Zone Cabling

"Blending an old idea with new technology"

July 9, 2000

Co Authored by:
John C. Leavitt BICSI Member
Nilgun A. Leavitt MSEM
Altug Consulting Engineers

Contributions and editing by:
Adrian Zvarych, FL PE# 41278

Zone Cabling
"Blending an old idea with new technology"

INTRODUCTION

Since the early days of telephone systems, the cabling architecture used for premise building wiring was a zone type configuration. Before our modern cubical cities, buildings used an open floor and managerial office that was combined to allow managers to peer out and watch the staff work. The telephone was the first major communications device commonly distributed to the desktop. Since the facilities hardly changed, cabling was installed using Telephone Terminal Cabinets (TTC's) which was tied back to a Main Distribution Frame (MDF) and associated key systems or patch facilities.

As common office communications grew to include fax machines and data lines (commonly used for computer dial up services), cabling that was once simplistic started to become more complex and difficult to manage. Furniture builders no longer satisfied with providing desk units began to produce cubical furniture for open office architecture that allowed for flexibility and a significant cost savings for space allocation. With the advent of Local Area Networks (LAN)/Wide Area Networks (WAN)-technology came deployment of newer cabling technology such as Category-3 (CAT-3), Coaxial (RF) Distribution, Category-5/5e (CAT-5/5e), and Fire-wire. The cabling used to reach from the MDF to the desktop became more and more important.

Communications infrastructure design has now essentially become an art form with as many as six different cables distributed to the desktop. Historically, most building designs especially older buildings such as schools and hospitals did not provide adequate space for cable distribution. In recent years, it was thought that cables should be run directly from the MDF or equipment room to the desktop to reduce splicing and connection losses as cables are stressed to evolving faster network speeds. EIA/TIA 568 began to address new requirements for campus premise cabling.

Due to ever-changing technology and the requirements of the cabling infrastructure, buildings now have more bulk weight from cables being run through their floors and ceilings than ever before. The lack of forethought given to cable distribution has made ceiling and floor plenums intertwined nightmares of cable infrastructure. This, compounded with a plethora of moves, adds, and changes (MACs), has driven the cost of communications higher and higher.

APPLICATIONS DRIVING THE NEW PARADIGM

The lack of accessibility has given rise to extended downtime during trouble-shooting efforts by technicians thereby adding to the already skyrocketing costs of installation and maintenance of buildings premise wiring. As technology advances, a need has been

identified to provide a more efficient, safer, and more cost effective way to design & deploy cabling systems for open office architecture. In today's business world, companies are scrambling to make fixed and recurring costs, such as communications installation and infrastructure maintenance, "Better, Cheaper, and Faster". Since communications and it's infrastructure have become such cost intensive items, it is reasonable to assume that corporate America now has a technology demand for this ever growing problem of communications infrastructures escalating costs.

Cable infrastructure has developed throughout the years. Typically the technology changes in premise cable wiring have been driven by the device requirements of higher speed data circuits to support other emerging technologies. Several of these emerging technologies include Internet Protocol (IP) based data, voice, and video services. As the device requirements have evolved, the cabling industry has provided better cable (Cat 5/5e/6 etc), and the National standards boards have created better standards. The one area that has not been exhaustively addressed has been distribution schemes. This paper will examine the use of three technologies to solve the dilemma of the average cable infrastructure design for a typical three-story building. The paper will take into account issues with the initial installation as well as with Move-Add & Changes (MACs).

According to the International Facility Management Association, 1998 Research Report-16, a 35% churn rate is the mean for businesses. This means that company personnel will either move or have services added or removed for approximately 35% of the average companies personnel annually. This churn rate is important to the recurring cost of the buildings cabling infrastructure. Imagine being an average company with 1500 employees -- if the average MAC costs $365.00[1] *per drop*, and several hours of downtime, the average recurring costs associated with cabling infrastructure would be $183,750 from the operations budget annually. This figure does not even address the downtime associated with the moves.

Some companies with churn rates over 60% have incredibly high costs for cabling MACs. Therefore, the lowering of cabling infrastructure recurring costs from MACs without raising the initial infrastructure build costs significantly becomes a very attractive proposition. The larger the business, or higher the churn rate, the more attractive these potential savings become.
Many sources have quotes of higher averages for MACs and the associated costs. One quote obtained from the Cabling Installation and Maintenance publication June, 2000 indicated the following: "Moves, adds, and changes (MACs) are everywhere. The International Facility Management Association (Houston) estimates that 44% of a company's workforce relocates every year. A related study indicates the cost of moving the cabling that supports these relocation's can reach $500.00 per workstation."[2] Many new advances in technologies and standards have made premise wiring design a challenge.

---

[1] This figure is based on $65 for material and two technicians for three hours at a billing rate of $50 per hour.
[2] Cabling Installation & Maintenance, June 2000; Mag-8, Iss-7 (A Switch to in-furniture cabling system).

MANY TECHNOLOGIES, MANY SYSTEMS, MANY CHALLENGES

Three of the current technologies available to cable infrastructure designers are Traditional Cabling (Home-run), Zone Cabling (Collapsed Backbone), Consolidation Point/Zone Cabling (takes advantage of some of Zone Cabling advantages):

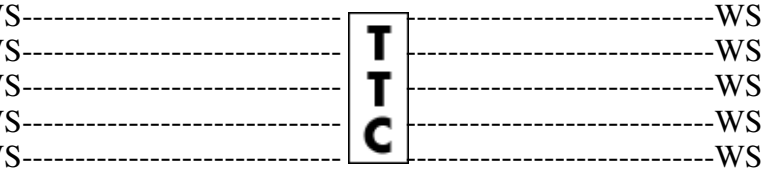
Traditional Cabling-

Traditional or *home run cabling* has become the norm over the past several decades whereby cables are run directly from the regional Telephone Terminal Cabinet (TTC), Intermediate Distribution Frame (IDF), or Main Distribution Frame (MDF) to the desktop or workstation. This technology works well for businesses with very small churn rates, requiring very few MAC's (5-10%) to be performed annually. However, with facilities that experience an average or high churn rate, this technology becomes very costly. Home Run Cabling uses a massive amount of cable; therefore, when it is time to make a change, the fact that the cable is distributed in this manner usually inhibits the technician from making the MAC in a timely manner. Therefore, the cost and sheer weight of the home run wiring option makes the initial cost 'high' both for labor and materials. In addition to the initial cost, the recurring costs of MAC's traditionally averaging 35% annually render Home Run cabling technology cost prohibitive for larger and higher churn rate businesses.

Traditional Cabling-

Pros:	**Cons:**
Simple design	Inflexible (lack of scaleable technology)
Reliable	Non-Reusable cable
Works without extra connections	High cable & labor costs
Easy to document	Costly to reconfigure (MAC's)
Can use CAT 3/5/5e/6/fiber	Bulk weight of cable

Each device home runs to IDF or to the MDF



WS= Work-station

The home run technology does take advantage of the initial requirement to provide an end-to-end solution. It is considered to be simple to design, reliable, and is easy to document. However, with the web of plenum cable in any ceiling or floor above or below cubicles, documenting the specific path of a cable may be possible; however, finding the proper cable needed within the maze could be a major challenge.

Zone Cabling-

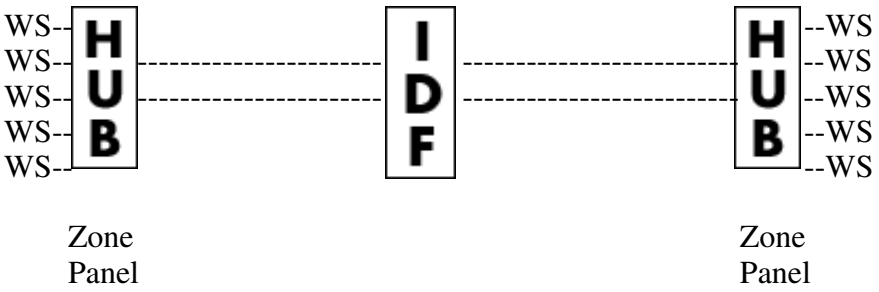
Zone cabling is a new look at an old idea. Zone cabling requires one distribution cable run (or two for redundancy) from the IDF to an appropriately placed zone cabinet (that could be installed within a dropped ceiling, raised floor or in the furniture). Cabling is then distributed from the zone enclosure to the desktop. Furthermore, it is now possible to place active devices within these high tech enclosures to create a collapsed fiber backbone. Imagine -- coming out of the Main Communications room with a fiber pair, dropped directly from the drop ceiling into a raised panel. The raised panel has an extension from the ceiling into the furniture wall housing the hub that will ultimately feed all the data jacks in the cubicle group 100Bt data.

This Zone Cabling technology meets a plethora of communications standards. Some of the standards met are ANSI, EIA, TIA, ISO, and IEC standards. All of these standards quantify and qualify how cable can and should be run to maintain expected reliability. The technology has been UL approved for Low Voltage Communications, and meets NEC standards. With Zone Cabling, the enclosure is strategically placed to feed several groups of cubicles. If entire cubical groups move away from the enclosure, another enclosure is available to take on the additional services. Therefore, the services can grow and change as the requirement changes. There is however, in this use of this technology, a requirement to strategically pre-plan where the zone cabinets should be placed for each floor.

Zone Cabling-

Pros:	**Cons:**
Reduced Mean Time To Repair (MTTR) as all ports accessible and easy to troubleshoot	Potentially a Single Point of Failure (SPF) if two Home runs are not made
MAC's are very fast and efficient and require less down-time	Design parameters require additional installation considerations
Reduces initial cost due to the reduction in required Comm. Room real-estate, and reduction of home runs	Must place in areas of accessibility
Future Proof can accept all new technologies	Documentation requires some skill as also documenting equipment staging
Scaleable by design	

Each device connection is connected to a Zone Cabinets Hub.



Zone Cabling- cont.

John Presley, President of American Access Technologies Inc. (AATK on the NASDAQ Small Cap) is recognized as the President of a leading Active Zone Cabling technology producer. Mr. Presley and his company currently hold several patents on this innovative technology. During an interview recently, Mr. Presley expressed his pleasure at the cabling industries acceptance of the Zone Cabling Products.

"Zone cabling may soon be considered the standard for major premise installations. Deployment of this technology not only appears to make the initial installation labor less intensive but the recurring cost savings makes the business case obvious".

Consolidation Point/Zone Cabling-

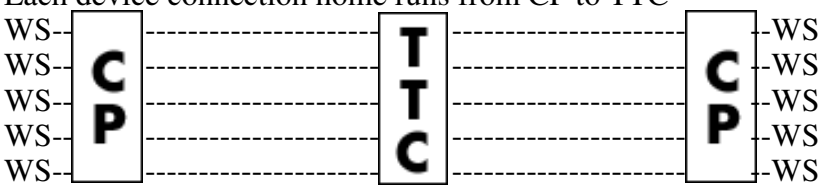
Consolidation Point/Zone cabling technology is a hybrid of both the home run technology and the zone cabling technology. This technology also meets many of the communications standards such as ANSI, EIA, TIA, ISO, and IEC.

Consolidation Point technology (typically passive only) allows moving within the same cubical group more efficient and less disruptive by placing access points in fixed panels, walls, or secured furniture as well as ceilings and floors.

Consolidation Point-

Pros:	**Cons:**
Reliable	Less Flexible (somewhat scaleable)
MAC's within the fed cube group are very fast and efficient	Documentation should include enclosure locations
Reduces recurring cost due to downtime for MAC's within the fed cubical group	High cable & labor costs
Easier troubleshooting effort	Costly to reconfigure (MAC's) if group moves away from feeding TTC or MDF
	Design parameters require additional installation considerations

Each device connection home runs from CP to TTC



CP= Consolidation Point

As you can see, the idea of Consolidation Point cabling is similar to Zone Cabling. However, Consolidation Point cabling does not use active devices. Since Consolidation Point Cabling and Zone Cabling are similar, with Zone Cabling taking advantage of the additional high technology of collapsed backbone to the enclosure, this paper will only address the cost difference between Traditional and Zone Cabling.

Easy Scalability of Cabling Infrastructure "Designed Growth"

Traditional cabling does not historically contribute to a scaleable design of ease. Once the traditional cable infrastructure is put in place, each time an additional service requires adding or moving cabling becomes a major effort. In layman's terms, traditional cabling does not normally lend itself towards planned growth or a futuristic design. In fact, using the traditional method of cabling, most infrastructure designers will account for growth by leaving space on the IDF or MDF for additional blocks to support future cabling needs.

Zone cabling takes an approach that incorporates designed growth. Providing a specific percentage of spare cabling from the IDF or MDF to the zone enclosure plans for future growth. This allocation of spare cabling eliminates the need to re-run the lines multiple times the total distance from the desktop to the IDF/MDF. This spare cable is terminated on a patch field and available should additional services be required. With zone cabling, the worst case scenario if planned right, is that additional cabling may be required between the zone enclosure and the individual desktops. This problem is not as difficult to resolve as running cable all the way from the TTC or IDF

During cabling additions, Zone Cabling seems to really outshine the other technologies. Yes, as with all Christmas presents, some assembly is required; however, an RCDD will have the instructions and specifications to complete a Zone Cabling installation. Mr. Vince Wolcott of Sverdrup CRSS's Deputy Director of Communications Solutions referring to an installation of modular zone cabling at the Dulles International Airport by the TRW Systems & Information Technology Group (SITG) stated: "The SITG choose a modular zone-cabling solution for its voice and data needs for three reasons:

- The ability to install quickly enabled the SITG to meet an aggressive construction schedule.
- By design, its configuration provides infrastructure flexibility.
- The system provides for low lifecycle costs".

In the same article, Mr. Wolcott was also quoted stating, "Delays, changes, and other factors are an inevitable part of every project. A modular zone-distribution system like this takes away some of the stress and reduces the labor required".[3]

As these products are relatively new to the market, I will pause here to give a short explanation of each different application ceiling, floor, and wall (furniture).
The products described below are known to be innovations in Zone Cabling technology. Lucent Technologies and others carry these specific products as well as their inventing company, American Access Technologies.

Ceiling Enclosure (A1024-LP/PP/HR-BAL-33): This enclosure can be procured in a passive cabinet style that can house as many as 2-300 pair narrow band punch down

[3] Cabling Installation & Maintenance, April 2000; Mag-8, Iss-5 (TRW integrates a zone-cabling design).

blocks (LP), or two 48-port patch panels with wire management (PP). The active cabinet can hold a Hub, Switch, or Router as well as two 48-port patch panels with wire management (HR).

Raised Floor Enclosure (0622/0822/1422-RF): These 6", 8", 14" raised floor units can hold from two 48-port patch panels to upwards of 264 ports with associated 8-pin modular jack and patch capability depending on the space available within the sub-floor.

Furniture Solution (Herman Miller) (HME 5448): This provides the capabilities to hold a plethora of cables and associated jack fields within its walls, and/or active devices such as Hubs, Switches, Routers, or a thin-line Server.

If additional information is required on these specific products, the web site at *WWW.AATK.COM* has an abundance of information regarding the products their applications and the individual specifications met with each product line.

Network Downtime of the Disparate Cabling Technologies

There are two areas in which downtime would affect an operational environment, Scheduled and Unscheduled downtime. Scheduled downtime for MACs or reconfiguration of the physical infrastructure can usually be offset by having the work done on off-shift hours (typically paid at time and a half) during a previously agreed to maintenance window. The cost of the downtime per minute/hour varies on every specific network and will not be challenged within the scope of this paper except to say that it is an expense to be considered.

Unscheduled downtime due to infrastructure problems is usually preceded by another event such as other trades technicians standing on the cat-5 cabling within the ceiling. In any event, when a problem with the network is found to be within the cabling, the traditional method makes repair a difficult task at best.
Finding the specific cable affected and tracing it through the maze of other cable within a plenum space can be exhausting and very time consuming. Often rather than trying to find and repair the problem, a technician will simply run more cable or re-terminate the existing cable. This in turn adds more cable and weight to already existing complexity. With the zone cabling method, the problem can easily be segmented to either the feed side or the distribution side from the enclosure to the desktop. This means that trouble resolution is much easier as the technician identifies the problem and either chooses another feeding pair, or runs another distribution pair if a spare is unavailable. There have been installations that have reduced network downtime associated with cable maintenance to less than one-third the time prior to the upgraded zone cabling installation.

Standards based solutions

Regardless of the cabling infrastructure method chosen, the designer should ensure that the applicable configuration standards are followed. Specifically, one should ensure that the infrastructure will meet the reliability demands of the network without compromising safety. Setting industry standards is the work of respected professionals and experts that may serve on national and international committees for months or even years to develop the guidelines that become industry standards. Depending on the installation, many standards may require evaluation or in some cases re-evaluation. Some of the standards organizations that should be consulted prior to commitment to a design are:

ANSI	American National Standards Institute
BICSI	Building Industry Consulting Services, International
EIA	Electronic Industries Alliance
IAEI	International Association of Electrical Inspectors
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Standards Organization
NFPA	National Fire Protection Association
NEC	National Electrical Code
TIA	Telecommunications Industry Association
UL	Underwriters Laboratory

Service Provisioning Challenges

The amount of time it takes to turn up a new service has a direct correlation to the amount of planning in the design of the network and cabling infrastructure. When the new service requested simply requires a patch cord within a Zone Cabinet enclosure, it certainly takes less time than the requirement to run a new cable to the TTC, IDF, or MDF from a desktop to the other side of the building.
The old adage "Time equals money" comes to mind.

Cost Benefits

To derive the cost benefits, one must be able to show an example of the savings. Therefore, begin by assuming a three-story building is in the construction phase and as usual, communications infrastructure was an afterthought. This hypothetical building[4] is designed to use open office architecture and to be a home for a medium sized service call center.

The main communications room is on the first floor and is a 20' x 10' room in the Northeast corner. This room is expected to hold the telephone switch and the IT and associated cabling infrastructure. There is conduit to a similar room on the second and third floor that will house an IDF back to the MDF in the first floor communications room.

[4] Our Hypothetical Building is modeled, not an existing example therefore the distances used will be approximations and averages.

The communications room on each floor that houses the associated IDF/MDF have fire rated walls on all sides per the NEC. The building is a 175'x250' rectangle providing approximately 43,750 SQ' per floor, and approximately 131,250 total square footage.

The first floor has a mailroom and delivery area set aside of 20' x 25', a storage area 20' x 25', and a foyer of 15' x 25'. The elevator and stairs relinquish an approximate 1000 SQ' area per floor. Bathrooms, janitors closets and a small kitchenette on each floor accounts for an additional 4000 sq' non-productive area[5]. 900 square feet are also dedicated to admin. stock rooms totaling slightly over 9000 SQ' total non-productive area[6]. The remaining 122,000 sq.' of productive workspace has been has been conservatively allocated as shown below:

The first floor has a total of 230 workstations in cubicles and offices.
The second floor has a total of 240 workstations in cubicles and offices.
The third floor has a total of 250 workstations in cubicles and offices.
Total workstations supported total 720.

4 drops of Cat-5 (2 IT, 2 Voice/Fax) to each workstation area – Total = 2,880 cable drops.

Horizontal cable runs average Traditional "Star Typology" method = 200'
Horizontal cable runs average Zone Cabling method = 75'
Distance between floors 15 ft.

Traditional method:
All cable drops (4 each per workstation) are Cat-5 rated cable or better (Voice & Data). All Data cables run from the associated communications room on each floor through drop ceilings to the desktop. Hubs are located on each floor that feed via fiber optic connection into the first floor main communications room for data cables. The voice (Telephone & Fax) cables also run from the associated communications room on each floor through drop ceilings to the desktop. The voice cables are connected through Cat-3 backbone cable for each floor into the main communications room on the first floor and integrated into the Telephone Switch.

Fiber distribution centers (FDC's) are in each communications room on each floor integrating the equipment to the main communications room and then on to the outside world. Each floor IDF will also have 1-300 & 1-100-pair Cat-3 backbone cables to the main communications room MDF on the first floor. Each IDF will have a combination of 300 & 100 pair 110 blocks used for cable feed and distribution of Cat-3 and Cat-5 cabling, a rack dedicated to fiber distribution, and space reserved for 50% expansion.

[5] Non productive area in this instance is defined, as area not used for workspace offices or cubicles.
[6] Non productive area in this instance is defined, as area not used for workspace offices or cubicles.

Zone Cabling method:
All data cabling will be subdivided into 8 zone enclosures per floor dedicated to IT-support. The data cabling will be in a collapsed backbone configuration-that will be fed with fiber from the IDF into the active components within the AATK 1024-HR, the active component enclosures will then distribute two data drops to each desktop. All of this cabling will be suspended in the interstitial space of the suspended ceilings except within the Service Control Center (SCC), the data room, and the foyer area. The Service Control Center and data room use a zone enclosure that is strategically placed within the raised floor of the Data Room. The foyer takes advantage of a zone enclosed furniture solution called Ethocom by American Access Technologies.

Each zone enclosure dedicated to data services will have two (1RU) 24 port hub/switches installed where applicable and associated patch facilities as well as wire/fiber management. Each of these zone enclosures will also be specified in such a way to account for more than 25% growth. There will be six voice zone enclosures per floor all installed in the interstitial space of the suspended ceilings except within the Service Control Center (SCC), and the foyer area. The AATK 1024-LP voice zone enclosures will be configured in a consolidation point configuration, distributing two voice lines to each desktop. Each zone enclosure (18 total) will have a 100 pair Cat-3 backbone cable feeding from the communications room. The two Cat-5 cables for voice grade services will be terminated within the enclosures on 110 blocks. The termination's for the Cat-3 feeder cable and cross-connects will be made as required. Wire/Fiber management will be a key to the success of this methodology.

Fiber distribution centers (FDC's) are in each communications room on each floor integrating the equipment to the main communications room and then on to the outside world. Each floor IDF will also have 4 100-pair Cat-3 backbone cables to the main communications room MDF on the first floor. Each IDF will have a combination of 100 and 300-pair and space for 50% expansion.

COST ANALYSIS

Traditional Cabling:

Materials Cost-	$175,860
Labor Cast-	$399,400
Total Cost-	$575,260

MAC Cost estimated $350.00 per
Assuming a 40% churn rate 720 workers will require 288 MACS annually
288 * $350 = 100,800 Annually or 100,800* 15 years = $1,512,000 for the 15 year lifecycle recurring costs.

TOTAL Traditional Lifecycle costs = $575,260 + $1,512,000 = $2,087,260

Zone Cabling Method:

Materials Cost-	$163,850
Labor Cast-	$279,450
Total Cost-	$443,300

MAC Cost estimated $125.00 per

Assuming a 40% churn rate 720 workers will require 288 MACS annually
288 * $125 = 36,000 Annually or 36,000* 15 years = $540,000 for the 15 year lifecycle recurring costs.

TOTAL Zone Cabling Lifecycle costs = $443,300 + $540,000 = $983,300

This cost analysis shows a saving on initial installation with Zone Cabling technology of approximately $132K. The savings becomes even more significant when considering a fifteen year lifecycle cost of MACS based on a constant 40% churn rate for 720 workers.

The total lifecycle savings for the above stated project are approximately $1,104,000.

Conclusions:

Technology is demanding infrastructure designers of campus premise wiring to foresee the future more than ever before. The one-time costs of cabling for IT and other services requiring premise cabling are unrealistic today. The cost of re-cabling in both capital dollar investment and downtime associated with a re-cabling effort is unacceptable. The churn rate of technology-driven businesses (stated to be from 35%-70% annually for most businesses) is rising rapidly. As a result of this increased turnover, concerns over cable infrastructure reoccurring costs are valid as a significantly high percentage of the IT maintenance budget.

Prudent businesses are turning to alternative methods from the traditional cabling schema to curtail the initial and recurring costs associated with premise wiring. Therefore, the business case presented in this paper using Zone Cabling to provide significant savings on cable, equipment, and labor both on the initial installation and re-occurring costs is shown to be credible and preferred to the traditional cabling methodology.

The cost savings shown through utilization of Zone Cabling due to MACs alone are significant. Many times the cost savings average $300 each. Therefore, for each 1000 employees using the 35% churn rate and a $300 average-MAC savings the resultant cost reduction due to the deployment of Zone Cabling would average $105,000 annually.

Using our conservative project above, describing 720 workstations the cost analysis showed a 15-year lifecycle savings of approximately $1.104 Million dollars. It has been assumed that the design, approval, and procurement costs would not be significantly different from those of traditional methods once the technology has been understood and used past the learning curve.

RCDD's and manufacturing representatives with American Access Technologies or other similar technology representatives are becoming more familiar with this technology and Zone Cabling is well on its way.

In conclusion, we have shown that (time = money), as demonstrated above, zone cabling has a significant advantage over traditional cabling methods.

Although the research for this paper was funded by one of the companies responsible for the re-invention of zone technology (American Access Technology Inc.) and its use of Active Components for collapsed fiber backbone to the desktop, the premise of this paper was to prove the cost benefit involved in the deployment of zone technology.

Appendix I

American Access Technology:

American Access Technology has been one of the driving forces of the re-invention of Zone Cabling Technology. A publicly traded company AATK – NASDAQ Small Cap American Access Technologies has offices in Lake Mary, Florida. Omega Metals the American Access Technologies manufacturing facility is located in Keystone Heights, near Gainesville Florida. With their product line of Zone Cabling products, they have made a significant impact on the telecommunications cabling industry.

Product History:

After establishing the need for the product line by meeting with School Board Officials and Contractors, their R&D department began working on a solution that would feed in fiber, and convert it to copper (CAT-5) for schools and other older institutions. After several consultations with engineers at Underwriters Laboratory (UL) it was determined that the need could be met with some modifications to their passive Zone Enclosure (ZCTC 1024) by adding the electronics, thereby creating the ZCTC 1024 HR.

Product Standards:

American Access Technologies provides solutions for raised floors (ZCTC-RF), dropped ceilings (ZCTC-1024), and cubical style furniture (EthoCOM). All ZCTC cabinets are constructed in accordance with UL-2043, UL-1863, Type 12, and Canadian Standard CSA 22.2 #94M91 & CSA 22.2 #4-M89. The ZCTC cabinets meet or exceed the NEC 300-22 B or C requirements when the appropriate fire foam kits are installed.

Manufacturing:

American Access Technologies Keystone Heights manufacturing facility is state of the art, the campus provides for adequate facilities into the expected five-year growth plan. The facility uses common machinery processes with new technology machinery and powdered coating equipment that produces a very professional finished product.

AATK OMEGA Metals campus

Inside manufacturing facility

For additional information on American Access Technologies, contact them @ 1-800 285-2070 or URL: www.aatk.com.

Appendix II

Additional Reference Material:

Construction Specifications Institute, Manual of Practice – Construction Contract Administration Module, 1996.

BICSI Telecommunications Distribution Methods Manual (TDMM), 9th edition, 2000

BICSI Telecommunications Dictionary (1999)

Telecommunications Cabling Institution Manual (TCIM) 2nd edition

Telecommunications Network Management
Technologies and Implementations
Salah Aidarous and Thomas Plevyak / IEEE 1998 NY

Telecommunications Network Management
Haojin Wang / McGraw-Hill 1999 Hightstown, NJ

America Online's Internet
Tom Lichty / Ventana Press 2nd edition, 1995

The TCP/IP Companion (A guide for the common user)
Martin Arick / John Wiley & Sons Inc 1993 NY

On-Duty U.S. Firefighter Deaths Reach