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ABSTRACT

This report describes the technical details and rationale behind the decisions in the design and development of the communications network installed as part of a 1991-1993 district-wide construction project in the West Ottawa Public Schools (Michigan). The project called for development of a communications network to carry voice, data, and video services to enhance instruction, improve learning, foster active involvement of students and staff, and improve communication between everyone involved in the educational process. The first section of the report summarizes the assumptions established to guide the decision-making process throughout the project; areas addressed by these assumptions include funding, quality, availability of services, standardization, and staffing. The second section describes network design and implementation, including the fiber optic network, building communication cable plant, computer network, video network, telephone system, and power systems. Several diagrams illustrate the document. (TMK)

Communication Network Design
West Ottawa School District

April 1993

David deS. Couch

I. Introduction

There have been many innovative technology projects in the West Ottawa Public Schools over the years and there will be many more in the future. This document describes the technical details and rationale behind the decisions in the design and development of the communications network installed as a part of the '91-'93 district-wide construction project.

Since the network was created, many people have visited West Ottawa to look at how these technologies have been applied to the educational and administrative process. During these visits there are always many questions: Who designed it, who installed it, who supports it? How does it work? Why did you choose one type of technological solution over another? This document will focus on a technical description of the network environments and an explanation of the logic behind the system.

II. Situation and Assumptions

The West Ottawa School District passed a major bond issue in September 1990 which included substantial funding for technology. In the spring of 1991 the district developed a Strategic Plan for Technology. A key part of that plan called for the development of a communication network to carry voice, data and video services to enhance instruction, improve learning, foster active involvement of students and staff, and improve communication between everyone involved in the educational process. This document describes the design and implementation of the network defined in that plan. The implementation of this network began in the spring of 1991 and will be completed by the end of the summer in 1993. The network implementation where possible has been completed in conjunction with the building construction funded by the same 1990 bond issue.

As the plans for the network design, installation and ongoing support were developed the following key assumptions or guidelines were established to guide the decision making process throughout the project:

1. With the educational funding situation in Michigan, the funding realities at West Ottawa and the September 1990 bond issue, funds exist now but there is no guarantee of funding in the future. So the system must be designed such that investments now will minimize the operating and support costs in the future.

2. Quality is of paramount importance. Considering the first assumption and the longevity of the investment, all decision criteria must have quality at the top list. All decisions regarding technology alternatives, selection of suppliers or manufacturers, and contractor workmanship were evaluated not only on cost, but on all aspects of the quality of the result.

3. All communication services should be equally available. Regardless of the size or location of a school, all services and functionality will be provided in every building and every classroom.

4. Leverage facilities through use of one system for both the educational and administrative functions.

5. Standardize on the same technological solutions in all buildings throughout the district.

6. The goal is to support the educational process and not deploy technology for the technology's sake.

7. Define and establish the staffing and funding for support, maintenance and evolution of the network, long term.

III. Network Design and Implementation

1. West Ottawa School District fiber optic network

One of the key parts of the communication strategy at West Ottawa is the ability to connect the various building networks together to form a district wide communication facility. This facilitates the sharing of information and resources, once available, to all buildings in the district. It also eases the process of general communication between all people in the district.

There are a number of ways to provide this functionality that are a function of the geography of the district, level of functionality desired, cost and offerings of the communication carriers in the area. As can be seen in Figure 1 the buildings are in a relatively small geographical area.

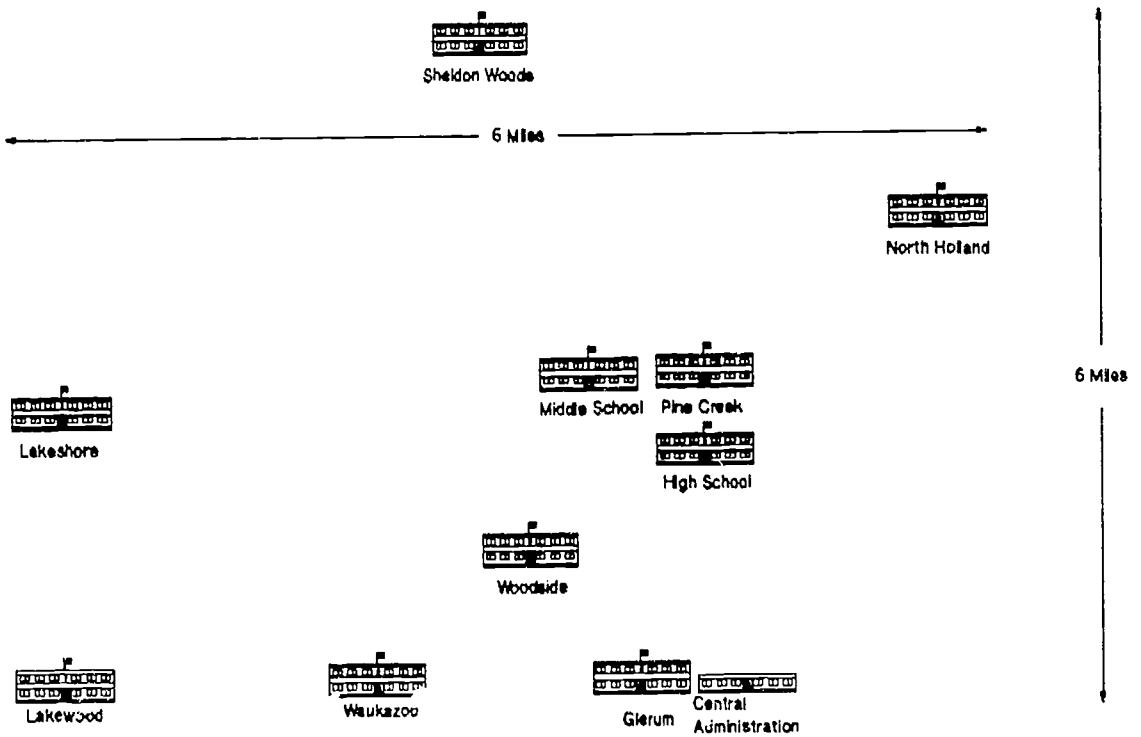

Figure 1

Prior to this project, the district's existing operating cost for communications was very low, so developing a network based on ongoing monthly service would have a significant impact on operating costs. At the time Michigan Bell Telephone's offerings for high performance video and data communication were very limited and very costly. Therefore we pursued the idea of having a private fiber optic network built for West Ottawa Schools. We developed a set of specifications and put the network out for bid. City Signal of Grand Rapids was awarded the contract.

City Signal built the fiber network largely above ground on existing power poles. While installing a fiber system that is all underground is desirable, it costs about three times more than one that is above ground. The West Ottawa area is served by two power companies, 90% is served by Consumers Power and the remaining 10% is served by Holland Board of Public Works. City Signal had to negotiate for the rights to use power poles from both organizations. Holland Board of Public Works was extremely uncooperative and would not grant City Signal or West Ottawa access to their poles. For this reason the routes taken by the network (see Figure 2) are more complex than needed and this added several miles and 10% to the cost of the project.

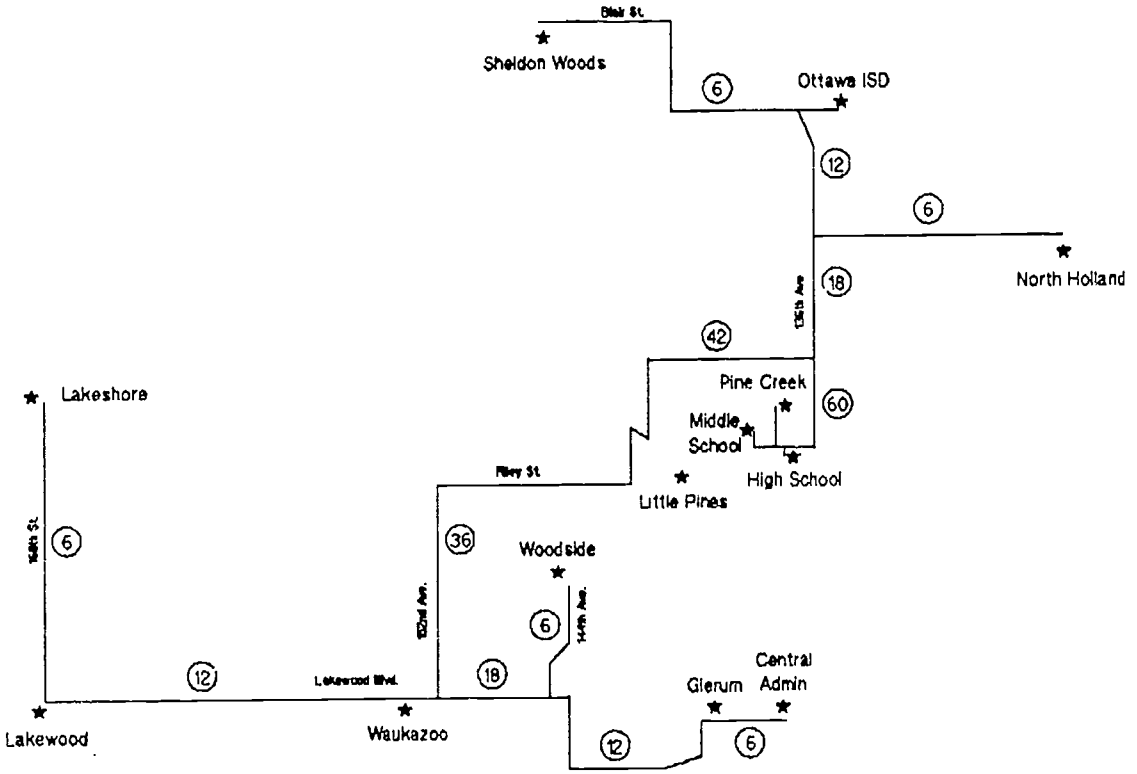

Figure 2

As we were developing our plans, the Ottawa County Intermediate School District was developing plans for a network between all of the school districts in the county. The Ottawa ISD facility and the Careerline Technical center are located on the north east corner of the West Ottawa Public School District geographic area and could easily be added to our network. City Signal negotiated with the Ottawa ISD and included their facility in our district network. The fiber optic communications network consists of running six single mode fibers from every building in the district to a central communications center in the high school. In Figure 2 the number in the circles represent

the number of fibers in the cable at each point in the network.

One of the many advantages of a fiber-based system is that while fiber technology itself is well established, the electronics will continue to improve in both capacity and capability. In the future as new needs come about or new capacity is required only the electronics need to be changed and the existing fiber can support new capabilities. Of the six fibers that we run to each building, two are used to support video communications, two are used for voice and data communications and two are spare (see figure 3).

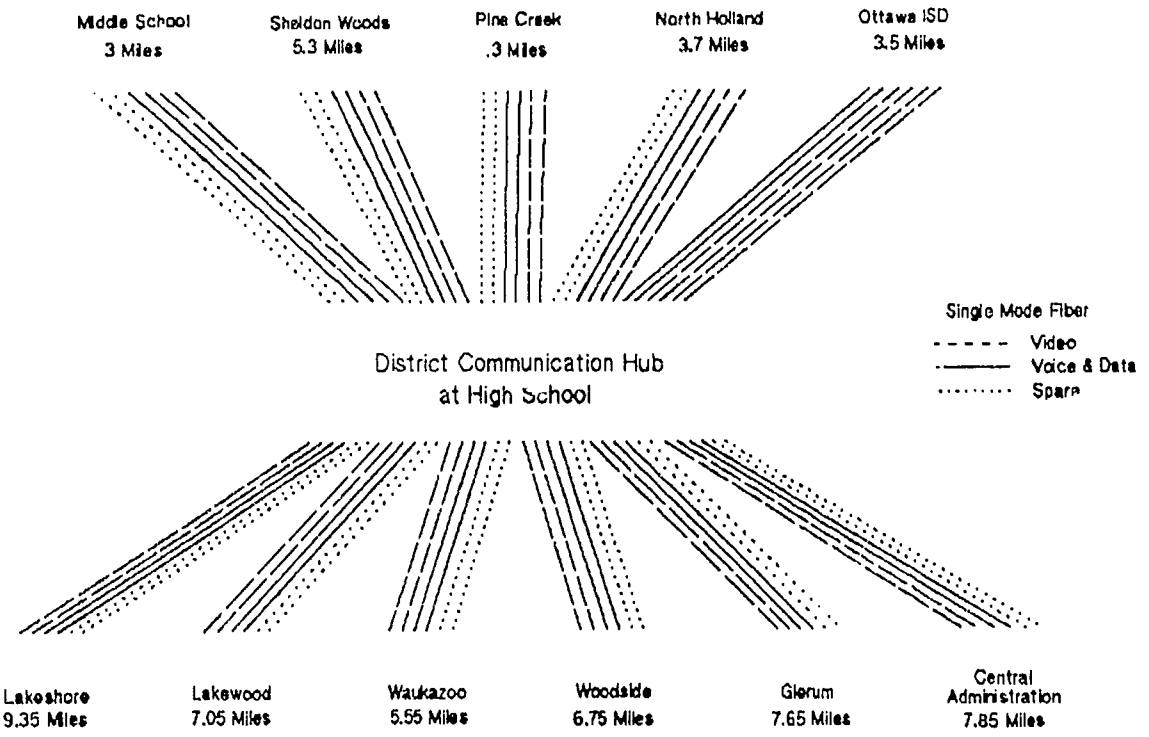

Figure 3

There are two multi-building campuses within West Ottawa Public Schools. On these campuses we installed multi-mode fiber cable (in addition to the single mode fiber) between buildings for future use. The first and largest campus contains the high school, middle school and Pine Creek elementary. On this campus we ran twelve stands of multi-mode fibers from the middle school and Pine Creek to the district communications hub in the high school. These fibers have been used at various times for low cost fiber twinax extenders for direct connect terminals to the AS/400 in the high school. On the campus that has central administration and Glerum elementary we ran 12 strands of multi-mode fiber and 100 pair copper cable for possible future use.

To provide voice and data communications on the district network we used Fibermux Magnum 100 fiber optic multiplexors. The multiplexors carry T1 voice connections between each building and the district communications hub and a backbone local area

network between each building. The multiplexors drive the fiber backbone ring at 100 Mbps using a proprietary scheme. We chose not to use FDDI based multiplexors because of the significantly higher cost at the time we purchased the equipment. Using the multiplexors and a pair of fibers to each building, we built the district voice and data transport on two very large rings (see Figures 4 and 5).

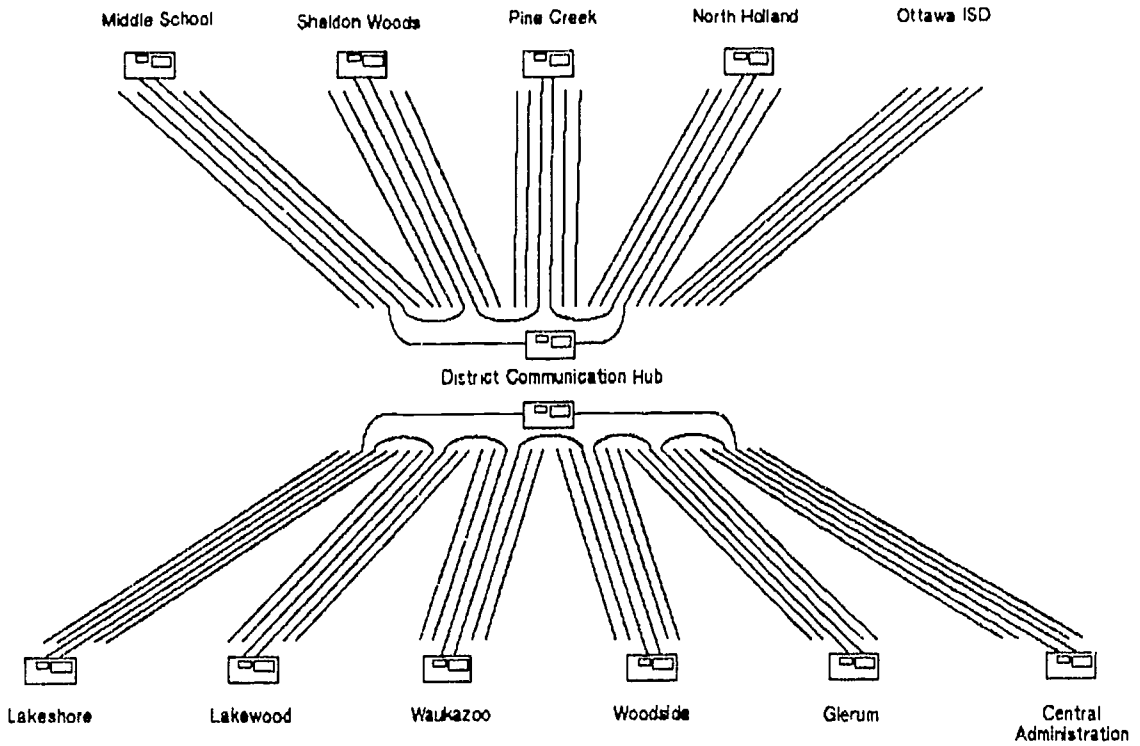

Figure 4

Video connections are a relatively simple analog two-way video and audio connection between each building and the district hub. This connection while simple, is very powerful and cost effective. As we develop our usage, individual buildings can be upgraded to more expensive multi-channel equipment as the traffic dictates. Again the fiber does not change. More detail on the voice, data and video networks will be discussed in the respective sections.

The district fiber network was purchased from City Signal for a single one time payment. They provide ongoing support and maintenance for the electronics, and all fiber cable. Based on City Signal's experience with fiber cable systems and electronic maintenance they suggest maintenance on a time and materials basis. They use Fibermux's Light Watch network monitoring system to monitor the Magnum 100 multiplexors and associated fiber cable. City Signal provides this service with the same response time and performance specifications as standard maintenance contracts in the commercial environment.

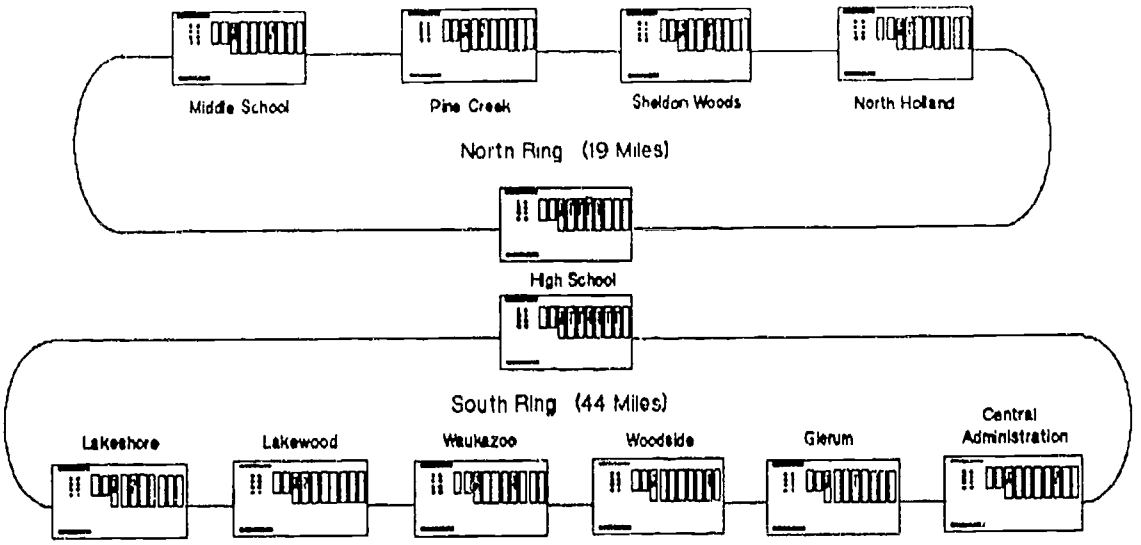

Figure 5

2. Building communication cable plant

The communication project was done in conjunction with extensive construction projects for virtually every building in the district. As part of each of the construction projects, architectural plans were developed or modified to have standardized raceways of cable tray in the halls, conduits to each room and/or wiremold in each room installed to facilitate installation, maintenance and evolution of the communications cable plant.

The plan called for every building to have standardized communications wiring installed to support current and future network needs. The building cable plant was designed with the following in mind: 1) In cable installation the single largest cost is typically the labor component; 2) It was unlikely that West Ottawa would again undertake major construction in virtually every building; 3) The district will most likely never have a staff of communication cabling technicians, so select cable types conservatively to minimize ongoing maintenance. In summary, cabling was selected so that it would only have to be done once.

The issue of communication outlet location standardization is very difficult to establish building wide and district wide. The follow describes generally what the district chose. It was not followed in all cases depending on room configuration, existing conduits, outlets etc. A video outlet for the TV, was placed in the front of the classroom to one side of the chalk board, if present. A second video outlet, for video origination or computer interface was placed in the center of the front wall of the classroom under the chalk board. The data outlet, fiber connection, and telephone outlet was placed on the opposite side of the same wall from the TV. An addition telephone wall outlet was placed near the classroom door.

For voice connections two four-pair unshielded twisted pair cables were run to each classroom, one to the wall outlet and one to the outlet with the data outlet. For video a traditional broadband CATV bus type cabling system was installed with drops to the various outlets.

As will be discussed in the data network section, 16 Mbps token ring technology was chosen for the computer network. Products for 16 Mbps token ring on unshielded twisted pair were just starting to hit the market. Most products had problems and they did not support some of the lobe lengths that we had in many of the buildings. So type I data cable was installed with active hubs for lobe lengths, future management and evolution.

In the high school existing phone cable was used, an existing video cable system was modified and used. With no major construction scheduled and the size of the facility we chose to use fiber optics to cable the data network in the high school. In all other buildings four unused strands of fiber optic cable were installed to each room. There are a number of vendors promoting the use of video and data on fiber in all situations. Our analysis indicated that it was not cost effective at time, so we installed 4 strands, terminating two in each room for future use. We used fiber internally in the buildings to connect wiring hubs in the larger and more complex structures. All fiber terminations used ST type connectors.

3. District computer network

To maximize the availability of educational materials and access to the district's current computer systems, a district wide computer network was built. There are a number of different computer networking technologies available. However, the district has made a sizable investment and commitment to IBM computer technology. Based on speed requirements, ease of maintenance, and the direction in the district towards IBM, 16 Mbps token ring local area network technology was installed through out the district. Each building has a token ring with all computers in the building attached to the network (see Figure 6). In the two larger buildings, the high school and the middle school there are multiple rings bridged together.

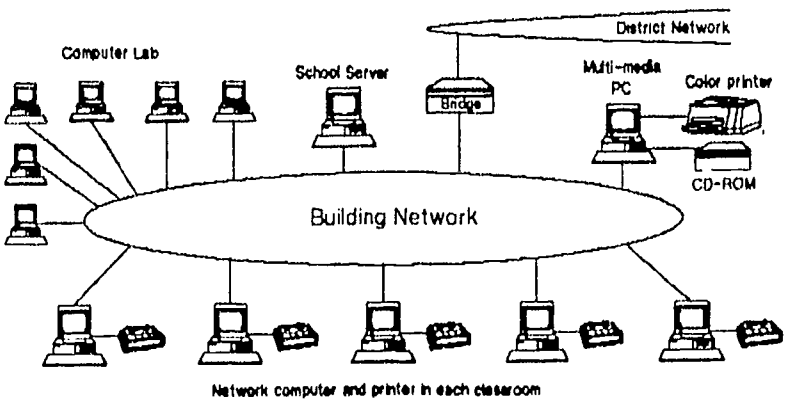

Figure 6

Through the district fiber system, two 16 Mbps backbone rings connect all buildings. These rings are connected with the high school and middle school to a district backbone ring. Through these connections any computer in the district can communicate with any other computer in the district based on need (see Figure 7). The rings are connected using IBM source routing bridges. The physical network is monitored and managed using the IBM LAN Network Manager product.

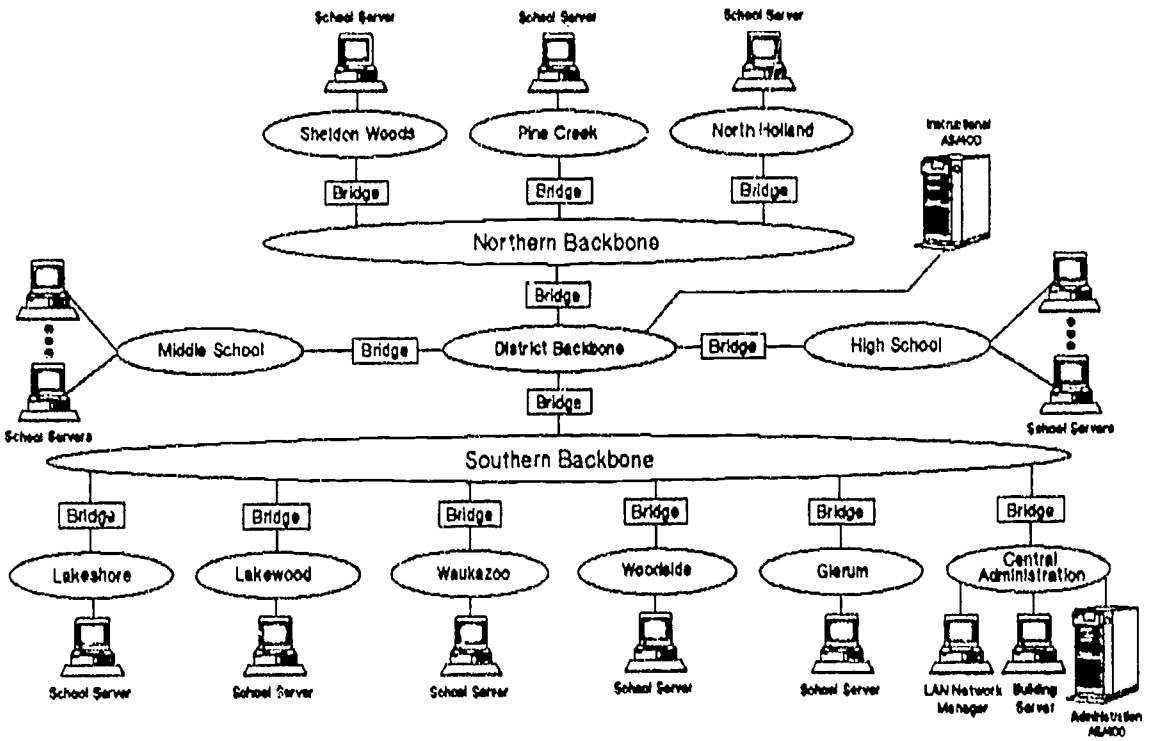

Figure 7

In each building every staffed classroom has a PC attached to the network and a printer. Each elementary school has a Novell file server, a computer lab with about 15 computers and shared printers, and a multi-media PC with CD-ROM drive. In the high school and middle school there are multiple computer labs and multiple multimedia PCs. The high school and middle school have four Novell file servers each and a CD-ROM server with seven CD-ROM drives each. All administrative PCs are also attached to the network. When the network is completed in the summer of 1993 there will be over 600 PCs attached to the network.

Multiple logical networks are carried on this physical network of rings. The district's has two IBM AS/400s that support the district's administrative applications and several educational applications. Any PC attached to the district network can communicate with the district's two AS/400s using the PC Support 400 software and the appropriate ID and password. The PC-based logical network is driven using Novell file servers and CD-ROM servers. The Novell file servers run the IBM ICLAS software for managing student

access and tracking progress with the many educational software packages.

There are plans to add external connections to the data network in the future (see figure 8). The first project is to provide for dial-in access from home for students and parents to access the services available on the network. The other major project is to connect the West Ottawa network to the Internet network. With the high performance nature of the district network, as new systems and services become available, by attaching them to the district network their services can be made available to any device in any building on the network. Basically one network connection provides access to all services.

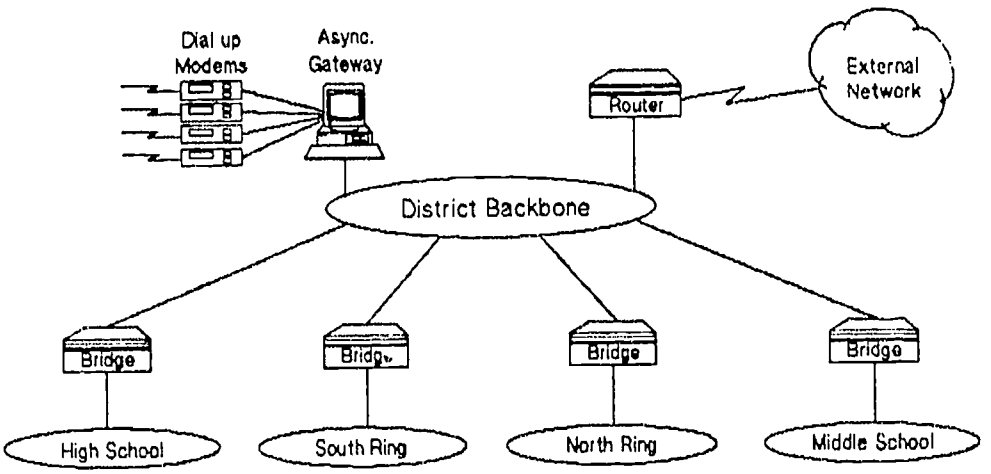

Figure 8

4. District video network

To maximize the district's ability to distribute video information sources within the schools and across the district, a district wide video network was built. Within each school a distribution system was installed to support broadcasting video information from at least six sources located in the media center (see Figure 9). The network is based on Cable TV (CATV) technology to each room. Each room has a TV and VCR that support the building network connection and an in-room video source connection. Carried on each in-building cable is the CATV system in the area (all buildings have C-TEC CATV except North Holland and Sheldon Woods). Then six channels are blocked and replaced with the following:

1. Channel 4 carries the video signal from the district hub (discussion of district network follows).
2. Channel 16 and 17 carry video from two remote controlled VCRs in the building hub.
3. Channels 30 and 32 are available for additional sources in each building's hub.
4. Channel 14 is an in-building broadcast channel.

Using a sub-channel return system each building can attach a video camera or other video source to any outlet in the building. That video signal will be broadcast on the building network on Channel 14 and will also be sent to the district video hub.

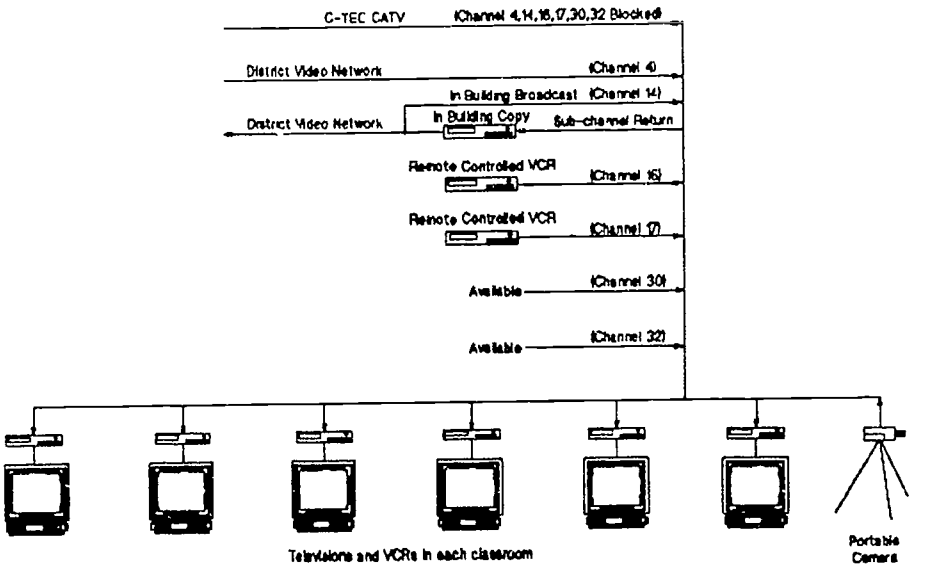

Figure 9

The district video network connects each building with a two-way video and audio signal to a central video routing switch at the high school video hub. At the central video routing switch, signals can be routed from one building to as many others as are required. Additionally, signals from other sources can be transmitted to any number of schools in the district (see Figure 10).

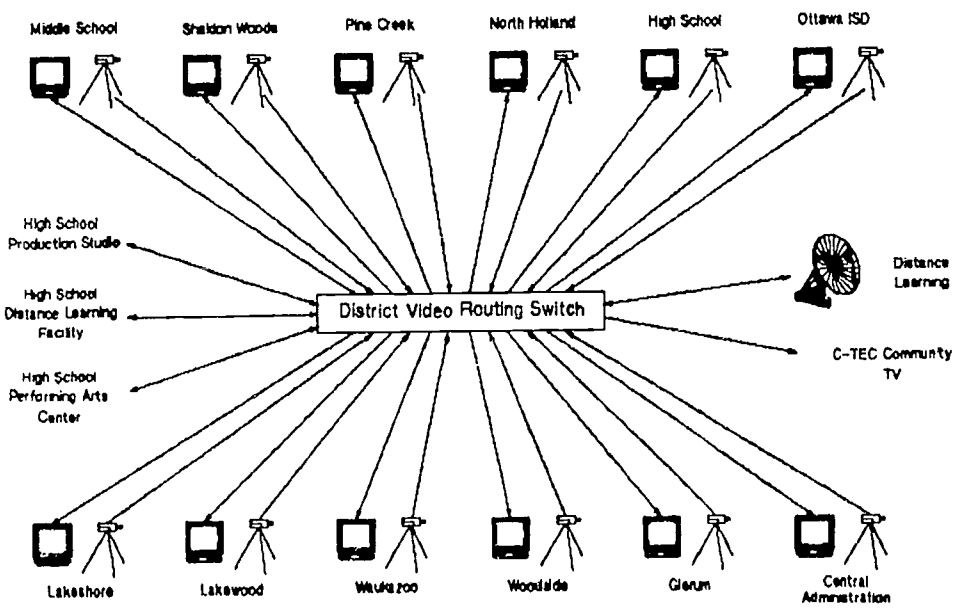

Figure 10

At the high school video hub there are connections to the district production studio, satellite down link, Ottawa ISD, the performing arts center, VCRs and other outside sources as they are added. Additionally there is a connection to C-TEC cable TV system so West Ottawa Public Schools can broadcast on a dedicated channel to the community. This dedicated channel connection is awaiting a planned expansion of C-TEC cable system.

Video distribution systems have been the center of a great deal of vendor attention in the last few years. There are a couple of vendors that promote high cost central video distribution systems that allow remote control of large banks of video sources and transmit the video signal to the classroom on fiber optic cable. These systems require someone to manage and control the scheduling of the central bank of sources. West Ottawa looked at these systems and chose not to pursue them. We chose not to pursue them because of administrative support costs, overall system costs and our belief that video in the future will migrate to the digital environment and merge with data network.

5. District phone system

To make communications efficient, cost effective and easy to use, a single standardized phone system was installed district wide. Each building has a full function Northern Telecom Meridian 1 Option 11 PBX (see Figure 11). The vast majority of the phones are digital to provide simple button access to the various PBX features. Display phones are used in most administrative areas. The PBX is connected to the building paging system to allow paging from any phone in the building. On all but the high school system the paging system supports access to individual rooms for two way conversation.

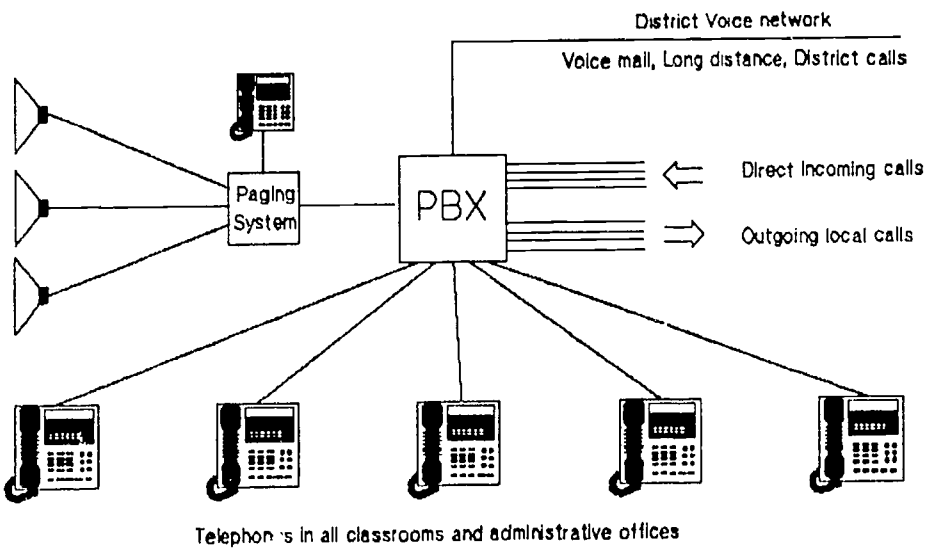

Figure 11

Using the T1 network connections over the district fiber network, all Option 11s are connected to a central Northern Telecom Meridian 1 Option 71 PBX and share a common Northern Telecom Meridian Mail voice mail system. The Option 71 and Meridian Mail system are located in the district communication hub in the high school (see Figure 12). All calls between schools travel across this private network eliminating local calling charges from Michigan Bell. Long distance calling is consolidated at the central PBX and use special Feature Group A circuits to reduce the cost of long distance calls in the 616 area code.

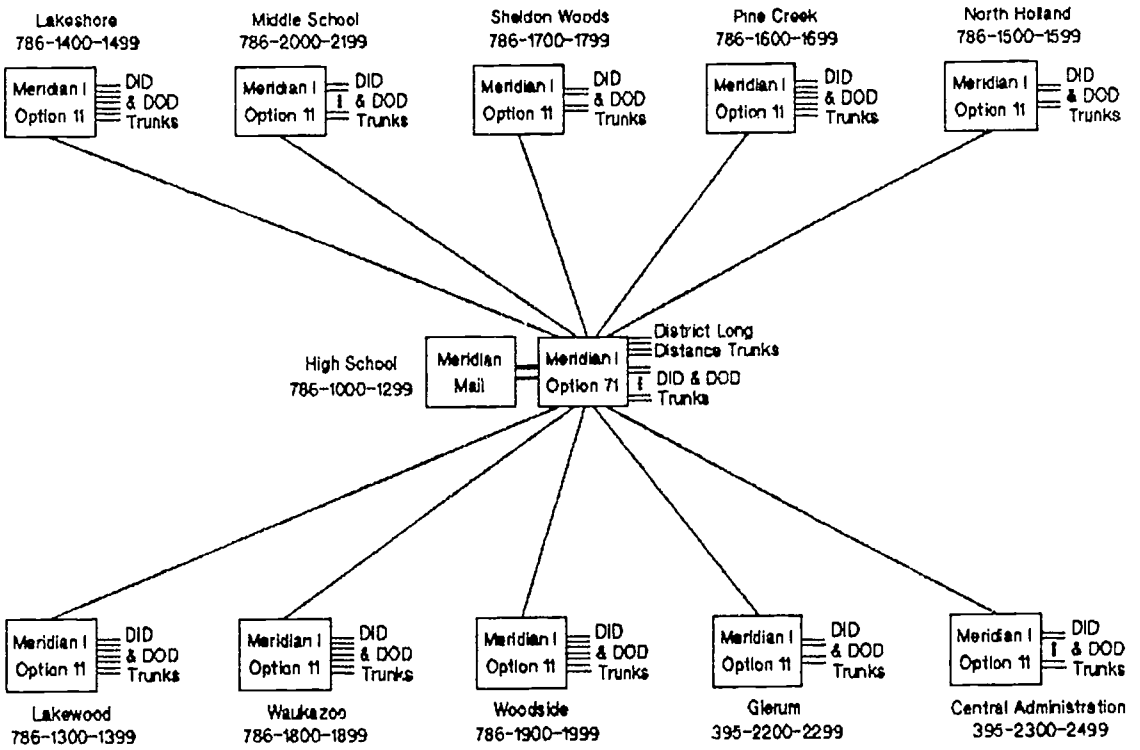

Figure 12

All phones support local, credit card, and 800 number calling 24 hours a day. Long distance calling is controlled through the use of access codes on all PBXs. Those district employees who are permitted long distance calling are assigned an access code for use when placing long distance calls. There is a call detail recording system on the central district PBX to track long distance calling and for cost allocation by building.

Direct inward dialling is supported on all PBXs so that any phone can be reached by direct dialing from the outside. There is a common numbering plan so that all phones have a unique four digit number for internal dialing. There are standards for certain phones such that the last two digits of a number are the same for all media centers, FAX machines, principles etc. Using this scheme the first two digits of a number indicate which school and the second two digits represent a phone in the school.

Voice mail is provided 24 hours a day for answering phones when there is no answer or the phone is placed in "do not disturb mode." Each classroom phone has an intercom function/line that allows the office to ring the phone and bypass the voice mail system in an urgent situation. There are two information services provided by the voice mail system. The West Ottawa Information Hotline has a menu, offering information on class schedules, school events, lunch menus, meeting schedules and school closing information. The other information service under development will provide general information for each individual classroom including homework assigned for that class.

6. Power Systems

Each of the communication hub rooms in the district has an Uninterruptable Power Supply (UPS) to provide power to certain parts of the communications equipment in those rooms. These UPS systems were designed to provide at least two hours of operation in the event of power loss. There are three parts of the communication network that require power for either human safety or network reliability (see figure 13). For safety purposes the paging system and the phone system are powered via the UPS system so that in the event of a power loss people in the building can communicate internally and externally. In the event of power loss from a storm, which does not permit the people in the building to leave, when the UPS batteries run down, power fail relays on the phone system's out going trunks engage, permitting external communications from two designated phones.

The district network fiber optic multiplexors operate on a non redundant fiber ring between the buildings. With this configuration any loss of power in a building would shut down the multiplexor node in that building and render the ring, that the building is part of, inoperative. For this reason the Magnum 100 fiber optic multiplexors are powered by the UPS system.

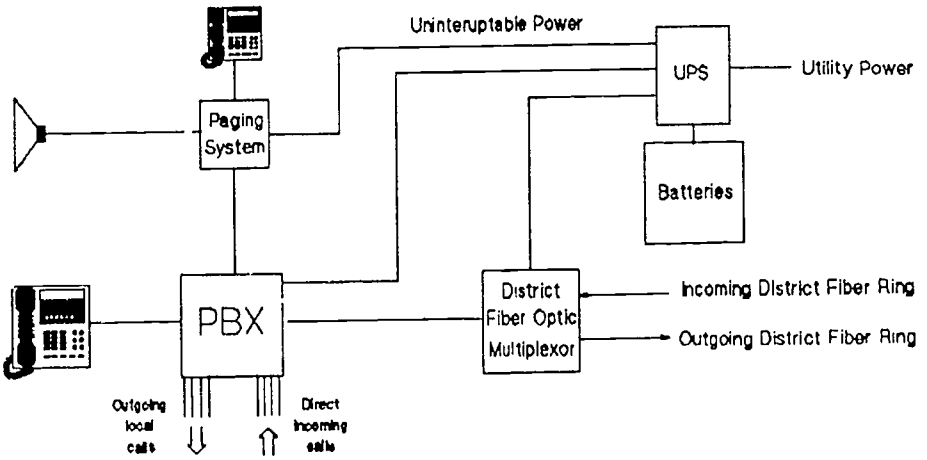

Figure 13

V. Conclusion

This document presents the details of the communication networking strategy at West Ottawa Public Schools. In conjunction with the details I have attempted to present the rational behind the strategy and design for the technology we have installed. There are many ways to provide solutions and services for communications in the education environment. This is further complicated by the rapid pace of change in the electronics industry and particularly the communication industry. What we chose was one of the many ways of solving the problem. For those of you looking to solve a similar set of problems, be sure to analyze the problem thoroughly. There is a high likelihood that what was right for West Ottawa may not be right for you. While we all go about solving a similar set of problems, the technology available, the carrier offerings, the facilities and money available are rarely the same.