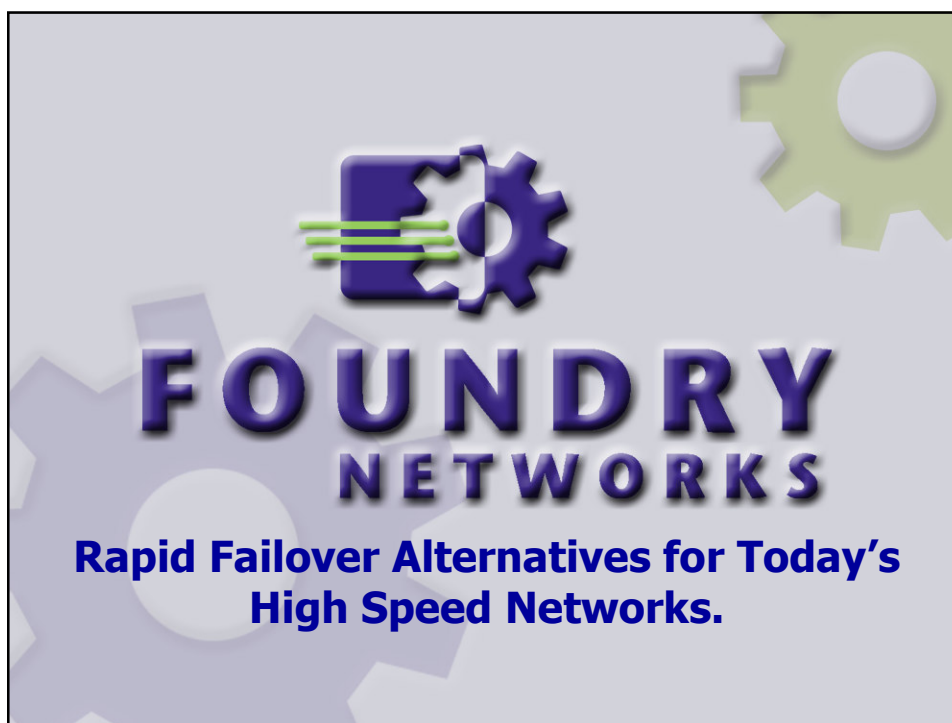




## Agenda

- Traditional Campus & MAN Resilience
- Drivers for Layer 2 Resilience
- Spanning Tree
- Rapid Spanning Tree
- SuperSPAN
- Topology Groups
- Edge Switch Redundancy
- Ethernet Ring Protocols

## Traditional Campus Resiliency

- 802.1D Spanning Tree
  - Slow >45 seconds convergence
- Full or Partial Mesh redundant topologies
- Routed Core for fast convergence
- Equal Cost Multi path for load sharing
- Each Building/Floor different IP Subnet
- Routers/Hubs –Traffic control

3

## Drivers for Layer 2 Campus & MAN Networks

- Switched Networking- traffic only on required ports
- User Mobility
  - Wireless networking L2 IAPP roaming across Campus
  - 802.1X with dynamic VLAN allocation
    - Student VLAN, Staff VLAN
- Security groups for Functional areas eg Accounts, Admin,
- VoIP
  - Layer 2
  - Use 802.1P bits for QOS

4

## Spanning Tree Limitations

- Slow convergence- blocking, listening, learning, forwarding >45 seconds
- Limited size of topology
- Single STP Domain
  - Single Root Bridge
  - Does not always make best use of topology
  - Can be enhanced by PVST
  - Many PVST VLAN's /STP's can bottleneck switch CPU's
- Link failure causes whole topology to reconverge

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## Rapid Spanning Tree 802.1w

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## What is IEEE 802.1w (RSTP)?

- 802.1w is an enhancement to the Spanning Tree Protocol
- Provides rapid convergence in case of a link / switch failure, regardless of the location of the failure
- 802.1w is also known as the Rapid Spanning Tree Protocol (RSTP)
- Already an IEEE standard, ratified mid 2001

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## Goals of 802.1w

- Be able to construct a loop free active topology out of any given topology
- Utilize advanced mechanisms in order to achieve very fast convergence for:
  - failures in networks (or network segments) with point to point links
  - link / switch failure
  - any location of failure
  - any current state (at the time of failure)
- Provide short predictable convergence time that is insensitive to the values of the protocol timers
- Be backward compatible with STP.

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## How Could RSTP Be So Rapid?

- RSTP achieves rapid convergence on point to point links only.  
Almost all L-2 switched networks built today rely on point to point links – No Hubs.  
=> simplifies the problem to be solved
- RSTP does not rely on timers to detect and fix a topology failure
- In contrast with STP, RSTP relies on explicit negotiations of port roles on each link in the network => timer insensitivity
- Timers are still there in RSTP, but they are used:
  - as a backup mechanism to the rapid convergence mechanisms
  - for backward compatibility with STP

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## STP vs. RSTP

### *Switch Roles*

#### STP

##### **Root Switch**

- Acts as the root for the active topology (spanning tree)

##### **Non-Root Switch**

- Maintains connectivity to the topology via its root port
- Provides connectivity to other switches via its designated ports

#### RSTP

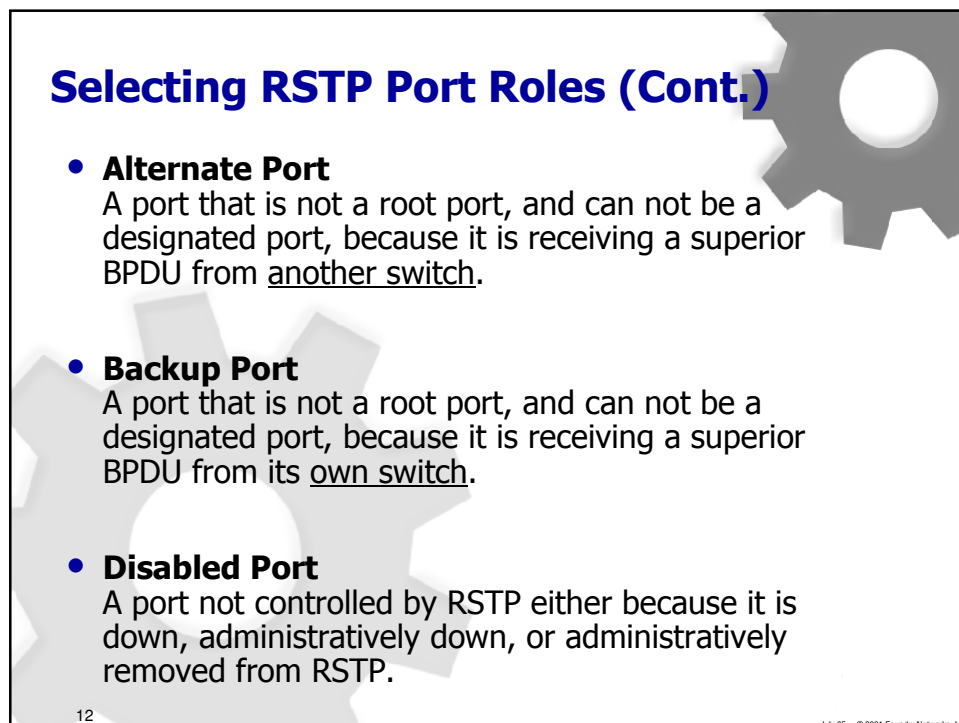
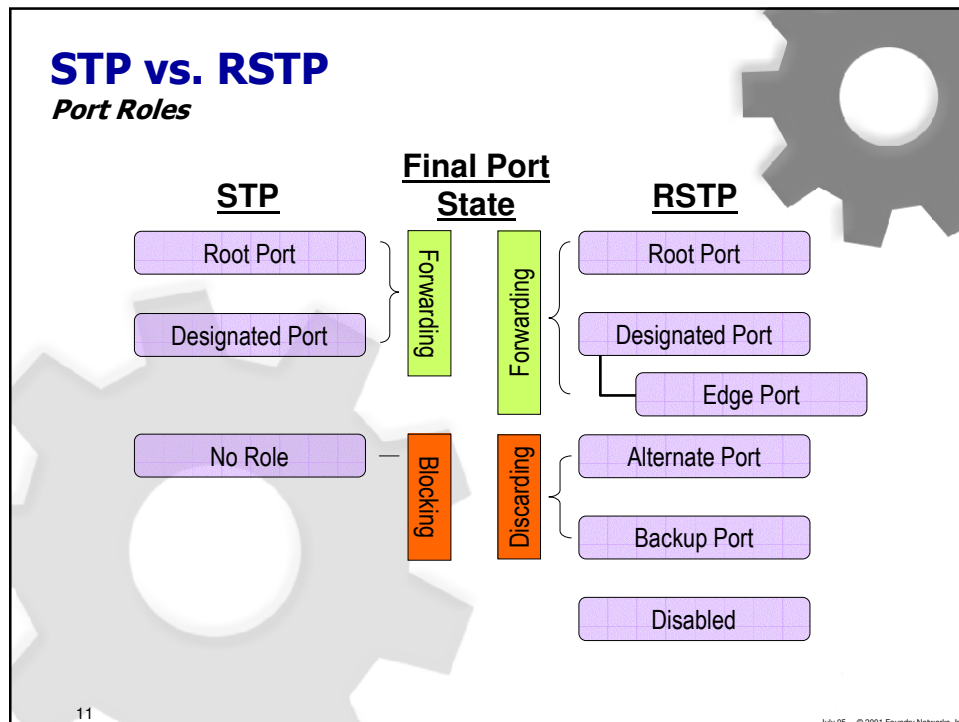
##### **Root Switch**

- Acts as the root for the active topology (spanning tree)

##### **Non-Root Switch**

- Maintains connectivity to the topology via its root port
- Provides connectivity to other switches via its designated ports

10



## Example Port Roles & States

**BID = Bridge ID\***  
(Bridge\_Pri.Bridge\_MAC)

**RP = Root Port**

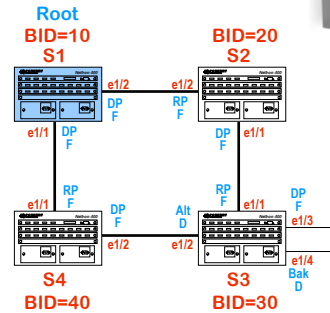
**DP = Designated Port**

**Alt = Alternate Port**

**Bak = Backup Port**

**F = Forwarding**

**D = Discarding**

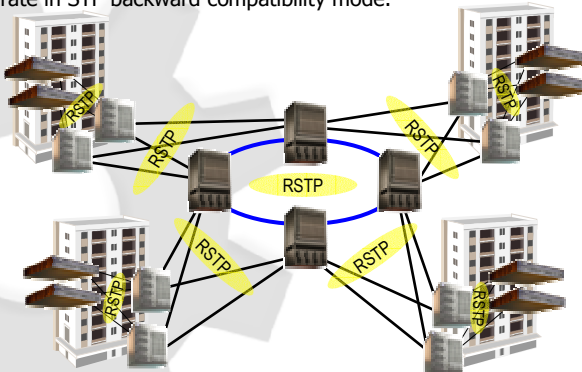


\* For the sake of simplicity, simplified bridge IDs are used here instead of the real ones: Bridge Priority followed by Bridge MAC Address

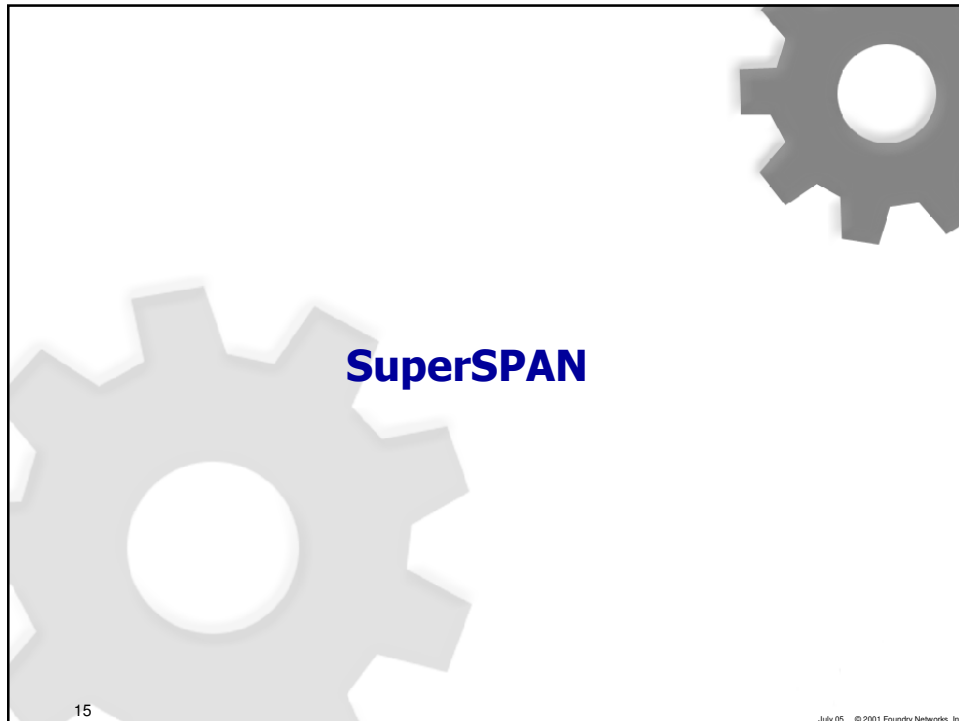
13

## Campus Applications

- Use where a high level of redundancy, and rapid failover are needed:
  - Wiring closet (access layer) to aggregation layer
  - Aggregation layer to the core
  - Core
- Multiple VLANs and topology groups for load distribution.
- Rapid failover is critical to VoIP.
- Could be easily integrated with existing enterprise STP switches. Each RSTP port could operate in STP backward compatibility mode.



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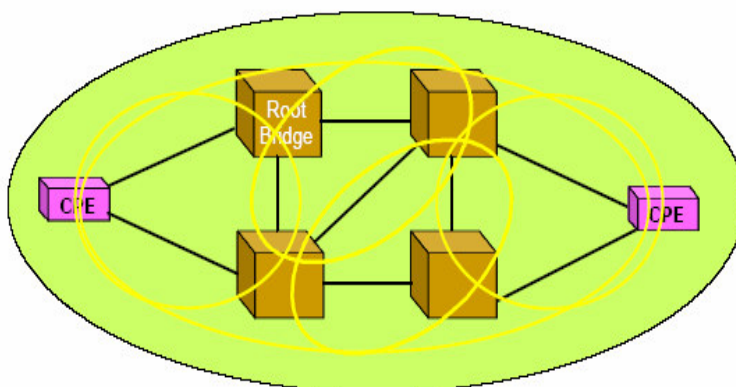
Slide 16 features the title "SuperSPAN" in a bold, blue, sans-serif font at the top left. Below the title is a bulleted list of features. The background is white with two large, light gray gear icons: one in the lower-left quadrant and another in the upper-right quadrant. The number "16" is printed in a small font at the bottom left corner. A small copyright notice "July 05 © 2001 Foundry Networks, Inc." is visible at the bottom right.

- Creates Multiple Spanning Tree Domains
- Allows a Campus network to have multiple root bridges
- A STP topology change in one Domain will not affect any other domain
- Support for 64k Domains
- Supports PVST, STP, Single STP, 802.1s Topology Groups
- Supports mixing of different flavours of STP
- Changes BPDU packets at configured Boundary Interfaces.



## Single STP Domain

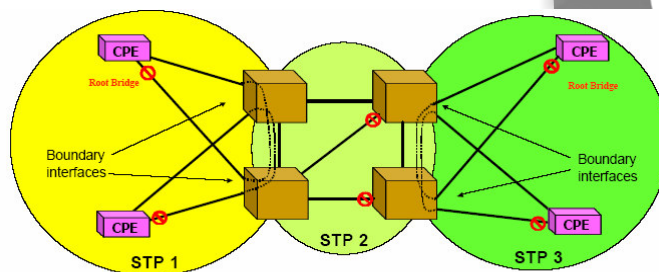
Single Spanning tree Domain



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## SuperSPAN *How it works*



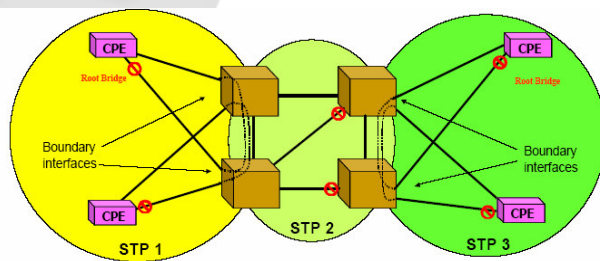
- Standard BPDU address
- The first Byte local admin bit is changed from 01 to 03
- The 4th & 5th Bytes are changed to reflect the Domain ID
- 01-80-c0-00-00-00
- 03-80-c0-00-00-00
- 03-80-c0-00-01-00

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## SuperSPAN design

- Plan SuperSPAN Domain structure
- Decide on Domain ID's
- Configure Boundary Interfaces
- Set root priorities for each Domain



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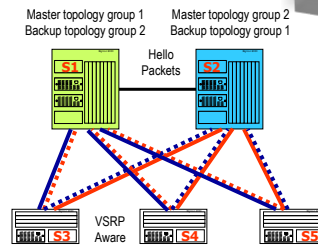
## Topology Groups 802.1s

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## Topology Groups -802.1s for maximizing Network Topology

- Topology groups are a collection of VLANs
- Each Topology group contains a Master VLAN and Member VLANs
- Master VLAN has the resiliency protocol configured
- Member VLANs follow config of Master
- 4096 VLANs can be divided among 32 Topology groups
- STP, RSTP, VSRP, MRP all support Topology groups to fully utilize switches and links
- Efficient alternative to PVST



Topology group 1 = Master VLAN 1  
Member VLANs 2 to 2048  
Topology group 2 = Master VLAN 2049  
Member VLANs 2050 to 4096

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## Edge Switch Redundancy

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## Edge Switch Redundancy

- Foundry
  - Virtual Switch Redundancy protocol
- Nortel
  - Multilink Trunking, MLT & SMLT

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## Virtual Switch Redundancy Protocol

- VSRP provides an alternative to Rapid Spanning Tree Protocol (RSTP) in dual home and Meshed configurations, providing sub-second fail-over and recovery.
  - Some customers dislike spanning tree!
- VSRP features provide
  - Sub-second fail-over
  - Efficient use of mesh bandwidth – no blocked links
  - Block and unblock ports at the per-VLAN group level
  - Large Scale L2 MANs with multi-tiered support
  - Highly flexible network designs
  - Configurable Tracking options
  - Works with other L2 features
- Works with all Ethernet interfaces, including 10 Gigabit
- Does not require new hardware!
- **VSRP is based on VRRP & can provide both L2 and L3 backup**

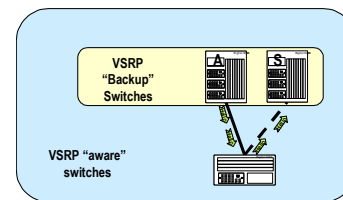
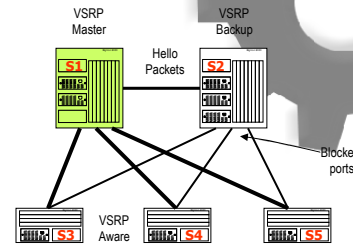
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## VSRP

### How it works

- VSRP uses an election process to select a Master switch and up to 4 backup switches.
- Only the Master switch forwards data, while Backup switches block traffic on all VSRP configured interfaces on a per VLAN or topology group basis.
- Master switch sends hello packets to all backup switches
- VSRP can track non-VSRP links to determine master states (router interfaces)
- Switches do not *have* to be VSRP aware. VSRP aware provides faster failover



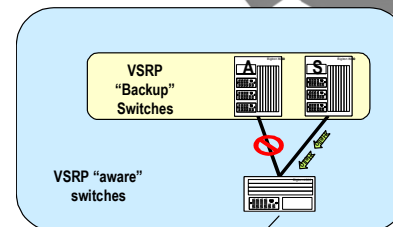
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## VSRP

### Rapid Failover

- VSRP aware edge switches monitor VSRP packets
- When the new master is elected, hello packets are seen on a different interface
- VSRP aware switches will transition the MAC addresses learned on the failed port to the new port
- Non-VSRP aware switches will not do this and normal MAC aging & learning will occur & transition will be slower



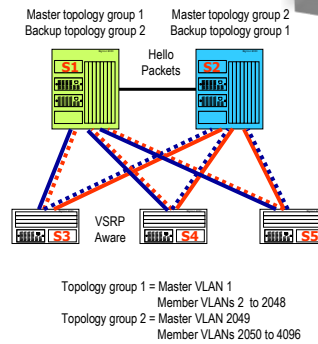
| Mac Type       | D    | = Dynamic | S    | = Static | H | = Host | R | = Router |
|----------------|------|-----------|------|----------|---|--------|---|----------|
| MAC            | Port | Age       | Type |          |   |        |   |          |
| 0060.F320.23a8 | 1    | 0         | D    |          |   |        |   |          |
| 0030.1007.0094 | 1    | 0         | D    |          |   |        |   |          |
| 0040.b758.88dc | 1    | 0         | D    |          |   |        |   |          |
| 0004.8039.5f00 | 1    | 0         | D    |          |   |        |   |          |

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## Topology Groups *for maximizing Network Topology*

- VSRP Supports Topology groups to fully utilize switches and links
- Topology groups are a collection of VLANs
- Each Topology group contains a Master VLAN and Member VLANs
- VSRP configured switches can be Master for some Topology groups while backup other for others
- 4096 VLANs can be divided among 32 Topology groups

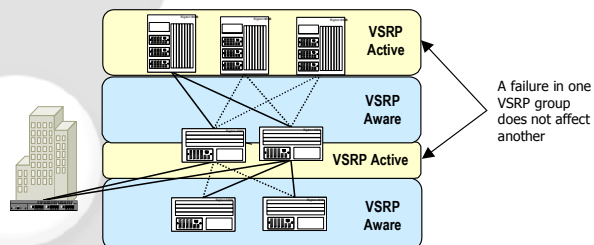


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## VSRP domains

- VSRP can be configured in separate domains
- Topology groups can be designed to use unique paths in each domain
  - Topology group 1 can be a high bandwidth tope group
- Different paths can be established through the network specific to the VLAN topology requirements using different groups in each domain (VLAN ingress and egress points)



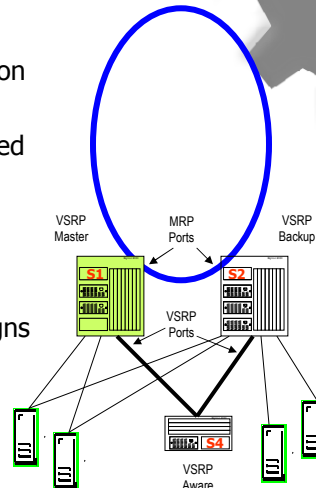
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## VSRP

### *Intelligent port-level control*

- VSRP can be configured to run only on designated ports
- Only VSRP configured ports are placed in blocking for Backup switches
- Supports Host attachments and dual NIC support
- Works in combination with MRP to provide flexible Metro Ethernet designs

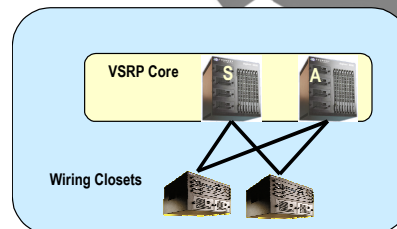


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## VSRP

### *Enterprise Applications*

- Use where a high level of redundancy is needed in the core
- Wiring Closet to core connections
- Every edge switch has a connection to each core VSRP switch
- Multiple VLANs for link utilization
- IP redundancy
- This is a compliment to standards based 802.1w RSTP
- Rapid failover is critical to VoIP



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## **VSRP – Summary of Benefits**

- Fast, sub-second protection without Spanning Tree
- Combines both switching and routing redundancy
  - Provides default gateway redundancy if needed
- Supports topology groups for full link utilization
- Can be combined with other Foundry features to provide complete end to end MAN designs
- Great for Campus networks

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## **Ethernet Ring Protocols**

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## Ethernet Ring Protocols

- 802.17 RPR Standard was stalled for a long time
- Many vendors have pre-standard Implementations
  - Foundry
  - Extreme
  - Cisco

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## Metro Ring Protocol

- Metro Ring Protocol is a Layer 2 protocol designed to utilize the qualities of ring topologies to provide SONET-like, high speed, fault tolerant, fast recovering Metro/Campus Ethernet networks
- MRP SONET-like features provide
  - Sub-second failover
  - Efficient use of bandwidth with topology groups (802.1s based)
  - Protection for multiple VLANs
  - Large Scale L2 MANs with multi-ring support
  - Highly flexible network designs
  - Works with other L2 features
- Runs on all Ethernet and PoS interfaces, including 10 Gigabit
- Does not require new hardware

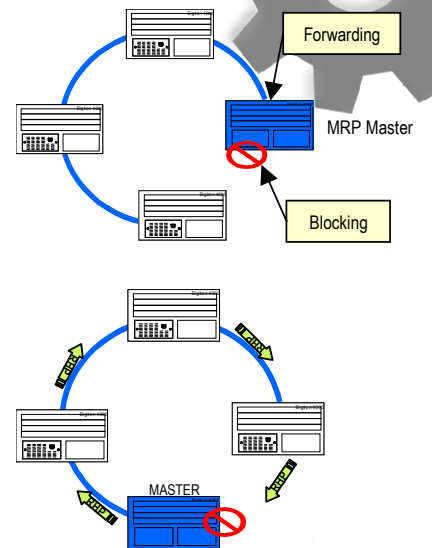
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## Metro Ring Protocol

### How it works

- A single node is selected as the Master Ring Node
- All other nodes are defined as Ring Nodes
- The Master Node prevents loops by blocking its secondary port
- Ring Health-check Packets are generated by the Master Node to maintain ring integrity
- Master node expects to receive its health packets on the blocked link



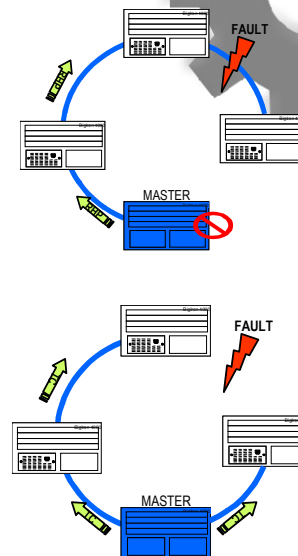
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## Metro Ring Protocol

### Sub-second recovery

- Health-Check packets are hardware forwarded by the nodes in the ring to ensure fastest failure detection (<100ms)
- Fault recovery occurs when Health check packets are not received (<300ms)
- Master Node will begin to forward on secondary port and send notification to all Ring nodes to flush Forwarding DB
- Health-Check packets continue to be generated by Master Node
- Low latency on Foundry devices allows large ring node count (10us)



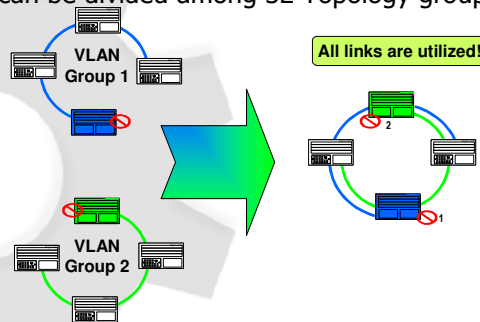
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## Metro Ring Protocol

### *Efficient use of Ring Bandwidth*

- MRP Supports Multiple (VLAN) Topology groups within a Ring
- An MRP Node can be both a Master node and Ring Node for different topology groups
- Each Topology group contains a Lead VLAN and Member VLANs
- Lead VLANs generate Health-Check packets and block secondary ports
- 4096 VLANs can be divided among 32 Topology groups

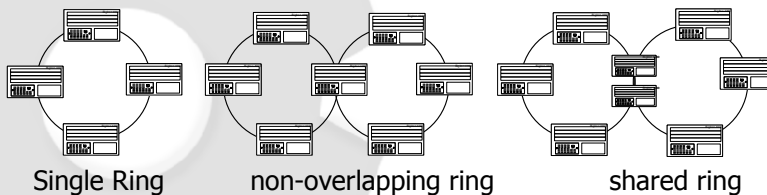


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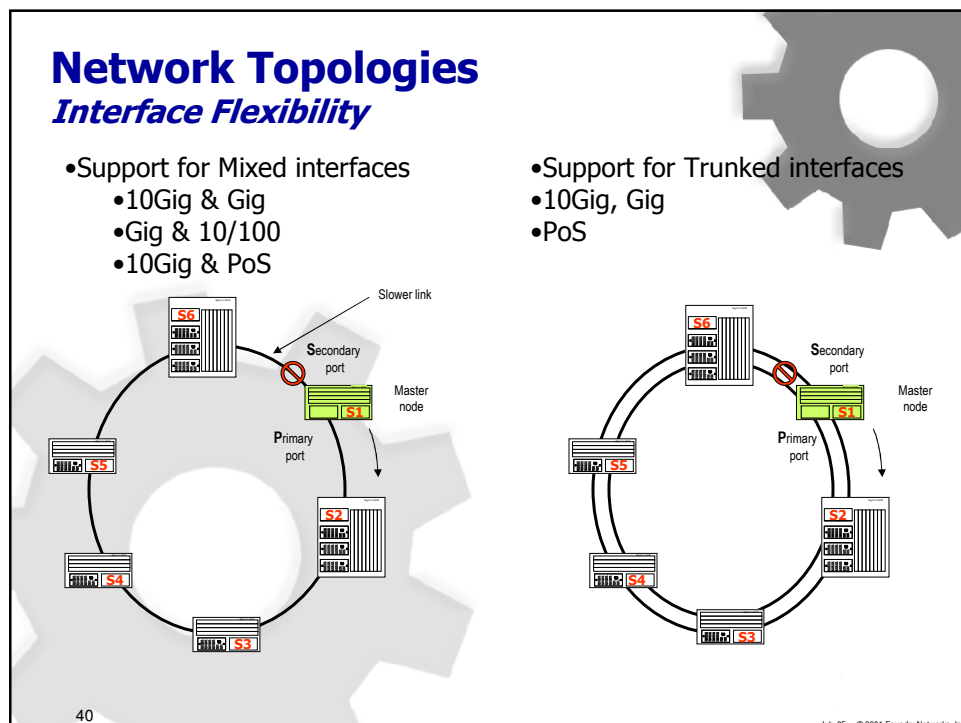
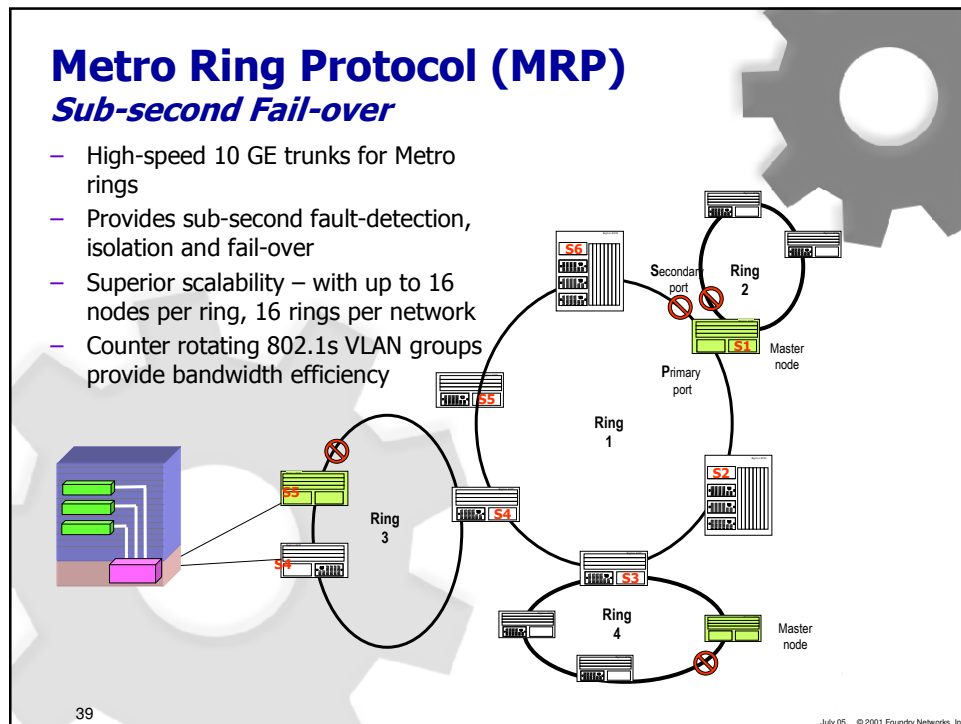
## Scalable L2 Ethernet MANs

### *Using Multiple Rings*

- There are 3 ring scenarios
  - Single ring,
  - Rings that don't overlap
  - Overlapping rings that share links
- Each Ring runs its own instance of MRP
- A ring node can be Master for Multiple rings
- No need for a 'backup' Master



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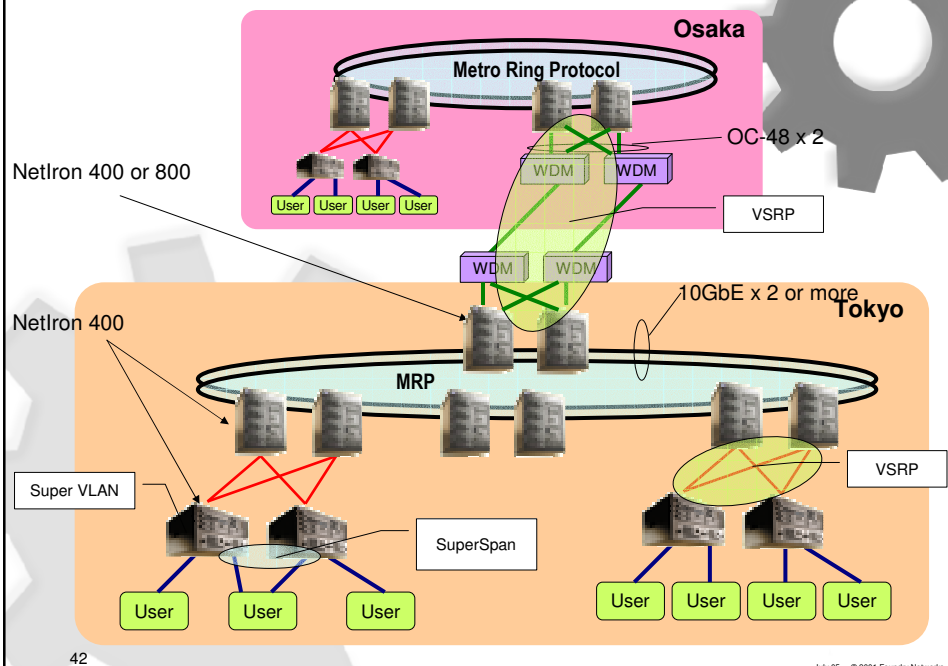
## MPR – Summary of Benefits

- Fast, sub-second, predictable fail-over functionality
- Maximizes Ring bandwidth utilization
- Cost effective alternative approach to resiliency and scalability
- Utilizes 802.3 Ethernet Packet standards and MACs
- Can be combined with other features to provide complete end to end Campus designs
- 10 Gig Cores today don't require a mesh

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## Case Study – Designing Metros With VSRP, MRP & SuperSpan

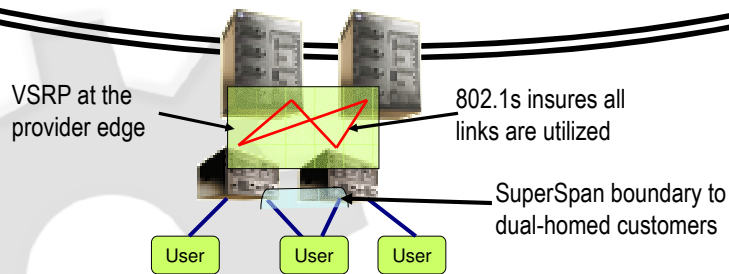


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## Using MRP with VSRP & SuperSpan

- SuperSpan decouples customer's STP from Metro network for dual-homed customers – Customer STP does not interfere with provider network.
- VSRP connects the provider edge to Metro ring
- VSRP interoperates with MRP in the Metro ring



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