Fiber Optic Local Area Networks,
A Part of the Future ATCCS Architecture

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ABSTRACT

The Army Tactical Command and Control System (ATCCS) Local Area Network (LAN) is currently based on commercial Ethernet data interface independent of circuit switched voice subscriber circuits. An evolution is anticipated which will utilize a mixture of fiber optic, wireless LAN technologies, and existing Army communication assets to support data users, followed by complete integration of all services in the local area. This paper describes how the proposed evolution to fiber optic networks in the ATCCS LAN Architecture can be accomplished. How the use of the Army’s Advanced Technology Demonstration Program (ATDP) can be utilized to insure Fiber Optic Networks will be compatible with existing military communications will be discussed. Finally, a proposed application of the current FDDI standard to support real-time voice and video services in a format compatible with the Army’s evolving ATCCS LAN architecture will be discussed.

1. INTRODUCTION

The Battlefield Information System (BIS-2020) is the future Army system to support ARMY 21 doctrine. It is envisioned that the Army Tactical Command and Control System (ATCCS) will be geographically dispersed, highly mobile and communications intensive. To support the BIS-2020 concept an evolutionary approach must be taken to insure that the latest technology is incorporated into the Army’s evolving C3 systems. The first step will be the ATCCS Baseline System which will provide network battlefield computers to support the five nodal command and control systems (Maneuver Control, Air Defense, Fire Support, Combat Service Support, and Intelligence/Electronic Warfare) at units deployed at echelons corps and below. The next step will be the ATCCS Target System, expected to be fielded in 1996, continuing on to the ATCCS Objective System which will be developed over the years 1995 through 2000 and culminating with BIS-2020. Throughout the process the local area communications must evolve to support future real-time command and control requirements. One of the key technologies for local area communications will be fiber optic LANs, in particular – Fiber Distributed Data Interface (FDDI).

2. ATCCS Baseline System

2.1. Architecture

The current baseline ATCCS LAN consists of two major components; a coaxial IEEE 802.3 10 base 2 [1] (“ThinLAN”) network used inside a Standard Integrated Command Post System (SICPS), and a fiber optic LAN that interconnects SICPS using a Fiber Optic Media Attachment Unit (FOMAUC) to provide a repeater function between the media, as shown in Fig. 1.

Each SICPS vehicle will consist of between one and six workstations connected on a ThinLAN segment. Communications external to the shelter will be over either the fiber optic backbone, or tactical Army communications using the CHS Adaptive Programmable Interface Unit (APIU). The APIU is a host programmable, multiple port modem that supports four tactical communication channels. The ThinLAN network can be extended outside the shelter to support a remote host capability or connection to non fiber systems, such as the Mobile Subscriber Equipment (MSE).

The baseline ATCCS LAN utilizes a fiber optic Ethernet ring implementation with a single ring topology. A single ring corresponds to a single IEEE 802.5 coaxial cable inter repeater link with each FOMAUC connecting a tapped segment. The cable plant will use a dual fiber optic cable assembly, therefore only one of the two fibers is utilized. The second fiber will allow for a migration to a dual ring architecture, including FDDI, with no change in the cable plant. The current LAN will support up to 100 nodes over a ring circumference of 8 km. While the number of SICPS interconnected on the backbone LAN will depend on the deployment scenario, the number is not expected to exceed fifteen.

2.2. Components

The ThinLAN network internal to each SICPS consists of a ThinLAN interface that resides in each host computer, connected by coaxial cable runs. An optional second LAN interface card may also be used to provide a second LAN interface in each host. The computers are interconnected in a bus topology using RG-223 coaxial cable terminated at each end with a 50W terminating resistor. The second LAN interface
Figure 1 - Baseline ATCCS architecture

provides an AUI interface, requiring a ThinLAN transceiver for connection to a ThinLAN network. The function of the second LAN is to allow the user to keep critical local traffic separate from other network users.

Each SICPS is attached to the fiber optic ring through a Fiber Optic Media Access Unit (FOMAU). FiberCom’s WhisperLAN/RPT-TW[2]. The FOMAU purchased by PM CHS is based on FiberCom’s WhisperLAN/SPT product, which has been modified to replace the AUI interface with a ThinLAN interface, and to add a repeater function to the unit. The FOMAU is an active device on the fiber optic ring that provides a standard Ethernet/IEEE 802.3 interface to the user. The fiber optic ring, however uses a proprietary protocol developed by FiberCom[3]. The FOMAU provides the physical and data link layer function as defined by the OSI reference model. The unit provides an internal optical bypass switch to bypass a failed or powered down FOMAU; the unit is specified to allow up to three units to be bypassed before the signal is lost. The FOMAU fiber optic interface uses ST-series bayonet style connectors and supports 50/125mm graded index multimode optical fiber. The transmitter is an LED with an output of -22dBm at a wavelength of 850 nm, and the receiver sensitivity is -46dBm.

The fiber optic cable plant will consist of the Tri-Service Standard Tactical Fiber Optic Cable Assemblies (TFOCA)[4] external to a SICPS. The fibers are radiation hard and fully militarized to withstand the tactical field environment. Each SICPS will house four TFOCA bulkhead connectors, allowing two dual ring LANs to be connected. Inside a SICPS radiation hard fiber optic cables with ST-connectors are used to connect the FOMAU to the bulkhead connectors [5]. This will allow for future upgrades to the FOMAU without requiring a special connector interface to be developed.

2.3. Limitations

The current single ring topology is not well suited for tactical applications. It is expected that in a battlefield scenario SICPS will be connecting and disconnecting from the ring frequently. With a single ring topology, insertion or deletion of a station will cause the ring to fail. Stations inside a SICPS will still be able to communicate, but intervehicle communications over the fiber optic ring will be disabled until the ring is reformed.

The Ethernet protocol is not well suited to evolving C3 applications. Ethernet’s 10Mbit/s bandwidth will become a bottleneck as new applications emerge. It is foreseen that an order of magnitude increase in speed will be needed to support new technologies, i.e. replicated data bases, bit mapped graphics, voice and video. In addition, due to its non-deterministic nature the CSMA/CD protocol is not a good candidate to support real time services (voice, video, sensor data) that need guaranteed access to the network.

2.4. Migration Path

Modifications have been proposed to the current ATCCS Baseline LAN to make it more suitable for tactical applications. The most important modification will be a migration from a single ring to a dual ring architecture. The dual ring will allow stations to be inserted and deleted from the network without adversely affecting network operation. FDDI was a prime candidate under consideration for this dual ring architecture, but due to size, cost, current instability of the standard, and schedule it was ruled out for use in the ATCCS baseline system. Other surrogate dual-ring products are being evaluated for use until FDDI is available for tactical use. It is important to note that the TFOCA cable plant and SICPS connections are already in place will support either a single or dual ring configuration without modification.
3. ATCCS TARGET SYSTEM

3.1. Architecture

FDDI is being planned for insertion into the ATCCS Target System, scheduled for fielding in the 1996 time frame. By this time FDDI technology will have matured sufficiently and dropped in price and size to make it a viable candidate for ATCCS. It is anticipated that FDDI will be phased into the ATCCS architecture gradually; most ATCCS users will still use the baseline ThinLAN network during the ATCCS Target timeframe. One notable exception will be Program Manager All Source Analysis System (ASAS). PM ASAS requires high end workstations with FDDI interfaces in the host computer. The challenge for the ATCCS Target System will be to design a network that can support the ATCCS low speed LAN requirements, and at the same time integrate users with high speed network requirements on the same network.

During the ATCCS Target System timeframe it will not be feasible for most of the ATCCS community to migrate to FDDI interfaces in the host computers for numerous reasons. It would not be cost effective to replace the Ethernet interfaces in the CHS I host computers with FDDI; also most ATCCS users will not have requirements to justify the cost of FDDI interfaces in the host computers. When the cost per FDDI host interface becomes cost effective, the Ethernet can be phased out of the architecture as requirements evolve. At present it appears that a mix of FDDI bridges, concentrators, host interfaces, and possibly routers will be used to implement the FDDI portion of the network.

A possible command post configuration using a mixture of FDDI products that are available today as non developmental items is shown in figure 2. In this configuration FDDI bridges will be used to connect the ThinLAN Ethernet segments inside the SICPS shelter to the FDDI LAN. The bridges will filter traffic so that only Ethernet traffic destined for other segments will travel on the FDDI ring. This would eliminate the "giant" LAN concept introduced in the ATCCS Baseline System where every station must process every message due the fact that the LAN is one giant Ethernet segment would be eliminated.

Concentrators will connect Single Attach Stations (SAS) to the FDDI LAN. Concentrators offer an attractive alternative to direct attachment of host computers to the FDDI LAN from a reliability standpoint. Concentrators are much more reliable than stations (hosts) since they have fewer components, no display tubes, smaller power supplies, and no disk drives. The mean time between failure of a concentrator should be orders of magnitude higher than a typical host computer. By using single attach stations and dual attached concentrators there is no limit to the number of stations that can be bypassed since that the concentrator electrically isolates the host from the network. Dual attach stations directly connected to the ring may impact the reliability of the network. If a station failed the ring would have to go into wrap state or be optically bypassed if a bypass switch was installed at the node. There is a limit on the number of stations that can be optically bypassed due to the optical link budget. For increased fault tolerance, Redundant Single Attach Stations (RSAS) could be put into the host computers, this is simply two separate single attach stations inside a host computer connected to the concentrator[6].

A router with an FDDI interface would need to interface to the Mobile Subscriber Equipment (MSE) packet switch to provide wide area access.

This architecture will allow hosts to communicate over the FDDI LAN in a transparent fashion. Hosts with Ethernet interfaces will be able to go through the FDDI bridge to communicate with hosts attached to the concentrators. Packets destined for other command posts will be routed by the MSE router into the MSE packet network. It is important to note that

Figure 2 – ATCCS Target System
the same TPOCA cable plant used in the Baseline ATCCS Architecture remains unchanged.

3.2. Benefits

FDDI will provide significant improvements in the LAN architecture over the ATCCS Baseline System. The circumference of the ring can be increased from a maximum of 8 kilometers to 200 Kms allowing the command post to be dispersed over a much greater geographical area. There will be an order of magnitude increase in speed on the fiber optic ring, allowing new applications on the battlefield, i.e. imagery, distributed databases, integrated voice. One of the most important advantages of FDDI is that it is based on a widely recognized commercial standard. This will allow interoperability between multiple vendor’s equipment, and allow for insertion of new FDDI products as they become available.

4. ATCCS OBJECTIVE SYSTEM

4.1. Architecture

It is anticipated that ATCCS will migrate to a full FDDI architecture during the Objective System timeframe. The actual insertion timeframe will be driven by funding, schedule, user requirements, operational doctrine, and technical maturity. The FDDI/Ethernet bridges will be phased out and replaced by FDDI concentrators. The ethernet interface in the host computer will be replaced with FDDI interface. A representation of an Army vehicle using FOTLAN is shown in figure 3.

![image](figure 3)

FOTLAN deployed in the field

This FDDI architecture will provide the communication fabric needed to integrate new emerging applications to support a dispersed survivable command post. New applications such as integrated data, voice and video over FDDI, demonstrated by the Army’s Fiber Optic Tactical Local Area Network (FOTLAN) Program [7] can now be implemented. Other such applications include distributed data bases, integrated services workstations, imagery, and other high bandwidth applications.

14.2.4
The benefit of this architecture is that it reduces the amount of cabling needed in the command post while increasing the survivability of the command post by using a dual ring architecture. Voice subscriber access to MSE over cumbersome 26 pair cable will be eliminated by integration of voice and data onto a single TPOCA cable plant connecting the local area system. Other real time services such as video can be readily distributed around the command post LAN without overload the wide area system.

5. INTEGRATION OF FDDI WITH OTHER ARMY COMMUNICATION ASSETS

FDDI offers the military a reliable high-speed cable plant for operations when deployed or on the short haul. If FDDI is to be accepted by the military communications community, then it must support access to a variety of alternate communications assets. Many of these devices operate at transmission speeds far below the FDDI standard of 100 Mbps.

One of the mechanisms available to the Army, for testing compatibility of new systems, is the use of an Advanced Technical Demonstration (ATD, formerly ATTD) The Army's Research Development and Engineering Centers (RDEC) conduct ATD's independent of, but coordinated through, interested Program Executive Offices (PEO) and Program Managers (PM). The Survivable Adaptive Systems ATD will demonstrate the application of FDDI and other LAN technologies (including wireless LANs) supporting standard military C3 devices such as SINCGARS, MSE, and CHS-1 along with selected BFA software packages. Upon completion of the demonstrations, the user and developer communities will understand the capabilities and limitations of FDDI when used in the tactical environment with standard Army C3 equipment.

The technologies to be integrated with FDDI include Low-cost Packet Radio (LPR), EHIF wireless LAN, high speed network security, Automated Network Management (ANM), and Tactical Multinet Gateways. These communications assets must support operation of the five battlefield functional Areas (BFAs) and future AirLand Battlefield Management software applications running on CHS-1 or CHS-2 systems. In addition to new communications systems, the network requires compatibility with present Combat Net Radio (CNR) and the Wide Area Network (WAN). To ensure multitelecom connectivity, access to the Mobile Subscriber Equipment (MSE) packet switch must be supported.

The ATD will provide an opportunity to examine issues associated with using FDDI in the Army. The issue of flow control will be a major one. The principle method of flow control with slower tactical communications devices revolves around the isolation of the tactical devices. Essentially the tactical devices will either connect directly to the CHS computer (through a TCIM or a commercial equivalent) or access the network through the tactical multinet gateway. Thus the buffering task from or into the FDDI network will be controlled by the gateway. Major communication devices identified for testing in the ATD include SINCGARS, EPLRS, JTIDS, and TRI-TAC. Additional systems will be supported as access cards are designed for the tactical multinet gateway.

6. CONCLUSION

With the emergence of FDDI compatible components it is only a matter of time before high speed networks will be in common use in the command post. It is imperative that a migration path be followed that allows the Army to take advantage of the newest network technology without having to sacrifice investments made today. The migration path described here shows how the Army can transition from the Baseline ATCCS LAN to an FDDI based LAN topology in a smooth low risk fashion. The FDDI LAN should provide the Army with the LAN communications infrastructure needed to achieve its goal of a distributed and survivable command post by the year 2000 and further smooth integration into other network architectures such as the ATM switch architecture proposed by NATO.

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8. REFERENCES

[4] MIL Spec, MIL-C-492924 Tactical Fiber Optic Cable Assembly
[5] MIL Spec, MIL-C-83526/13 Tactical Fiber Optic Cable Assembly Bulkhead Connector