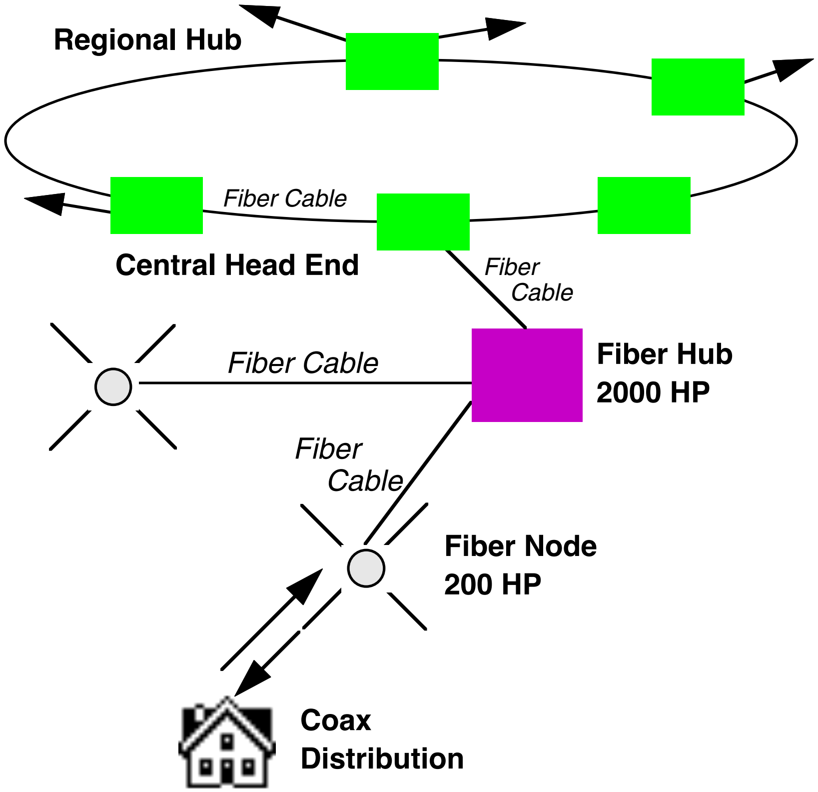
Regional Hub

Fiber Cable

Central Head End

Fiber Cable

Fiber Cable

Fiber Hub
2000 HP

Fiber Cable

Fiber Node
200 HP

Coax
Distribution

Security and Reliability of Hybrid-Fiber Coax Networks

Presentation to
IGI Exec Telecom Briefing

Homeland
Security:
IT Local
Optical Network
Opportunities

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Date October 30, 2002

Outline

HFC networks are rapidly transforming from broadcast entertainment to mission critical 2way primary telephone line & broadband internet services.

- Broadband Cable Services
- HFC Network Architectures
- Reliability Issues
- Security Issues
- Conclusion

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Broadband Cable Services Legacy Services

1st generation cable systems were simple broadcast entertainment pipes.

Entertainment

Broadcast TV

Pay per Month

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2way HFC networks facilitate multiservice broadband network offerings.

Entertainment

- Broadcast TV
- Pay per Event
- Video on Demand
- Video Games
- Pay per Month
- Near Video on Demand
- Interactive TV
- Program Guide

Education

- Interactive Training
- Distance Learning

Public Network Communications

- POTS + AIN
- Internet/WWW
- PCS
- Videophone/conferencing

Transactions and Information Services

- Home Shopping
- Travel Reservations
- Bulletin Board Access
- Banking
- Yellow Pages
- Advertising

Private Network Communications

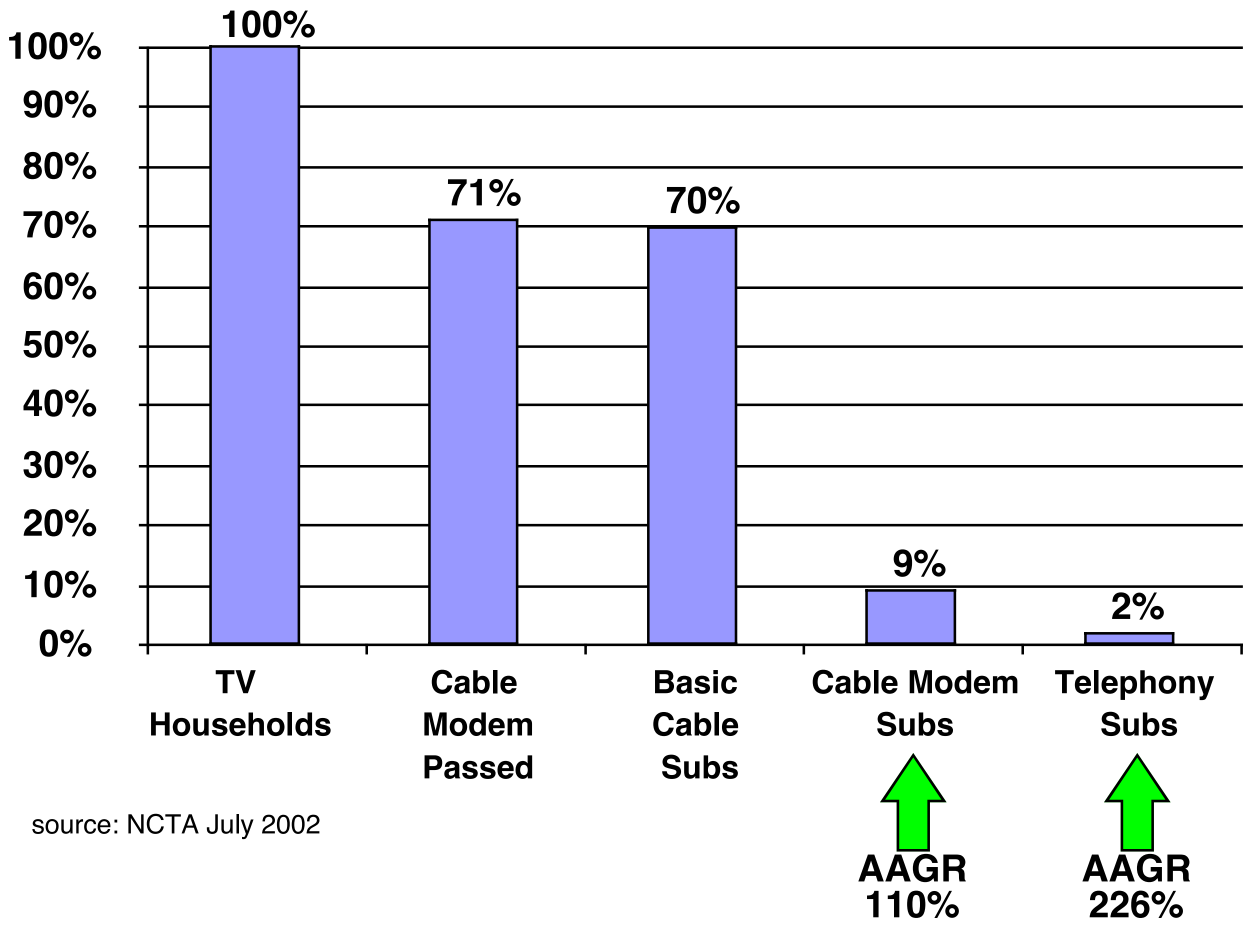
- Telecommuting
- Groupware
- LAN/WAN Access
- Telemedicine

Building Automation

- Security Monitoring
- Meter Reading
- Energy Management
- Telemetry

Broadband Cable Services USA Household Adoption

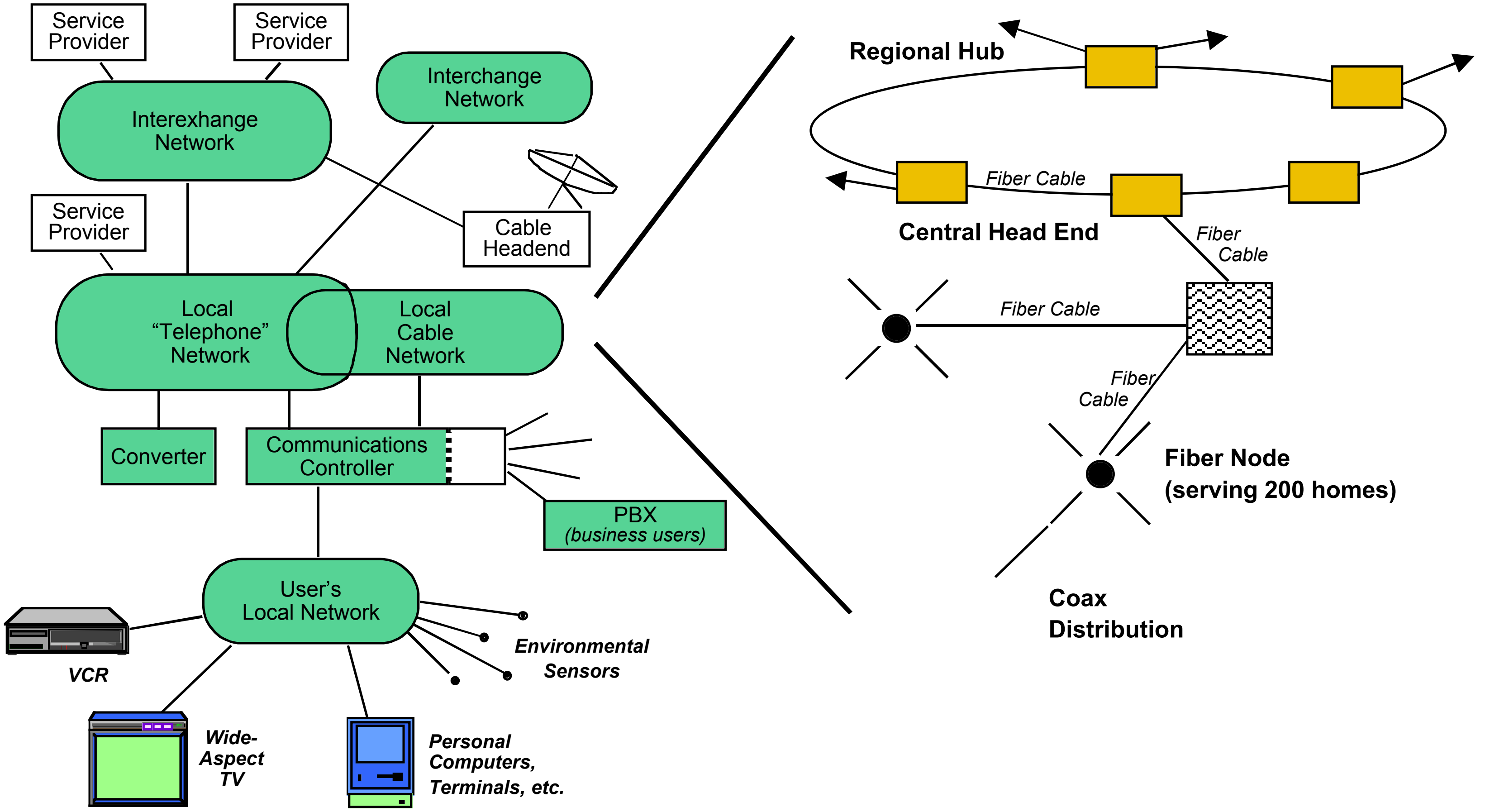
Cable modem services are already in 9% of USA households and available to 71% of the households.



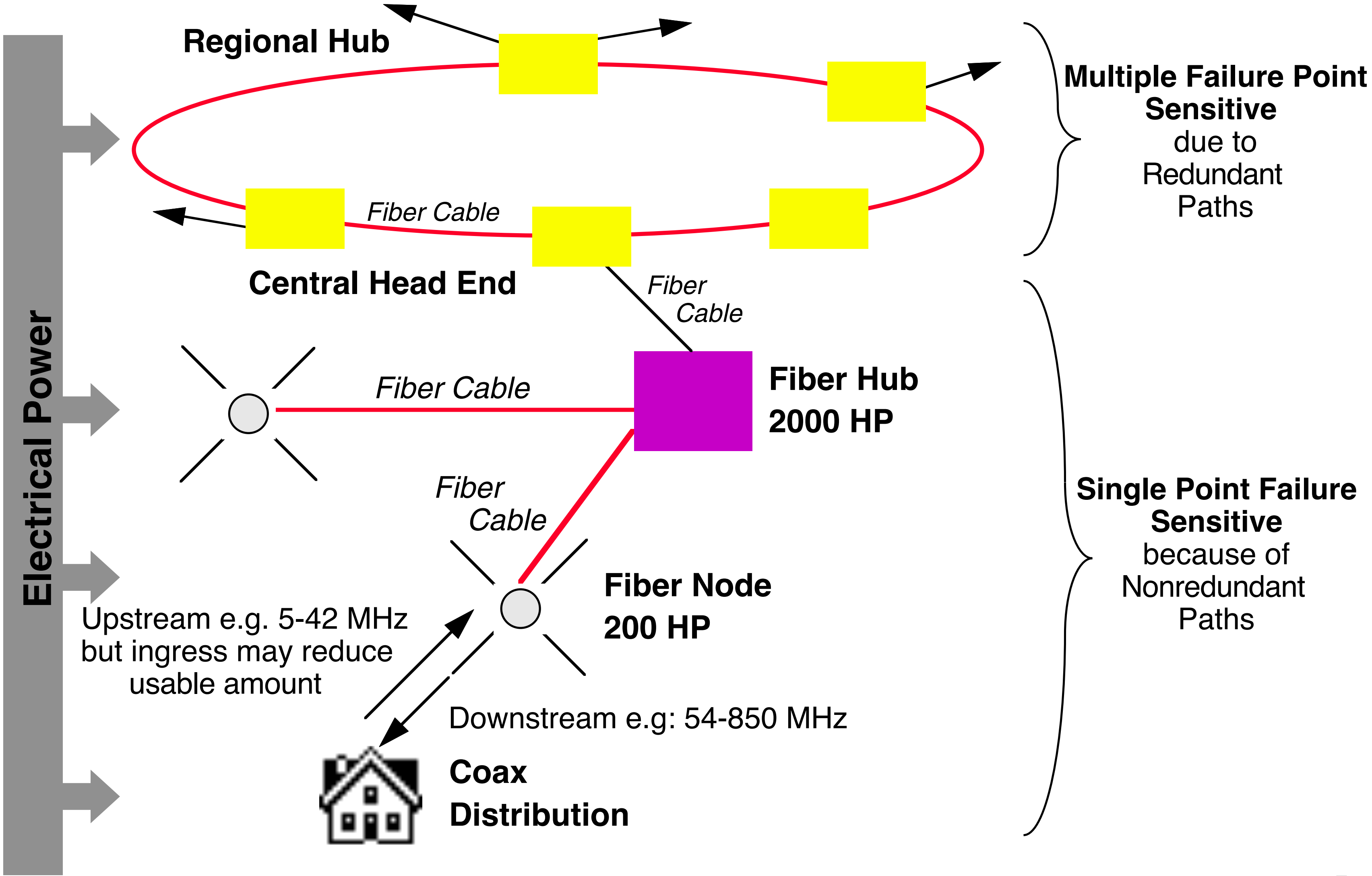
USA Households Percent Adoption of New Services

source: NCTA July 2002

Modern cable systems have become multiservice networks



Fiber is introduced into three levels of transport in the outside plant.



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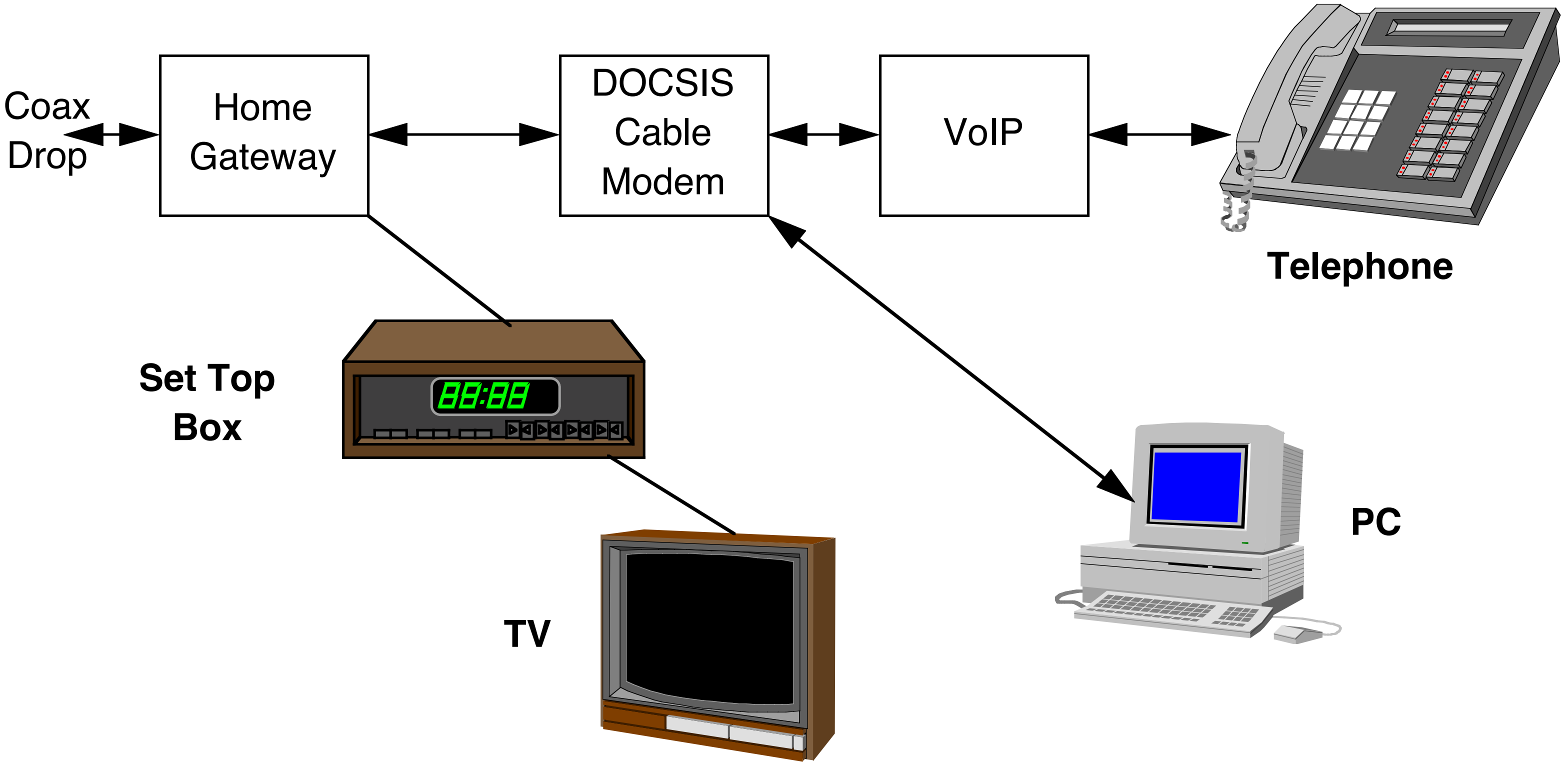
There are a variety of possibilities for service delivery but all involve a mix of analog and digital transmission to subscriber premise devices with a DOCSIS cable modem at the heart of mission critical services.



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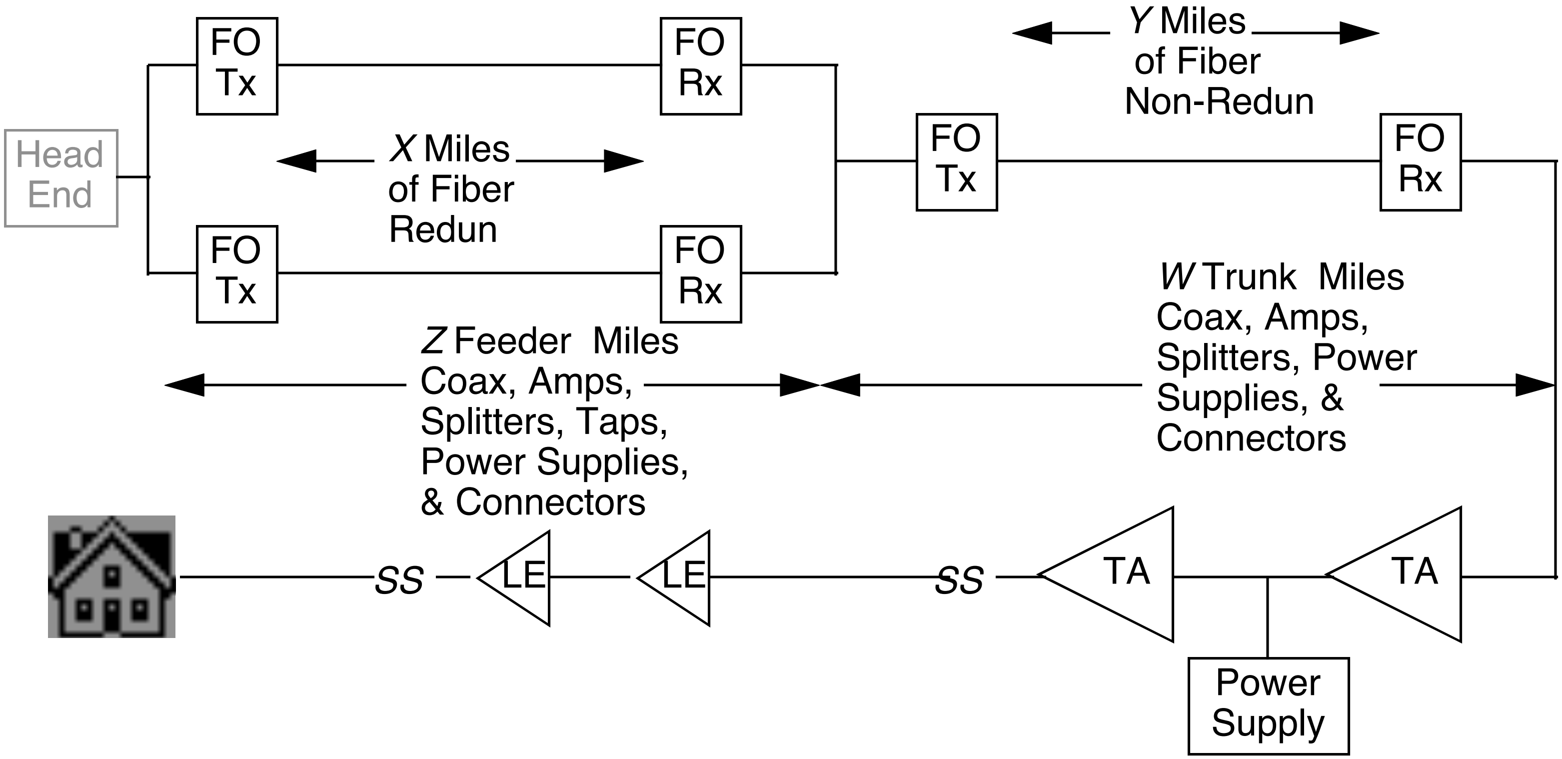
From the point of view of a single customer the reliability model for typical HFC plant would look like



Reliability Issues Benchmark for Voice Telephony

Although LECs use different technology, with a different architecture, different topology, and different mode of use; they are still a yardstick by which HFC networks will be compared. Typical annual performance is:

Component of Fiber-in-the Loop Local Access Plant *	Minutes Unavailable
Fiber	6
Host Digital Terminal	10
Optical Network Unit	26
Other	11
Total	53 (0.01%)

* Bellcore TA-NWT-000418 and TA-NWT-000909

Notes:

1) Does not include unavailability due to electric utility power failures
2) Access plant only, does not include switch, drop, or in-home failures

The LEC perspective is a yardstick that will be used, but it is not entirely suitable to measure an HFC network with video and other multimedia services due to:

- Differences between LEC star/star vs. HFC star/bus architectures the number of customers impacted due to a failure varies
- Higher usage rate of video vs. voice telephone sessions, a video failure will be more noticeable to consumers
- Distributed actives and distributed powering, the impact of an electric power utility outage will have a greater consequence
- Significant differences in series actives in coax portion between the nearest and farthest customers, the customer’s reliability perspective will vary

Stating with the LEC 53 minutes/year there are a number of possibilities

- Adjust for notice-ability
- Weight by number of customers impacted by a failure (e.g. total customer minutes of outages)
- Scale by actual LEC performance (they don’t actually meet the 53 minutes)
- Use worst case for HFC farthest customer
- Adjust for differences in HFC sensitivity for power failure

However we suggest the use of a term called *Downtime Factor*

- Downtime factor= average of unavailability for nearest and farthest customer without consideration of power failures
- Consider HFC plant comparable to LEC access plant=>up to but not including HeadEnd and up to and including the Tap but not including the drop and beyond

The basic theory for parallel and series structures is

- Individual availabilities and unavailabilities were computed for each component:
  - A=MTBF/(MTBF+MTTR)
  - U=1-A=MTTR/(MTBF+MTTR)
- The availability of a series structure (from a reliability standpoint) is the product of the component availabilities.
- The unavailability of parallel structure (from a reliability standpoint) is the product of the component unavailabilities.

There are four categories of assumptions that need to be made

- Component failure rates
- Component repair times
- Design rules for number and spacing of components
- Electric power reliability and impacts

The mean time to repair (MTTR) has several contributions

	Duration
Time to recognize outage (customer call-in or network monitor reporting)	15 minutes typical (without network monitoring)
Time to locate and dispatch appropriate crew (call-in crew after hours or reassign a crew from another location)	30 minutes maximum (field failure)
Travel time	45 minutes maximum
Time to troubleshoot and locate fault	45 minutes maximum (this may include waiting while preempted by other emergency crews, e.g., police, fire, electrical utility)
Time to repair or replace defective component (based upon temporary service-restoration or repair of active components only)	Estimated from several minutes to several hours depending upon problem

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Failure rates are based on a composite of field data from several sources while repair times are based on discussions with several MSO’s not using status monitoring

Component	Failure Rate (%/year)	MTTR/HE (hours)	MTTR/Plant (hours)
FO Tx	2.33	1	2.5
FO Rx	1.396	1	2.5
Fiber/mile	0.439		4.5
Trunk Amps	0.514		2.5
LE Amps	0.599		2.5
Split/Coupler	0.13		3
Tap	0.13		3
Hard Connector	0.28		3.68
Coax/mile	0.439		3.5
Power Supply	2		2.5

Consistent with The *Bellcore Yardstick* we do not include power impacts but do note that with typical 2-4 hour HFC backup, power impacts will likely dominate reliability

Backup Provided	Average Downtime (Net of Backup Time)	Percent Event Coverage
No Backup	370 minutes	0%
4 Hours	235 minutes	99.96%
8 Hours	200 minutes	99.97%
12 Hours	186 minutes	99.98%

Source: Black, Spencer, & Dorr (based on Best Power Data)

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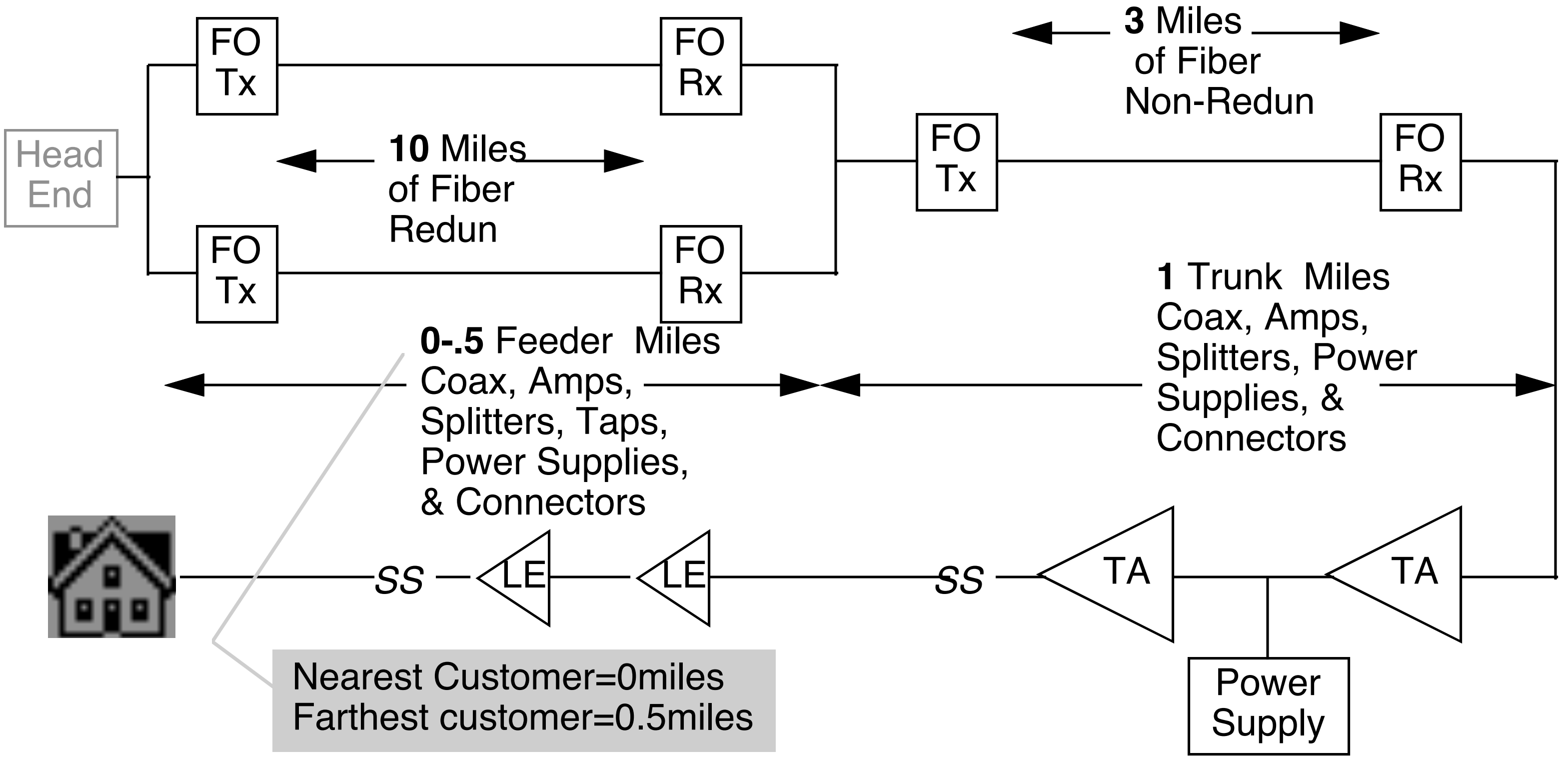
An example provides perspective on typical numbers



Our calculated results yields an unavailability of 32-50 minutes or DTF=41 minutes-- comparable to the LEC 53 minute number.

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Security Issues Introduction

This is an area we have studied less than reliability but the general nature of threats should fall into the following categories.

- Denial of service attacks
- Information privacy
- Theft of service
- Subscriber authentication
- Rights management violations

Security Issues Denial of service attacks

This is an area we have studied less than reliability but the general nature of threats should fall into the following categories.

- Denial of service attacks
- Information privacy
- Theft of service
- Subscriber authentication
- Rights management violations

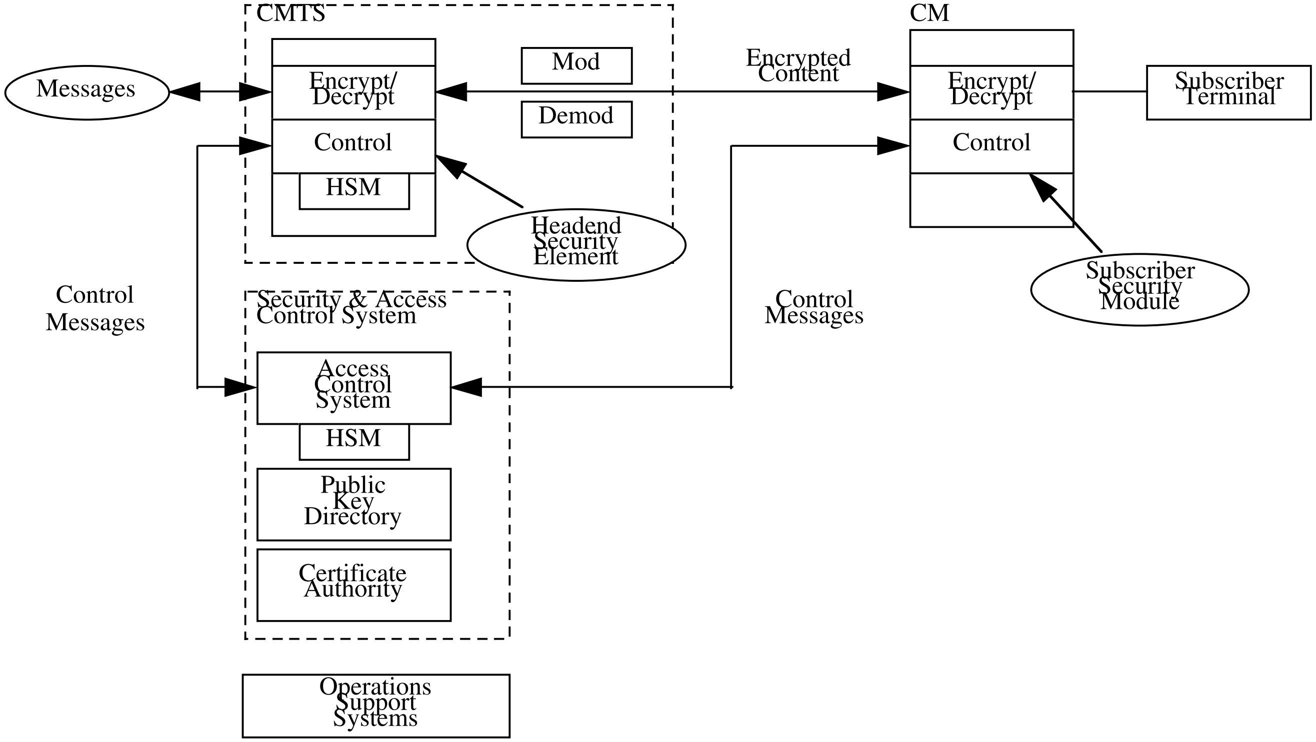
- Physical damage to outside plant
- Signal injection into the return path
- IP traffic storms

Security Issues Information Privacy

This is an area we have studied less than reliability but the general nature of threats should fall into the following categories.

- Denial of service attacks
- Information privacy
- Theft of service
- Subscriber authentication
- Rights management violations

- 1st Generation cablemodems did not employ privacy safeguards
- Current DOCSIS modems include baseline privacy and have options for plug in modules



Security Issues Information Privacy

This is an area we have studied less than reliability but the general nature of threats should fall into the following categories.

- Denial of service attacks
- Information privacy
- Theft of service
- Subscriber authentication
- Rights management violations

- DOCSIS provides some safeguards for terminal but not subscriber authentication

- In general these are topics not yet well addressed for advanced cable services

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Conclusions

Today’s cable network have evolved well beyond 1st generation entertainment centric networks, but are not yet hard to threats.

- Denial of service is possible via a number of entry points
- Reliability of the HFC networks is otherwise comparable to LEC outside plant
- Information privacy is well addressed for IP traffic over DOCSIS networks
- As these networks start to carry “on-demand” valuable content capabilities for rights management and transaction authentication will need to be upgraded

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Abstract

Not very long ago cable TV service providers were employing simple tree and branch, all metallic coaxial cable networks to deliver one way entertainment video content. While these first generation networks were neither reliable or secure, the nature of the content did not require anything more. However, today's networks are have largely become two-way and are configured with hybrid combinations of fiber optics (HFC) followed by short runs of coaxial cable to the subscriber. While the bulk of the today's traffic is still largely video entertainment, there is a significant use for high speed cablemodem access to the internet, and plans are well underway to provide primary line voice telephone services. This presentation will describe modern HFC architectures and point out the features being deployed to enhance reliability. The security issues and weaknesses of these networks will also be identified both in terms of privacy as well as robustness to attack.

About the Author

Stuart Lipoff is a partner at the technology and management consulting firm of Applied Value (AV) where he is responsible for the firm’s practice in communications, information technology, media, and electronics. He assists clients to develop business plans and product strategies where technology is a key factor in the success of the venture. His clients include service providers and manufacturers in media, cable TV, consumer electronics, and wired/wireless communications. Prior to joining AV, Mr. Lipoff spent 25 years at Arthur D Little as VP in The Technology and Innovation Division preceded by 7 years at Motorola and Bell & Howell in wireless communications equipment R&D. Among his accomplishments are leadership of projects that developed the hybrid fiber coax architectures in cable TV, developing the international standards for DOCSIS compatible cable modems, a co-inventor of Commercial Free technology in today’s VCRs, and developing the recommendations just adopted by the FCC to accelerate the introduction of digital television in the US marketplace. He is currently working on projects looking at digital rights management technologies for the secure electronic distribution of valuable content and also exploring business opportunities in telematic services.

Stuart Lipoff has BS degrees in EE and Engineering Physics from Lehigh University, an MSEE from Northeastern, and an MBA from Suffolk University. He is an IEEE Fellow, past president of the IEEE Consumer Electronics Society, a current member of the CE Adcom, and present chair of the IEEE CE standards committee. Other IEEE activities have included chair of The Boston Fall 2000 Vehicular Technology Conference and organizer/lecturer of an IEEE Boston short course on fiber optics technology. He is a registered professional engineer in Massachusetts and holds a Certificate in Data Processing (CDP) from the ACM sponsored ICCP.