National Radio Astronomy Observatory
PO Box O
Socorro, NM 87801

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Authors: Wayne M. Koski

EVLA Systems Group

EVLA Hardware Networking Specification

Wayne M. Koski

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1 Introduction

Each Module Interface Board (MIB) will be connected to the EVLA Network as shown in Figure 1: Basic MIB Network Block Diagram. It shows a MIB contained in a module, and the equipment that establishes it on, and connects it to the network.

The purpose of this document is to describe this block diagram and all related networks requirements or needs. The discussions will be kept to the minimum necessary to convey to NRAO personnel details that they need to understand, without going to the great depths that one could. There are various books that can provide these details especially on the various protocols that are in use in networking systems.

In order to describe the various requirements, this document consists of five parts: Media Access Addressing, Internet Protocol Addressing, Module to IP Assignments, Slot-ID Data Structure Definition, and the Naming Convention.

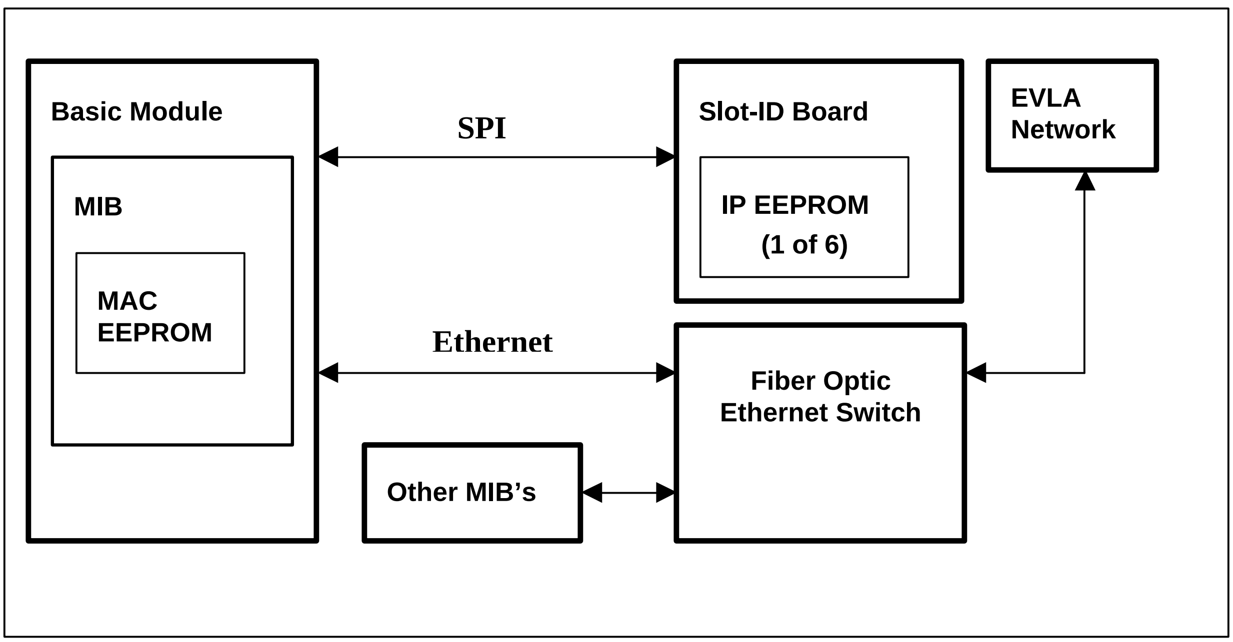

Figure 1: Basic MIB Network Block Diagram

2 Media Access Control (MAC) Addressing

All devices on a Ethernet based network requires an unique Hardware Address (HA), also known as the Media Access Control (MAC) address. The MAC address consists of six bytes, three of which are the Organizationally Unique Identifier (OUI), with the other three being under control of a user. NRAO bought and was assigned an OUI number by the IEEE Standards Organization. No other company can use the OUI number, thus in effect allowing our equipment to be placed on networks anywhere without causing problems. The reason that the IEEE Standards Organization is involved, is due to the fact that Ethernet is a formal standard of the IEEE LAN/MAN Standards Committee. The specific standard is IEEE Standard 802 Part 3 (802.3): Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications. This approximate1500 page living document covers everything one would care to know about Ethernet.

With the other three bytes under the control of NRAO, this allows approximately sixteen million unique addresses for Ethernet based network devices developed by and for NRAO. These three bytes combined is basically the MIB serial number. Any other NRAO produced network device would also contain a serial number starting with the value of one and going to 16,777,214. Note that zero and 16,777,215 are not allowed at this time. Finally, note that commercially bought network equipment will have a MAC address set by the manufacturer, and does not fall under this section.

As shown in Figure 1: Basic MIB Network Block Diagram, the MAC is contained in an EEPROM located on the MIB itself. The first six bytes of memory starting at EEPROM address location $0000 will contain the MAC address. Starting at address location $0100, this EEPROM will contain other MIB specific information such as revision level, status, etc. This information is now as yet to be defined, and will be found in the Module Interface Board Hardware Definition Document A23710N0001.

Finally, Ethernet is basically a hardware or physical layer standard combined with a defined message format called an Ethernet frame. Contained in this frame is a sixteen-bit value that allows 65536 software communication protocols. In other words, Ethernet merely transports other communication protocols between machines. It is these machine software programs that sends or receives these software communication protocols to one another.

3 Internet Protocol (IP) Addressing

NRAO has chosen to use the Internet Protocol (IP) to send and receive messages across Ethernet between machines or devices on the EVLA network. Additionally NRAO is utilizing the Transmission Control Protocol (TCP) that is always combined with IP. This is better known as TCP/IP and from these two items the TCP/IP Internet Protocol suite has come into existence, which also dominates the marketplace. The best way to understand TCP/IP is to think of it as a software communication method that can activate specific TCP/IP functions, as well as to pass data to other software applications.

TCP/IP also requires a unique address for each machine or device on a network, which is known as the IP address. The IP address consists of four bytes, which is usually described as four decimal numbers (0 to 255) separated by periods (.).

For example: 20.252.5.0

There will be two networks, one for the EVLA site, and one for the Array Operations Center (AOC).

The breakdown for these Network IP addresses is fairly straightforward:

AOC IP	10.64.XX.YY
EVLA IP	10.80.XX.YY

Both of the above networks are known as private or non-routable. This provides an early degree of security for these networks, as only NRAO internal routers, hosts etc. will be given direct access. Our network administrators will accomplish this, and the exact details will not be described here. The values XX and YY are determined by location. XX is basically determined by the Antenna serial number. YY is the Slot-ID value for a given module at a known physical location. One of the more interesting aspects of having two networks, is the fact with careful IP assignments and Naming Convention, the networks can be duplicates of one another without any interference between them.

Normally the IP address is assigned and fixed to a machine or device for its lifetime. Once it is retired then that IP address can be re-used by a replacement machine or even used elsewhere. Another degree of flexibility is that a machine can request a temporary IP address via the Dynamic Host Configuration Protocol (DHCP). This works well with machines that may be at times located at different places or networks.

At the EVLA, for hardware devices such as the MIB, the IP address is locked to a specific place and therefore module, rather then by a specific MIB. Looking again at Figure 1, the MIB obtains its IP by accessing the Slot-ID board EEPROM via a Serial Peripheral Interface (SPI) access. This EEPROM will provide the unique IP address for the MIB, the IP address of the Gateway (Switch), the IP address of the slave Domain Name Server (DNS), and the IP address of the master DNS. This provides the MIB with enough information to easily go onto the network. Additionally, the Slot-ID board will provide information about the slot itself, such as the module name the slot is linked to, the revision level, etc.

Each of the six uniquely programmed EEPROM's on the Slot-ID board will be wired to six different places in the rack. Also, due to the fact that only a specific module will work at that location, that Slot-ID IP will always be for that module. If the Slot-ID board doesn't exist or isn't functioning, then the MIB will attempt to get an IP via DHCP instead.

The D301 through D304 modules are the only exceptions to this. Because of the need to contain any Radio Frequency Interference (RFI) generated by high-speed digital logic inside this module, these modules do not link to a Slot-ID board. Rather the Slot-ID function is part of these modules. The management of Slot-ID in these modules is still yet to be determined. The paragraph in italics that follows is a rough outline of one proposed solution that is currently on top of the list. However, it may be replaced with another method or procedures that would accomplish this task for this special case.

The module will read in the enough of the Slot-ID in order to determine that it is on either the AOC or EVLA network. It will also read in the slot value as well. It will then utilize DHCP in order to determine its network as well as physical (rack) location. The MIB will then close the DHCP request, merge the required network values it received from DHCP with the Slot-ID information and establish itself on the network using the merged network details. It will also derive the Gateway address IP using the same merging operation. For the DNS values, both values for the AOC and EVLA network will be provided, and the MIB software will choose the correct set of DNS IP's to utilize.

4 Module to Internet Protocol (IP) Assignments

Recalling the two network IP's 10.64.XX.YY at the AOC and 10.80.XX.YY for the EVLA Site, the value XX was earlier given to be the EVLA antenna number. While this is still true, NRAO will use the XX number to define other specialized network locations besides an antenna. The following Table 1: Network Location Values shows the breakdown of the XX value into the various usages that NRAO has currently determined to be required.

Table 1: Network Location Values

Location Values	Network Locations or Network Usage
0 – 96	Network Use/Reserved for Future Expansion
97	MIB and Module Development Efforts for Individuals
98	Bench Integration or Bench Work for Testing Individual Modules
99	Antenna Test Racks
100	Master Rack and EVLA Site Infrastructure
101 – 128	EVLA Antennas (1 – 28)
129 – 253	Future Antennas (VLBA, Phase II Antennas) or Future Expansion
254, 255	Network Use

The YY value is simply the Slot-ID number. For both the AOC and EVLA networks, the Slot-ID value was kept as consistent as possible. The only times they are not consistent is when XX = 97, XX = 100, or it is a network use or future effort. For XX = 97, the Slot-ID value will be assigned to individuals on an as needed basis. Any MIB or module development effort would use this assigned Slot-ID for their work. After development, the module would then be assigned its final IP number for use in the EVLA. When XX = 100, that denotes the Master Rack equipment. The Master Rack affects the entire EVLA, the modules used are few in number, and none are used in the EVLA antennas. Because of this, the Slot-ID assignments were specialized for the Master Rack.

In establishing the Slot-ID number, ranges of values were assigned to the various groups at NRAO who are responsible for specific modules or equipment. Table 2: Antenna Slot-ID Ranges by Groups shows the breakdown of these assignments for the Antennas. Table 3: Master Rack Slot-ID Ranges by Groups shows the breakdown of these assignments for the Master Rack.

Table 2: Antenna Slot-ID Ranges by Groups

Slot-ID Ranges	Responsible Group
0 – 63	Network Group or Reserved for Future Expansion
64 – 127	Computer Group (Used by DHCP)
128 – 137	Engineering & Services (E&S) Group
138 – 147	Front End (FE) Group
148 – 187	Local Oscillator/Intermediate Frequency (LO/IF) Group
188 – 207	Monitor & Control (M&C) Group
208 – 227	Sampler/Data Transmission (DTS) Group
228 – 247	Systems Group
248 – 253	Reserved for Future Expansion
254, 255	Network Use

Table 3: Master Rack Slot-ID Ranges by Groups

Slot-ID Ranges	Responsible Group
0 – 63	Network Group or Reserved for Future Expansion
64 – 127	Computer Group (Used by DHCP)
128 – 147	Local Oscillator/Intermediate Frequency (LO/IF) Group
148 – 207	Monitor & Control (M&C) Group
208 – 227	Sampler/Data Transmission (DTS) Group
228 – 247	Systems Group
248 – 253	Reserved for Future Expansion
254, 255	Network Use

The next set of tables shows the assigned Slot-ID for each Antenna module by Group. An example for the complete IP for Antenna 1 at the EVLA site is included.

Table 4: Engineering & Services (E&S) Group Antenna IP's:

Module	Slot-ID Value	Antenna 1 Example
Antenna Control Unit (ACU)	128	10.80.101.128
Focus Rotation Mount (FRM)	133	10.80.101.133

Table 5: Front End (FE) Group Antenna IP's:

Module	Slot-ID Value	Antenna 1 Example
F317-1 (FE Controller)	138	10.80.101.138
F317-2 (FE Controller)	139	10.80.101.139
F318 (Water Vapor Radiometer Interface)	141	10.80.101.141
F320 (FE Transition)	142	10.80.101.142

Table 6: Local Oscillator/Intermediate Frequency (LO/IF) Group Antenna IP's:

Module	Slot-ID Value	Antenna 1 Example
L301-1 (12-20 GHz Synthesizer)	148	10.80.101.148
L301-2 (12-20 GHz Synthesizer)	149	10.80.101.149
L302-1 (10.8-14.8 GHz Synthesizer)	150	10.80.101.150
L302-2 (10.8-14.8 GHz Synthesizer)	151	10.80.101.151
L302-3 (10.8-14.8 GHz Synthesizer)	152	10.80.101.152
L302-4 (10.8-14.8 GHz Synthesizer)	153	10.80.101.153
L304 (LO Reference Receiver)	154	10.80.101.154
L305 (Reference Generation & Distribution)	155	10.80.101.155
L352 (Round Trip Phase Measurement)	157	10.80.101.157
L353 (LO Transmit)	158	10.80.101.158
T304-A (Downconverter)	168	10.80.101.168
T304-B (Downconverter)	169	10.80.101.169
T304-C (Downconverter)	170	10.80.101.170
T304-D (Downconverter)	171	10.80.101.171

Table 7: Monitor and Control (M&C) Group Antenna IP's:

Module	Slot-ID Value	Antenna 1 Example
M301 (Converter Interface)	188	10.80.101.188
M302-1 (Utility)	189	10.80.101.189
M302-2 (Utility)	190	10.80.101.190

Table 8: Sampler/Data Transmission (DTS) Group Antenna IP's:

Module	Slot-ID Value	Antenna 1 Example
D301 (Sampler/DTS)	208	10.80.101.208
D302 (Sampler/DTS)	209	10.80.101.209
D303 (Sampler/DTS)	210	10.80.101.210
D304 (Sampler/DTS)	211	10.80.101.211
D351-A (VLA Sampler)	220	10.80.101.220
D351-B (VLA Sampler)	221	10.80.101.221
D351-C (VLA Sampler)	222	10.80.101.222
D351-D (VLA Sampler)	223	10.80.101.223

Table 9: Systems Group Antenna IP's:

Module	Slot-ID Value	Antenna 1 Example
P301-1 (Bin Power Supply)	228	10.80.101.228
P301-2 (Bin Power Supply)	229	10.80.101.229
P301-3 (Bin Power Supply)	230	10.80.101.230
P301-4 (Bin Power Supply)	231	10.80.101.231
P302-1 (Front End Bin Power Supply)	232	10.80.101.232
P302-2 (Front End Bin Power Supply)	233	10.80.101.233
P303 (Bin Power Supply)	234	10.80.101.234

Table 10: Computer Group Antenna IP's are specialized at each antenna in that they are allocated by DHCP for next available Slot-ID number within 64 through 127. Basically laptops, test equipment or other network devices would be plugged into these locations on a temporary basis. Additionally, any MIB that couldn't read its Slot-ID would use DHCP and be assigned as well to be within 64 through 127. The only fixed Computer Group device is the Cisco switch at each antenna.

Table 10: Computer Group Antenna IP's:

Device	**Slot-ID Value**	**Antenna 1 Example**
Pad Port	(64-127)	10.80.101.(64-127)
Azimuth Axis Port	(64-127)	10.80.101.(64-127)
Elevation Axis Port	(64-127)	10.80.101.(64-127)
Pedestal Room Port-A	(64-127)	10.80.101.(64-127)
Pedestal Room Port-B	(64-127)	10.80.101.(64-127)
Vertex Room Port-A	(64-127)	10.80.101.(64-127)
Vertex Room Port-B	(64-127)	10.80.101.(64-127)
Vertex Room Port-C	(64-127)	10.80.101.(64-127)
Dish Port	(64-127)	10.80.101.(64-127)
Prime Focus Port	(64-127)	10.80.101.(64-127)
Test-Equipment #1	(64-127)	10.80.101.(64-127)
Test-Equipment #2	(64-127)	10.80.101.(64-127)
Cisco 4503 Switch	254	10.80.101.254

The next set of tables shows the assigned Slot-ID for the Master Rack modules by Group. An example for the complete IP for the Master Rack at the EVLA site is included.

Table 11: Local Oscillator/Intermediate Frequency (LO/IF) Group Master Rack IP's:

Module	Slot-ID Value	Master Rack Example
L350-1 (Central Reference Generator)	128	10.80.100.128
L350-2 (Central Reference Generator)	129	10.80.100.129
L351-1 (Master Offset Generator)	130	10.80.100.130
L351-2 (Master Offset Generator)	131	10.80.100.131

Table 12: Monitor and Control (M&C) Group Master Rack IP's:

Module	Slot-ID Value	Master Rack Example
M351 (Timing Rack Monitor)	148	10.80.100.148
M352 (Weather Station)	149	10.80.100.149
M353 (Atmospheric Phase Interferometer)	150	10.80.100.150

Table 13: Systems Group Master Rack IP's:

Module	Slot-ID Value	Master Rack Example
P301-1 (Bin Power Supply)	228	10.80.100.228
P301-2 (Bin Power Supply)	229	10.80.100.229
P303-1 (Bin Power Supply)	230	10.80.100.230
P301-2 (Bin Power Supply)	231	10.80.100.231
P302-3 (Bin Power Supply)	232	10.80.100.232

5 Slot-ID Data Structure Definition

As stated before, each MIB will be connected to an external EEPROM for all modules except the D301 through D303, where the EEPROM will be internal. The D301 example discussed below is still yet to be determined so it is in italics. This includes its table as well. It will remain in italics until a final resolution is reached, which could involve an entire rewrite.

Starting at EEPROM Address 0x0000 is the network information. They are four bytes long each and in order they are: IP address for the MIB, the IP address of the Gateway (Switch), the IP address of the slave Domain Name Server (DNS), and the IP address of the master DNS.

For a D301 the first DNS's are for the EVLA site. Two additional sets of four bytes are included afterwards for a D301, which are: the IP address of the slave AOC DNS, and the IP address of the AOC master DNS. As stated earlier, once the D301 MIB has located itself, it will choose the proper DNS slave and Master to utilize.

At EEPROM Address 0x0100 is textual information for the slot itself. Each text string is terminated by a 0x00 byte. The textual information is the module name of the slot, the location of the slot, and finally the slot revision level. *For the D301, the Antenna Number will need to be filled in once the Antenna location has been determined.*

The following two tables give an example of the Data Structure for both an ACU and D301 at Antenna One.

Table 14: ACU Slot-ID Example

Address	**Data**
0x0000	0x0A, 0x50, 0x65, 0x80 (10.80.101.128) ACU IP
0x0004	0x0A, 0x50, 0x65, 0x01 (10.80.101.1) Antenna Gateway IP
0x0008	0x0A, 0x50, 0x01, 0x1F (10.80.1.31) Slave DNS IP
0x000C	0x92, 0x58, 0xC9, 0x08 (146.88.201.1) Master DNS IP
0x0010-0x00FF	N/A
0x0100	'ACU', 0x00
0x0104	'Antenna 1', 0x00
0x010E	'Revision: -', 0x00

Table 15: D301 Slot-ID Example

Address	***Data***
0x0000	*0x0A, 0x00, 0x00, 0x80 (10.00.00.128) D301 IP*
0x0004	*0x0A, 0x00, 0x00, 0x01 (10.00.00.1) Antenna Gateway IP*
0x0008	*0x0A, 0x50, 0x01, 0x1F (10.80.1.31) Slave DNS IP (EVLA)*
0x000C	*0x92, 0x58, 0xC9, 0x08 (146.88.201.1) Master DNS IP (EVLA)*
0x0010	*0x92, 0x58, 0x01, 0x0C (146.88.1.12) Slave DNS IP (AOC)*
0x0014	*0x92, 0x58, 0x01, 0x04 (146.88.1.4) Master DNS IP (AOC)*
0x0018-0x00FF	*N/A*
0x0100	*‘D301’, 0x00*
0x0105	*‘Antenna X’, 0x00*
0x010F	*‘Revision: -‘, 0x00*

6 Naming Convention

The naming convention is a method to avoid memorizing the raw IP addresses. One can certainly do so, and the system will be able to respond properly. However, a simple naming convention should be able to locate a particular module anywhere as easily as possible.

Figure 2: Naming Convention Breakdown shows the basic method needed to locate a particular module anywhere in our networking system. Once a match has been found then the Domain Name Server (DNS) will generate the entire name. In the above example, the full name would be: EA1-L301-1.evla.nrao.edu. Users can of course, type in the entire name if an exact match is important. Please note that the name will probably not be case sensitive.

The convention itself is a top-down system that simply locates the module somewhere on a network. The first letter chooses whether you desire the AOC or EVLA network. The next letters further locates the desired device to a place such as an antenna or test rack. After the dash, you then denote the module you want communicate with. If there are multiple modules installed in this location, you must follow with the unit number or with the IF channel letter.

All of the possible names have been stored on the DNS servers in tables, such that any refinements can be easily dealt with in the future.

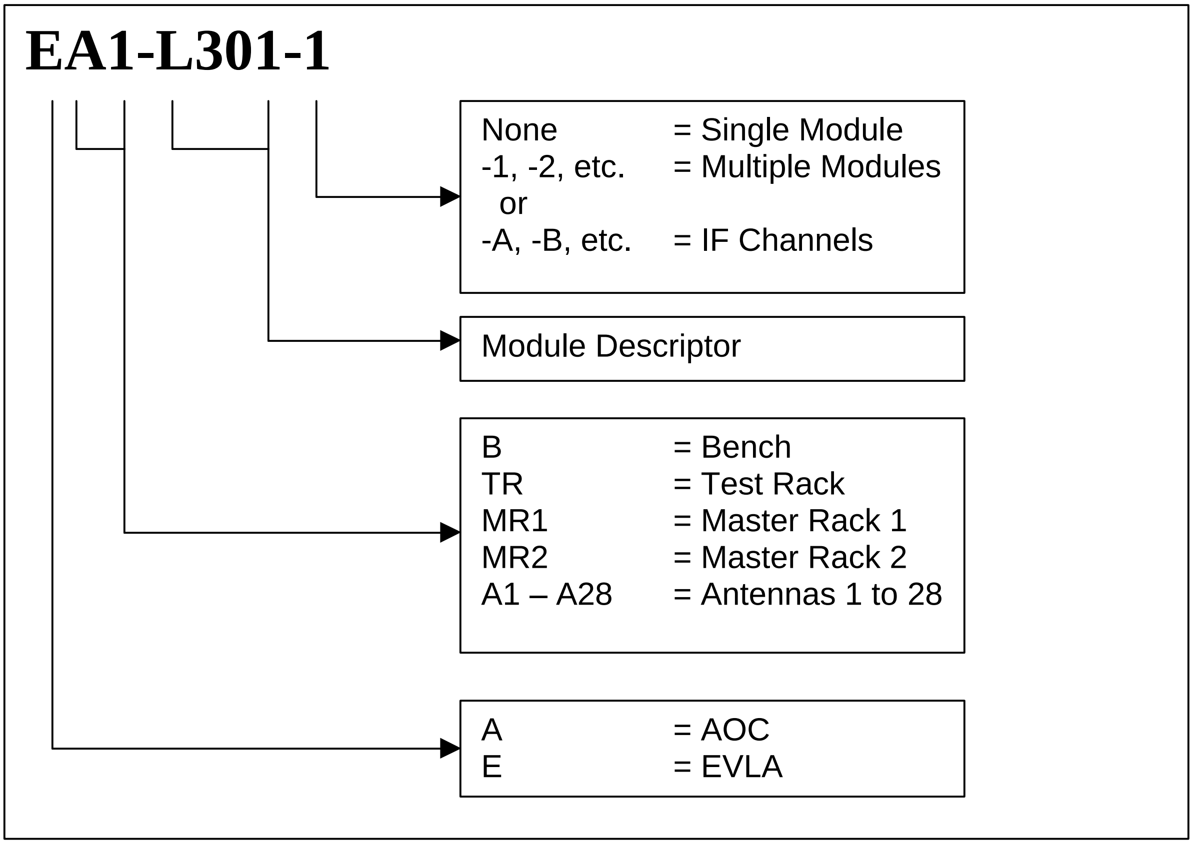

Figure 2: Naming Convention Breakdown