

Passive Metro WDM: “Capacity on the Cheap”

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How It Works

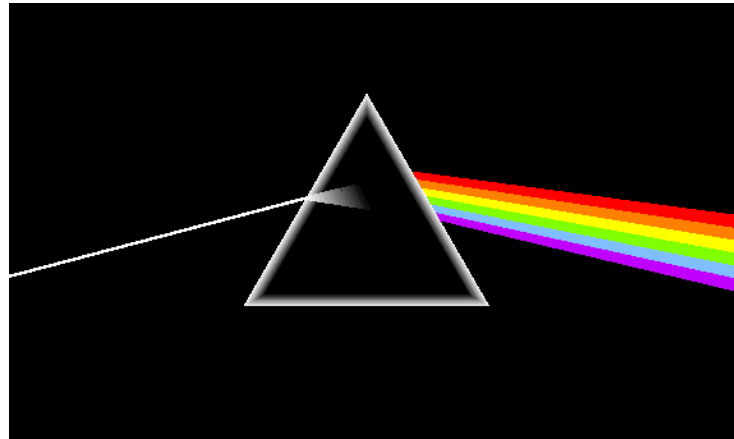
(a/k/a “Whut it dew?”)

- Single Mode Fiber: multiple wavelengths (also called “colors” or “lambdas”) coexisting separately
- Pluggable optics as enabler
- Low cost for passive optical equipment (particularly grey-market)

Why WDM in the Metro?

- “In my country, there is problem, and that problem is transport”
- Reasonable cost of dark fiber IRUs: often comparable to NRC/MRC for gigabit wave (“lit service”) between carrier hotels.
- Low capex/opex; good tool for fiscally-responsible regional networks looking to upgrade backbone capacity.

How does it work?



Spectrum Bands:

O band - Original - 1260 to 1360

E band - Extended - 1360 to 1460

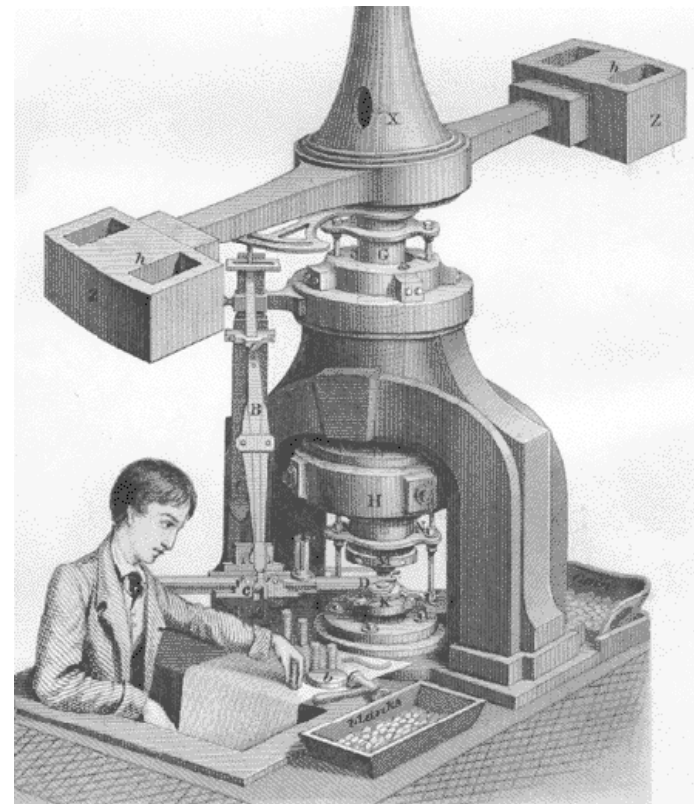
S band - Short - 1460 to 1530

C band - Conventional 1530 to 1565

L band - Long wavelength 1565 to 1625

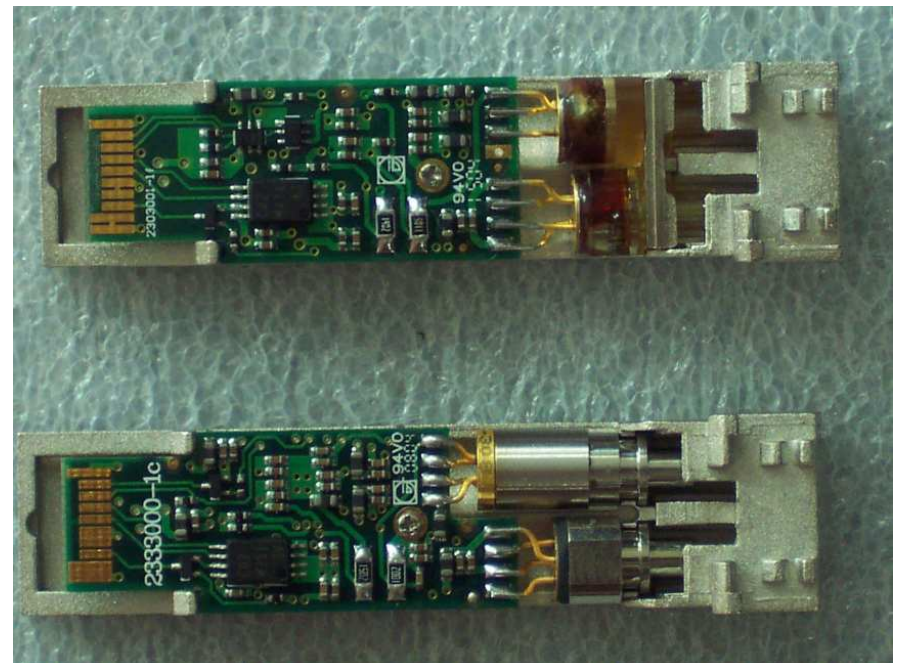
Implementation Options

- Active WDM (Cisco 15xxx, Ciena, Movaz, ... many new entrants)
- Passive WDM using optical filters
 - Self-assembled patch panels ----->
 - Complete systems (CUBO)



This talk is useless without PICs

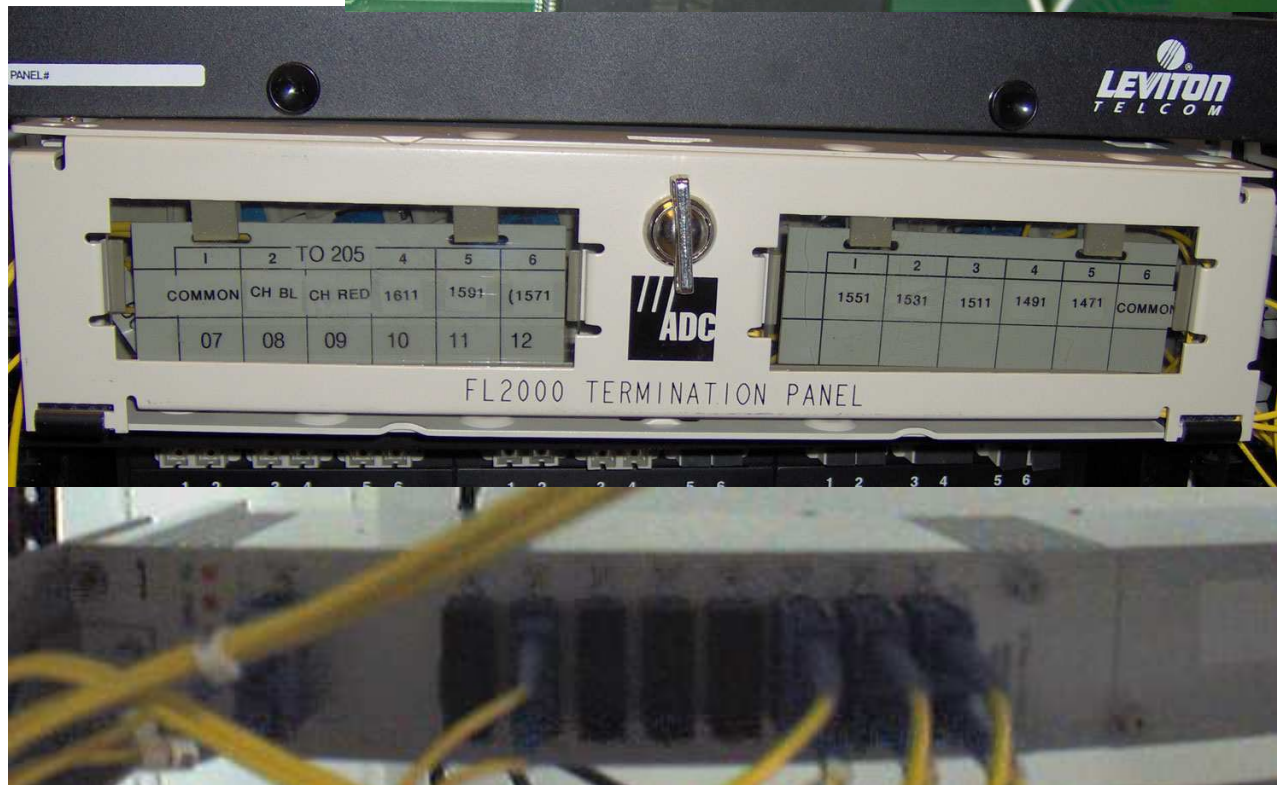
- GBIC/ SFP Transceivers



Components:



Assembled:



GWDM* / WWDM

- Wideband Multiplexing (1310/1550)
- 2 GE fdx per pair, 1 GE fdx per strand
- Single Strand networking: the receiver is *always* wideband
- Low cost for transceivers (LX/ZX, <500\$)
- Low cost for splitters (<100\$)
- 10GE possible (ER/LR)

* Ghetto Wave Division Multiplexing

Active xWDM

- Beyond the scope of this discussion.
- Everybody knows how to do (active) xWDM by giving a lot of money to [insert vendor of choice]; we're here today to talk about doing it in a financially responsible manner.

Passive CWDM

- Wavelength range: 1470-1610 'conventional', 1270-1470 'low range'
- Water Peak Dispersion (1370-1450)
- Optical Component vendors: CUBO, Taiwanese hardware manufacturers
- Cost: ~1000\$ per strand per end for CUBO
- 300-1000\$ per GBIC, depending on quality
- No XENPAKs readily available
- Low availability on 'low range' GBIC/SFP

Passive DWDM

- Different bands due to amplification requirements
- Largest potential capacity (0.8nm at 100Ghz per wave, 120nm wide)
- Systems available with 25Ghz spacing
- Research at 12.5Ghz spacing
- “ITU Grid”
- C-band, L-band
- XENPAKs available, 9000\$+
- Few available GBICs, 1500\$+

Filters

- Build / Add as you grow by mixing and matching
- Available in various ranges (center wavelength, bandpass width)
- Going from GWDM to GWDM/CWDM to GWDM/CWDM/DWDM

Testing and Management



- Optical Power Meter
- Communication is key ----->
 - OOB access: HOOTS, Cell Phone, ...
 - You need to talk site-to-site to coordinate – what if cell phones depend on your fiber?
- Optical Power Monitoring / APD receivers in GBICs ('show interface blah trans')
- Spectrum Analyzer

Caveats

- Few complete commercial systems available
- Systems require glue (and duct tape) to put together
- Need to tune with attenuators if signal is too strong, attenuators differ with wavelength
- Flaky GBIC / SFP vendors
- Small-time passive optical vendors
- Expensive equipment for testing (spectrum-analyzer, light sources, etc)
- Lack of operational expertise (get hit by a bus)

Exotic Options

- Circulators (same wave both directions)
- Interleavers (half the light, double the wavelengths)
- CWDM light into DWDM channel (similar to above)
- 10GE LX4 / LR multiplexing
- Future NANOG talk?

Simple Economics

- 2 GE GWDM: ~1k\$
- 8 GE CWDM: ~5k-10k\$
- 2*10GE GWDM: ~5-10k\$
- N*10GE DWDM: N*10k\$
- Prices include passive and active components, per end, fdx over one pair
- Contrast with commercial systems (Ciena, Cisco 15xxx) – an order of magnitude lower



Vendors



- CLOUDY YAYA, ORIENT DONG, CAROL SO – “grey-market” GBIC/SFP transceivers
- Agilestar – GBIC/SFP
- GlzTech.com (the “Doctor of Fiber Optics”) – filters and misc. components
- OEMarket.com – filters and misc. components
- CubeOptics.com – filters, GBIC/SFP, systems
- MRV – filters, GBIC/SFP, systems (pricey)
- Owl-Inc.com – HOOTS™, Optical power meter

Vendors (continued)

- Metro Platform (L2 switch; N * pluggable optical needed):
 - Extreme Summit x450
 - Riverstone 155xx
 - Cisco 49xx/65xx/76xx Series
 - Foundry BigIron
- Passive optical equipment makers: AOC, Avanex, E-TEK

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Questions?

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