# Gigabit Transmission

## What's the Limit?

**Fanny Mlinarsky**



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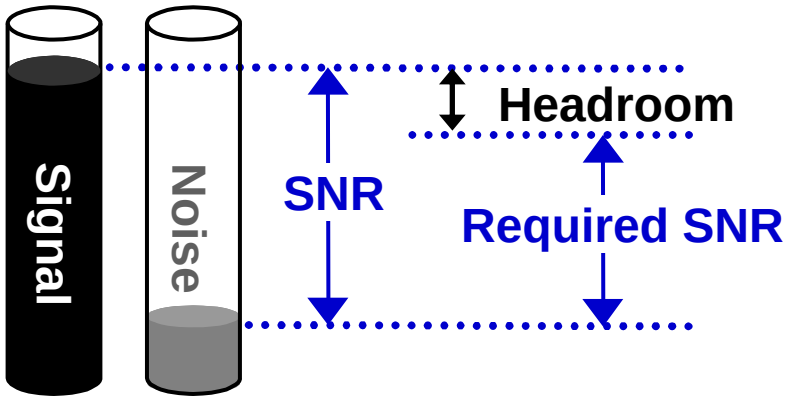
# What's the Limit?


- **Speed**
  - → Faster→ higher frequency → higher attenuation → less headroom
- **Distance**
  - → Longer → higher attenuation → more jitter → less headroom
- **Headroom**
  - → How close to collapse?



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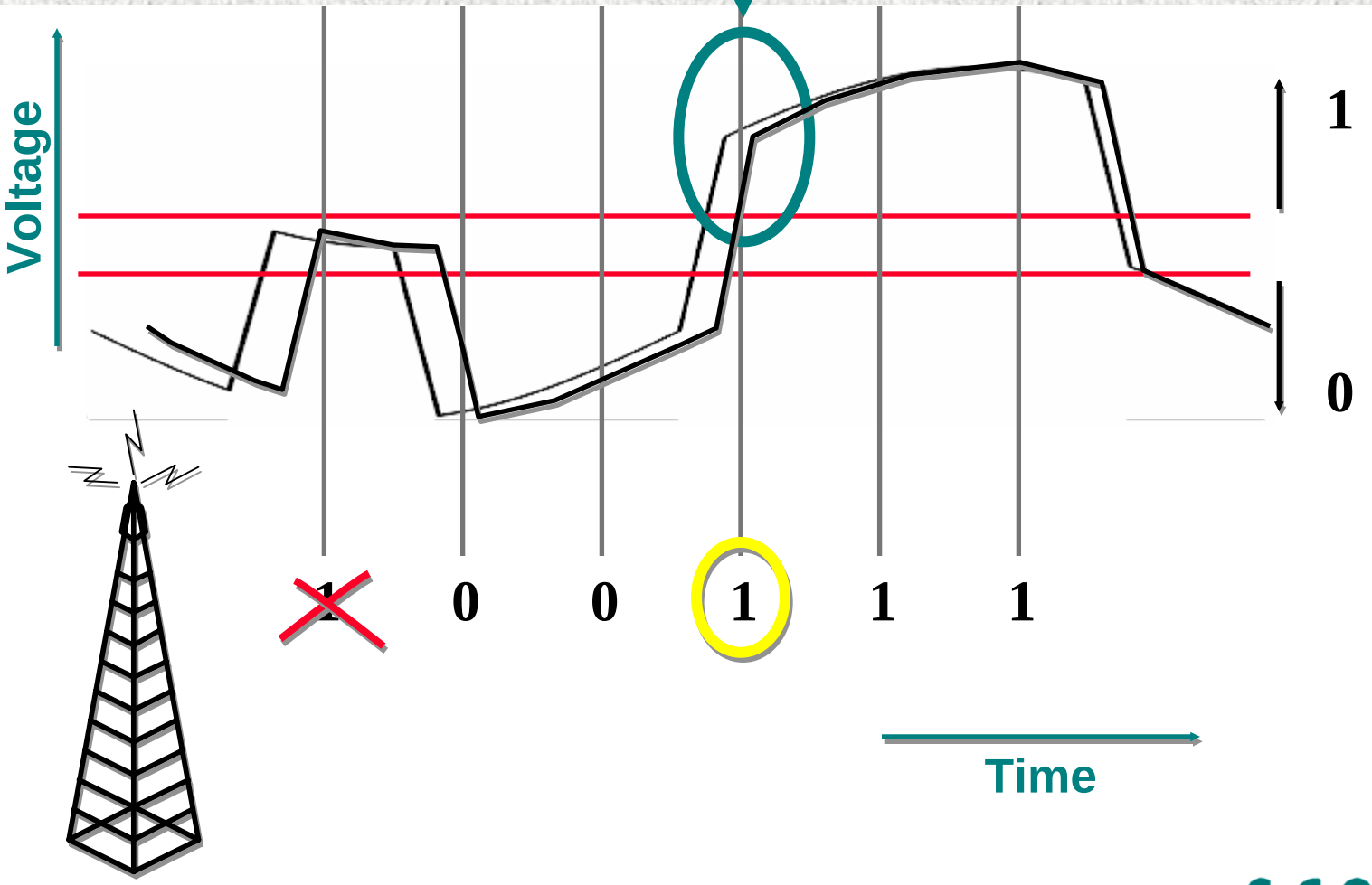
# Noise+Jitter→Headroom



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# Effect of Low Headroom -- Slow Network Response


- **A single bit error can cause re-transmission of the entire message**
- **Re-transmission cuts throughput to less than half due to ...**
- **… overhead of detecting corrupt data and arranging the re-transmission**



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# Headroom Guarantees Expected Throughput

- **Bit errors can significantly slow down throughput**
- **Headroom is needed to withstand**
  - **Ambient noise**
  - **Build-up of jitter over distance**
- **On twisted-pair the major cause of errors is inadequate SNR**
- **On fiber the major cause of errors is excessive jitter**



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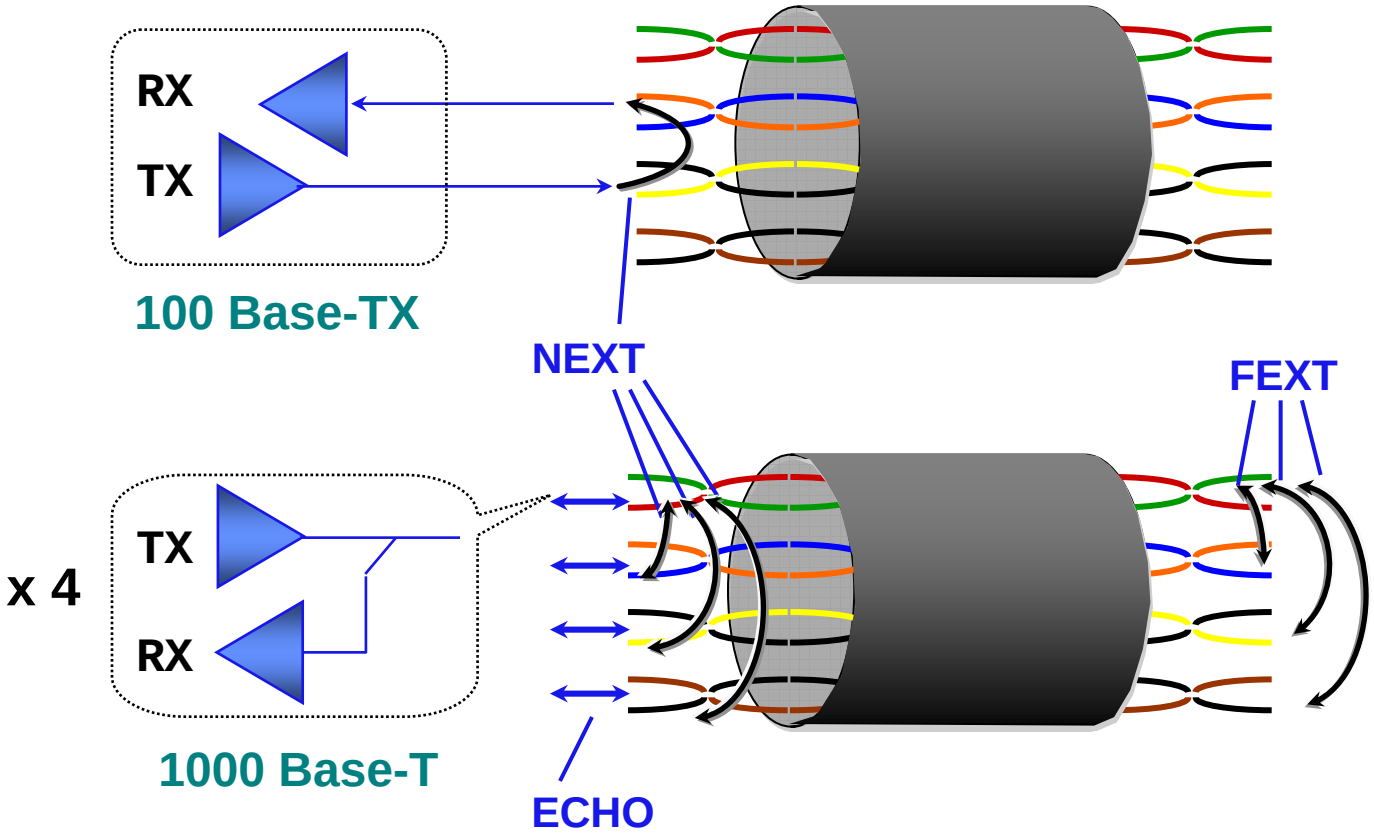
# Noise Environment is Application-Dependent



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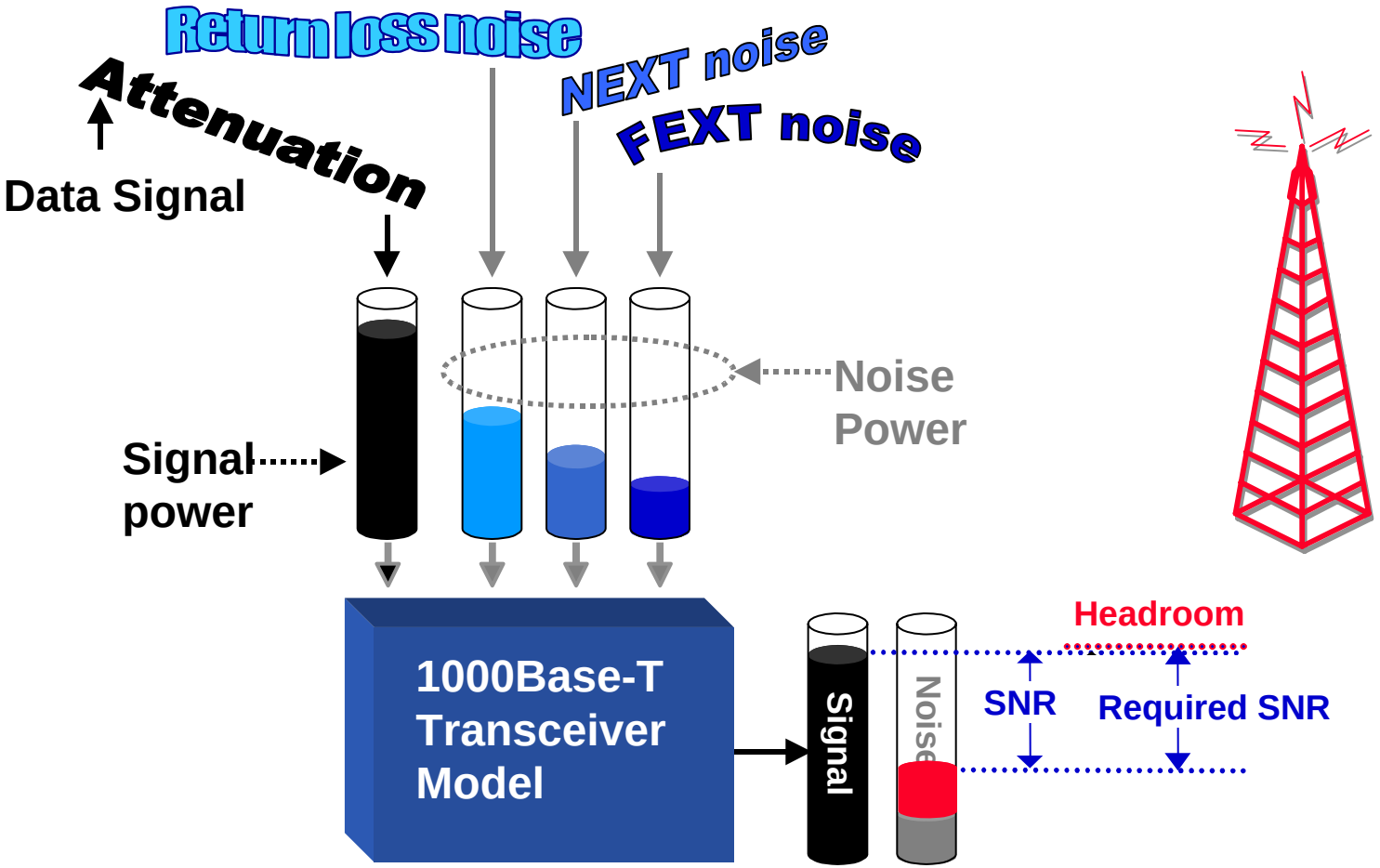
# Gigabit Ethernet SNR Environment



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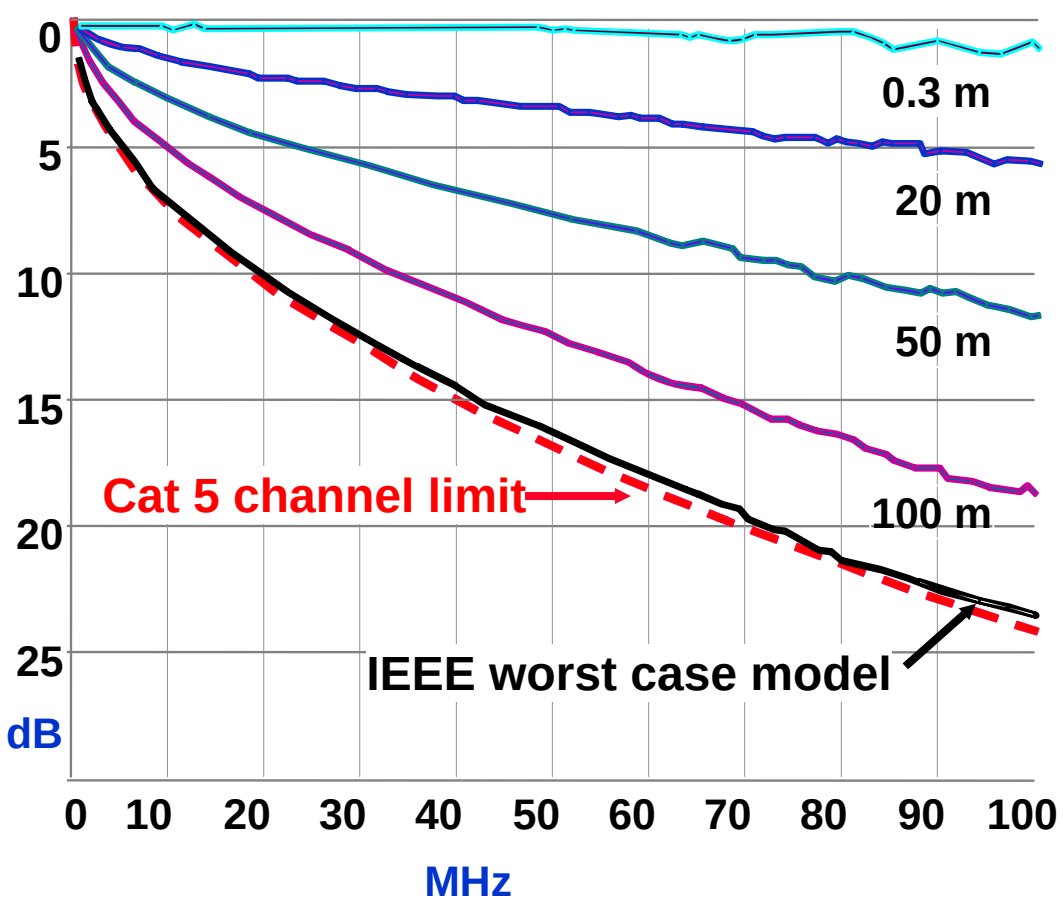
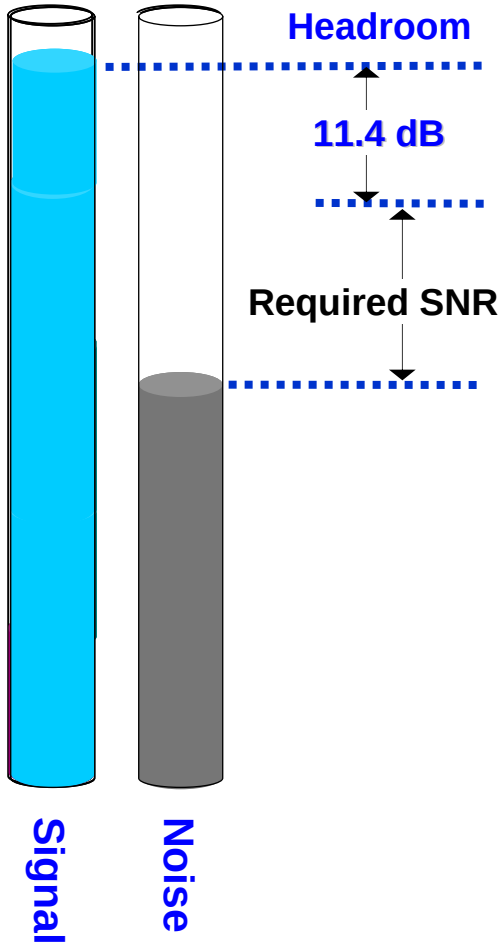
# Gigabit Ethernet Headroom vs. Distance



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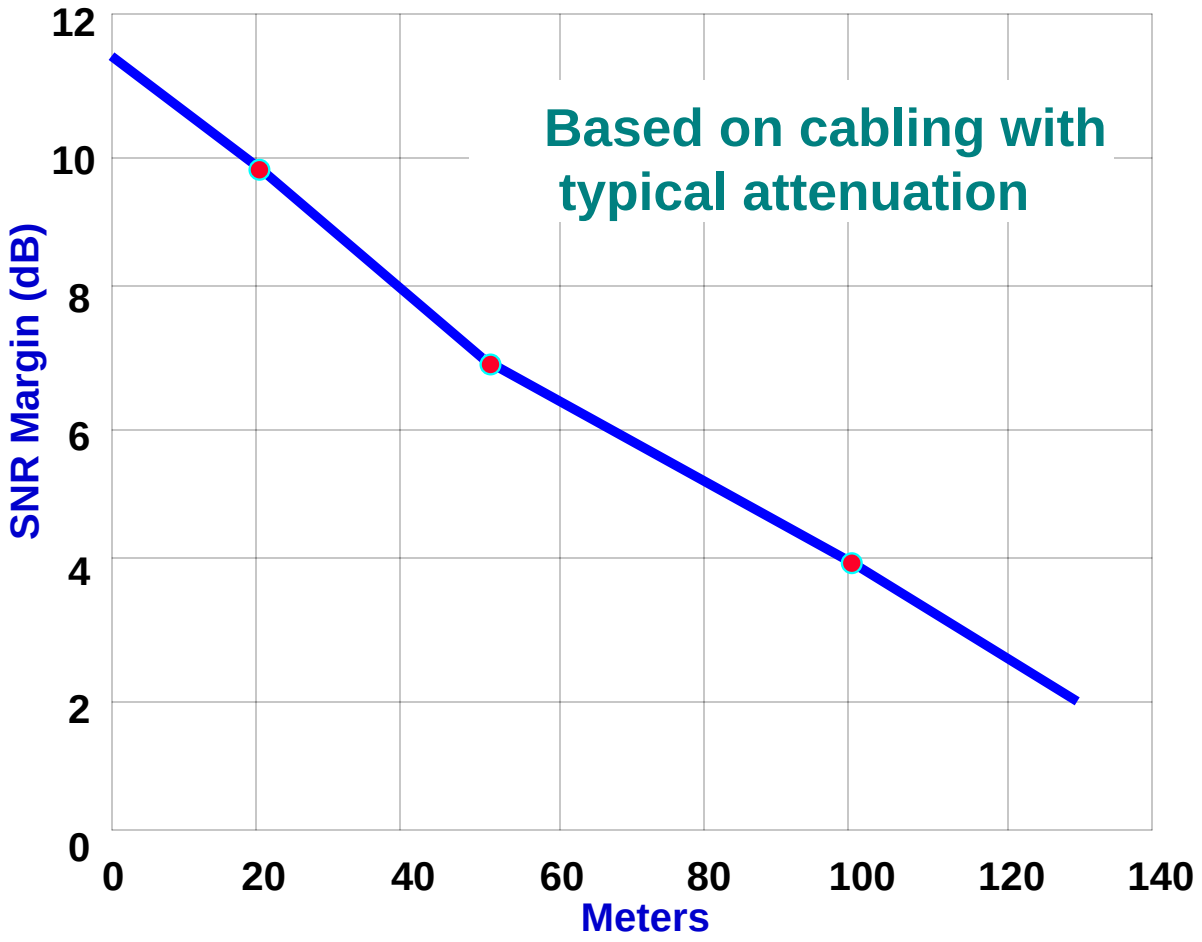
# Gigabit Ethernet Headroom vs. Distance



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# Cabling Requirements of 1000Base-T

- **1000Base-T is expected to work on category 5 installations that meet draft TSB95**
  - **Attenuation, NEXT, ELFEXT, return loss, delay and skew**
- **Will existing installations meet the requirements of TSB95?**
  - **Some parameters, such as return loss and ELFEXT, might not meet TSB95 limits, but ...**
  - **… 1000Base-T might still have sufficient headroom**
- **Category 5E will have sufficient headroom by design**
  - **> 3 dB**
- **Category 6 will offer more headroom**



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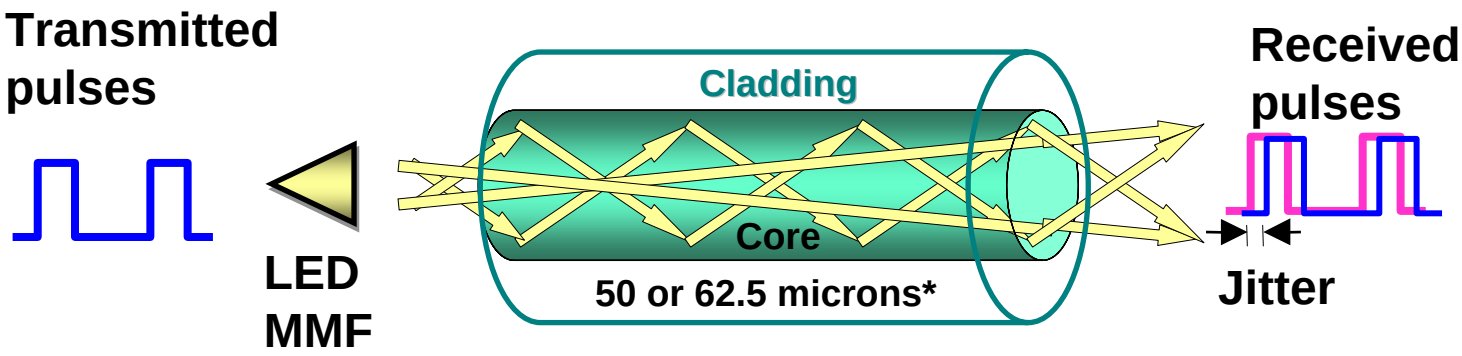
# Fiber Optic Transmission




* Micron = $10^{-6}$ meter



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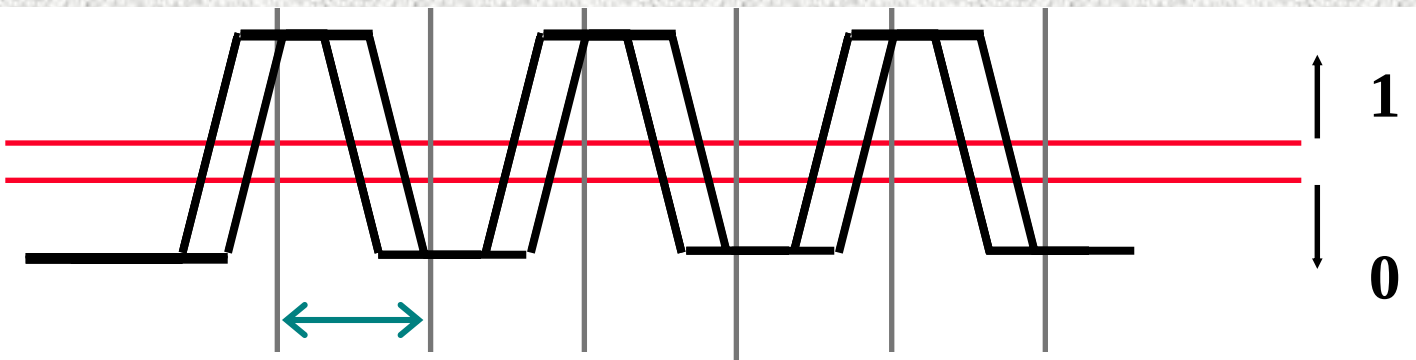
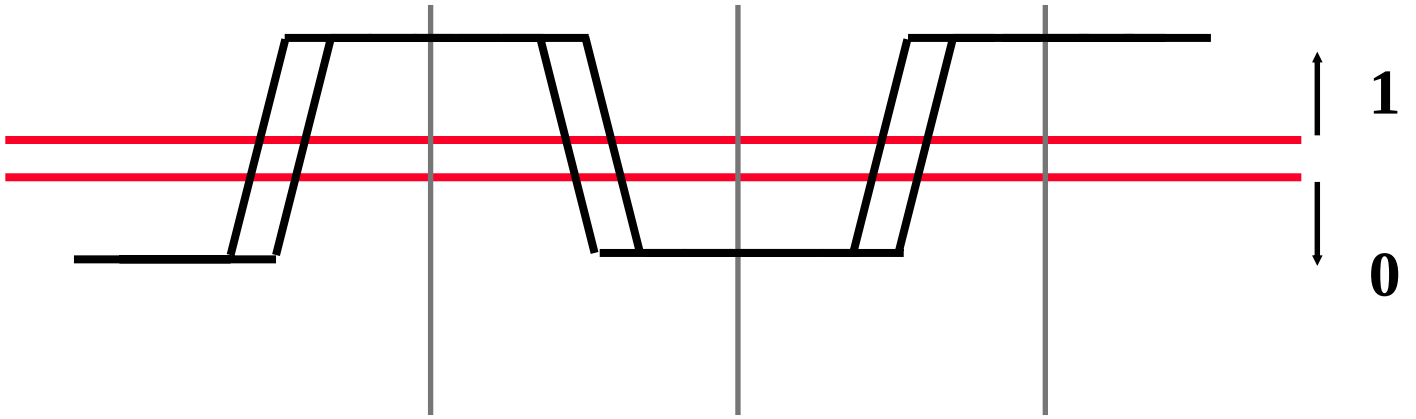
# Jitter Tolerance vs. Data Rate




Clock period = 800 ps for gigabit Ethernet



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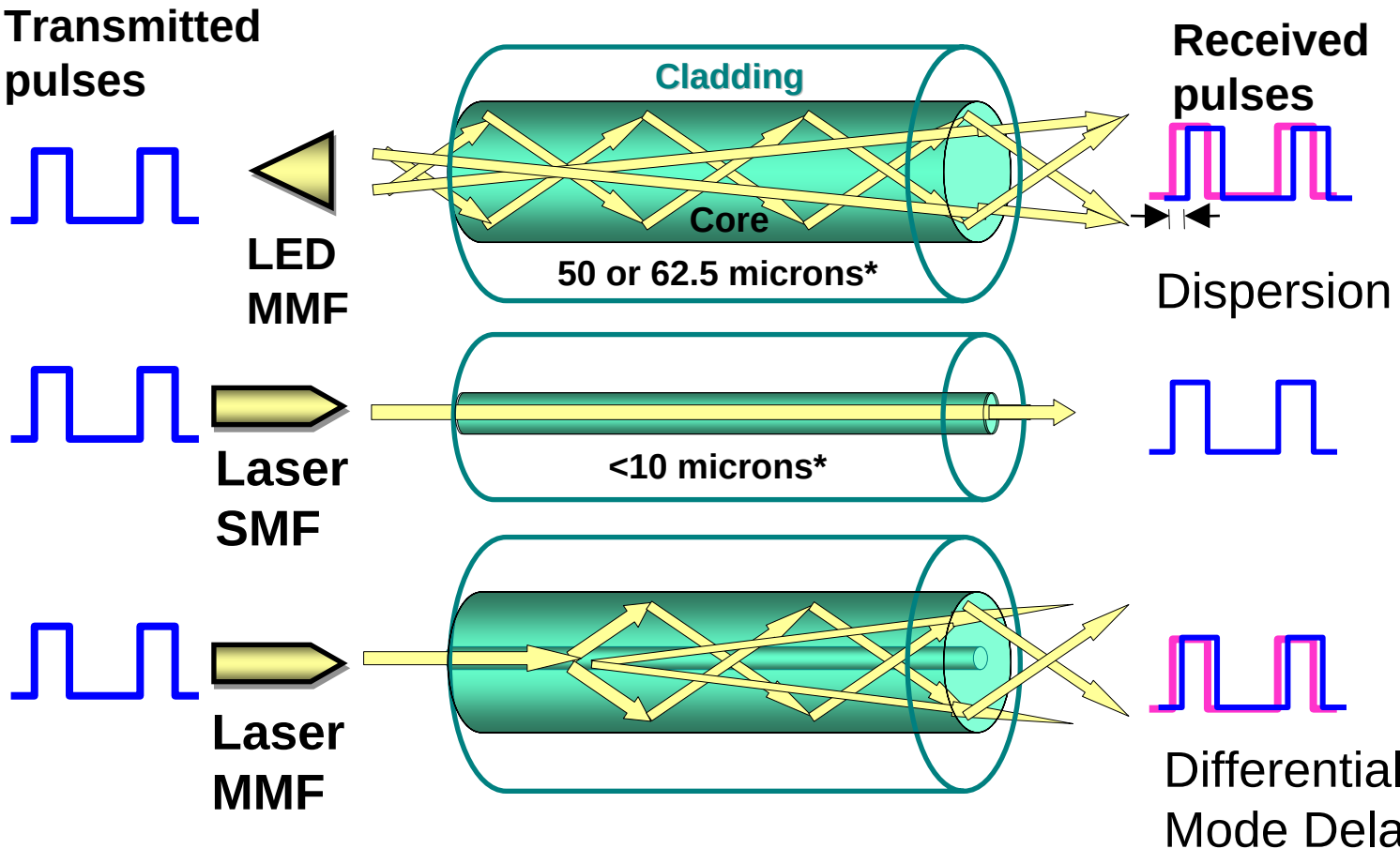
# Fiber Optic Transmission

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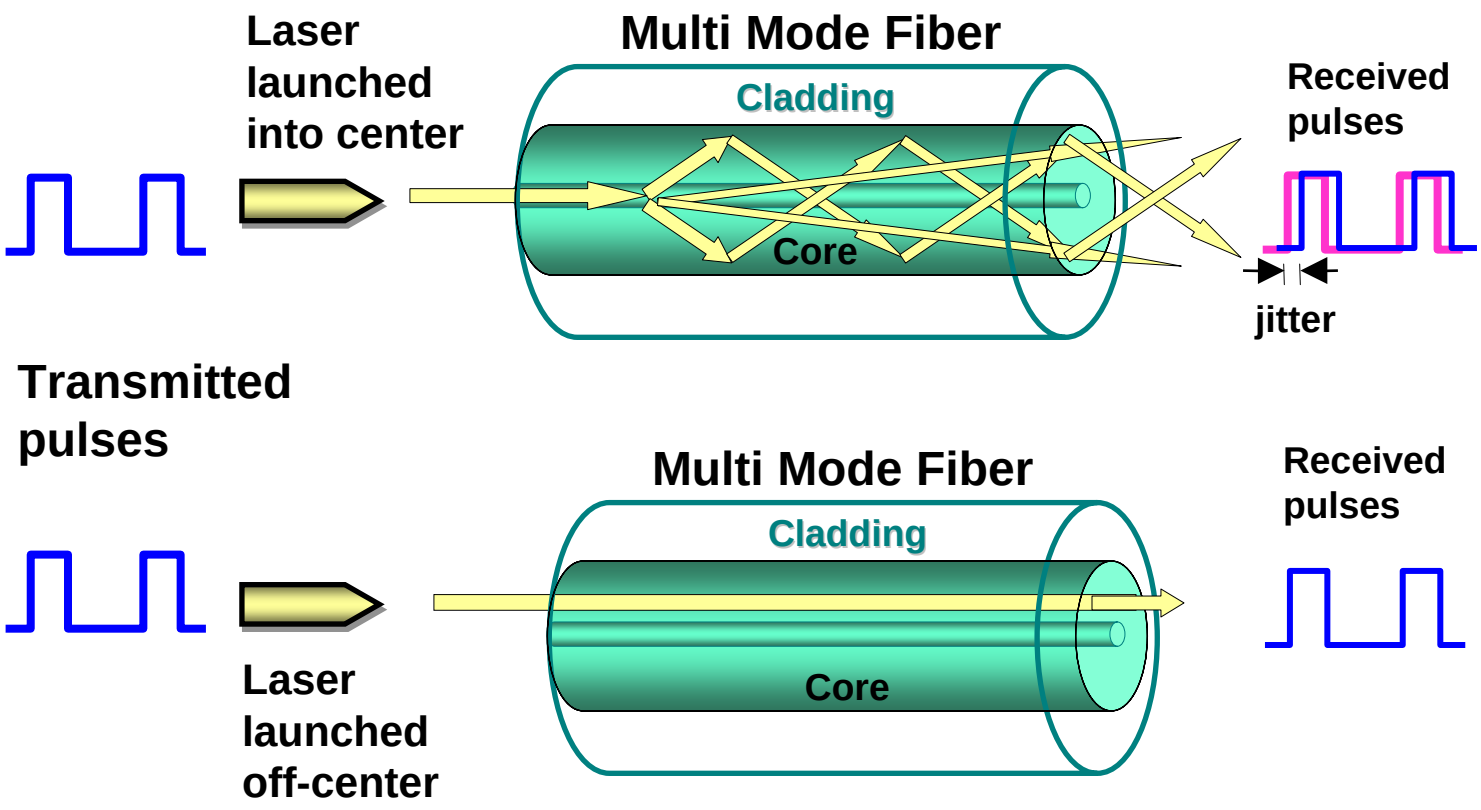
# Differential Mode Delay (DMD)



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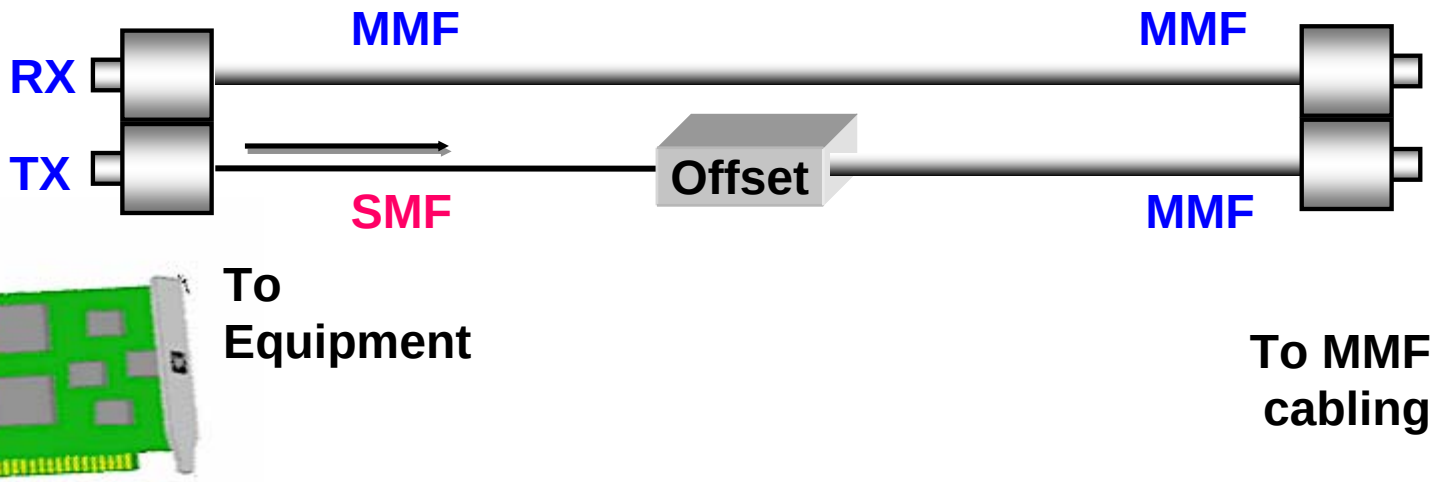
# Offset Patch-cord




- **Offset patch-cord can be used with 1000Base-LX (1310 nm) gigabit Ethernet devices to address the DMD problem**



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# IEEE 802.3z Gigabit Ethernet Limits

| Gigabit Ethernet Specification | Type of Fiber | Wave-length (nm) | Fiber Core Size (microns) | Modal Bandwidth (MHz * km) | Maximum Distance (m) | Attenuation (dB) |
|---|---|---|---|---|---|---|
| 1000Base-SX | MMF | 850 | 50 | 400 | 500 | 3.37 |
| | | | | 500 | 550 | 3.56 |
| | | | 62.5 | 160 | 220 | 2.38 |
| | | | | 200 | 275 | 2.60 |
| 1000Base-LX | MMF | 1310 | 50 | 400, 500 | 550 | 2.35 |
| | | | 62.5 | 500 | 550 | 2.35 |
| | SMF | 1310 | 10 | | 5,000 | 4.57 |

**Attenuation budget is based on length restrictions.**

Link power budget, based on transmitter launch power and receiver sensitivity, is 7.5 dB for multi-mode fiber.



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# 1000Base-X Loss Budget -- LED vs. Laser

| | LED Source | Laser Source |
|---|---|---|
| **Approximate measured loss of one connection** | 0.5 dB | 0.2 dB |

- **When LED source is used for field testing…**
  - **... a link with 4 connections can easily fail the tight attenuation limits for 1000Base-X**
- **When a laser source is used …**
  - **… the same link might pass**



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# IEEE 802.3z Fiber Field Testing Issue

- **Issue**
  - IEEE 802.3z channel loss limits cannot be met by some installations when measured with an LED source but may be within limits when measured with a laser source
- **802.3z references for channel insertion loss measurement (sec 38.10)**
  - ANSI/TIA/EIA-526-14A/method B (MMF)
  - ANSI/TIA/EIA-526-7/method A-1 (SMF)
  - IEC1280, IEC 1280-4-1 and IEC 1280-4-2
    - » Based on above TIA standards
- **TIA-526-14A specifies the use of an LED source**
- **No guidance from the IEEE 802.3z standard as to the required source for channel loss measurement**



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# Liaison Letter Regarding Fiber Loss Measurements

**Liaison letter of May 13, 1998 from TIA TR41.8.1states:**

***"We are concerned that users may reject acceptable systems because of attenuation based on LED test sets as established in TIA-526-14-A"***



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# Cabling Requirements for 802.3z

- **Several different length and loss limits depending on type of fiber and type of equipment (1000Base-LX, 1000Base-SX)**
  - **Not defined by any generic cabling standard**
- **Issues with the designated TIA loss measurement method**
  - **Possible false failures due to the use of LED sources**
- **Clearly, 802.3z calls for an application-specific cable test**
- **Fiber length measurement is very important because jitter -- the major disturber in the optical systems -- builds-up as a function of length**



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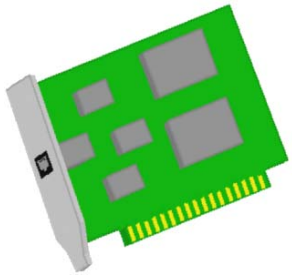
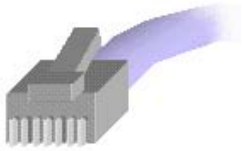
# Standards Chain Reaction



*New LAN Equipment Standards*



*Structured Cabling Standards*

- **IEEE 802.3 Gigabit Ethernet Standards**
  - **1000 Base-SX, 1000Base-LX (Optical Fiber)**
  - **1000 Base-T (Category 5, Category 5E)**
- **TIA Cabling Standards**
  - **TSB95**
  - **TIA-568-A Addendum 4**
- **ISO/IEC Cabling Standards**
  - **Proposed Draft Amendment 3 to ISO/IEC 11801**



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# Conclusion

- **Characterization of application-specific headroom is not just a good idea**
- **It is practically a “must” for some applications due to the lack of generic cabling standards**
  - **For example, 802.3z gigabit Ethernet over fiber**
- **Noise and jitter environments are application-dependent**
- **Application headroom carries information about network robustness and its ability to deliver the expected throughput**



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# Announcement

**For more discussion on related topics …**

You are cordially invited to join Mohawk/CDT for a **lunch and a presentation of "Next Generation of High Performance Fiber Optic and Copper Cables"** in the Grand Ballroom of The Mirage Convention Center…

… starting right now



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