VLB ARRAY MEMO No. 299

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

December 15, 1983

TO: B. Clark

FROM: A. Shalloway

SUBJECT: VLBA Communications Recommendations

INTRODUCTION:

The final communication specification should be arrived at by a study of all three components: communication links, associated computer hardware and associated computer software. Included in these three is the protocol to be used. Because I have no information on which computers are to be used, I have suggested six possible AT&T voice channel communications systems, plus a discussion with costs of satellite systems. Each one requires one or more types of protocol but cannot use all types.

Each of the systems can be configured to operate in one of two modes: 1) multipoint-polling or 2) point-to-point-nonpolling.

Certain requirements are necessary in all of the systems: reliability, maintainability and backup. All of this will be discussed, but first I will discuss the specifications for the system as I understand them.

SPECIFICATIONS:

None of the following include overhead (i.e., start-stop bits, headers, CRC, etc.).

1. DATA TRANSMISSION - CENTRAL SITE TO EACH ANTENNA SITE.

a. Data - Control

Rate - 2,500 bits every 5 minutes. This assumes a new observation every 5 minutes.

Average rate: per antenna = 8.33 bits/sec.
10 antennas = 83.3 bits/sec.

Reference: L. D'Addario

2. DATA TRANSMISSION - EACH ANTENNA SITE TO CENTRAL SITE.

a. Data - Monitor

Rate - 1,000 bits/sec. continuously

Average rate: 1,000 bits/sec./antenna

Reference: L. D'Addario

b. Data - Graphic Test Data

Rate - 300 bits/sec. randomly when testing but not during fringe transmissions

Average rate: 300 bits/sec. during transmission

Reference: B. Clark

c. Data - Fringe Check

Rate - 4,000,000 bits per 30 minutes per antenna repeated once per ten hours for each antenna.

Average rate: 2,222 bits/sec./host computer input. Each host input would receive the fringe data from only one antenna at a time.

Reference: K. Kellermann

NOTE: No monitor or graphics data need be sent while fringe data is being transmitted; however, the backed up monitor data should then be brought back up to date - while the graphics data is also being transmitted - within a reasonable time, which I have selected to be one hour.

At the present time, these values represent maximum values including safety factors. Based on these figures, a full-duplex line from each antenna station which can operate at 2400 baud will be satisfactory and should cover the overhead required also.

INTRODUCTION TO COSTS:

In the following discussion of the four methods, I have not covered any facet in fine detail. To do this would take more time than I have and would mean nothing a year or two from now when the equipment is ordered. In selecting a system, there has to be a careful, complete investigation including all of the following: the communication system, the computer and the software. Some of the obvious computer decisions are: should there be a separate computer for the communications, the monitoring and the control or should two or all three of these functions be accomplished in one computer. I have also found that if I want to have the complete software supplied by the computer manufacturer, I receive recommendations from the manufacturer that I must have a computer system of a certain minimum size. Whereas, if we assemble the computer software system ourselves, we can do - at least the communications job - with something as simple as an IBM or compatible PC plus a $1,000 plug-in card. Therefore, considerable investigation must be made into the computer and software and fitted into one of the six communications systems listed here.

COMMUNICATIONS SYSTEMS COSTS:

A. DEDICATED VOICE CHANNELS FROM AT&T

1. Center at Charlottesville

a. Point-to-point CPU output = asynchronous (Fig. 1)

Transmission costs:

Monthly rental = $14,190.00

Yearly rental = $170,280.00

Non-recurring charges = $4,351.00

Equipment costs: $172,000.00

b. Point-to-point CPU output = synchronous (Fig. 2)

Transmission costs:

Monthly rental = $14,190.00

Yearly rental = $170,280.00

Non-recurring charges = $4,351.00

Equipment costs: $135,862.00

c. Multipoint-polling CPU output = synchronous (Fig. 3)

Transmission costs:

Monthly rental = $14,532.00

Yearly rental = $174,378.00

Non-recurring charges = $1,665.00

Equipment costs:

1) If antenna station CPU's are medium to large IBM's = $196,029.00

2) If antenna station CPU's are IBM PC's or compatible = $146,029.00.

2. <u>Center at Albuquerque</u>

a. Point-to-point CPU output = asynchronous (similar to Fig. 1)

Transmission costs:

Montly rental = $12,228.00

Yearly rental = $147,360.00

Non-recurring charges = $4,351.00

Equipment costs: $157,342.00

b. Point-to-point CPU output = synchronous (similar to Fig. 2)

Transmission costs:

Monthly rental = $12,280.00

Yearly rental = $147,360.00

Non-recurring charges = $4,351.00

Equipment costs: $121,242.00

c. Multipoint-polling CPU output = synchronous (similar to Fig. 3)

Transmission costs:

Monthly rental = $12,540.00

Yearly rental = $150,480.00

Non-recurring charges = $1,665.00

Equipment costs:

1. If antenna station CPU's are medium to large IBM's = $196,029.00

2. If antenna station CPU's are IBM PC's or compatible = $146,029.00

B. SATELLITE SYSTEMS

1. Turnkey system from one company

Quotations from Vitalink and American Satellite

a. American Satellite would only supply a leased system at $350,000 per year. This is too expensive and therefore I will cover no further details.

b. Vitalink will sell us a completed system - all antennas, electronics, concrete pads, electronic buildings, including site surveys and licensing.

Antenna site systems - $110k to $140k or $60k to $90k if we provide the foundation, building, etc. Variation in price depends on more precise quotation (this is ballpark) and how much redundancy we require.

Central site system - $175k. This is a C-band system. Entire system could be rented to us for about $19 per month. Because of the remote locations, service would be about $1k/month/antenna. Transponder channels would cost about $2,000 per month on a seven-year lease basis. This would provide 10 each, full-duplex channels of 4800 bps to each antenna site with full backup-redundancy-transponder channels.

2. System Components Selected and Purchased by NRAO From One or More Vendors

Quotations from Scientific Atlanta and Harris.

a. Scientific Atlanta gave a very rough ball park price for the antennas and electronics installed: $90k to $95k per location. This is a 7-meter, C-band system with one 56k bps, full-duplex system. We obtain our own transponder channels - probably at about $2,000/month.

b. Harris proposed a Ku-band system with 56k bps, full-duplex. Cost installed antenna and electronics: $60k to $75k per antenna. If a second 56k bps channel is desired at the control site to double the data transmission rate = $40k to $50k extra. Spares kept at the central site = $50k. Transponder rental is probably $2,000 per full- duplex channel per month - as above.

DISCUSSION OF INFLUENCING FACTORS:

I. Telephone Line Communications vs. Satellite vs. Fiber Optics

From my experience with dedicated telephone lines, we can definitely expect to have downtime and this time can be as much as 48 hours or longer. Therefore, the first obvious precaution we take is to have dial backup. This certainly will greatly improve the situation; however, there are still two things to keep in mind: dial backup is not a complete guarantee of communications from these remote locations when the dedicated line goes down and, secondly, dial backup used for 10, 20, 30 or more hours at a time gets expensive and should be included in the cost equation.

The satellite companies talk routinely of uptime of 99.5% and some are building systems with specifications of 99.9% uptime. In the long run (5 to 10 years), a satellite system is cheaper with less headaches. However, it will take more work on our part to obtain such a system and to be sure it is a good one that is properly designed. However, I believe someone like Chuck Broadwell could do such a job properly.

Fiber optics have already been installed on the east coast from north to south. Also, fiber optics are installed from the east to Chicago and is planned out to San Francisco and then down to Los Angeles. In a matter of time, it will blanket the United States.

Predictions made by those in communications who make predictions, generally go this way: Dedicated telephone lines are going to increase in cost. There are new tariffs which will go into effect about April 1984 which increase the cost of short lines (less than a few hundred miles) by a considerable amount and decrease the cost of long lines (over 1,000 miles) by a small amount so that on a system like ours, AT&T estimates an increase of about 30%. To continue with the predictions - satellite communications will do down in cost because of all the new transponders being put up and the feeling that TV use of satellites has reached a peak and will start to drop off soon. Then at some point in the future (5 to 10 years), fiber optics will become sufficiently cheap communications to induce most of the narrow band communications (which we are) back down from the satellites. My guess is that in our case, the fiber optics enticements will be on a longer time scale because of the remoteness of our locations and the likeliness of fiber optics going into those sites after all other sites have been satisfied.

II. Communication Protocol Discussion

This is an area which will be greatly influenced or determined by the programmers. The discussion here is from my point of view which is a hardware oriented person with lots of machine language (assembly language included) experience but only a small amount of high level language experience.

I lean toward asynchronous communications because it seems to be easier to implement and easier to service. But, because modems and network control systems are getting so sophisticated, my statement about asynchronous communications may no longer be true. However, if one uses synchronous communcations and lets someone like IBM dictate what equipment to use, it ,can turn out to be very expensive and sometimes not as flexible as a system determined by our study and design of the system. As an example, when discussing the problem with IBM people for a polling synchronous system, they recommended computers connected to 3274 and 3705 systems. The 3274 is about $6,000 and the 3705 is more - I estimated $10,000 but it may be even more. From what I read, the functions can be accomplished with a plug-in card for an IBM PC or compatible computer for $1,000 or less for each computer. This assumes that the IBM PC does one or more of the jobs previously specified: communications, monitor and control. However, even if it only did the communications job - which it certainly could do - for a polling synchronous system it would be cheaper than the way recommended by IBM.

In the point-to-point systems, I have shown each antenna site as capable of sending and receiving simultaneously (full-duplex) at 2400 bps. In the multipoint polling system, I show each site as capable of 9600 bps. This allows data to flow at a minimum average of 2400 bps in one direction. Although the multipoint equipment is all full-duplex, no one I know of transmits in both directions (on the same line) simultaneously. Therefore, as normally used, point-to-point systems provide an easier method of greater data transfer. An advantage of the multipoint polling system is that by restricting transmission from all but one station on a line, the fringe data can be transmitted to the central site at 9600 bps and thus in a short period of time. However, if fringe data is required from all stations, the multipoint system does not save any time because in the point-to-point system, all stations can send fringe data simultaneously.

Some (Vitalink) of the satellite systems were quoted with separate channels for each station so that polling is not necessary, and others (Scientific Atlanta and Harris) were quoted with one or two wide bands so that polling would be required.

In all of the land-line systems, I planned on a Network Control System (NCS) and modems which have a low baud rate secondary channel to return line condition information back to the NCS for monitoring. This does not add greatly to the cost and is extremely desirable for pinpointing and anticipating problems.

For backup phone systems, I tried to include enough money so that the main modems could remotely be made to dial up two backup lines and if this didn't work - because the modems were defective - there would also be a 212A type modem at each site and some switching so that it could be used in place of one of the main modems until it could be repaired. I did not include any spares of anything for maintenance except where specifically mentioned in the satellite systems.

I have discussed this investigation with Chuck Broadwell and passed on some of the literature to him so that after I leave, further questions can be addressed to him.

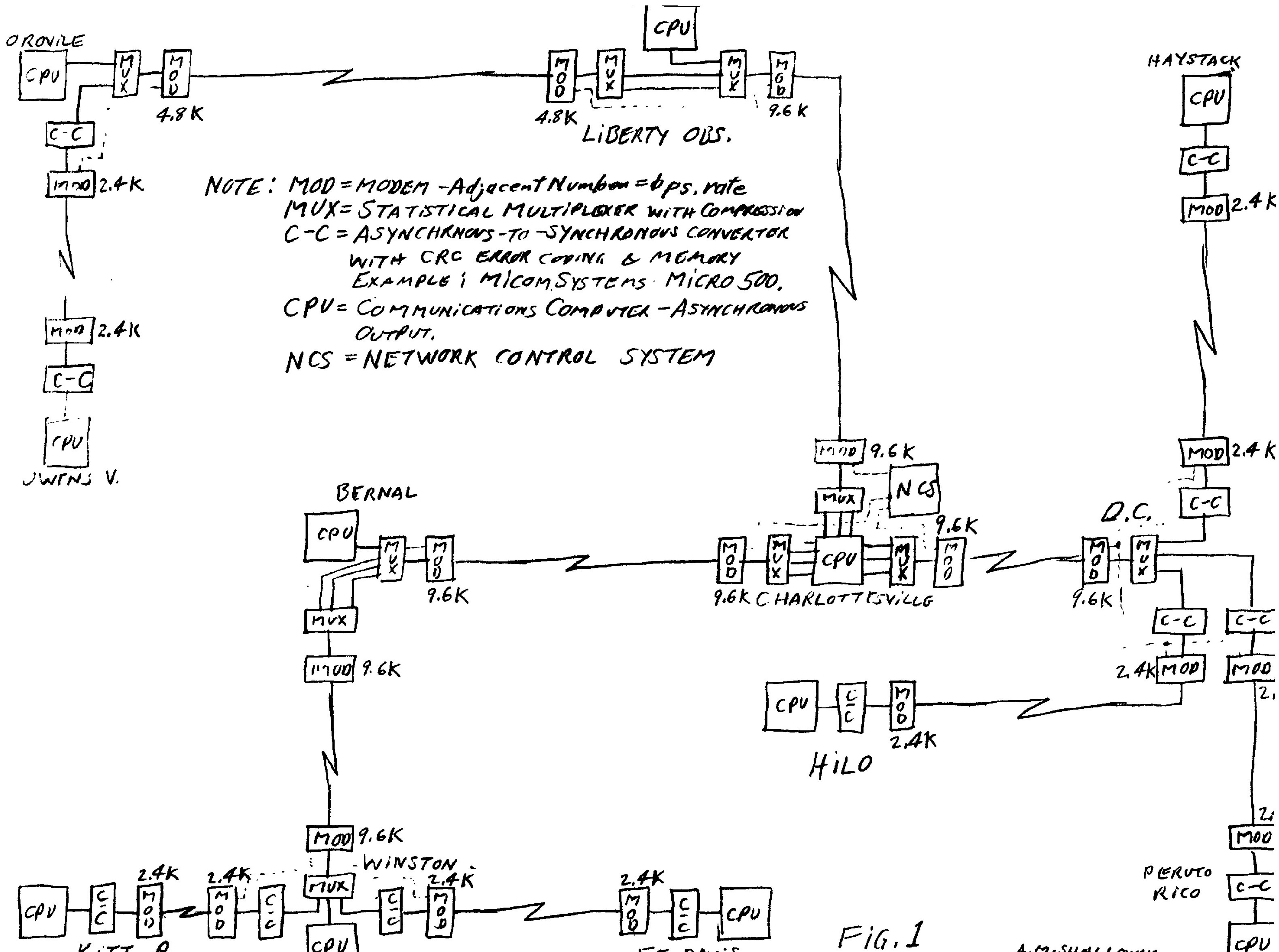

FIG. 1

VLBA NETWORK – CENTER CHARLOTTESVILLE – POINT-TO-POINT

A.M. SHALLOWAY
12/5/83

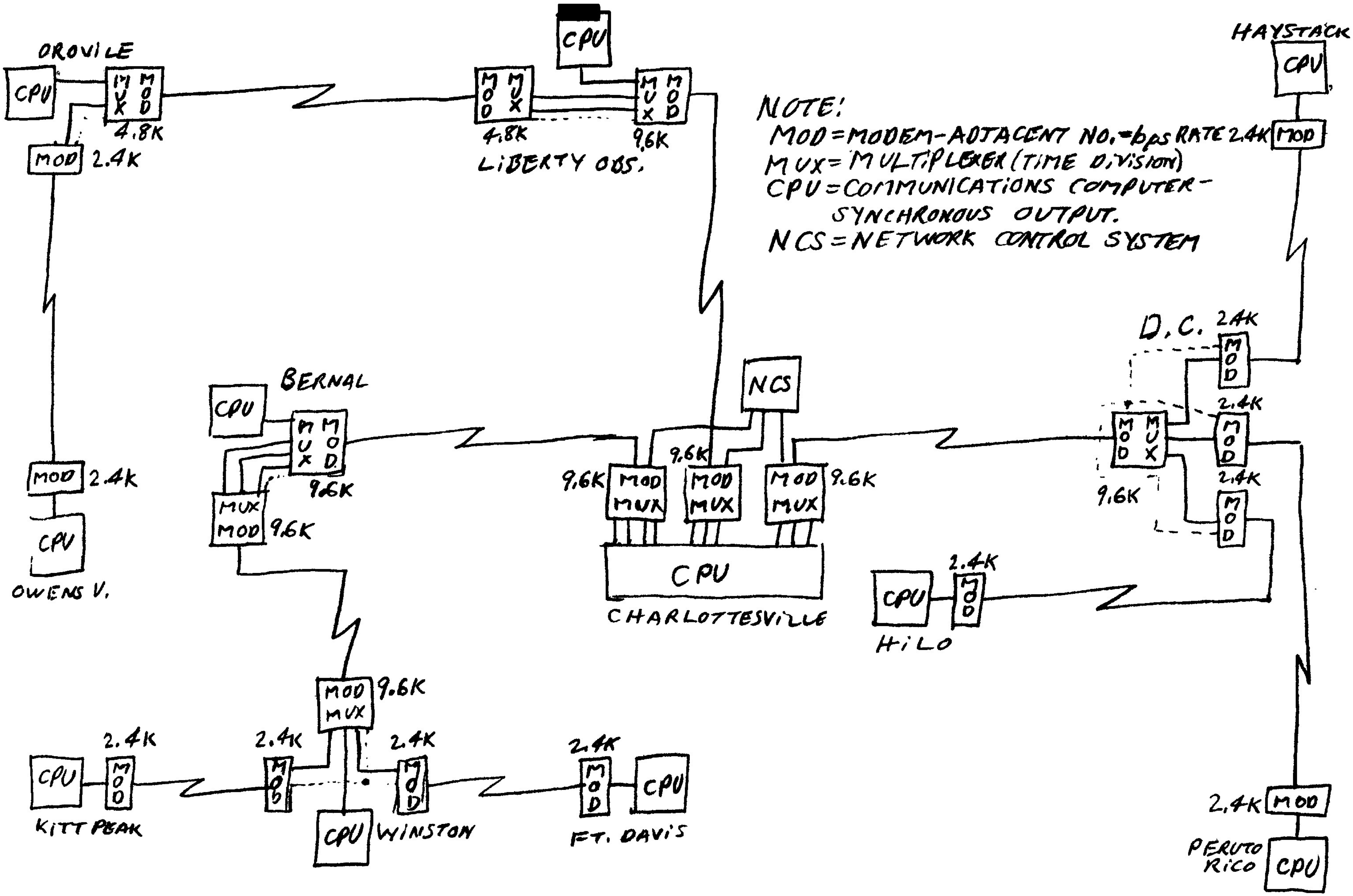

FIG. 2

VLBA NETWORK-CENTER=CHARLOTTESVILLE-POINT-TO-POINT

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12/6/83

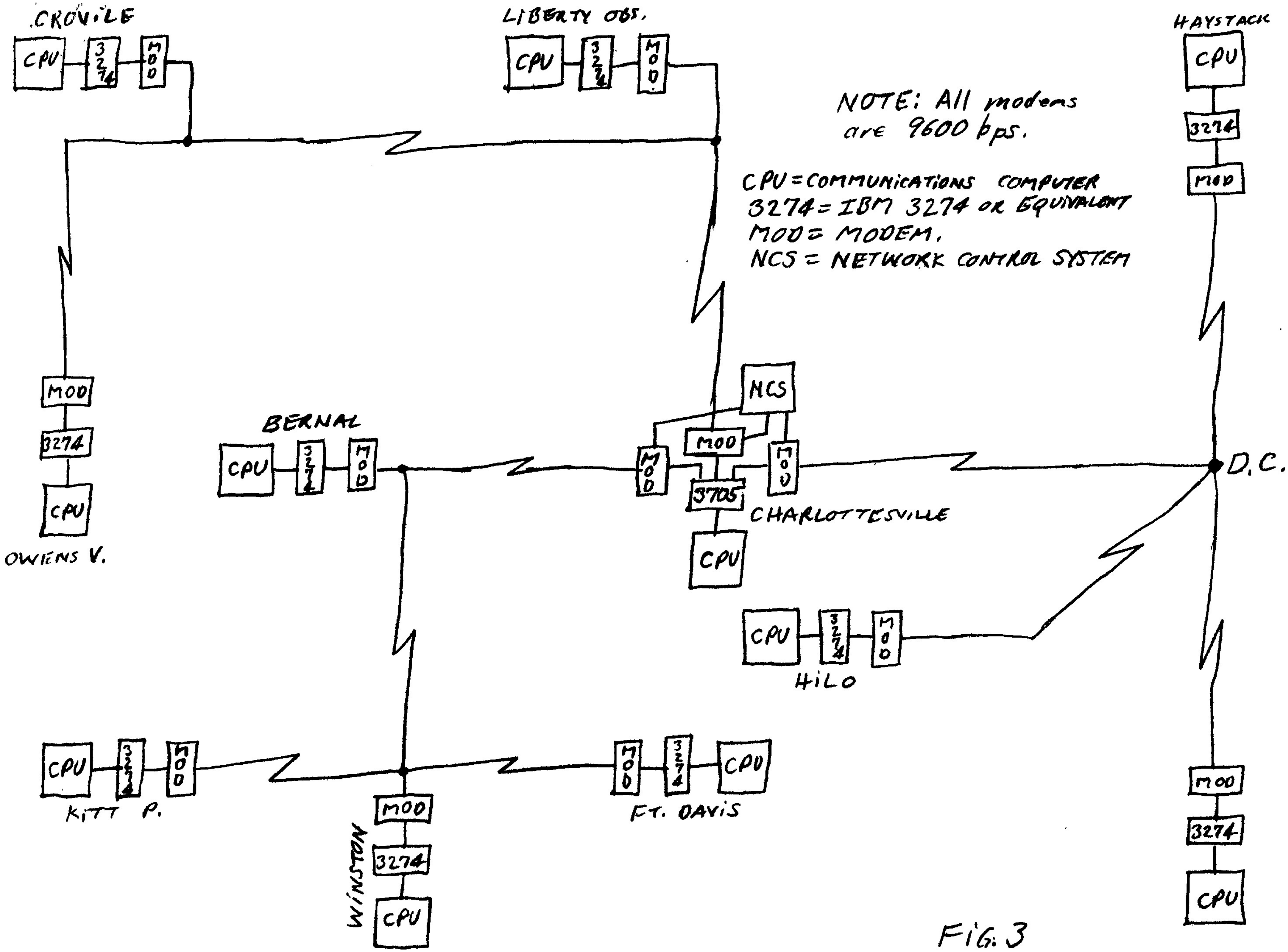

FIG. 3

VLBA NETWORK-CENTER=CHARLOTTESVILLE - MULTIPOINT POLLING

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