



The Current State Of The Optical Industry



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Overview

The Current State Of The Optical Industry

- Quick Look Back on 2000
- Reality vs. Myth
- Innovations in Optical Networking
- Challenges to Success
- Looking Forward

The title "2000 In Review" is centered on the page in a large, white, sans-serif font. The background is a solid dark blue with a faint, stylized atomic model graphic on the right side.

2000 In Review

2000 In Review

Over the next decade, computer speeds will rise about a hundredfold while bandwidth increases a thousandfold or more.... the last two decades have been the epoch of the computer industry; the next two decades will belong to the suppliers of digital networks.

- George Gilder, *Telecosm*

2000 In Review

- Everyone recognized the need to “improve” or “replace” SONET, although the approaches vary
- Optical networking gains prominence in the longhaul core—meshed becomes the ring alternative
- Optical networking successfully creates many new service and infrastructure improvements

- Services
 - New wavelength services
 - Faster provisioning intervals
 - Declining prices
 - Priority-based protection options

2000 In Review

- Infrastructure
 - Scalability increased and cost decreased by new orders of magnitude
 - Reduced signal regeneration improves transmission economics and lowers costs per bit
 - 3000+ km transmission distances achieved
 - Protection switching achieved with meshed infrastructure (“SONET-like” protection without SONET)
 - Steps taken to reduce network layers and infrastructure complexity
 - DWDM increasing number of available channels per fiber
 - Power and space consumption reduced with many new solutions
- The excitement and innovation that began in longhaul cores extends into metropolitan networks

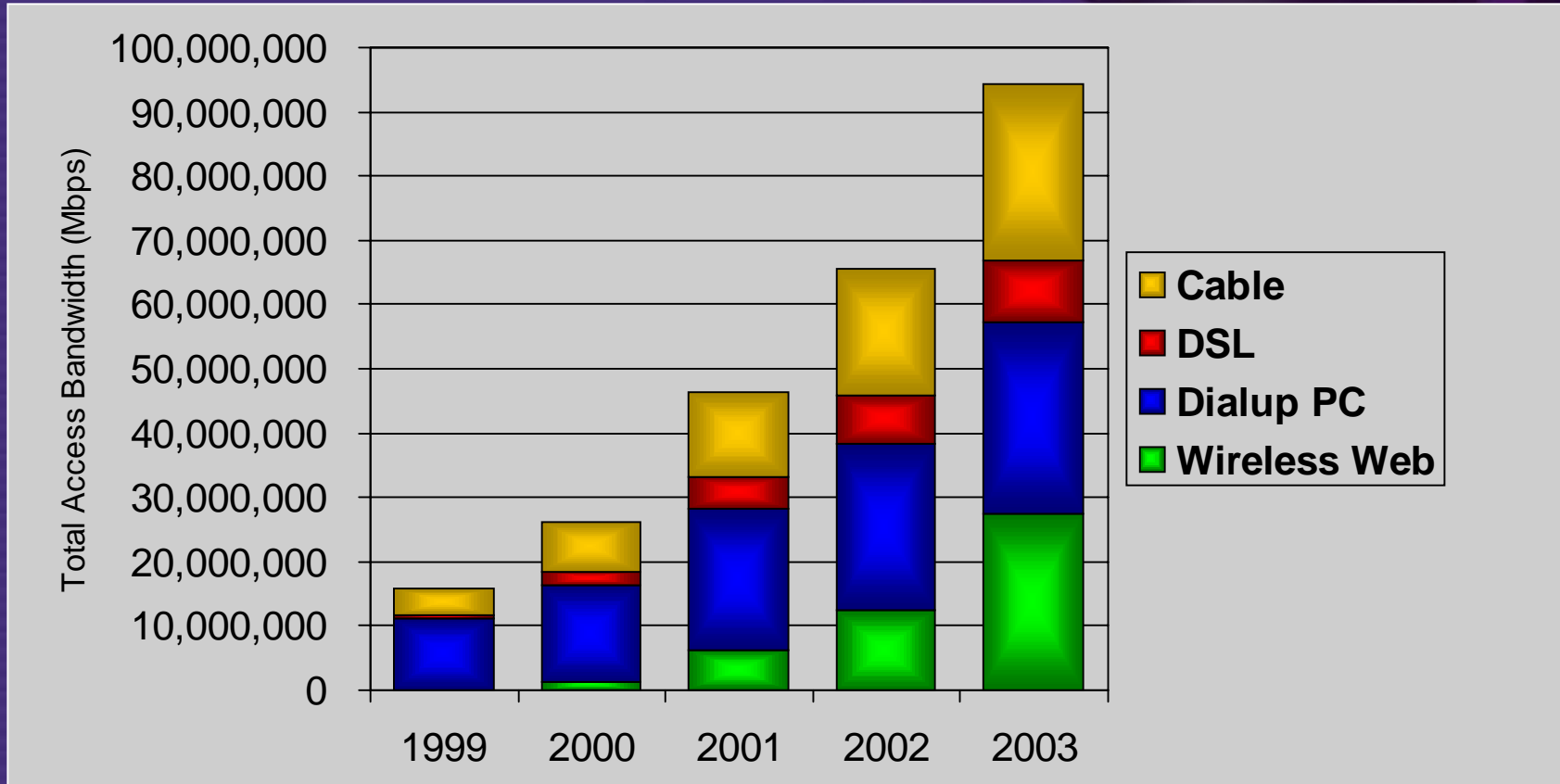
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Reality Vs. Myth

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Optical Network Drivers

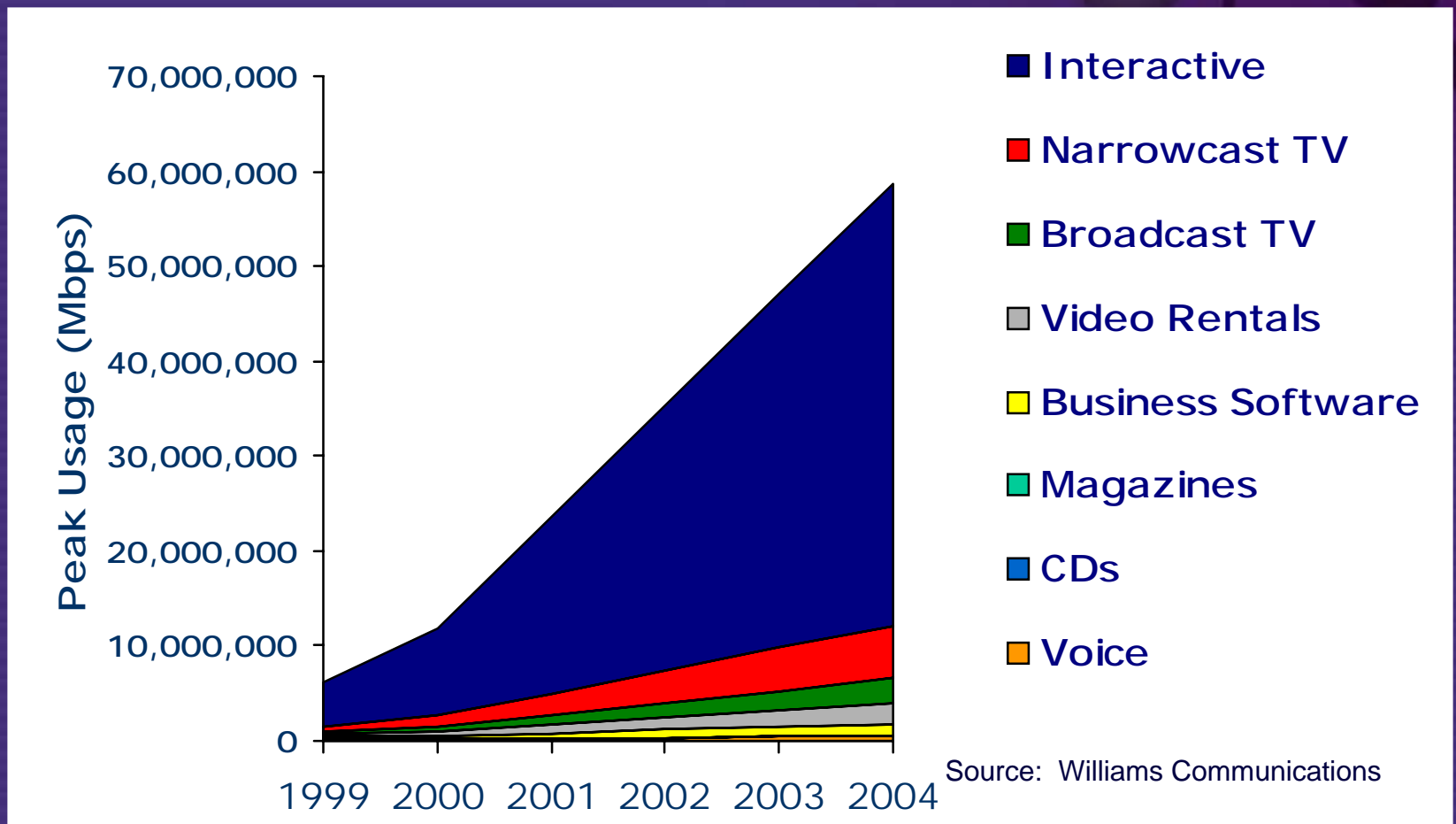
Interactive Access



Assumes average bandwidth per connection of:
 50Kbps for wireless Web, 56Kbps for dialup, 1Mbps for DSL, 3Mbps for cable

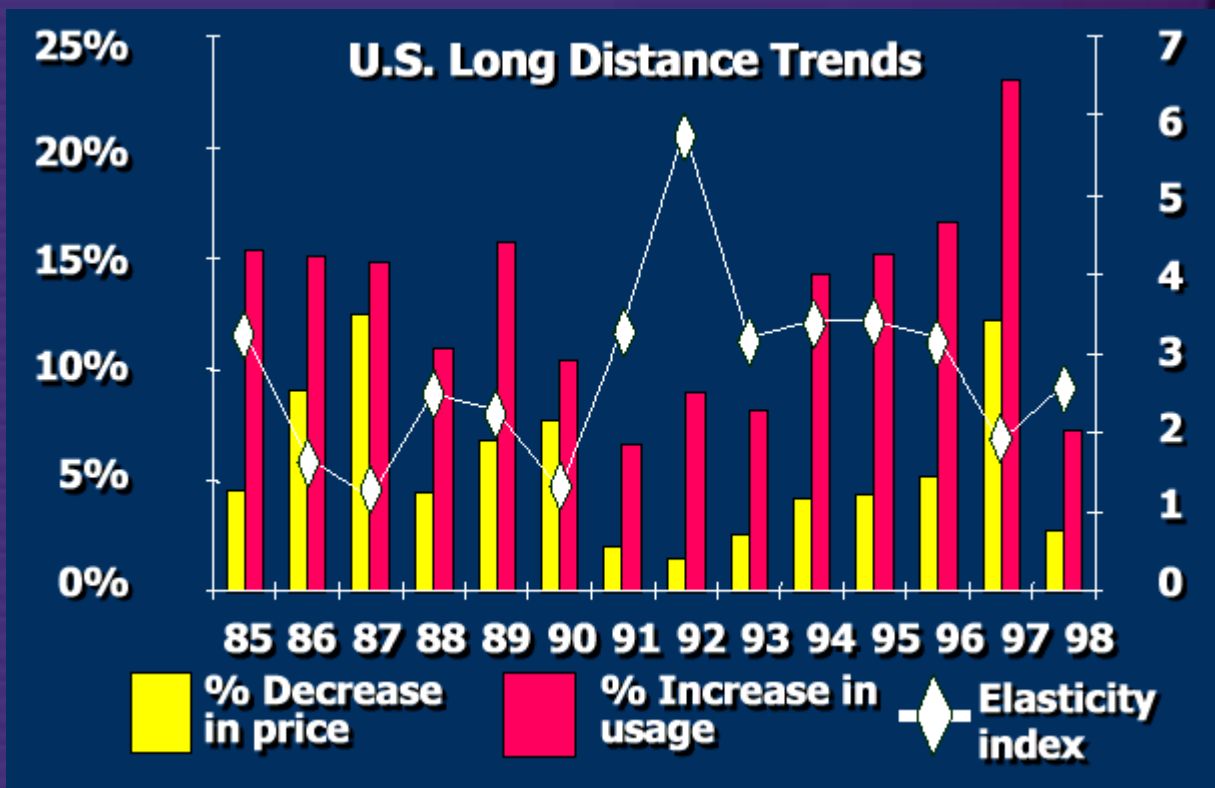
Optical Network Drivers

Future Bandwidth Drivers



Optical Network Drivers

- Every 1% decrease in costs equals a 3% increase in demand



Source: Williams Communications

Facts Imply A Bandwidth Glut

- Technology improves bandwidth bottlenecks and bandwidth delivery
 - Lower cost per bit
 - Increased wavelengths per fiber
 - Increased utilization per wavelength
 - Improved fiber utilization
- More fiber is being deployed than ever
 - Fiber is replacing copper in metropolitan networks
 - CLECs and longhaul players are leveraging metropolitan fiber networks

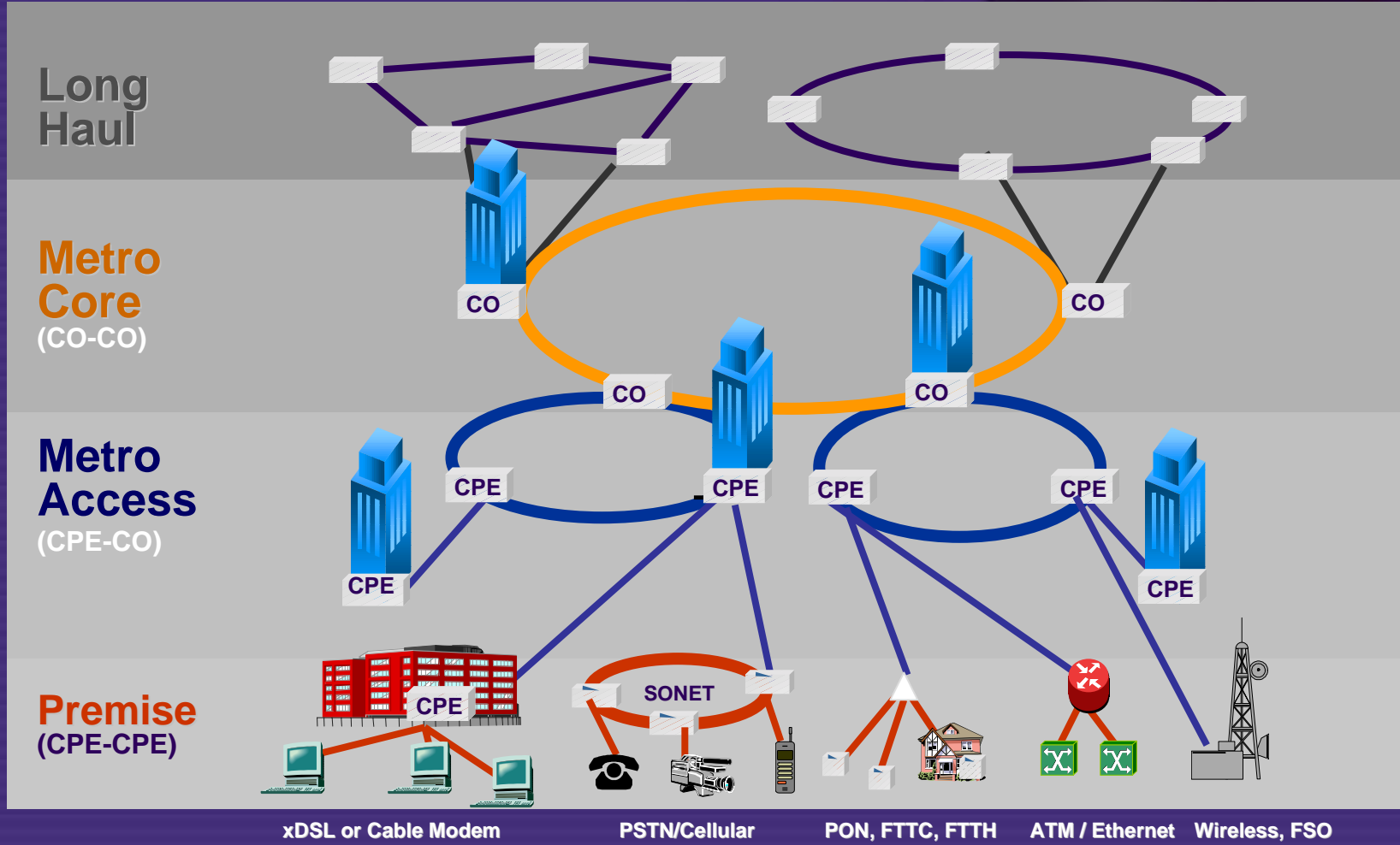
Dispelling The Bandwidth Glut

- “More Fiber” does not mean capacity is available
- Service providers continually evaluate economics of lighting fiber vs. maximizing wavelength channels per fiber
 - More longhaul capacity will be required as high-speed metro services take off
- Additional capacity will be required but availability may never exceed demand
 - Equivalent to demand because of just-in-time deployment practices
 - No incentive for carriers to deploy more bandwidth than what's required
 - Funding and capital restrictions
 - Risks to successful business plan warrant conservative approach

The title "Optical Network Innovation" is centered on the page in a large, white, sans-serif font. The background is a dark blue gradient with a faint, stylized atomic model on the right side. The top of the slide features a decorative header with a green and yellow pattern on the left, a red bar, and a purple background with a grid and glowing points.

Optical Network Innovation

Innovation impacts equipment value propositions in all segments



Optical Network Innovation

■ Premise

- Optical service activation platform for managing multiple services using software tools and a single Ethernet interface

■ Access

- “The layerless edge” is introduced to provide unprecedented scale
- Dense Virtual Routing
- Wavelength splitting for providing high-speed optical access
- Open-air, optical-meshed networks

Optical Network Innovation

■ Metropolitan

- Optics and routing collapsed together
- Increasing network utilization by oversubscribing the optical layer
- Increased wavelength utilization by packing multiple services onto the wavelength
- Displace legacy ADM, multiplexers, access routers, SONET with Gigabit Ethernet
- Simplified metropolitan networks to accommodate legacy traffic while optimizing for data
- Incorporating DWDM, SONET, and layer 2-3 intelligence for switching and routing into one box

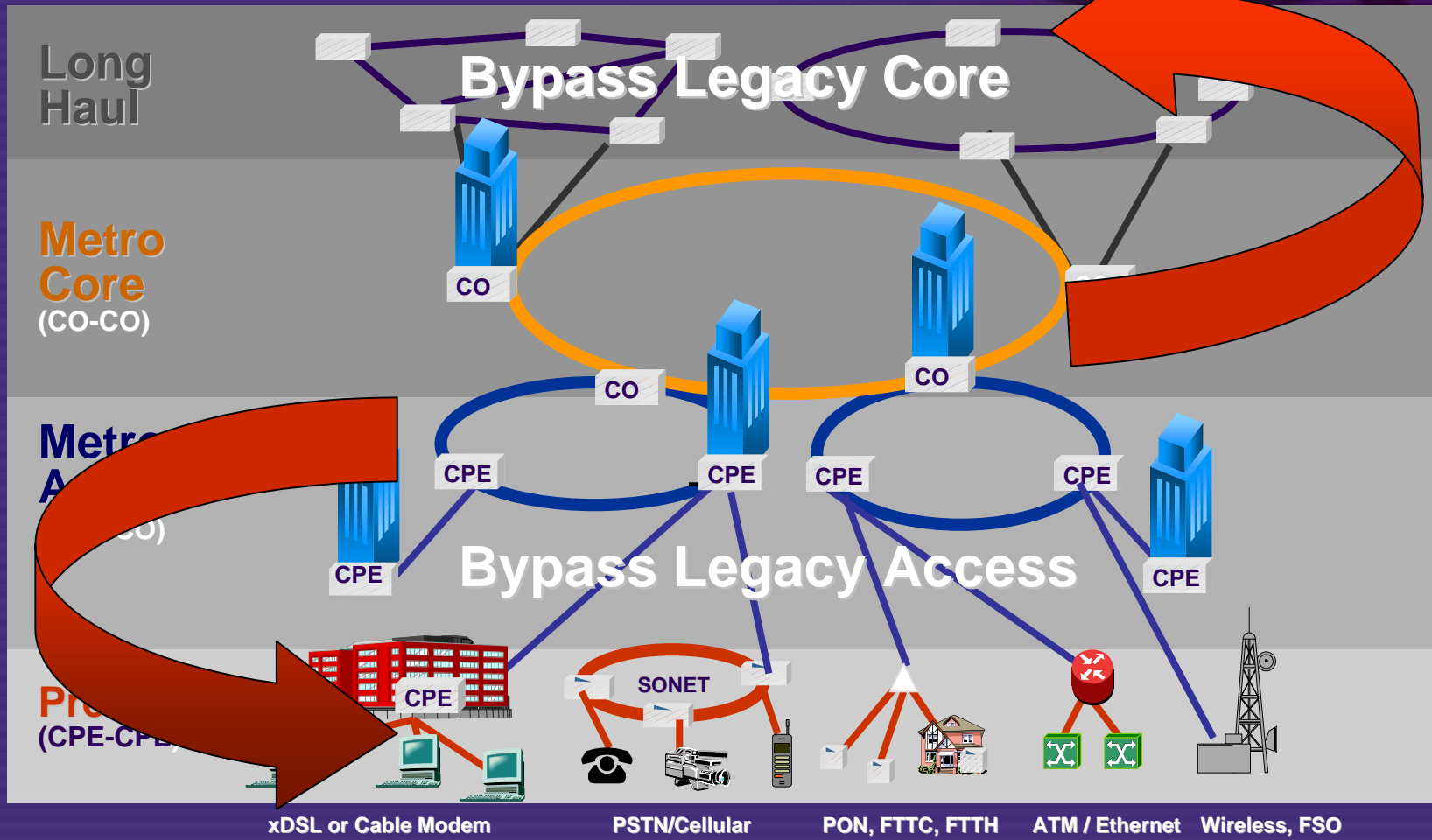
Optical Network Innovation

■ Longhaul Core

- Improved port scalability while consuming less space and power by using a photonic switching core
- Optical service creation
- Optical switches are being introduced with higher port densities
- Building optical switches using fiber amplifiers
- Continuing to improve longhaul transmission distances

Optical Network Innovation

Innovation impacts service providers



Optical Network Innovation

■ New Internet Providers

- Providers seeking to extend performance guarantees (SLAs) across multiple ISP networks

■ New Access and Building-Centric Providers

- Metro providers using Gig E, WDM, and optics to provide high-speed access at lower prices
- High-speed, in-building connectivity with tailored bandwidth and services via Web portal
- Free fiber upgrade in exchange for customer ownership rights
- Integrating applications, services, and transport for building-centric markets

Optical Network Innovation

■ Service Providers

- Content delivery management
- Bandwidth clearing houses
- Fixed high-speed wireless services (1-20Mbps)

■ Storage Providers

- Software for replicating data across distances over dial-up lines, or dedicated access lines using T-1 or ATM
- Hybrid storage devices that switch, route, and bridge Fiber Channel and SCSI traffic over IP networks for bridging geographically distant storage networks with DWDM

New Developments In Optical Networking

■ Equipment solutions targeting:

- Wavelength management
- Improving fiber capacity
- Bandwidth efficiency
- Increased port switching density

■ Optical switches with various switching cores

- MEMS
- Liquid crystals
- Bubbles
- Thermal optical

Holograms
Liquid gratings
Acousto optics

■ Increasing available wavelength channels at higher distances

New Developments In Optical Networking

Technology Solutions

- Tunable lasers
- Hybrid optical switches with OEO and OO cores
- Dispersion compensation modules limit chromatic dispersion and improve bit rate, optical channels, and span length
- Use of Metropolitan DWDM when dark fiber leases cannot be justified
- Raman amplification improves transmission distances
- Integrated L-band and C-band amplifiers
- Emergence of FTTC, FTTH, and FSO

New Developments In Optical Networking

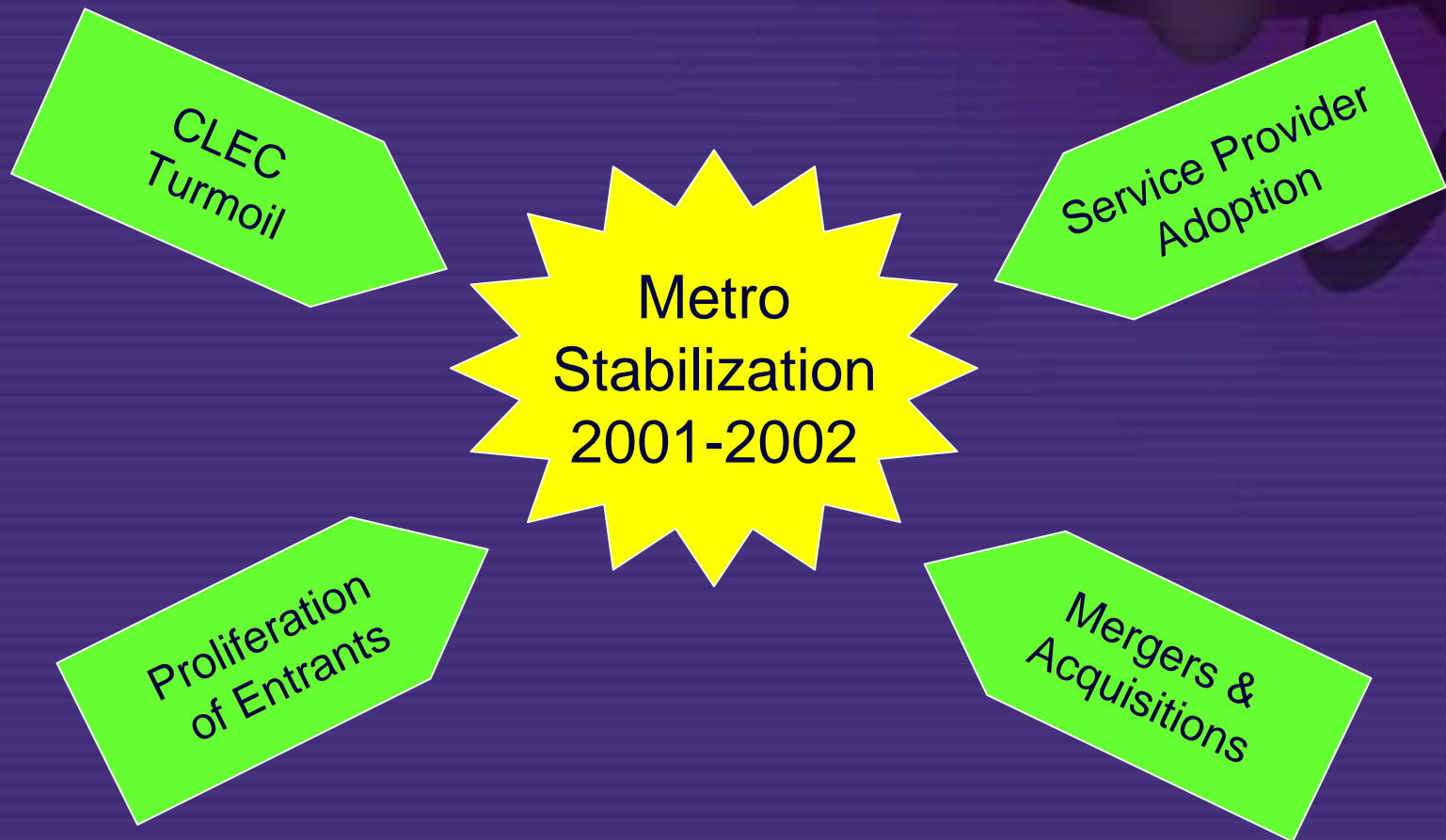
Architecture changes

- Service layer displaced to the network's edge
- Rings migrate to meshed networks in longhaul, regional metro networks but remain in access networks
- ADMs and cross connects replaced by a new generation of optical equipment
- ATM and SONET continue to lose ground to Gig E
- Elimination of OEO where it's not required
- IP over DWDM
- Network layers are streamlined to improve scale, service delivery, operations, network management, etc.

The background is a dark blue gradient. In the top left, there is a collage of images including a circuit board, a globe, and abstract patterns. A red horizontal bar runs across the top. On the right side, there is a large, faint, stylized atomic model with three spheres and intersecting orbits.

Challenges To Success

Optical Market Challenges



Optical Networking Challenges

- Relieving metro and access network bottlenecks
- Broken service provider business models may begin the demise for many service providers and equipment vendors
- Hiring, training, and retaining talented employees
- Proliferation of wavelength services creates the need for additional value and differentiation
- End-to-end network management, interoperability, and SLA reporting across a growing number of vendor solutions
 - Need to provide fault detection and isolation
 - High level of granularity and segmentation

Optical Networking Challenges

- Improving costs for metro DWDM solutions
- Increasing the number of available wavelength channels at higher distances
- Equipment implementation and validation by service providers
- Disagreement among optical interworking standards
- Delayed equipment adoption and implementation
 - Service providers' back-office systems
 - Equipment manufacturing delays

Conclusion

- 2000 provided a good start
- Technology continues to drive changes in solutions and service provider business models
- There will be just enough bandwidth – no glut
- Metropolitan market and solutions stabilize
- Many challenges will be overcome by innovation and new equipment developments
- Solutions and providers will compete for viability in 2001
- The next 12 to 18 months will lead to a handful of winners and the consolidation or end to many

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Thank You!

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