



# 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 main title "2000 In Review" is centered on the page in a large, white, sans-serif font. The background is a dark blue gradient with a faint 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

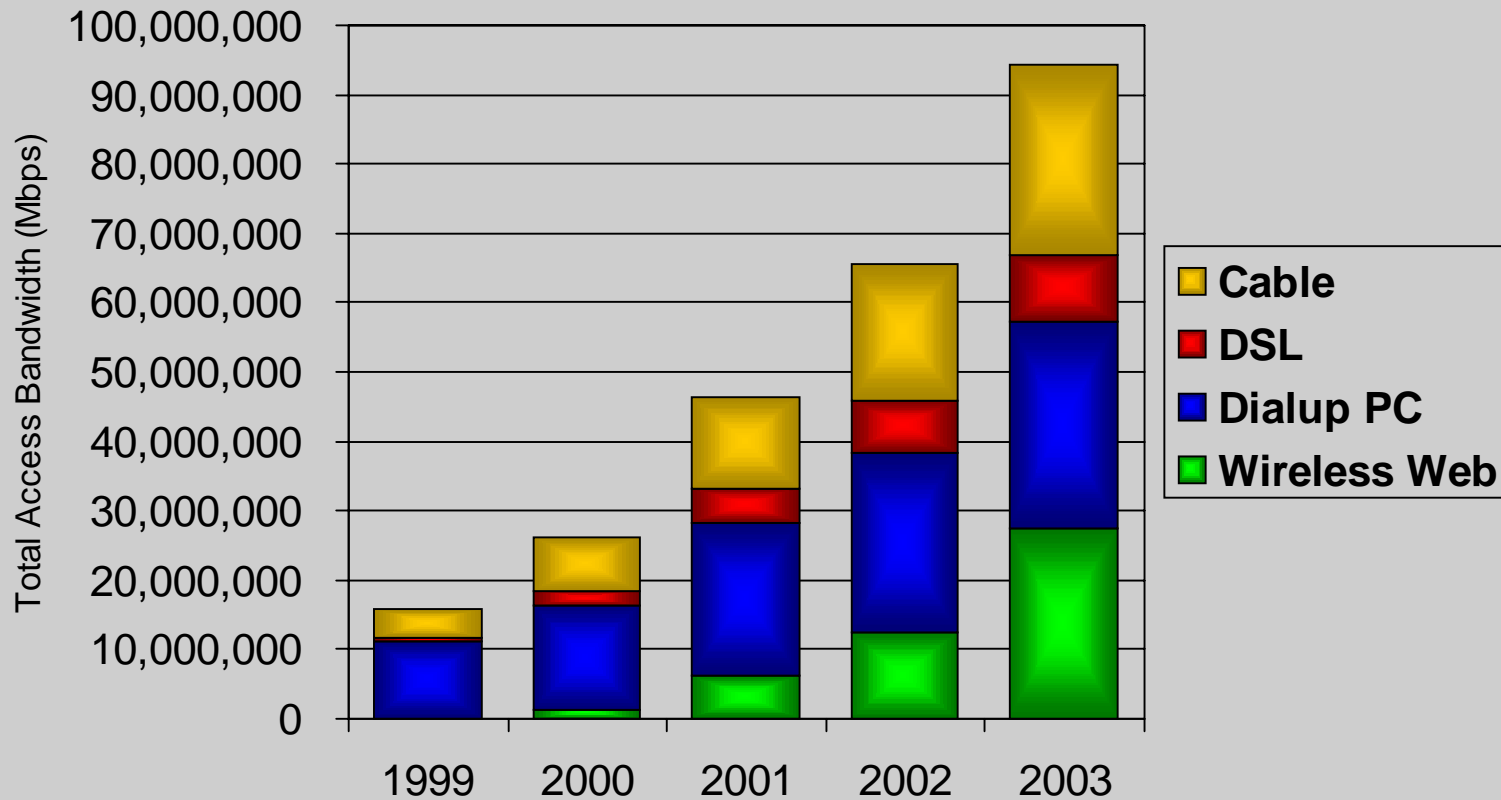
The top left of the slide features a decorative header with a green and yellow grid pattern, a small white box containing the letter 'v', and several overlapping white squares.

# Reality Vs. Myth

A large, faint graphic of an atom is positioned on the right side of the slide. It consists of three dark grey spheres (nuclei) connected by three intersecting elliptical orbits.

# Optical Network Drivers

## Interactive Access

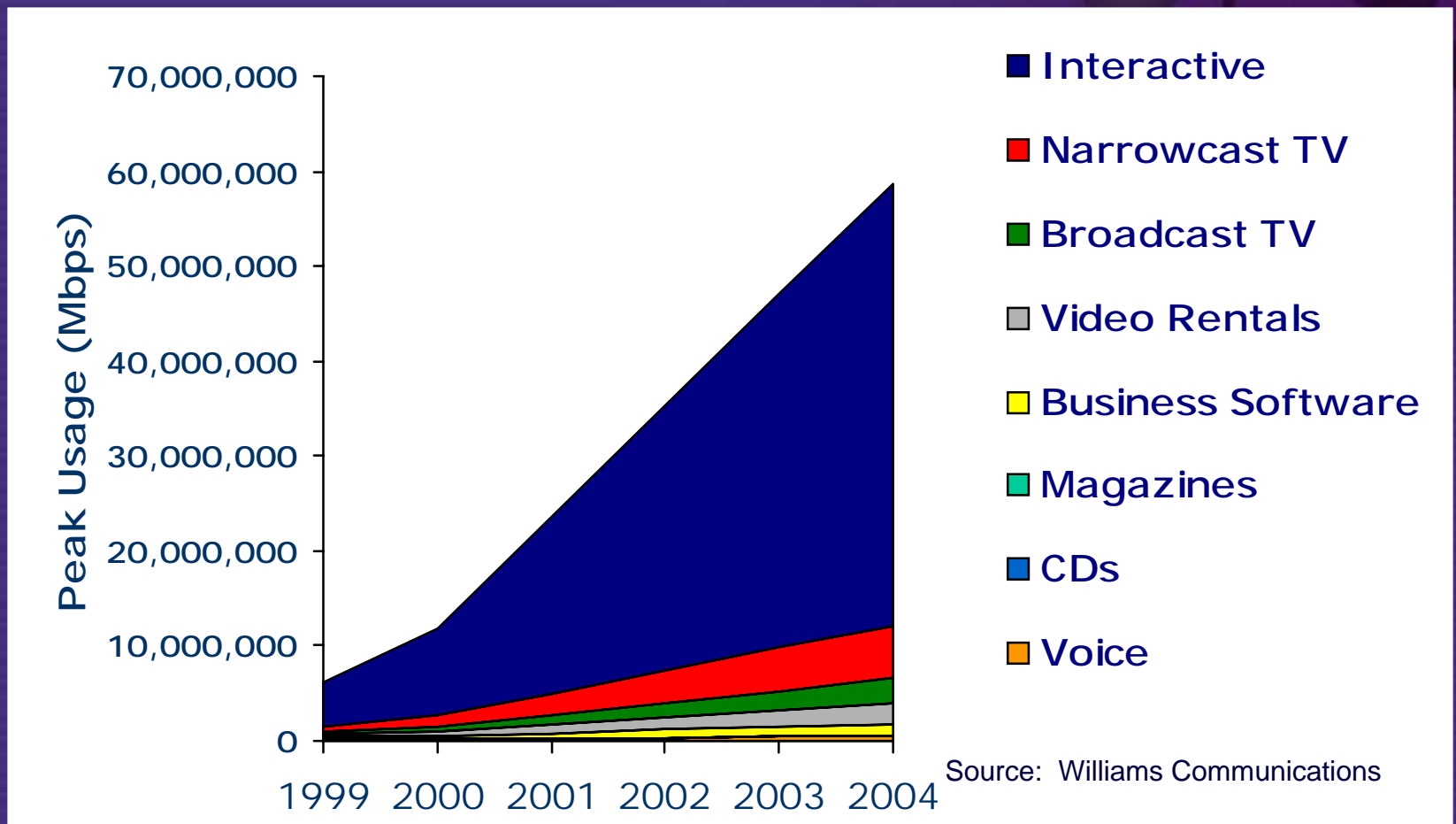


Assumes average bandwidth per connection of:  
 50Kbps for wireless Web, 56Kbps for dialup, 1Mbps for DSL, 3Mbps for cable



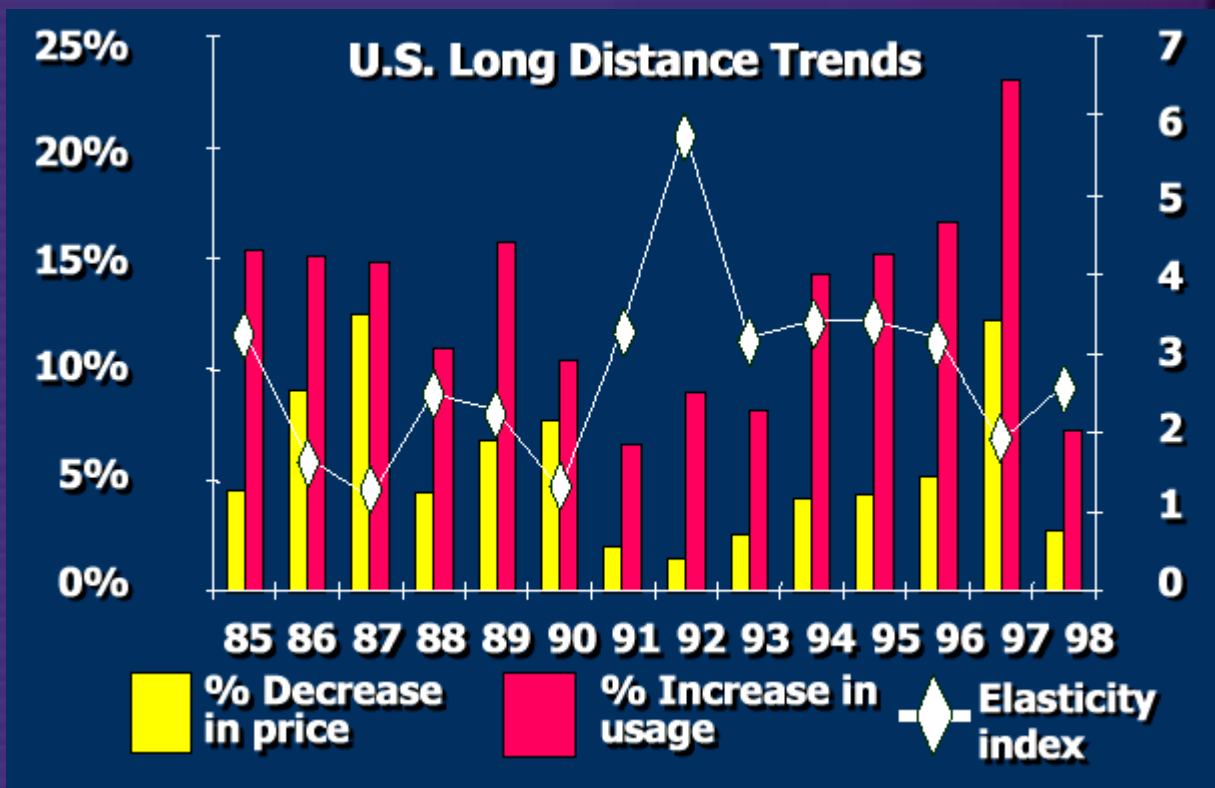
# Optical Network Drivers

## 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

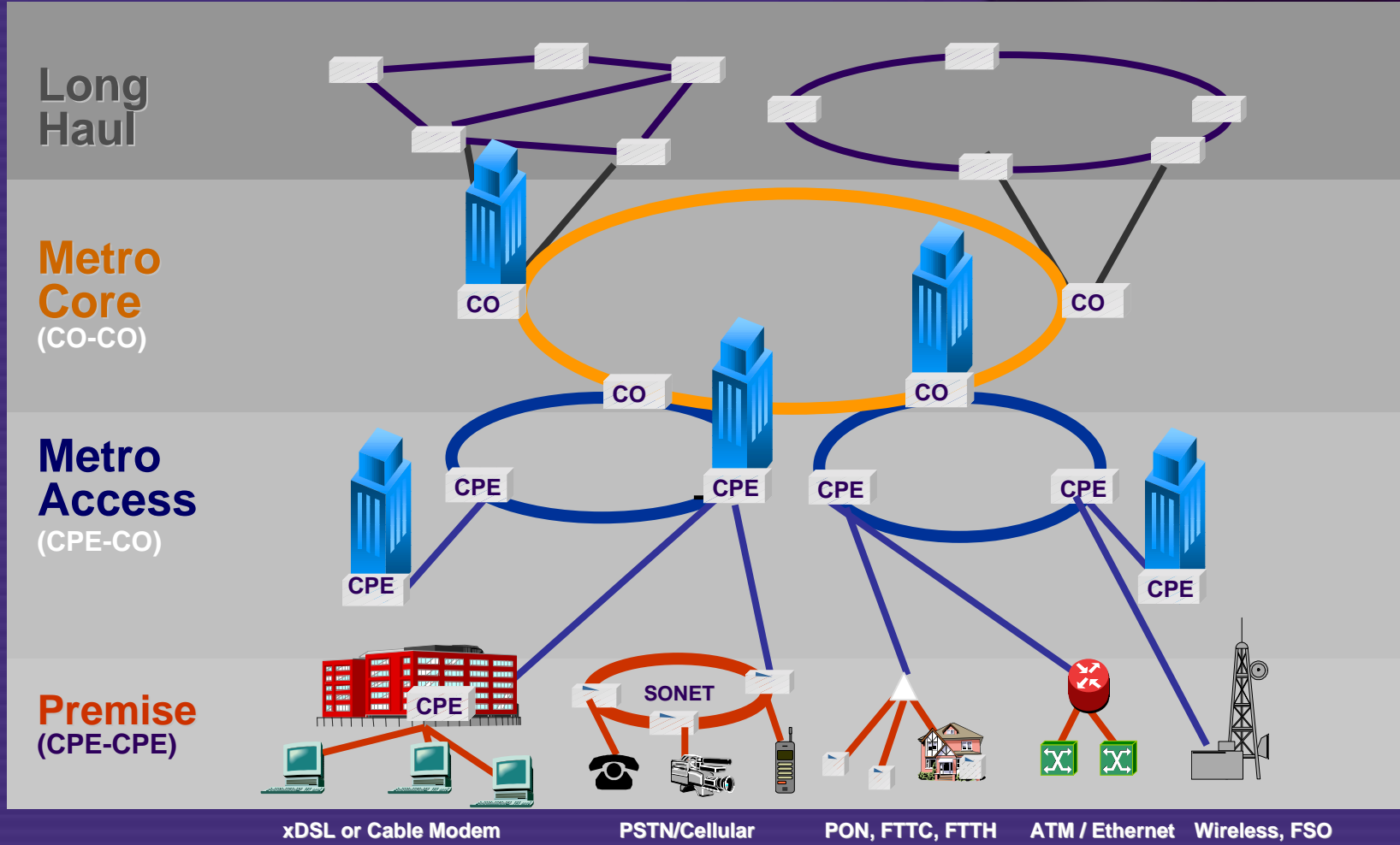
- “More Fiber” does not mean capacity is available
- Service providers continually evaluate economics of lighting fiber vs. maximizing wavelength channels per fiber
  - More longhaul capacity will be required as high-speed metro services take off
- Additional capacity will be required but availability 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 on the right.

# Optical Network Innovation

# 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



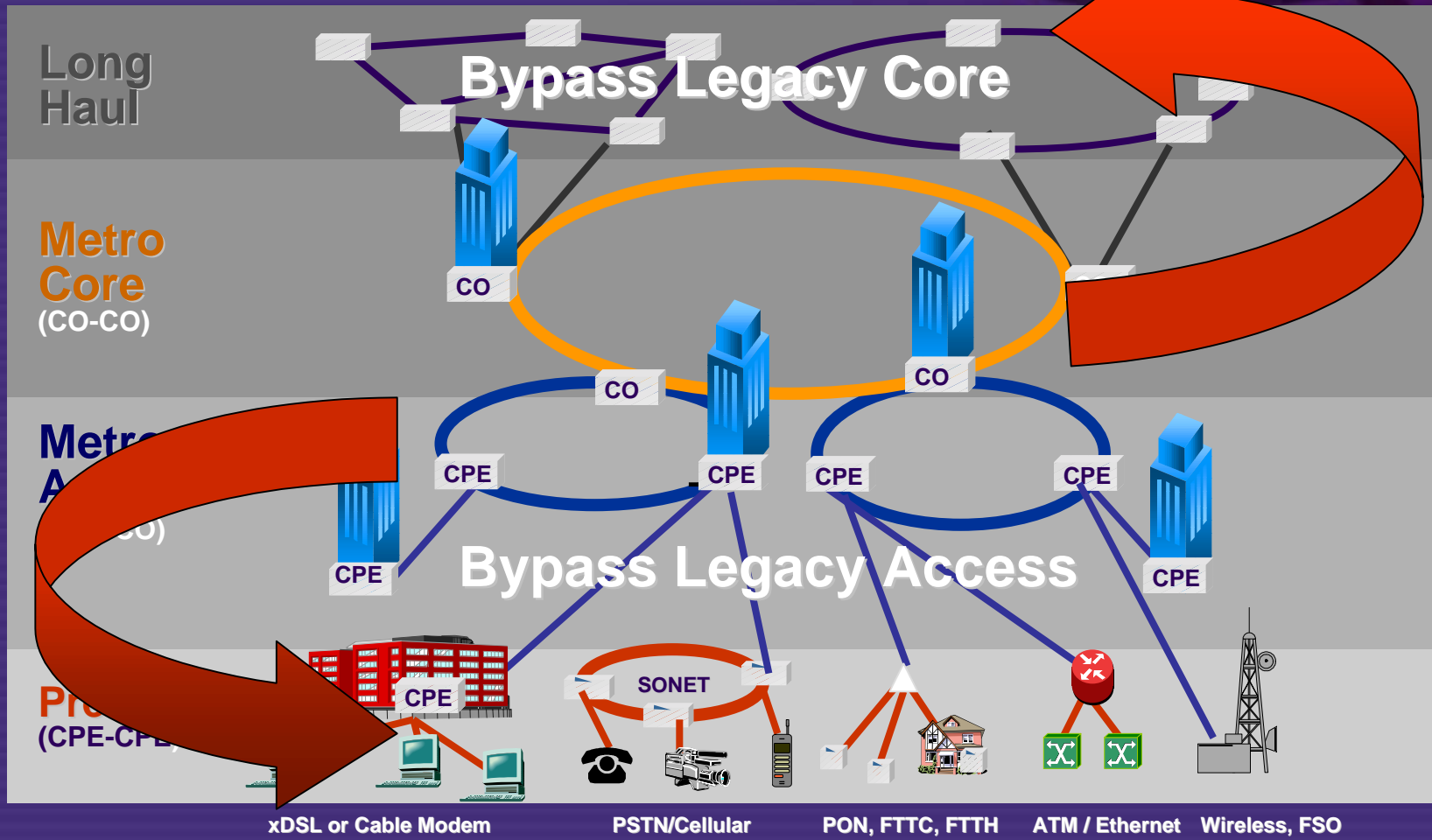
# Optical Network Innovation

## ■ 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

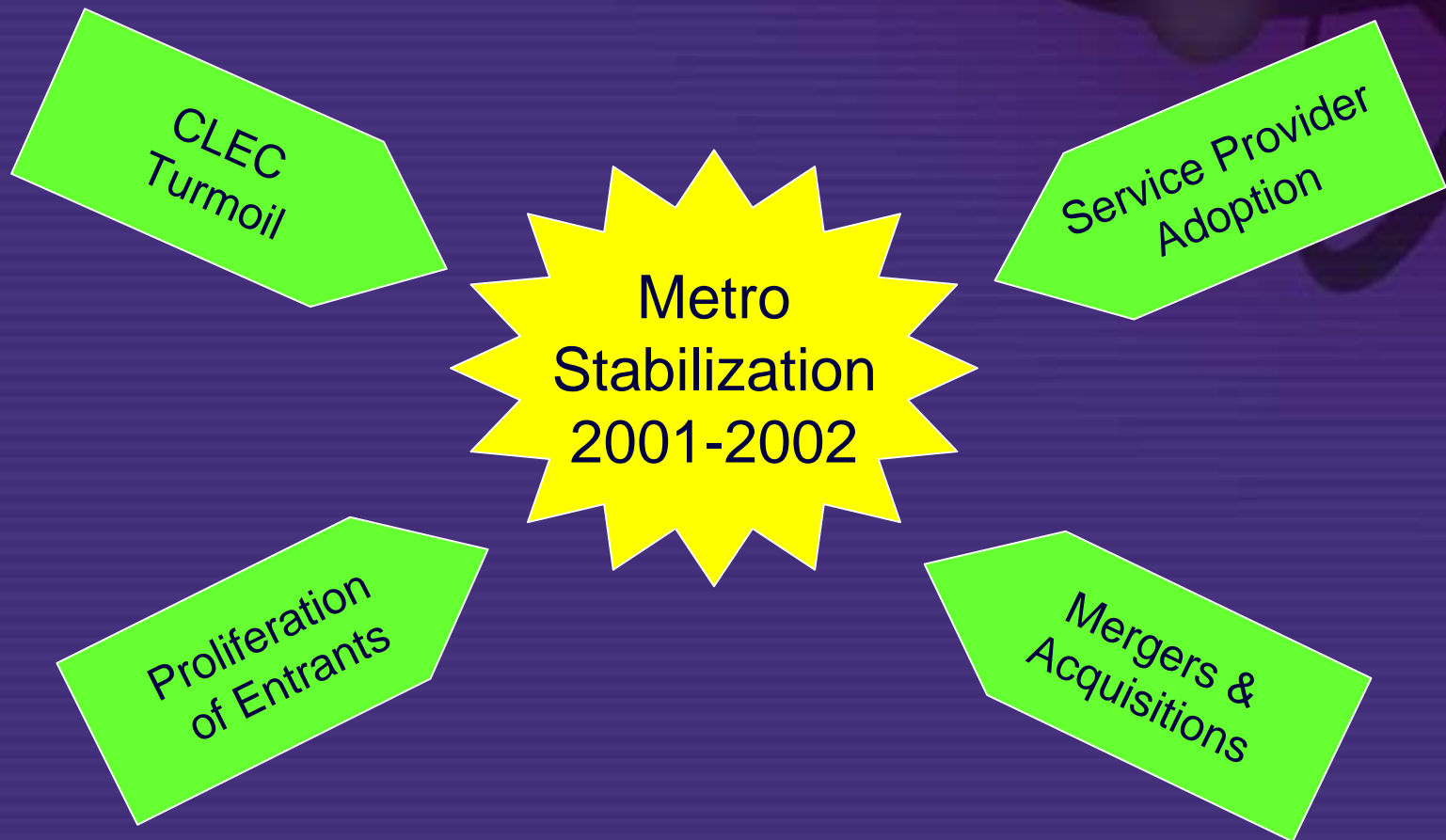
- Service layer displaced to the network's edge
- Rings migrate to meshed networks in longhaul, regional metro networks but remain in access networks
- ADMs and cross connects replaced by a new generation of optical equipment
- ATM and SONET continue to lose ground to Gig E
- Elimination of OEO where 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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