

Optical

Lecture 4

- Ethernet physical
 - Copper... 10Base5,2,T, 100/1000/10G
 - Optical
- Optical transmission
- Frequency response
- WDM

Ethernet Physical

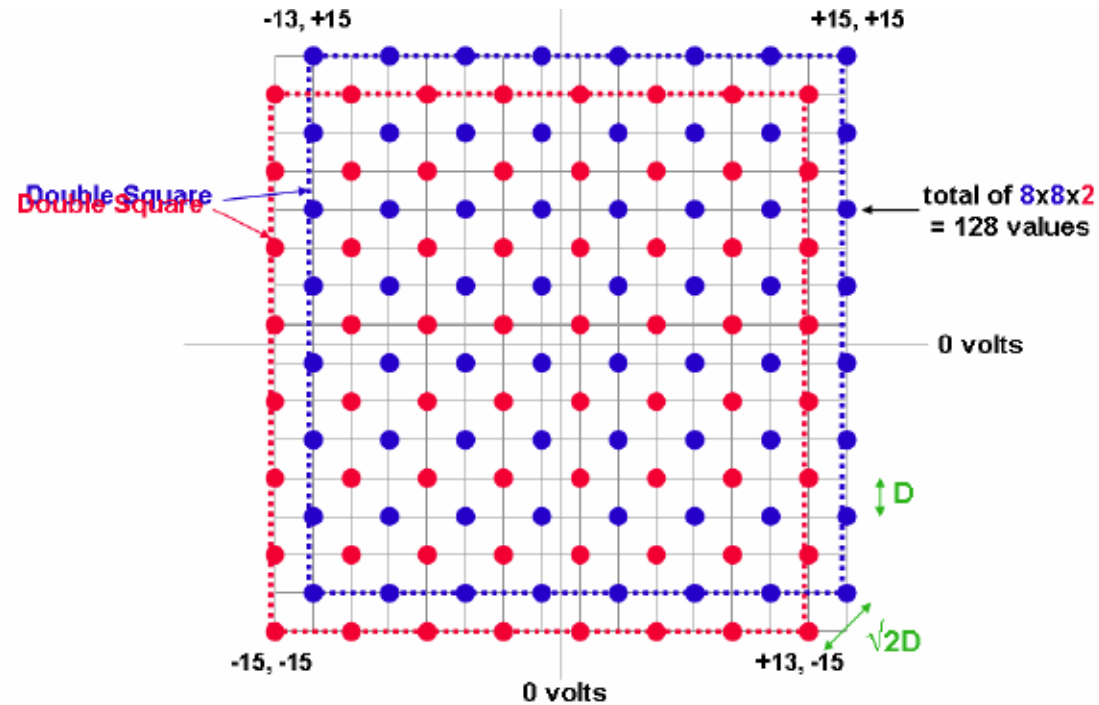
- 10Base5 – Vampire taps
- 10Base2 – “Thinwire” BNC
- 10BaseT – Twisted pair (500m)

All above Manchester encoding..



- 100BaseT – see TX, T4, T2 (100m), 4b5b
- 1000BaseT – use 2 pairs, “PAM5” encoding

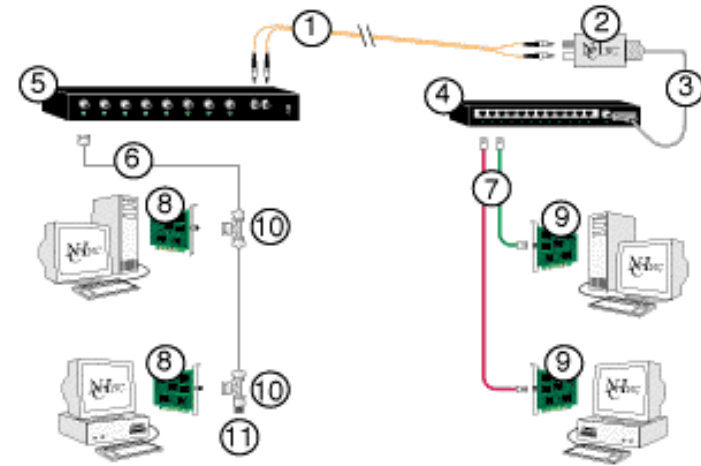
10GBase-T



- “PAM16” - DSQ128

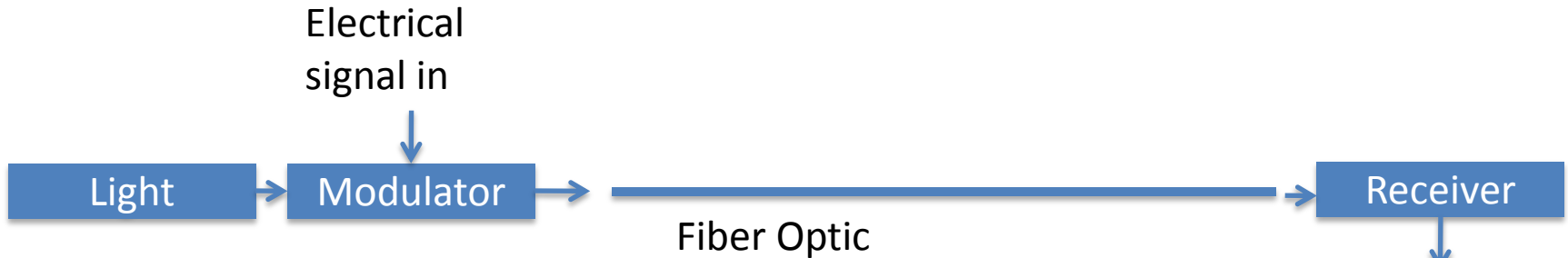
Ethernet Optical

- 10BaseFL
 - 850nm 2km
- 100Base...
 - FX – 1300nm 2km
 - SX – 850nm cheaper
 - LX – 1300nm 10/20/40km – “single-mode”
- 1000Base
 - even more variants
- 10G
 - and even more...



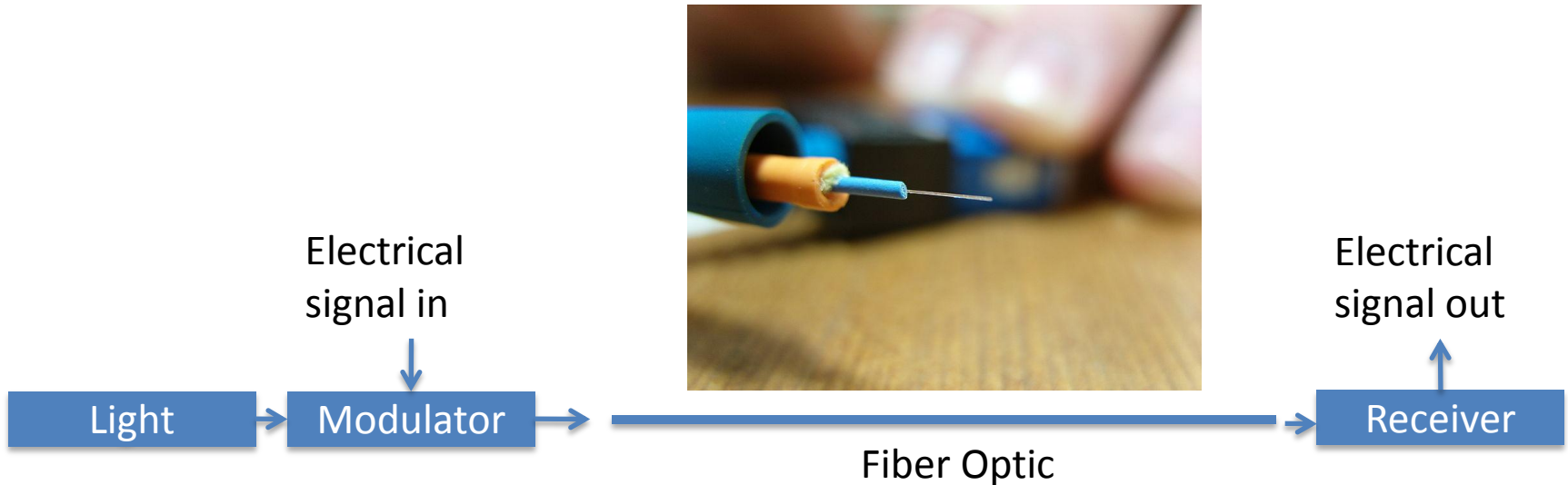
Why??

Optical Fiber

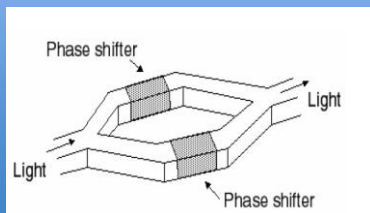


- Light sources (lasers, LEDs) generate continuous light
- Signal modulated onto light
- Transmission over various distances....
- Received by photodetector
 - Very long distances (>1000 km)
 - Very high speeds (>40 Gbps/wavelength)
 - Nearly error-free (BER of 10^{-15})
- Profound influence on network architecture
 - Dominates long distance transmission
 - Distance less of a cost factor in communications
 - Plentiful bandwidth for new services

Optical Fiber



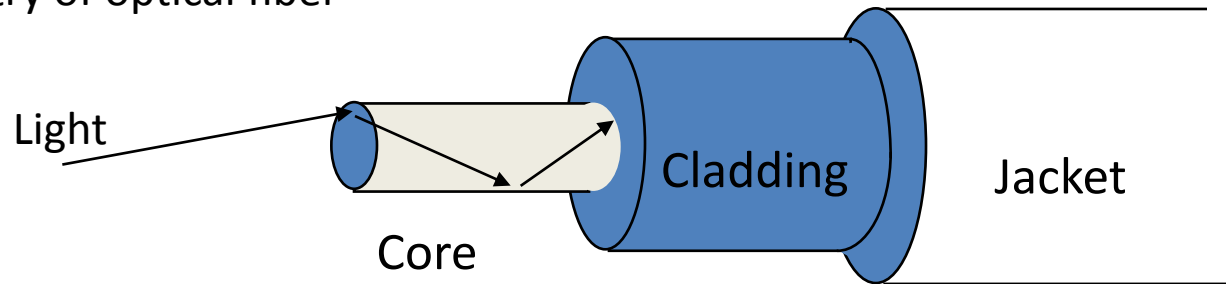
e.g. Mach-Zender
uses interference to
modulate signal



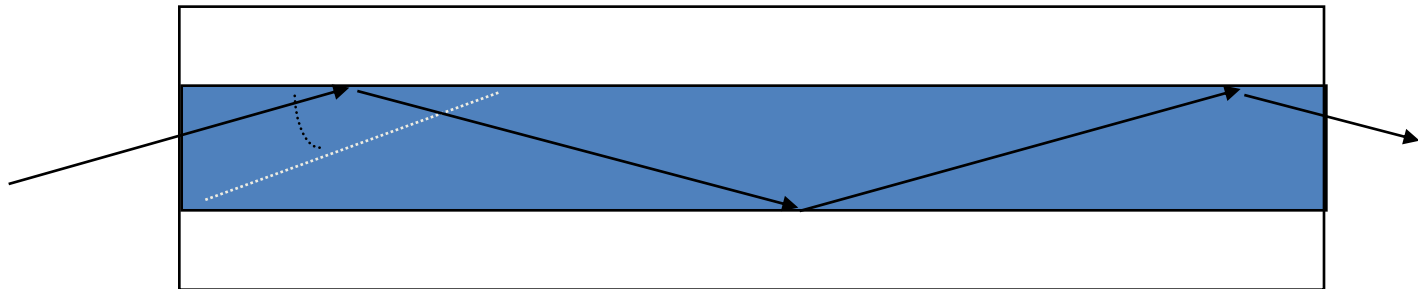
- Light sources (lasers, LEDs) pass to...
- Modulator
- Injected into fibre and..
- Received by photodetector

Transmission in Optical Fiber

Geometry of optical fiber



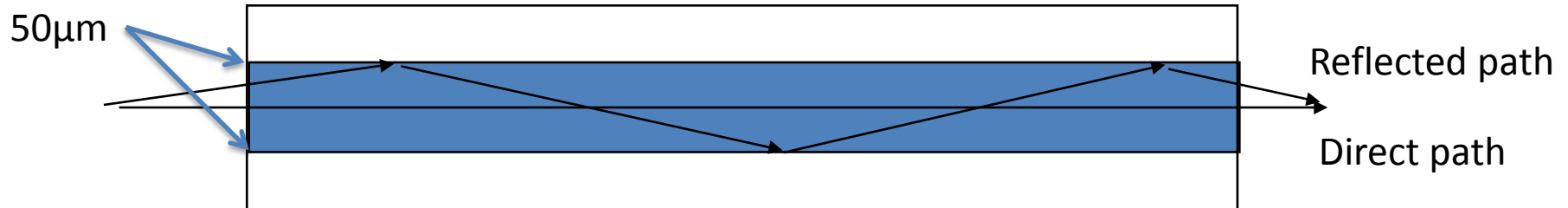
Total Internal Reflection in optical fiber



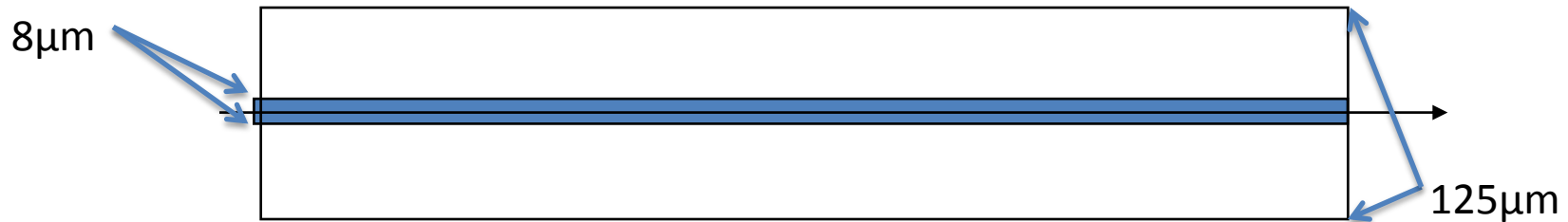
- Glass core surrounded by layer of cladding
- Core has higher index of refraction than cladding
- Light rays undergo “total internal reflection”
 - That’s the simple form of the explanation....

Multimode & Single-mode Fiber

Multimode fiber: multiple rays follow different paths



Single-mode fiber: only direct path propagates in fiber



- Multimode: $50\mu\text{m}$ in $125\mu\text{m}$
 - Rays on different paths interfere causing dispersion
 - LEDs and Lasers as source
- Single mode: $8\mu\text{m}$ in a cladding of $125\mu\text{m}$
 - Lasers

Optical Fiber Properties

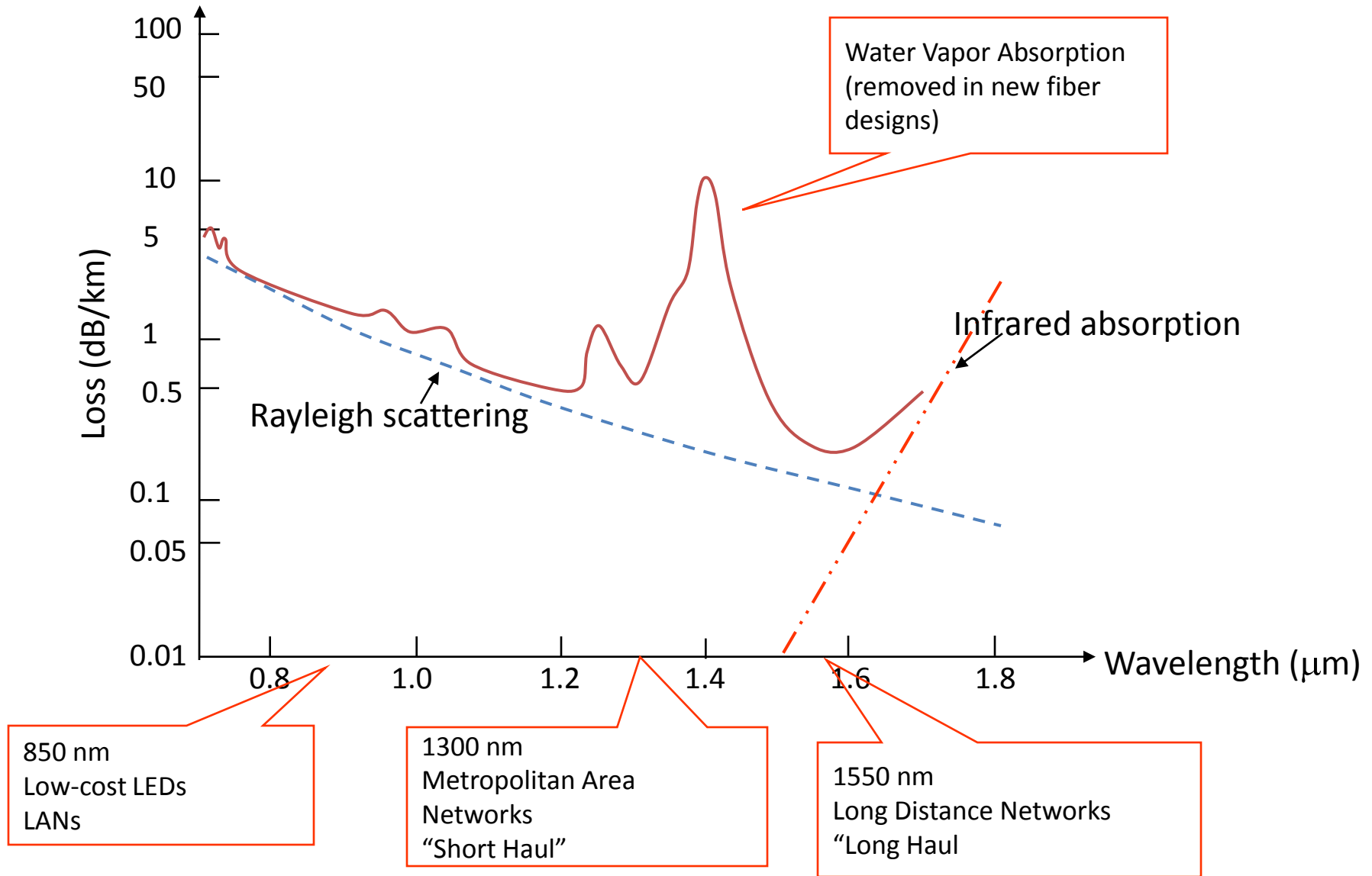
Advantages

- Very low attenuation
- Noise immunity
- Extremely high bandwidth
- No corrosion
- More compact & lighter than copper wire
- Long distances (>1000 km)
- High speeds (>40 Gbps/wavelength)
- Nearly error-free (BER of 10^{-15})

Disadvantages

- New types of optical signal impairments & dispersion
 - Polarization dependence
 - Wavelength dependence
- Limited bend radius
 - If physical arc of cable too high, light lost or won't reflect
 - Will break
- Difficult to splice
- Mechanical vibration becomes signal noise

Very Low Attenuation



Optical fibre submarine systems



The following information is available from the National Highway Traffic Safety Administration (NHTSA) regarding the recall of certain 2004-2005 Ford Focus vehicles. For more information, please visit the NHTSA website at www.safercar.gov.

NHTSA is recalling certain 2004-2005 Ford Focus vehicles equipped with a 2.0L engine and a manual transmission. The recall is due to a defect in the front suspension system, specifically the lower control arm (LCA) bushings. The LCA bushings may wear prematurely, which could lead to a loss of vehicle control and an increased risk of a crash.

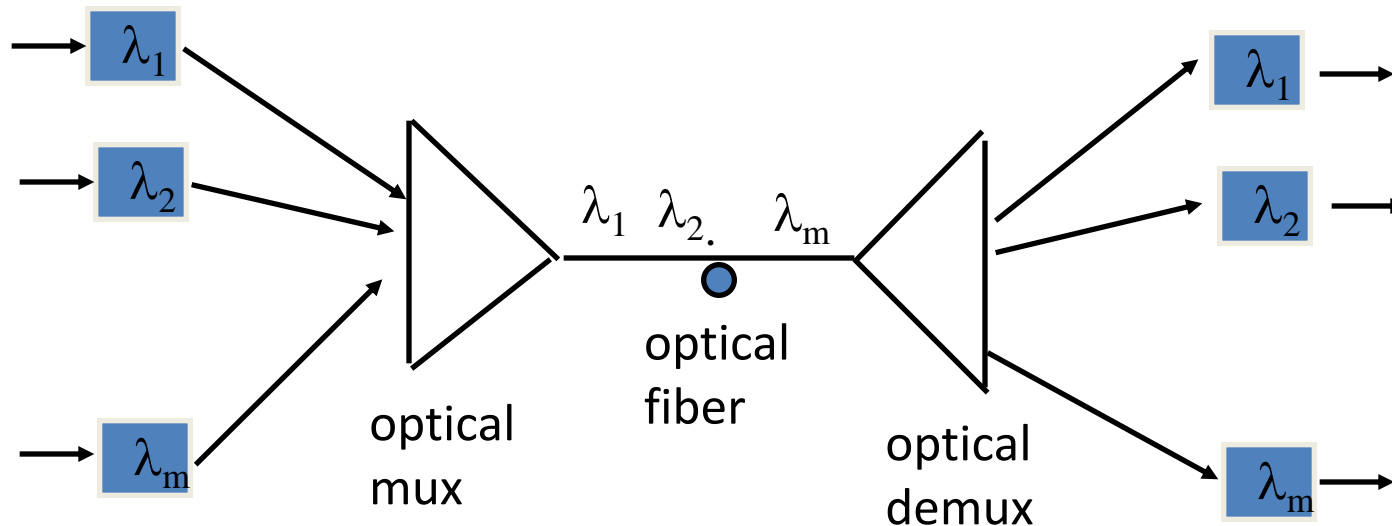
The recall covers the following vehicles:

- 2004 Ford Focus, 2.0L engine, manual transmission, produced between January 1, 2004 and February 2, 2004.
- 2005 Ford Focus, 2.0L engine, manual transmission, produced between February 3, 2004 and March 1, 2004.

Owners of the affected vehicles should contact their nearest Ford dealership or call 1-800-FORD-3636 for more information. Ford is covering the cost of the repair.

Wavelength-Division Multiplexing

- Different wavelengths carry separate signals
- Multiplex into shared optical fiber
- A single fiber can carry 160 wavelengths, 10 Gbps per wavelength: 1.6 Tbps



Regenerators & Optical Amplifiers

- The maximum span of an optical signal is determined by the available power & the attenuation:
 - Ex. If 30 dB power available,
 - then at 1550 nm, optical signal attenuates at 0.25 dB/km,
 - so max span = $30 \text{ dB} / 0.25 \text{ km/dB} = 120 \text{ km}$
- Optical amplifiers amplify optical signal (no equalization, no regeneration)
- Impairments in optical amplification limit maximum number of optical amplifiers in a path
- Optical signal must be regenerated when this limit is reached
 - Requires optical-to-electrical (O-to-E) signal conversion, equalization, detection and retransmission (E-to-O)
 - Expensive
- Severe problem with WDM systems

Optical Fiber Attenuation and Fiber Amplifier Gain

