Transforming Lab Automation with Layer-1 switching fabrics based on SDN and whitebox switches

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Challenges of the Modern Test Lab

**Automation – Business Drivers**

Accelerate service onboarding, testing of updates and patches, developing and testing new services – **Accelerate time-to-revenue**

Eliminate manual, error-prone, slow, topology moves, adds – **Reduce OPEX**

Maximize utilization and sharing of expensive tools like traffic generators across groups/projects – **Reduce CAPEX**

**Traditional Labs Realities**

Time consuming, error prone reconfigurations of topologies

Expensive equipment is often located in silos around the company, simultaneously underutilized and inaccessible to many

*Increase test velocity while reducing capital equipment costs and cutting overall operational expense*
L1 Switching Concept

Once an internal connection is made within the layer 1 switch, the now-paired routers ‘appear’ to be directly connected to each other.

The name layer-1 switch comes from the fact that they’re trying ’emulate’ the behavior of a physical cable between the two devices.
L1 Switching Concept

“software-controlled patch panel”

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- The name layer-1 switch comes from the fact that they’re trying ’emulate’ the behavior of a physical cable between the two devices.
## Traditional Solutions For L1 Fabrics

<table>
<thead>
<tr>
<th>Feature</th>
<th>Packet Brokers</th>
<th>Optical Cross-connects</th>
<th>Media Cross Connect (Optical-Electrical)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical System Configuration</td>
<td>Modular Chassis / leaf-spine</td>
<td>Modular Chassis</td>
<td>Modular Chassis</td>
</tr>
<tr>
<td>Flexible Media types</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Cost</td>
<td>$$$$</td>
<td>$$$</td>
<td>$$$</td>
</tr>
<tr>
<td>Speed/Media conversion</td>
<td>✓</td>
<td>not always</td>
<td>X</td>
</tr>
<tr>
<td>L2-4 Packet handling</td>
<td>✓</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Automatic Path Discovery with guaranteed connectivity</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Path Resiliency and Dynamic Failover</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>DUT Circuit Sharing</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Extends L1 Across Labs</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Traditional L1 Do Not Keep Up With Ethernet Speeds And The Multitude of Ethernet PMDs

![Ethernet Speed Chart](image)

**Ethernet Port Transition**

![Ethernet Port Shipment Chart](image)

*Includes 200 Gbps*
Advantages of Whitebox Ethernet Switching Hardware

- Unmatched interface flexibility and density \( \rightarrow 1, 10, 25, 40, 50, 100, 200, 400G \)
- SMF | MMF | Optical and Copper speed and media conversion
- Scale-out, pay-as-you-grow with leaf-spine topologies based on 1U commodity switches
- L1 fabric capacity 20X of legacy solutions
- Significantly lower Capex and Opex than any traditional L1 solution
Two Architectural Approaches To Emulate L1 Technology

- **L1 VirtualWire**
- **“L1+” VirtualWire**

**Simplicity**

**Flexibility**

L1 emulation with IP+Overlay
L1 Ethernet VirtualWire Concept

Merchant Silicon Ethernet Switch Hardware:
1. Network OS must disable MAC learning
2. Disable Routing/L3 processing
3. Disable stp/vlan checks, BPDU processing
4. Network OS must disable control plane processing
5. Circuit switch emulation via ACL TCAM programming

6. It is possible to configure the switch chip* to pass through transparently errored frames (e.g. CRC, runt...)
7. Implement logic to propagate link-up/down events between two mapped ports

* Verified with at least one merchant silicon chip family
Whitebox Switch VirtualWire Properties

Transparency to any Ethernet packet

Errored Packets**
CRC
Control Plane Packets
LACP  LLDP  BGP
Ethertypes
MPLS  FCOE  RoCE

Speed and Media Conversion

100G
1G
3G
fiber
Copper

1G
10G
L1 VirtualWire Fabric Scalability Example
2,048 10G/25G DUTs Non-blocking fabric

32 x 10G/25G per leaf to DUTs
Spine 64 ports → 32 leaf
Total 10G DUTs: 32x64=2,048
Whitebox L1 VirtualWire Capabilities

- Transparent to ALL kinds of Ethernet traffic and encapsulations and frame errors
- Flexible interfaces from 1G to 100+G copper and fiber
- Any speed, any media conversion
- OS must implement Link status Tracking logic to emulate a true L1 switch

Programmability of Modern Whitebox OSes: RESTful API, CLI, Ansible

End-to-end automatic discovery of available paths via external Lab automation controller

Modular, scale-out, pay-as-you-grow design

Lab Automation Software

Diagram showing 16 switches connected via lines to a cloud icon labeled "Lab Automation Software."
L1+ VirtualWire Based On IP+Overlay

Can be implemented with a Point-to-point Virtual Private Wire Service (VPWS) using VXLAN Transport:

- No MAC lookup
- No learning
- Transparency to L2/L3 protocols
- Transparent to different Ethertypes
- Failure propagation
- Few implementations exist today
Automated path discovery with guaranteed connectivity

Dynamic bandwidth utilization with DUT path sharing

Path resiliency and automatic failover…upon link and node failures

Extend VirtualWires across geographically distributed Labs (MTU adjustments might be necessary to accommodate for the VXLAN encap)

IP control plane is more complex than traditional L1 switching
L1+ Path Auto-discovery With Guaranteed Connectivity

DUTs cannot find a path even if the bandwidth is not oversubscribed

Leads to overprovisioning of the fabric interconnections to prevent path conflicts → $\$ and complexity

Path auto-discovery with guaranteed connectivity even with oversubscription

Simpler provisioning and more cost effective with fewer links to manage
L1+ Dynamic Bandwidth Utilization With DUT Path Sharing

VirtualWire and Any L1 Technology

Static provisioning of path bandwidth through the fabric

40G

1G

1G

Leads to poor bandwidth utilization when low speed DUT traverse the high-speed fabric links

L1+ Virtual Wire

Dynamic sharing of fabric bandwidth across many DUT ports

40G

40x1G

40x1G

More efficient link utilization, more cost effective and with fewer links to manage
L1+ Path Resiliency And Automatic Failover

VirtualWire and Any L1 Technology

- No ability to failover is any of the path links fail
- More complex to manage, manual recovery, longer outages

L1+ Virtual Wire

- Dynamic sub-second Failover
- Resilient to multiple link or node failures.
- Transparent failover to the DUTs.
L1+ Multi-Lab Fabric Extension

Share Equipment Across Any Location – Operates as a Single Lab

Salt Lake City

SmartBits
Analyzer
Traffic Generators

Evaluation Activity

PoC

Dallas

Any WAN or Dark Fiber

UC Servers
MS Servers
ADC
Networked Devices
Security Devices

Atlanta

SmartBits
Traffic Generators
Servers
Security Devices

LoB/BU Demo

Test Lab

Boston

Servers
Security HW
ADC
# Transforming Lab automation With Commodity Whiteboxes and SDN Fabrics

<table>
<thead>
<tr>
<th></th>
<th>Traditional L1 Switches PB, Optical &amp; Media x-connects</th>
<th>L1 VirtualWire</th>
<th>L1+ VirtualWire IP+Overlay</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scalability</strong></td>
<td>Scale up – chassis backplane limited</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Scale-out – modular leaf-spine</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>$$$</td>
<td>$</td>
<td>$</td>
</tr>
<tr>
<td><strong>Any Media/Speed conversion</strong></td>
<td>✗</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td><strong>Automated path discovery with guaranteed connectivity</strong></td>
<td>✗</td>
<td>✗</td>
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<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Dynamic bandwidth utilization with DUT path sharing</strong></td>
<td>✗ (Static (link size increments))</td>
<td>✗ (Static (link size increments))</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Extend VirtualWires across geographically distributed Labs</strong></td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Errored Frames Transparency</strong></td>
<td>✓</td>
<td>✓</td>
<td>Limited</td>
</tr>
<tr>
<td><strong>Wirespeed – no overhead</strong></td>
<td>✓</td>
<td>✓</td>
<td>✗ (50 bytes VXLAN hdr overhead)</td>
</tr>
</tbody>
</table>

- ✓: Available
- ✗: Not available
- $$$: High cost
- $: Low cost
- Limited: Limited availability
The Network Matters.™

www.pluribusnetworks.com