

# Internet Backbone

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Carlo Vallati

Assistant Professor@ University of Pisa

[c.vallati@iet.unipi.it](mailto:c.vallati@iet.unipi.it)

# Internet Backbone architecture



The

"Internet"



# Outline



- Introduction to GNS3
- Basic commands for CISCO routers configuration
- IPv6 interoperability
- QoS enforcement, the DiffServ architecture
- MPLS

# Cisco IOS: Basic commands

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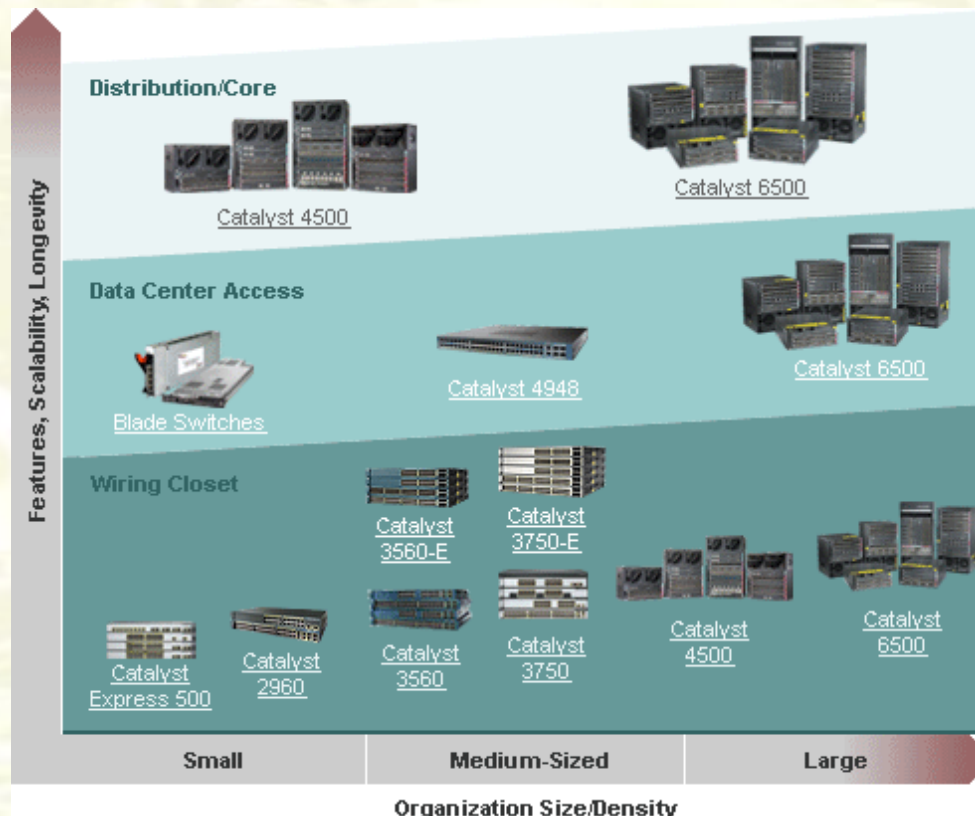
[c.vallati@iet.unipi.it](mailto:c.vallati@iet.unipi.it)



# Routers are “specialized” computers



# From small to big



# The operating system

- Cisco Internetwork Operating System (IOS)
- Juniper Network Operating System (Junos)
- ...



Internetwork Operating System for Cisco networking devices



# Cisco IOS modes



User EXEC Command-Router>

ping  
show (limited)  
enable  
etc...

Privileged EXEC Commands-Router#

all User EXEC Commands  
debug commands  
reload  
configure  
etc..

Global Configuration Commands-Router(config)#

hostname  
enable secret  
ip route

interface ethernet  
serial  
bri  
etc.

router rip  
ospf  
eigrp  
etc..

line vty  
console  
etc.

Interface Commands-Router(config-if)#

ip address  
ipx network  
encapsulation  
shutdown/ no shutdown  
etc..

Routing Engine Commands-Router(config-router)#

network  
version  
auto summary  
etc...

Line Commands-Router(config-line)#

password  
login  
modem commands  
etc..



# IOS prompt structure

```
Router>ping 192.168.10.5
```

```
Router#show running-config
```

```
Router(config) #Interface FastEthernet 0/0
```

```
Router(config-if) #ip address 192.168.10.1 255.255.255.0
```

The prompt changes to denote the current CLI mode.

```
Switch>ping 192.168.10.9
```

```
Switch#show running-config
```

```
Switch(config) #Interface FastEthernet 0/1
```

```
Switch(config-if) #Description connection to WEST LAN4
```



# Moving between primary modes

```
Router con0 in now available.
```

```
Press RETURN to get started.
```

```
User Access Verification
```

```
Password:
```

```
Router>enable
```

```
Password:
```

```
Router#configure terminal
```

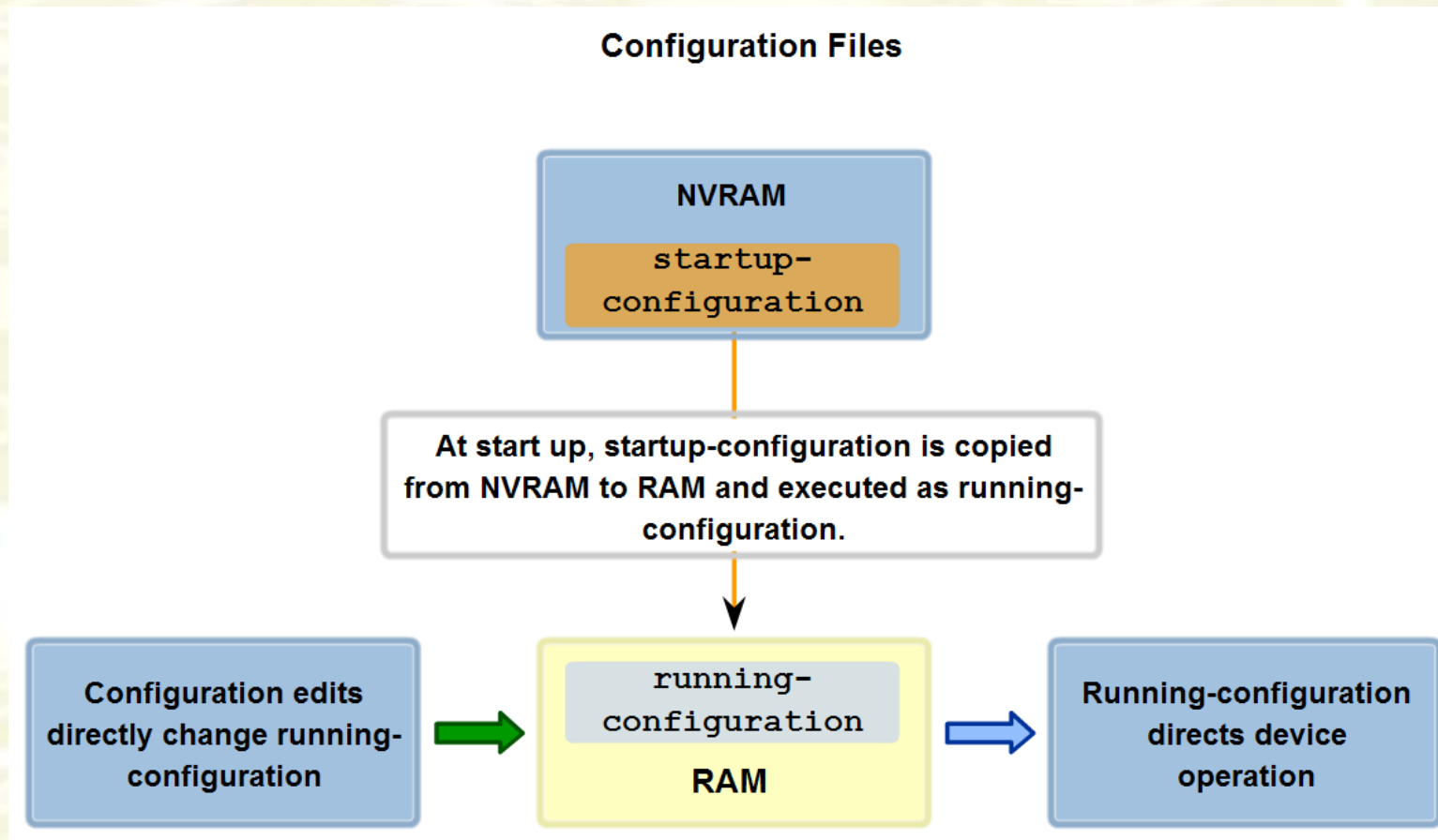
```
Enter configuration commands, one per line. End with CNTL/Z.
```

```
Router(config)#^Z
```

```
Router#disable
```

```
Router>exit
```

# Configuration files



# Managing configuration files

```
Router# show running-configuration
```

**Lists the complete configuration currently active in RAM.**

**The active configuration can be copied to NVRAM.**

```
version 12.2

hostname Router

!interface FastEthernet0/0

no ip address
duplex auto
speed auto
shutdown

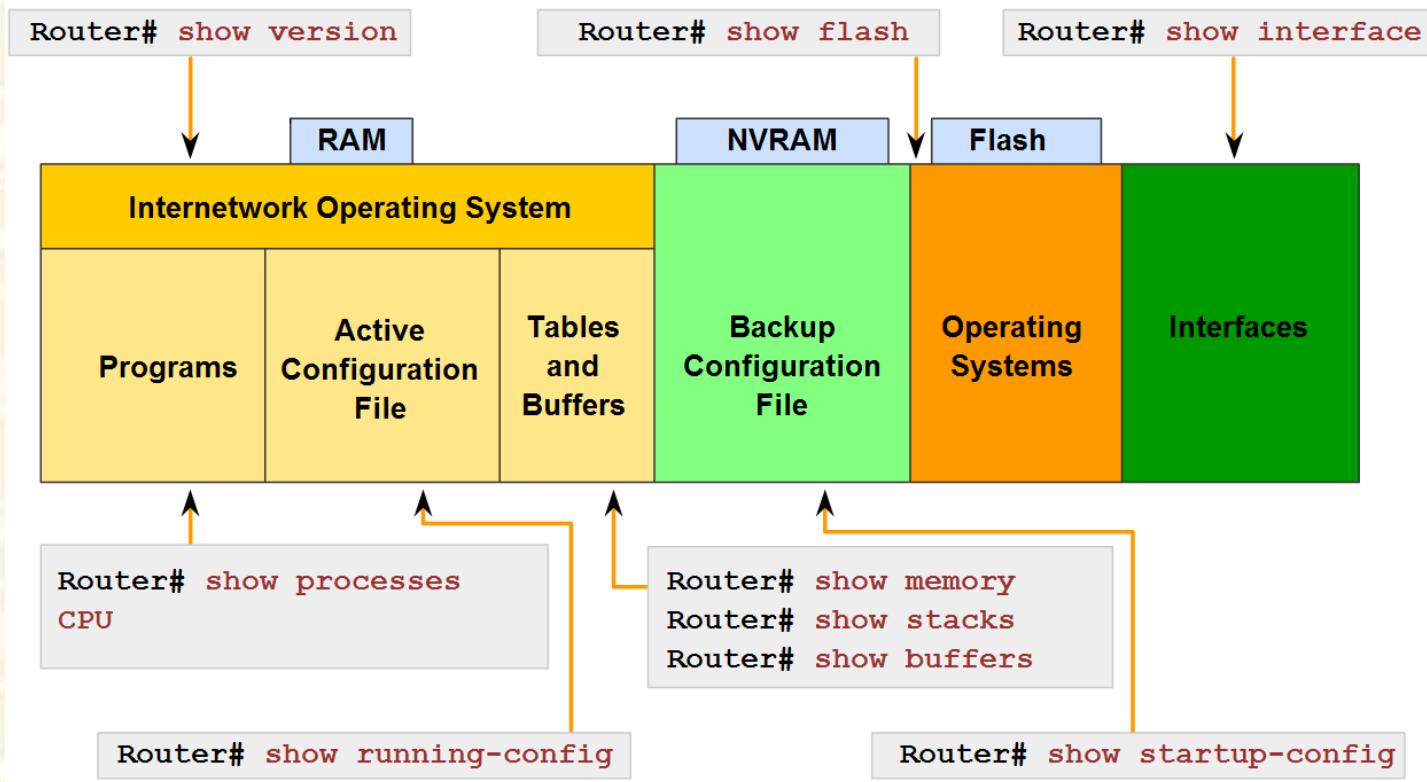
interface Serial10/0
no ip address
shutdown
!
interface Serial10/1
no ip address
shutdown
```

```
Router# copy running-configuration startup-configuration
```

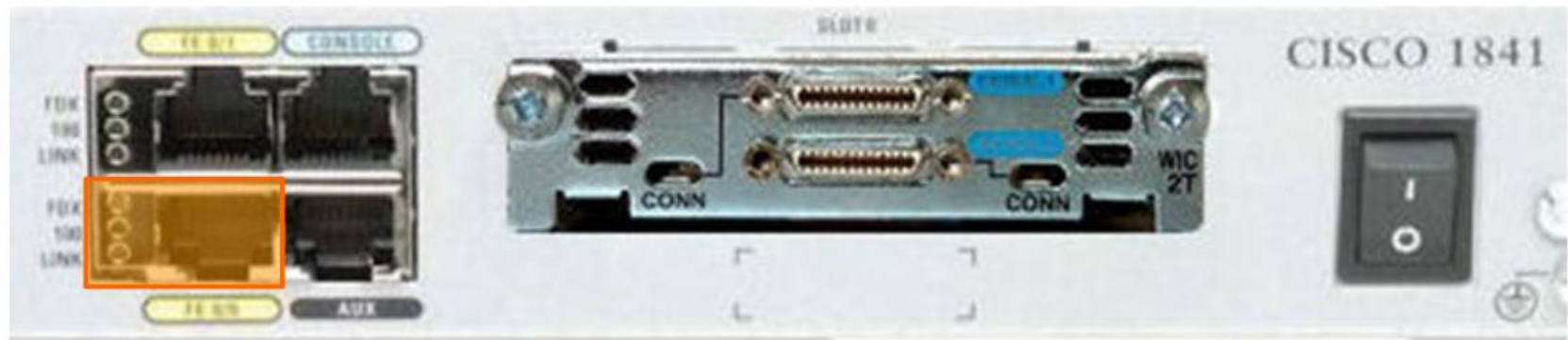


# The IOS show command

IOS show commands can provide information about the configuration, operation and status of parts of a Cisco router.



# Configuring Ethernet interfaces



```
Router(config)#interface FastEthernet 0/0
Router(config-if)#ip address 192.168.10.1 255.255.255.0
Router(config-if)#no shutdown
Router(config-if)#exit
Router(config)#
```

# Configure a DHCP server on a router



- Define a range of addresses that DHCP is not to allocate
  - static addresses reserved for the router interface, switch management IP address, servers, and local network printers
- Create the DHCP pool
- Configure the specifics of the pool.

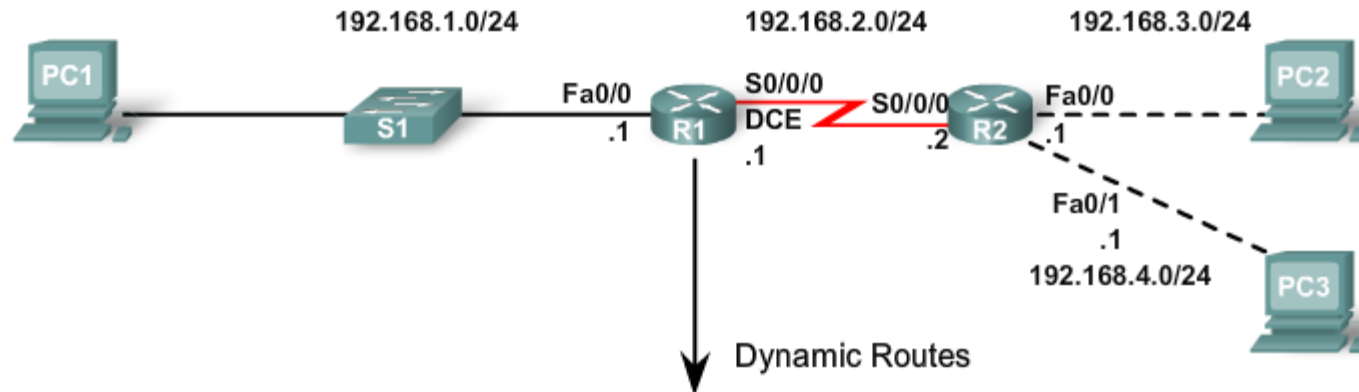
```
R1(config)# ip dhcp excluded-address 192.168.10.1 192.168.10.9
R1(config)# ip dhcp excluded-address 192.168.10.254
R1(config)# ip dhcp pool LAN-POOL-1
R1(dhcp-config)# network 192.168.10.0 255.255.255.0
R1(dhcp-config)# default-router 192.168.10.1
R1(dhcp-config)# domain-name span.com
R1(dhcp-config)# end
```

Required Tasks	Command
Define the address pool	<code>network network-number [mask   /prefix-length]</code>
Define the default router or gateway	<code>default-router address [address2...address8]</code>

# Routing table



Connected, Static and Dynamic Routes



```
R1#show ip route
```

```
Codes: C - connected, S - static, I - IGRP, 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, E - EGP
       i - IS-IS, 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
```

```
Gateway of last resort is not set
```

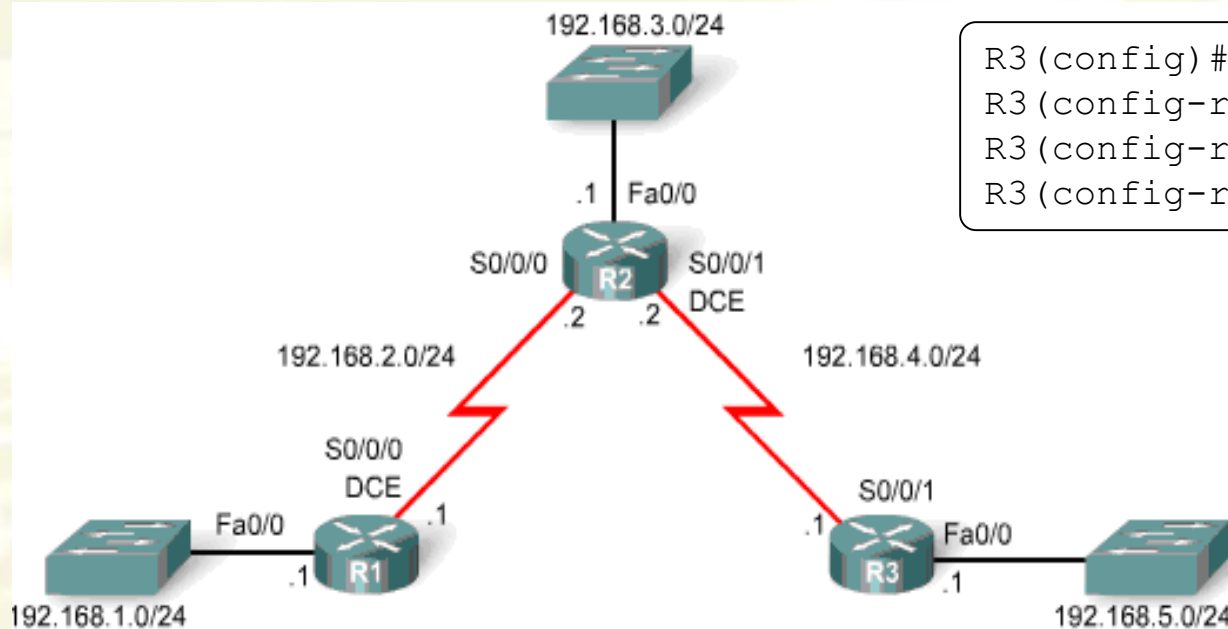
```
C 192.168.1.0/24 is directly connected, FastEthernet0/0
C 192.168.2.0/24 is directly connected, Serial0/0/0
S 192.168.3.0/24 [1/0] via 192.168.2.2
R 192.168.4.0/24 [120/1] via 192.168.2.2, 00:00:20, Serial0/0/0
```



# IOS RIPv1 configuration

Router (config-router) #**network** *directly-connected-classful-network-address*

- Enables RIP on all interfaces that belong to a specific network. Associated interfaces will now both send and receive RIP updates.
- Advertises the specified network in RIP routing updates



```
R3 (config) #router rip
R3 (config-router) #network 192.168.4.0
R3 (config-router) #network 192.168.5.1
R3 (config-router) #exit
```

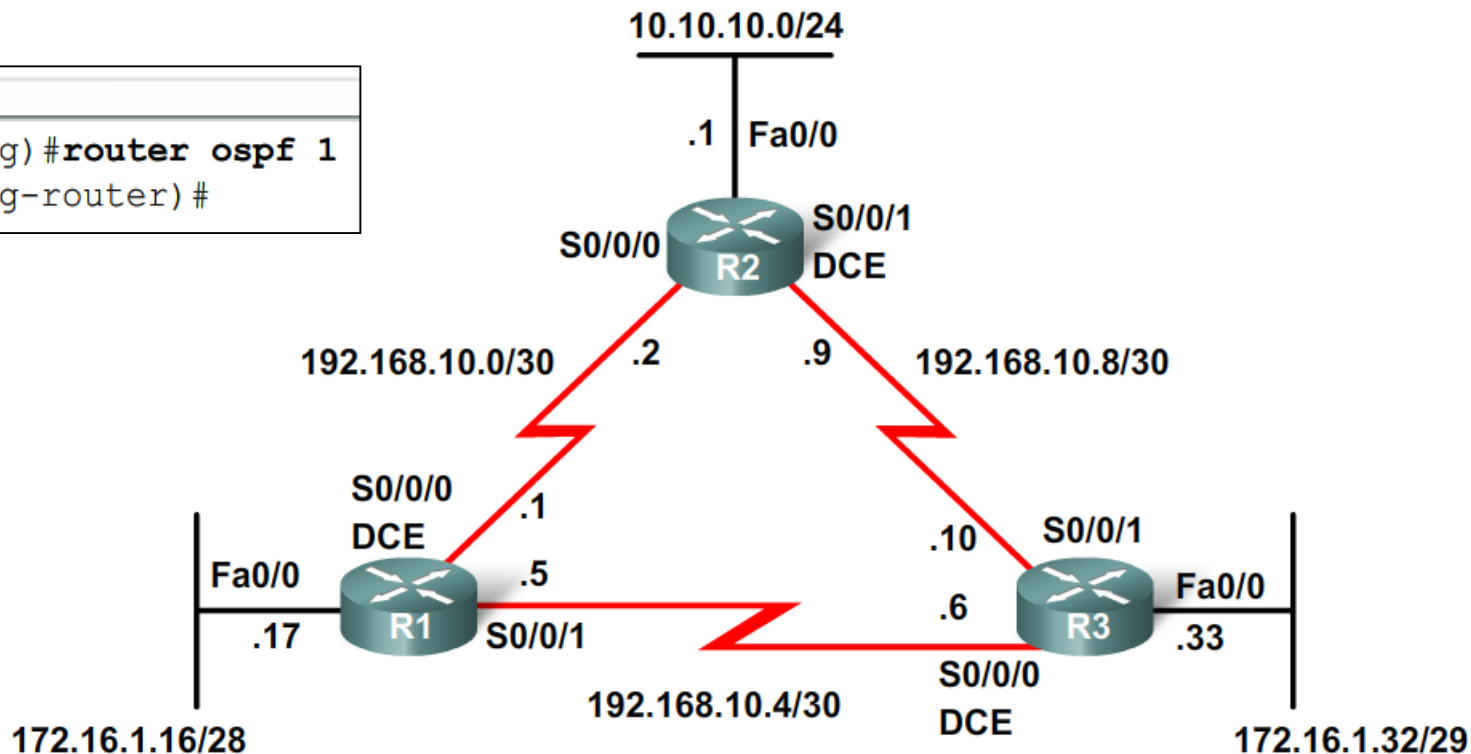
```
R3#show running-config
!
router rip
network 192.168.4.0
network 192.168.5.0
!
```

# Configuring OSPF

```
Router(config)#router ospf process-id
```

- Enabling OSPF routing
  - Default bandwidth 1544kbps on all serial links

```
R1(config)#router ospf 1  
R1(config-router)#
```



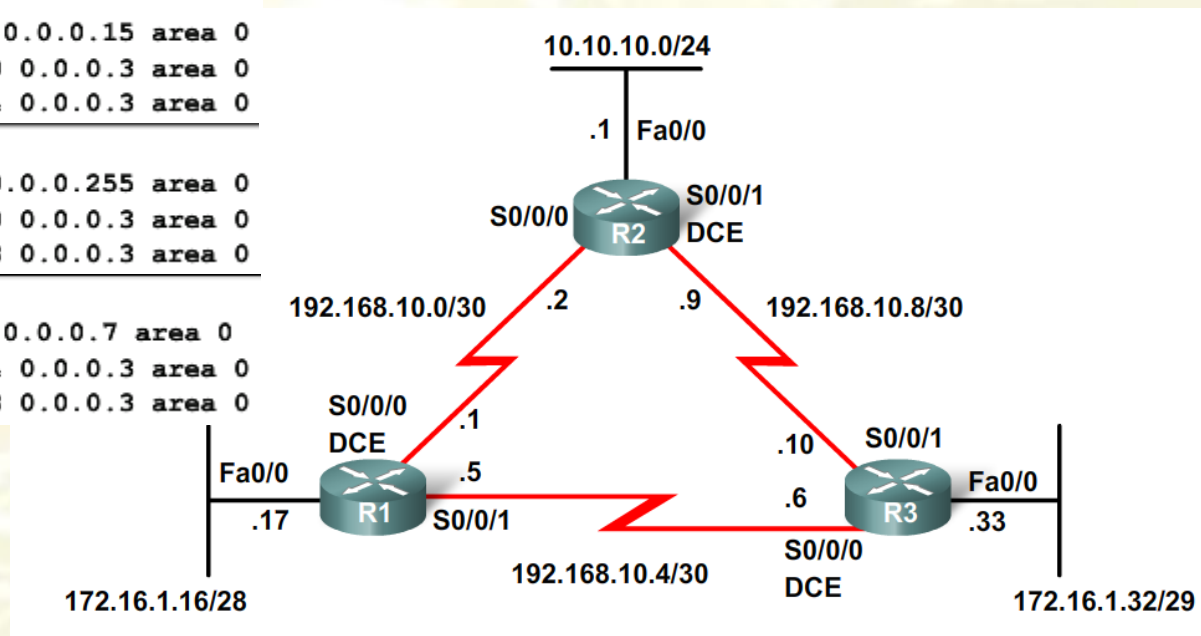
# Configuring OSPF



```
Router(config-router)#network network-address wildcard-mask area area-id
```

- Configuring OSPF subnetworks
  - Any interface matching the network address will be enabled to send and receive OSPF packets
  - This network (or subnet) will be included in OSPF routing updates

```
R1(config)#router ospf 1
R1(config-router)#network 172.16.1.16 0.0.0.15 area 0
R1(config-router)#network 192.168.10.0 0.0.0.3 area 0
R1(config-router)#network 192.168.10.4 0.0.0.3 area 0
R2(config)#router ospf 1
R2(config-router)#network 10.10.10.0 0.0.0.255 area 0
R2(config-router)#network 192.168.10.0 0.0.0.3 area 0
R2(config-router)#network 192.168.10.8 0.0.0.3 area 0
R3(config)#router ospf 1
R3(config-router)#network 172.16.1.32 0.0.0.7 area 0
R3(config-router)#network 192.168.10.4 0.0.0.3 area 0
R3(config-router)#network 192.168.10.8 0.0.0.3 area 0
```



# Configuring OSPF



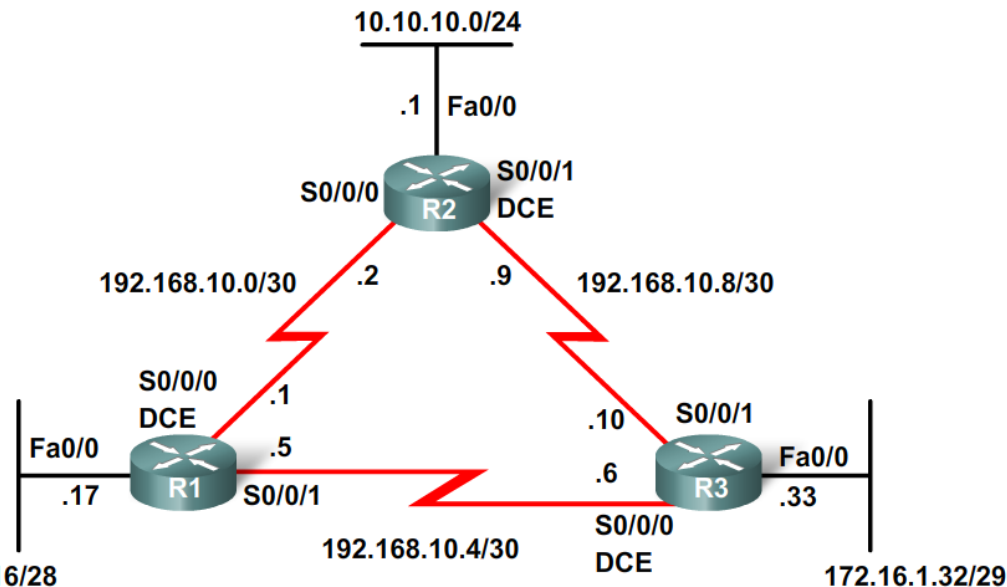
Router (config-router) #**router-id** *ip-address*

- Determining the router id
  1. IP address configured with the router-id command
  2. The highest IP address of any of its loopback interfaces
  3. The highest active IP address of any of its physical interfaces

```
R1#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.10.5
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
```

```
R2#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.10.9
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
```

```
R3#show ip protocols
Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 192.168.10.10
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
```

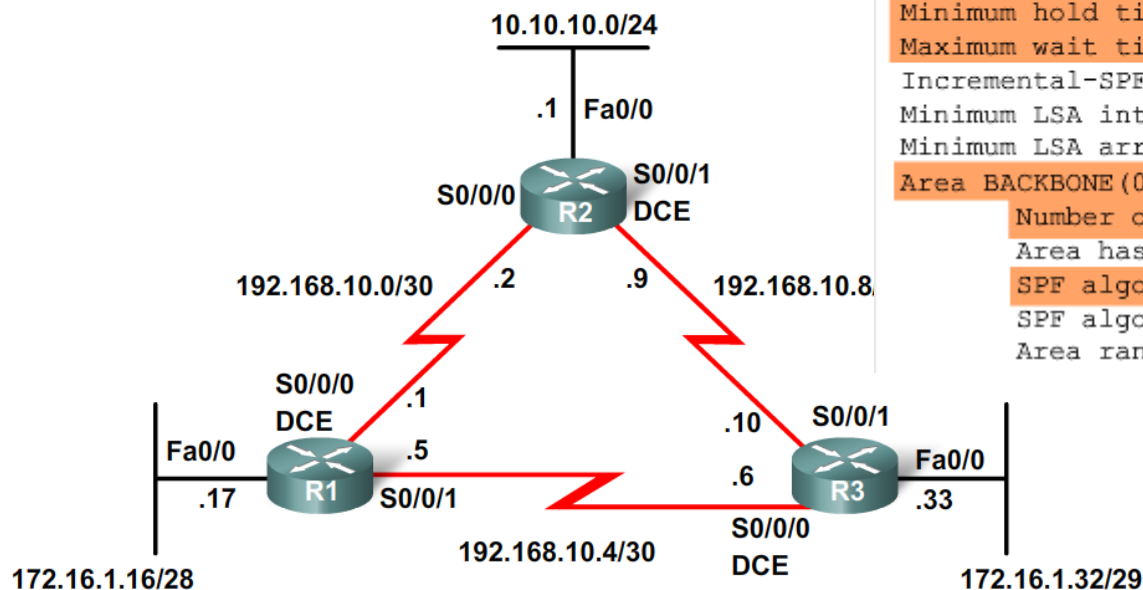




# Verifying OSPF configuration

- OSPF troubleshooting commands

- `show ip protocols`
- `show ip ospf`
- `show ip ospf interface`



```
R1#show ip ospf
```

```
***output omitted***
```

```
Routing Process "ospf 1" with ID 10.1.1.1
```

```
Start time: 00:00:19.540, Time elapsed: 11:31:15.776
```

```
Supports only single TOS(TOS0) routes
```

```
Supports opaque LSA
```

```
Supports Link-local Signaling (LLS)
```

```
Supports area transit capability
```

```
Router is not originating router-LSAs with maximum metric
```

```
Initial SPF schedule delay 5000 msecs
```

```
Minimum hold time between two consecutive SPF's 10000 msecs
```

```
Maximum wait time between two consecutive SPF's 10000 msecs
```

```
Incremental-SPF disabled
```

```
Minimum LSA interval 5 secs
```

```
Minimum LSA arrival 1000 msecs
```

```
Area BACKBONE(0)
```

```
Number of interfaces in this area is 3
```

```
Area has no authentication
```

```
SPF algorithm last executed 11:30:31.628 ago
```

```
SPF algorithm executed 5 times
```

```
Area ranges are
```

# GNS3



- Graphical Network Simulator 3 is a network software emulator
- It allows the combination of virtual and real devices to emulate complex networks
- Specifically it allows the emulation of real hosts and real Cisco Routers
- The emulated routers run a real IOS image downloaded from a real router

# Do IT!



- Create a simple network composed of at least two routers and two hosts
- Boot the routers
- Configure the IP addresses of all the interfaces in the routers
- Set two DHCP servers to autoconfigure IPv4 address to the hosts
- Boot the hosts
- Configure RIP as routing protocol
- Check connectivity between hosts
- Save the configuration
- Use Wireshark to check traffic

# IPv6 Configuration

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Carlo Vallati

Assistant Professor@ University of Pisa

[c.vallati@iet.unipi.it](mailto:c.vallati@iet.unipi.it)



# IPv6 address configuration

- Configuration:

- interface Ethernet0/0
- ipv6 enable
  - (Automatically configure an IPv6 link-local address on the interface, and enable the interface for IPv6 processing)
- ipv6 address 2001:aaaa:bbbb:cccc::/64 eui-64
- ipv6 unicast-routing
  - Enable forwarding of IPv6 unicast data packets

- Check configuration status:

- show ipv6 interface Ethernet0/0

# IPv6 host configuration

- Go to Linux Console 1:
  - `ifconfig`
    - Address already obtained! When a Router Advertisement is received by a client, and IPv6 autoconfiguration is enabled (default on non-router), the client configures itself an IPv6 address according to the prefix contained in the advertisement.
- Ping:
  - `ping6 [IPv6 address]`
    - From Host, try both link-local and global
  - Use Wireshark to see what's going on the net!

# RIPv6 Configuration

- Configuration:
  - `ipv6 unicast-routing`
    - Enable forwarding of IPv6 unicast data packets
  - `interface fastEthernet0/0`
    - From Host, try both link-local and global
  - `ipv6 rip process1 enable`
- Check IPv6 Routing Table
  - `show ipv6 route`