CHARA TECHNICAL REPORT

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Timing and Network Requirements on Mount Wilson

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1. INTRODUCTION

The control system for the CHARA Array will consist of many computers, each responsible for a particular real-time or asynchronous task, distributed around the site. In order for the system to function correctly, these machines need to be able to communicate with each other and share some kind of common time base. This document gives a brief description of the network to deliver these data and timing signals around the Array. More information about the CHARA Array can be found at our WWW home page listed below.

2. TIMING IN THE ARRAY

In a large distributed real time system like the Array the issues of absolute time and synchronous digital servos loom large. It is essential that each instrument control program is properly synchronized with the rest of the control system and that each digital servo runs in a synchronized manner. If this is not the case, aliasing and beating can occur within the control system with unpredictable results. Furthermore, if we wish to properly place the OPLE carts within the fringe envelope in an open loop manner, which we do, the absolute time must be known better than 1 millisecond, the goal being 0.1 milliseconds.

Apart from the OPLE control, the basic time unit for all systems within the array will be 1 millisecond. This signal will be distributed by twisted pair inside buildings and by fiber between buildings. There will be identical clock software on each of these computers and the 1-millisecond tick will be used to fire interrupts controlled by this software.

In order to properly synchronize these clocks a 1-second tick will also exist, distributed in the same manner, and this signal will also be monitored by each control computer. Periodically the time of the next 1-second tick will be propagated via TCP/IP, thereby enabling each device to set it's local clock to the same value. The OPLE electronics also requires a 16 MHz clock, along with the 1-second tick and the TCP-IP absolute time updates.

It is very important for these clock signals to be in sync with one another. For example, the smoothness of OPLE cart motion is directly related to the 16 MHz and 1-second clock

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ticks. Thus, as suggested by Laszlo, all timing signals will derive from a single 16 MHz oscillator. Absolute time can be acquired from a GPS system, or the Internet, although a GPS system would probably be more reliable. The local clock will essentially be free running, only occasionally requiring syncing to the absolute time, most probably once per day. In order for the absolute time in each controller to remain within 0.1 millisecond of true time then, this oscillator needs to be accurate to one part in 10^9.

3. NETWORK

A schematic layout, not including the clock system, of the network on the mountain is given in figure 1. Because of the long runs and large amount of RF interference from the transmitters nearby all outside connections will be made using fibers. Internal network connections will use twisted pair CAT5 cables and connectors. Timing signals within the building will also be transported over twisted pair cables.

There are two independent networks in the Array computer system: the control system network and the office network. It is extremely important to isolate the control system from the outside world, not only to protect it from hackers, but also to ensure that the only traffic on the control network consists of control messages. A number of real-time servos will operate over the control network and since TCP/IP is not a synchronous protocol we must keep network traffic within the control system to a minimum. For these reasons the control system server will act as a firewall and protect the control system behind it. Atlanta-based astronomers will be able to monitor the Array control system by logging into this server. No other outside access will be permitted.

We will have a C class license on the mountain. This will give us up to 256 IP numbers. The lowest 64 numbers will allocated to the office machines and the remaining numbers to the control system. This breakup can be altered in the future if necessary, although it must use a power of two in order to keep the network masks as simple as possible.

High-speed servos will not be able to use the TCP/IP network since there will be no way to guarantee speedy delivery of control messages. Thus the fringe-tracker/OPLE connection will be done using shared memory within the OPLE electronics 19″ rack and the Tip/Tilt detector to telescope connection will use RS232 channeled through a separate fiber pair.

The office network is a standard setup, with a single file server and a number of single computers. Unfortunately the office system will consist of a strange mix of operating systems (Windoze, Mac and Unix) but there is nothing we can do about that, short of convincing all personnel to agree on one OS. We might as well convince them all to vote the same way. All servers, and most office machines, will be Linux-based machines using the 2.0.33 kernel. Windoze will be supported using the Samba suite of software, thereby allowing the mounting of home file systems as drives, printer access and so on. Mail will be supported via a POP3 service on the office file server. No other operating systems will be supported — people will be on their own if they want to use something other than Linux or Windoze95.

Due to the low bandwidth of the connection to the outside world it is very undesirable to have extensive web services on the mountain. Nevertheless, a simple web page will exist on the office file server. This page will consist of a welcome message and a pointer to the web services in Atlanta. Private home pages will not be supported on the mountain; all private web pages should remain on the Atlanta network. We will support an anonymous FTP server on the mountain, although for similar reasons, its use for large files will not be encouraged. Uploads to the FTP server will not be permitted by anonymous users.

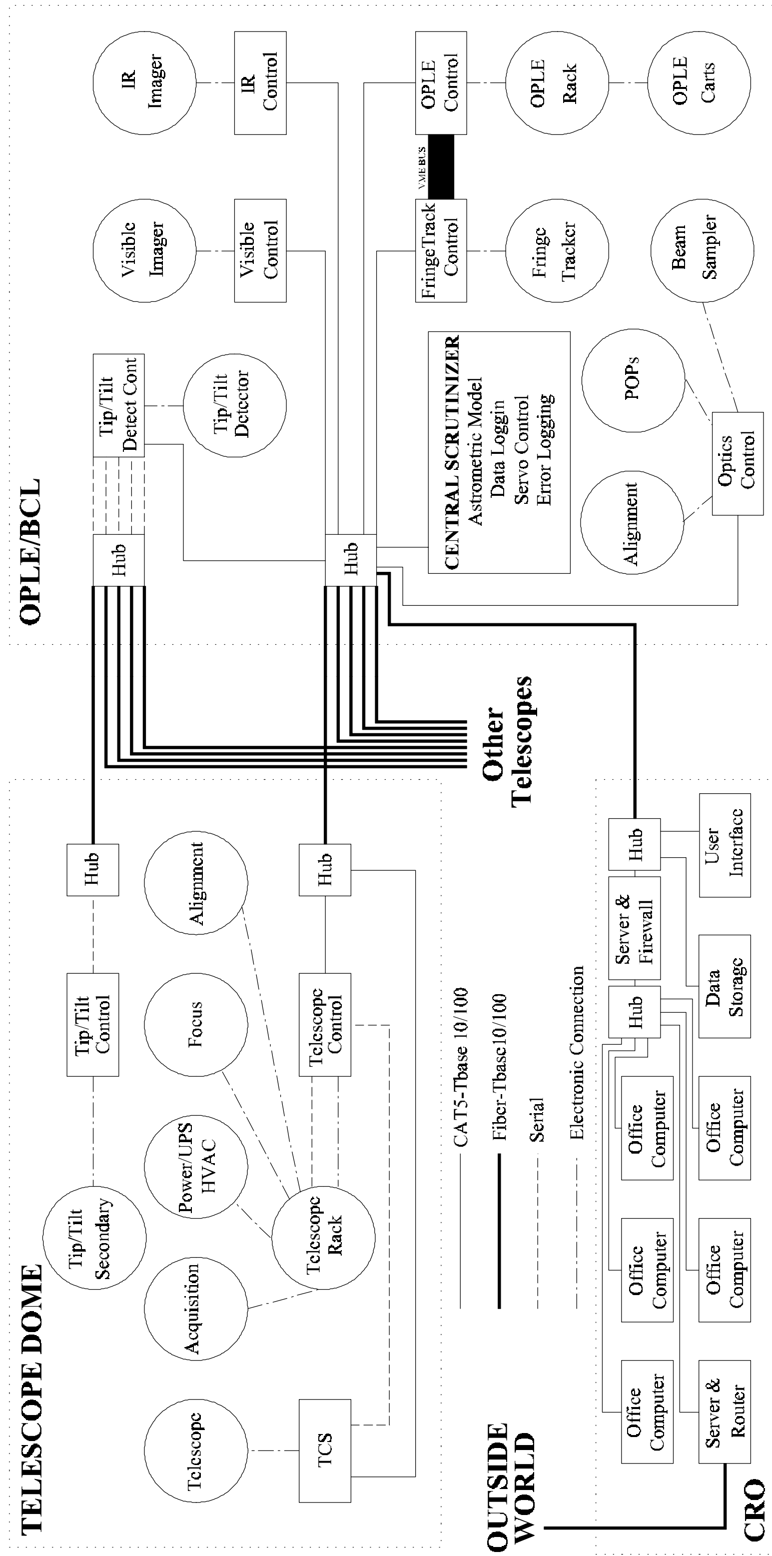

FIGURE 1. Schematic of the network connections for the CHARA Array.

Web and FTP services may be used internally for a local documentation archive, but these services will be blocked from outside use.

3.1. Fibers

The fibers will be multi-mode fibers with a diameter of 62.5 microns designed for outdoor and conduit use. Each run of fiber is to be a single length containing no splices. The connectors will be SC multi-mode Unicam for 62.5 micron fibers. Table 1 shows the number of pairs each cable will contain. This table also shows how many of the individual fibers in each line need to be terminated. The extra fibers not initially terminated are for MWI connectivity and their termination will be the responsibility of MWI. Termination will include testing of the completed lines.

TABLE 1. Fiber Numbers

From	To	Fiber Pairs	Initial Terminations
OPLE	S1	3	6
OPLE	S2	12	8
OPLE	E1	3	6
OPLE	E2	3	6
OPLE	W1	3	6
OPLE	W2	3	6
OPLE	CRO	6	12
OPLE	100″	12	2

In the OPLE building the fibers will terminate on a panel to the east of the door in the inner enclosure between the BCL and the electronics area. This panel will be on the northern side of the wall, that is in the electronics area, and will be suitable for placement in one of the 19″ racks to be installed there. Enough extra cable will be required in order for us to be able to place the panel in any location within that 19″ rack. The 100″ termination panel will be placed in a location to be specified by MWI.

Termination points in the telescope bunkers will be in the top of the 19″ rack in each bunker closest to the conduit. As for the OPLE building, enough spare cable will be required to allow us to move this panel within the 19″ rack itself.

The termination point within the CRO has yet to be determined, but will need to be close to the control room and like all the others will be placed within a 19″ rack. It is to be hoped that the CRO construction will include wiring for the CAT5 network.

Apart from S2 each telescope has three fiber pairs. One of these pairs will be used for TCP/IP communications and will be the channel used for all commands, data transfer and error messages. A second pair will be used as a dedicated link for the Tip/Tilt servo signals. The final pair will be used to transport timing signals, that is, the 1-second and 1-millisecond clock signals described in section 2. It is also possible to multiplex the time signals onto a single fiber, or imbed them into the carrier of one of the other fiber pairs. However, this requires extra hardware and work and should be considered only when we need more fiber capacity.

Of the extra fiber pairs in the cable between the OPLE and S2, one will be used as a connection to the outside world and the others are there for MWI use. Similarly, one of the pairs between the OPLE and the 100″ is for our use and the rest for MWI.

3.2. Connectivity to the outside world

At present the mountain is connected to the outside world via a T1 line that terminates in the 150-foot solar tower building. A router is in place there, although no real routing is done. All groups on the mountain share the same class C address range and packets from each device are sent around the entire mountain network. Currently we use a PPP connection to a computer in the 60″ dome and make use of IP-Masquerading to enable connectivity to all the machines in the Mark III. This is adequate for email, web browsing and so on, but is slow and does not allow video conferencing or any other high-bandwidth applications. We will progress to a proper connection to the outside world in five steps.

Initially, CHARA will tie into the current system using one of the fiber pairs between the OPLE building and the 100″ telescope dome. A simple patch cord will have to be run from the OPLE building to the Mark III building so that we can connect our computers there. With this in place we can continue to use our current set of IP numbers and remain part of the Mount Wilson network.

The second step will involve GSU installing a router in the S2 bunker. It is for this reason that we have so many fibers between the OPLE and this telescope (see section 3.1). When the light pipes are installed MWI will run a fiber between the MWI office building and the S2 bunker, thereby giving us a connection to the outside world and replacing the link to the 100″ dome.

The third step will be using our own class C license and separating our internal network traffic from the rest of the mountain. This will not involve any hardware changes, but will require some changes to the router in the 150-foot and our own router in the S2 bunker. This will not significantly change anything, except to shield the rest of the mountain from our internal network traffic.

The forth step will involve changing the entire mountain network. The GSU router in the S2 bunker will become the main hub for the entire mountain. The connection to the outside world will still come from the fiber between the S2 bunker and the MWI offices, but it will be a direct connection between the GSU router and the T1 line off the mountain. The extra fibers on the OPLE-S2 run and the OPLE-100″ run will allow us to run a separate fiber loop for each group on the mountain. Assuming the other groups' are willing to reconfigure their computers, this will allow more complex routing and a cleaner separation of each groups network.

The final step involves getting VBNS ('Internet II')onto the mountain, which will terminate in the S2 bunker. This will enable very high data rates between the Array and the offices in Atlanta. These high data rates will be very useful for the exchange of data, monitoring of the array in Atlanta, video conferencing, and eventually remote operations of the site. Of course we will always require an operator to be physically present on the mountain, but with VBNS, it will not be necessary for Astronomers to actually be on the mountain in order to observe.