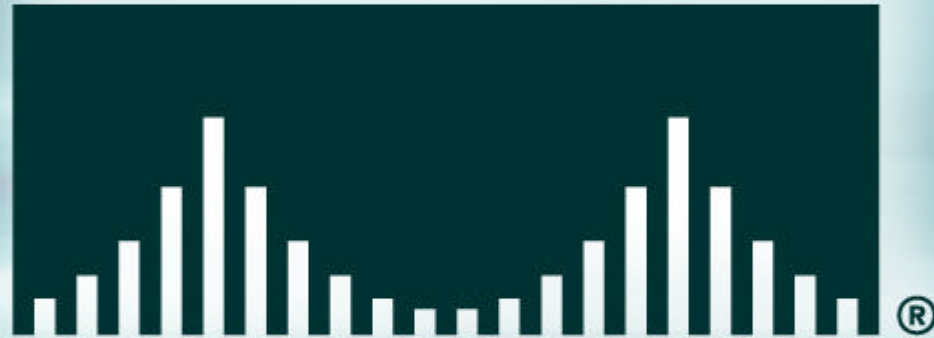


CISCO SYSTEMS



Successfully Scaling the Cable IP Network

Agenda

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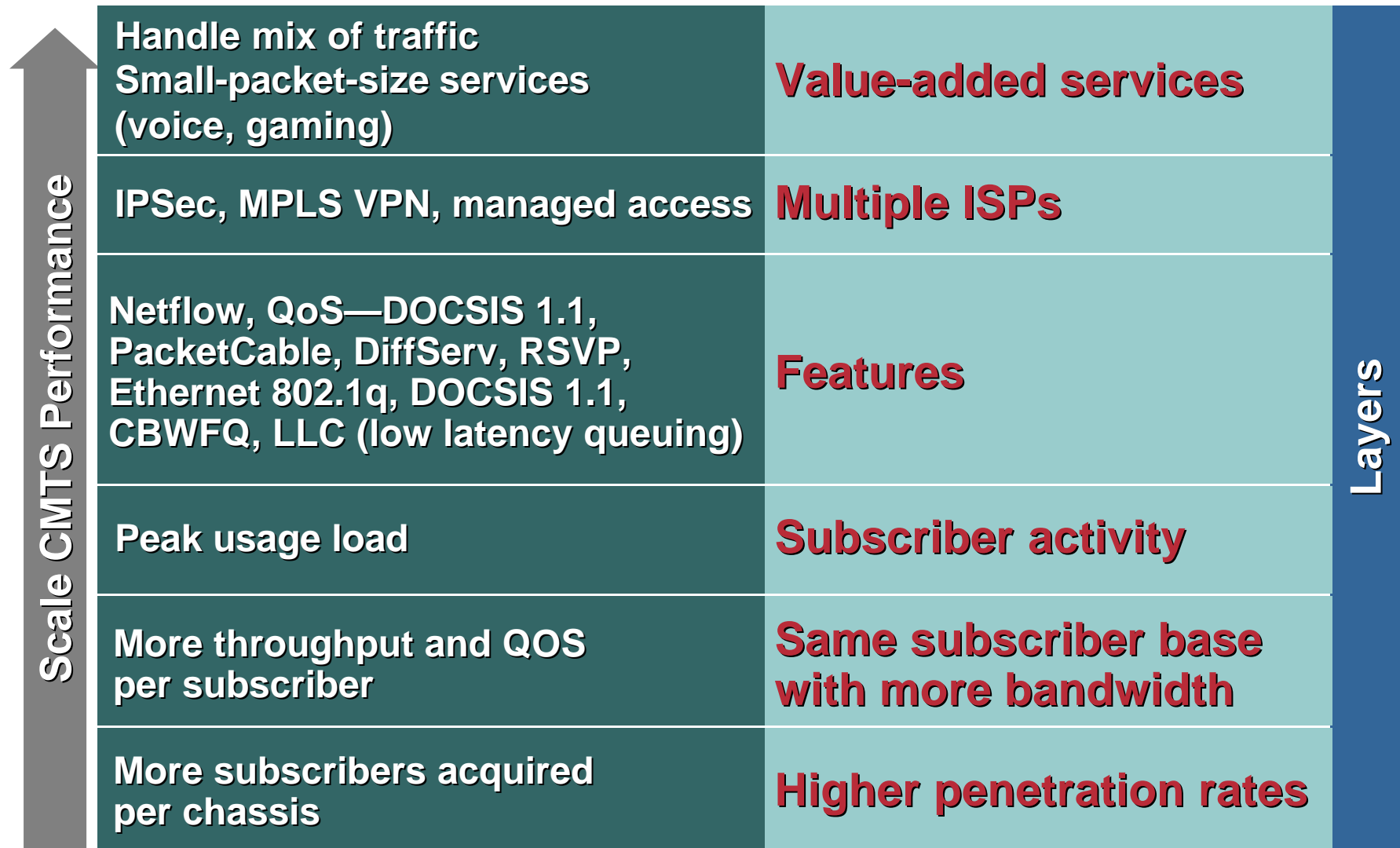
- **Current Situation**
- **Capacity Drivers**
- **Cisco uBR7246VXR Overview, Road Map**
- **Scaling Services With Cisco uBR7246VXR**
- **Scaling Services With Cisco uBR10012**
- **Deployment Guidelines**

Current Situation

- **HSD service deployed and growing rapidly**
High subscriber growth rates driving large-scale infrastructure upgrades to VXR/NPE-400s
- **Multiple ISPs**
MISP will drive higher penetration rates demanding increase in existing capacity during 2002
- **New services on horizon**
Successful Voice over IP deployments over Cable to begin in 2002, which demand additional increase in CMTS capacity

Capacity Drivers for Scaling Broadband Services

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Frequently Asked Questions About Capacity Planning

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- How do I effectively scale capacity to align investment to demand?
- How do I accommodate high growth rates while enabling high-touch services?
- How do I provide affordable converged multimedia IP services with the lowest total cost of ownership?
- How do I continue to scale performance so I can serve more IP subscribers per chassis and achieve lower cost-per-sub?
- How do I enable risk-free growth and add services on a single platform?
- How do I ensure sufficient capacity with a guaranteed expansion path?

Multiple ways to approach this challenge:

RF optimization, CMTS optimization, or both

RF Optimization

Cisco.com

- Increasing the available upstream throughput by varying channel width and/or modulation scheme

RF Bandwidth (MHz)	Baud Rate (Ksymbol/Sec)	QPSK Raw Bit Rate (Mbits/sec)	16 QAM Raw Bit Rate (Mbits/Sec)
3.2	2560	5.12	10.24
1.6	1280	2.56*	5.12
0.8	640	1.28	2.56
0.4	320	0.64	1.28
0.2	160	0.32	0.64

* The “Default Rate” Used Currently

Next Options Commonly Considered

RF Optimization

Cisco.com

- **Port bundling**

Different combinations of upstreams and downstreams can be created

For example, MC28U can be used as 1:1 (for a business customer) + 1:7 (for residential customers)

- **Load balancing**

Distributes cable modems based upon random or equal distribution, available channel bandwidth, preferential treatment, or requested services

Efficient distribution of cable modems across ports for more efficient bandwidth usage without node splitting

- **Upstream combining/splitting**

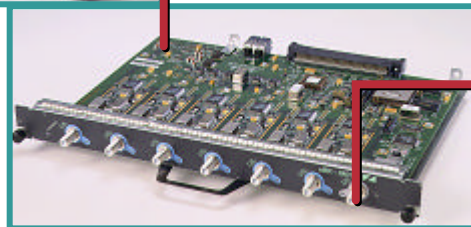
Examples in the next three slides...

RF Optimization

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uBR7246VXR

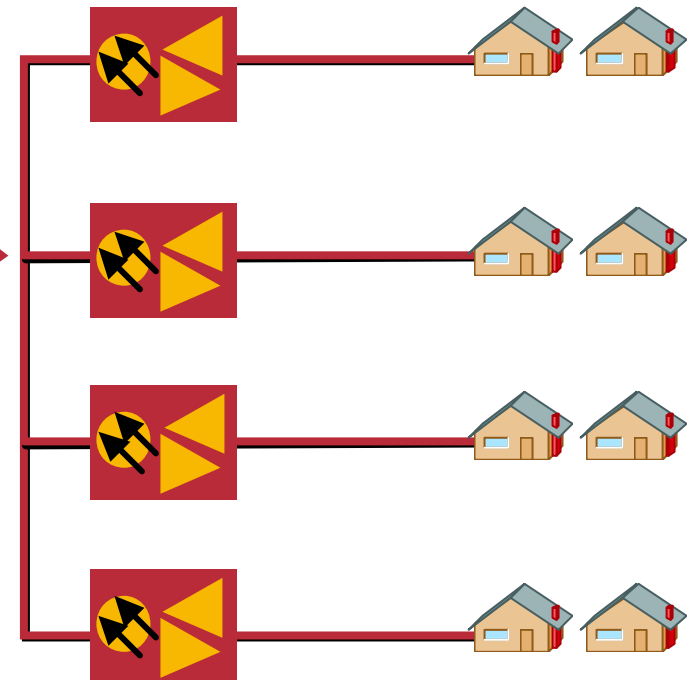


1 DS x 6 US line card

4:1

Fiber
Node

500 Homes
Passed



@ 20% Market penetration → 100
subs per FN, with QPSK, 1.6 MHz
(2.5 Mbps per upstream)

Low bandwidth (data only)

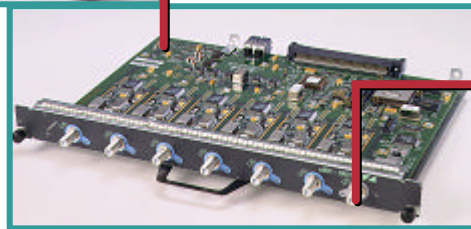
4:1 combining, 400 subs per US port, 5 kbps per sub

RF Optimization

Cisco.com



uBR7246VXR

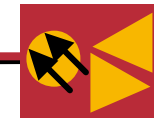


1 DS x 6 US line card

1:1

Fiber
Node

500 Homes
Passed



@ 20% Market penetration → 100
subs per FN, with QPSK, 1.6 MHz
(2.5 Mbps per upstream)

Moderate bandwidth (higher speed data)

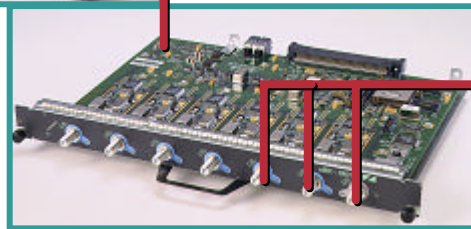
1:1 combining, 100 subs per US port, 20 kbps per sub

RF Optimization

Cisco.com



uBR7246VXR

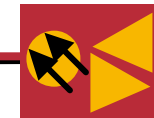


1 DS x 6 US line card

Fiber
Node

500 Homes
Passed

1:3



@ 20% Market penetration → 100
subs per FN, with QPSK, 1.6 MHz
(2.5 Mbps per upstream)

High bandwidth (higher speed data + voice over IP)

1:3 splitting, 33 subs per US port, 60 kbps per sub

CMTS Optimization

Cisco.com

- **Scale performance by modular upgrade to**
 - Performance-optimized features/software**
 - Higher-performance processor**
 - Higher-performance line cards**
 - Bandwidth-efficient LAN/WAN cards**
- **Scale density**
 - Add line cards (if not fully utilized)**
 - Upgrade to higher-density line cards**
- **Both**
 - Upgrade to higher-performance and higher-density cards**
 - Add a chassis**
 - Upgrade a chassis**

Cisco CMTS Router

Cisco.com

- **Modular and evolutionary approach with the Cisco CMTS flexible architecture; scaling candidates include**
 - Software performance tuning
 - Routing and switching performance
 - Backplane capacity boost
 - Bandwidth-efficient LAN/WAN interfaces
 - Distributed processing on line card
 - Select port bundling and load balancing features
 - Chassis upgrade with investment protection
 - nonVXR ✂ VXR ✂ uBR10K
- **Depending on scope and scale of a market segment, you may need to go beyond VXR to Cisco uBR10012**
 - For higher per-port performance today
 - For higher port density in near future

Cisco uBR7246VXR Overview, Road Map

Cisco uBR7246VXR

Cisco.com

Key Features Shipping Today

- **Modular Scalability**

Highest rack density and capacity

Fully upgradable processors and line cards

Sufficient current capacity plus guaranteed expansion path

- **High Availability (HA)**

Exceeds PacketCable High Availability requirements—1+1

A proven track record with millions of hours of uptime

Redundant power, service-transparent insertion and removal of cards

- **Lowest Cost of Ownership**

Leverages the current HSD infrastructure

Multiple standards—IETF, ITU, DOCSIS, PacketCable, MPLS, RPR/DPT

Industry's only robust provisioning and management



**DOCSIS 1.1
qualified**

Cisco uBR7246VXR

Cisco.com

Recent Enhancements

NPE-400

- **Carrier class availability**

1+1, PacketCable HA

- **Advanced spectrum management**

MC16S s/w updates, interface to Acterna spectral display application

- **New services and software features**

DOCSIS 1.1, MPLS VPN

- **Management features**

Cisco Cable Manager 2.2, Broadband Troubleshooter 2.2, Network Registrar 5.5, Address and Name Registrar, Broadband Provisioning Registrar

- **Increased versatility**

New I/O controller, new port adapters, line card BNC connectivity

Cisco uBR7246VXR

Cisco.com

CY '02 and CY '03 Enhancements

- **Enhanced performance**
S/w performance tuning*, NPE-G1, Universal line cards
- **Carrier class availability**
N+1/RF switch
- **Universal** functionality**
MC28U, MC16U line cards
- **New services and software features**
PacketCable Voice***, DOCSIS 2.0 (A-TDMA initially)
- **Management features**
Cisco Cable Diagnostic Manager, Resource Manager Essentials for Cable, Cisco Cable Manager 2.3+, CBT 2.3, Enhanced Cisco Network Registrar
- **Increased versatility**
Continued support for new port adapters, new Video Muxing (Media) line card (MLC)

* Available now

** Details in a later slide

*** DQoS, CALEA, Event Messaging

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Scaling Services with Cisco uBR7246VXR

 **DOCSIS 1.1
Qualified**

Why Upgrade?

NonVXR to VXR

Cisco.com

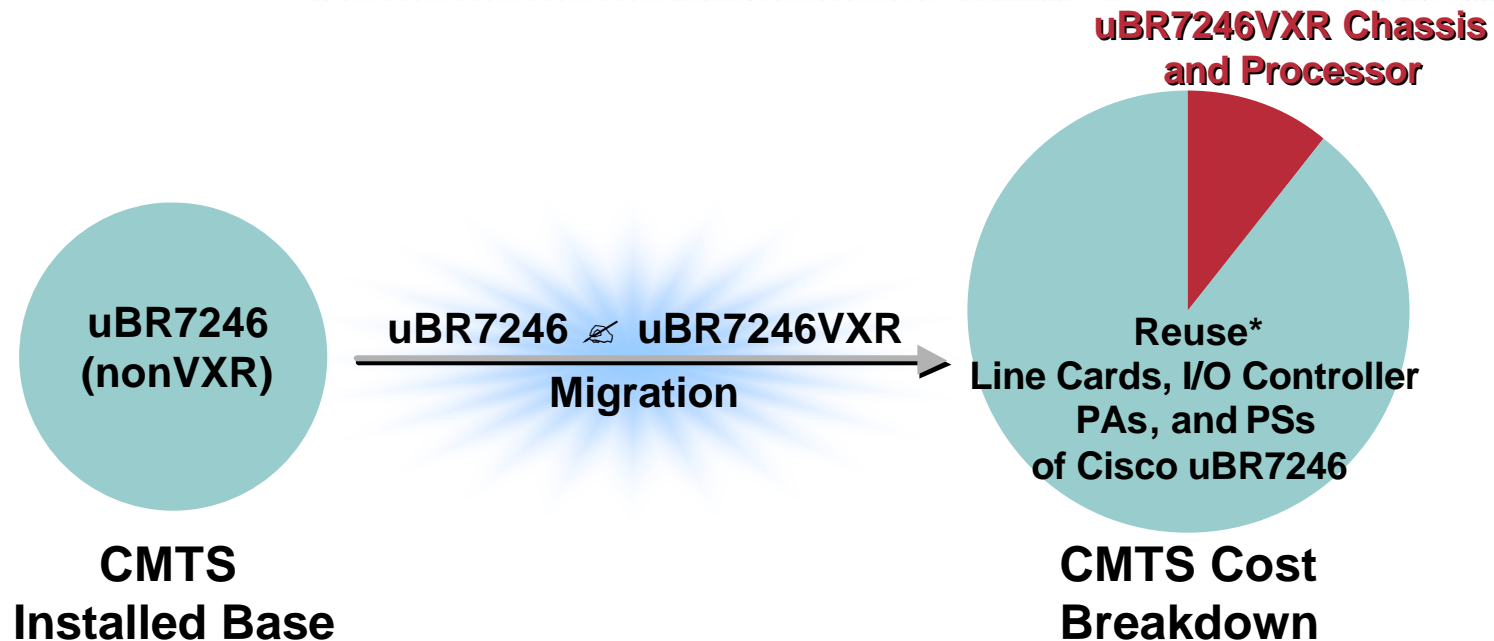
- **Cisco uBR7246VXR—the industry's first qualified DOCSIS 1.1 Layer 3 CMTS**
- **Increased backplane bandwidth—Provides 2x throughput increase over Cisco uBR7246 (nonVXR)**
 - Cisco uBR7246—1.6-Gbps* backplane
 - Cisco uBR7246VXR—3.2-Gbps* backplane
- **Support for new high-performance processors and line cards**
 - Cisco uBR7246—NPE-200, NPE-225
 - Cisco uBR7246VXR—NPE-225/300/400/G1, MC28U, MC16U, synchronous clock card

VXR accommodates high growth rates while enabling the high-touch services

* Some de-rating apply due to A) Multiplexing address and data on a PCI bus, B) % mix of read (slow) vs. write (fast) operations, and C) Burst transfer sizes

Investment Protection— Cisco's Advantage

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- **Best investment protection** via modules' **reusability***
- **Attractive trade-in credit** for **remaining** modules (i.e. nonVXR chassis, NPE)

In most cases, trade-in credit > net book value of **remaining** modules (i.e. list price of remaining modules **less** sales discount **less** depreciation)

- **Net gain to customers**

Upgrade Impact

Cisco.com

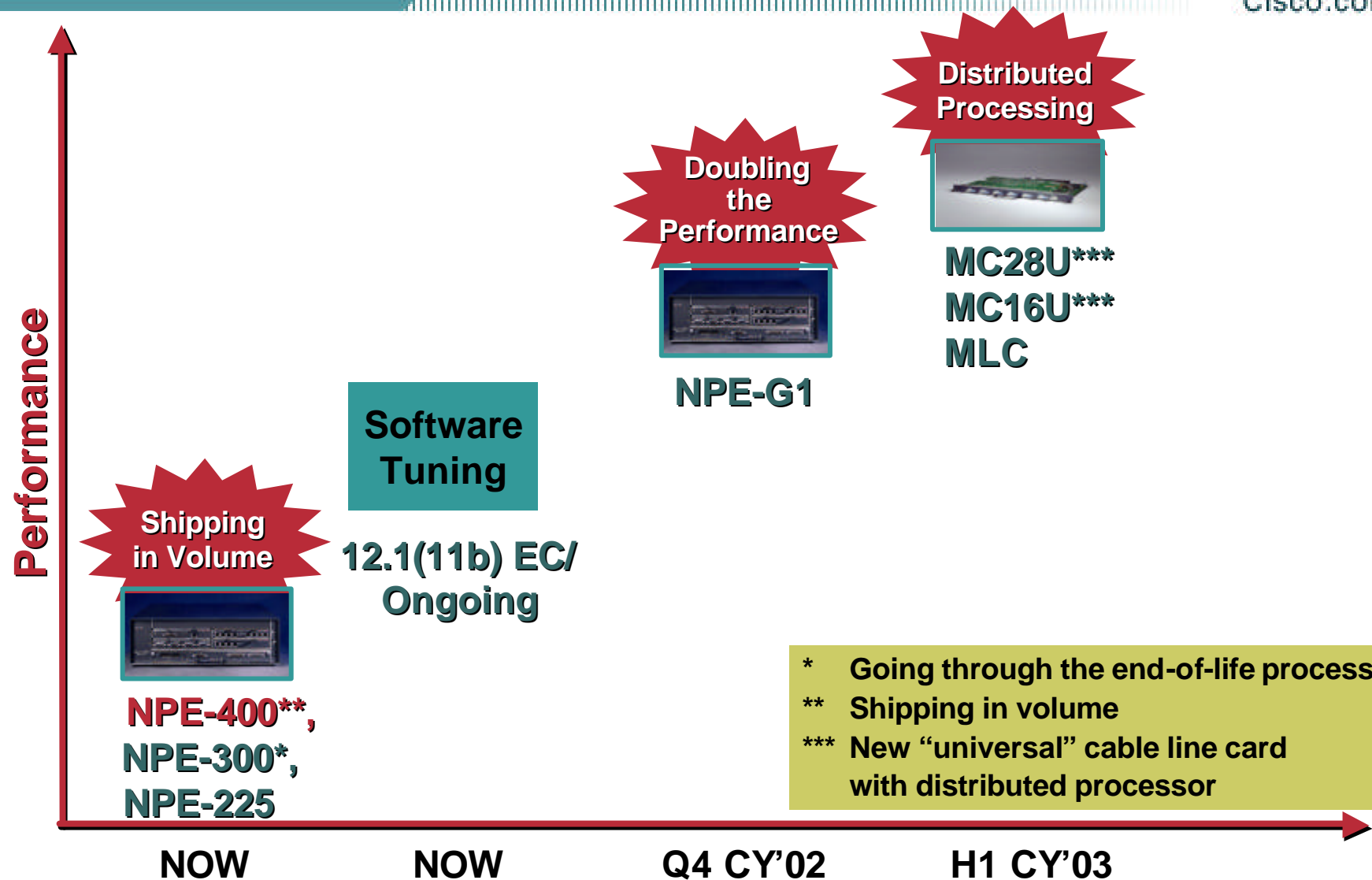
		Physical Impact			Operational Impact		
Upgrade	Downtime	Power	Cabling	Layout	Procedures	Tools	Training
Chassis and NPE*	45 min	—	—	—	—	—	—

No Impact

* The latest release of Cisco IOS® Release 12.1 EC is recommended. In May 2002, this is **Cisco IOS Release 12.1(11b) EC**, but a later version might be available at the time of your upgrade.

Cisco uBR7246VXR: Scaling Performance over Time

Cisco.com



Software Performance Tuning

Software Performance Tuning

Cisco uBR7200 with Cisco IOS Release 12.1(11b) EC or Later

Cisco.com

- Ongoing tuning starting from IOS 12.1(11b) EC

- What is optimized?

Mostly upstream data path without impacting DOCSIS specifications

- What to expect?

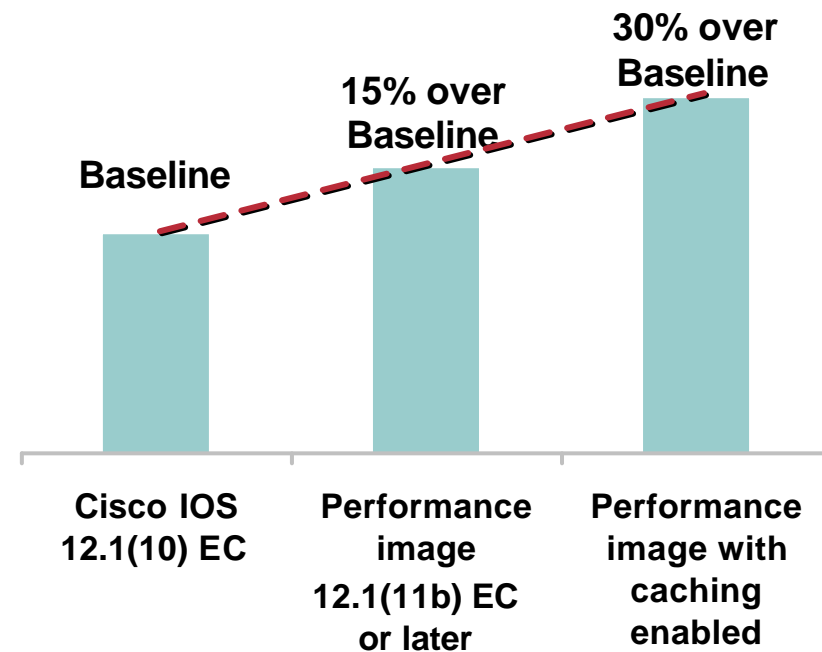
Up to 30% (stretch) improvement*

More PPS each subscriber sends to CMTS, the greater the performance improvement observed

- Greatest benefit in

Stable networks with clean RF plants

CMTS with concatenation and caching enabled



Cisco uBR7246VXR lab performance results (% improvement in maximum forwarding rate)

* For Cisco uBR7246VXR with NPE-400 processor, 4xMC16C line cards, and bidirectional 64-byte packets with Cisco IOS 12.1 EC performance image with caching enabled. Actual performance improvement varies depending on traffic and usage patterns, number of subscribers, features turned on, and so on.

Routing and Switching Performance

Real-World Data (No. Sub. per NPE) for DOCSIS 1.0

Cisco.com

- Recommended maximum subscribers per CMTS* for **DOCSIS 1.0** based on data collected from the field and the lab:

Processor	NPE-200	NPE-300	NPE-400	NPE-G1**
Subscribers per Chassis	2800	3500	4600	7200

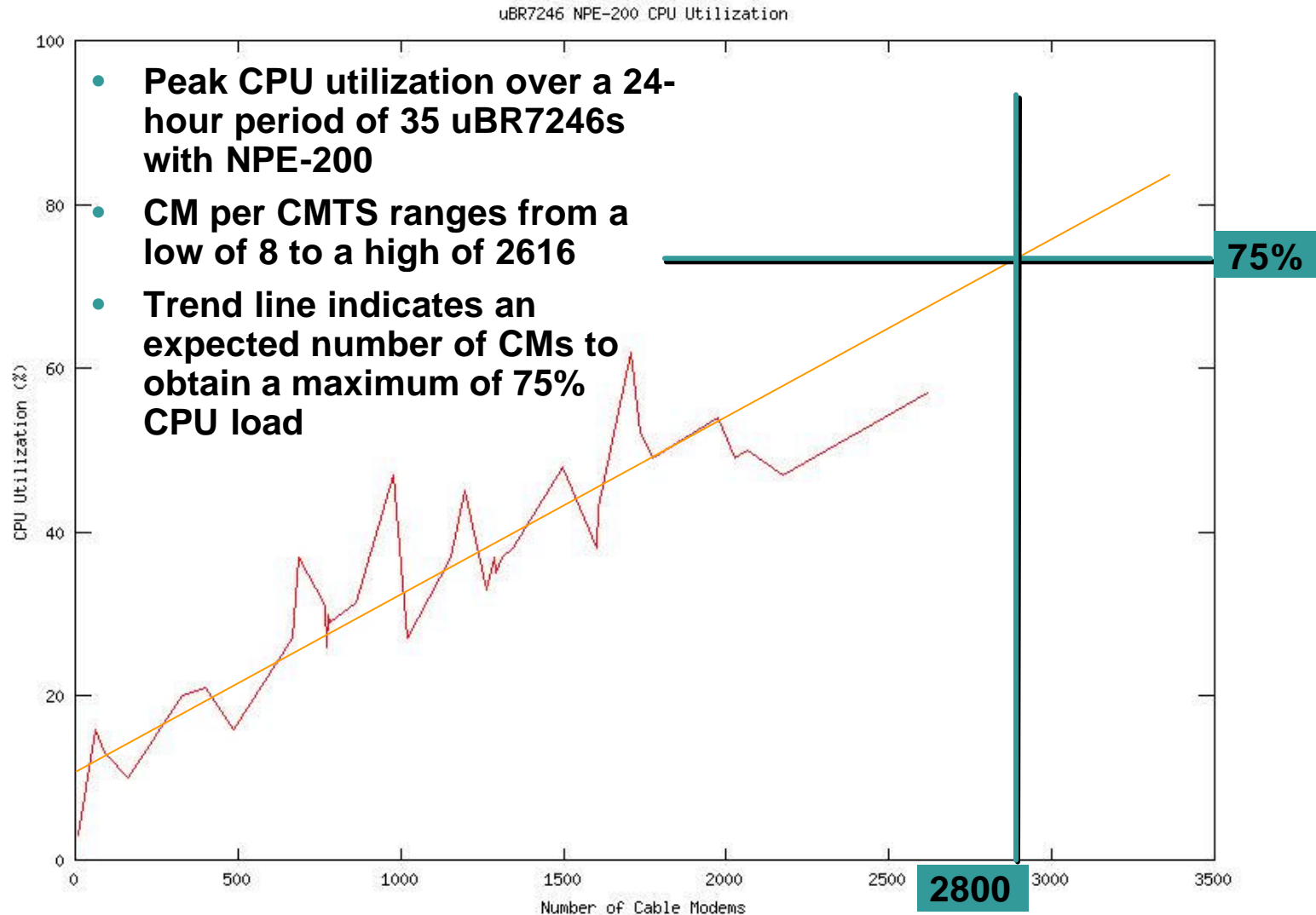
- Upgrading from a Cisco uBR7246+NPE-200 to a uBR7246VXR+NPE-400 allows the CMTS to support 1800 more subscribers
- The NPE-400 and NPE-G1** will provide the performance required to add more subscribers per CMTS and sell additional services
- Usage patterns of subscribers will impact the number of subscribers per CMTS

* At steady state CPU utilization of 75%

** Target FCS Q4, CY'02

Real-World Data— Cisco uBR7246/NPE-200

Cisco.com



Upgrade Impact

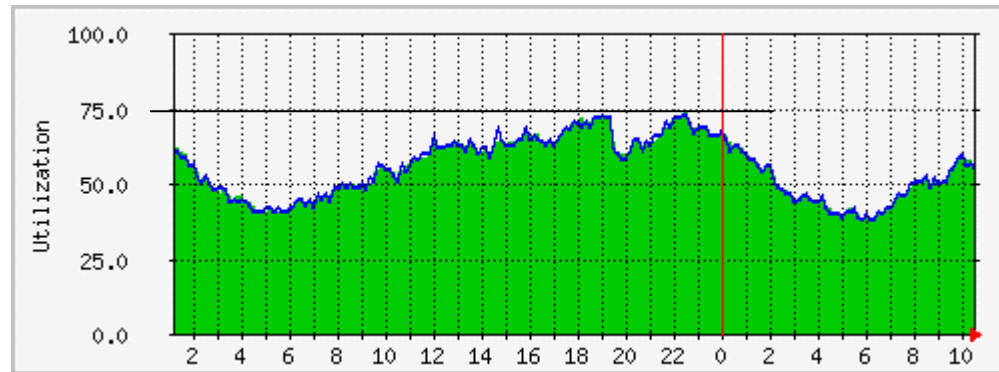
NonVXR/NPE-200 ✎ VXR/NPE-400

Cisco.com

Site X CPU Utilization Plots:

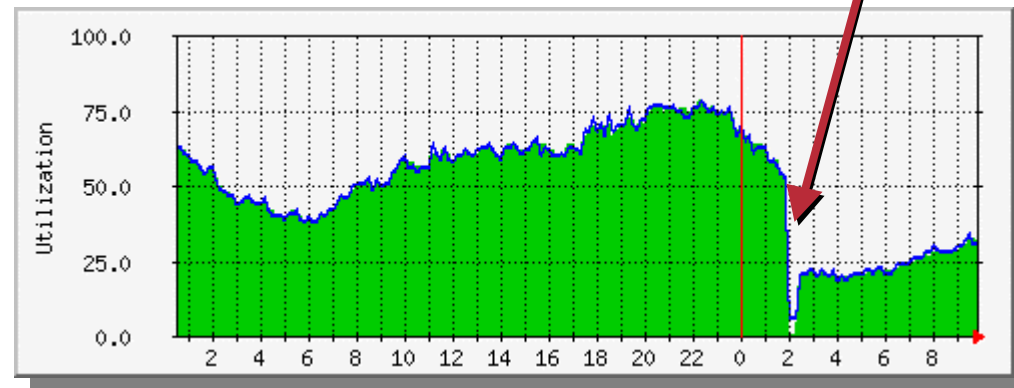
- CPU utilization varies with user traffic—as it should/is expected
- Customer felt more comfortable with it maintained below 75%
- Upgrade to VXR/NPE-400 resulted in
CPU utilization ? by 44% to 48%
- Upgrade yields substantially more new headroom

Cisco uBR7246/NPE-200*



Cisco uBR7246VXR/NPE-400*

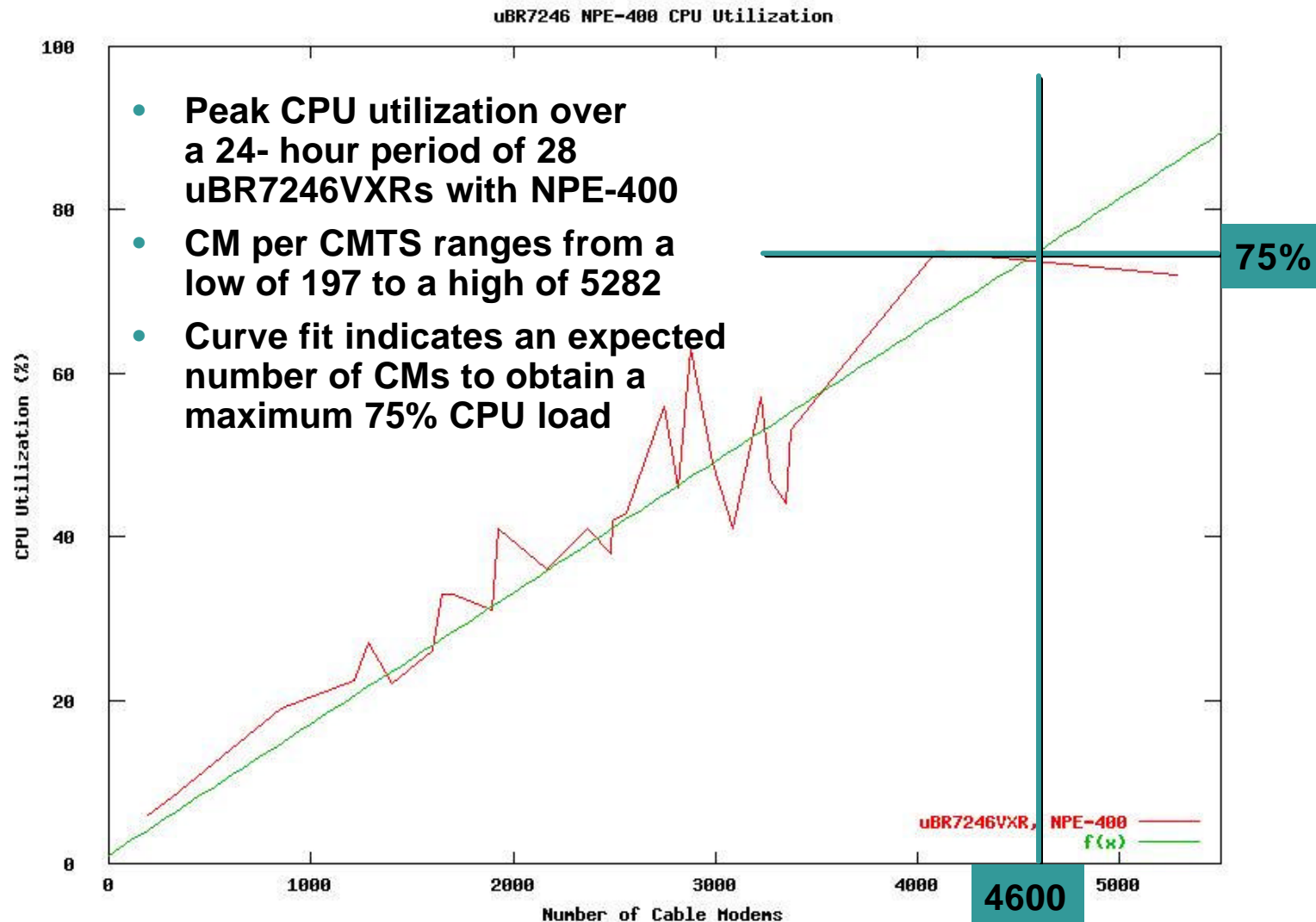
CPU utilization ?



* Configuration: 4xMC16C line cards, 64 QAM DS, QPSK 16MHz US, 3635 CMs, over subscription ratio of 97:1

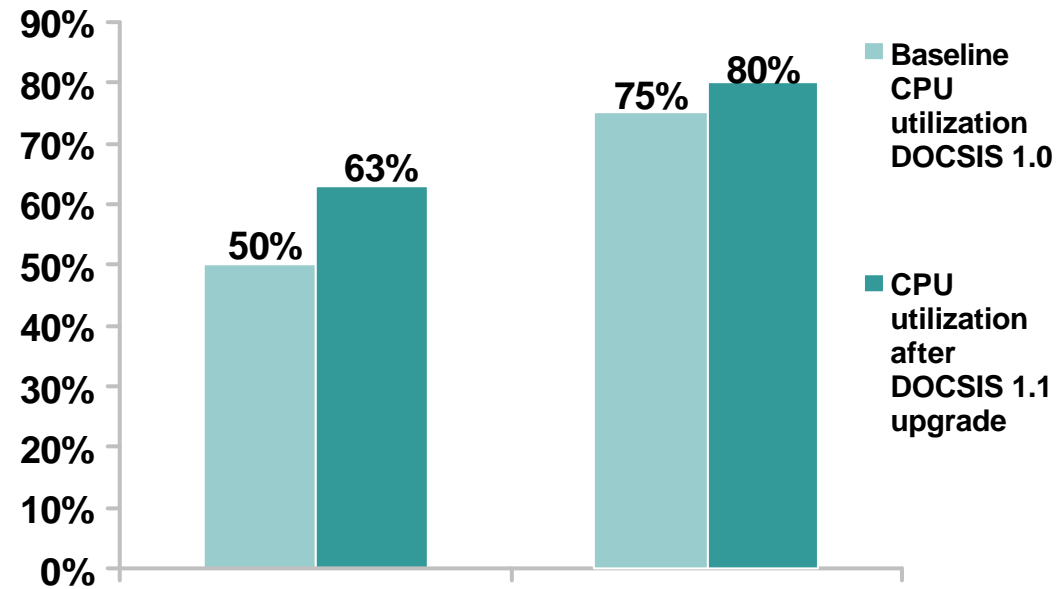
Real-World Data— Cisco uBR7246VXR/NPE-400

Cisco.com



DOCSIS 1.0 ✍ DOCSIS 1.1 Impact

Cisco.com



Cisco uBR7246VXR Lab Performance Results*

- **Recommended max. subscriber per uBR7246VXR w/ NPE-400**
DOCSIS 1.0 CMTS and 1.0 CMs—**4600**
DOCSIS 1.1 CMTS and 1.0 CMs—**4296**
DOCSIS 1.1 CMTS and 1.1 CMs—**4000 (estimated)**

* CMTS Cisco IOS images used: uBR7200-k1p-mz.12.1-10EC and uBR7200-k8p-mz.4.XF1 for DOCSIS 1.0 and DOCSIS 1.1, respectively

No. Subscriber Projection for DOCSIS 1.1

Cisco.com

- **DOCSIS 1.1 with NPE-400**
~ 4000 subscribers*
- **DOCSIS 1.1 with NPE-G1**
~ 6000 subscribers*
- **DOCSIS 1.1 with MC28U**
~ 8000–10,000 subscribers*

* Estimated Subscriber Counts for a fully loaded system

Backplane Capacity Boost with Cisco uBR7246VXR/NPE-G1

Backplane Capacity Boost

Cisco.com

- **Cisco uBR7246VXR provides 2x backplane capacity increase over uBR7246 (nonVXR)**

Cisco uBR7246—1.6-Gbps* backplane

Cisco uBR7246VXR—3.2-Gbps* backplane

- **NPE-G1 improves backplane efficiency further**

Three onboard GigE/FE ports boost effective backplane bandwidth

NPE-G1 adds two new I/O controller buses, which don't take up backplane bandwidth

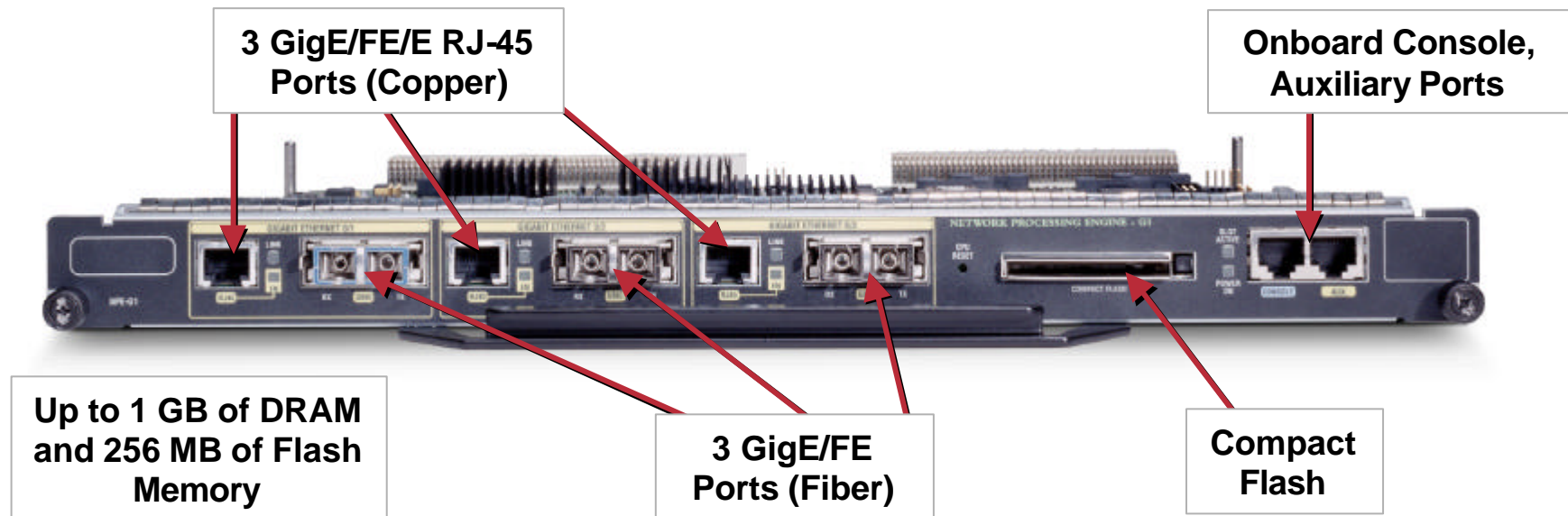
Details on the next four slides...

*** Some de-rating apply due to a) multiplexing address & data on a PCI bus, b) % mix of read (slow) vs. write (fast) operations, and c) burst transfer sizes.**

Cisco NPE-G1

Extending the Value of Cisco uBR7246VXR

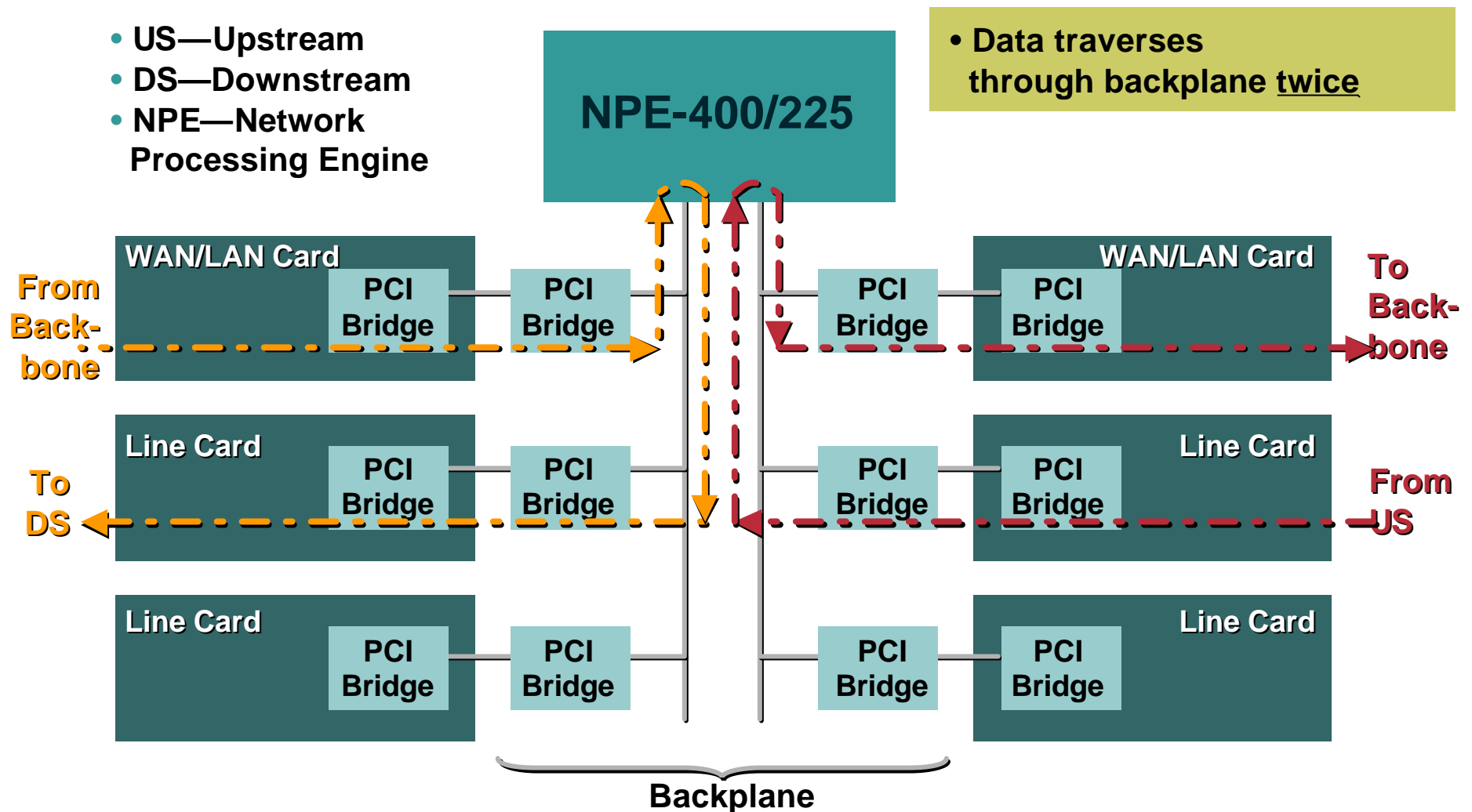
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- Dramatically increasing performance
- 3 built-in GigE/FE ports don't take up backplane bandwidth
- Doubles the DRAM (1 GB of memory)
- Eliminates the need for an I/O controller
- Adds two new I/O controller buses, which don't take up backplane bandwidth

NPE-400/225-Based VXR Architecture (Packet Flow)

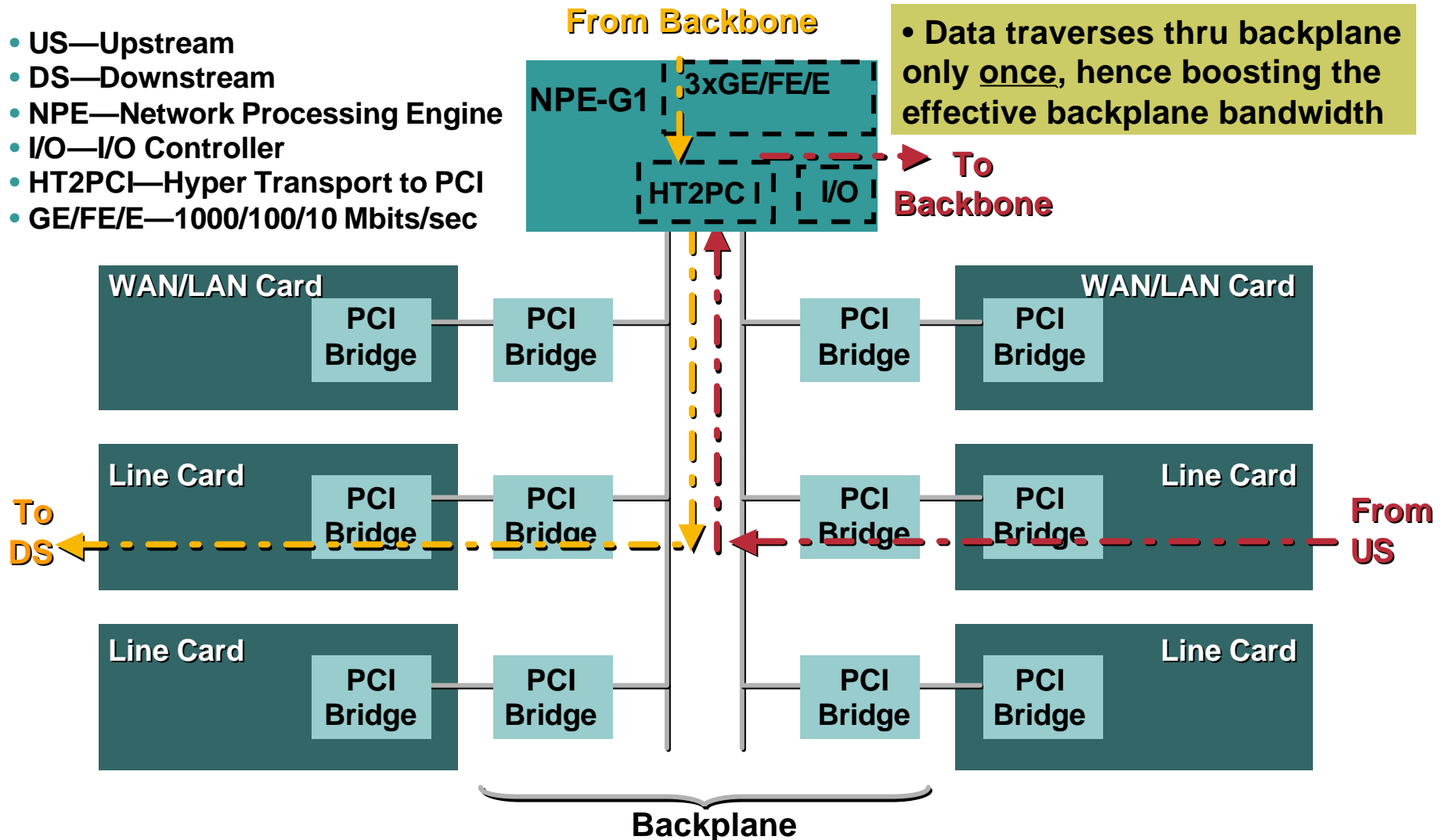
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Example 1: NPE-G1 Improves Backplane Efficiency Thru On-Board GigE/FE/E Interfaces

Cisco.com

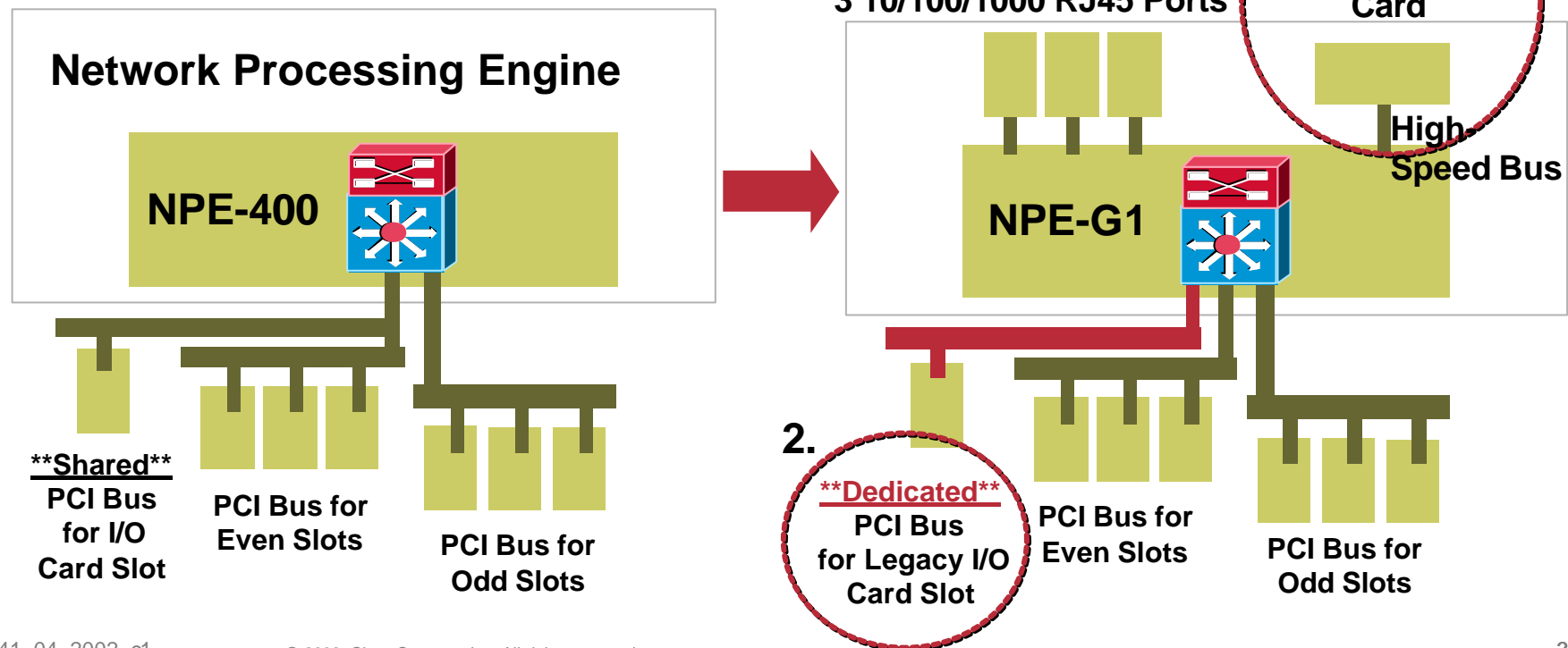
- US—Upstream
- DS—Downstream
- NPE—Network Processing Engine
- I/O—I/O Controller
- HT2PCI—Hyper Transport to PCI
- GE/FE/E—1000/100/10 Mbits/sec



Example 2: NPE-G1 Improves Backplane Efficiency Thru Two New I/O Controller Buses

Cisco.com

- NPE-G1 adds two new I/O controller buses, which don't take up backplane bandwidth
 1. High speed bus for on-board I/O controller ports
 2. Dedicated (not shared) PCI bus for a legacy I/O controller



Scaling Services with Cisco uBR10012

 **DOC SIS 1.1
Qualified**

Candidate Sites for Cisco uBR10012

Cisco.com

- **Density**

If you currently have or expect to need >1x uBR7246VXR per hub

If, in the future, you expect to need >4x density over commonly deployed uBR7246VXR configuration and have physical space constraints

- **Performance**

If penetration rates and traffic characteristics result in relatively high ratio of voice over HSD traffic or

If you need consistent high performance with high-touch Layer 3 services

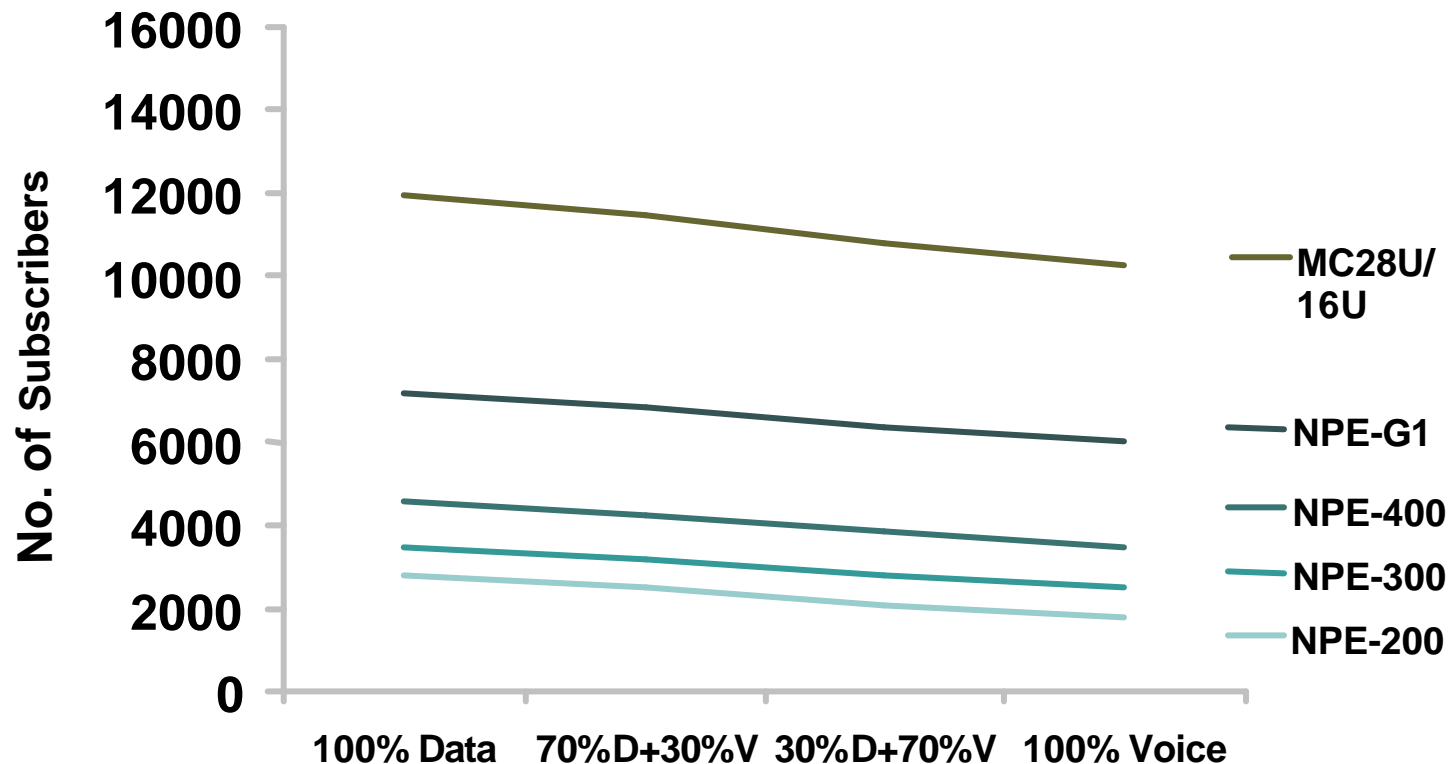
- **Other considerations**

If you prefer in-box vs. inter-chassis redundancy

If you need N+1 redundancy prior to Q4, CY '02

Cisco uBR7246VXR— No. Subscribers Per Cable IP Services

Cisco.com

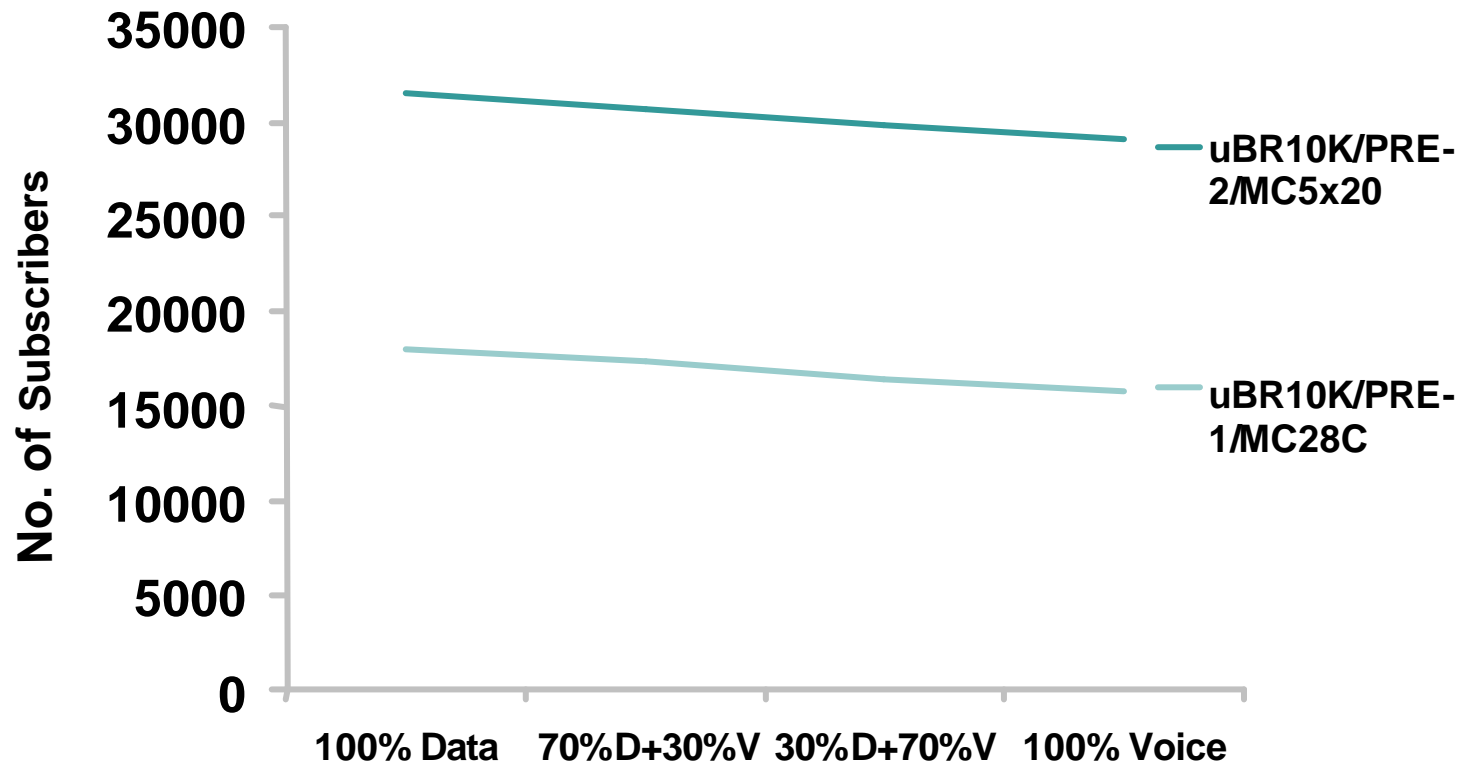


Subs per Chassis ? ✍ Cost per Sub. ?
Services per Chassis ? ✍ Revenue per Sub. ?

- Chart is based on real-world data and estimated projections for common configurations for current and future products respectively. The steady state CPU utilization of 75%, 64QAM DS, QPSK/1.6MHz US; and fully loaded chassis assumed.
- Actual performance may vary depending on traffic and usage patterns, number of subscribers, features turned on, and so on.

Cisco uBR10012— No. Subscribers vs. Cable IP Services

Cisco.com



Subs. per Chassis ? ✍ Cost per Sub. ?
Services per Chassis ? ✍ Revenue per Sub. ?

- Chart is based on performance tests data and estimated projections for common configurations for current and future products respectively. The steady state CPU utilization of 75% , 64QAM DS, QPSK/1.6MHz US; and fully loaded chassis assumed.
- Actual performance may vary depending on traffic and usage patterns, number of subscribers, features turned on, and so on.

Deployment Guidelines

Recommendations

- **CPU load:**
CPU should not run steady state at more than 75% to accommodate traffic peaks
- **Number of cable modems per upstream (US) port**
Cable modems contend for access to US time slots
Excessive collisions increase overhead and decrease throughput
Maximum of 200–250 users per US port is recommended (oversubscription ratio of 40:1 and steady-state CPU utilization of 75%)
- **Number of cable modems per downstream (DS) port**
Limited by worst case download speed customer experiences at peak busy hour
At current usage patterns 1000 to 1200 users per DS port is satisfactory (oversubscription ratio of 80:1 and steady-state CPU utilization of 75%)
- **Actual subscriber count may vary depending on traffic and usage patterns and new services**

Thank You

CISCO SYSTEMS



EMPOWERING THE
INTERNET GENERATION

Backup Slides

Call to Action — Power Up!

Cisco.com

- **VXR/NPE-400 Power Up bundle – Shipping in volume!**

Ordering code/trade-to part# : **uBR7246VXR-NPE400=**

Starts at USD \$24,500 list

Includes Cisco uBR7246VXR chassis (spare) and NPE-400 with configurable memory options

Recommend the *latest* Cisco IOS 12.1 EC release and 256MB memory

- **Trade-in part#s**

CHAS-UBR7246= (NOT UBR7246=)

NPE-150= or NPE-200= or NPE-225=