LAN Cabling Design For The New BLS Building

Peter B. Stevens
Bureau of Labor Statistics
Washington, D.C. 20212

ABSTRACT

The third generation of the Cabling Architecture for the BLS LAN in its new building is described. For each architectural element the design is described and the major alternatives are identified, and for each alternative the major trade-offs are identified. The application of this architecture to the Bureau's Regional Offices is discussed.

Introduction

The Bureau of Labor Statistics (BLS) compiles and publishes national economic statistics in the areas of employment, unemployment, wages, prices, economic growth, and productivity. Its well-known products include the monthly Unemployment Rate, the Consumer Price Index, and the Producer Price Index. The Bureau has used machines for statistical data processing for more than seventy-five years. The majority of its production systems run on large mainframe computers, and its first Ethernet LAN was installed in 1982.

Currently the Bureau has about 1,300 PC workstations connected to Ethernet LANs in Washington, D.C. and in its eight Regional Offices. Leased telephone lines connect all of the LANs together. Several hundred more PCs are on order and the end is nowhere in sight. The original LAN used first-generation Ethernet cabling techniques: Thick Ethernet cable, transceivers, and drop cables. When the growth of the number of PCs made this approach impractical, second generation cabling techniques were introduced. The Thick Ethernet was made into a Backbone and the PCs were connected to Thin Ethernet cable segments which were coupled to the Backbone by Repeaters.

This approach allowed the very rapid growth in the number of connections to be accommodated, but reliability and maintainability left something to be desired. Faults on any segment still frequently impacted an entire building, and some cable-related problems remain very difficult to locate. This paper describes the third-generation approach to Ethernet LAN cabling that is now being developed in conjunction with the planning for the Bureau's move to a new building in Washington.

Policy Background

The most important policy objective is to achieve a highly reliable LAN operation. To reach this objective the cabling must be as robust as possible to reduce cable faults to the minimum and to allow faults in the cable or in any attached equipment to be quickly identified and located from a LAN Control Center. Further, it must be possible to isolate any fault immediately so that the failure of one or more PCs cannot bring down the entire LAN. Additional policy objectives are to support the constant reconfiguration of the LAN by adding or moving equipment and to be able to collect statistics about all aspects of LAN performance.

Cabling Architecture Overview

The cabling architecture consists of the following three elements: the Central Backbone Segment, a number of Primary Distribution Segments, and a much larger number of Secondary Distribution Segments. The Name Service and other centralized LAN resources are connected to the Central Backbone Segment. One end of each Primary Distribution Segment (PDS) is coupled to the Backbone by a (MAC-level) Bridge, and the other end is connected to one or more multi-port repeaters. For this analysis the assumed multi-port repeater is the Cabletron Systems Multi-Media Access Center (MMAC). The MMAC supports all of the cable media alternatives and has the required network management functions. Similar devices from other manufacturers will probably become available in the not-too-distant future.

A MMAC can be configured to support between 12 and 84 Secondary Distribution Segments (SDS). Each SDS can support the connection of from 1 to 99 computers depending on the media used. Each of the
Bureau's PCs and Distributed LAN Servers will be connected to a SDS. Each such computer will be able to communicate with any other BLS computer by means of the Ethernet LAN.

**Ethernet Cabling Media**

There are five major alternatives in the selection of the cabling media for an Ethernet LAN. They all support the 10 MB transmission rate and function electronically as a bus, i.e. every station on a segment receives every packet. Standard Ethernet coaxial cable (Thick Ethernet) is the original Ethernet cable and can be used in lengths of up to 500 meters (1,640 feet, IEEE specification) or 1,000 meters (3,280 feet if only 3Com transceivers are used). It is very thick and stiff which causes enough installation and maintenance problems to make its use very doubtful. Thin Ethernet (RG-58 coaxial cable) was originally introduced by 3Com and is smaller, more flexible, and easier to install than is Thick Ethernet. It is the least expensive of all the cabling alternatives. The maximum segment length is less: 185 meters (607 feet, IEEE) or 305 meters (1,000 feet, 3Com). For both types of coaxial cable the maximum number of stations that can attached to a segment is 100. Fiber Optic Cable is the third alternative. No IEEE standard exists for such cable but reasonable de facto standards do exist. Much longer segment lengths are possible with 3,000 meters (9,843 feet) being a reasonable maximum length.

The last two alternatives use Unshielded Twisted Pair wire: bi-directional signaling (TP-1) which requires 1 pair, and uni-directional signaling (TP-2) which requires 2 pairs. The TP-1 approach was developed by and is being advocated by DEC and 3Com. It has been certified by the IEEE 10Base2 group as conforming to the Thin Ethernet standard. The TP-1 approach uses one twisted pair with baluns to link a multi-port repeater to a Thin Ethernet segment to which the computers are attached. The maximum total length is a function of the combined twisted pair/coax cable lengths with a maximum twisted pair length of 76 meters (250 feet) allowing about 60 meters (200 feet) of coax cable. The TP-2 approach is represented by SymOptics Communications' LattisNet which is being used by the Department of Labor for the Frances Perkins Building. LattisNet uses 2 twisted pairs with a maximum length of 110 meters (360 feet) and a twisted-pair transceiver to connect each computer directly to a concentrator in a wire closet. The concentrators are similar in function to a multi-port repeater. No IEEE standard exists for TP-2 wiring, but the 10BaseT Working Group has developed a draft standard for connections up to 100 meters (328 feet) long. The draft standard is different from LattisNet and from every other currently-marketed TP-2 product. To date obtaining objective and reliable technical information that compares the TP-1 and TP-2 approaches has been very difficult.

Each of the cabling approaches has its advantages and limitations which are best discussed in the context of a specific application. The following sections describe the three architectural elements and discuss the trade-offs applicable to each.

**Central Backbone Segment**

The Central Backbone Segment is critical in that it contains resources, such as the Name Service, which are essential to the proper operation of the LAN. It can be made very robust relatively easily because the entire segment can be confined to a single room and because adding or removing devices will be infrequent. This room will be named the LAN Control Center because all of the network management functions will be performed here. In addition to the central servers, the LAN management PCs and PDS Bridges will be connected. From the LAN Control Center it will be possible to check the status of any Primary or Secondary Distribution Segment, to identify the source of a network disturbance, and to reconnect the damaged segment from the rest of the LAN. The network management PCs will monitor the status of the Bridges and MMACs, collect network statistics, and respond to alarms generated by unusual network conditions.

There are no significant alternatives in how this segment is wired. Any Ethernet media could be used, but Thin Ethernet cable appears the best choice without any significant trade-offs. The most robust way to cable this segment would be to use a PVC duct system to completely enclose the cable along with AMP Thinnet Tap System Connectors in outlet boxes and AMP Drop Cable Assemblies for machine connections. This connection system is also marketed by DEC. Access to the LAN Control Center room should be strictly controlled and limited to trained personnel in order (hopefully) to eliminate accidental damage to the Backbone Segment. Spare cabling parts should be kept on hand to allow immediate repair should the unlikely actually occur.

**Primary Distribution Segments**

A Primary Distribution Segment (PDS) has the sole function of connecting the Backbone to one or more MMACs via a (MAC-level) Bridge. The PDS cable will be routed to the MMACs through risers and via conduit from wire closet to wire closet. Connections will be made to these segments only in wire closets so
access to them at other points is not required. The
cable itself should never fail unless it is mechanically
damaged by building-maintenance operations unre-
related to the LAN. The planned conduit runs between
wire closets are essential to PDS reliability. The
Bureau's experience to date is that cable laid on top of
ceiling panels has been damaged frequently enough to
adversely impact the reliability of the LAN as a whole.
In the new building the LAN monitoring fa-
cilities already described will allow a damaged PDS to
be quickly disconnected from the rest of the LAN, but
locating and repairing the damage to the PDS cable
could still be a difficult process.

The mean time to repair for the PDSs could be sub-
stantially improved by having two cables to each MMAC with the second cable being for back-up. The
MMAC unit supports automatic switching to a back-
up segment, but there are some technical questions
that need to be resolved about how to configure the Bridges. Even manual switching at the Bridge to the
back-up cable would still greatly reduce the repair
time for a PDS. The trade off is between doubling the
costs for the PDS wiring against reducing the mean
time to repair a PDS by at least an order of
magnitude.

Secondary Distribution Segments

A Secondary Distribution Segment (SDS) is used to
connect the vast majority of the Bureau's PCs and
servers to the LAN. There will be a large number of
these segments: at least 10 and possibly as many as
200 for each PDS. There should be an outlet box for
each workstation, office, and other place where a
computer may be placed. The cable should be in-
stalled in the floor, ceiling, and/or walls so that unpro-
tected surface wiring is never used. The objective is
to have a LAN connection point at each place where a
computer may ever need to be connected to the LAN.

The three best candidates for this application are
Thin Ethernet and the two twisted-pair-wiring
approaches. Thick Ethernet is too inflexible and does
not support high-density applications well because of
its requirement for an 8-foot spacing between
transceivers. Fiber Optic cable is possible, but
installation would be relatively difficult and the costs
would be much higher than the preferred alterna-
tives. The additional costs are mostly for the elec-
tronics and connectors. If these costs should decline
in the future, this alternative will need to be reconsid-
ered. The most promising new development is
plastic optical cable.

The choice between the three remaining alternatives
is more difficult. To ensure that comparisons between
these technologies is fair and reasonable, the concept
of the Segment Load Factor (SLF) needs to be intro-
duced. The SLF equals the number of computers that
are serviced by a port on a bridge or repeater. For
network management purposes a port is the smallest
addressable unit, so the SLF at each level defines the
number of computers that are switched into or out of
the LAN for installation or maintenance work. For a
Secondary Distribution Segment the SLF is the num-
ber of machines serviced by a port on a MMAC. For a
Primary Distribution Segment the SLF is the sum of
the load factors for each port on the MMAC(s) that it
services (or the average SLF times the number of
ports).

The selection of the SLF is the most important trade-
off decision in the entire LAN design. Higher SLFs
reduce the initial cost because each port services mul-
tiple devices, but more people's work will be disrupted
when a segment goes down. Lower SLFs raise the
initial cost, but the LAN will be perceived to be more
reliable and the time necessary to locate a network
fault will be reduced as the SLF is lowered. When the
SLF for the Secondary Distribution Segments equals
1, the status of each device on the LAN can be
monitored from the LAN Control Center.

It is possible to have a SLF of 1 with Thin Ethernet
wiring, but the space required for a large number of
thin segments to enter a wire closet might be too large
to be manageable. A SLF in the range of 2 to 8 would
lower the MMAC and cabling costs dramatically, but
would still provide substantial improvements in the
reliability of the LAN when compared to our present
situation. Using one SDS for each continuous unit of
systems furniture would simplify the wiring and
would probably not hurt reliability. The need to reconfigure the cable from the wiring closet to the systems furniture should be infrequent, and adding or moving a small number of machines would not even require access to the wire closet.

TP-1 and TP-2 wiring can be used with SFLs between 1 and 10. With both approaches the possible congestion in the wiring closets is reduced, but costs are increased. Using TP-2 wiring with an SFL of 1 will be five times as expensive as using Thin Ethernet with an SFL of 4. The most important technical questions deal with the ability of either the TP-1 or TP-2 wiring approaches to carry the Ethernet signal in a fully satisfactory manner. Whether or not there are technical advantages to either approach is a matter of some controversy. Advertising and anecdotal claims are common, but unbiased technical information is very hard to find.

TP-1 is less expensive than TP-2 because it uses baluns rather than a transceiver. The TP-2 twisted pair approach has the advantage of being the LAN wiring approach favored by the Department of Labor, but it lacks an approved IEEE standard and is even more expensive than is the TP-1 approach. Products that conform to the draft IEEE standard can be expected within the next six months, but currently-available products do not conform. SynOptics is the major supplier of TP-2 technology, and their technical product information is significantly more cautious than is their advertising literature.

**Regional Office Considerations**

The Bureau's Regional Offices are small enough so that single MMAC will probably be sufficient for their needs. The New York Regional Office has already been wired using the Thin Ethernet approach with a earlier version of the Cabletron multi-port repeater, and the maintenance experience of that installation has been quite good. The cable maintenance situation of each Regional Office is unique, and a single cabling approach may not be practical for all Regions.