

# Metro WDM, part 2: “**More** Capacity on the Cheap”

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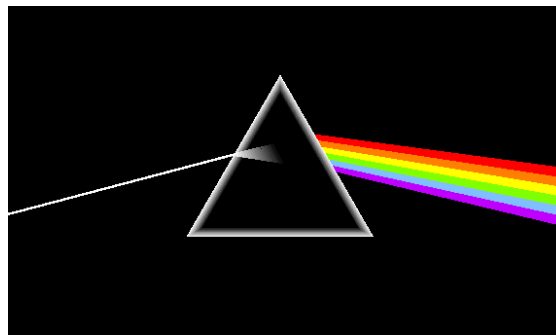


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# Overview of Previous Talk

- “In my country, there is problem, and that problem is transport”
- Single Mode Fiber: multiple wavelengths (also called “colors” or “lambdas”) coexisting separately
- Reasonable cost of dark fiber IRUs
- Available at <http://www.nanog.org/mtg-0606/pdf/lightning-talks/4-pilosov.pdf>



# “Standard” passive WDM

Technology	Wavelengths (nm)	Capacity	Price
GWDM/WWDM GE (LX/ZX)	1310 & 1510	2*GE	~1000\$
GWDM/WWDM 10G (LR/ER)	1310 & 1510	2*10GE	~5000\$
CWDM GE	1470..1610 (20nm spacing)	8*GE	~5000-10000\$
DWDM GE	1530..1610 “ITU grid” (0.8nm spacing)	N*10GE N<64	~N*5000\$

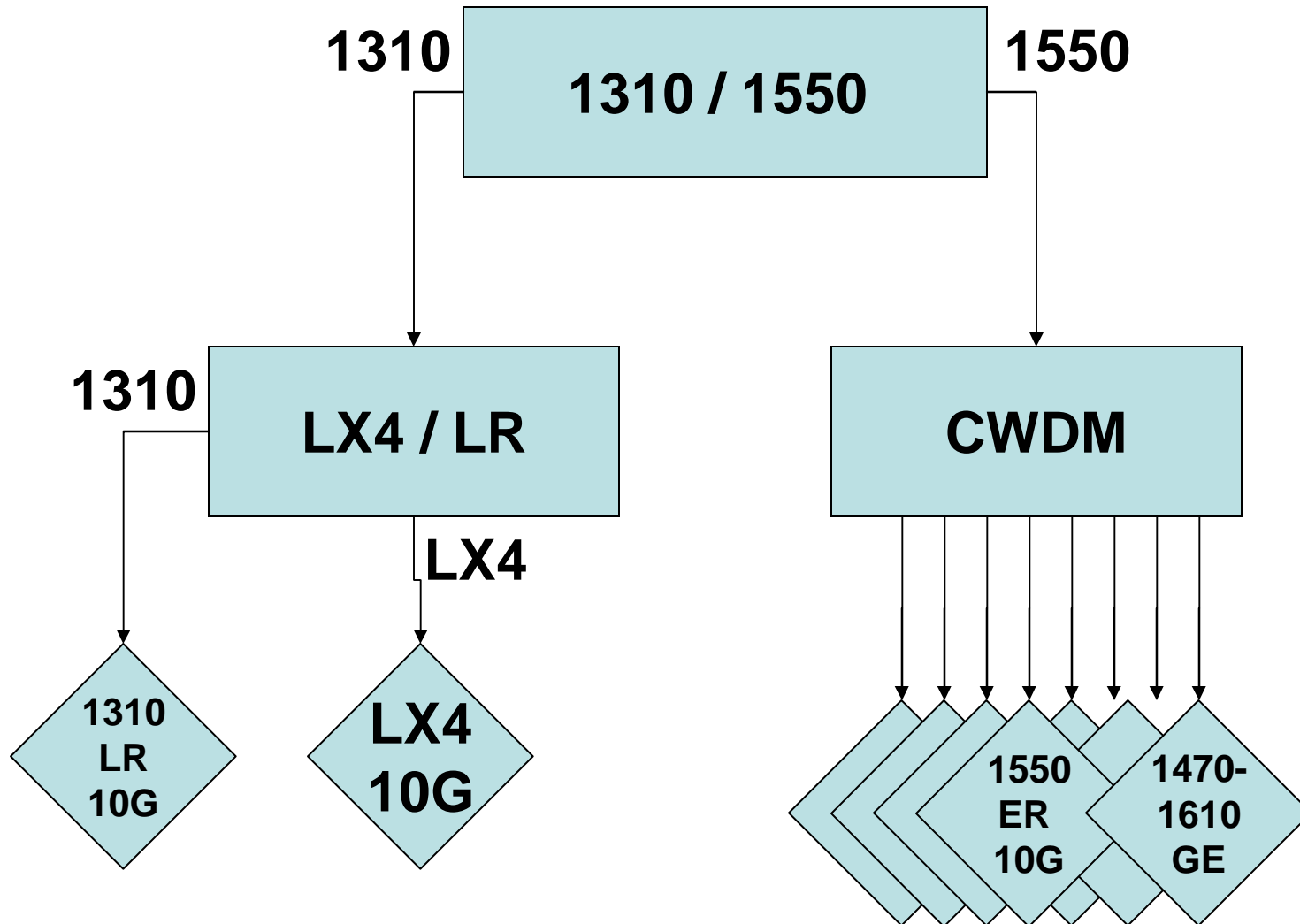
Approximate Prices include passive and active components, per end, full duplex, over one pair

# 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

\* GWDM = Ghetto Wave Division Multiplexing

# Thread useless without pics!



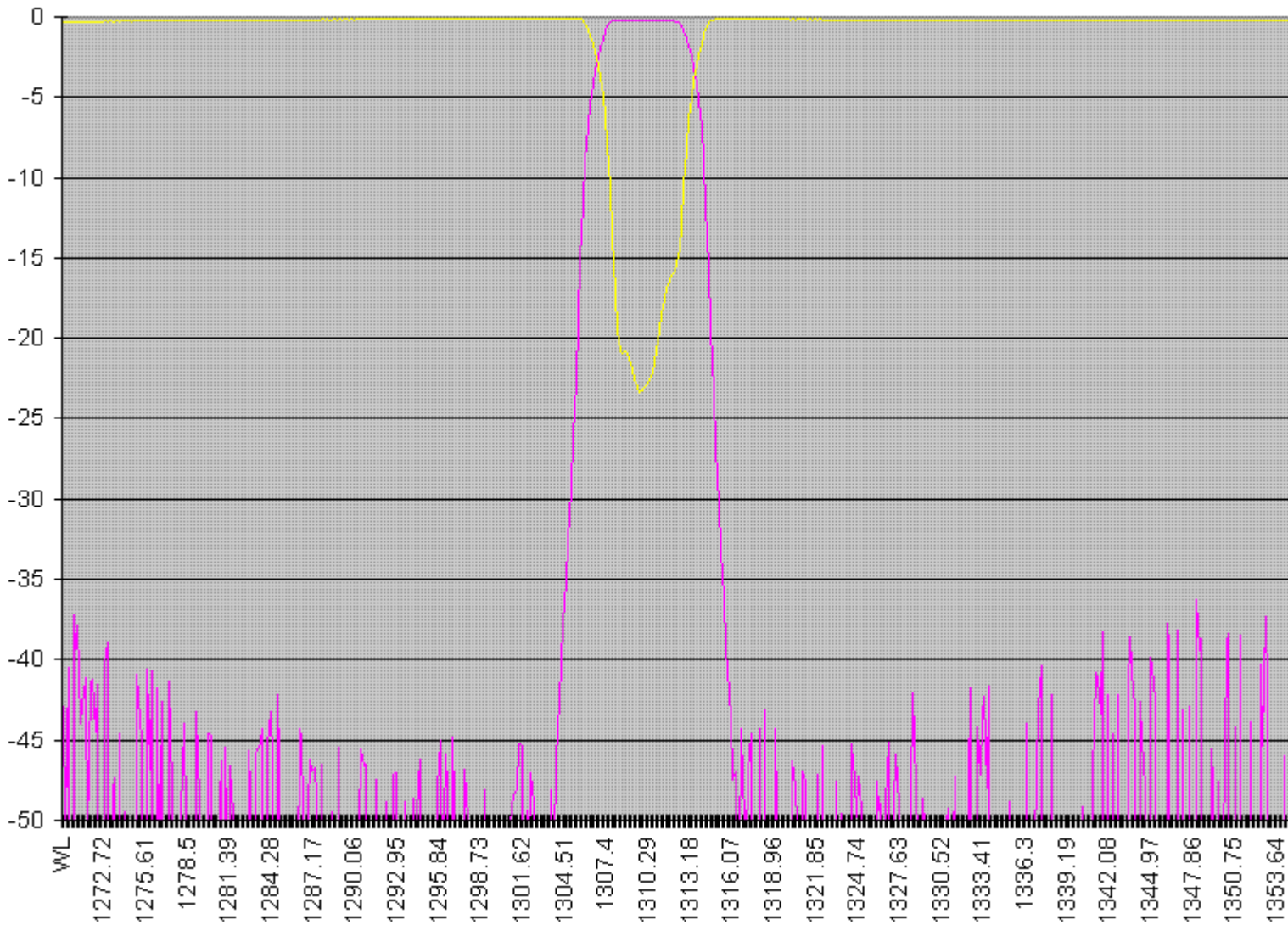
# New: Additional Options

- LX4 / LR splitters: adding another 10G channel on an existing system (...because “10 Gig is the new Gig”)
- Interleavers: double the capacity of a CWDM system with “overlapping” channels
- Circulators: double capacity of any system

# LX4 / LR splitters

- LX4 is a standard for *10GE over 4 WDM channels at 1310nm band*
- 1275.7, 1300.2, 1324.7, 1349.2nm
- XENPAK-only (no XFP or X2)
- Inexpensive XENPAKs
- Does not interfere with 1310nm LR
- Custom-made filters required
- Some light loss unavoidable due to filters not being perfectly square-wave

# LX4 / LR spectrum diagram



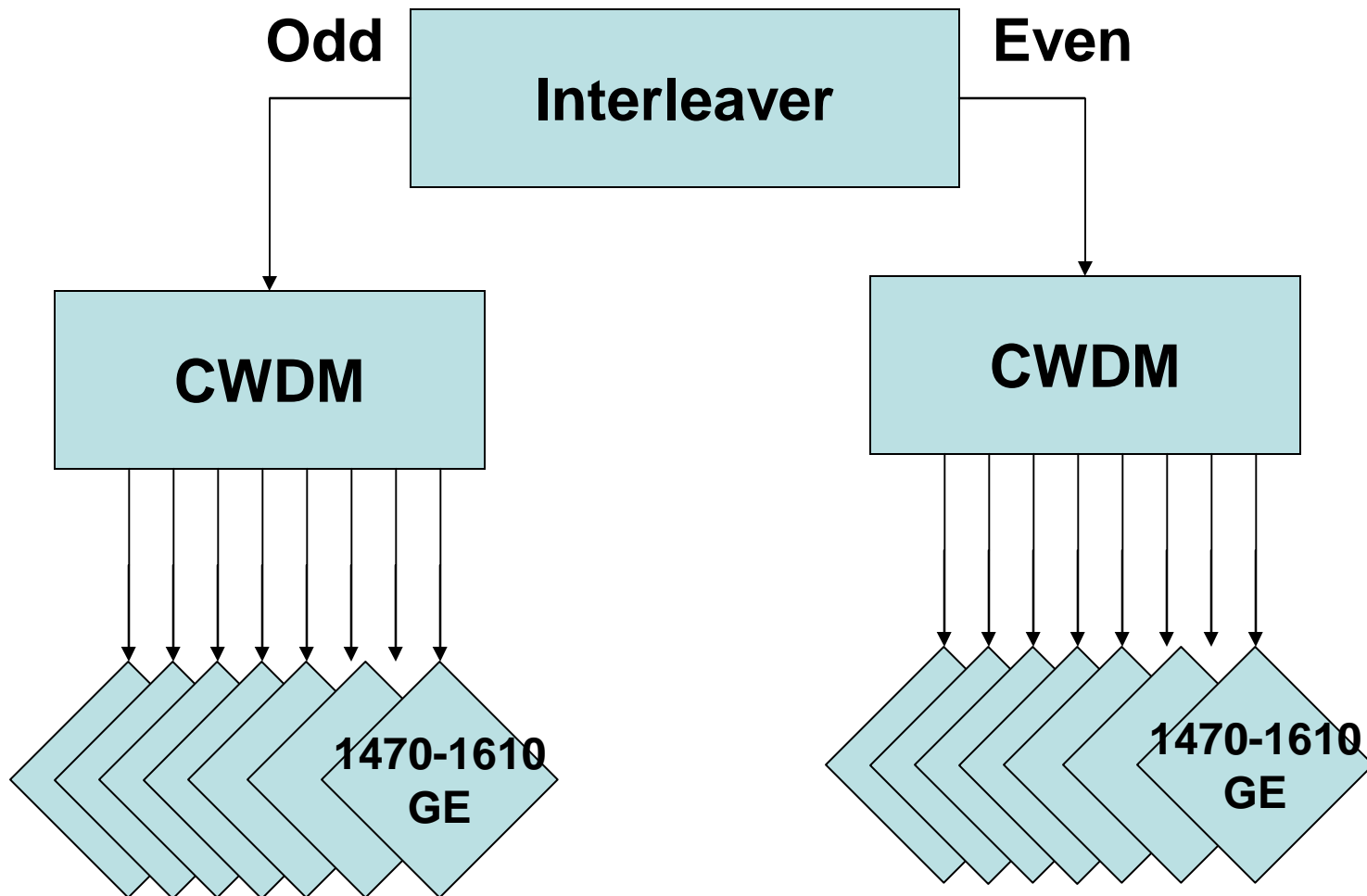


# Interleavers

- Interleaver is an optical device which takes one input and produces two outputs, taking even/odd channels at X nm separation
- Lose ~70% of the light (4-5dB), double capacity on a CWDM system
- Useful because output of CWDM equipment has wide spectrum (1-2nm)
- Interleavers available with 0.4nm (50GHz) spacing



# Interleaver diagram

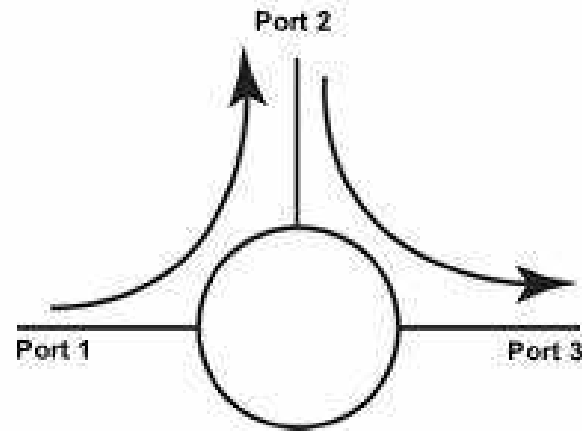


# Circulators

- Using polarization to transmit data over same wavelength in opposite directions
- Putting full-duplex link onto a single strand of fiber
- Reflectivity is a problem – if fiber splices or connectors have significant internal reflection, it is impossible to distinguish reflected signal from original - “Loopback link”.

# Circulator, picture

- “Port 2” connects to fiber
- “Port 1” and “Port 3” are input and output
- Non-polarization maintaining fiber in the field – solved, beyond scope of this talk



# Caveats (same as before)

- **NO** complete commercial systems available
- Systems require glue (and duct tape) to put together
- Tricky attenuator levels to reduce phantom signal
- Expensive equipment for testing (spectrum-analyzer, light sources, etc)
- Lack of operational expertise (get hit by a bus)



# Vendors



- EBay!
- Circulators/Interleavers: AOC, Avanex, E-TEK
- Custom filters: [oemarket.com](http://oemarket.com)

# Questions?

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