The Evolution of Cable TV Networks

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Outline

- Introduction
- Traditional Coaxial System
- An End-to-End HFC Network
- Deep Fiber Penetration
- Conclusion

Introduction

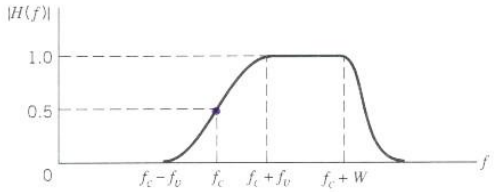
- Initially, CATV just broadcast multichannel video to home users.
- With the advent of new technology, such as RF device improvement and lightwave technology, CATV supports not only video but many other services.

Traditional Coaxial System

- Broadcast multi-cannel analog video
- AM-VSB (analog modulation-vestigial sideband) signals.
- Frequency multiplexed
- Transmitted over coaxial cable
- 50 to 80 analog channels

Traditional Coaxial System

- AM-VSB
  - We generate a DSB-SC modulated wave and pass is through a band pass filter.



Magnitude response of VSB filter; only the positive-frequency portion is shown.

Traditional Coaxial System

- VSB modulated wave:

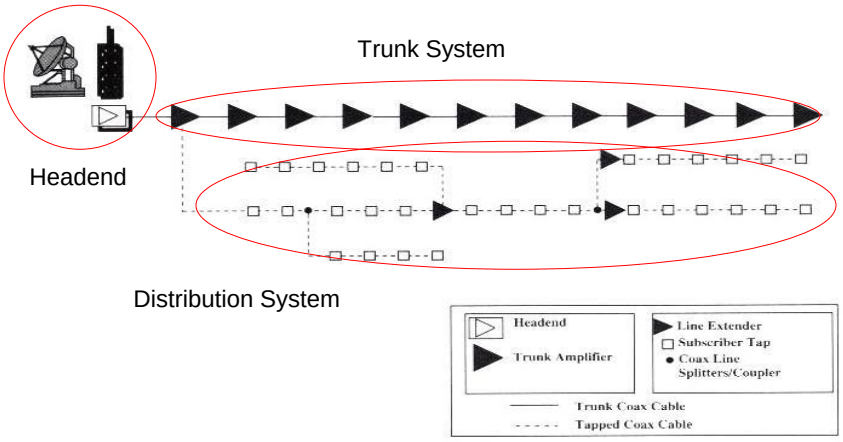
$$s(t) = \frac{1}{2} A_c m(t) \cos(2\pi f_c t) \pm \frac{1}{2} A_c m'(t) \cos(2\pi f_c t)$$

- Envelope detector output:

$$y(t) = A_c \left\{ \left[1 + \frac{1}{2} k_a m(t) \right]^2 + \left[\frac{1}{2} k_a m'(t) \right]^2 \right\}$$

$$= A_c \left[1 + \frac{1}{2} k_a m(t) \right]^2 \left\{ 1 + \left[\frac{\frac{1}{2} k_a m'(t)}{1 + \frac{1}{2} k_a m(t)} \right] \right\}$$

Traditional Coaxial System



Traditional tree-and-branch (point-to-multipoint) coaxial network.

Traditional Coaxial System

- Headend:
  - Served as connection point
  - Video coded with proprietary codes in TDM fashion
  - Certain processing equipment and RF-combing networks used to assemble the signals

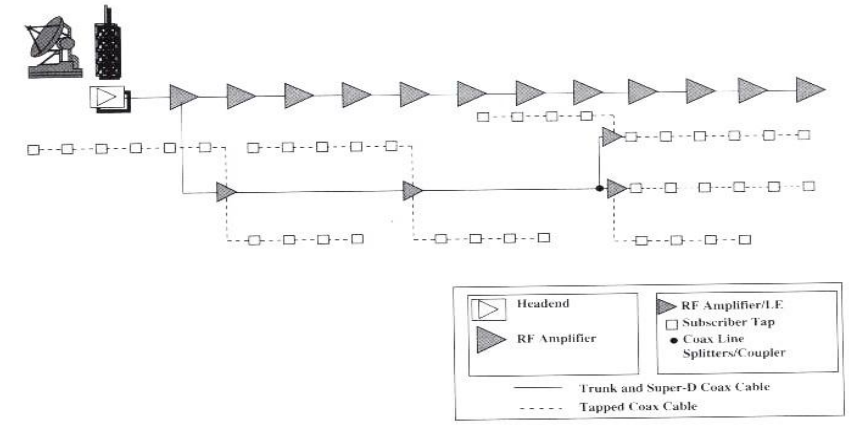
Traditional Coaxial System

- Trunk system:
  - Built for long reach but acceptable quality for distribution system.
  - Limited number of amplifiers due to noise accumulation.
  - Balance between gain and the amplifier uncertainties (thermal stability)

Traditional Coaxial System

- Distribution system:
  - Branching out from the truck system
  - Deliver adequate signal level to home users.
  - Distribution amplifiers used to cover the serving area in certain branch.
- Superdistribution system:
  - Bridger amplifier used to separate the trunk system and the tapped coax bus.
  - Better reach and reliability

Traditional Coaxial System

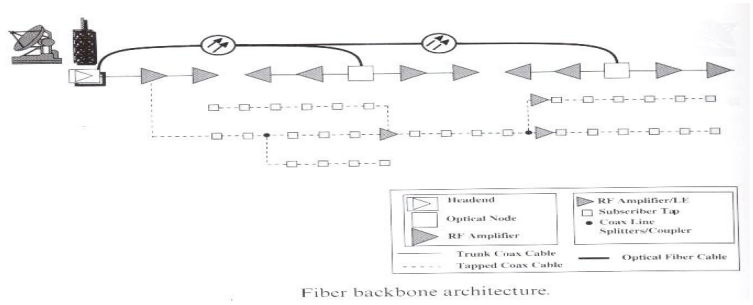


Superdistribution architecture.

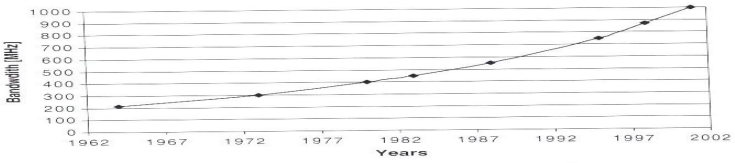
Traditional Coaxial System

- Moving to hybrid fiber/coax networks
  - Advent lightwave technology enable operator to replace coaxial cable used in the trunk system with optical fiber.
  - DFB laser with increased power, lower relative-intensity noise, and better linearity.
  - Also, external modulator, EDFA, predistortion and noise reduction further improve the system performance and reach.
  - More than 80 channels over distances in excess of 60km

Traditional Coaxial System



Fiber backbone architecture.

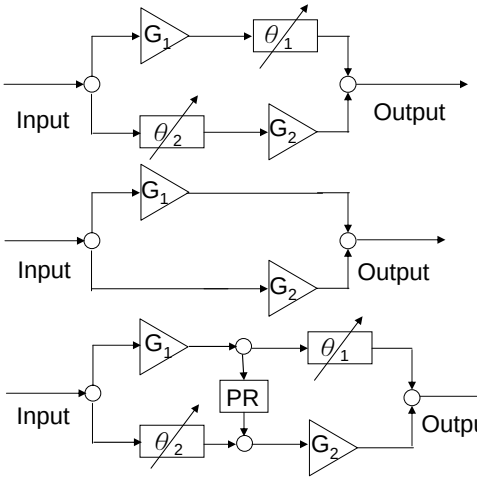


Bandwidth expansion of cable network.

Traditional Coaxial System

- RF technology
  - Progress in RF active device technology provides the ability of accommodating higher loss at higher frequency while maintaining the same level of performance.
  - When bandwidth grows from 250MHz to 700+MHz, the active devices per mile increases only from 4.0 to 5.2.

Traditional Coaxial System

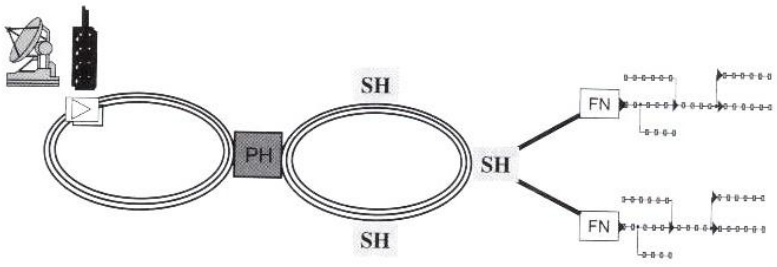


Push-Pull Hybrids

Power Doubling Hybrids

Feed-Forward Technology

An End-to-End HFC Network



A modern hybrid fiber/coax cable network.

An End-to-End HFC Network

- Metro network:
  - Mater headends connected by the metro rings are served as primary signal/content sources and interconnection points with other service providers.
  - Traditional headends are consolidated into a so-called primary ring.
  - Different transmission system based on the requirements for signal quality and on technology availability.
    - Analog FM, Analog AM, Linear PCM and SONET

An End-to-End HFC Network

  - Increasing demand on high speed data, digital video, and telephony service.
- To support new applications, two platforms are becoming more popular and competing to address these requirements.
  - SONET Multiservice Provisioning Platform (MSPP)
    - Full SONET TDM: Voice and video traffic transmitted over standard TDM channel. Packet-based IP traffic is encapsulated and framed and then transmitted over optical channel.
    - SONET-lite: TDM and packet-based IP traffic is encapsulated in frame prior to transmission.
  - Resilient Packet Ring (RPR)

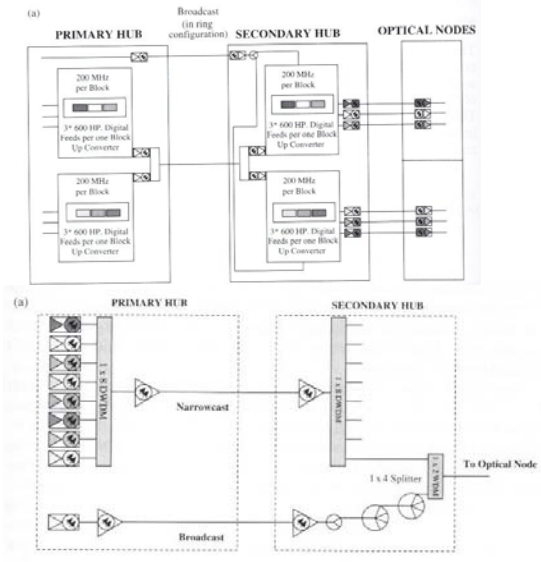
An End-to-End HFC Network

- Secondary hub architecture:
  - Secondary hubs serve as signal concentration and distribution points .
  - Two topologies commonly used in the secondary hub architecture, star architecture (ring-star-star-bus) and ring architecture (ring-ring-star-bus).
  - The ring topology enables a cost-effective and highly reliable network with a limited number of fibers between the primary and secondary hubs.

An End-to-End HFC Network

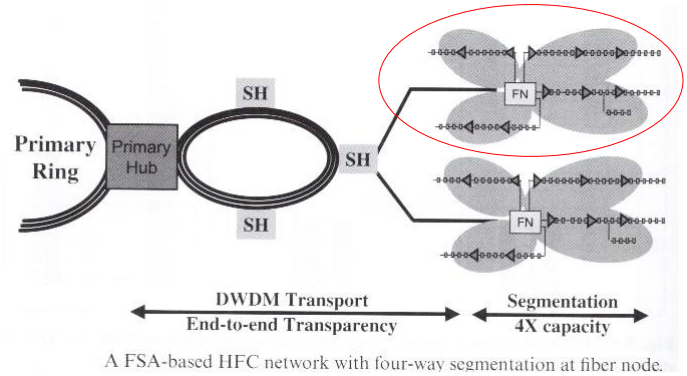
- Secondary ring multiplexing:
  - Using FDM technology: Broadcast analog and digital videos are carried by one fiber and distributed to SHs. Target services addressing each finer node are up-converted and combined at the PH over a separate fiber and down-converted at the SH.
  - Using DWDM: Narrowcast signals are multiplexed over optical wavelength instead of RF frequency.

An End-to-End HFC Network



An End-to-End HFC Network

- Access network: Fiber to the Serving Area (FSA)



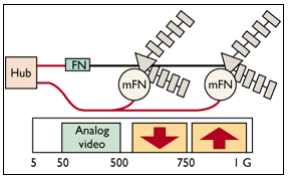
A FSA-based HFC network with four-way segmentation at fiber node.

An End-to-End HFC Network

- Each FN is the center of its serving areas covered by the FN.
- Without segmentation, the entire serving area shares the 5~42 MHz upstream band.
- With four-way segmentation, each branch occupies the entire upstream band and these signals are multiplexed at FN using DWDM technology.

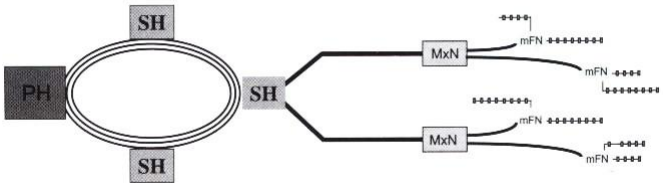
Deep Fiber Penetration

- To solve the upstream limitations, mini fiber node (mFN) was proposed.
- Each mFN contains a low-cost laser and a low-cost receiver.
- The mFNs couple directly into the coax after each distribution amplifier (i.e line extender).
- A new path for digital service without affecting analog TV services.



Deep Fiber Penetration

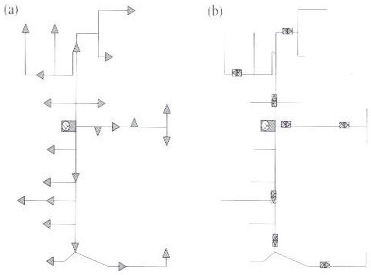
- LightWire™ for deep fiber penetration:



The LightWire™ architecture.

Deep Fiber Penetration

- Coaxial amplifiers are replaced by mFNs. Thus the maintenance of active components and power consumption are reduced. There is about 11$/HHP annular saving
- MuxNode provides mux/demux function between mFN and secondary hub.



Deep Fiber Penetration

- Oxiom™ for cost effective network expansion

Fig. 9.14 OXiom™ architecture.

  - Physical optical bus
  - Flexibility for future expansion and growth
  - Low cost of parity with that of traditional HFC
  - Logical bus or star operation can be implemented

Deep Fiber Penetration

- Logical bus operation
  - Optical splitter used at each mFN to tap off downstream broadcast signals.
  - Narrowcast and switched service with TDM
  - For upstream transmission, the RF subcarrier signals are repeated and combined at each mFN.
- For logical star operation
  - Certain in-line DWDM add-drop multiplexer used to provide one or more dedicated channel for each mFN.
  - Wavelength-specific laser can be used at each mFN.

Deep Fiber Penetration

- In the system, only the analog video from headend and upstream signals from home users are analog. Digitizing the two traffic, the high-quality linear laser can be replaced by low-cost laser and thus the capital cost is reduced.
- This needs every home user being able to receive the digital video.

Conclusion

- Initially, the cable TV system uses coaxial cable and RF amplifiers to transmit analog signals.
- With the advent of lighwave technology and deep fiber penetration, the system has larger bandwidth and provides more services.