Communications & Power Industries
satcom division

EARTH STATION MONITOR AND CONTROL SYSTEMS GROW UP

The Next-Generation Interface to Earth Station Equipment: Ethernet

Over the last few decades, monitor and control interface in earth stations has changed drastically, evolving from hard-wired to minicomputers and then microcomputers. Now, the interface is undergoing another shift to the higher speed Ethernet. There are many advantages, as well as a few disadvantages, to using Ethernet as the communications interface for monitor and control systems, but overall the benefits far outweigh the shortcomings. To best understand the benefits of the interface, let's first look at the evolution of monitor and control systems in satellite earth stations.

1970s and earlier: Discrete Controls and Remote Panels

Up until the mid-to-late 1970s, the only way to control equipment was through a discrete interface. This interface used many individual wires to bring switch contacts and meter voltages out of the devices so that they could be monitored and controlled at a remote location, the control console. Each equipment manufacturer designed a remote panel for its equipment, and the control console would have a remote panel mounted in it for each device being controlled.

The advantages of this system were that on a small scale it was simple and it was all that was available. The disadvantages were numerous: it did not scale well because the remote panels consumed lots of room in the control console; it was sensitive to noise and RFI/EMI; and individual multi-conductor cables were required from each device to its remote panel, often resulting in literally thousands of wires and making troubleshooting very difficult.

1980s: Minicomputers

In the late 1970s until the mid-80s, minicomputers were becoming available at a reasonable price, enabling operators to address the issues related to discrete remotes. The minicomputer, typically a DEC MicroVAX, had a CRT display that could display the pertinent status of many devices at once, freeing up the control console of all those remote panels. The software running on the minicomputers was written specifically for each customer's requirement and configuration, but was not capable of being modified by the user without large amounts of training on writing code.

The minicomputer-based monitor and control systems also addressed the problem of too many cables. They used a multi-drop serial interface that allowed them to connect to multiple devices on a single serial port on the minicomputer. This significantly reduced the number of cables, but it also required that equipment manufacturers put microprocessor controllers in their equipment in order to be able to communicate over a serial bus. The initial minicomputer-based systems were single supplier, such as Scientific Atlanta's MicroVAX-based system.

The advantages of this system over the discrete interface were profound. The users did not have the space, wiring or troubleshooting issues they had before, and the multi-drop scheme used the expensive serial ports efficiently.

This system was not without disadvantages however. The serial port data rate was kept low due to the additive effect of the multiple serial ports on the bus, starting at 1.2 kbps and ending up at around 19.2 kbps. The large number of devices on each port (typically 8 to 16 but up to 32), coupled with the low data rates, caused a phenomenon called poll-wrap delay. Poll-wrap delay is caused by the controller polling each of the devices in turn. The device responds with a status message and then the controller moves on. For example, if each interrogation takes half a second and there are 32 devices, up to 16 seconds can elapse before the controller detects a problem. If the problem is transitory, the controller may never even know the problem existed. Termination of the serial line was very important and often misunderstood. A missing or incorrectly terminated line could slow data transmission speed as the reflections bounced back and forth, causing errors. A break in the line would interrupt communications to all of the devices "downstream" of the break, garbling the communications of the devices that were still connected and making troubleshooting difficult.

1990s: Personal Computers

As the PC revolution swept through the consumer market, computer capabilities drastically increased, fostering the creation of several dedicated monitor and control companies that drove the systems to new levels. The software became much more advanced and was generalized to the point where the user could customize the configuration to match the earth station's particular requirements.. Multi-drop serial communications were still used, but over the years a transition was made to a star topology, where each device had its own serial port on the PC. This demand for more and more serial ports on the PC drove the evolution of serial-port multiplexers, which allowed 4, 8, 16 and now 32 ports in the PC resource that was formerly used for one port. As the number of serial ports increased, responsiveness improved, and with port multiplexers the limit of one port per device was approached. Unfortunately, the actual interface from the serial multiplexer to the device still required a serial cable that had to be manufactured, tested and troubleshot for each device. Also, due to the serial port's relatively low data rate, it could take seconds for the response to a status request to be fed out the serial port to the controller.

2000s: Ethernet

As the PC's speed increased enormously, it became more capable of supporting much higher data rates than standard serial ports could. Along with the amazing improvements in processor speed, Ethernet has become ubiquitous. Ethernet is a computer-industry standard protocol that operates at 9,600,000 bits per second in its most common implementations (10 Base-T). The 10 Base-T implementation is typically connected in a star (or modified star) configuration. The use of hubs (to extend and split the signal) along with switches and routers (to segregate traffic) gives the user the ability to flexibly and economically use all of the 10 Mbps of the available bandwidth.

Ethernet is enormously faster than serial ports: 10 Megabits per second is 1,000 times faster than 9.6 kbps and 172 times faster than 56 kbps. The higher data rate means that the poll-wrap issues disappear. As devices become optimized for Ethernet they can even operate asynchronously. They can still respond to polls, but in the case of a time-sensitive event they can broadcast their state immediately. In addition to the speed advantage, a large number of devices can be connected to one port on the computer.

The advantages of the star architecture are combined with the ability to consolidate connections with inexpensive, readily available hubs, switches, routers and higher-speed aggregate connections at 100 Mbps (Fast Ethernet) and 1,000 Mbps (Gigabit Ethernet). Ethernet is also easy to troubleshoot, less sensitive to noise and EMI/RFI than serial communications and does not require special knowledge by the troubleshooter of the issues affecting serial communications busses.

The Future: CPI's Gen IV

CPI's newest klystron power amplifier, the Gen IV, has an Ethernet option that will be used to present the advanced features that an Ethernet bus provides. The Gen IV is the fourth generation in CPI's line of klystron power amplifiers (KPA). It was the first KPA to use multi-stage depressed-collector (MSDC) technology, substantially reducing prime power consumption and cooling requirements, and therefore minimizing the size and expense of the electrical, battery back-up and HVAC systems.

The Gen IV has an Ethernet option that offers the advanced features that the Ethernet protocol provides. CPI has implemented the standard Ethernet protocols that apply to earth station monitor and control systems and additional, more advanced features that take advantage of the protocol. The standard features are:

- Network Time Protocol (NTP), where all of the clocks in all of the KPAs are synchronized to a timeserver;
- File Transfer Protocol (FTP) Server, which allows the user to access the KPA's logs and upload new software revisions.

Some of the advanced, earth station specific, features are:

- Enhanced FTP functionality that allows a snapshot of the KPA to be saved and retrieved later. Because the Ethernet interface contains a virtual FTP file system, several snapshots can be stored at once. These snapshots contain all of the parameters of the KPA when each snapshot was taken, as well as the log file. After downloading the snapshot file, it can be viewed by the operator in a "Virtual KPA" on their computer. This virtual KPA will look exactly as the KPA looked when the snapshot was taken;
- Serial port "pass through" to allow non-Ethernet capable equipment located near the KPA to be controlled. Typically this is an up converter, but it could be any device, or a string of devices multi-dropped on the serial port;
- An Uplink Power Control (UPC) system that will replace stand-alone controllers that are used now. This removes the single point-of-failure from the UPC chain that improves availability. The UPC controller algorithm uses the industry standard formula for determining the uplink degradation and decreases the KPA's attenuator to compensate for it. In the CPI implementation of UPC, the beacon levels from up to two beacon receivers are broadcast on the Ethernet and received by all of the KPAs at once.

Because the Ethernet protocol is used on the Internet, a firewall must be used to isolate the LAN that the KPAs are on if there is a connection to the Internet. The firewall simply requires the standard configurations that the IS department understands well. The system needs to be protected just as any other of the company's key assets.

Conclusion

The high-speed Ethernet port, coupled with the advanced features and user interface of the CPI Gen IV, enables the earth station operator to more efficiently install and reconfigure cabling, using flexible, reliable and inexpensive computer-industry standard equipment. The addition of UPC, FTP, NTP, serial pass-through, log file downloads and configuration snapshots give the operator unprecedented power to control and monitor their KPAs.

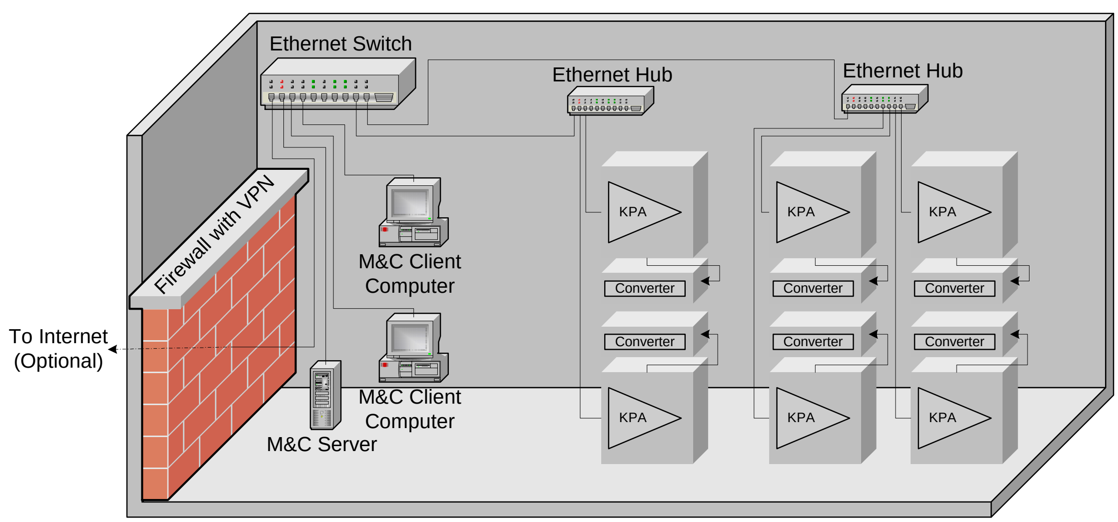

Figure 1 - Example of Ethernet Earth Station Wiring

Learn More

For more information on Ethernet: www.ethermanage.com/ethernet/ethernet.html

For more information on CPI’s klystron amplifiers:
www.cpii.com/satcom/products/index.html#type/klystron

For more information on CPI: www.cpii.com

About the Author

John Overstreet is VP of the Satcom Design Center for CPI, where all of CPI Satcom’s new and innovative products are designed. He has been in the Satcom industry since 1980. In 1982 he designed and built his first earth station: a 40-foot, C-band analog video transportable uplink. He then went on to build nine more transportables of diminishing size as well as the Houston International Teleport (HIT). John joined IDB Systems as VP of Engineering and later served as General Manager. IDB Systems is a systems integration company that designed and manufactured one of the first microcomputer-based monitor and control systems, the MACS-50. For more information, contact the author at john.overstreet@cpii.com.