

TOMORROW starts here.



Cisco *live!*

Cisco Modelling Labs - Lessons from a Virtual World

BRKRST-2646

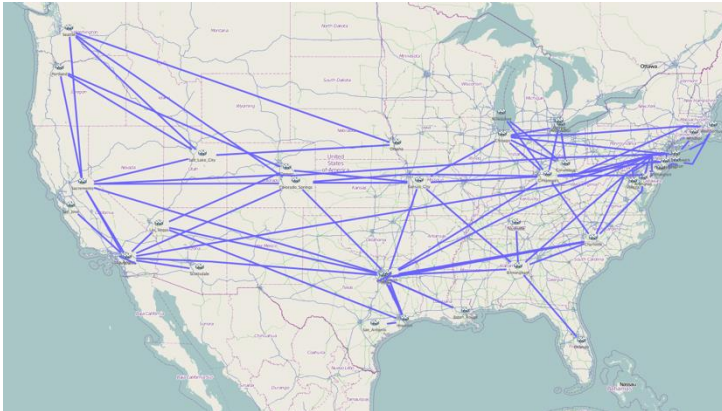
Joel Obstfeld

Distinguished Engineer

Network Virtualisation

The challenge -

- How do you deploy new services, make changes, or troubleshoot in the live network
 - Quickly, Consistently, Efficiently
 - And at scale



Network Virtualisation

Lab equipment comes at premium

- More equipment requires the more power, space and cooling
 - and there's never enough equipment for all of the people who want to use it!

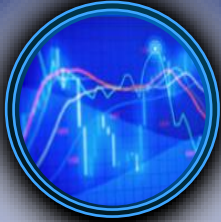
Similar challenges have already been faced in the Data-centre world

- Improve the utilisation of compute hardware while reducing power, space and cooling

Can we apply a similar approach to network devices?

Why use Virtual Networks?

Technical Opportunities



- Build and deploy networks at scale – virtually
- Verify designs and validate configurations
- Prototyping of new capabilities
- Reduce risk and errors through improved training

Benefits



- Decrease time to deployment for new services
- Replay “events” for training or fix verification
- 100 router testbed - 1 physical and 99 virtual
- Test combinations of new services

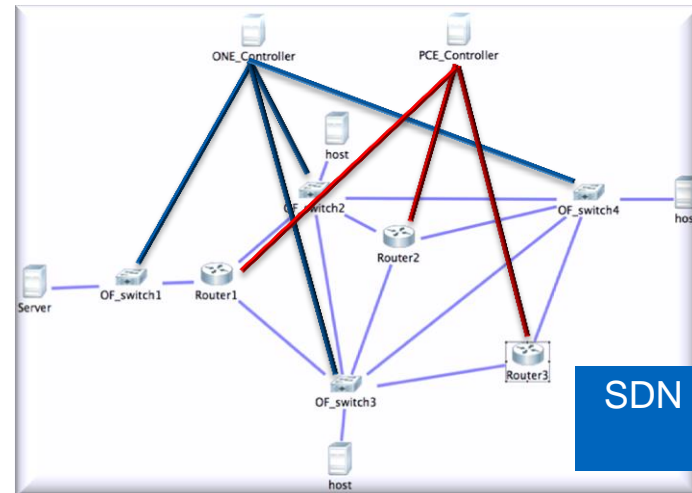
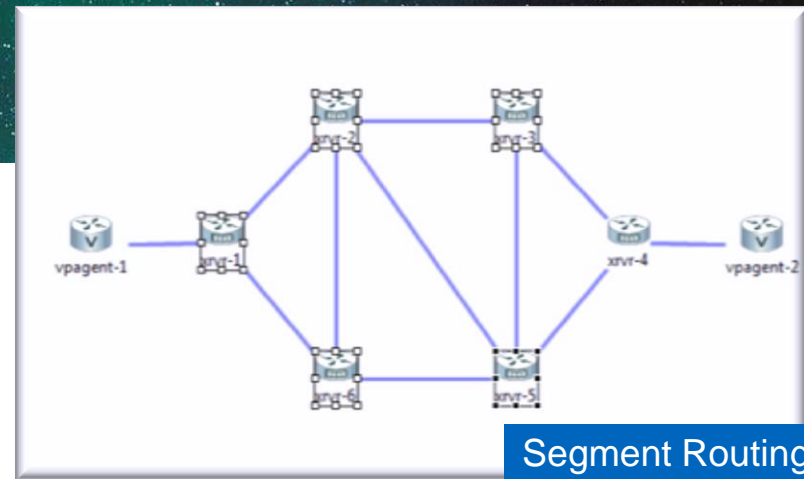
Training & Education

- Teach and train the next generation
 - Network engineers
 - Operators
 - Designers
 - Architects
- Students need ‘hands-on’ experience but the challenge is access to hardware
 - Learn by doing!
 - 10 students to 1 router or 1 student to 10 routers?
 - Real-world operating systems or Open-source?



New Features, New Capabilities

- Build, test, experiment and learn SDN technologies – new paradigms create new challenges
- Cisco OnePK network programmability framework – developers must be able to test and validate applications before deploying to the real network
- How do you test and trial new control-plane capabilities such as ‘Segment Routing’ if you don’t have a lab?



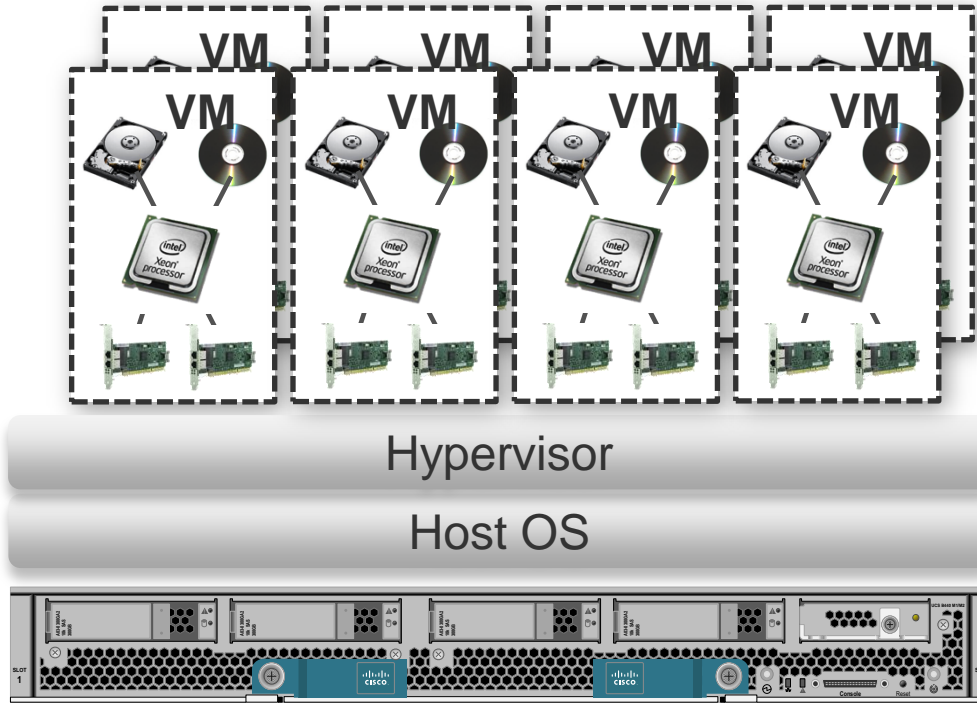
Agenda

- Virtualisation - a brief tour
- Building the virtual world
- Student testbed – cutting your teeth
- Topology building
- Cisco Modelling Labs in action...Live demo
- Case studies
- Summary
- Q & A



Virtualisation – A Brief Tour

Virtualisation



- Virtual Machines are presented with a set of virtual hardware resources
- Resources can be shared between the virtual machines or can be reserved
- What is the performance expectation?
- Is performance predictable and consistent?



Ubuntu / KVM Machine Virtualisation Suite

- Virtualised devices (CPU, I/O, memory) enable a single host to support many virtual machines
- KVM / QEMU provides a kernel-based Hypervisor / host-virtualisation facility
- Ubuntu 12.4 provides the basic host operating system
- Intel VT-x / AMD-V capable CPUs expose hardware-virtualisation functions to Host O/S and Hypervisor



Virtual Machines



Hypervisor



Host O/S



Physical Host

Virtualised Platform Operating Systems

IOS XR



Virtualised
in
IOS XRv

NX-OS



Virtualised
in NX-OSv

IOS XE



Virtualised in
CSR1000v

IOS



Virtualised
in IOSv

Servers



Ubuntu, Cirros,
3rd party
appliances

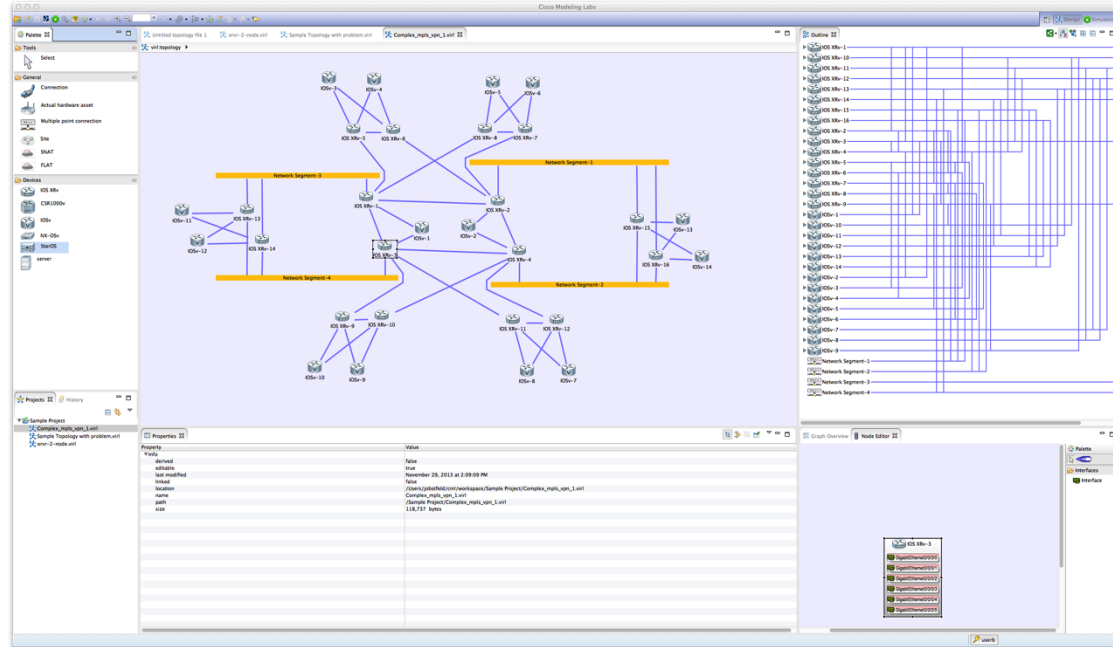
Virtual Machines run the operating system but are NOT representations of a particular hardware platform – no fans, no switch fabric, no ASIC models



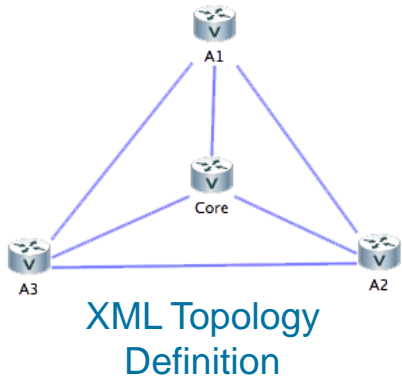
Building the Virtual World

Cisco Modelling Labs workbench

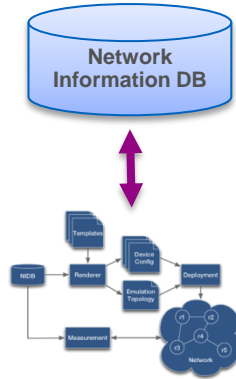
- The graphical topology design tool used to create XML topology files
- Powerful topology design functionality
- Drag and drop ease
- Attributes attached to network element define:
 - ✓ Addressing schema
 - ✓ IGP's
 - ✓ BGP
 - ✓ Additional control-plane elements
- Provides simulation management and console access to virtual routers



Automated Network Configuration / Rendering



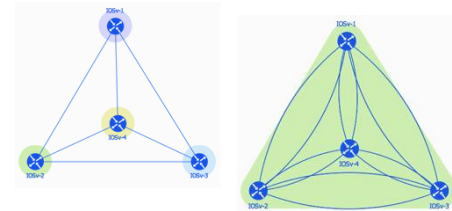
AutoNetKit



Configurations

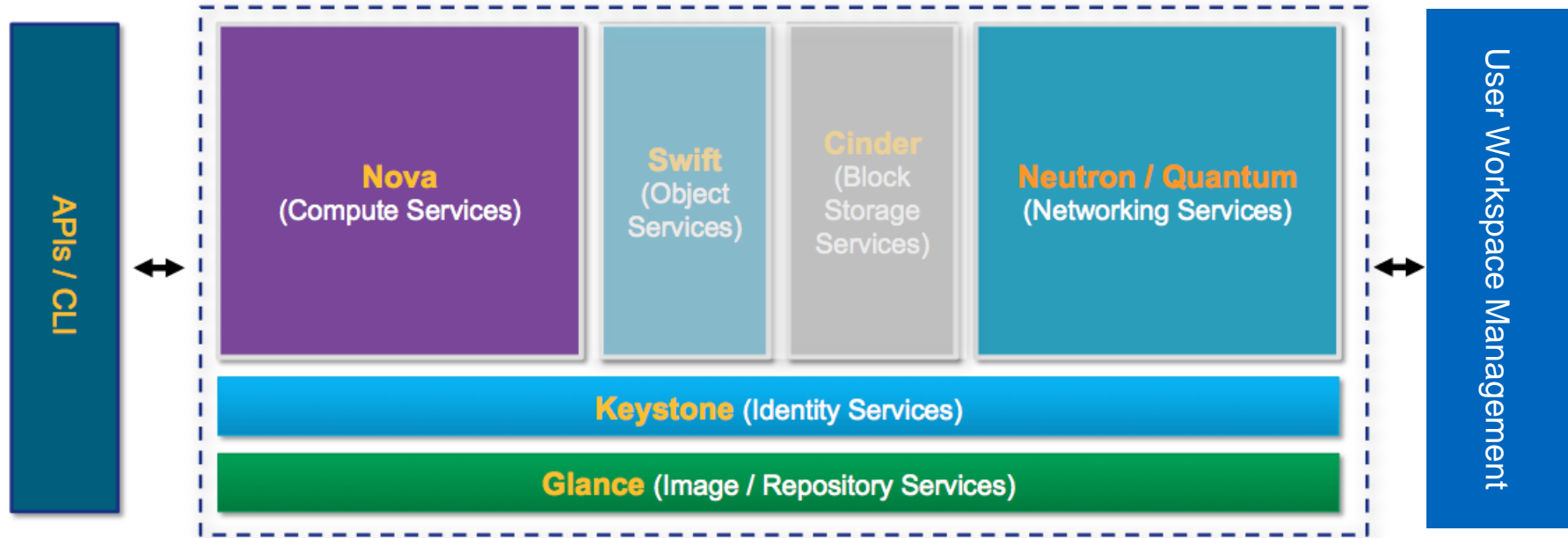
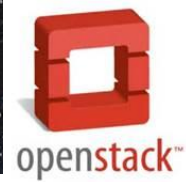
```
line vty 0 4
exec-timeout 720 0
password cisco
login
line con 0
password cisco
!
interface Loopback0
description Loopback
ip address 192.168.0.4 255.255.255.255
!
interface GigabitEthernet0/0
description OOB Management
! Configured on launch
no ip address
duplex auto
speed auto
no shutdown
!
interface GigabitEthernet0/1
description to IOSv-1
ip address 10.0.128.2 255.255.255.252
ip ospf cost 1
duplex auto
speed auto
no shutdown
```

- ### Automated configuration Engine
- Uses a DB containing device- and OS-specific information to create configurations for each virtual device
 - Presents graphical representations of many topology-specific attributes – links, interfaces, adjacencies, areas
 - Creates OS-type specific configurations



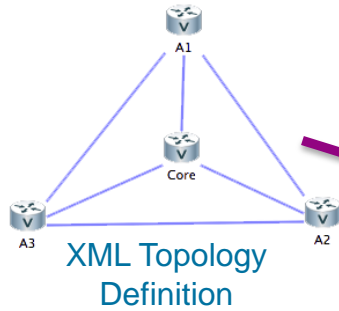
Topology Renderings

Openstack for VM Orchestration



Openstack creates, links, and deletes virtual compute and network resources according to API- or CLI-based instructions

From XML to Virtual Machine



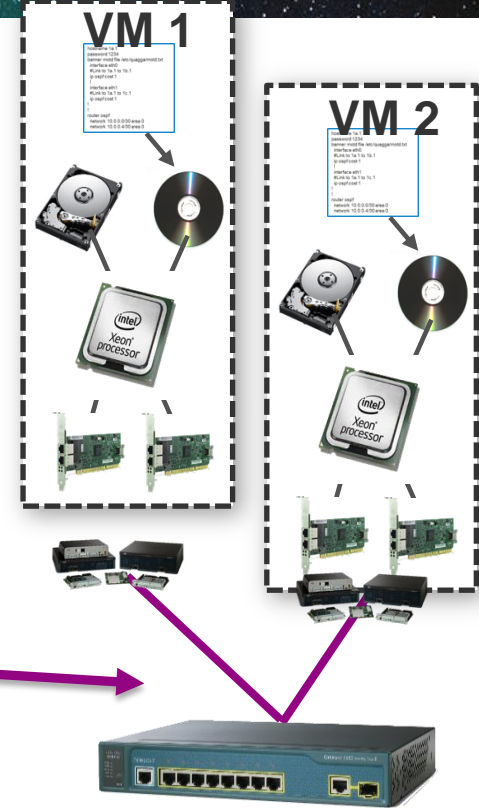
- The Services Topology Director generates Openstack calls for the creation of virtual routers and links based on the XML topology definition
- Injects configuration into the virtual routers

Create Routers

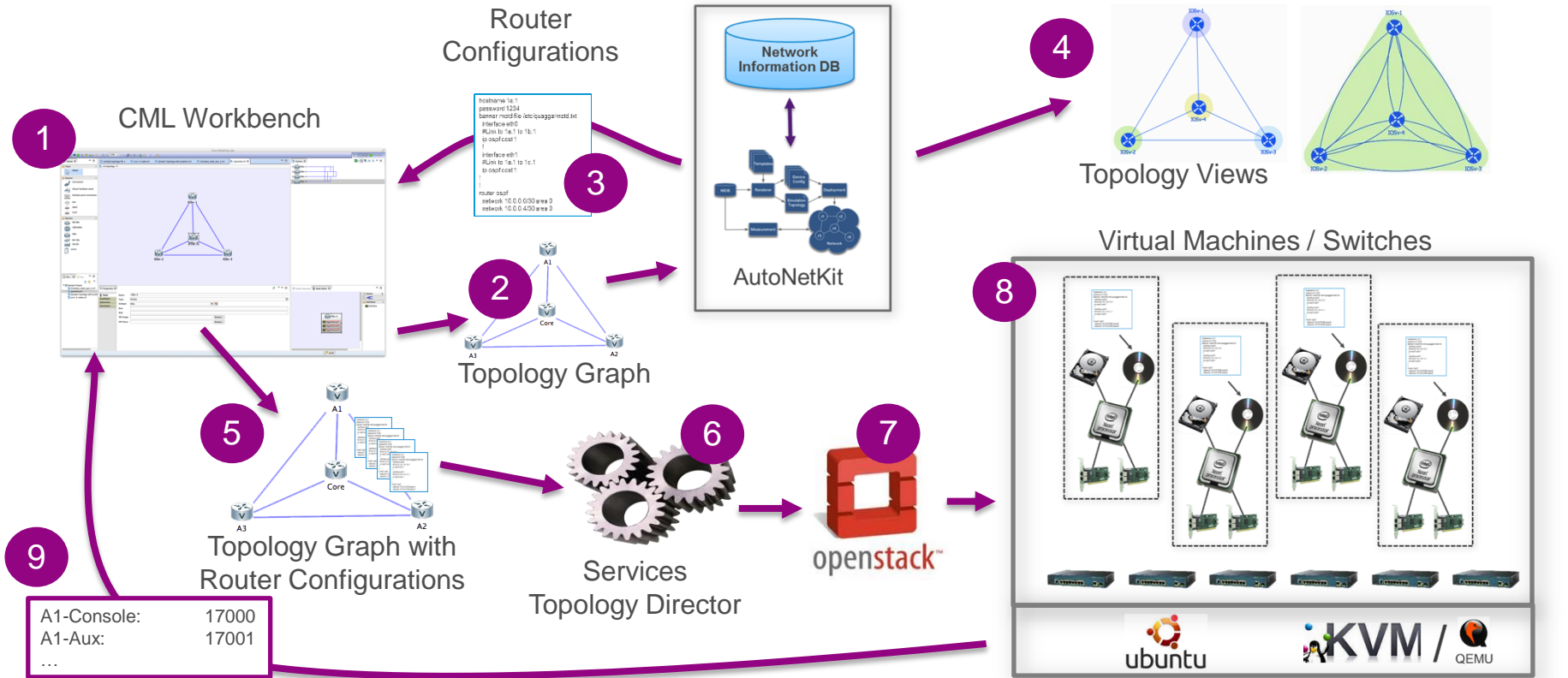
- Identify Type / Flavor
- Associate Image (**Glance**)
- Identify / Assign Resources
- Associate Configuration file
- Launch the VM (**Nova**)

Create Networks / Links

- Identify Links and End-Points
- Assign End-Points to VMs
- Assign Network / Link Characteristics
- Launch the Switch (**Quantum**)

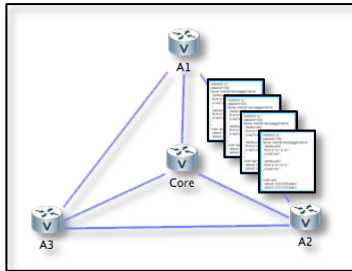


Workflow



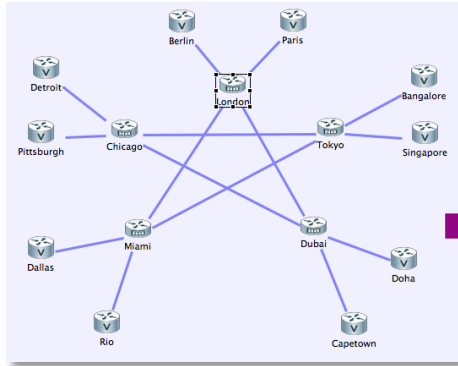
Topology Files

- Complete topology definition together with device configurations held in flat XML file
- Files are highly portable to enable easy sharing
- Integrated GIT repository support enables multi-user file sharing and version control

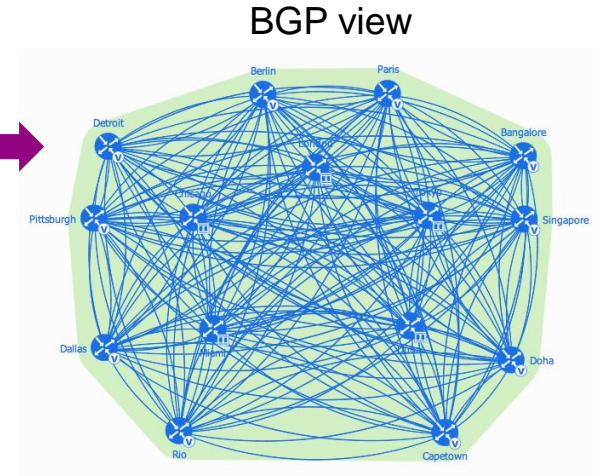
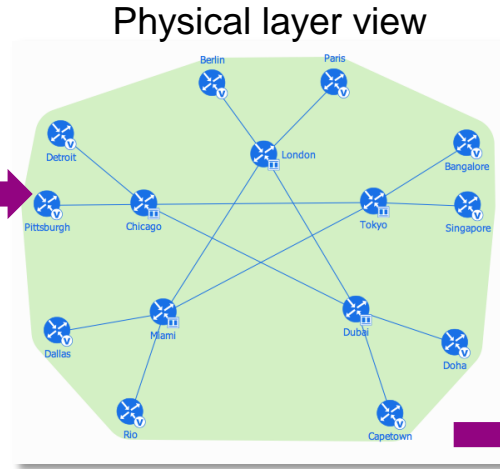


```
<?xml version="1.0" encoding="UTF-8" standalone="yes"?>
<topology xmlns="http://www.cisco.com/VIRL" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" schemaVersion="0.6" xsi:schemaLocation="http://www.cisco.com/VIRL http://www.cisco.com/VIRL-0.6.xsd">
  <extensions>
    <entry type="String" key="AutoNetkit.IGP">ospf</entry>
  </extensions>
  <node location="373,292" subtype="IOSv" type="SIMPLE" name="iosv-1">
    <interface name="GigabitEthernet0/1" id="0"/>
    <interface name="GigabitEthernet0/2" id="1"/>
    <interface name="GigabitEthernet0/3" id="2"/>
  </node>
  <node location="392,170" subtype="IOSv" type="SIMPLE" name="iosv-2">
    <interface name="GigabitEthernet0/1" id="0"/>
    <interface name="GigabitEthernet0/2" id="1"/>
    <interface name="GigabitEthernet0/3" id="2"/>
  </node>
  <node location="269,368" subtype="IOSv" type="SIMPLE" name="iosv-3">
    <interface name="GigabitEthernet0/1" id="0"/>
    <interface name="GigabitEthernet0/2" id="1"/>
    <interface name="GigabitEthernet0/3" id="2"/>
  </node>
  <node location="475,388" subtype="IOSv" type="SIMPLE" name="iosv-4">
    <interface name="GigabitEthernet0/1" id="0"/>
    <interface name="GigabitEthernet0/2" id="1"/>
    <interface name="GigabitEthernet0/3" id="2"/>
  </node>
  <connection src="/virl:topology/virl:node[3]/virl:interface[1]" dst="/virl:topology/virl:node[4]/virl:interface[1]"/>
  <connection src="/virl:topology/virl:node[1]/virl:interface[1]" dst="/virl:topology/virl:node[2]/virl:interface[1]"/>
  <connection src="/virl:topology/virl:node[3]/virl:interface[2]" dst="/virl:topology/virl:node[2]/virl:interface[2]"/>
  <connection src="/virl:topology/virl:node[2]/virl:interface[3]" dst="/virl:topology/virl:node[4]/virl:interface[2]"/>
  <connection src="/virl:topology/virl:node[3]/virl:interface[3]" dst="/virl:topology/virl:node[1]/virl:interface[2]"/>
  <connection src="/virl:topology/virl:node[1]/virl:interface[3]" dst="/virl:topology/virl:node[4]/virl:interface[3]"/>
</topology>
```

Topology Visualisation

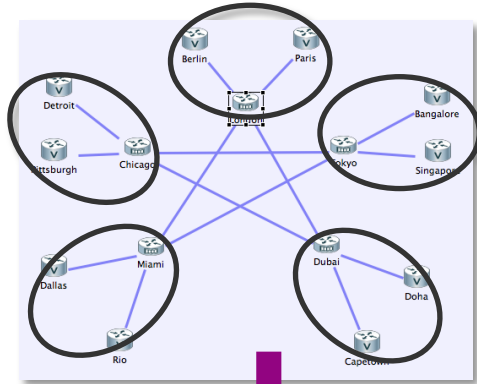


Network topology design as input



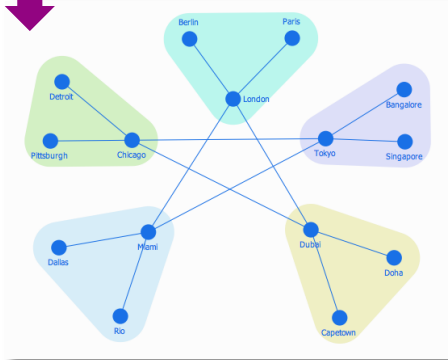
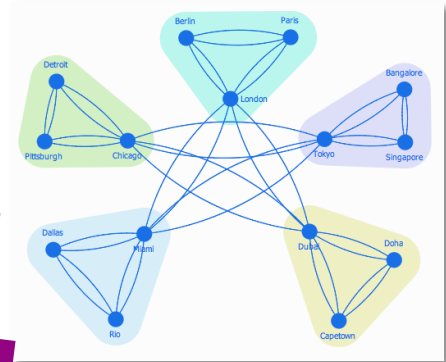
- Configuration Engine generates two outputs – per-node configuration files and network visualisation diagrams
- ‘Layer views’ show protocol-centric topologies

Configuring Attributes in AutoNetkit

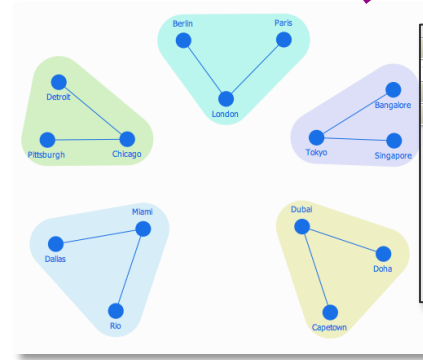


Setting ASN values on groups of nodes

BGP view – five AS, all nodes are BGP speakers



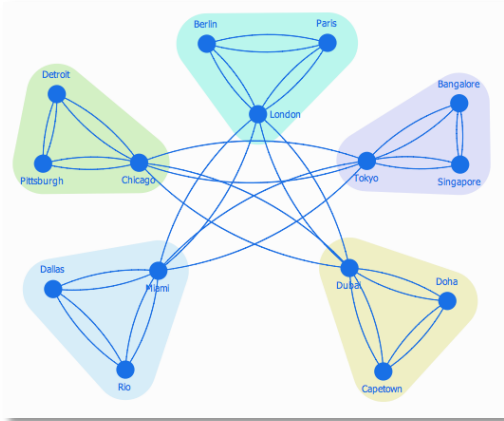
Physical layer view



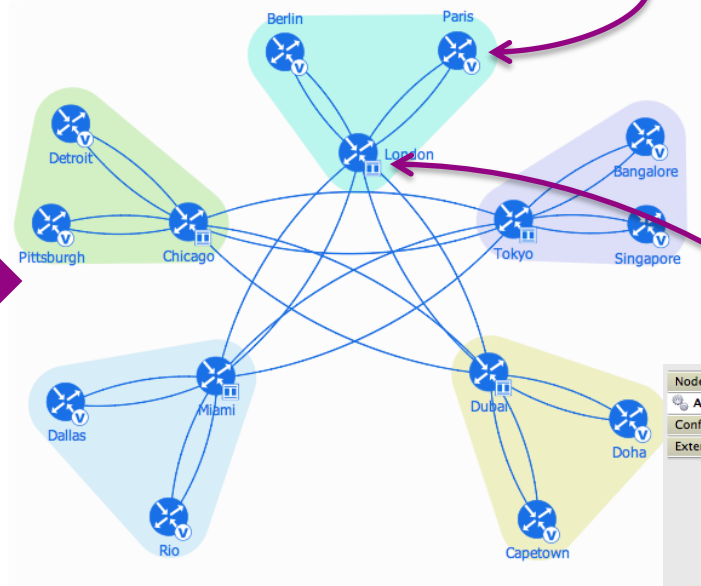
IGP view – five AS's, five area 0's

Node	<input checked="" type="checkbox"/> Auto-generate the configuration based on these attributes.
AutoNetkit	
Configuration	ASN: 100
Extensions	IGP OSPF Area: 0
	iBGP iBGP Role: <not specified> RR Cluster: HRR Cluster:

Configuring Attributes in AutoNetkit



BGP full mesh within each AS



BGP route-reflector clusters and AS's configured

Node

Auto-generate the [configuration](#) based on these attributes.

Configuration

Extensions

General

ASN: 100

IGP

OSPF Area: 2

IBGP

IBGP Role: **RR**

RR Cluster: one

HRR Cluster:

Node

Auto-generate the [configuration](#) based on these attributes.

Configuration

Extensions

General

ASN: 100

IGP

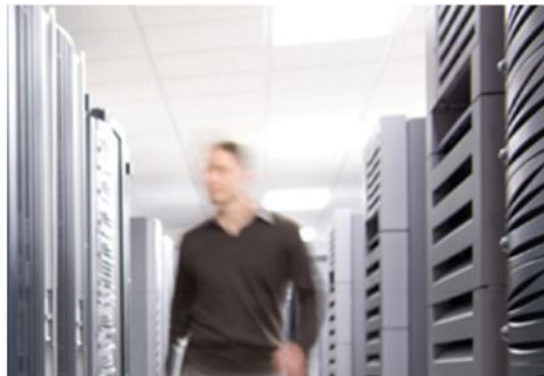
OSPF Area: d

IBGP

IBGP Role: **RR**

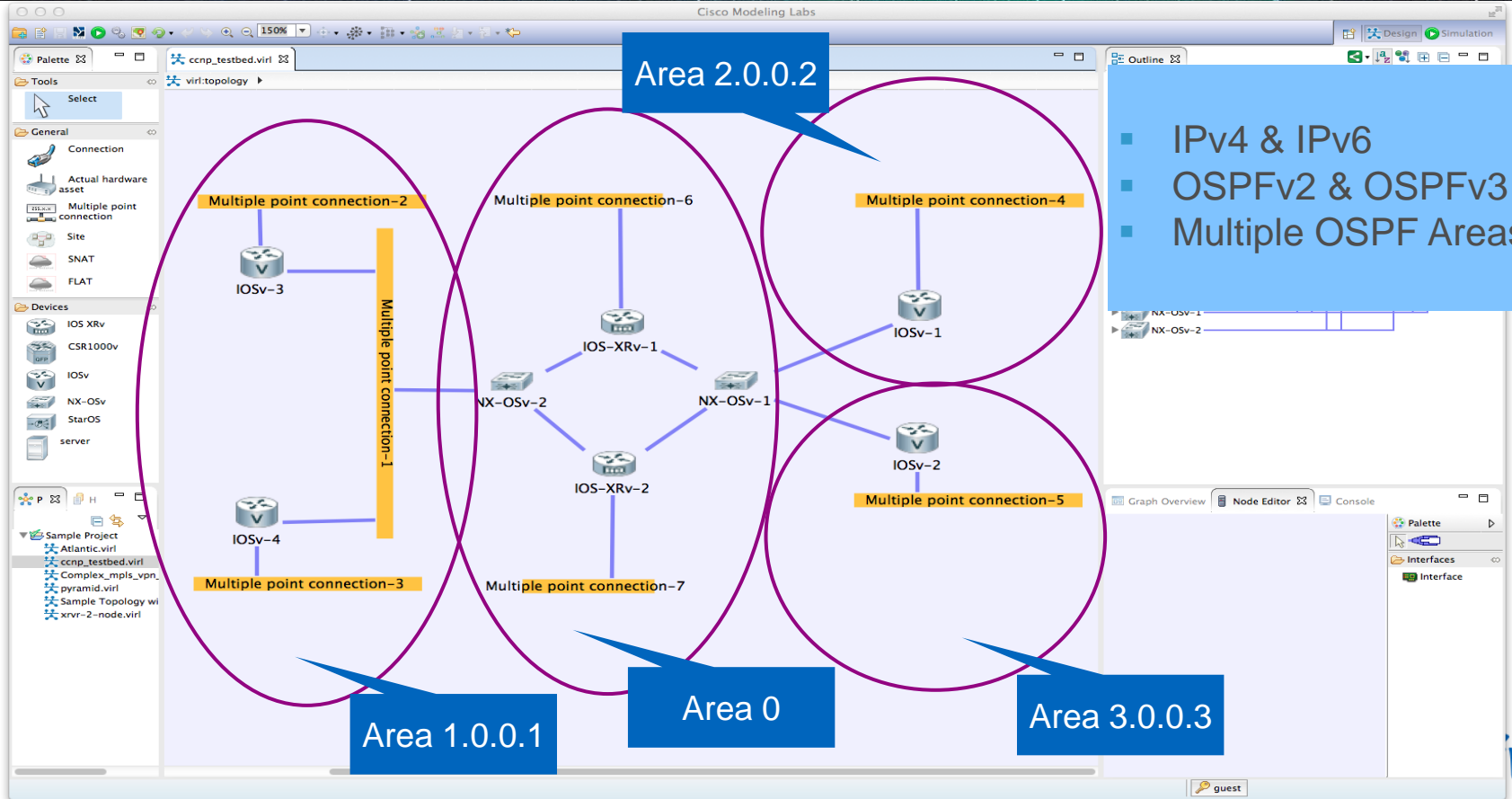
RR Cluster: one

HRR Cluster:



Student Testbed – Cutting your Teeth

Study Topology



Study Topology – Setting Address Families and IGP

The screenshot displays the Cisco Modeling Labs interface. The main workspace shows a network topology with several devices: IOSv-3, IOS-XRv-1, IOSv-1, NX-OSv-2, and NX-OSv-1. Connections are labeled as 'Multiple point connection-2', 'Multiple point connection-6', and 'Multiple point connection-4'. A vertical orange bar is labeled 'Multiple point connection-'. The Properties panel at the bottom is open to the 'Addressing' section, where 'dual_stack' is selected in the IP Address Family dropdown. In the 'Routing' section, 'ospf' is selected in the IGP dropdown. The Outline panel on the right shows a tree view of the topology. A blue callout box on the right contains the following text:

- IPv4 & IPv6
- OSPFv2 & OSPFv3
- Multiple OSPF Areas

The Properties panel also shows the following configuration details:

- General: Enable CDP: true (Default), Enable OnePK: <not specified> (Default)
- Addressing: IP Address Family: dual_stack (selected), IPv4 Infrastructure Subnet: (Default), IPv4 Infrastructure Prefix: (Default), IPv4 Loopback Subnet: (Default), IPv4 Loopback Pool Prefix: (Default), IPv4 VRF Subnet: (Default), IPv4 VRF Prefix: (Default)
- Routing: Enable Routing Protocols: true (Default), IGP: ospf (selected)
- MPLS: Enable MPLS OAM: <not specified> (Default)

ve!

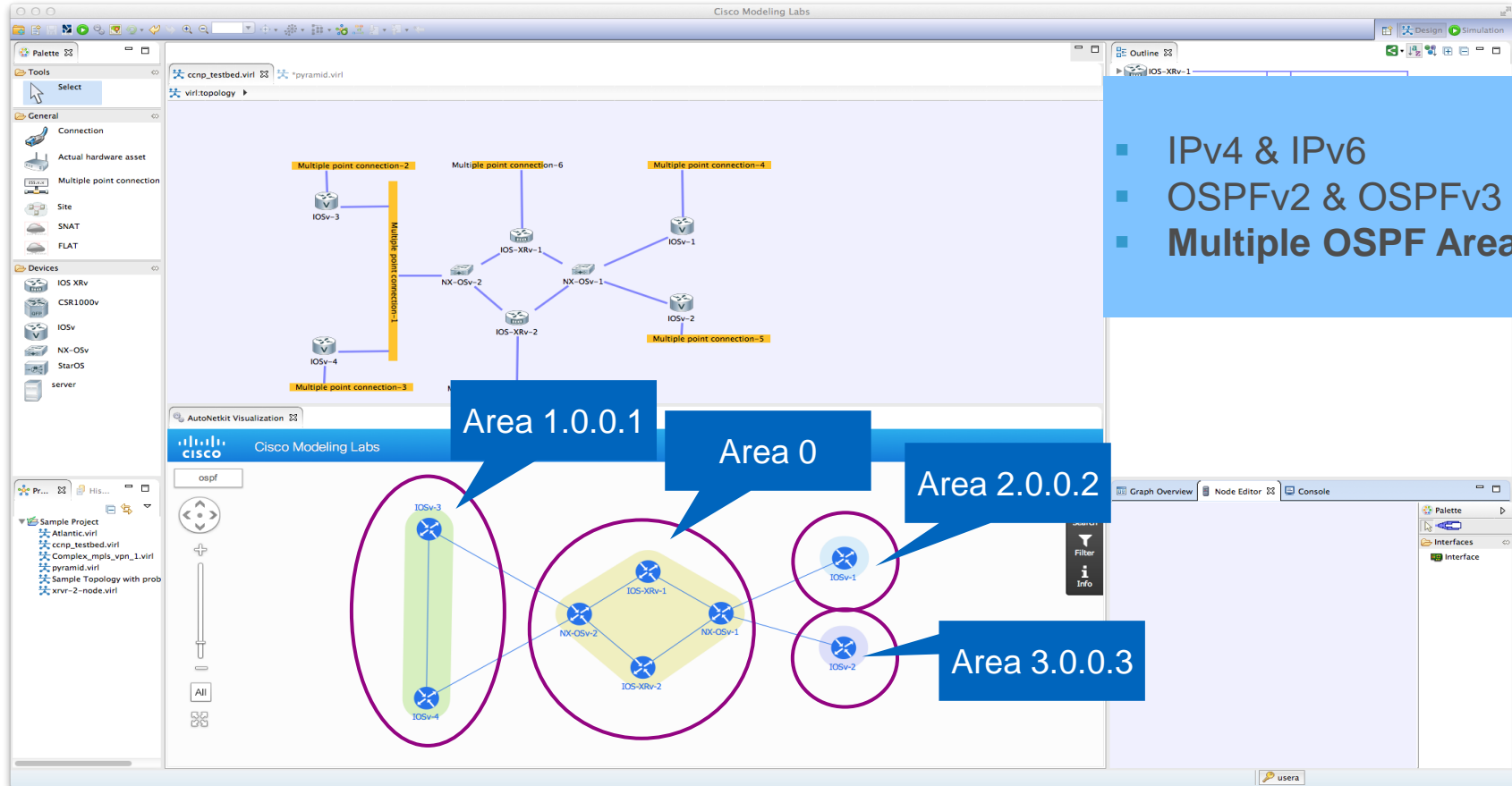
Study Topology – Setting OSPF Areas

The screenshot displays the Cisco Modeling Labs interface. The main workspace shows a network topology with several devices: two IOS-XRv routers (IOS-XRv-1 and IOS-XRv-2), two NX-OSv switches (NX-OSv-1 and NX-OSv-2), and four IOSv switches (IOSv-1, IOSv-2, IOSv-3, and IOSv-4). Connections are labeled as 'Multiple point connection-1' through 'Multiple point connection-5'. A blue callout box points to the topology with the text 'Area 1.0.0.1'. A purple oval highlights two IOSv-3 devices, and another purple oval highlights the 'OSPF Area: 1.0.0.1' field in the configuration panel. The configuration panel is open for a node, showing the 'OSPF Area' field set to '1.0.0.1' and the 'IBGP' section expanded.

- IPv4 & IPv6
- OSPFv2 & OSPFv3
- Multiple OSPF Areas

ve!

Study Topology - Visualise



- IPv4 & IPv6
- OSPFv2 & OSPFv3
- Multiple OSPF Areas

re!

Key: router config

```
interface GigabitEthernet0/1
description to Multiple point connection-1
ip address 10.0.0.3 255.255.255.248
ipv6 address ::b:1:2:0:1/96
cdp enable
ip ospf cost 1
ipv6 ospf cost 1
ipv6 ospf 1 area 1.0.0.1
duplex auto
speed auto
no shutdown
!
interface GigabitEthernet0/2
description to Multiple point connection-2
ip address 10.0.0.9 255.255.255.252
ipv6 address ::b:1:3:0:1/96
cdp enable
duplex auto
speed auto
no shutdown
!
!
router ospf 1
# Loopback
network 192.168.0.8 0.0.0.0 area 1.0.0.1
log-adjacency-changes
passive-interface Loopback0
network 10.0.0.0 0.0.0.7 area 1.0.0.1
router ospfv3 1
!
address-family ipv6 unicast
exit-address-family
!
```

Type: String

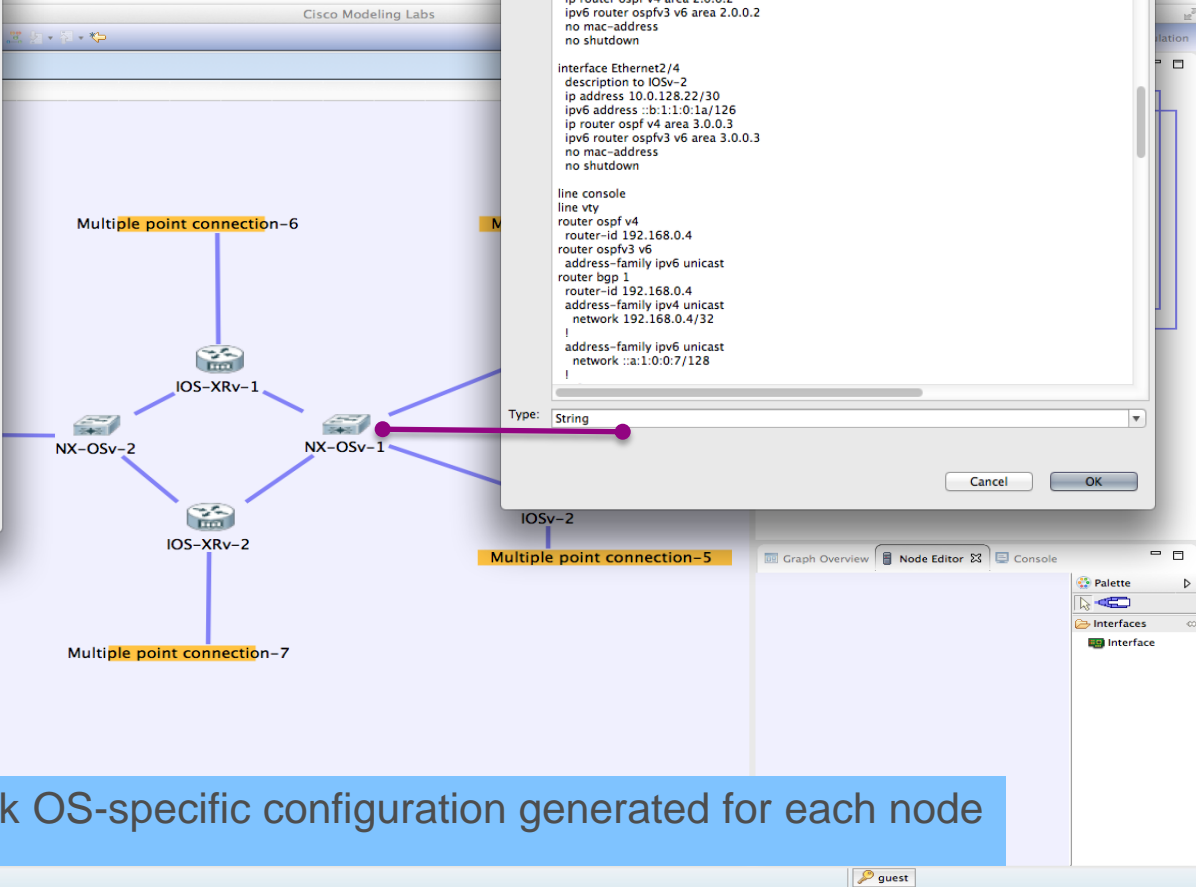
Cancel OK

Key: router config

```
interface Ethernet2/3
description to IOSv-1
ip address 10.0.128.17/30
ipv6 address ::b:1:1:0:16/126
ip router ospf v4 area 2.0.0.2
ipv6 router ospfv3 v6 area 2.0.0.2
no mac-address
no shutdown
!
interface Ethernet2/4
description to IOSv-2
ip address 10.0.128.22/30
ipv6 address ::b:1:1:0:1a/126
ip router ospf v4 area 3.0.0.3
ipv6 router ospfv3 v6 area 3.0.0.3
no mac-address
no shutdown
!
!
line console
line vty
router ospf v4
router-id 192.168.0.4
router ospfv3 v6
address-family ipv6 unicast
router bgp 1
router-id 192.168.0.4
address-family ipv4 unicast
network 192.168.0.4/32
!
address-family ipv6 unicast
network ::a:1:0:0:7/128
!
```

Type: String

Cancel OK



Framework OS-specific configuration generated for each node



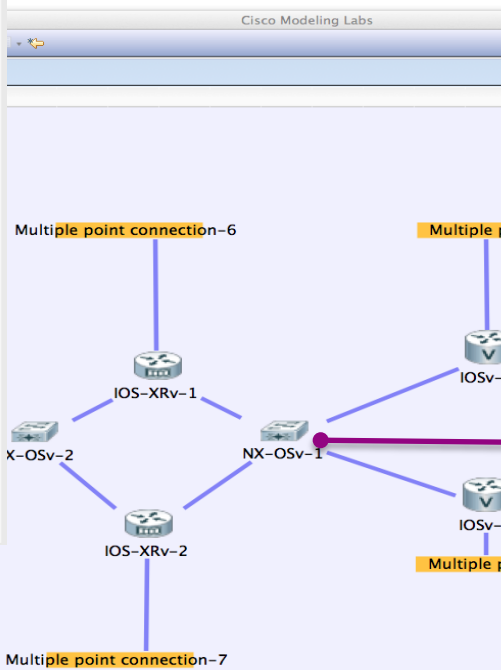
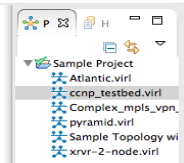
```

IOSv-4 (Console) - usera.ccnptestbed-50cg7z.virl-ucs-11.IOSv-4
Telnet over Web Socket: (6e091827-160c-482e-9f61-38be3881d84f - CONNECTED)
Password:
IOSv-4#show ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
a - application route
+ - replicated route, % - next hop override

Gateway of last resort is not set

10.0.0.0/8 is variably subnetted, 12 subnets, 4 masks
C    10.0.0.0/29 is directly connected, GigabitEthernet0/1
L    10.0.0.1/32 is directly connected, GigabitEthernet0/1
C    10.0.0.12/30 is directly connected, GigabitEthernet0/2
L    10.0.0.13/32 is directly connected, GigabitEthernet0/2
O IA  10.0.128.0/30 [110/42] via 10.0.0.2, 00:30:25, GigabitEthernet0/1
O IA  10.0.128.4/30 [110/41] via 10.0.0.2, 00:30:33, GigabitEthernet0/1
O IA  10.0.128.8/30 [110/42] via 10.0.0.2, 00:30:18, GigabitEthernet0/1
O IA  10.0.128.12/30 [110/43] via 10.0.0.2, 00:30:33, GigabitEthernet0/1
O IA  10.0.128.16/30 [110/82] via 10.0.0.2, 00:30:25, GigabitEthernet0/1
O IA  10.0.128.20/30 [110/82] via 10.0.0.2, 00:30:25, GigabitEthernet0/1
C    10.11.12.0/24 is directly connected, GigabitEthernet0/0
L    192.168.0.0/32 is subnetted, 8 subnets
C    192.168.0.1 is directly connected, Loopback0
O IA  192.168.0.2 [110/42] via 10.0.0.2, 00:30:25, GigabitEthernet0/1
O IA  192.168.0.3 [110/42] via 10.0.0.2, 00:30:18, GigabitEthernet0/1
O IA  192.168.0.4 [110/43] via 10.0.0.2, 00:30:25, GigabitEthernet0/1
O IA  192.168.0.5 [110/2] via 10.0.0.2, 00:30:33, GigabitEthernet0/1
O IA  192.168.0.6 [110/83] via 10.0.0.2, 00:30:25, GigabitEthernet0/1
O IA  192.168.0.7 [110/83] via 10.0.0.2, 00:30:25, GigabitEthernet0/1
O IA  192.168.0.8 [110/2] via 10.0.0.3, 00:31:26, GigabitEthernet0/1
IOSv-4#

```

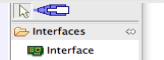


```

NX-OSv-1 (Console) - usera.ccnptestbed-50cg7z.virl-ucs-11.NX-OSv-1
Telnet over Web Socket: (d93833ba-d344-4b27-9470-c2915ecdef56 - CONNECTED)
NX-OSv-1# show ipv6 route
IPv6 Routing Table for VRF "default"
** denotes best ucast next-hop
*** denotes best mcast next-hop
[x/y] denotes [preference/metric]

::a:1:0:0:1/128, ubest/mbest: 1/0
  *via fe80::f816:3eff:feb5:e315, Eth2/1, [110/41], 00:32:25, ospfv3-v6, intra
::a:1:0:0:2/128, ubest/mbest: 1/0
  *via fe80::f816:3eff:feb5:84ff, Eth2/2, [110/41], 00:32:29, ospfv3-v6, intra
::a:1:0:0:3/128, ubest/mbest: 1/0
  *via fe80::f816:3eff:feb5:5196, Eth2/3, [110/40], 00:32:32, ospfv3-v6, intra
::a:1:0:0:4/128, ubest/mbest: 1/0
  *via fe80::f816:3eff:feb5:d762, Eth2/4, [110/40], 00:32:31, ospfv3-v6, intra
::a:1:0:0:5/128, ubest/mbest: 2/0
  *via fe80::f816:3eff:feb5:84ff, Eth2/2, [110/81], 00:32:24, ospfv3-v6, inter
  *via fe80::f816:3eff:feb5:e315, Eth2/1, [110/81], 00:32:24, ospfv3-v6, inter
::a:1:0:0:6/128, ubest/mbest: 2/0
  *via fe80::f816:3eff:feb5:84ff, Eth2/2, [110/81], 00:32:24, ospfv3-v6, inter
  *via fe80::f816:3eff:feb5:e315, Eth2/1, [110/81], 00:32:24, ospfv3-v6, inter
::a:1:0:0:7/128, ubest/mbest: 2/0, attached
  *via ::a:1:0:0:7, Lo0, [0/0], 00:32:47, direct,
  *via ::a:1:0:0:7, Lo0, [0/0], 00:32:47, local
::a:1:0:0:8/128, ubest/mbest: 2/0
  *via fe80::f816:3eff:feb5:84ff, Eth2/2, [110/41], 00:32:24, ospfv3-v6, intra
  *via fe80::f816:3eff:feb5:e315, Eth2/1, [110/41], 00:32:24, ospfv3-v6, intra
::b:1:1:0:4/126, ubest/mbest: 1/0, attached
  *via ::b:1:1:0:6, Eth2/1, [0/0], 00:32:44, direct,
::b:1:1:0:6/128, ubest/mbest: 1/0, attached
  *via ::b:1:1:0:6, Eth2/1, [0/0], 00:32:44, local
::b:1:1:0:8/126, ubest/mbest: 1/0
  *via fe80::f816:3eff:feb5:e315, Eth2/1, [110/41], 00:32:25, ospfv3-v6, intra
::b:1:1:0:c/126, ubest/mbest: 1/0, attached
  *via ::b:1:1:0:e, Eth2/2, [0/0], 00:32:44, direct,
::b:1:1:0:e/128, ubest/mbest: 1/0, attached

```



VMs booted, control-plane established, prefixes installed



Study Topology

- NX-OSv-1 node shutdown
- IOS-XRv-1 sees OSPF adjacency terminate

The screenshot displays a network simulation interface with a topology diagram on the left and console logs on the right. The topology diagram shows several nodes: IOSv-3, IOSv-4, NX-OSv-2, IOS-XRv-1, IOS-XRv-2, IOSv-1, and IOSv-2. Connections are labeled as 'Multiple point connection-1' through 'Multiple point connection-7'. A large red 'X' is placed over the IOS-XRv-1 node, indicating a problem. The console logs show OSPF neighbor status for two interfaces on IOS-XRv-1.

```
IOS-XRv-2 (Console) - user.ccnp_testbed-50cg7Z.virl-ucs-11.IOS-XRv-2
Telnet over Web Socket: (a5ee99c-f3b4-46de-bfa0-ce443360721b - CONNECTED)
User Access Verification

Username:
Username: lab
Password:

RP/0/0/CPU0:IOS-XRv-2#show ospf neighbor
Mon Dec 2 23:58:47.924 UTC

* Indicates MADJ interface

Neighbors for OSPF 1

Neighbor ID  Pri  State           Dead Time   Address         Interface
192.168.0.4   1  FULL/DR       00:00:03   10.0.128.10    GigabitEthernet0/0/0/0
Neighbor is up for 00:44:50
192.168.0.5   1  FULL/DR       00:00:38   10.0.128.14    GigabitEthernet0/0/0/1
Neighbor is up for 00:44:40

Total neighbor count: 2
RP/0/0/CPU0:IOS-XRv-2#show ospf neighbor
Mon Dec 2 23:58:57.654 UTC

* Indicates MADJ interface

Neighbors for OSPF 1

Neighbor ID  Pri  State           Dead Time   Address         Interface
192.168.0.5   1  FULL/DR       00:00:37   10.0.128.14    GigabitEthernet0/0/0/1
Neighbor is up for 00:44:49
```

ve!

Study Topology

- Reconfigure for EIGRP

The screenshot shows a 'Text Compare' window titled 'Compare ccnp_testbed.virl Local Revision and Current'. The window is split into two panes. The left pane shows the 'Local' configuration for a router, featuring OSPF and OSPFv3 configurations. The right pane shows the 'Current' configuration, which has been updated to use EIGRP. The configuration includes interface settings for mgmteth0/0/CPU0/0, GigabitEthernet0/0/0/0, GigabitEthernet0/0/0/1, and Loopback0. A route-policy named 'bgp_in' is also defined. The background shows a network topology diagram and a device palette.

```
Local history: ccnp_testbed.virl Dec 2, 2013, 11:39:29 PM
ipv4 address 10.0.0.29 255.255.255.252
ipv6 address ::b:1:8:0:1/96
cdp
no shutdown
!
interface mgmteth0/0/CPU0/0
description 008 Management
! Configured on launch
no ipv4 address
cdp
no shutdown
!
router ospf 1
log adjacency changes
area 0
interface GigabitEthernet0/0/0/0
cost 1
!
interface GigabitEthernet0/0/0/1
cost 1
!
interface Loopback0
passive enable
!
!
router ospfv3 1
router-id 192.168.0.3
area 0
interface GigabitEthernet0/0/0/0
cost 1
!
interface GigabitEthernet0/0/0/1
cost 1
!
interface Loopback0
passive
!
!
address-family ipv6 unicast
route-policy bgp_in
!
!
description Multiple point connection
ipv4 address 10.0.0.29 255.255.255.252
ipv6 address ::b:1:8:0:1/96
cdp
no shutdown
!
interface mgmteth0/0/CPU0/0
description 008 Management
! Configured on launch
no ipv4 address
cdp
no shutdown
!
!
router eigrp 1
address-family ipv4
router-id 192.168.0.3
interface GigabitEthernet0/0/0/0
!
interface GigabitEthernet0/0/0/1
!
interface Loopback0
passive-interface
!
!
!
address-family ipv6
interface GigabitEthernet0/0/0/0
!
interface GigabitEthernet0/0/0/1
!
!
!
route-policy bgp_in
pass
end-policy
!
route-policy bgp_out
pass
end-policy
!
router bgp 1
```

- Side-by-side diff viewer + configuration rollback

ve!



Topology Building – Physical to Virtual

Physical to Virtual

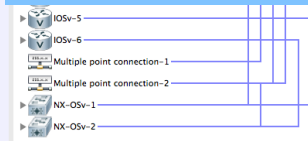
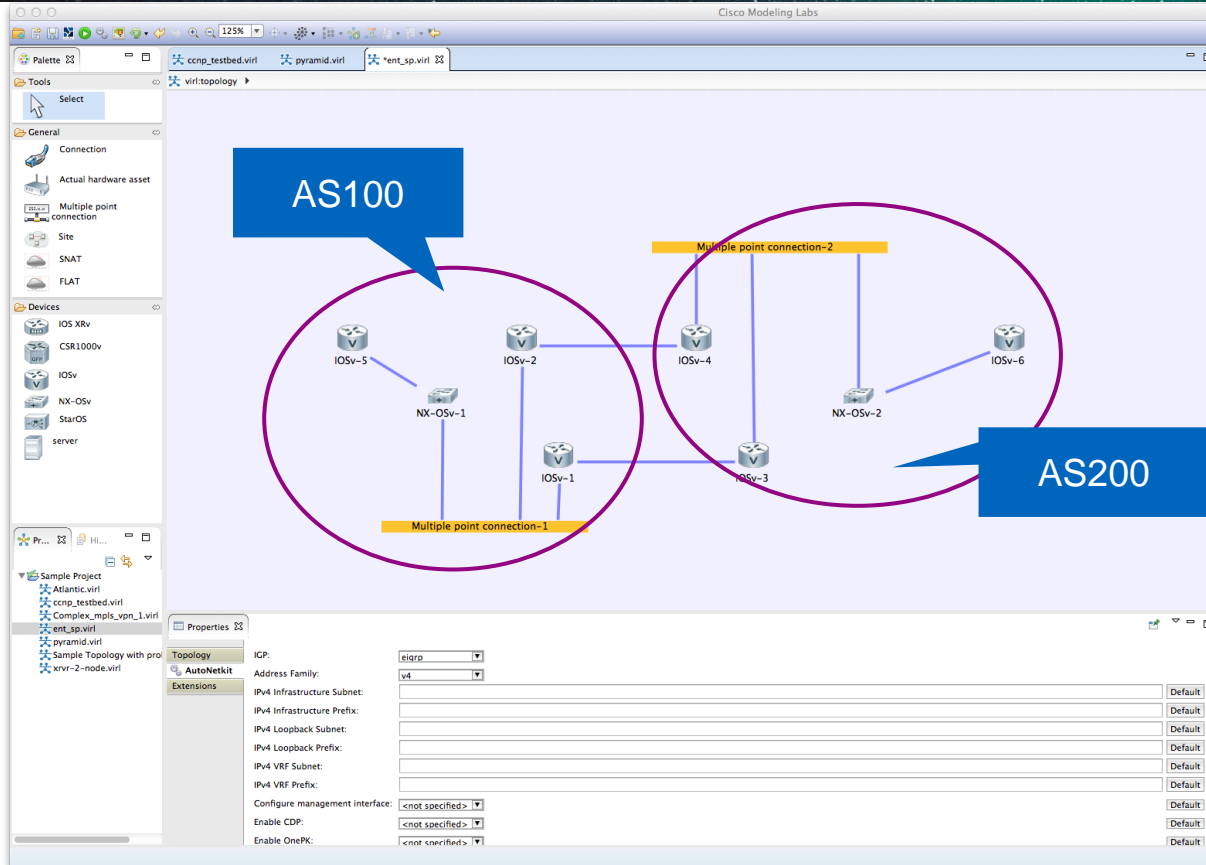
Networking functionality in Cisco Modelling Labs enables connectivity from Virtual Machines to the physical world

- Option 1 – Out-of-band management network connecting all VMs
- Option 2 – Connections into specific data interfaces on designated VMs
- .1q provides ‘trunking’ between VMs and physical devices...trunk to physical switch and ‘break-out’ to individual physical machines

Enables ‘hybrid’ test environments – 1 router, 99 VMs!

Connecting Physical to Virtual

- EIGRP enabled
- IPv4 only
- Two AS's – BGP between border peers

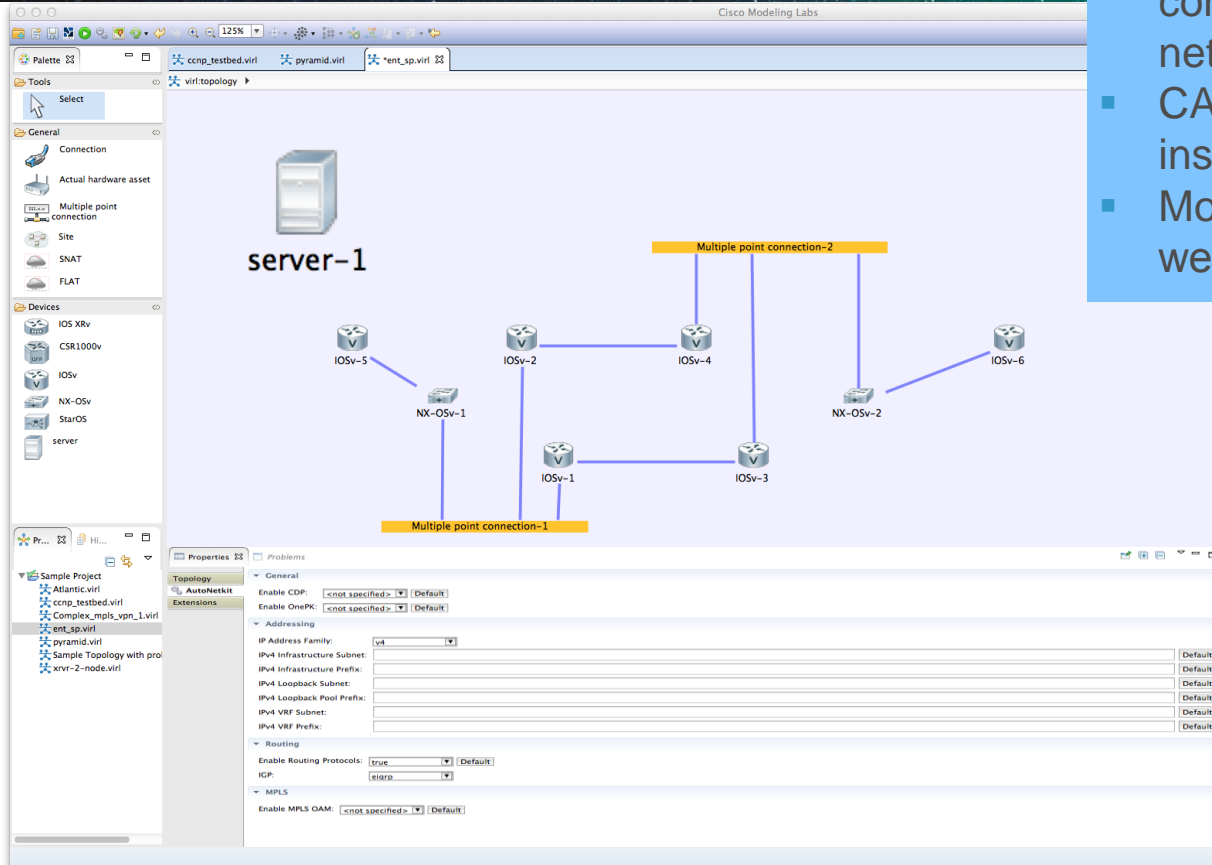


Connecting Physical to Virtual

The screenshot displays the Cisco Modeling Labs interface with two network topology views. The top view is labeled "BGP view" and shows a network with six IOSv routers (IOSv-1 to IOSv-6) and two NX-OSv virtual routers (NX-OSv-1 and NX-OSv-2). The routers are arranged in two rows, with IOSv-1 and IOSv-2 in the front row, and IOSv-3, IOSv-4, IOSv-5, and IOSv-6 in the back row. Connections are shown between IOSv-1 and IOSv-2, IOSv-3 and IOSv-4, and between the two rows. The bottom view is labeled "EIGRP view" and shows the same network topology. The interface includes a left-hand palette with tools and device types, a top navigation bar, and a right-hand outline and node editor panel.

Connecting Physical to Virtual

- External physical Linux host connected to OOB mgmt network
- CACTI Graphing software installed
- Monitoring network as if nodes were 'real' routers



Connecting Physical to Virtual

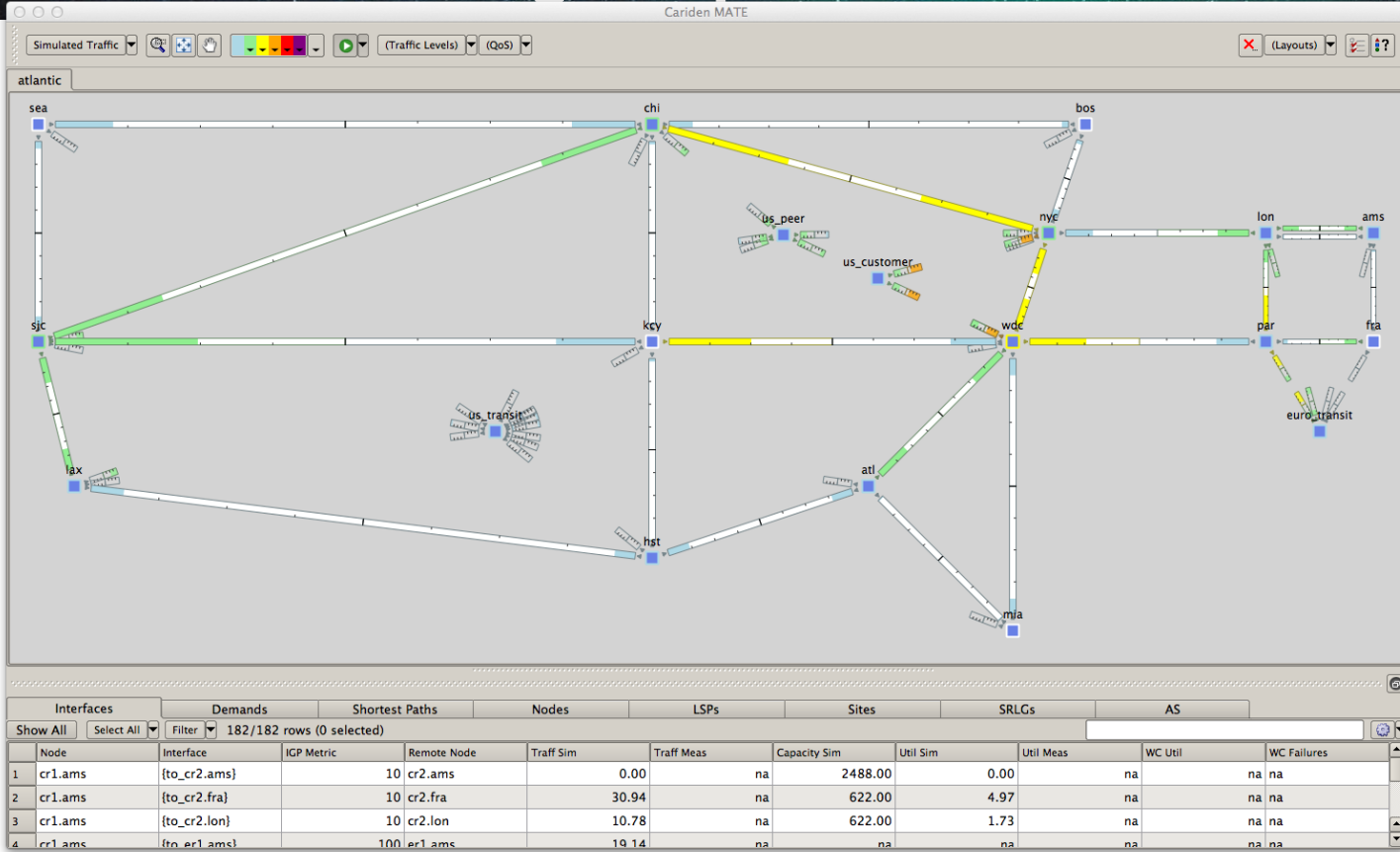
■ Graphing tool collecting stats from Cisco VMs, just as if they were physical devices

The screenshot displays the Cisco Modeling Labs (CML) interface. On the left, a network topology is shown with a server labeled 'server-1' connected to a central switch 'NX-OSv-1'. This switch is connected to several virtual IOSv devices (IOSv-1 through IOSv-5) and two other switches (NX-OSv-2 and NX-OSv-1). Two 'Multiple point connection' labels are visible, indicating connections to other parts of the network. The right side of the image shows a 'Graphs -> Preview Mode - Mozilla Firefox' window displaying a grid of traffic monitoring graphs for various IOSv devices. Each graph shows 'bits per second' over a 12-hour period (Tue 00:00 to Tue 12:00). The graphs for IOSv-1, IOSv-2, IOSv-3, and IOSv-4 show a sharp spike in traffic at approximately 12:00. The graphs for IOSv-5 and the NX-OSv switches show zero traffic. The interface also includes a 'Properties' panel for the selected device, showing configuration details such as IP Address Family, Routing Protocols, and MPLS.



Topology Building – Cariden MATE Design Import

Cariden MATE Design Import



Into CML Workbench

The screenshot displays the Cisco Modeling Labs (CML) Workbench interface. The main window shows a network topology diagram with various nodes and connections. The interface includes several panels:

- Palettes:** On the left, there are tool palettes for "Tools" (with a "Select" tool highlighted), "General" (with options like "Connection", "Actual hardware asset", "Multiple point connection", "Site", "SNAT", "FLAT"), and "Devices" (with options like "IOS XRv", "CSR1000v", "IOSv", "NX-OSv", "StarOS", "server").
- Outline:** On the right, an "Outline" panel lists the nodes in the topology, including: ams, atl, bos, chi, euro_transit, fra, hst, kcy, lax, lon, mia, myc, par, sea, sjc, us_customer, us_peer, us_transit, and wdc.
- Bottom Panels:** At the bottom, there are panels for "Graph...", "AutoN...", "Node ...", "Console", and "Palette".
- Top Bar:** The top bar shows the application name "Cisco Modeling Labs" and the current project name "Atlantic.virl".

The network diagram in the center shows a complex mesh of connections between nodes, with some nodes labeled with "vml_peer" and "vml_transit".

To the AutoNetkit Visualiser

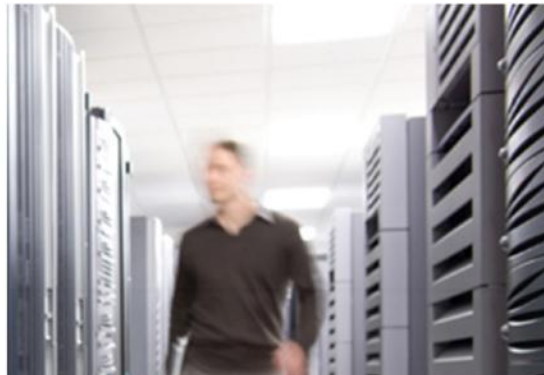
The screenshot displays the Cisco Modeling Labs AutoNetkit Visualiser interface. The main window title is "Cisco Modeling Labs". The interface includes a top toolbar with "Design" and "Simulation" modes, and a "Palettes" section on the left indicating "A palette is not available". The central area shows a network topology with various nodes and connections. The nodes are labeled with identifiers such as "or1.sea", "or2.sea", "er1.lax", "er1.sjc", "er1.tor", "er1.hat", "er1.mia", "er1.atl", "er1.par", "er1.fra", "er1.lon", "er1.wdc", "er1.nyc", "er1.chi", "er1.key", "er1.hai", "er1.ams", "er2.sea", "er2.sjc", "er2.lax", "er2.tor", "er2.hat", "er2.mia", "er2.atl", "er2.par", "er2.fra", "er2.lon", "er2.wdc", "er2.nyc", "er2.chi", "er2.ams", "us_transit_het", "us_transit_bog", "us_transit_lax", "us_transit_pas", "us_transit_wdc", "us_transit_sea", "us_transit_atl", "us_transit_key", "us_transit_nyc", "us_transit_chi", "us_transit_ams", "us_peer_chi", "us_peer_lax", "us_peer_wdc", "us_peer_nyc", "us_peer_key", "us_peer_sea", "us_peer_atl", "us_peer_mia", "us_peer_hai", "us_peer_par", "us_peer_fra", "us_peer_lon", "us_peer_ams", "eu_transit_lon", "eu_transit_pis", "eu_transit_par", "eu_transit_ams". The nodes are connected by lines representing network links. A sidebar on the right contains "Settings", "Search", "Filter", and "Info" icons. A bottom-right pane shows a smaller "Graph..." view and a "Console" area. The interface is branded with the Cisco logo and "Cisco Modeling Labs" text.

ve!



Cisco Modelling Labs in Action...Live Demo





Enterprise Case Study – Introduction of MPLS Traffic Engineering

Project Outline

ENT-B planned to deploy new CRS-1 routers and enable MPLS Traffic Engineering using Fast Re-route for the first time, controlling traffic flows from their edge locations to their Data-Centre

The need –

- Understand the configuration changes required to enable MPLS TE/FRR on IOS and IOS XR devices
- Implement Class-Based Tunnel selection profiles in IOS
- Observe changes to traffic flows under failure conditions
- Ensure zero (little) impact to traffic flows under failure conditions

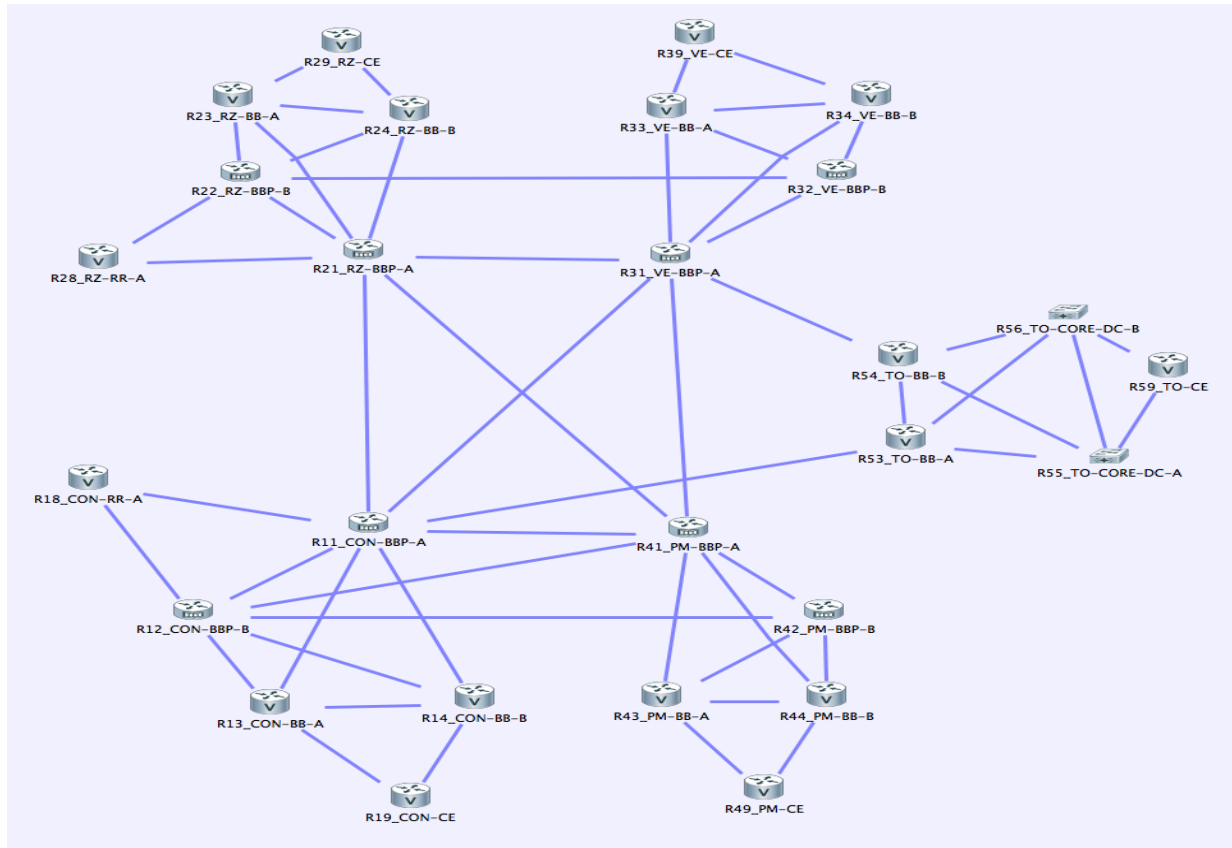
The challenge –

- No lab equipment! Typically use the live network to test with...

Topology Requirements

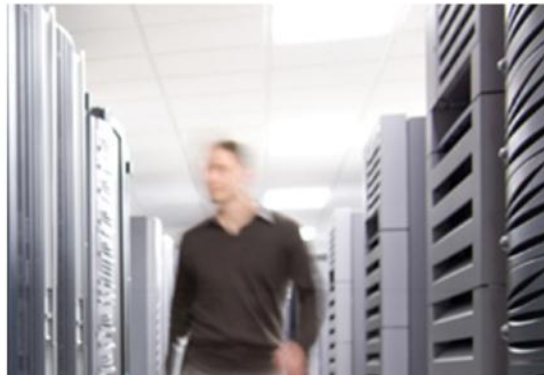
- Full representation of network core and data-centre edge
 - 8 CRS-1
 - 17 IOS routers
 - 2 NX-OS router/switches
 - 55 interconnects
- Simulate traffic feeds from edge locations to data-centre to enable flow engineering

Simulation Topology



Benefits Brought to this Project

- Capability to simulate the production network has previously been impossible for the customer
- The simulation greatly increased the accuracy of configurations and design ahead of deployment with detailed analysis of MPLS TE/FRR implementation
- Operations team were able to spend time ‘hand’s on’, improving their confidence in the operation and behaviour prior to deployment
- “Surprises” in simulation are good, “surprises” in the live network...not so good



ISP Case Study – BGP Re-architecture

Project Outline

ISP-A planned to deploy new Peering & Transit nodes on their Internet Edge to replace legacy systems

The need –

- Perform the migration steps in the lab
- Observe changes to BGP routing from key locations within their network
- Understand affect on traffic flows between legacy PE and next-gen PE during the migration of BGP sessions
- Ensure no impact to customers

The challenge –

- Very limited lab equipment!

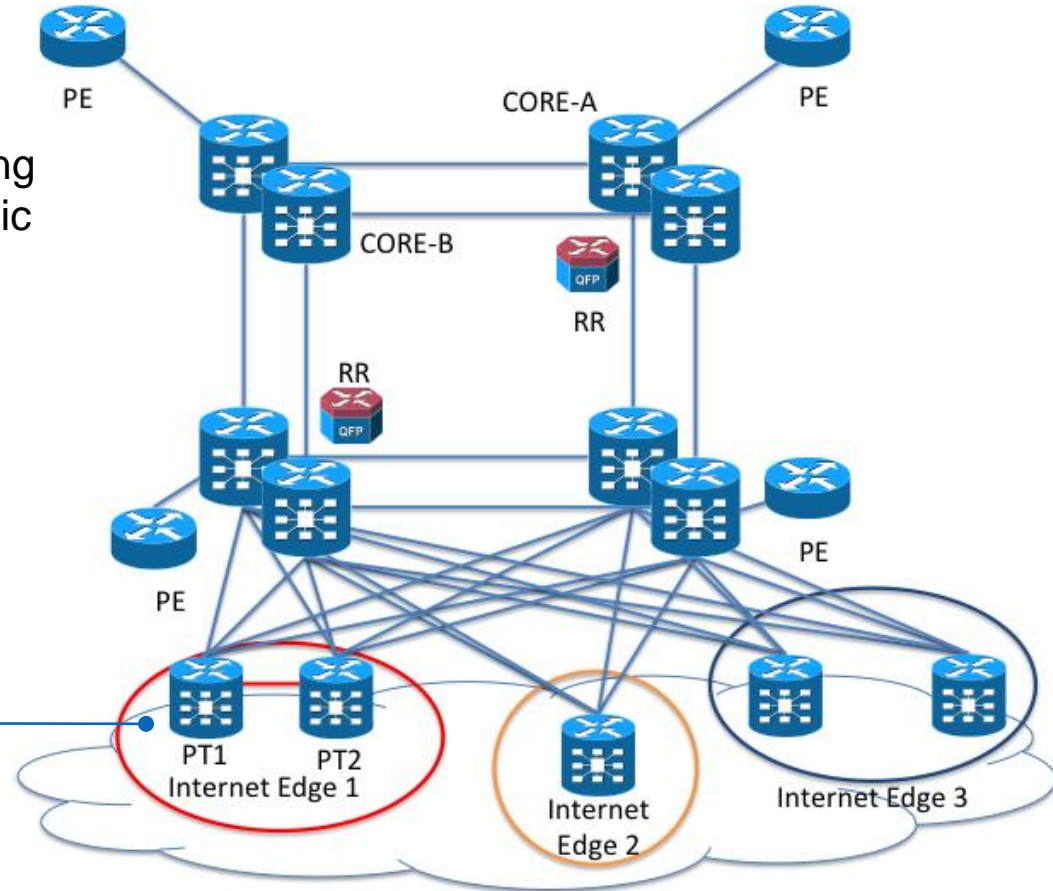
Topology Requirements

- Full representation of network core and Internet edge (12 CRS-3 and ASR9000-series routers running IOS XR)
- Use production BGP feeds
- Use production Route Policy Language configuration (over 12k lines)

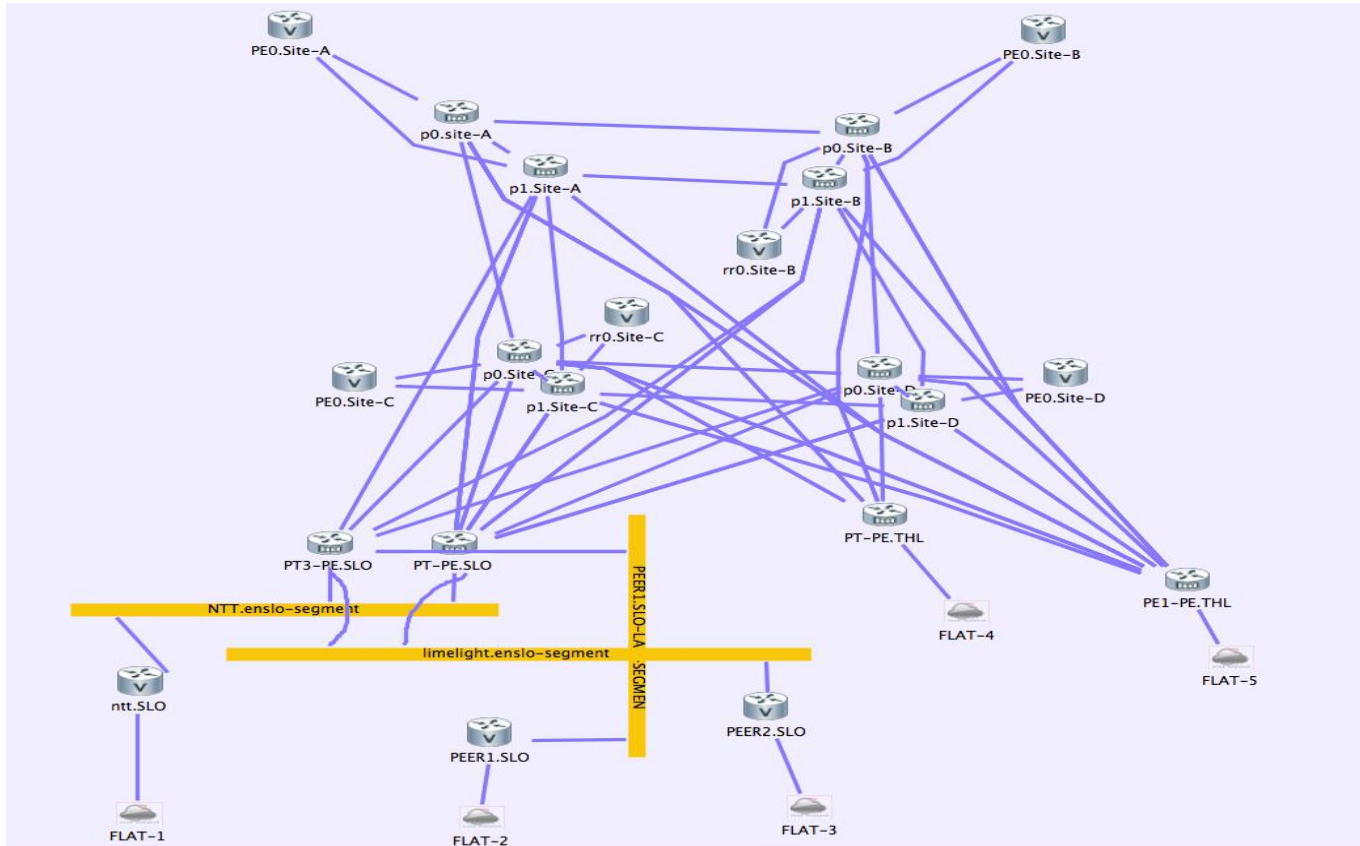
High-Level Diagram

Simulation to highlight expected changes to the network-wide BGP table during this period, and to model traffic flows over PT1 <-> PT2 interconnect.

- BGP sessions to be moved from PT1 to PT2 over a 1 month period
- During transition both PT1 and PT2 will be the primary exit point



Simulation Topology



Highlights

- 1 hour to build topology foundations
 - 12 IOS XRv Nodes
 - 4 IOSv Nodes
 - 2 CSR1000v Nodes
 - 80 interconnects
- Traffic Generator connected into topology via network, replaying production BGP feeds (470k BGP prefixes, 700k paths)
- 1 Day to integrate production configuration into VIRL running configurations (inc 12,000 lines of RPL)

BGP Feed to Route Reflector

```
ACTIVE - guest.session-ygmEmb.virl.PT-PE1.THL (Cons) ACTIVE - guest.session-ygmEmb.virl.TRANSIT.SLO (Co ACTIVE - guest.session-ygmEmb.virl.rr0.Site-B (Consol
Telnet: (10.52.212.251:17001 - CONNECTED)
*****
RR0.SITE-B>en
Password:
RR0.SITE-B#sh ip bgp
BGP table version is 461004, local router ID is [REDACTED]
   Network          Next Hop        Metric LocPrf Weight Path
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
               x best-external, a additional-path, c RIB-compressed,
Origin codes:  i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found

   Network          Next Hop        Metric LocPrf Weight Path
* > i 1.0.0.0/24      [REDACTED] 128.219      15000     100      0 [REDACTED] 2419 15169 i
* > i 1.0.4.0/24      [REDACTED] 128.219      15000     100      0 [REDACTED] 419 6939 7545 56203 i
* > i 1.0.5.0/24      [REDACTED] 128.219      15000     100      0 [REDACTED] 419 6939 7545 56203 i
* > i 1.0.6.0/24      [REDACTED] 128.219      15000     100      0 [REDACTED] 419 6939 4826 38803 56203 i
* > i 1.0.7.0/24      [REDACTED] 128.219      15000     100      0 [REDACTED] 419 6939 4826 38803 56203 i
* > i 1.0.20.0/23     [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 2516 2519 i
* > i 1.0.22.0/23     [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 2516 2519 i
* > i 1.0.24.0/23     [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 2516 2519 i
   Network          Next Hop        Metric LocPrf Weight Path
* > i 1.0.26.0/23     [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 2516 2519 i
* > i 1.0.28.0/22     [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 2516 2519 i
* > i 1.0.64.0/18     [REDACTED] 128.219      15000     100      0 [REDACTED] 419 6939 4725 7670 7670 7670 18144 i
* > i 1.0.128.0/18    [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3356 38040 9737 9737 i
* > i 1.0.128.0/17    [REDACTED] 128.219      15000     100      0 [REDACTED] 419 38040 9737 9737 i
* > i 1.0.160.0/19    [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 2914 38040 9737 9737 i
* > i 1.0.192.0/19    [REDACTED] 128.219      15000     100      0 [REDACTED] 419 38040 9737 9737 i
* > i 1.0.192.0/18    [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 6762 38040 9737 9737 i
* > i 1.0.224.0/19    [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3356 38040 9737 9737 i
* > i 1.1.1.0/24      [REDACTED] 128.219      15000     100      0 [REDACTED] 419 15169 i
* > i 1.1.64.0/19     [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 2516 2519 i
* > i 1.1.127.0/24    [REDACTED] 128.219      15000     100      0 [REDACTED] 419 3257 2516 2519 i
--More--
```

BGP Prefix Scaling

```
Telnet: (10.52.212.251:17043 - CONNECTED)
RP/0/0/CPU0:Nov  4 17:03:14.879 : exec[65703]: %SECURITY-login-6-AUTHEN_SUCCESS : Successfully authenticated user 'cisco' from 'console' on 'con0_0_CPU0'

RP/0/0/CPU0:PT-PE1.THL#sh bgp ipv4 uni summ
Mon Nov  4 17:03:18.689 UTC
BGP router identifier 89.200.128.217, local AS number 65444
BGP generic scan interval 60 secs
Non-stop routing is enabled
BGP table state: Active
Table ID: 0xe0000000 1293448
BGP main routing table 1293448
BGP NSR Initial initsync version 16 (Reached)
BGP scan interval 60 secs

BGP is operating in STANDALONE mode.

Process          RcvTblVer    bRIB/RIB     LabelVer     ImportVer    SendTblVer   StandbyVer
Speaker          1293448      1293448      1293448      1293448      1293448      0

Neighbor        Spk   AS  MsgRcvd  MsgSent  TblVer  InQ  OutQ  Up/Down  St/PfxRcd
89.200.128.88   0 65444 179342   83932   1293448  0    0 02:31:20 326589
89.200.128.90   0 65444 185504   83931   1293448  0    0 02:31:20 326589
172.16.1.102    0 65010 269648   13      1293448  0    0 00:04:39 134761
172.16.1.103    0 22822  498      3      1293448  0    0 00:00:25  495

-PE1.THL#
-PE1.THL#
RP/0/0/CPU0:PT-PE1.THL#
RP/0/0/CPU0:PT-PE1.THL#
RP/0/0/CPU0:PT-PE1.THL#
```

Using IOS XRv to Validate Configurations

```
ACTIVE - guest.session-ygmEmb.virl.PT-PE1.THL (Consol) ACTIVE - guest.session-ygmEmb.virl.TRANSIT.SLO (Co ACTIVE - guest.session-ygmEmb.virl.rr0.Site-B (Consol)
Telnet: (10.52.212.251:17043 - CONNECTED)
Please login with any configured user/password, or cisco/cisco

User Access Verification
Username: cisco
Password:
RP/0/0/CPU0:Nov  4 17:32:05.630 : exec[65703]: %SECURITY-login-6-AUTHEN_SUCCE
0_CPU0'

RP/0/0/CPU0:PT-PE3.SL0#copy tftp://172.16.1.254/BGP-NODE-MODE-Step1.cfg runn
Mon Nov  4 17:32:17.540 UTC
Parsing.
47 bytes parsed in 1 sec (45)bytes/sec
Committing.
Prepared commit in 0 sec

4 items committed in 1 sec (3)items/sec
Updating.RP/0/0/CPU0:Nov  4 17:32:20.789 : config[65725]: %MGBL-CONFIG-6-DB_COMMIT : Configuration committed by user 'cisco'. Use 'show configurat
ion commit changes 100000007' to view the changes.

Updated Commit database in 1 sec
RP/0/0/CPU0:PT-PE3.SL0#
RP/0/0/CPU0:PT-PE3.SL0#
RP/0/0/CPU0:PT-PE3.SL0#
RP/0/0/CPU0:PT-PE3.SL0#
```

As per changes to a production node, configuration changes were made via TFTP, which validated the step changes prepared for the migration

Benefits Brought to this Project

- Far more comprehensive topology than their lab infrastructure could have provided
 - The use of production IP addressing highlighted a number of key path changes
 - The virtual topology was dedicated for this purpose, which allowed for complete control over the prefixes / protocols in use within the network
 - The time to build the base configurations was drastically reduced compared with the time to build a physical alternative (combined with zero tear-down time – typically 0.5 days saved).
-
- Topology provides a robust foundation for future projects for the same customer network



Network Virtualisation – Because Breaking the Simulator is Free!

Cisco Modelling Labs

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- For Proof of Concept
- For configuration verification
- For bug-fix verification



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