VLBA Bookkeeping Operations

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I have been asked to review the Bookkeeping Operations associated with the running of the VLBA, with particular reference to their impact on choice of computer hardware and design of software.

1. OVERVIEW

The principle bookkeeping operations are concerned with:

1. Schedules: instructions for controlling the antennas must be communicated to all the antennas in the Array.

2. Log files: records of what actually happens at each antenna must be sent back to the control center and collated for control of the correlator.

3. Tape inventory: observation and correlation must not be held up by a lack of tapes.

4. Correlator data base: all visibilities and associated data will end up in a data base accessible to the experimenters.

Figure 1 shows the flow of schedules and log files between the antennas, the Array control computer and the Correlator control computer.

2. SCHEDULES

2.1 Schedule preparation

Detailed schedules for each experiment must be prepared by the PIs. Several points should be noted:

1. The PI will not normally know precisely when his experiment will be observed; this is up to the Array operators to decide, depending on weather and instrumental problems. Thus the final schedule should be prepared from the PI's instructions by the operations staff.

2. The operations staff (or an automatic program) should also review the schedule to eliminate obvious mistakes.

3. The PI should be able to prepare his schedule on site at the Array control center, at a remote terminal via a telephone data link, off-line (e.g., on a floppy disk mailed to the control center), or on paper for computer entry by the operations staff.

4. The requirements for the interactive schedule-preparation program have been discussed by N. Vandenberg in VLBA Memo No.128. This program should do extensive checking to ensure that it does not generate an inefficient or impossible schedule.

2.2 Transmitting the schedule

The final schedule must be transmitted from the control center to the individual antennas.

1. Schedules can be transmitted either for each experiment or in larger scheduling periods. The antenna has to know how to start a new schedule when it has finished the old one.

2. How far in advance should the schedule be transmitted? It should be possible to change the schedule in real time from the Array control center; but to cover possible communications failures the antennas should be able to run autonomously for some time (a few days?).

3. Experience with Mark-II and Mark-III suggests that the *same* schedule should be transmitted to all the antennas to minimize confusion. This does not imply that all the antennas have to observe the same source at the same time (see VLBA Memo No.128). The ability to divide the Array into two or more sub-arrays should be available.

4. Use of non-VLBA antennas with the Array poses a problem, particularly remote antennas for which real-time control will be impossible. These antennas should at least be able to interpret a VLBA schedule and generate a standard log file.

2.3 Executing the schedule

In normal operations, each antenna will interpret its (local) schedule, record all operations and status information in a (local) log file, and transmit status information back to the control center, where it will be merged with the information from the other antennas to create a real-time display for the Array operators and a master log file of the whole experiment.

Two abnormal situations arise:

1. Real-time schedule changes: means are required for ensuring that all antennas have the same schedule, and that changes are recorded for later use by the correlator.

2. Communications failures: if the phone link to an antenna fails, status will not be recorded in the master log file. It must be possible to recover this information later from the local log files.

3. LOG FILES

At the end of an experiment, all the information about that experiment will be recorded in two places: the local antenna log files and the master log file at the control center. Both of these should be archived for later use.

Some of the information in the log files will be analysed separately from the video tapes. For example, weather information could be extracted from the logs for statistical analysis. Analysis of this sort can be carried out at either the remote antenna or the control center, or both. This is an argument for using compatible (identical?) computers for individual antenna control and for the central array control, so that the same analysis programs can be used at both. At the very least, the log files should have identical formats at both locations.

The following is a by-no-means exhaustive list of things to be included in the log files:

1. system temperatures;
2. tape labels and start/stop times;
3. weather information (temperature, humidity, pressure, wind);
4. water-vapor radiometry and cable calibration data;
5. antenna status (on/off source status; pointing offsets, focus, antenna monitor points);
6. receiver status (presumably there will be various monitor points associated with the receivers);
7. recorder and time standard status (etc.);
8. recording quality (depending on the record system used, this could either come from a read-after-write head or be obtained by playing back part of the tape after recording);
9. local interference (if it can be reliably detected).

Correlation should be as automatic as possible. All the necessary information should be recorded in the computer-readable log files; no additional instructions should be necessary. This has been the goal of the Mark-III system, but in practice it has not worked very well, because of last-minute schedule changes made by hand without corresponding changes in the schedule file, and software limitations in interpreting the log files. The log files should be designed to facilitate automatic correlation and calibration.

The correlator will also generate its own log files which will supplement the observing log files to provide a complete record of the experiment, and provide a record of correlator usage for assistance in maintenance, etc.

4. TAPE INVENTORY

Each antenna must have a sufficient supply of tapes; the recorded tapes must be shipped to the correct correlator; the processed tapes must be cleaned, certified, and shipped back to the antennas. It is important to weed out bad tapes as early as possible, and to keep track of the recording quality at the antennas. Mark-II and Mark-III experience indicates that computer control of the inventory is needed.

Inventory control will be simplified if all the correlators have a computer link to the Array control center, which is in any case valuable for the other operations of the Array.

It would be nice if the tapes had a non-erasable, machine-readable label on them which could be recorded automatically in the log files for use at correlation time. This need not be magnetic; e.g. a bar-code would suffice.

5. CORRELATOR DATA BASE

The correlator output data base will be large. How long should the data base be kept on disk? Should it be archived on tape (as is done at the VLA)? Will the data be made available immediately to the experimenter? If this is the form in which the experimenter will receive his data, care should be exercised in the data base design. It is better to include too much information than too little. As it is sometimes not possible to assess data quality until a map has been made, a full history of the data should be included in the data base (including, e.g., which recorders were used in the correlation, etc.) so that hardware problems detected later in the analysis can be immediately traced. It is likely that at any time part of the data base will be in one or more disk-files (cf. Memo No.127) and the remainder will be on tape; book-keeping is required to keep track of what is where.

Data editing should be automated as far as possible by ensuring that the correlator has access to all necessary status information (e.g., on/off source) in the log files and maybe on the video tapes themselves. Similarly calibration will at least be partially automatic if all system temperature information, etc., is recorded in the log files. Editing and calibration should not make irreversible changes to the data base: i.e., it must always be possible to get back to the original data.

Subsequent data analysis of astronomical experiments will probably follow similar lines to VLA analysis, and no unusual bookkeeping problems arise. Geodetic/astrometric experiments require that data be recorded in an archival data base (see Memo No.125).

6. MISCELLANEOUS OPERATIONS

1. Real-time fringe verification: to be scheduled periodically and analysed on the Array control computer. The results must be passed to the correlator and fed back to the antenna staff so that clock adjustments can be made if necessary.

2. Station and source locations: the operations staff must maintain catalogs containing the best estimates of antenna and source parameters for use in the scheduling program and for calibration (including such things as polar motion and Earth rotation). These will be by-products of the calibration and geodesy/astrometry programs.

3. Antenna program development. Updates to the antenna control program can be distributed either over the phone lines or by mail.

4. Proposing, refereeing etc. This is the first stage in the execution of an experiment. Experience with the VLB Network and the VLA shows that some computer assistance is helpful in this stage.

5. Spare parts inventory control.

VLBA Bookkeeping

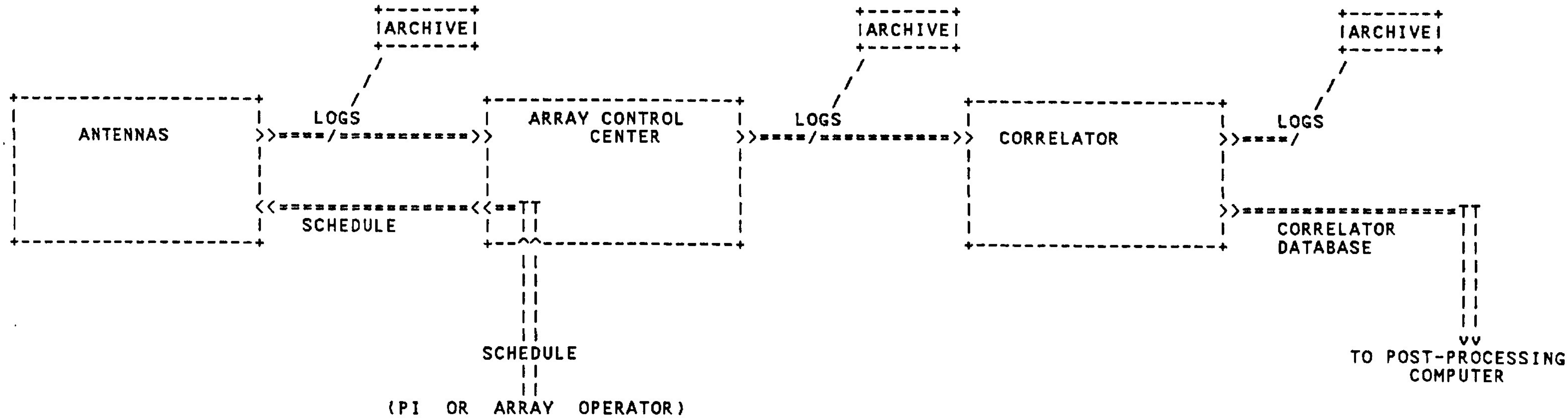

Figure 1: V L B A : F L O W O F L O G S A N D S C H E D U L E S (TJP 10/82)