

# WELCOME



## **APRICOT 2012**

### **MPLS WORKSHOP**

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..... Alcatel-Lucent 

# AGENDA

1. Introduction
2. Alcatel-Lucent system info
3. Workshop

# INTRODUCTIONS

- Instructors
  - Alastair Johnson
  - Ram Krishna
  - Shivlu Jain
  - *Santanu Dasgupta*
  - *Srinivasa Irigi*
- Class introductions

# HOUSEKEEPING

- Attendance
  - Attendance registers need to be signed each day
  - If you are not here we can't sign the end of workshop attendance workshops
- Schedule is 9am-6pm, but we'll run longer if we need to
  - Morning tea                      10:30am (20 mins)
  - Lunch                                1:30pm (60 mins)
  - Afternoon tea                      4pm (20 mins)

# HOUSEKEEPING

- Wireless
  - “apricot” – 802.11n/802.11a, dual stack
  - “apricot-b” – 802.11b, dual stack
  - “apricot-v6” – IPv6 only
  - “apricot-IVI” – IVI only
- Captive portal
  - Government requirement, will go into effect around lunch time
  - Username is your APRICOT registration email address
  - Password is your registration number (on your badges)
- Wired access
  - Available on an as-needed basis, please talk to us

These networks are public  
There is no firewall  
***Be careful!***

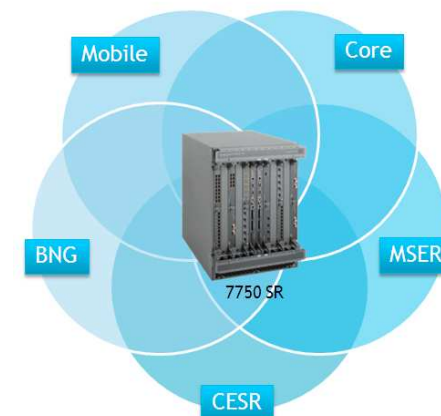
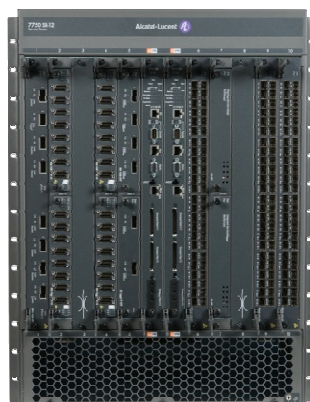


# INTRODUCTION

- Theory
  - Understand the theory behind MPLS, applications, and technologies used
- Practical
  - Hands on lab using Cisco IOS and Alcatel-Lucent SR-OS platforms
  - Virtual labs
  - You will need to be able to use SSH (download PuTTY if you do not have a client)
  - Understanding of IP routing and routers required !



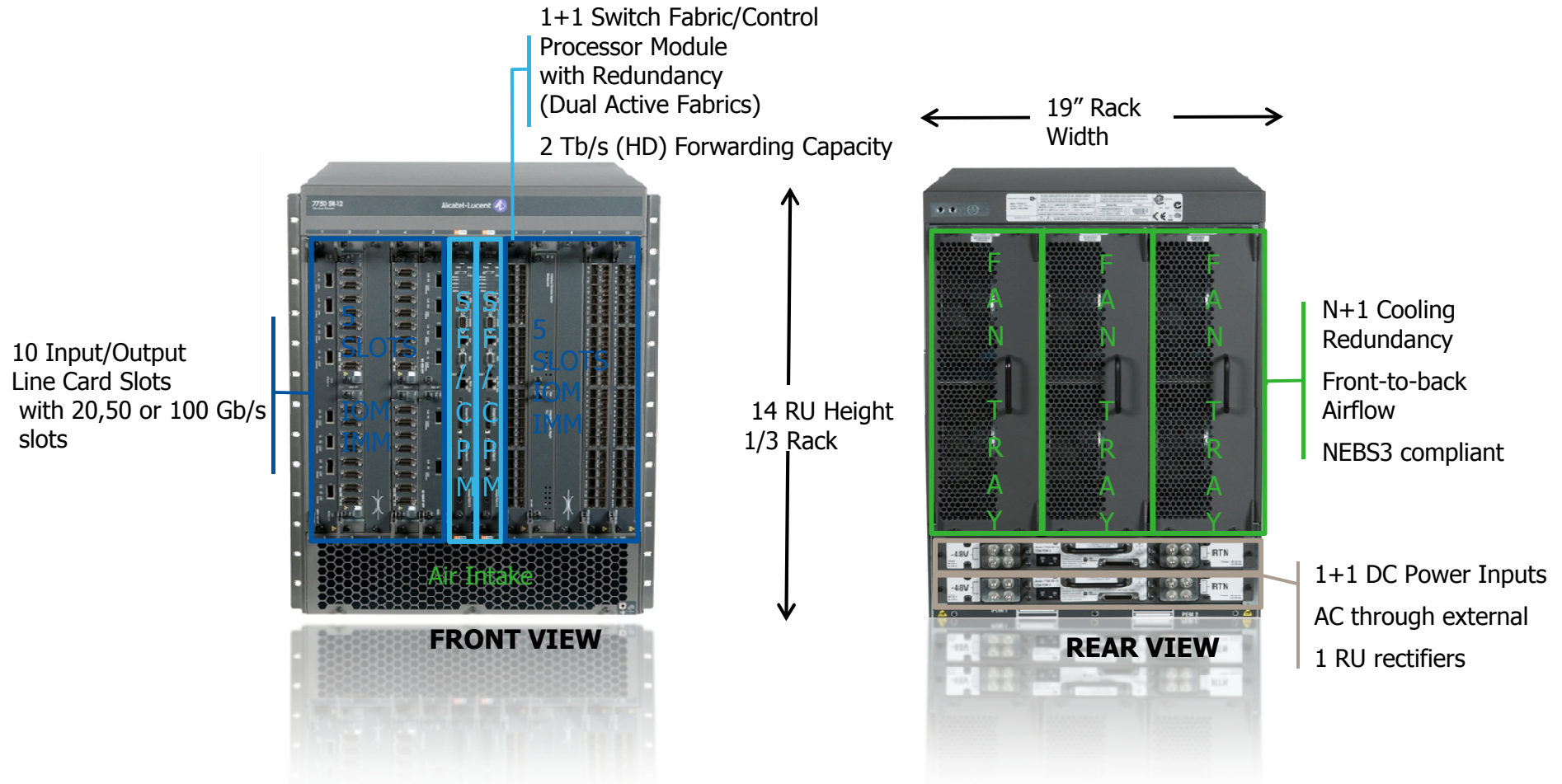
# THE 7750 SR PRODUCT FAMILY



| 7750 SR-12                           | 7750 SR-7                             | 7750 SR-c12                          | 7750 SR-c4                                  |
|--------------------------------------|---------------------------------------|--------------------------------------|---|
| 2 Tb/s                               | 1 Tb/s                                | 90 Gb/s                              | 90 Gb/s                                     |
| 12 slots (10 user slots) in 1/3 rack | 7 slots (5 user slots) in 8RU         | 12 compact slots (or 3 full slots)   | 4 compact slots - fully front accessible    |
| High Availability, ISSU              | High Availability, ISSU               | High Availability, ISSU              | Red't pwr & cooling                         |
| Terabit IP/MPLS multiservice router  | Mid-scale IP/MPLS multiservice router | Small POP router for SPs & Verticals | Small POP router for business services edge |

**Four chassis variants in the 7750 SR family**

# ALCATEL-LUCENT 7750 SR-12 CHASSIS OVERVIEW



High-end multi-service edge/core router

# ROUTER COMPONENTS

- **BOF – Boot Options File – defines the configuration for router bootstrap (config, software, etc) and out-of-band configuration.**
- POST – Power On Self Test – checks for basic functionality of router hardware and determines what interfaces are present.
- RAM – holds the running software, routing memory, packet buffers, etc. There are multiple types of RAM in the 7750SR present on multiple cards.
- Flash – holds the software, log files, and persistent configuration. There are three flash slots in the 7750SR (per SF/CPM).
- **SF/CPM – Switch Fabric/Control Plane Module, that provides the switch fabric between slots and the control processor that runs the main SR-OS software and centralised functions like routing protocols.**
- **IOM – I/O Module that provides connectivity to MDAs and the switch fabric, hosts the queuing and packet forwarding functions.**
- **MDA – Media Dependent Adapter hosted in an IOM, and provides the physical layer connectivity.**

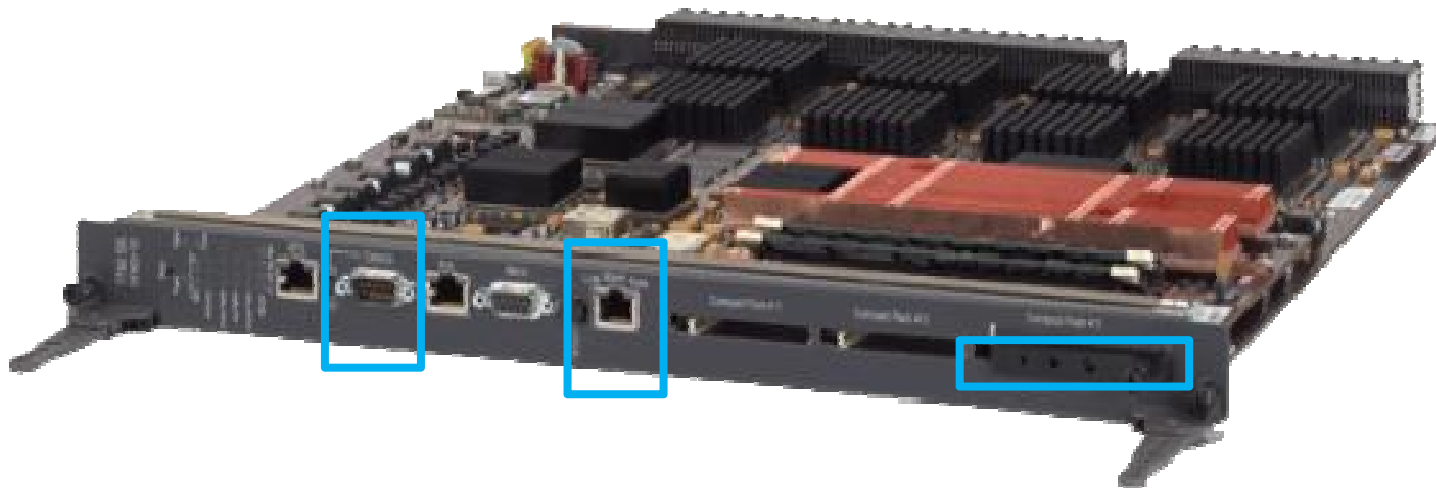


# IN THE LAB

- Virtualised lab, based in Mountain View, California
  - Access will be via SSH only – you will need an SSH client!
- 13 7750SR-12
  - 1 IOM2-20G-B (slot 1)
  - 20-port Gigabit Ethernet card (slot 1/2)
- Physical full mesh between routers
  - Port descriptions are prepopulated so you can find the mappings
  - The individual lab pods will use their designated routers, and the physical connectivity between routers

# ACCESS ROUTER'S MANAGEMENT PORTS

- Console
  - DB9 EIA-232 @ **115200bps**, 8/N/1 (pre-configured)
- Management Port, using telnet or SSH
  - Requires configuration



# INITIAL LOGIN - SROS

- TiMOS-B-8.0.R5 both/hops ALCATEL SR 7710 Copyright (c) 2000-2010 Alcatel-Lucent.
  - All rights reserved. All use subject to applicable license agreements.
  - Built on Tue Sep 28 18:27:04 PDT 2010 by builder in /rel8.0/b1/R5/panos/main
- 
- Login: **admin**
  - Password: **admin**
  - \*A:cses-A15#



# EMAC STYLE SHORTCUTS

| Shortcut                     | Key Combination |
|------------------------------|-----------------|
| Start of Line                | Ctrl-A (^A)     |
| End of Line                  | Ctrl-E (^E)     |
| Delete Line                  | Ctrl-U (^U)     |
| Delete Cursor to End of Line | Ctrl-K (^K)     |
| Delete Previous Word         | Ctrl-W (^W)     |
| Redraw Line                  | Ctrl-L (^L)     |
| Exit from config mode        | Ctrl-Z (^Z)     |

# COMMAND COMPLETION

- Space bar completes a command
- Tab key completes a variable
- \ or / can be used to run a top-level command from any context

- config>router>service#\show time

- Help is available with ? after any command

A:NS065051303# configure service

- service

[no] apipe + Provision an ATM-Pipe Service

[no] cpipe + Provision a Circuit Emulation Pipe Service

[no] customer + Provision a customer

[no] egress-multica\* + Create an Egress Multicast Group

[no] epipe + Provision an Ether-Pipe Service

[...]



# USING | (PIPE)

- The pipe function is used to filter output
- Available in some modes and context

- `match <pattern> context {parents|children|all} [ignore-case] [max-count <lines-count>] [expression]`
- `match <pattern> [ignore-case] [invert-match] [pre-lines <pre-lines>] [post-lines <lines-count>] [max-count <lines-count>] [expression]`

|                                  |                                |
|----------------------------------|--------------------------------|
| <code>&lt;pattern&gt;</code>     | : string or regular expression |
| <code>&lt;pre-lines&gt;</code>   | : [0..100]                     |
| <code>&lt;lines-count&gt;</code> | : [1..2147483647]              |

# ROUTER MODES CHANGE AND PROMPTS

- A:Router#
  - Default privileged mode at the root prompt.
  - 'A' refers to the SF/CPM
  - 'Router' is the hostname
- A:Router>config#
  - Configuration mode
- A:Router>config>service#
  - Sub-context within configuration mode
- A:Router>config>service>vprn\$
  - Newly created context
- \*A:Router#
  - Config has been changed **and is unsaved**

# KEY CLI COMMANDS

- show
  - Applicable to most things: ports, cards, interfaces, routing table, services, etc.
  - The **detail** keyword is often very useful.
- admin
  - Admin commands such as upgrade, save, reboot, time setting, etc.
- tools
  - Debugging and OAM tools that run on the router
- configure
  - Enter configuration mode. You can append full configure statements to this, e.g. ``configure port 1/1/1 ethernet speed 1000``
- monitor
  - Port/SAP/service/etc monitor commands
- tree
  - Explain the command tree from the present context. Try ``tree flat detail | match bgp``
- And many more. Start with ``?`` !



# ROUTER AND SERVICE CONSTRUCTS

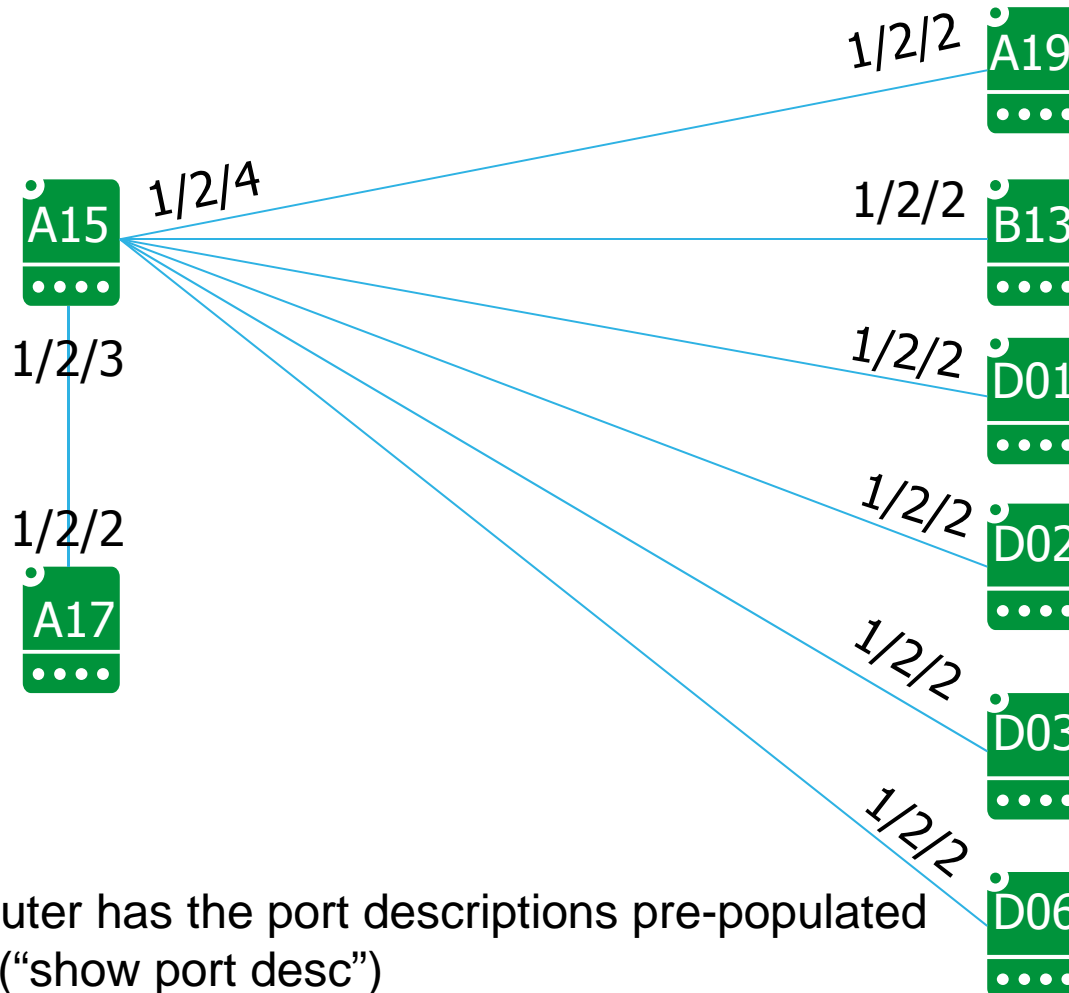
- **Ports** refer to physical ports and their local config
  - **Logical interfaces** ("router interface", SAPs in Service Constructs) are associated to ports
- **Router** refers to the base routing instance
  - This is the backbone configuration for the router, mostly used for forming routing adjacencies between other PE and P routers.
  - All MPLS, BGP, OSPF, IS-IS, etc configuration is performed here.
  - Ports must be configured for **network** mode.
- **Services** are configured under the **service** construct
  - VLL = EPIPE, IPIPE, APIPE, FPIPE, CPIPE
  - VPLS = VPLS
  - VPRN = Virtual Private Routed Network (VRF)
  - IES = Internet Enhanced Service, **use this for Internet Routing Services**
- Services are associated with **customers** – this is mostly a billing construct, and we can use a single customer ID for the workshop.
- Services must be configured on **access** ports.



# ROUTER AND SERVICE CONSTRUCTS

- Services have Service Access Points (SAP)
  - These are logical interfaces within the service, that are associated to a port.
  - The interface name does not have to be the same as the port name.
  - E.g: `interface "test" sap 1/2/3:4` refers to an interface called 'test' on physical port 1/2/3, sub-interface 4.
  - For consistency, I like to refer to the port and interface type, e.g. interface "gig-1/1/1:4".
- Services also have Service Distribution Points (SDP)
  - SDPs are logical references to router-router tunnels.
  - SDPs are associated with LSPs.
  - VPRNs can auto-bind to SDPs based on MP-BGP information
  - L2 services require static assignment to SDP (unless VPLS BGP-AD or RADIUS config is in use).
- It's all about abstraction!

# LAB TOPOLOGY



- Each router has the port descriptions pre-populated (“show port desc”)
- Full mesh is available, but only use your assigned routers
- Ports for each router are consistent on the far-end routers

# INITIAL CONFIGURATION CHECKLIST

- The following items should be configured at initial system configuration:
  - Admin password
  - Host name (this is already done)
  - Domain name
  - Configuration file location (this is already done)
  - System logging
  - Default and backup routers for management (this is already done)
  - Configure remote access services
  - User accounts
  - System time
  - System and transient interfaces
  - Remaining configuration needed to put the router into service (protocols, filters, etc)

# INITIAL CONFIGURATION

- Log in as admin

```
Login: admin
```

```
Password: admin
```

```
*A:NS065051303#
```

- Configure router name

```
*A:NS065051303# configure system name cses-A15
```

```
*A:<<name>>#
```

- Configure router domain name

```
*A:NS065051303# bof dns-domain <<domain-name>>
```

# INITIAL CONFIGURATION

- Adjust logging parameters if needed.
  - Default log 99 is configured.
  - Additional logging destinations may be configured (e.g. syslog)
- Commit changes so far
  - admin save
  - bof save

# INITIAL CONFIGURATION

- Configure system services for remote access

- `configure system security ssh preserve-key`
- `configure system security ssh no server-shutdown`
- `configure system security telnet[v6]-server`
- `configure system security ftp-server`

- Configure banner

- `configure system login-control banner`
- `configure system login-control motd`
- `configure system login-control pre-login-message`

- Configure user accounts

- Define roles

- Super-user
- Read Only
- Read Write

- `configure system security profile`
- `configure system security user`

# INITIAL CONFIGURATION

- Configure time zone and manually set the time of day

- configure system time zone
- admin set-time

- Configure NTP

- configure system time [s]ntp <<server>>

- Configure system interface

- configure router interface "system" address x.x.x.x/32
- configure router interface "system" address X:X:X:X/128
- configure router interface "system" no shutdown

# INITIAL CONFIGURATION

- Validate your port configurations
- Configure port 1/2/n
  - `configure port 1/2/1 ethernet mode network`
  - `configure port 1/2/1 ethernet ?`
- Configure interfaces between your lab routers
  - `configure router interface "gig-1/2/n"`
  - `address X.X.X.X/30`
  - `port 1/2/n`
- Use descriptions
- Consider other options you might want:
  - MTU
  - Encapsulation (dot1q, qinq, null...)
  - Speed/duplex
- `configure router (bgp|ospf|mpls|ldp|...)`

**Network** mode for router-  
router interfaces

**Access** mode for service  
interfaces

Other options configurable here  
(encapsulation, MTU, etc)

**For this workshop, you  
should not need to change  
these values  
(MTU=1500, encaps=null)**



# CLI COMPARISON

| JUNOS                                 | IOS                 | SR-OS                                 |
|---------------------------------------|---------------------|---------------------------------------|
| set date                              | clock set           | admin set-time                        |
| ping                                  | ping                | ping                                  |
| request system reboot                 | reload              | admin reboot                          |
| request message                       | send                | write                                 |
| show system uptime                    | show version        | show uptime                           |
| show chassis environment              | show environment    | show chassis environment              |
| show cli history                      | show history        | history                               |
| show log [file <name>]                | show log            | show log log-id <nn>                  |
| show system processes                 | show process        | show system cpu                       |
| show configuration                    | show running-config | admin display-config                  |
| request support information           | show tech-support   | admin tech-support                    |
| show system users                     | show users          | show users                            |
| show version<br>show chassis hardware | show version        | show version<br>show card<br>show mda |
| set cli screen-length                 | terminal length     | environment terminal length           |
| set cli screen-width                  | terminal width      | Should auto size                      |
| trace                                 | tracertoute         | tracertoute                           |

# ACCESSING THE LAB

```
login as: apricot
apricot password:
Linux ipd-app-v2-101 2.6.26-2-686 #1 SMP Sat Dec 26 09:01:51 UTC 2009 i686
```

The programs included with the Debian GNU/Linux system are free software;  
the exact distribution terms for each program are described in the  
individual files in /usr/share/doc/\*/copyright.

Debian GNU/Linux comes with ABSOLUTELY NO WARRANTY, to the extent  
permitted by applicable law.

Last login: Mon Feb 20 23:26:00 2012 from alastaij.lra.lucent.com

apricot@ipd-app-v2-101:~\$ ssh admin@al5

TiMOS-B-9.0.R11 both/i386 ALCATEL SR 7750 Copyright (c) 2000-2012 Alcatel-Lucent.

All rights reserved. All use subject to applicable license agreements.

Built on Fri Feb 17 16:12:57 PST 2012 by builder in /rel9.0/b1/R11/panos/main

admin@al5's password:

This software is the property of Alcatel. It may not  
be sold, leased, loaned or licensed to any non-Alcatel entity.

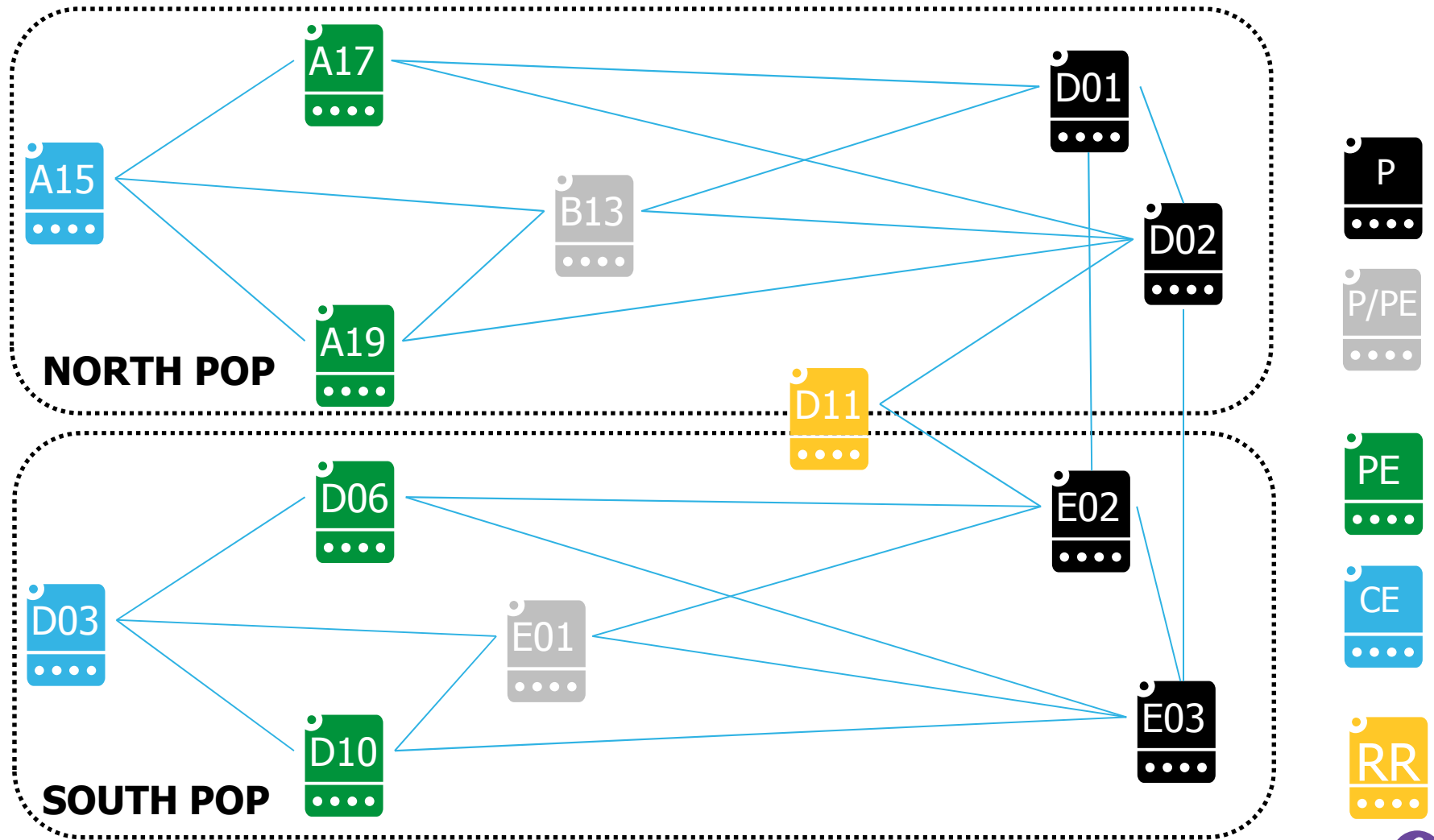
A:cses-A15#

..... Alcatel-Lucent  
AT THE SPEED OF IDEAS™



# LAB TOPOLOGY

## AS65000



# LAB NUMBERING

## SYSTEM (LOOPBACK) ADDRESSES

| DEVICE | SYSTEM IP       |
|--------|-----------------|
| A15    | 172.16.0.214/32 |
| A17    | 172.16.0.216/32 |
| A19    | 172.16.0.230/32 |
| B13    | 172.16.0.169/32 |
| D01    | 172.16.0.231/32 |
| D02    | 172.16.0.232/32 |
| D03    | 172.16.0.233/32 |
| D06    | 172.16.0.236/32 |
| D10    | 172.16.0.240/32 |
| D11    | 172.16.0.241/32 |
| E01    | 172.16.0.243/32 |
| E02    | 172.16.0.244/32 |
| E03    | 172.16.0.245/32 |

# LAB NUMBERING

## INTERFACE ADDRESSES NORTH POP

| DEVICE-A | DEVICE-B | SUBNET          |
|----------|----------|-----------------|
| A15      | A17      | 172.16.10.0/30  |
| A15      | A19      | 172.16.10.4/30  |
| A15      | B13      | 172.16.10.8/30  |
| A17      | D01      | 172.16.10.12/30 |
| A17      | D02      | 172.16.10.16/30 |
| A19      | B13      | 172.16.10.20/30 |
| A19      | D02      | 172.16.10.24/30 |
| B13      | D01      | 172.16.10.28/30 |
| B13      | D02      | 172.16.10.32/30 |
| D01      | D02      | 172.16.10.36/30 |
| D01      | E02      | 172.16.10.40/30 |
| D02      | E03      | 172.16.10.44/30 |
| D11      | D02      | 172.16.10.48/30 |

# LAB NUMBERING

## INTERFACE ADDRESSES SOUTH POP

| DEVICE-A | DEVICE-B | SUBNET          |
|----------|----------|-----------------|
| D03      | D06      | 172.16.20.0/30  |
| D03      | D10      | 172.16.20.4/30  |
| D03      | E01      | 172.16.20.8/30  |
| D06      | E02      | 172.16.20.12/30 |
| D06      | E03      | 172.16.20.16/30 |
| D10      | E02      | 172.16.20.20/30 |
| D10      | E03      | 172.16.20.24/30 |
| E01      | E02      | 172.16.20.28/30 |
| E01      | E03      | 172.16.20.32/30 |
| E02      | E03      | 172.16.20.36/30 |
| E02      | D01      | 172.16.10.40/30 |
| E03      | D02      | 172.16.10.44/30 |
| D11      | E02      | 172.16.20.48/30 |

# LAB CONFIGURATION

## 1. Configure OSPF on all P and PE routers

- a. Use a single process  
`config router ospf <enter>`
- b. Use a single OSPF area (0.0.0.0 – backbone)  
`config router ospf area 0.0.0.0`
- c. Ensure that OSPF is enabled on all network interfaces, **including** *system*  
interface "system"  
interface "to-A15"
- d. On each router, verify that the system (loopback) addresses are visible and reachable (ping and traceroute)

# LAB CONFIGURATION

2. Configure MPLS on all P and PE routers
  - a. Using Interface LDP (I-LDP)  
config router ldp
  - b. Configure LDP on all network (PE-P-P-PE) interfaces  
config router ldp interface-parameters
  - c. Configure paths and LSPs (loose mode) between the routers  
config router mpls path  
config router mpls lsp
  - d. Validate that LDP is up, peers are up, bindings are up, LSPs are up  
show router ldp session  
show router ldp peer  
show router ldp binding  
show router mpls lsp
  - e. Enable LDP *ldp-shortcut*  
config router ldp-shortcut



# LAB CONFIGURATION

- f. Traceroute the system IPs between two PE routers  
Validate that IP hop-by-hop routing is in effect, and each hop is seen in a traceroute
- g. Disable mpls TTL propagation for shortcuts on all routers in the path  
config router mpls no shortcut-transit-ttl-propagate  
config router mpls no shortcut-local-ttl-propagate  
config router ldp no shortcut-transit-ttl-propagate  
config router ldp no shortcut-local-ttl-propagate
- h. Rerun traceroute and observe the results

# COMMAND EQUIVALENTS

## SLIDE 91

| IOS                                    | SR-OS  |
|--|--|
| ip cef                                 | No equivalent  |
| mpls label protocol <ldp   tdp   both> | No equivalent (bindings are made elsewhere)  |
| tag-switching tdp router-id Loopback0  | Auto derived from "system" IP, or explicitly configured via<br>configure router ldp interface-parameters local-lsr-id                    |
| mpls ldp explicit-null (optional)      | No equivalent (always enabled, unless implicit-null is sent)   |
| no mpls ip propagate-ttl               | Enabled by default<br>configure router ldp [no] shortcut-local-ttl-propagate<br>configure router ldp [no] shortcut-transit-ttl-propagate |
| mpls ip                                | config router ldp interface-param int <intf> no shutdown   |



# COMMAND EQUIVALENTS

## SLIDE 98

| IOS   | SR-OS  |
|---|--|
| show mpls interface <int> detail                    | show router mpls interface<interface><br>show router ldp interface <interface> |
| show mpls ldp discovery                             | show router ldp discovery [detail]   |
| show mpls ldp neighbor                              | show router ldp peer [detail]  |
| show mpls ip/ldp binding <prefix> <prefix-length>   | show router ldp bindings {prefix <prefix/length>}                              |
| show mpls forwarding-table <prefix> <prefix-length> | show router tunnel-table   |
| show ip cef <prefix>                                | show router route-table <prefix><br>tools dump router fib <slot>               |
| show mpls ldp parameters                            | show router ldp peer-parameters<br>show router ldp status                      |



# COMMAND EQUIVALENTS

SLIDE 98, 117

| IOS   | SR-OS  |
|---|--|
| show mpls interface <int> detail                    | show router mpls interface<interface><br>show router ldp interface <interface> |
| show mpls ldp discovery                             | show router ldp discovery [detail]   |
| show mpls ldp neighbor                              | show router ldp peer [detail]  |
| show mpls ip/ldp binding <prefix> <prefix-length>   | show router ldp bindings {prefix <prefix/length>}                              |
| show mpls forwarding-table <prefix> <prefix-length> | show router tunnel-table   |
| show ip cef <prefix>                                | show router route-table <prefix><br>tools dump router fib <slot>               |
| show mpls ldp parameters                            | show router ldp peer-parameters<br>show router ldp status                      |
| debug mpls ldp advertisements                       | No equivalent command  |
| debug mpls ldp binding                              | debug router ldp peer <peer-ip> event bindings                                 |
| debug mpls ldp message sent received                | debug router ldp interface <int> event messages                                |



# DAY 1

## WRAPUP

What we learned today

- MPLS theory
  - Why we use MPLS
  - MPLS concepts – terminology, architecture
  - MPLS header construct
  - How labels are generated and distributed
- LDP
  - Concepts
  - Protocol Data Unit
  - Interface (multicast) LDP v. Targeted (unicast) LDP
- Configuring and troubleshooting MPLS and LDP
- Lab exercise – discover topology, configure IP interfaces, OSPF, LDP

# DAY 1

## SOME LEARNINGS

What we learned today:

- Always check your documentation!
  - Loopback address mismatch meant some routers shared the same loopback 😊
- Topology discovery has limitations
  - CDP doesn't work when interfaces are *shutdown*
  - CDP is not necessarily a good idea in production networks
- Always double-check configuration implementation on both nodes
  - 172.16.34.0/24 is not the same as 172.116.34.0/24 😊
  - When routing protocols are involved, we might not fully notice a break in connectivity

# DAY 1

## QUICK QUESTIONS...

1. Name two label distribution protocols
  - a. LDP
  - b. RSVP-TE
2. What does the EXP (as in "EXP bit") mean? What purpose does it serve?
  - a. EXPerimental bit, used for signalling QoS/CoS in the MPLS packet header.
  - b. Note EXP was renamed to *Traffic Class Field* by RFC5462
3. How many bytes is the MPLS header? Why is this important?
  - a. 4 bytes (32-bit). *AJ can't do math*
  - b. Impacts MTU calculations
  - c. ***Per label imposed!*** Think about the maximum number of labels you may have
4. What are two commonly believed benefits of MPLS?
  - a. Performance
  - b. Traffic engineering
5. What (TCP) port does LDP use?
  - a. 646

# DAY 2

## *THAT'S TOMORROW*

- IP-VPNs
  - RFC2547bis
  - RFC4364
  - L3VPNs
- BGP
  - In the core
  - PE-CE

AT  
THE  
SPEED  
OF  
IDEAS™



AT  
THE  
SPEED  
OF  
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