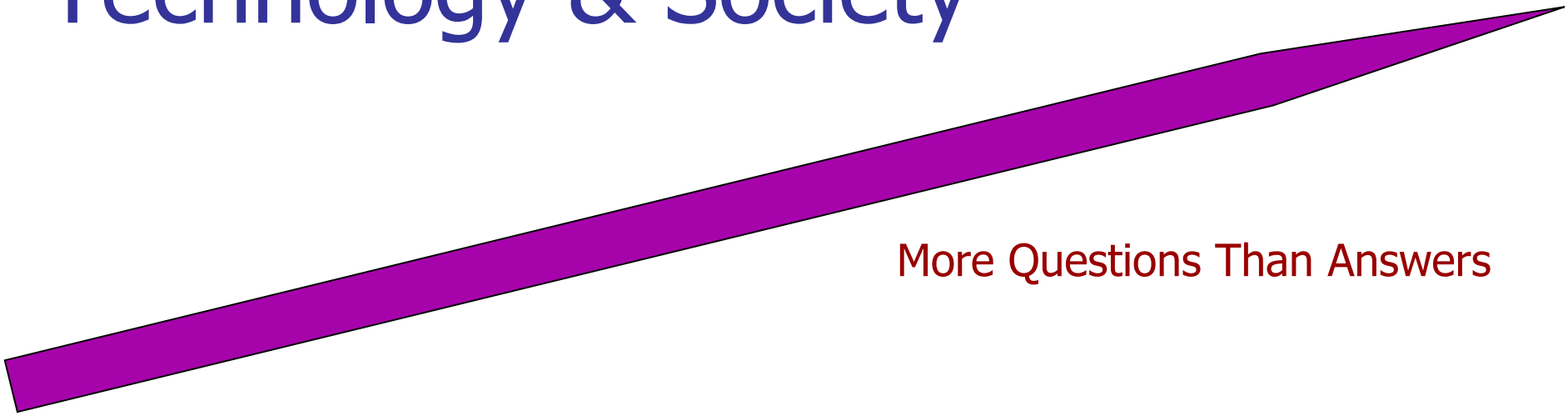
Technology & Society



More Questions Than Answers

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The Light at the end of the Tunnel

Some Technology Innovation

- Fire
- Writing
- First book, press, commodity press, copy machine, laser printer
- Wheel, wagon, steam engine, train, ship, car, airplane,
- Phone, radio, TV
- Consumer electronics

Technology and Sociology

- Mapping of social communication on top of the technology communication
- Focus - social behavior of the technology and technology adoption
- Technology aspects give a different point of view
- Technologies that change our community

Technology Advancements

- Facing many technology revolutions that some of them might have huge impact of our lives and we need to understand it

Need for question mark after every single point

Technologies - Agenda

- Big-Bandwidth Pipes
  - Video Conferencing
  - Virtual Presence (Holograms)
  - Last Mile - Optical Network availability
- Big Disk availability
  - Video Files, Storage capacity
- Computation
- Silicon
- New Applications

Big Bandwidth Pipes

- What if Last Mile is solved?
  - Optical, FTH, MEF, EFM, RPR, CDM……
  - Dedicated connection (circuit)
- Video Conferencing
  - does not really work (yet)
  - TV quality – 2.2Mbs , DVD 4.5Mbs (each direction)
- Virtual Presence – (not science fiction)
  - 8Gbs dedicated

Big Disk Availability

- What is the implication of having very large disk?
- What type of usage we will do with abounded disks?
- Currently disk cost is about $700/TB
- What type of applications can we use it?
- Video files – movie 1GB, - 70 cents store, in 5 years – 0.3 cents
  - How this change the use of personal storage?
  - type of new things we will store if the disk is so inexpensive?

Computation

- We have massive amount of computation in our hands
- In our watch, we have more computation that we needed to send Apollo 11 to the moon and the processor cost less than one cent
- We have amount of computation on our desk that is larger than supercomputer 15 years ago
- How this affects us?

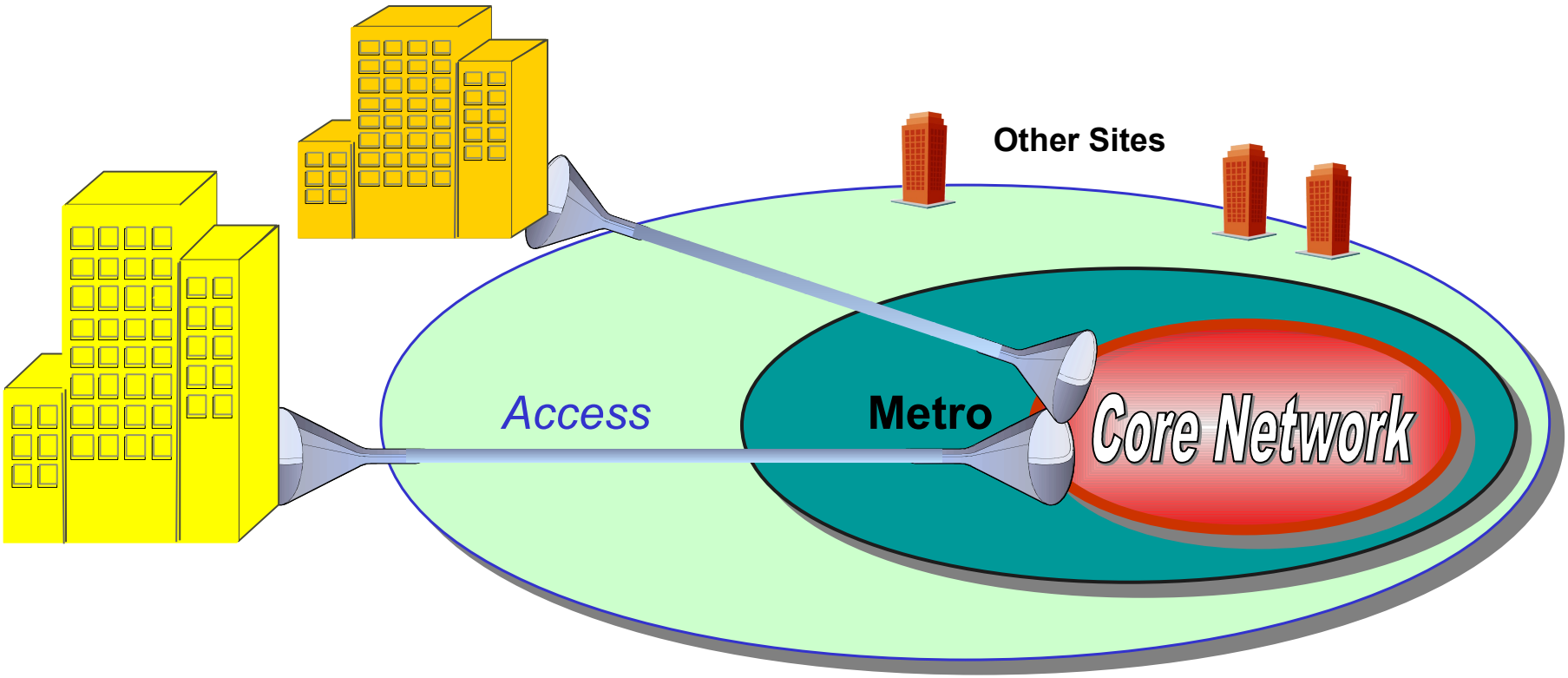
Silicon

- Moor's Law still working
- We can add much more functionalities into silicon
- Price point – consumer electronics
- The cost of new gadgets - commodity

Application adoption

- New innovations and adding new applications is a very simple process in the web time
  - Web itself
  - P2P apps
  - Recording Industry
  - Open Source

The Metro Bottleneck



End User	Access	Metro	Core
Ethernet LAN	DS1 DS3	OC-12 OC-48 OC-192	OC-192 DWDM n x !
IP/DATA 1GigE	LL/FR/ATM 1-40Meg	10G	40G+

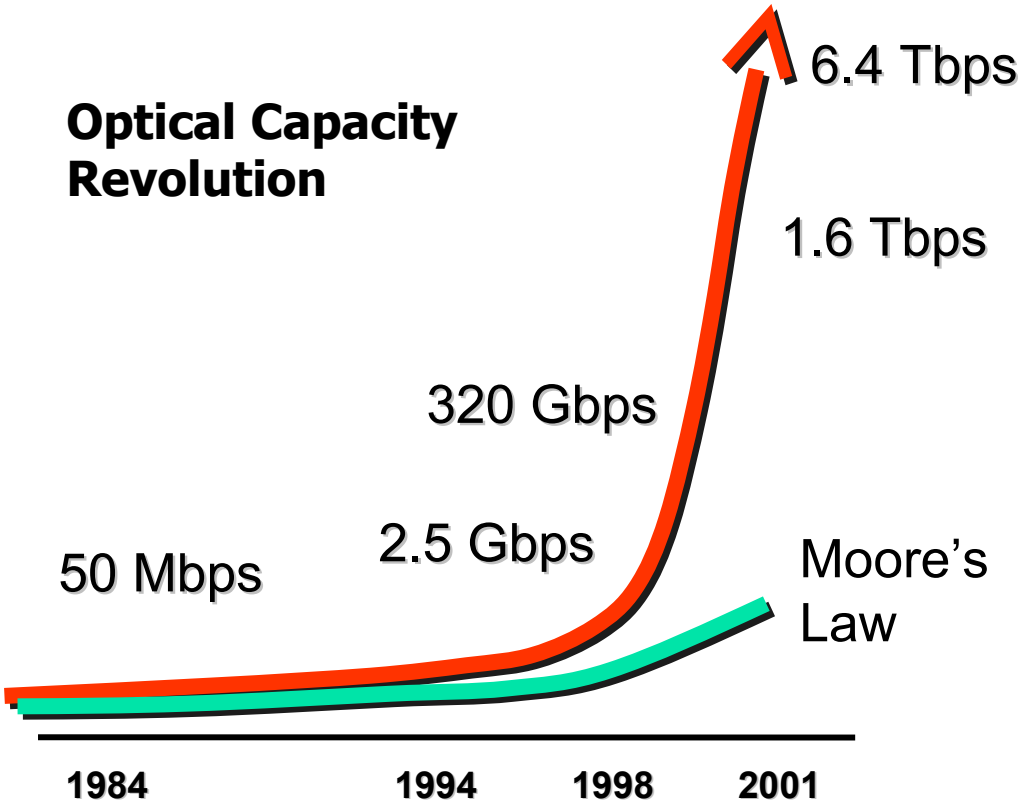
Bandwidth is Becoming Commodity

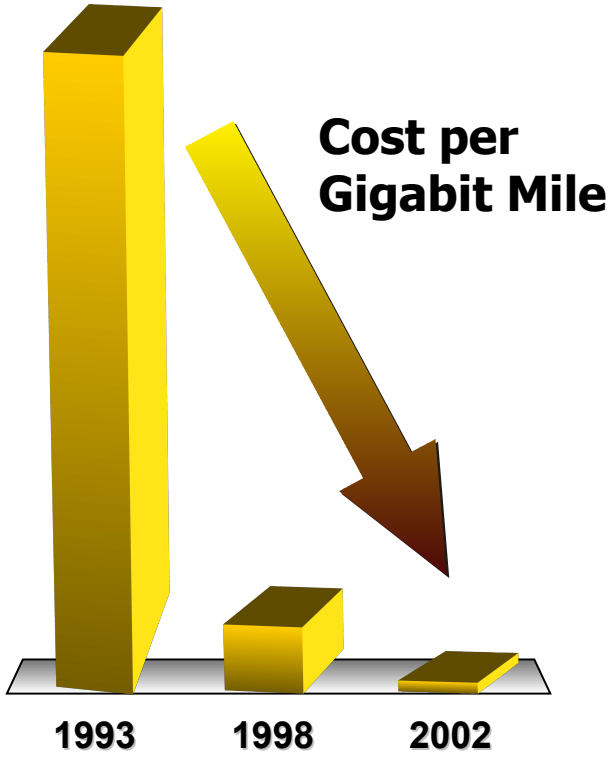
- Price per bit went down by 99% in the last 5 years on the optical side
  - This is one of the problems of the current telecom market
- Optical Metro – cheap high bandwidth access
  - $1000 a month for 100FX (in major cities)
  - This is less than the cost of T1 several years ago
- Optical Long-Haul and Metro access - change of the price point
  - Reasonable price drive more users (non residential)

Summary

- Optical transport brings abundant bandwidth
- Efficient use of bandwidth becomes crucial
- Network Services enable
  - Use network flexibly and transparently
  - Add customized intelligence
- Killer Applications night be OVPN or any other dynamic bandwidth provisioning

Breakthrough...Bandwidth





Wavelengths will become the communications circuits of the future...

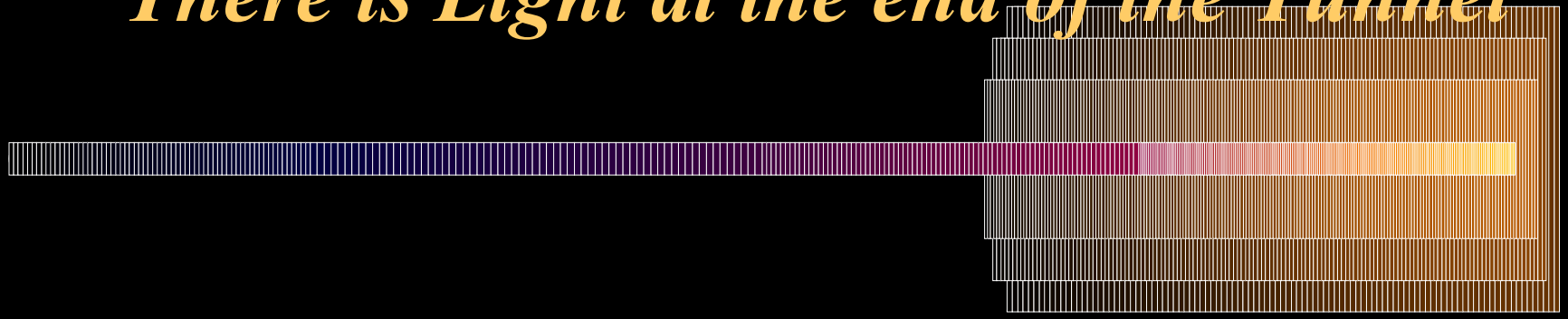
Source: Nortel marketing

"Blindsided by Technology"

- When a base technology leaps ahead in a dramatic fashion relative to other technologies, it always reshapes what is possible
- It drives the basic fabric of how distributed systems will be built

Source – Nortel's marketing

There is Light at the end of the Tunnel



Backup Slides

Agenda_

- Technology and market drivers
- Abundant bandwidth
- Underline the Internet is optical
- What is WDM?
- Where are the bottlenecks?
- Architecture and protection
- Summary
- Backup slides
  - Underline technologies
  - Protection Rings

Changing the big picture

- Now the converged network looks different
- Dial-up bandwidth has huge implications
- Pushing bandwidth to the edges of the network
  - Affects service placement, for example

Bandwidth at the edges

- Services placed there (ServicePoP)
- Need to connect services to customers and other services
- Metro networks
  - Use of Ethernet as low cost/flexible mechanism
- Eventually fibers to pcmcia?!

Metro networks

- Interim step: services in servicePoPs
- Tap into fast connections here for enterprises
- Use of Ethernet as protocol to connect the enterprise to the MAN
- Avoid need for last mile for certain applications/services

Abundant Bandwidth

Why does this change the playground?

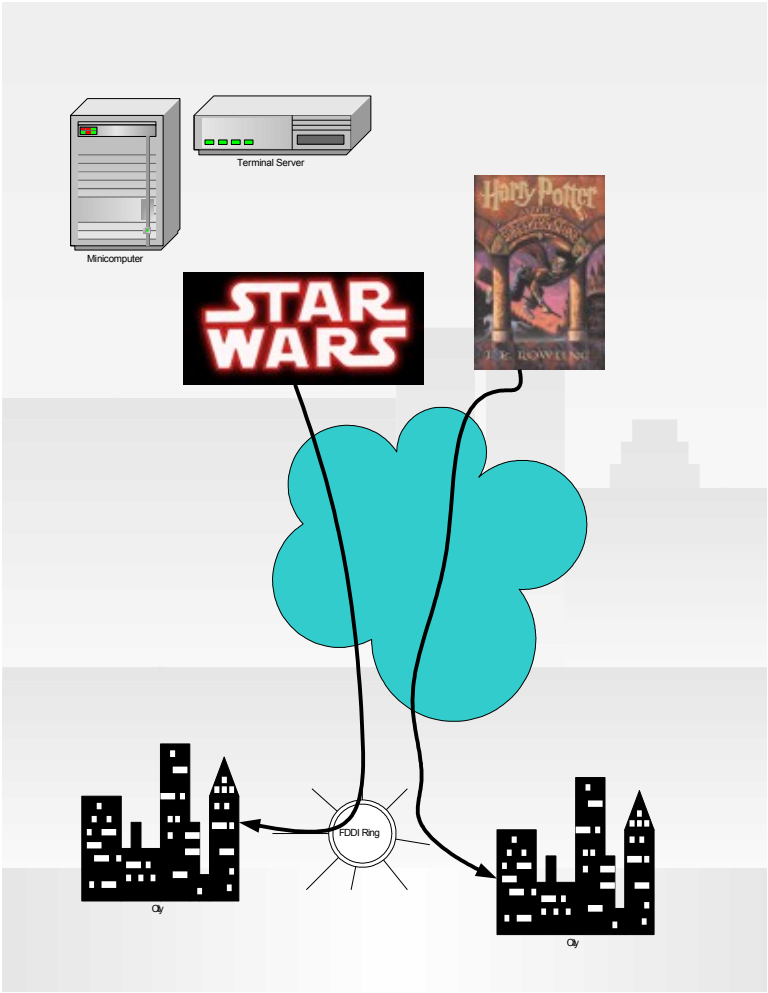
- Optical core bandwidth is growing in an order of magnitude every 2 years, 4 orders of magnitude in 9 years
  - 1992 – 100Mbs (100FX, OC-3)
  - 2001 – 1.6Tbs (160 DWDM of OC-192)
  - OC-768 (40Gbs) on single ! is commercial (80Gbs in lab)
- 2-3 orders of magnitude bandwidth growth in many dimensions
  - Core – Optical bandwidth - (155mb/s ! 1Tb/s)
  - Core Metro – DWDM optical aggregation – (2.4Gb/s ! N*10Gb/s)
  - Metro – Access for businesses (T1 ! OC3, 100FX, 1-Gb/s)
  - Access – Cable, DSL, 3G – (28kb/s! 10mb/s, 1.5mb/s, 384kb/s)
  - LAN – (10mbp/s ! 10Gbp/s)

Why Does This Matter?

- How do these photonic breakthroughs affect us?
- This is a radical change to the current internet architecture
- WAN starts to be no longer the bottleneck
  - How congestion control/avoidance affected?
  - Why DiffServ if you can get all the bandwidth that you need?
  - Why do we need QoS?
  - Why do we need cache? (if we can have big pipes)
  - Where to put the data? (centralized, distributed)
  - What changes in network architecture needed?
  - What changes in system architecture needed?
  - Distributed computing, central computing, cluster computing
  - Any changes to the current routing?

Movie Distribution

- Each movie theater in a large area (SF, New York, Houston) requests 1 hour of bandwidth a week (OC192)
- All movies transferred during this time
- Efficient use of expensive but necessary fat pipe



Move to optical

- The key is to find a way to use the infrastructure that we have available in an efficient manner
- What services are available? What can we do?
- Challenges?

New type of businesses

- Data warehousing: no more mailing tapes
- Have tape vaults with gigabit connectivity
- Data is sent optically to destination, where it is written to magnetic tape

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How this Affects our Lives?

- What are the new applications to use this abundant bandwidth?
- Distance learning?
- Telecommuting? (for the average person, not us)
- Broadcasting?(I want to see TV channel 48 from Japan)
- Video conference?
- What else? (this is a BIG question)
  - What are the new applications and services?

Need for new services

- Optical networking is evolving
  - Much more bandwidth
  - Agile reconfiguring of light path
- Need to take advantage of this and tie it to applications and services
  - Need to define the glue and the interface between the applications and lower levels.
- Can't do computation in the optical core
  - Need to move the intelligence from the core to the edge.

- I'd like to focus and formulate a research program in this area of providing intelligent services at the Optical core.

Where are the bottlenecks

- Optical networking is evolving
- As soon as one problem is solved, the bottleneck is moving to a new place
- Currently it looks like the bottleneck is at the first mile
- Streaming media - bottleneck push on routers
- Much more bandwidth in the MAN move the bottlenecks away from the access and the edge
- Peering points between service provides

Streaming media as bandwidth driver

- Streaming needs big pipes – 2-3 orders or magnitudes more than web surfing.
  - Speed of 3Mbs is about 1GB per hour
- Constant traffic (can be turn on for hours with no one watching)
- Web looks like a big traffic driver on the edge – but it is small traffic on the core.
  - One hour web, 10 second a page, 360 pages, 10KB page → 3.6MB

EFM –Ethernet First Mile

- Ethernet at the first mile start to be attractive.
- Drive more bandwidth to the end users
- Three proposals :
  - 22Mbs on the current phone line
  - PON –Passive Optical Network – split the optical link to 4 and additional 8 total 32 customers (60Mbs per residence)
  - Point-to-point optical – more expansive
- SBC and alike are interested.

- The tight of way is the main issue. Optical fibers work fine in harsh environment
  - Sewer net, Power line, Gas line, water line.

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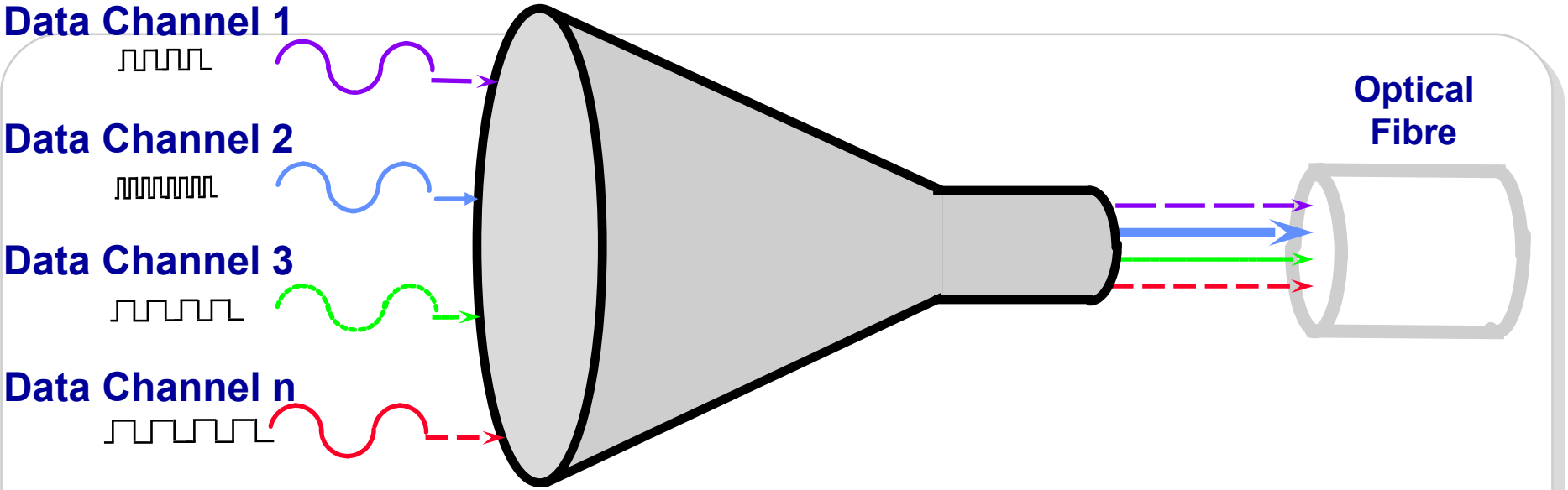
If we had the bandwidth…

- What if we all had 100Mb/s at home?
  - Killer apps, other apps, services
  - Peer-to-peer video swapping
  - Is it TV, HDTV, something else?
- What if we had larger pipes at businesses?
  - 1Gbs home office, 10GE/DWDM large organizations
- How would the network architecture look, if we solve the last mile problem?

Summary_

- DWDM – phenomenal growth
- Abundant bandwidth
- Underline optical technologies
- The access is still bottleneck
- Reliability and protection

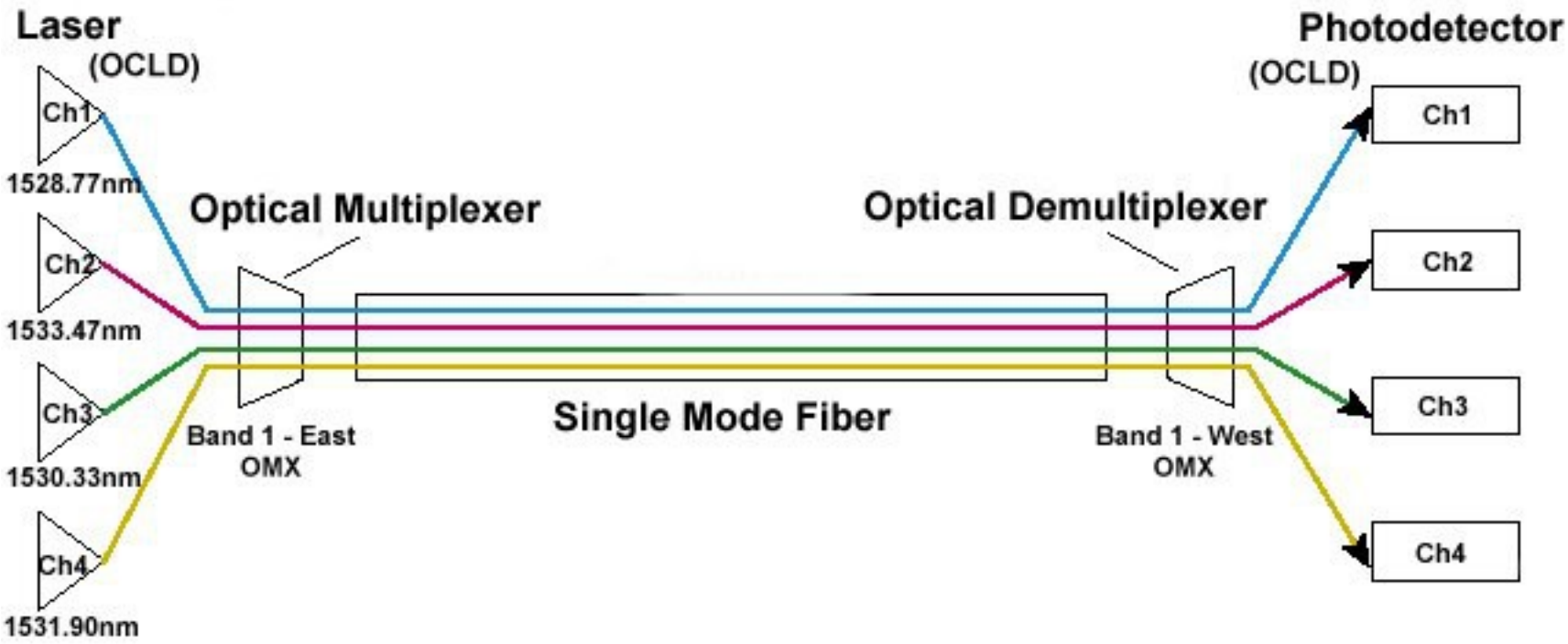
What is WDM?



Wavelength Division Multiplexing (WDM) acts as "optical funnel" using different colors of light (wavelengths) for each signal

Source: Prof. Raj Jain Ohio U

Wavelength Division Multiplexing



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