WDM Video Overlays on EFM Access Networks

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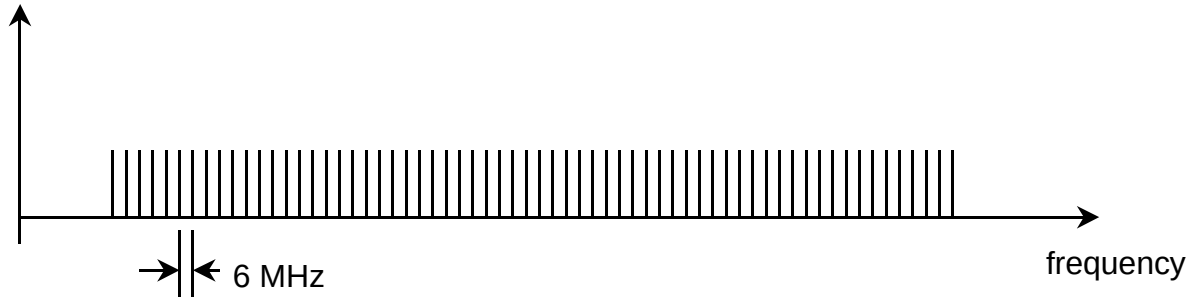
Main points of presentation

- Respond to reflector discussions on this subject.
  - Review HFC technology and its application to all-fiber access networks
  - Address technical concern areas
  - Set the stage to provide details
- WDM video overlays have been widely deployed in P2P and P2MP topologies
- A WDM video overlay provides significant advantages for service providers

Analog video modulation

Analog video information is encoded on discrete RF sub-carriers (channels):



For NTSC-80: channels range from 50 to 550 MHz
For NTSC-110: channels range from 50 to 750 MHz
For PAL-80: channels range from 50 to 870 MHz
(with 8 MHz separation)

The other QoS: Quality of Signal

- Transmission quality criteria: noise and distortion
- Carrier to noise ratio, CNR
  - > 55 dB for supertrunking
  - > 47 dB @ Home for no “snow”
- Intermodulation distortion: Composite second order, CSO, and composite triple beat, CTB
  - <- 65 dBc for supertrunking,
  - < -54 dBc @Home for no “lines”
  - also referred to as “linearity”

CTB, CSO

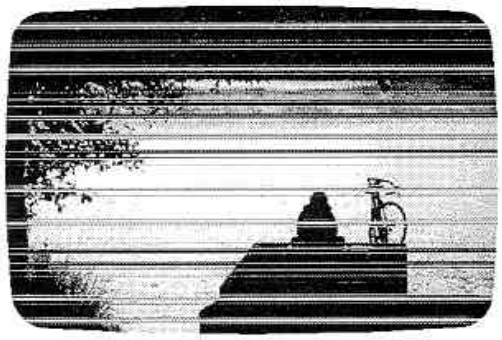


Figure 76. Composite triple beat that often appears as horizontal streaks covering one or more lines of video.

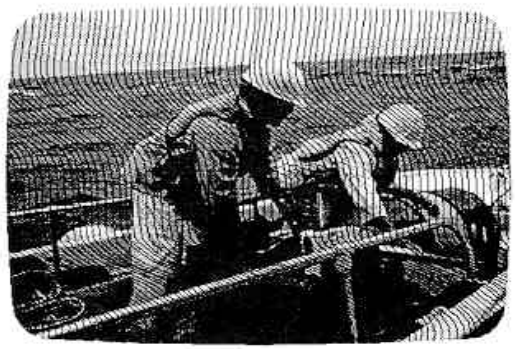


Figure 77. Composite second-order distortion that usually appears as swimming diagonal stripes in the TV picture.

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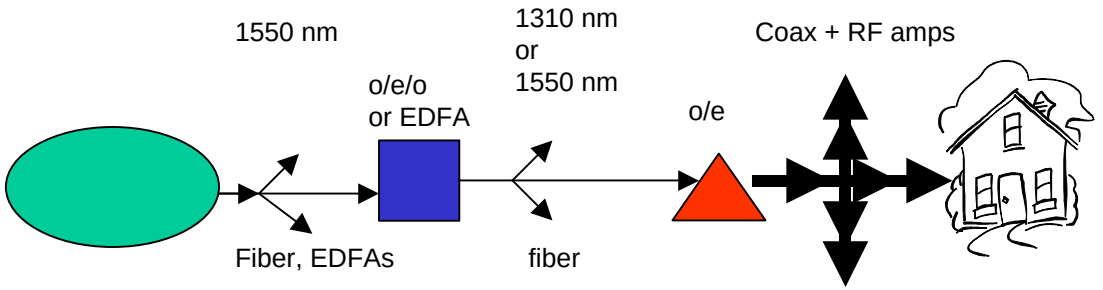
Classic HFC system:



	HEADEND	HUB	NODE	HOME
CNR		54 dB	52 dB	47 dB
CSO, CTB		65dBc	62 dBc	54 dBc

NODE to HOME link contributes 48.7 dB CNR, 55 dBc CSO

RF amplifiers produce most of the noise and distortion

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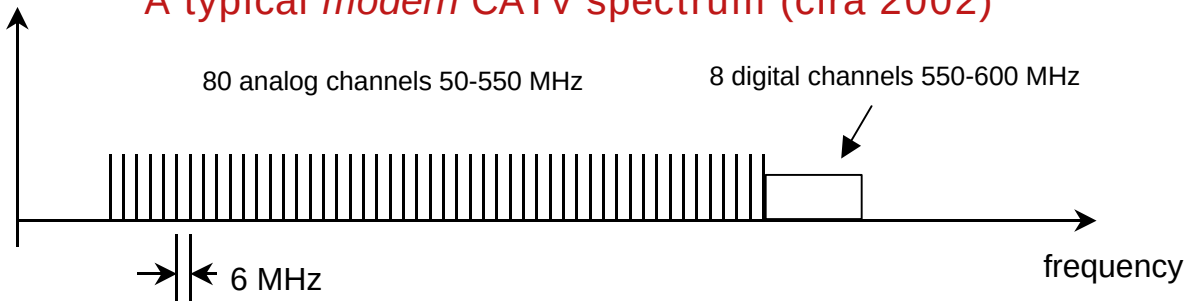
Digital Video (and data)

A typical *modern* CATV spectrum (cira 2002)



Digital Channels:

- Contain downstream cable modem traffic and digital video
- Are 64- or 256-QAM modulated
- Are spectrally efficient
  - A 6-MHz 64-QAM subcarrier carries 28 Mb/s of data
- Are much more robust than an analog channel
  - Require much lower CNR, CSO, CTB
  - MPEG compression + statistical multiplexing allows > 10 video channels to be delivered on a single 6 MHz RF subcarrier

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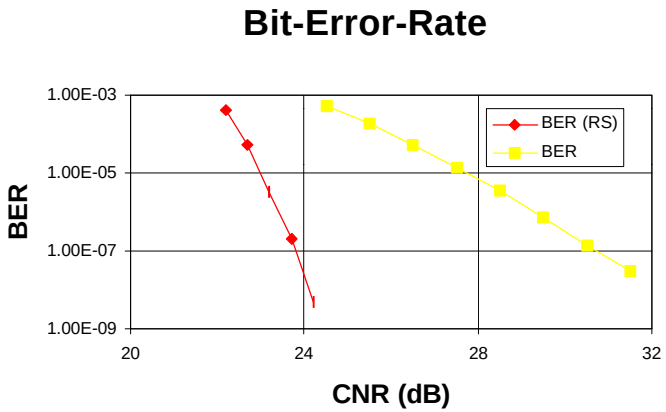
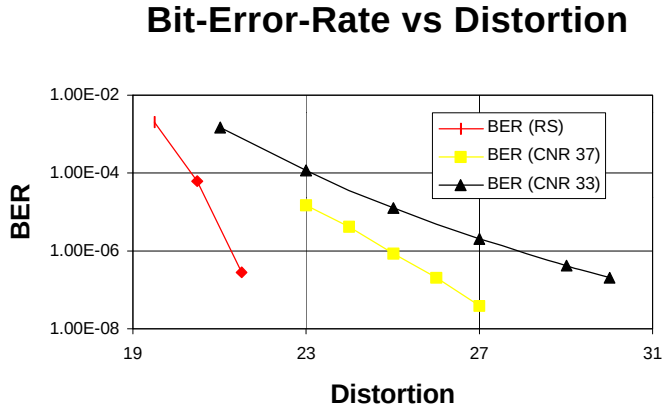
64-QAM data





64-QAM

With FEC, 10^{-9} BER can be achieved with CNR, distortion at 30 dB(c)

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SCM Video in FTTx

- Typical HFC deployments require (CNR/CSO/CTB) 55/65/65 optics
- Analog video in FTTH architecture requires 47/54/54 optics
- Digital (subcarrier multiplexed) video in FTTH architecture requires 30/30/30 to 40/40/40 optics
  - (depends on modulation order, FEC and design margin)

The all-fiber network and use of digital video make the optical requirements significantly less demanding compared to traditional HFC

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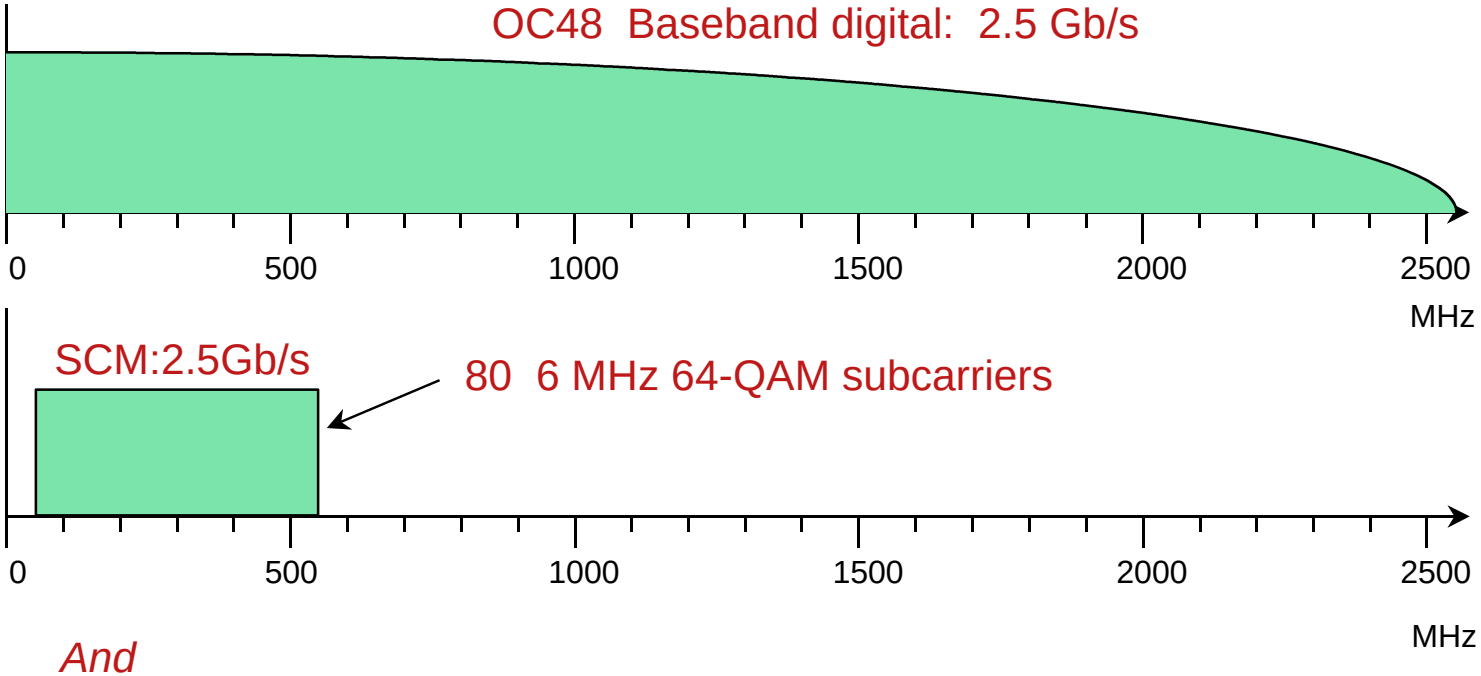
Subcarrier multiplexing is the most efficient use of bandwidth



And

the demodulation electronics (set top boxes, cable modems) are produced and used in commercial volume

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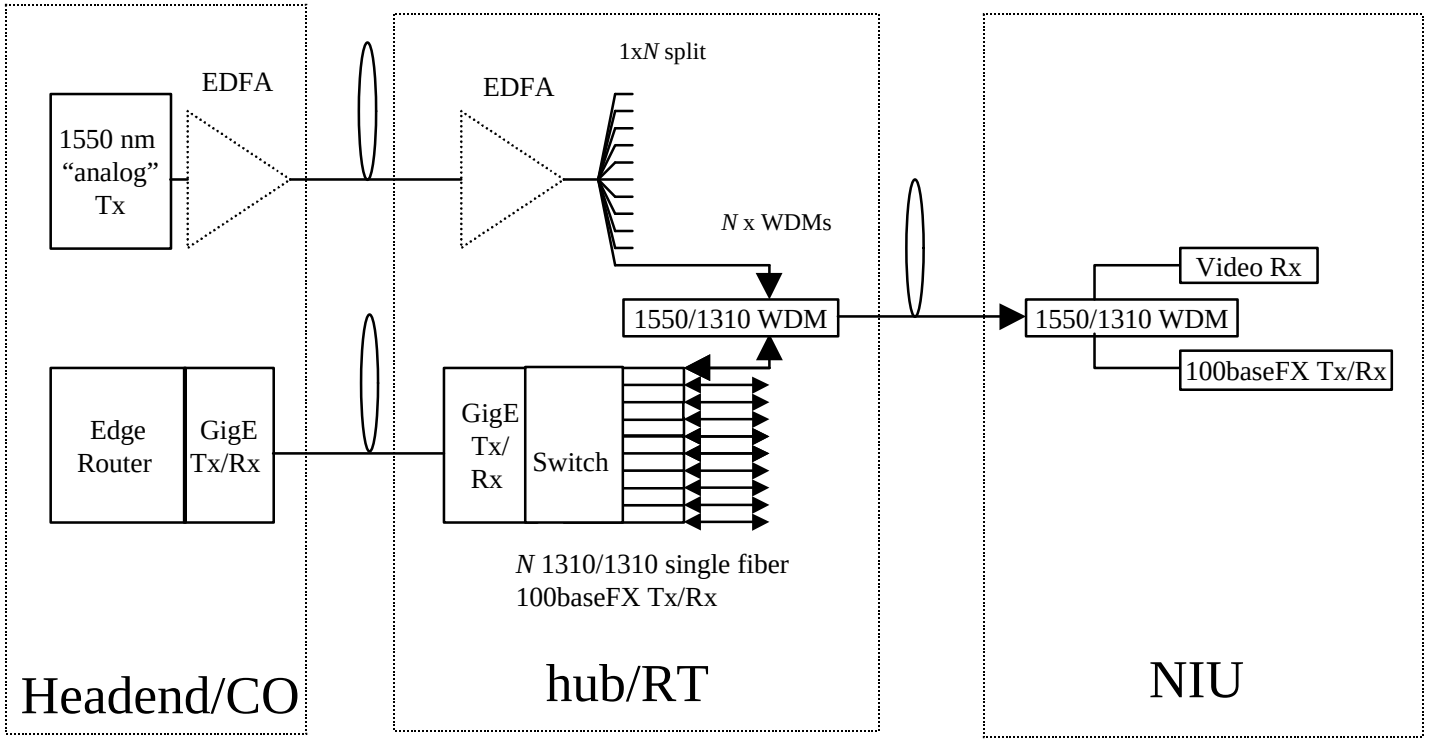
The video overlay - how?

- A broadcast video network can exist in the same physical plant as an existing P2P or P2MP EFM network

by the use of WDM

Video PON w/ P2P EFM network



A US ILEC has widely deployed this in a FTTC architecture
(*replace EFM with ATM*)

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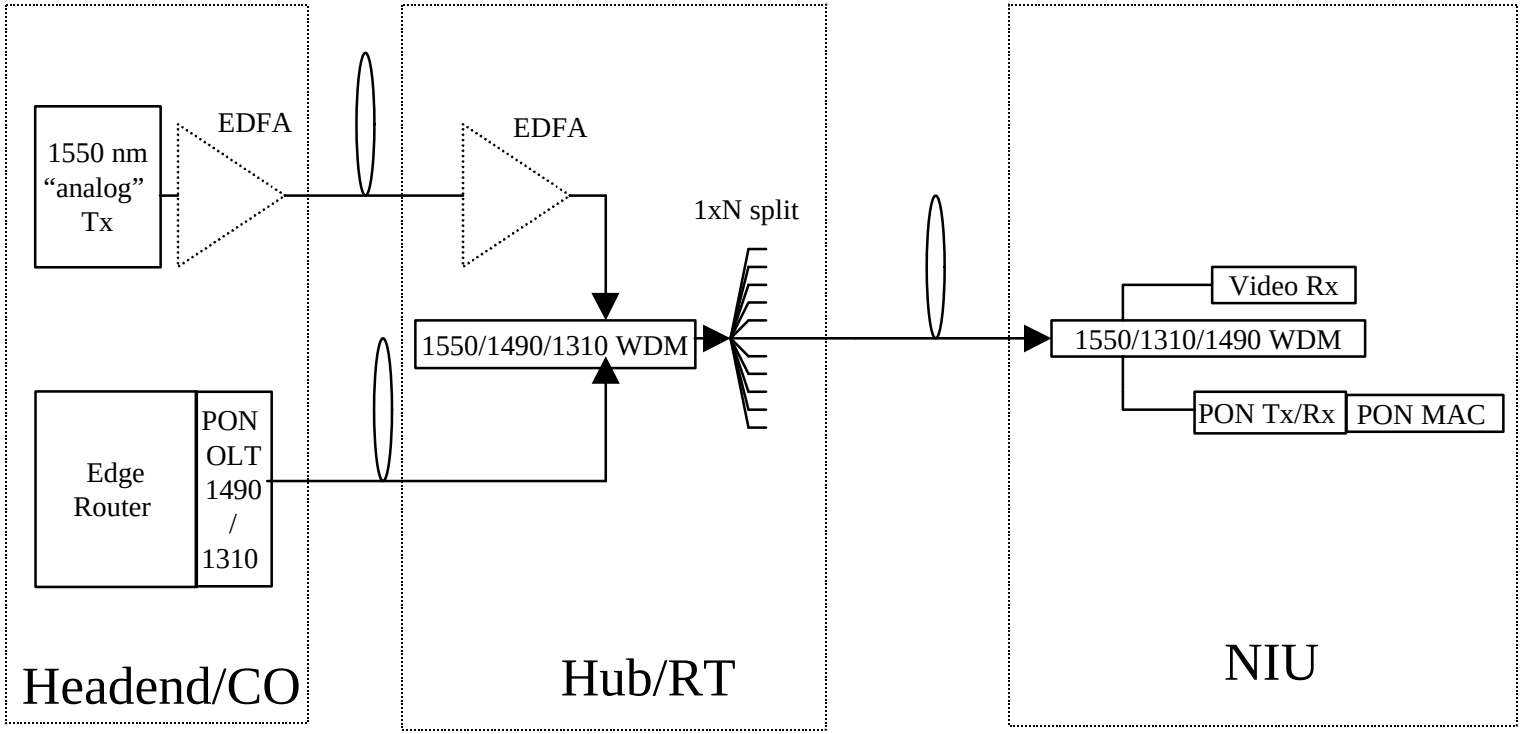
Video PON with P2MP EFM network



Technical issues

- Review issues
  - Solutions exist
  - Technical details can be discussed off-line or in future presentation
- Issues are
  - Optical power for video receiver
  - Optical isolation requirements for WDM at NIU
  - Raman Crosstalk
  - Double Rayleigh Scattering

“Analog” receivers require more power than digital receivers

$$\frac{\text{Carrier}}{\text{Noise}} = \frac{(\text{modulation index})^2 I_{\text{photo}}^2}{B_e (i_{\text{thermal}} + 2eI_{\text{photo}} + (\text{RIN}) I_{\text{photo}}^2)}$$

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Isolation requirements

- High power analog signal cannot leak into low power digital signal.
- Low power digital signal cannot leak into analog receiver and raise noise floor.

Raman Crosstalk

Double Rayleigh scattering

- Multipath interference creates noise floor which effect predominately the low frequency channels.
- MSOs *always* use angled connectors to reduce back reflections
- Telcos seem allergic to angled connectors
- Flat connectors work fine *as long as proper craftsmanship is followed*.
- Video overlays widely deployed with flat connectors.

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Why does a video overlay make sense for service providers ?

- The “analog” TV is the most common residential gateway in the world.
- Digital set top box volume driven by CATV applications - digital tiers and video on demand
- Digital SCM technology is amenable to HDTV
- Broadcast video is a proven market with proven revenue.
- But, it’s a new / unfamiliar business for some
  - Telcos

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Video is the bandwidth hog

Applications	**Example worst case scenario**	**Generated traffic, DL (Mbps)**
TV & VoD	2 * HDTV (20Mbps/ch) + 2 TV (5Mbps/ch)	50
Video Conferencing	~2Mbps	2
Web browsing	<10Mbps	10
Streaming sound	CD quality (200kbps)	0,2
Telephony	~100kbps	0,1
Approximate total		**62,3**

Source: Ericsson P2P

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The big payoff

- Broadcast video (“analog” or “digital”) is very bandwidth efficient
- “Switched” video is a bandwidth hog.
- If video is the dominant bandwidth application, use of an overlay can relax bandwidth requirements on an EFM network, enabling
  - lower cost
  - more splits
  - more distance

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Wavelength Allocation

- 1550 -1560 nm (G.983.3) for video overlay is fine.
- *However,* realize that a video overlay may use more than one video wavelength to
  - Enable optical narrowcasting
    - for targeted video services
    - segment the video broadcast
  - Increase the CNR
- The 1550 - 1560 nm band will accommodate multiple wavelengths

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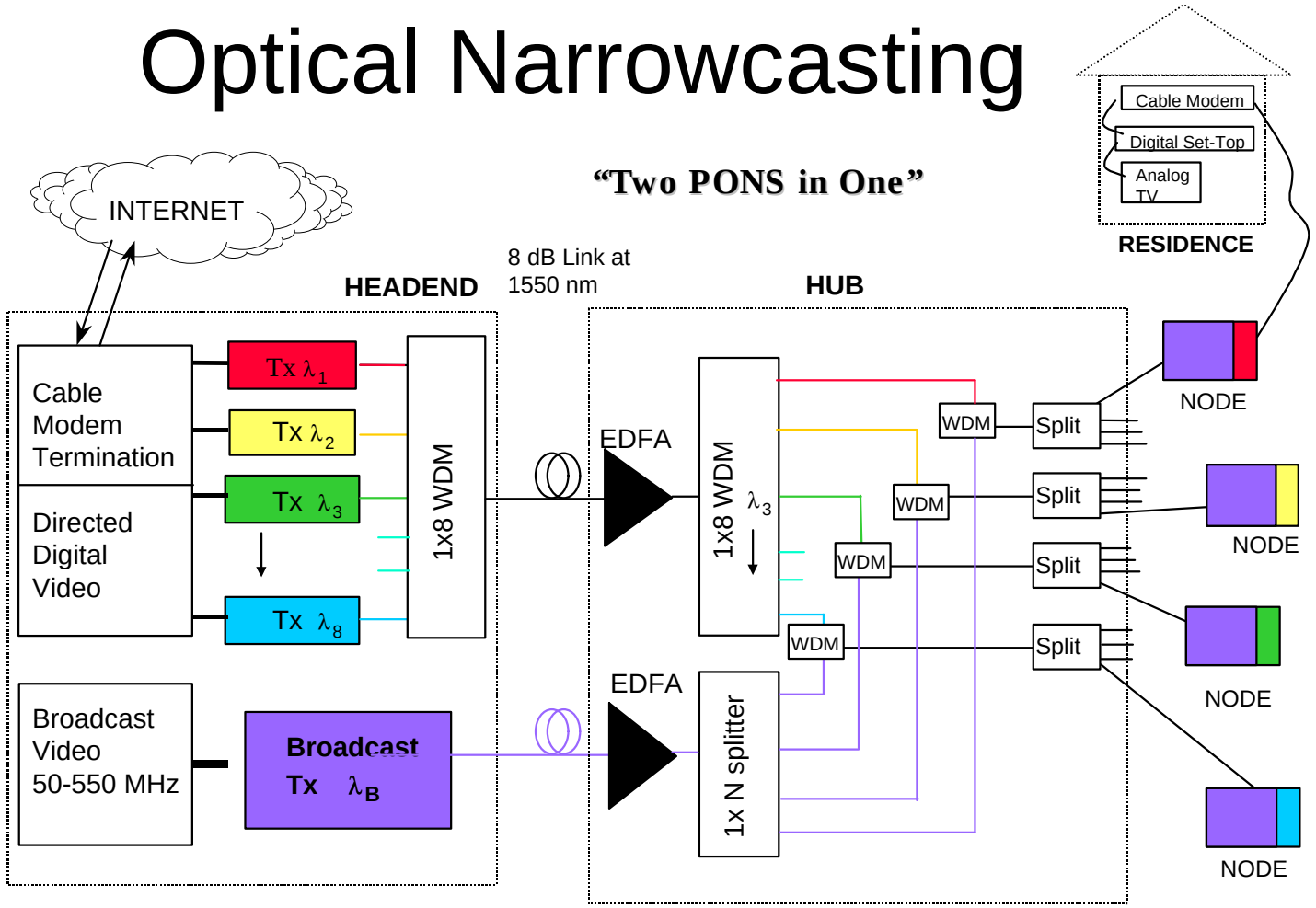
Optical Narrowcasting



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