Provider Ethernet
VLAN Cross Connect

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Jan 2006
COM FN A SB SE

SIEMENS Communications
Provider Ethernet - Network Challenges

- Business and residential customers require an SLA with guaranteed bandwidth, jitter and delay (which cannot be provided end-to-end by legacy Ethernet bridging)
- Network resiliency with ~50ms recovery
- Huge number of MAC addresses in a single Ethernet domain
- Scalable VLAN networks to provide dedicated VLAN per customer in wholesale solutions
- Networks and services must be secured
- Networks should be kept simple to minimize CAPEX
VLAN Cross Connect – Taking Ethernet One Step Further

- Connection-oriented technique
- Enables traffic engineering & fast recovery
- Resolves MAC scalability
- Resolves VLAN scalability
- Inherent subscriber identification
- Resolves security issues
- Keeps the network simple

Can scale up to millions of subscribers per port based on standard Ethernet frame format
### VLAN Cross Connect Concept

- **Standard VLAN Bridging**: Switching based on MAC addresses and VLANs
- **VLAN Cross Connect**: Cross Connect according to the **ingress port** and the VLAN-XC Tag, **regardless of the MAC addresses**

#### Ingress L2 packet

<table>
<thead>
<tr>
<th>MAC DA</th>
<th>MAC SA</th>
<th>VLAN Tag</th>
<th>Etype/Len</th>
<th>Data</th>
<th>FCS</th>
</tr>
</thead>
<tbody>
<tr>
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</table>

- VLAN Cross Connect **co-exists** with standard VLAN bridging, even on the same port
- VLAN Cross Connect **eliminates** MAC learning per VLAN
- VLAN Cross Connect **enables** up to 16M connections per port
The Concept of VLAN Cross Connect (cont.)

[Diagram showing VLAN Cross Connect concepts with labeled ports and VLAN XC Tags, illustrating the connection from Ingress Port to Egress Port through VLAN Cross Connect.]
Provider Edge Nodes (PE-Nodes) reside at the boundary of the provider network and create/terminate VLAN-XC connections.

Provider Internal Nodes (P-Nodes) perform VLAN Cross Connect switching.
- Provider Edge Nodes (**PE-Nodes**) reside at the boundary of the provider network and create/terminate VLAN-XC connections.
- Provider Internal Nodes (**P-Nodes**) perform VLAN Cross Connect switching.
Hybrid VLAN Cross Connect & Bridging Network

Provider Ethernet network incorporating both bridging & VLAN Cross Connect methods to apply the optimum method per service:

- Bridging for residential multicast services & basic Ethernet transparent LAN services
- VLAN Cross Connect for business-critical services with associated SLAs

<table>
<thead>
<tr>
<th>Service</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPTV</td>
<td>Bridging</td>
</tr>
<tr>
<td>Business VPN MPtMP (E-LAN)</td>
<td>Bridging</td>
</tr>
<tr>
<td>Network management</td>
<td>Bridging</td>
</tr>
</tbody>
</table>

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<tr>
<th>Service</th>
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<tr>
<td>High Speed Internet Service</td>
<td>VLAN-XC</td>
</tr>
<tr>
<td>Business VPN PtP (E-Line)</td>
<td>VLAN-XC</td>
</tr>
<tr>
<td>Business &amp; Residential Voice Services</td>
<td>VLAN-XC</td>
</tr>
<tr>
<td>Residential Video-on-Demand</td>
<td>VLAN-XC</td>
</tr>
<tr>
<td>Wholesale services</td>
<td>VLAN-XC</td>
</tr>
</tbody>
</table>
Hybrid Network Benefits

- **Traffic Engineering**
  - VLAN Cross Connect allows end-to-end TE for services with associated SLAs

- **Fast Recovery**
  - ~50ms recovery for VLAN Cross Connect services
  - Significantly reduces the recovery time for bridging services due to small FDB (yields from correct service partitioning between VLAN Cross Connect and bridging methods)

- **MAC Scalability Traffic Engineering**
  - VLAN Cross Connect allows end-to-end TE for services with associated SLAs

- **Fast Recovery**
  - ~50ms recovery for VLAN
  - VLAN Cross Connect for services that consume a large number of MAC addresses
  - Small FDB (used for bridging services) due to the insignificance of MAC addresses in the VLAN Cross Connect

- **VLAN Scalability**
  - VLAN Cross Connect identifiers have local port scope
    - *Up to 24-bit wide VLAN Cross Connect identifier*
  - Bridging VLAN identifiers have global scope
Hybrid Network Benefits (cont.)

- **User Isolation**
  - In the VLAN Cross Connect, users are inherently isolated by the end-to-end connection
  - In Bridging, user isolation requires additional methods such as PVLAN, Port Isolation, etc

- **User Identification**
  - In the VLAN Cross Connect, users are natively identified along the provisioned end-to-end connection

- **Protection against MAC spoofing and MAC attacks**
  - MAC Address insignificant in VLAN Cross Connect switching
  - MAC Learning inhibited for VLAN Cross Connect
VID of the frame’s outer VLAN tag acts as method selector.
VLAN Cross Connect and bridging services coexist in the same provider network.
VLAN Cross Connect Frame Semantic

- VLAN Cross Connect identifier has local port scope
  - Frame format as defined in IEEE 802.1Q
- VLAN Cross Connect tagged frame allows up to 4K VLANs per port

VLAN Cross Connect tagged frame

```
12-bit VLAN Cross Connect ID:
up to 4k VLANs per port
```
**Extended VLAN Cross Connect**

- Frame format as defined in IEEE 802.1ad
- VLAN Cross Connect tagged frame allows up to 16M VLANs per port

**Extended VLAN Cross Connect tagged frame**

24-bit VLAN Cross Connect ID: *up to 16M VLANs per port*
## VLAN Cross Connect Process Example

<table>
<thead>
<tr>
<th>In Port</th>
<th>Ingress VLAN</th>
<th>Out Port</th>
<th>Egress VLAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>7</td>
<td>110</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>5</td>
<td>120</td>
</tr>
<tr>
<td>3</td>
<td>30</td>
<td>5</td>
<td>130</td>
</tr>
<tr>
<td>3</td>
<td>40</td>
<td>6</td>
<td>130</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>7</td>
<td>140</td>
</tr>
<tr>
<td>4</td>
<td>50</td>
<td>Bridging according to MAC DA &amp; VLAN ID</td>
<td>50</td>
</tr>
</tbody>
</table>

**Diagram:**

- **Cross Connect**
  - VID = 10
  - VID = 10
  - VID = 30
  - VID = 40
  - VID = 40
- **Bridge**
  - VID = 50
At the boundary of the VLAN-XC domain, the VID of the outer tag (C-TAG or S-TAG) can be used to associate the frame with a particular VLAN-XC connection.

If required, the outer tag (C-TAG or S-TAG) is preserved and transparently transported within the VLAN-XC domain.
VLAN Cross Connect Example (with CE-VLAN Preservation)

**MAC DA**
**MAC SA**
**CE-VLAN**

VLAN Cross Connect Connection

**PE-Node**
1. L2 Frame 3
2. MAC DA
3. MAC SA
4. VXC=1024
5. CE-VLAN

**P-Node**
2. L2 Frame 2
3. MAC DA
4. MAC SA
5. VXC=236
6. CE-VLAN

**PE-Node**
4. L2 Frame 4
5. MAC DA
6. MAC SA
7. VXC=2623
8. CE-VLAN

**P-Node**
6. L2 Frame 6
7. MAC DA
8. MAC SA
9. VXC=236
10. CE-VLAN

Optional CE-TAG Preservation
Extended VLAN Cross Connect Example

VLAN Cross Connect Connection

PE-Node -> P-Node -> P-Node -> PE-Node

L2 Frame

MAC DA
MAC SA
CE-VLAN

EVXC=12045

EVXC=645

EVXC=15320

MAC DA
MAC SA
CE-VLAN

MAC DA
MAC SA
CE-VLAN

MAC DA
MAC SA
CE-VLAN

MAC DA
MAC SA
CE-VLAN
VLAN Cross Connect Services for Ingress Untagged Frames

All-to-one bundling for untagged frames:
- All frames received on a particular ingress port are associated with a single connection over the provider network.

- All-to-one bundling
- up to 4K VLANs per port
- up to 16M VLANs per port in extended mode
VLAN Cross Connect Services for Ingress Tagged Frames

Service multiplexing with no ingress outer V-TAG preservation:

- Multiple outer VLANs received on a particular ingress port can be associated with multiple connections over the provider network.
- Outer VLAN tag is not preserved over the network (but may be retrieved from the penultimate VLAN Cross Connect identifier received by the egress PE-Node)
VLAN Cross Connect Services for Ingress Tagged Frames (cont.)

On the same ingress port:

- Bundling: Multiple outer VLANs can be associated with a single connection over the provider network.
- Multiplexing: Multiple outer VLANs can be associated with multiple connections over the provider network.
- CE-VLAN preservation with both methods

4K * (up to 16M VLANs per port) in extended mode
VLAN Cross Connect enables traffic engineering:

- Can be implemented using a domain-wide provisioning tool
- GMPLS control plane once standardized
1:1 Global Protection with extra traffic
Pre-provisioned backup paths using network-wide provisioning tools
Sub-50ms recovery
Revertive or non-revertive mode
GMPLS resiliency mechanisms (including Fast Reroute) could be applied once GMPLS for Ethernet is standardized
Scalability

- VLAN Cross Connect can be naturally extended to work with hierarchical domains using tunneling
- Uses standard VLAN stacking
Point-to-Multipoint Services

- VLAN Cross Connect can be naturally extended to provide point-to-multipoint services
- Subject to a forthcoming contribution
Thank You!

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