VLB ARRAY MEMO No. 142

Interoffice Memorandum
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Subject: IF-TAPE-CORRELATOR Interfaces

1.0 INTERFACE PHILOSOPHY

In a recent Data Acquisition meeting, I proposed an interface philosophy based on the "layered protocols" found in modern data communications systems, such as X.25 or DECnet. These schemes isolate the logical interpretation of data from the physical details of how the data is transmitted. In this way, the technical means used to transmit data can be changed transparently at any time if the interface to the "user" is maintained.

In transporting VLBA data from the IF samplers to the correlator, a similar philosophy can be used. The data recording and playback system can be treated as the "lower level" in a two-level protocol. The concern at this level is simply the transmission of all data bits presented with minimum error rate. Control communication between the recording/playback system and the rest ot the VLBA would be concerned mainly with error rates, recorder servo performance, tape quality, and the like. High accuracy time information would <u>not</u> be required here.

On the "upper level" are the astronomical data source (the sampled outputs of the IF converters) on the transmitting side and the data user (the correlator) on the receiving side. Here, precise time-tagging must exist, and data streams must be identified with polarization, frequency, etc.

The situation is summarized in Figure 1.

```
                    Telescope            Operations Center

                 +---------------+      +---------------+
 Astronomy       |Sample/Time Tag|      |Delay/Correlate|
 Level           +---------------+      +-------^-------+
                         |                      |
        -..-..-..-..-..-|.-..-..-..-..-..-..-|.-..-..-..-..-..
                         |                      |
                 +-------V-------+      +---------------+
 Physical Level  |Format/Record  |      |Play/Decode    |
 (recording)     +---------------+      +-------^-------+
                         |   (tape shipment)    |
                         +->>---------------->>-+
```

Fig. 1. A VLBA Data Interface.

Note that all components that dependent on a particular recording technology lie below the dashed line. Thus any new technique could be used if it has the same two principle interfaces (across the dashed line).

A control interface must also be specified. At the telescope this interface will be simple, consisting of RECORD, STOP, and information regarding tape status. At the correlator, control must include the ability for at least rough synchronization of tapes from all the telescopes.

2.0 A GENERAL INTERFACE

Figure 2 shows a possible VLBA dataflow diagram based on the principles discussed above. The astronomy data formatter takes IF signals, samples them, and forms "frames" with suitable time tagging. Additional information from the station computer may also be incorporated, such as experiment, date, and telescope ID. Any other desired logging data could be included, since the tape channel will support an enormous amount of ancillary data.

The astronomy data formatter has an aggregate data interface with the tape controller system. This data interface may be in the form of a few, high-rate channels (e.g., 8 25 Mb/s channels as in the red report) or more, lower-rate channels (e.g., 28 8 Mb/s channels as in Mark III).

Presumably the digital channelization at this interface would reflect the IF channelization. (A lower rate would allow for gradual increments in capacity and for flexible bandwidth synthesis, but a higher rate would require fewer IF converters.) However, the digital data at this point could be arranged in any arbitrary manner. In particular, it would be efficient to transmit time codes and ancillary data on a separate channel across this interface.

The tape formatter accepts framed and time-tagged data from the astronomy data formatter, adds parity or CRC protection fields, and multiplexes or demultiplexes the data streams as appropriate for the chosen recorder technology. This device does not need precise timing or any other information concerning the experiment in progress; its only concern is the reliable recording of the input bit stream(s).

The details that need to be specified for the aggregate data interface are as shown in the following table:

NUMBER OF CHANNELS:	1 for each IF channel plus 1 for ancillary or time info?
WORD LENGTH PER CHANNEL:	1 bit (i.e. serial), 8 bits parallel?
CLOCK RATE:	Per bit or per byte?
ANCILLARY DATA:	Synchronous stream, vs asynchronous "RS-232" technique?
TIMING DATA:	Incorporate in IF stream or independent stream? Serial or byte parallel?
CONTROL DATA:	Select Mode: (Bit rate, channels) Run/Stop/Rewind/etc. Load/Unload tape Delay/Advance playback streams Read Status (servos, dropouts)

I will not attempt to specify in greater detail here, since I do not feel we have adopted a firm IF channelization scheme.

On the data playback side, the dataflow is the reverse of that at the telescopes as shown in Fig. 3. The tape decoder system is concerned with the reliable regeneration of the bit streams as they were presented to the tape formatter at the telescopes. No decoding of the astronomical data is performed here. Tape playback quality is monitored and transmitted to the correlator control computer.

The correlator deformats the IF data streams and examines the timing information. The control computer determines the time differences between telescope data streams and sends control commands to the tape playback system to synchronize tapes.

3.0 CONCLUSIONS

It is possible to define an interface between the IF system and the tape recorders at the telescopes which permits the astronomical information to be separated from technical recording details. The same interface can exist at the correlator. The interface permits recording technologies to be changed "transparently," with no change in the IF system or the correlator.

This approach is new to VLBI. Both Mark II and Mark III systems were designed around their respective tape recorders. However in order to have the best chance of effectively using new recording or transmission techniques, the VLBA data interfaces should be specified as independently as possible of any specific technology.

```
                                                                           OUTPUT STREAMS
                                                                           TO CASSETTES OR HONEYWELL
                +-----------------------+                +----------------------------+  TRACKS
                |                       |                |                            |
IF 1 ---------->|  ASTRONOMY DATA       |                | ADD SYNC AND PROTECTION    |---------> 1
                |    FORMATTER          |                | FIELDS TO DATA STREAMS     |
IF 2 ---------->|                       |                |                            |---------> 2
                |   ACCEPT DATA &       |  AGGREGATE DATA|MULTIPLEX AND/OR            |
      ...       |      RECLOCK?         |================>>|DEMULTIPLEX N INPUT STREAMS|   ...
                |                       |  INTERFACE     |TO FORM M OUTPUT STREAMS    |
      ...       |                       |                |                            |   ...
                |                       |      .         |ACCEPT CONTROL COMMANDS     |
IF N ---------->|                       |      .         |AND RETURN EQUIPMENT/TAPE   |---------> M
                |                       |      .         |STATUS                      |
                |                       |      .         |                            |
                +---^---^-----^---------+      .         +----^-----------------------+
                    |   |     |                .              |
+--------------+    |   |     |                .              |
|CLOCK   1 PPS|-----+   |     |                .              |
|         TIME |---------+     |                .              |
+--------------+              |                .              |
                              |                .              |
+--------------+ EXPT INFO    |                .              |
|TELESCOPE     |--------------+                .              |
| COMPUTER     | RECORDER CONTROL/MONITOR      .              |
|              |----------------------------------------------+
+--------------+                               .
```

FIGURE 2. RECORD DATA INTERFACES

```
INPUT STREAMS                                                                               REGENERATED IF STREAMS
FROM RECORDING                                                                              TO CORRELATOR
SYSTEM
               +--------------------------+                            +----------------------+
               !                          !                            !                      !
1 --------->!  DECODE SYNC AND PROTECTION!                             !  ASTRONOMY DATA      !-----------> IF 1
               ! FIELDS FROM DATA STREAMS  !                           !  DEFORMATTER         !
2 --------->!                             !                            !                      !-----------> IF 2
               !MULTIPLEX AND/OR          !   AGGREGATE DATA           !  DECODE IF DATA      !
    ...        !DEMULTIPLEX M INPUT STREAMS!=====================>>!  STREAMS, TIME,        !    ...
               !TO FORM N OUTPUT STREAMS  !   INTERFACE                !  AND ANCILLARY       !
    ...        !                          !                            !  INFORMATION         !    ...
               !ACCEPT CONTROL COMMANDS   !            .               !                      !
M --------->!AND RETURN EQUIPMENT/TAPE    !            .               !                      !-----------> IF N
               !STATUS AND SYNC. WITH OTHER!           .               !                      !
               !TELESCOPES                !            .               !                      !
               +--------------------------+            .               +--------------V-------+
                          !                            .                              !
                          !                            .                              !   TIME AND
                          !                            .                              !   EXPERIMENT
                          !                            .                              !   INFORMATION
                          !                            .                              !
                          !                            .                          +---V--------------------
                          ! CONTROL/STATUS INFO.       .                          !  CORRELATOR CONTROL
                          +----------------------------------<---->-----------!  COMPUTER
                                                       .                          !
                                                       .                          +--------------------------
                                                       .
                                                       .
                                                       .
```

FIGURE 3. PLAYBACK DATA INTERFACES