: BistaticHub and xbistat. BistaticHub does most of the work, accepting the incoming data, performing wind calculation, and writing the resulting data stream. The xbistat program displays the bistatic radar data, either in real time with BistaticHub as the data source, or in a post-processing mode using an existing data file as its source. Each of these two programs is described in more detail below.

2.2 The BistaticHub Program

The BistaticHub program provides the bistatic radar system's means for calculating dual-Doppler winds from the multiple radar receivers. At its front end, it accepts data rays sent from the receivers and puts them into a buffer of incoming data. For each arriving ray of data, the buffer is checked to see if previously received rays are available from all other enabled receivers and with matching times. If not, the program simply adds the new data to the buffer and waits for more data. When a time-matched set of rays is found for all receivers, though, wind processing is performed. For each radar/bistatic receiver pair, a gate-by-gate dual-Doppler calculation is done and u and v wind components for the pair are added to a new output ray. In addition, a "best" wind is calculated using a weighted average of all the other computed u and v components. The output

ray is written to a storage device and also written to a socket for display by the xbistat program. After generating a new ray, BistaticHub again waits for new data from any of the receivers.

2.2.1 Running BistaticHub

The BistaticHub program is actually comprised of two pieces: the main program and its graphical user interface. The program is run simply by starting up the graphical interface, which automatically starts the main program:

```
BistaticHub.py [options] &
```

2.2.2 BistaticHub command line options

The command line options for BistaticHub are as follows:

```
--base_data_dir <dir>
--rcvr_info <receiver_information_file>
```

The `--base_data_dir` option will override the default base data directory, beneath which BistaticHub writes its data files. The default directory is `/data`. The `--rcvr_info` option will make BistaticHub read a receiver information file different from its default of `RcvrInfo`.

2.2.3 Receiver information file

The receiver information file is a required text file which gives some necessary facts about each of the receivers in the bistatic radar system. The file has one line per receiver with exactly five elements per line, each separated by white space:

1. site name for this receiver
2. receiver data format (currently either VIRAQ or PIRAQ)
3. azimuth from the transmitting radar to this receiver in degrees clockwise from north
4. range from the transmitting radar to this receiver in kilometers
5. IP address for the receiver's processing computer, in standard dotted-quad notation.

Comment lines, marked by a pound sign (#) in the first character, may be added anywhere within the receiver information file. The first non-comment information line in the file *must* be for the transmitting radar. Figure 2.1 shows an example receiver information file for a system with just one bistatic receiving site.

```
#
# Site Name     Format  Azimuth Range   IP Address
#=================================================
Radar           VIRAQ   0.0     0.0     192.168.0.2
Lichtenau       PIRAQ   212.0   27.2    192.168.1.1
```

Figure 2.1: example BistaticHub receiver information file

2.2.4 The BistaticHub window

Once BistaticHub has successfully read its receiver information file, it displays a single window with a receiver status and information section at the top, a text area for displaying log messages, and some control buttons at the bottom of the window. Figure 2.2 shows the BistaticHub interface window.

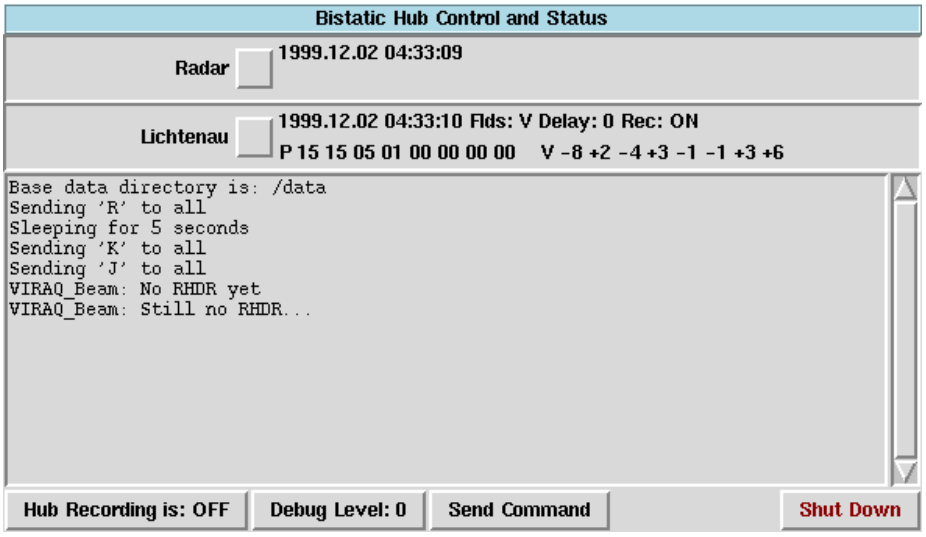

Figure 2.2: the BistaticHub window

The top of the window is divided into sections by receiver. For each receiver, the receiver site name is shown, in black if the receiver is enabled or in gray if the receiver is currently disabled. The name is followed by a button which toggles the enabled/disabled state of the receiver. An enabled receiver is expected to be sending data to the hub computer; BistaticHub will not generate a ray of data with dual-Doppler winds until it has rays of data for a given time from *all* enabled receivers. Hence, a receiver which is not currently sending data must be disabled for BistaticHub to generate rays. Note that the transmitting radar is *always* in the enabled state and that clicking the enabled/disabled button for the radar has no effect. Following the enable/disable button is status information for the receiver showing times from incoming data on the upper line and the

first eight gates of reflectivity and velocity data below. If data are not incoming from an enabled receiver, the status line will indicate in red how long it has been since data have been received.

The middle of the window is a text area which logs various informational messages. Unexpected events will be reported here, as will debugging messages when debugging is enabled. If an abnormal exit occurs, the contents of the log area will be written to a file named `BistaticHub.log`.

The bottom of the window has control buttons: Hub Recording, Debug Level, Send Command, and Shut Down. The Hub Recording button shows whether data are currently being recorded on the hub, and will toggle recording on or off if pushed. The Debug Level button shows the current debugging level, and when pushed will pop up a window allowing the user to set the debug level. Debug level 0 prints the minimum amount of information, with information increasing through levels 1, 2, and 3. See Section 2.2.5 below for a description of debug levels and status information. The Send Command button pops up a window allowing text commands to be sent to any or all of the receivers; see receiver documentation for allowed commands. Finally, the Shut Down button will shut down BistaticHub.

2.2.5 Status information

The status information portion of the BistaticHub window displays useful information, with more information being shown as the debug level is increased. At debug level zero, only critical messages will be displayed; this should be sufficient information under most operating conditions. All other debug levels will show the same information as level zero, but extra information is added. At debug level one, a number representing the source receiver will be printed for each complete ray coming in to BistaticHub. The receivers are numbered in the order they appear in the receiver information file, starting with zero for the transmitting radar. This allows basic confirmation of data flow into the program. Debug level two is similar to the previous level, but it will also print a lower-case letter identifying the receiver for each packet which comes into BistaticHub. The letters assigned to each receiver are again in the order of the receiver information file, with the radar being "`a`." Finally, at debug level three, very complete information is printed about the data coming into BistaticHub. A line of text is printed for each incoming ray, identifying its source and either labelling it as bad, or printing a number of pieces of information from the ray such as pulsewidth and number of gates. It is recommended that debug levels greater than zero be used only when debugging specific problems, since a great deal of I/O is generated by the higher debug levels.

2.3 The xbistat Program

The xbistat program provides graphical display of the data generated by the BistaticHub program. It is generally run in real-time whenever BistaticHub

is running. It can also be run separate from BistaticHub to display data files generated by BistaticHub. The program is usually run in the background via one of the commands:

```
xbistat [options] &                              (for real-time)
xbistat [options] <data_file> &          (for looking at existing files)
```

In the second mode, `<data_file>` is simply the name of the BistaticHub data file to be viewed. For other command line options, see Section 2.3.1 below. When it is run, xbistat pops up a single window as shown in Figure 2.3.

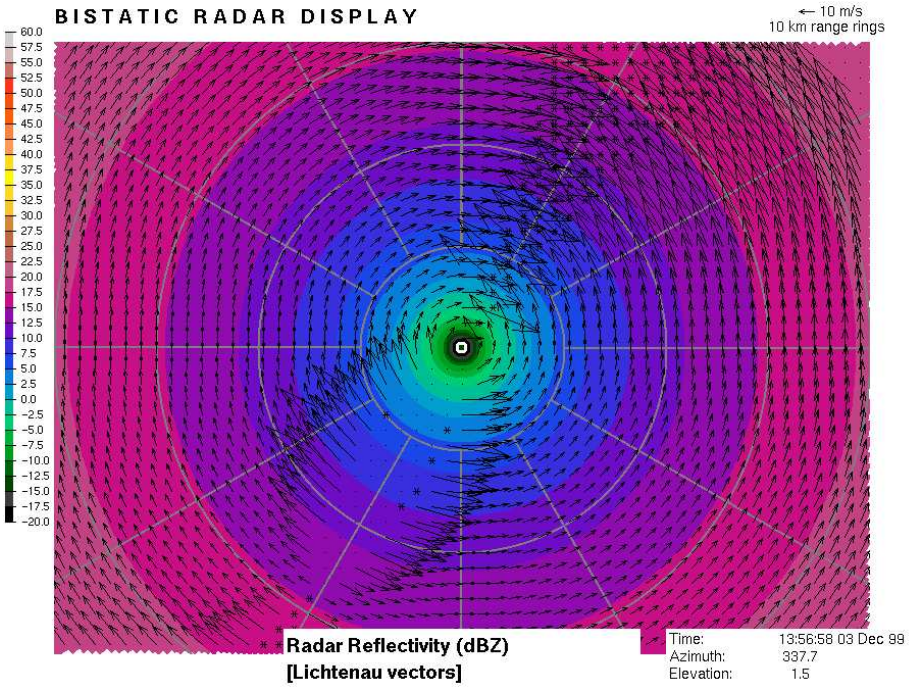

Figure 2.3: the xbistat window

2.3.1 xbistat command line options

There are a few command line options for controlling the initial display state of xbistat:

```
-x, --xcenter <xval>          x center w.r.t. the radar, in km (default 0)
-y, --ycenter <yval>          y center w.r.t. the radar, in km (default 0)
-p, --pixels_per_km <pval>    magnification, in pixels/km (default 2.5)
-i, --init_file <file>              initialization file (none by default)
```

Section 2.3.2 below describes the format of the optional initialization file.

2.3.2 Optional initialization file

Using the `--init_file` command line option, xbistat can be given a text file to read for setting initial conditions. This initialization file can contain the following commands, which parallel the command line options described above:

```
xcenter <xval>
ycenter <yval>
pixels_per_km <pval>
```

The commands must be one per line and must begin at the first character of the line.

2.3.3 Controlling xbistat

When xbistat starts up, it will be displaying a raster data field overlaid with wind vectors. The display is centered on the radar and will show a fairly wide area of view. Means are provided, via mouse button clicks and single key commands, for changing the fields and area displayed as xbistat runs. Table 2.1 shows the available xbistat commands. Letter case is important here; some letters are used in both upper and lower case for different commands.

key	Action
(left mouse button)	move center of display to the point under the cursor
(space)	stop or resume display update
(up arrow)	change to the next available raster field
(down arrow)	change to the previous available raster field
(right arrow)	change to the next available wind field
(left arrow)	change to the previous available wind field
c	clear the raster portion of the display
C	clear the vector portion of the display
q	quit the xbistat program
r	toggle display of the raster field
u	decrease magnification (unzoom) by a factor of 1.2
U	decrease magnification (unzoom) by a factor of 2.0
w	toggle display of the vectors (winds)
z	increase magnification (zoom) by a factor of 1.2
Z	increase magnification (zoom) by a factor of 2.0

Table 2.1: xbistat commands