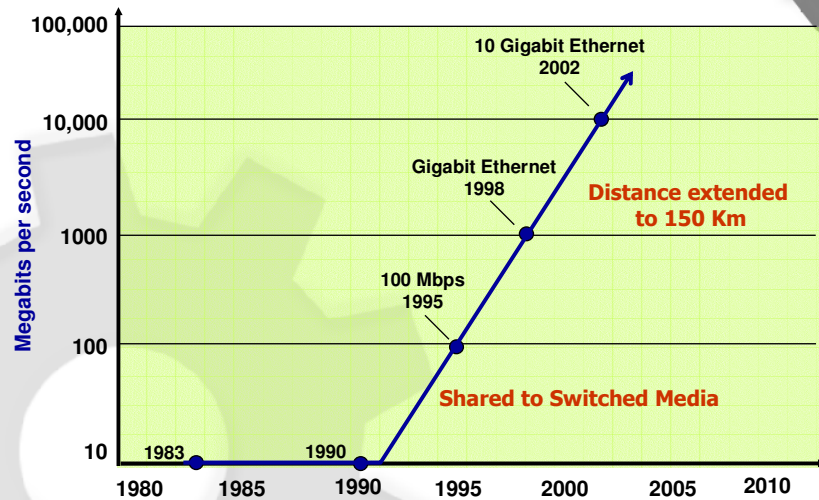




Agenda

- ☐ Market Overview
- ☐ 10 Gigabit Ethernet – The Technology
- ☐ 10 Gigabit Ethernet Applications
 - ☐ LAN, MAN and WAN

Ethernet Technology Evolution



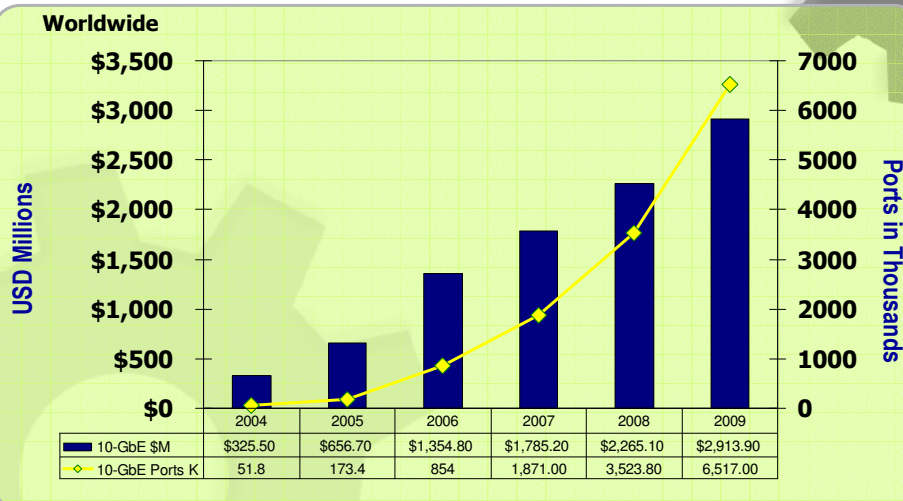
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10 Gigabit Ethernet Growth - Revenue



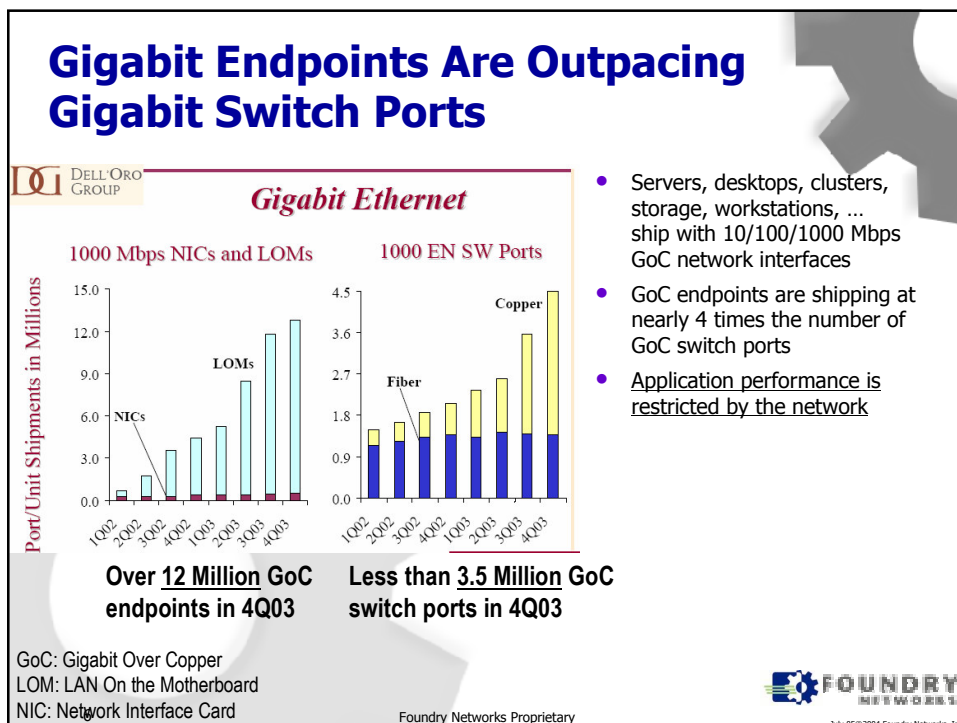
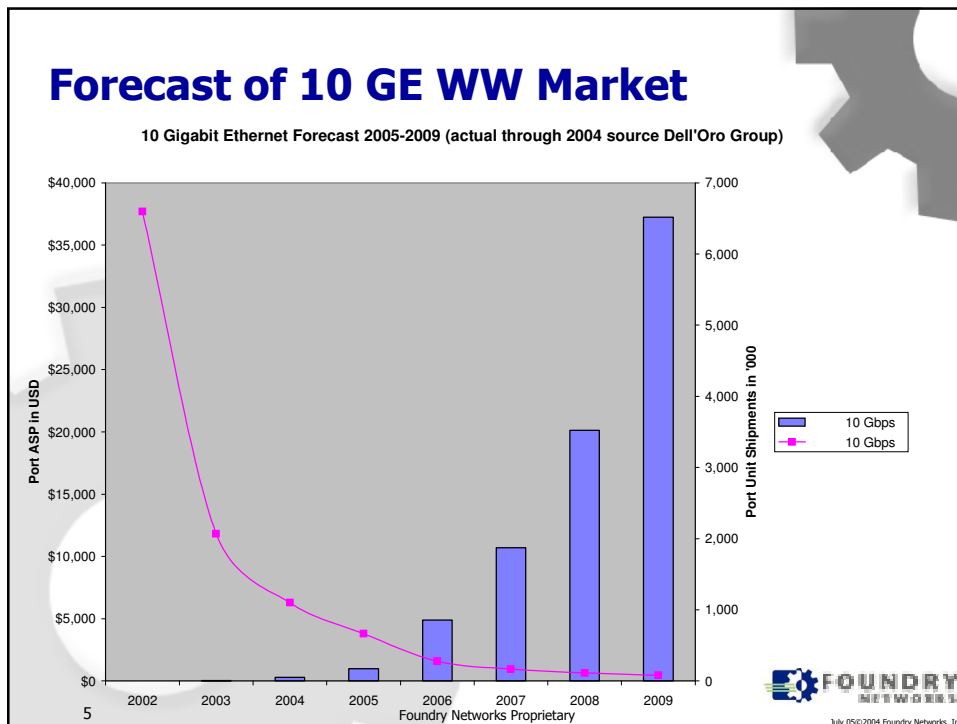
Source: Dell'Oro Group (Dec 2004)

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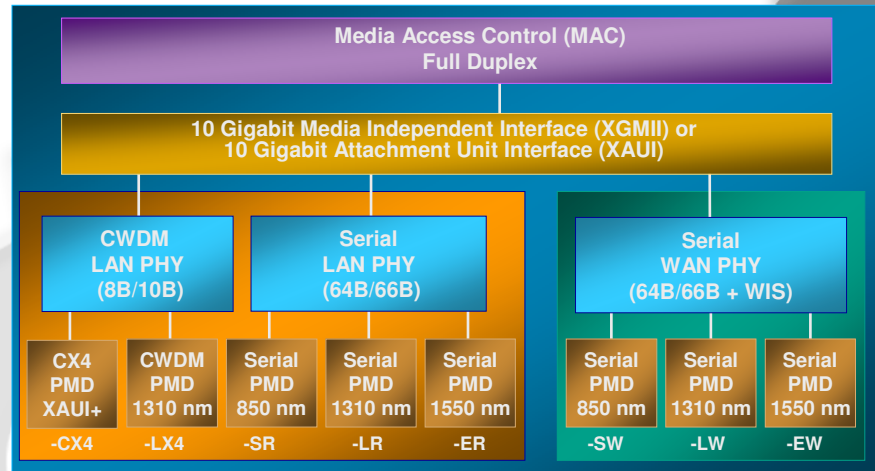
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10 GbE Layer Diagram



CWDM – Coarse WDM

PMD – Physical media dependent sublayer or transceiver

WIS – WAN interface sublayer



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10 Gigabit Ethernet Package Evolution

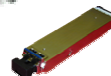


300 pin MSA

Xenpak MSA



XFP MSA



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Current 10 Gigabit Ethernet Media

	Description	Use
10GBASE-SR	Multi-mode Fiber 330 m using high performance fiber	Data centers, wiring closet uplinks, short distances
10GBASE-LR	Single Mode Fiber up to 10 km distance intermediate reach	Inter-floor and inter building campus connections.
10GBASE-ER	Single Mode Fiber up to 40 km distances	Inter building MAN connections. WAN PHY version for OEO OADM connections as OC-192
10GBASE-CX	Infiniband copper cables for 15 m distances	Data Center and Cluster Computing interconnects (no XFP version)
10GBASE-LX4	4 Lambda WWDM over a pair of fiber. Either 330m FDDI-grade MMF or 10 km over SMF	Interconnections over legacy FDDI-grade MMF fiber (no XFP version)

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Future 10 Gigabit Ethernet Media

	Description	Use
10GBASE-ZR	SMF 80 km reach optic Q3 2005	Dark fiber, long distance point to point connectivity
10GBASE-ZRD	SMF 80 km reach select from 40 DWDM channels, Q3 2005	Connection to Passive OADM DWDM devices for MAN interconnect
10GBASE-LRM	Dual MMF and 10km Q1 2006	Alternative to LX4 with support for XENPAK, X2 and XFP MSA
10GBASE-TX	10 GE over 100 m UTP Q3 2006	Inexpensive aggregation, data center, cluster connectivity

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10 Gigabit Ethernet – Applications

- LAN
 - LAN backbone scalability – single building
 - Server Farm Scalability – Gigabit Ethernet to Servers
 - Data Center/Campus High Speed Backbone & Inter-switch extensions
- MAN
 - High performance Metro backbone to provide broadband and native Ethernet connectivity from 1 Mbps to 1 Gbps
 - 10 Gbps becomes a Lambda in the DWDM optical systems
- WAN
 - High speed connections from Metro to WAN backbone and between carriers
 - Seamless interoperability with SONET infrastructure

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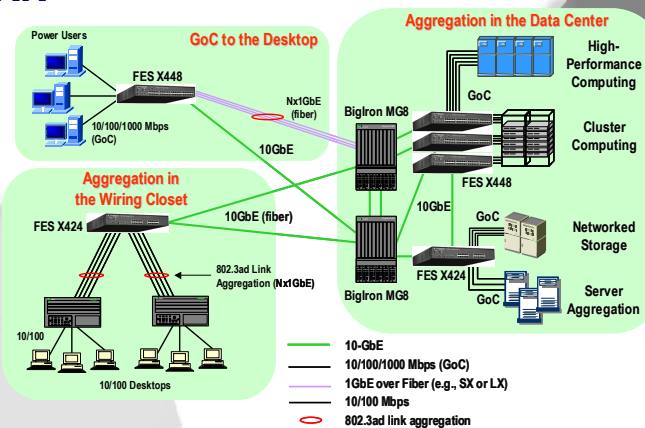
10 GbE Applications - Enterprise LAN

GoC to the Desktop

- Low cost GoC to the desktop for high-end users
- End-to-end 10GbE infrastructure
- End-user network traffic accounting from 10Mbps up to 10Gbps

Aggregation in the Wiring Closet

- Migrate from 1-GbE to 10-GbE with same fiber
- High density GoC ports – ideal for aggregating many wiring closet switches
- Delivers 10GbE connectivity back to the backbone



Aggregation in the Data Center

- 10GbE connectivity from the data center to the backbone
- High density GoC for high-end servers and storage
- Very low latency

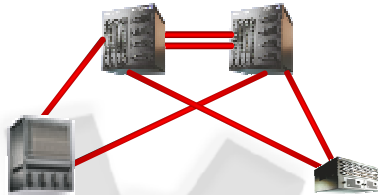
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10 GbE Applications – Enterprise Backbone

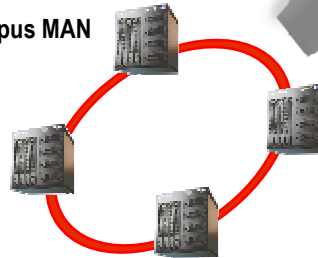
Enterprise Data Centers



Mission Critical applications with high bandwidth requirements

- Increases 10GbE density for core connectivity
- Simplifies and facilitates HA designs
- Reduces overall operating costs
- Delivers optimal access to server farms and clusters

Campus MAN



High Speed Campus MAN

- Efficient use of available fiber plant
- Full use of 20Gbps switching with add/drop capabilities
- Scalable bandwidth using cross-module trunking
- SONET-Like resiliency for maximum network availability

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10GbE Case Study - Walter Reed Army Medical Center



- World-renowned US medical center in Washington, DC
 - Largest in the world
 - Over fifty different specialty and subspecialty clinics
 - Cardio-vascular care, neurosurgery, and organ transplantation capability
- Required Gigabit Ethernet-based network for converged data, voice, and video infrastructure

Network Overview

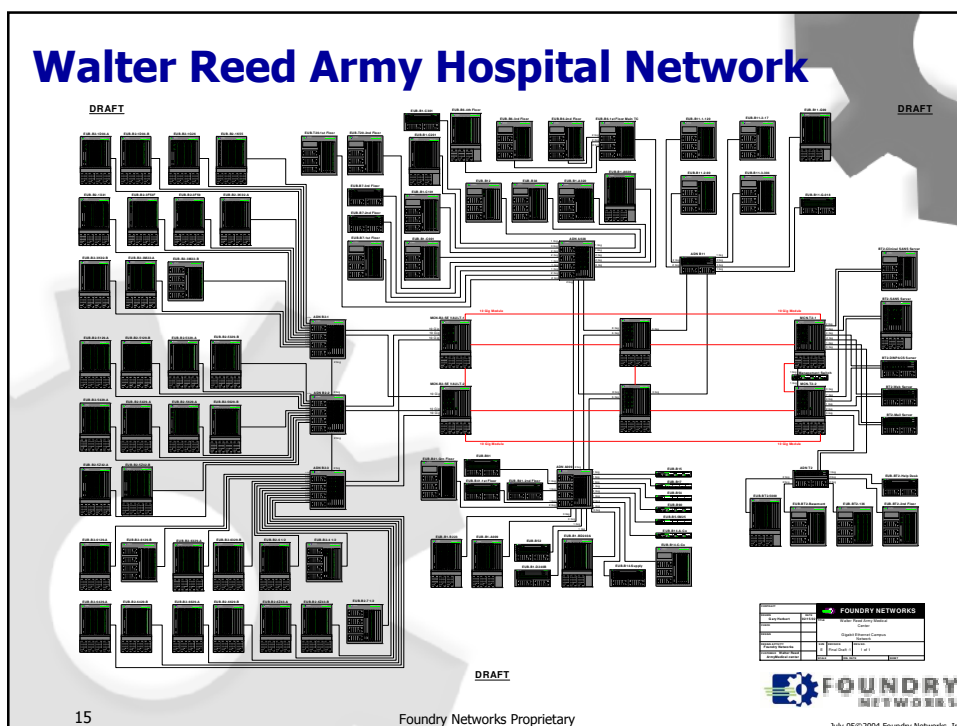
- 13,000 node network
- 60G backbone
- 10 GbE in the Core
- 1 GbE in aggregation
- Full mesh, fully redundant

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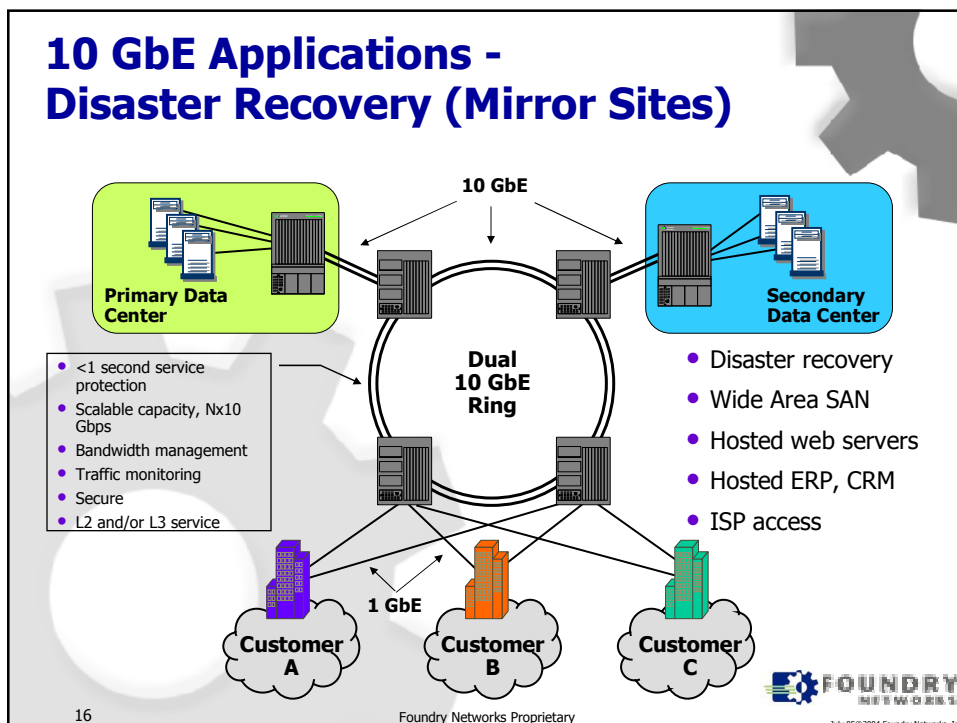
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Walter Reed Army Hospital Network



10 GbE Applications - Disaster Recovery (Mirror Sites)



Grid Computing & Clustering

- One large job shared by all computers at the same time
 - Constant communication between nodes
 - Nodes may share each other's memory and storage
 - Low latency is VERY important
 - Non-blocking performance is important
 - Nodes are typically in the same room
 - Sometimes called a Beowolf cluster
 - Typically used in research environments
- One large job that has been broken into many pieces with each computer working on one small piece at a time
 - Controlled by a Master Node that distributes the jobs
 - Requires large amounts of bandwidth to deliver the job to the node and to get the results back quickly
 - Jumbo frames can help
 - Non-blocking is not as important, but still a consideration
 - Nodes may be geographically disperse
 - Entertainment industry uses these type of clusters

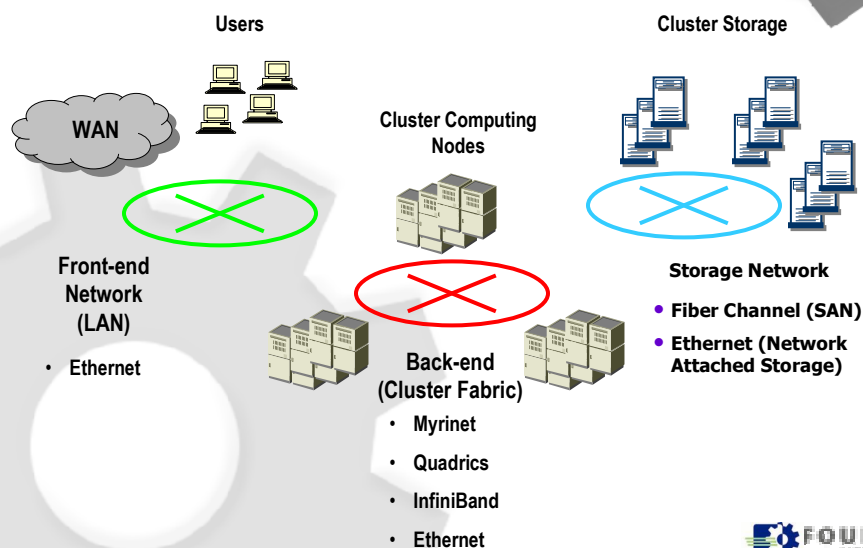
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High Performance Computing - Three Switching Domains

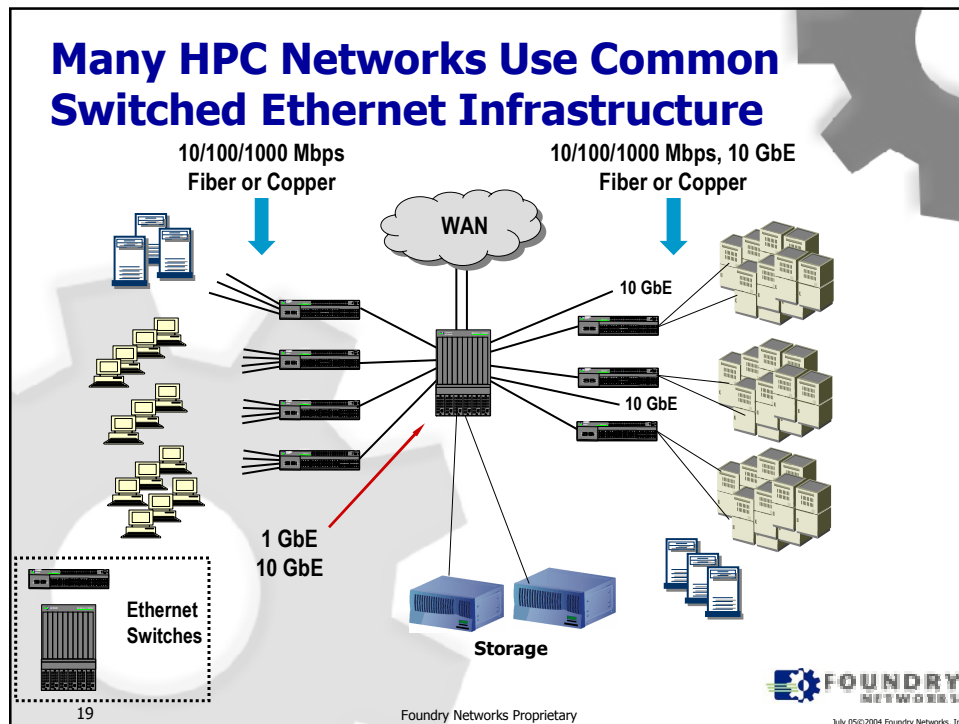


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Ethernet is becoming Fabric of Choice for HPC

- Ubiquitous & interoperable
 - Over 35 of the "Top 100" use Ethernet for cluster interconnect
 - Pervasive, standards-based technology: LAN, WAN, MAN, NAS
- Scalability
 - 100 Mbps to 10 Gbps to 80Gbps (trunked 10Gbps)
- Resiliency (<100 msec restoration)
 - Rapid Spanning Tree Protocol (802.1w), Virtual Switch Redundancy Protocol, Protected Link[†], 802.3ad link aggregation
 - Link, node and topology resilience
- Ease of management
 - One network to configure
 - Availability of tools, know-how and talent pool
- Cost-effective
 - Range of topologies supports variety of solution costs
 - High port volumes help drive down cost of GigE & 10Gig ports
 - GoC uses existing CAT5 cable infrastructure

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Latency & Cost Comparisons

Interconnect	Topology	MPI Latency [†]	Bandwidth	Total Connection Cost	Cost per Mbit
GigE (Foundry)	Various	~20 μ s	> 117 MB/s	\$125	\$0.13
InfiniBand 4x	Various	< 6 μ s	805 MB/s	\$1000	\$0.16
Quadrics	Fat Tree	< 3 μ s	900 MB/s	\$2400	\$0.33
Dolphin SCI	2D/3D Torus	2.3 μ s	667 MB/s	\$2200	\$0.41
Myrinet	Fat Tree	~6 μ s	248 MB/s	\$1195	\$0.60

[†] Application latency



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Sandia Labs Case Study

- Industry: Government
- Computing architecture: Cray Massively Parallel Processing Supercomputer
- Compute nodes: 10,000 processors
- Interconnect: 100+ ports of 10 GbE in BigIron MG8
- Application: 3D, full-physics simulations in support of the U.S. nuclear weapons stockpile
- Designed for 40 Teraflops

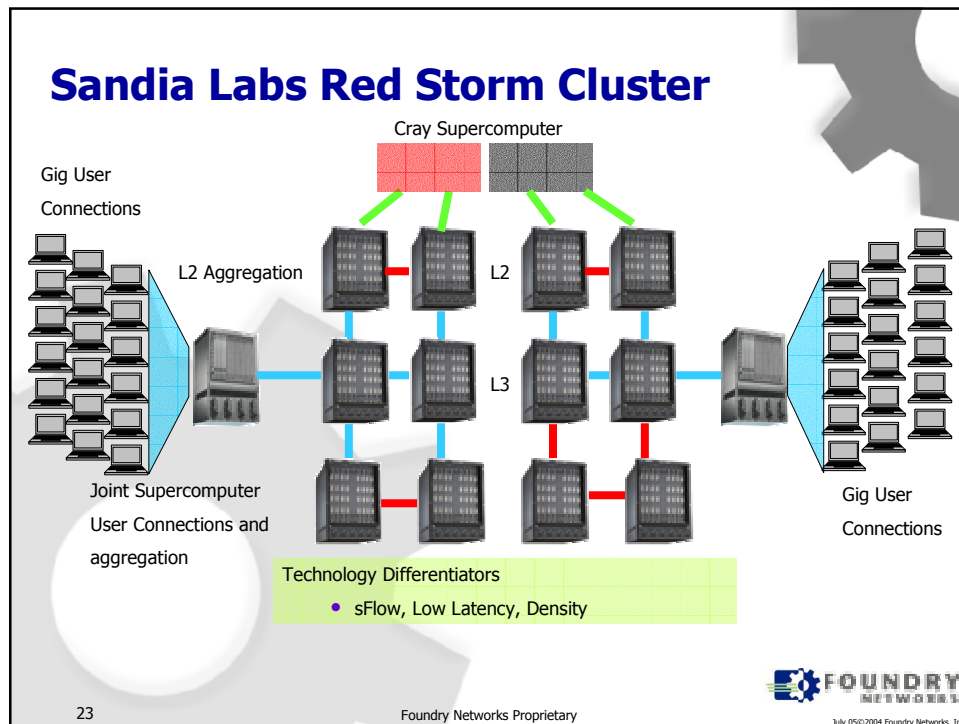
Failsafe Technologies – The MC2912 is the Arming, Fusing, and Firing System (AF&F) designed by Sandia and employed on the W76/Mk4 nuclear warhead. The AF&F's safety features ensure the weapon does not detonate in accidental or other unintended scenarios.



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Los Alamos Space Simulator

- Industry: Government
- Computing architecture: Beowulf Linux Cluster (3rd Gen)
Loki => Avalon => Space Simulator
- Compute nodes: 294 Shuttle XPC SS51G
2.53 GHz Pentium 4, 1 GB SDRAM
- Interconnect: Gigabit Ethernet
- Driver: \$\$
Cost less than \$.5M, \$639/Gflop (one of the first supercomputers to break \$1/Mflop)
- Application:
Space simulation
- 757 Gflops (#344 Jun04)

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Cardiff University & Welsh e-Science Centre

- Industry: Education
- Computing Architecture: Cluster and grid
- Interconnect: Gigabit Ethernet
- Applications:
Cross-collaboration research, immersive visualization for medical, geological and biological studies

“e-Science is about global collaboration in key areas of science, and the next generation of infrastructure that will enable it.”

John Taylor

Director General of Research Councils, Office of Science and Technology

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Industrial Light and Magic (IL&M)

- Industry: Entertainment
- Computing architecture: Linux Cluster
- Compute nodes: 1500-processor (Athlon, Alpha) rendering farm; 600 Pentium 4 workstations
- Interconnect: 10/100, 1GbE and 10GbE
- Driver: \$\$
- Application:
Special effects, Rendering

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WETA Digital

- Industry: Entertainment
- Computing architecture: Linux Cluster
- Compute nodes: 200 dual-Xeon servers; 150 IBM 6580 Linux workstations
- Interconnect: 10/100, 1 GbE, 10 GbE
- Driver: \$\$ and time to deployment
- Application: Special effects, Rendering
- 1.755 Tflops (#77 & #80 Jun04)

"The choice to go with modularity and to stick with off-the-shelf technology was critical in our ability to deliver the film."
 – John Labrie, Weta CTO



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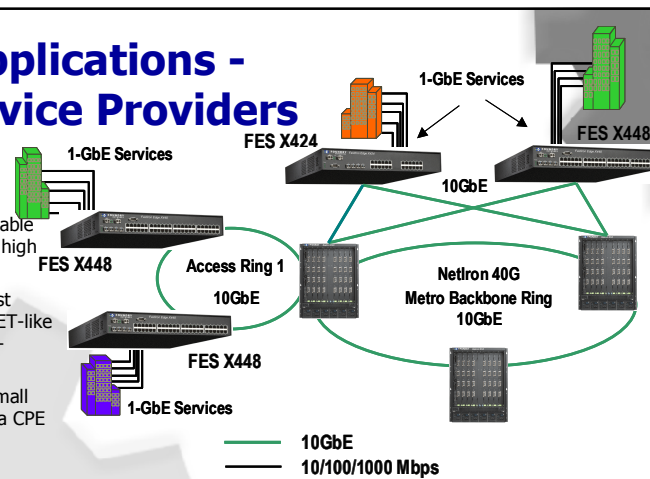
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10 GbE Applications - Metro Service Providers

- Redundant and removable power supply ensures high availability
- Metro ring and low cost 10GbE leverages SONET-like infrastructure and self-healing properties
- 1.5RU form factor – small footprint and ideal as a CPE device



- Low cost GbE service offering – ideal for bandwidth hungry customers
- sFlow delivers detailed network traffic accounting without impact to network performance

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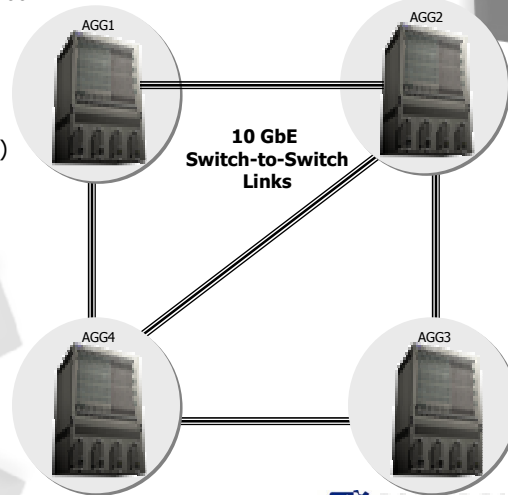
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10 GbE Case Study – London Internet Exchange and AMS-IX

- 10GbE backbone aggregates more than 100 ISPs
- Simplified network topology simplifies network administration
- Migration completed in minutes
- Layer 2 interconnect (Ethernet and VLAN) enables:
 - Over 10,000 peering relationships
 - ISP interconnectivity without intrusion to peering relationship
 - Flexible service offerings:
 - Public and Private ISP Peering
 - Support for IPv6
 - Multicast Peering and the creation of Multimedia Internet Exchanges



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Metro Ethernet Case Study – California Clark County School District

- 6th Largest School District in the US
- GIGA MAN network to connect over 200 schools
- Convergence: Data, VoIP and Streaming Video
- Large campus switched LAN, OSPF and multicast routing
 - sites interconnected using GbE over leased fiber
- 53 BigIron 15000s; 220+ FastIron 400s

Key differentiators

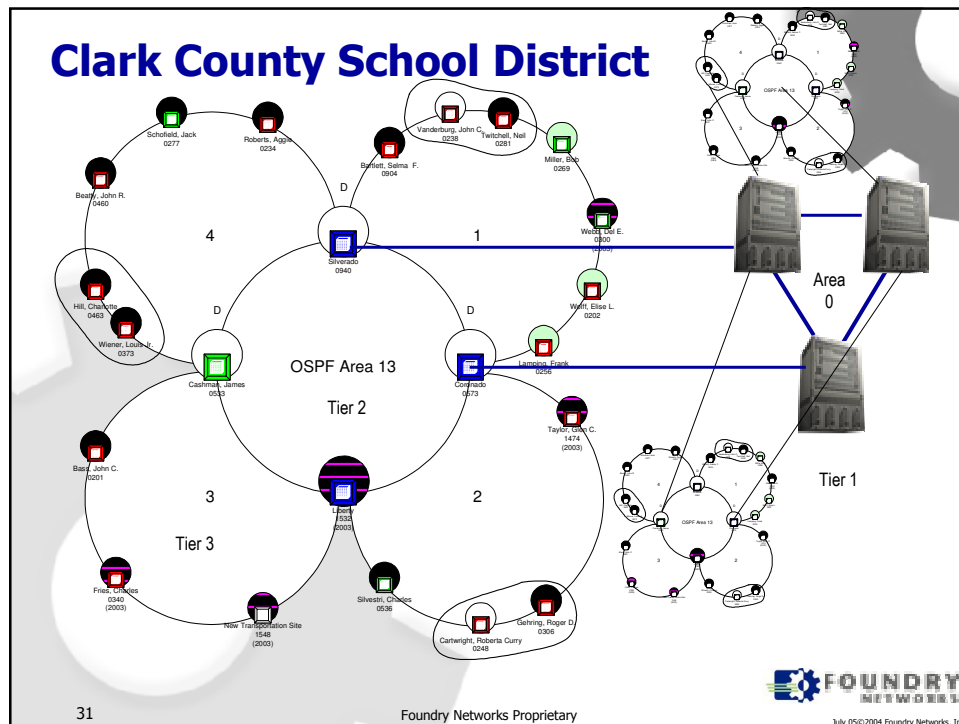
- Hardware-based network traffic monitoring
- 10GbE investment protection
- Lowest packet latency
- Highest packet switching performance
- Complete multicast routing feature set
- Robust OSPF routing implementation

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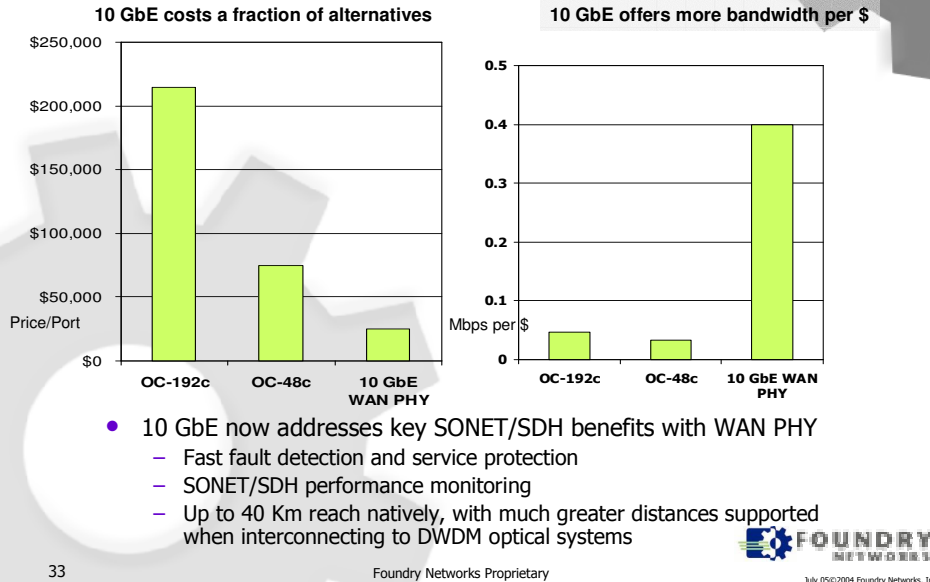
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The WAN PHY (10GBase-SW/LW/EW)

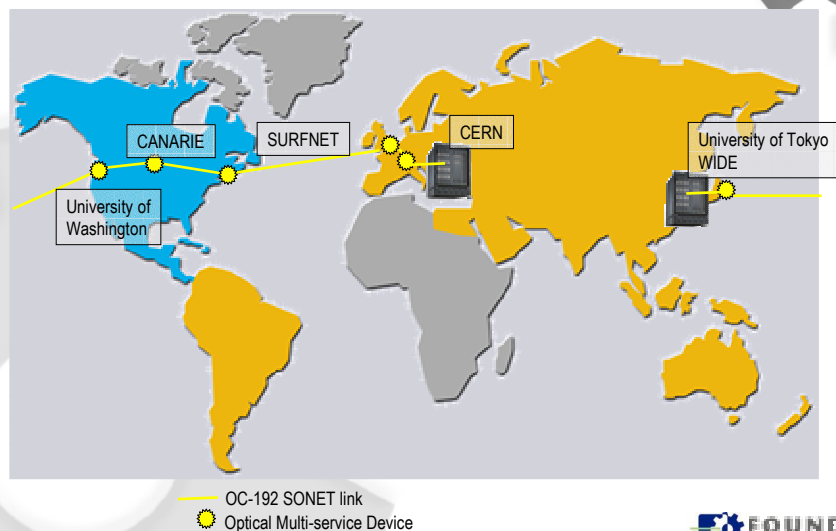
- **Enables 10 Gigabit Ethernet to be transported at OC-192c rates on SONET/SDH transport equipment**
- **Exploit the advantages of SONET**
 - Uses SONET infrastructure for Layer 1 transport
 - Utilizes existing SONET infrastructure such as ADMs, DWDM Transponders, and Optical Regenerators
 - Maintains SONET compatibility – OC-192 link speed, SONET framing
- **Leave the disadvantages of SONET behind**
 - It's packet switched, not TDM (concatenated OC-192c)
 - No addition protocol overhead such as PPP – it's Ethernet packet in a SONET frame
 - Do not need to meet rigid SONET specifications to lower cost for 10 Gigabit interfaces

The Price Advantage of 10-GbE vs. SONET/SDH



World's Longest Native 10-GbE Connection

Transcontinental Data Reservoir Using Foundry's 10GbE WANPHY



sFlow (RFC 3176) For Wire-speed Network Monitoring

- **The network monitoring challenge**
 - Need an approach for monitoring high performance networks without impacting network performance
 - Must be cost-effective and scale with the network
 - Traditional approaches don't scale, impact network performance, and are expensive
- **The sFlow (RFC 3176) approach**
 - JetCore ASIC based packet sampling coupled with port statistics for every frame and byte in/out
 - sFlow collector with Foundry's IronView Network Manager or from InMon provide sophisticated analysis and reporting
- **sFlow implementation advantage**
 - Built into ASICs – cost-effective and scalable
 - Sophisticated network monitoring, capacity planning, security analysis, and network accounting for departmental charge back
 - Wire-speed network throughput - no impact on network performance

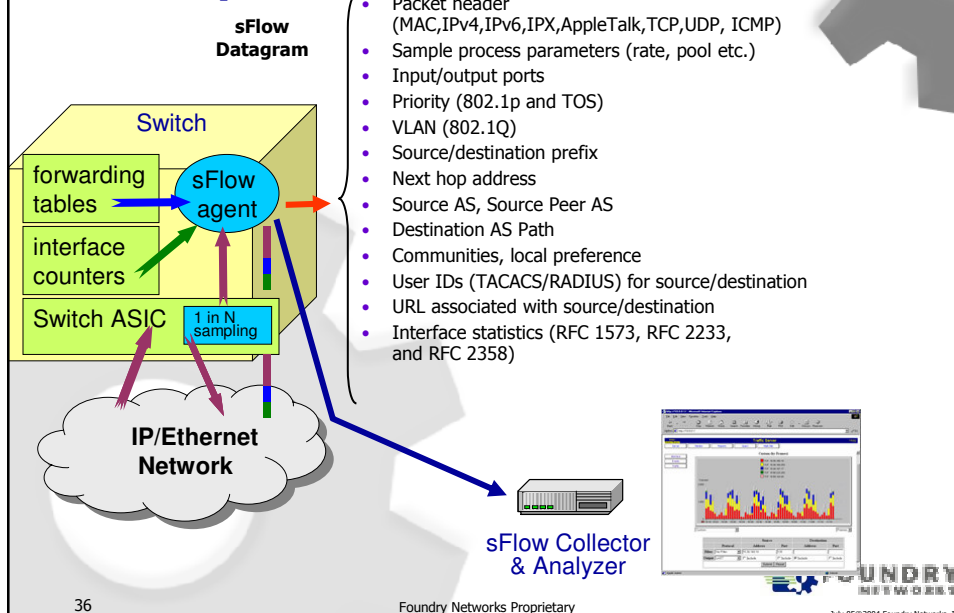
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sFlow Operation



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10 Gigabit Ethernet: Summary

- It's Ethernet at 10 Gbps
 - Simple, Cost-effective, Scalable
 - Large pool of trained manpower
 - Same management architecture, no changes above MAC
- LAN – Scales campus backbones, server farms
- MAN – Extends Ethernet to Metro for broadband connectivity
- WAN – Utilizes the existing SONET infrastructure at a fraction of the cost of OC-192c

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Company Overview



World
Headquarters
San Jose, California

- **#1 Performance Leader, #2 Enterprise Solutions**
- **Revenues:** \$400 M
- **Profitability:** 6 Consecutive Years
- **Cash:** \$700M with No Debt
- **Total Customers:** 7,800+
- **Awards:** 50+
- **Industry Leading and Seasoned Executive Team**

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10-Gigabit Ethernet Everywhere

Automotive

Computer-aided Design
Structural Analysis
Crash Simulation

Aerospace

Computer-aided Design
Finite Element Analysis
Structural Analysis
Crash Simulation

Financial

Trading Systems
Hedge Funds Management
Stock Analysis
Financial Modeling
Transaction Processing
Fraud Detection

Genomics

Virus Analysis
Cancer Cure Research
Gene Research

Energy

Oil & Gas Exploration
Seismic Capture & Analysis
Reservoir Simulation
Geological Analysis

Pharmaceutical

Drug Simulation
Drug Synthesis
Computational Chemistry

Technology

Chip Design and Synthesis
Chip and Circuit Simulation
Software Iteration

Industrial

Computer-aided Design
Materials Synthesis
Structural Analysis
Failure Analysis

Internet

Search Engine
Data Mining

Others

Computer Rendering
Fluid Dynamic
Clustered Database
Weapon Research
Weather Forecast

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