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ONLINE COMPUTER SYSTEM OF GMRT

1. SCHEDULING AND OPERATOR INTERFACE ("Central Supervisory Computer" - Unix)

The observing schedule will be contained in a file which can only be modified by the operator. If the observers want to modify the schedule, they will need to create their own copy of schedule for a specific duration and then request the operator to incorporate it in the observing program. The operator will have access to a command to replace any portion (defined by the start and end time) of the observing schedule by the contents of any file in the network. The revised schedule will come into effect only when the old scan ends or when the operator explicitly introduces a pause in observation through a specific command.

An "observation" is defined in terms of the antennas it wants to use; all antennas for a given observation track the same region of sky. If different sub-arrays are used for observing different regions of sky or for any other purpose, each sub-array is deemed to be controlled by a separate "observation". Each observation will have its own supervisory program which is responsible for scheduling, control/ monitor, display, etc by appropriate initiating independent processes or communicating with the active processes in the network.

Thus there is no explicit restriction introduced on the number of sub-arrays possible -- each antenna could be controlled by a different program in the extreme case. However, this is only of academic interest, and the available resources may not permit more than a few sub-arrays in practice in addition to any antennas controlled by diagnostic engineers.

From the software point of view, a "sub-array" is simply a short form for a group of antennas provided for typing convenience of operators. In this sense, it is entirely feasible for an antenna to belong to multiple sub-arrays. For instance, a special sub-array can be "ALL" to include all antennas; in this case, every antenna belongs to two (or more) sub-arrays - "ALL" "xxx" where xxx is the name of the antenna. Certain names (like "Sub-1","Sub-2"...)may be standardised for exclusive use of observing programs initiated by the operator. All sub-array definitions are validated by a specific software (The Communication Hub) which ensures that there is no clash of any name with an existing (or reserved) name.

A typical observation is split into a number of "SCAN"s. Each scan has a stop-time beyond which the Station Supervisory Computer (SSC) will normally stop the antennas and stop updating monitored data-base until a new command is sent by the Central Supervisory Computer(CSC). A typical scan may last for 2-20 minutes. By convention, scans of long durations will be broken up by CSC into scans durations 30 minutes or less; however, updates will be sent to SSC early enough to prevent any break in the recording or data or tracking of antennas. Thus, this specal splitting of long scans into 30-minute scans is entirely transparent to the user and does not result in any discontinuity of observation. This procedure ensures that SSC gets a re-confirmation of essential observing parameters like coordinates at least once every 30 minutes.

2. PERIODIC UPGRADE of Array coordinates, delays, LO-phase, etc as required by the observing program. (operator -- Unix)

There will be a separate process for each subarray for this purpose; they will allocate the respective antennas through the communication handler.

3. ONLINE DISPLAY (WINDOW-BASED) - both text and graphics (Unix)

This corresponds to all the operator/observer screens except those specifically related to the display of visibilities.

4. VISIBILITY MONITORING, as required by astronomers (Unix w/s)

5. ANTSOL (CSC - Online server? - Unix)

During the observation of a calibration source, the observed visibilities are fitted by a nonlinear least-squares criterion to determine the gain and instrumental phase at each antenna; it is essential to make this procedure online in order to enable proper monitoring of visibilities during observation.

6. ARRAY CONTROL AND MONITOR (Unix+ VxWorks)

The assumption is that each subarray is controlled by a dedicated process, and a separate dedicated process will control the central electronics at the master station. One other process will be the communication handler, with which other processes will interact in order to exchange information with specific stations. Thus, for 30-station GMRT, there can be upto of 32 independent processes - the communication handler, central electronics control/monitor process and the 30 processes for control/monitor of each station by interacting with the appropriate station computers.

The communication handler is always present irrespective of whether observations are going on or not. This has an allocation mechanism to "allocate" an antenna to an active process. The process could be resident in any workstation in the network, and is identified by a unique combination of node+process names. While multiple antennas could be allocated to the same process, it is not permitted to allocate the same antenna to more than one process. When a new process requests for allocation of antenna, the communication handler checks if the antenna is already allocated; if it is, it verifies if the corresponding process is still active in the appropriate node. A new allocation is granted only if the previous process either "deallocates" the antenna or if the previous process is aborted (kill signal 9) in the relevant node.

Due to security reasons, there will be some restrictions on the allocation of antennas by processes. The allocation is retained as an "operator command", requiring the use of operator console. Typically, if any process (anywhere in the network) wants to allocate an antenna, it sends a message on the operator screen, following which the operator EXPLICITLY types a command on his console which results in the desired allocation and an acknowledgment sent to the concerned process; the process has to wait for this acknowledgment before it can get the desired control privileges.

Note that the operator can change any existing antenna allocation by using privileged commands available only operator console, overriding any privileges granted to an existing process.

All control commands related to antenna-movement are centrally logged irrespective of which process in the network is responsible for the command. The logged data-base includes command name and argument, time-stamp, originator of command.

The second job of communication handler is to provide a buffer the processes wanting to communicate with an antenna and the control/monitor system. A FIFO queue with 4kB buffer for each antenna will be maintained for this purpose. The buffer is split into transmit and receive buffers. An internal table maintains an update of status of each antenna -- (a) is it to be polled? (b) if so, the interval in seconds; (c)owner process id (blank if no process has allocated it); (d) size of input buffer + FIFO particulars; (e) size of output buffer + FIFO info ; (f) time of last successful communication (communication may simply be related to protocol and not necessarily contain any significant data).

7. LONG TERM ACCUMULATOR

The Long Term Accumulator has the principal function of converting the multiplier output into IEEE Floating Point, adding channels to reduce the data rate for the data acquisition system. The adding may be needed for several combinations: (a) adding adjacent samples of each channel to provide integration upto about 15 sec; (b) adding neighbouring channels to reduce the effective spectral resolution; (c) when the spectral resolution has already been lowered by choosing FFT of a smaller size, adding the appropriate "channels" which are not adjacent but correspond to the frequency; e.g., if a 64 point FFT has been chosen to give 32 independent spectral channels, and only RR,LL has been requested in the observing program, the 512 complex numbers read from the correlator consist of 8 sets of correlations for each of RR & LL -- thus 8 complex numbers correspond to the spectral channel which, when added, will result in one number per channel with an integration time of 100 ms.

The Long Term Accumulator will be designed to be able to handle an input data rate of 2.5 Mw/s (complex) from the correlator (100 ms integration - 32 antennas). The word length is decided by the hardware converting the VLBA floating point to IEEE-like floating point -- the current plan is to enable the hardware to transfer the 24 most significant bits of each single-precision floating point word with a normal IEEE representation. This corresponds to a data rate of 15 MB/s for the 2.5 Mw/s. The output data will be in IEEE floating point format - 8 bytes per complex word. The maximum output data rate will correspond to adding 16 channels across frequency/time, a peak rate of 1.6 MB/s; the typical data rate will, however, correspond to a 10 sec integration - 200 kB/s.

8. CORRELATOR CONTROL AND DATA ACQUISITION (VxWorks on Sun 1E board)

The data output from the long-term-accumulator depends on the sampling interval required for observation. The visibilities may need to be sampled as fast as once a second at low frequencies and in any case should be sampled every 10-12 sec to fulfil the Nyquist criterion. The peak output data rate from Long Term Accumulator is 1.6 MB/s, but the typical case corresponds to all the channels sampled at 10 sec which results in 200 kB/s for a regular IEEE single precision representation for the complex numbers. As a reasonable compromise between the peak requirement and the budgetary constraints of GMRT, we plan to restrict the data archival rate to a peak value of 250 K complex words if sampled at 10 sec -- i.e., 25 K complex words/sec. However, a convenient data compression algorithm will be employed to reduce the number of bits required for each complex word. One possibility being seriously considered is 32 bits per complex word, represented as scale amplitude and phase; one of 16 possible scale factors can be chosen for each amplitude, represented by 16 bit scaled integer, and a 4 bit - scaling code; phase will be represented by 10 bits and further 2 bits will be used for real-time flagging. This representation will require a total of 4 B (=32 bits) for each complex word, i.e., 100 kB/s peak for the data archival rate. This results in a total of about 4 GB data accumulated in a single observing session of 12 hours.

The data acquisition system has a local archival support - 8mm Exabyte drive (which currently can hold 2.3 GB but is expected to hold twice the size very soon.) The raw visibilities will be written to the archival medium in real time, and also written into the disk of the on-line server through Ethernet/NFS for providing access to a visibility-monitoring process initiated elsewhere in the network.

In order to enable such high data rates, the strategy is to use a VME-based fast single-board-computer (e.g. SUN 1E) with on-board ethernet and SCSI controllers. This will share the VME bus with the long-term-accumulator of the correlator system. The high input data rate of 1.6 MB/s is then feasible through the VME bus, and after processing/compression, data are output through SCSI and ethernet ports. The software for data acquisition will be written under the real-time operating system VxWorks.