FIBER TRUNK AND FEEDER -- THE CONTINUING EVOLUTION

BY: David M. Pangrac & Louis D. Williamson

American Television and Communications Corporation

ABSTRACT

Cable Television technology has been in a constant state of evolution since the first crude mountain top installation many years ago.

Since the beginning of this industry, we have seen the introduction of hard line coaxial cable, solid state amplifiers, directional taps, satellite delivered programs, addressable converters and, in 1988, the introduction of the "Fiber Backbone" architecture which made use of VSB-AM modulated optics and a significant amount of fiber optic cable.

This paper will focus on ATC's evolution of the "Fiber Backbone" into the new "Fiber Trunk and Feeder" architecture designed for new builds and rebuilds.

The basic concept will be examined as well as the technical specifications.

INTRODUCTION

In 1988 when the "Fiber Backbone" architecture was introduced, its primary purpose was to enable cable operators to cost effectively upgrade their plants, improve reliability and picture quality. The key to making the project a reality was the ability to use VSB-AM modulation to drive the lasers used for fiber optic transmission.

The first lasers used were marginally acceptable with CNR of 48 dB to as high as 51 dB and CTB approaching -63 dB. CSO numbers of -54 dB to -57 dB were also common. Channel loading ranged from 12 to 40 per laser.

In the last two years, a significant improvement in the performance of lasers has occurred. With many laser manufacturers developing products specifically to be used for AM applications, it is now possible to obtain equipment capable of 55 dB CNR, CTB and CSO at -65 dB or better and power budgets as high as 10 dB. Channel loading at these levels have been as high as 42 and some "new" lasers have been close to these specifications with as many as 80 channels.

This performance has allowed the next evolution of the "Fiber Backbone" known as "Fiber Trunk and Feeder".

"FIBER BACKBONE" LIMITATIONS WHEN USED WITH "NEW BUILD" OR "REBUILD" SCENARIOS

The original concept of the "Fiber Backbone" architecture was to allow a system operator to reuse the most expensive part of his plant during a bandwidth expansion project, his cable.

ATC has determined that about 58% of the cost of a cable plant is made up of the cable, strand, hardware and labor to install it. The balance, 42%, includes the plant passives and electronics.

By using fiber to transport the signals from the head end to points deep in existing amplifier cascades, we are able to develop small "neighborhood" cable systems. (See Figure 1) The heart of the small cable system is the optical node where the "light" is converted back to "RF" which then feeds the small coaxial tree and branch system. The short amplifier cascades create an increase in our distortion head room budget that can be used in various ways.

New broadband electronics are installed in the same locations as the original equipment and in some cases, physically turned around. (See Figure 1) The increased distortion head room budget created by the short amplifier cascades can then be used to overcome the cable loss at the higher frequencies and improve picture quality at the same time. (See "Off Premises Broadband Addressability: A CATV Industry Challenge", by James A. Chiddix and David M. Pangrac, 1989 NCTA Technical Papers.) This then results in a cable TV system that has a greater bandwidth, better picture quality and improved reliability over the original system, but costs about 50% less than a new, conventionally built tree and branch system of the same bandwidth. (See "Lake City Cablevision: A Case Study in the Fiber Optics Application", by Ronald W. Wolfe, Proceedings Manual: Collected Technical Papers, SCTE Fiber Optics 1990.)

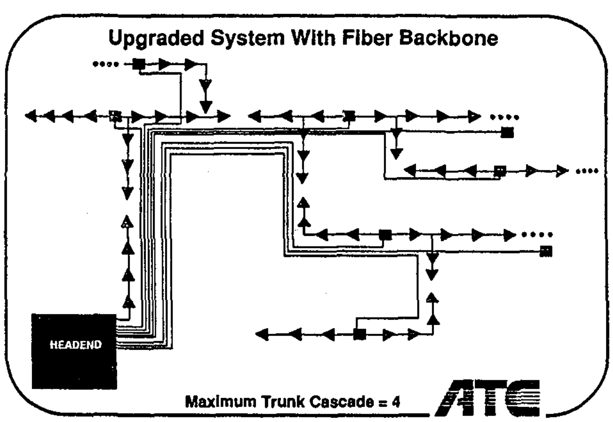

FIGURE 1

While the "Fiber Backbone" architecture works well for a system "upgrade", it is not financially well suited for a new or rebuild application. When a new or rebuild scenario is looked at, using "Fiber Backbone", it can be seen that almost the same amount of trunk cable and amplifiers are needed as would be used for a conventional build.

In addition, fiber and fiber optic electronics must also be installed. Since there is no cost savings available from reusing existing cable as in an upgrade, the cost of the fiber, fiber construction and fiber optic electronics become a significant incremental cost to a conventional plant. This can add as much as $2,600 per mile to the build.

"FIBER TRUNK AND FEEDER"

"Fiber Trunk and Feeder" (FTF) makes use of the technology that was developed for the "Fiber Backbone" but changes the basic cable TV architecture to simplify it and to make more efficient use of fiber. While the "Fiber Backbone" achieves its economics by leaving the coaxial cable in place during an upgrade, the FTF system achieves its economics by eliminating the labor and material needed to build the trunk portions of a rebuild or new build. But the system does more than eliminate the coaxial trunks, it also reduces the number of actives to a maximum of five for any subscriber in the system. These features make the system both economical and reliable.

As can be seen in Figure 2, the concept takes fiber deeper into the system than was previously possible. The optical equipment needed in the system is very similar to the current equipment being built for the "Fiber Backbone". It requires an optical transmitter/receiver pair capable of 54 dB CNR, -65 dB on the other distortions and a 10 dB power budget.

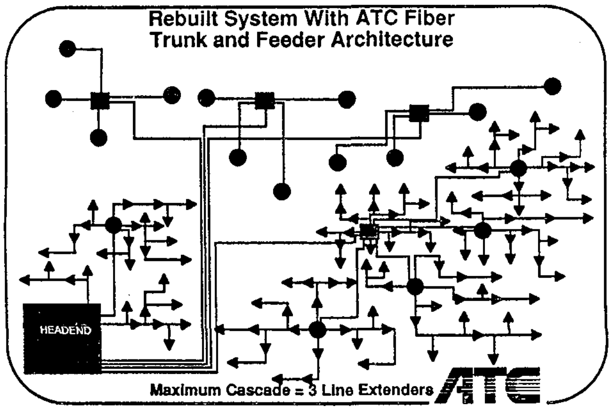

FIGURE 2

A CLOSER LOOK AT THE TECHNICAL SPECIFICATIONS

The signal performance that ATC desires at the tap is shown below.

Desired Tap Performance

	Today	Future
CNR	46 dB	49 dB
CTB	-53 dB	-54 dB
CSO	-53 dB	-54 dB

The RF portion of a FTF plant, which consists of three push pull line extenders, will contribute the following:

CNR	56.4 dB
CTB	-59.5 dB
CSO	-66.8 dB

To meet ATC's future desired tap specification, the fiber portion of the plant must have the following minimum specification at the output of the receivers:

CNR	50 dB
CTB	-59 dB
CSO	-60 dB

As long as the performance at the receiver meets the specification shown above, the tap performance will be met. This allows for a wide variety of configurations from 8 way optical splitting to optical repeating. By using various combinations of laser and splitting networks, all of a CATV system can be served with the FTF architecture.

DEPLOYING THE "FIBER TRUNK AND FEEDER" ARCHITECTURE

The area immediately around the headend is served by three line extender cascades that originate from the headend. The reach of the three line extender cascades is approximately one mile.

After this initial area, the remainder of the plant is served by optical systems. The optical system that is required is assumed to have the following specifications:

CNR	54 dB
CTB	-65 dB
CSO	-65 dB
Loss Budget	10 dB
TV Channels	60

Since this level of performance is not required at the tap, some of it is traded for a larger loss budget. If the loss budget is increased to 12 dB, the CNR of the system will be decreased to 50 dB. The distortion should be unaffected. This allows you to serve the distance and still achieve the desired optical specification at the receiver. (See Figure 3)

FIBER TRUNK AND FEEDER CONFIGURATIONS

DISTANCE (Miles)	NODES Served	SPLITTING Loss (dB)	PATH Loss(dB)
1	NA	NA	NA *
1.6	8	10.7	1.3
3.5	6	9.2	2.8
6.1	4	7.1	4.9
10.8	2	3.3	8.7
14.3	4	7.1	11.75 **

* 3 line extender cascade
** optical repeater needed

FIGURE 3

As is shown in Figure 3, most of a system can be served with passive splitting of lasers that are kept at the headend. It is not until you reach a distance of more than 10.8 miles that an active optical repeater is required.

The optical repeater is shown in Figure 4. Since the optical repeater has to convert the light back to RF to re-modulate the laser, the area immediately around the repeater is fed by three line extender cascades that are driven with this RF signal. The remainder of the RF signal is used to feed the laser for the second optical path. This laser feeds a four port optical coupler, which then feeds four secondary receivers. The secondary receivers can be a maximum of 1.75 dB from the repeater. (See Figure 5)

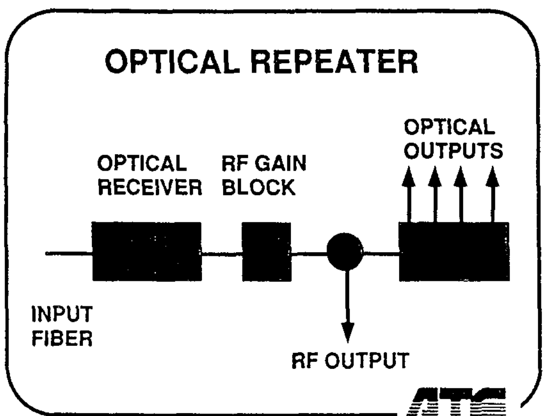

FIGURE 4

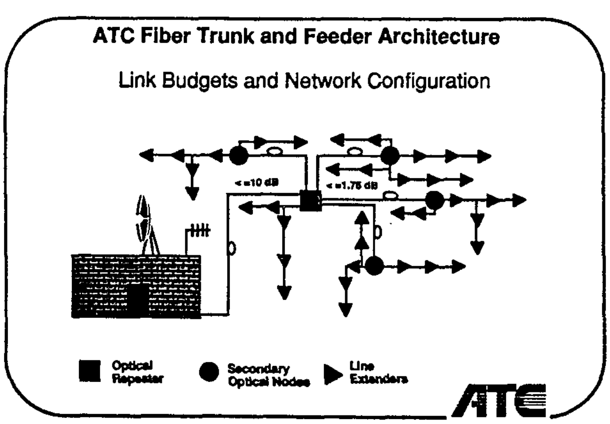

FIGURE 5

In test designs completed by ATC, it appears that each secondary node/three line extender cascade combination can serve an area covering about the same geographical size as four conventional bridgers designed to the same bandwidth.

The diagram in Figure 6 shows an eleven hundred mile plant that was designed using only passive links. The actual design is not shown (for the sake of clarity) but rather the concept that was used to cover all parts of the system with the passive links. The system had two headends that were connected via AM super trunks and the passive links were then served from these locations.

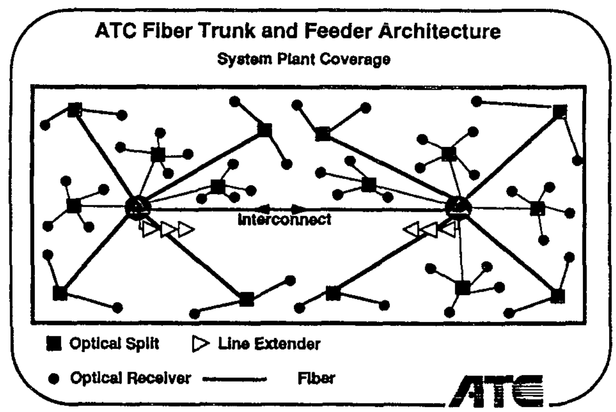

FIGURE 6

CONCLUSIONS

Calculations made by ATC have indicated that when using the "Fiber Trunk and Feeder" architecture to rebuild a 450 MHz plant, the cost for this fiber intensive system will be the same or a little less than a conventional tree and branch coaxial plant.

Nothing has to be invented to make this architecture a reality. The performance of many of the required lasers need be only mediocre by today's standards. The most challenging piece of equipment needed is the inexpensive optical receiver which needs very little development work to become a production item.

With all the benefits of fiber and no increase in cost over a conventional system, the development of this new architecture, "Fiber Trunk and Feeder", will now be the design of choice for ATC, starting this year.

Dave Pangrac is the director of engineering and technology for American Television and Communications Corporation (ATC), the country's second-largest cable television operator.
Pangrac has been in the cable television business for 23 years. He joined ATC in 1982 as Vice President and chief engineer for American Television of Kansas City and in 1987 joined the ATC corporate staff as director of engineering and technology.
Pangrac is a member of the Society of Cable Television Engineers and past president of the Hart of America Chapter. In 1989 he was awarded the NCTA Vanguard Award for Engineering and Technology.
Pangrac is currently involved in ATC's effort to develop the use of fiber optic technology in cable television plants.

Louis D. Williamson received his B.S.E.E. degree from Virginia Polytechnic Institute and State University in 1980. From 1980 to 1983 he was employed at Martin Marietta Aerospace in Denver, CO as a Design Engineer.
Since 1983, he has worked for American Television and Communications Corporation as a Member of the Technical Staff. His responsibilities involve applying new technology to CATV. His is also involved with HDTV and serves as Vice Chairman of the Standard Working Party of the System Subcommittee of the FCC Advanced Television Committee.