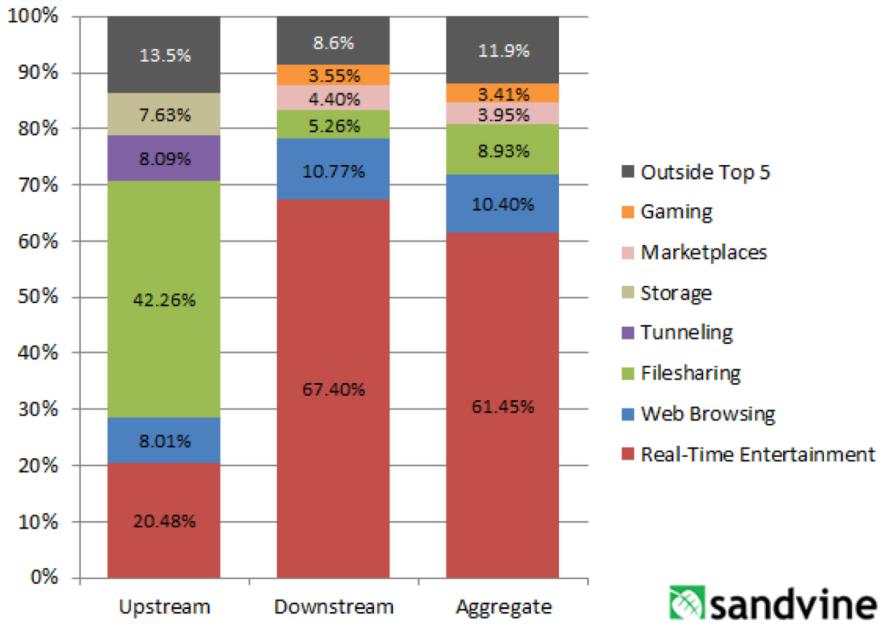


Infrastructure QoS support

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Peak Period Traffic Composition (North America, Fixed Access)

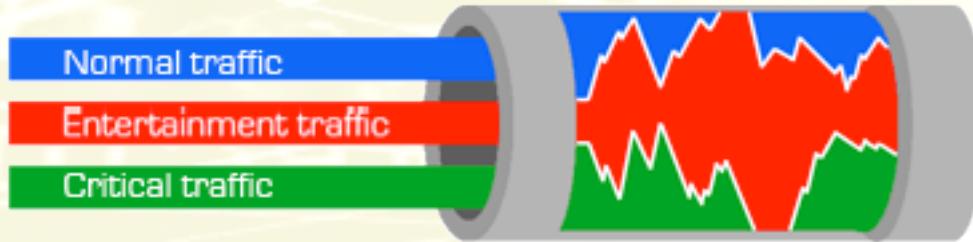


Rank	Upstream		Downstream		Aggregate	
	Application	Share	Application	Share	Application	Share
1	BitTorrent	36.35%	Netflix	31.62%	Netflix	28.18%
2	HTTP	6.03%	YouTube	18.69%	YouTube	16.78%
3	SSL	5.87%	HTTP	9.74%	HTTP	9.26%
4	Netflix	4.44%	BitTorrent	4.05%	BitTorrent	7.39%
5	YouTube	3.63%	iTunes	3.27%	iTunes	2.91%
6	Skype	2.76%	MPEG - Other	2.60%	SSL	2.54%
7	QVoD	2.55%	SSL	2.05%	MPEG - Other	2.32%
8	Facebook	1.54%	Amazon Video	1.61%	Amazon Video	1.48%
9	FaceTime	1.44%	Facebook	1.31%	Facebook	1.34%
10	Dropbox	1.39%	Hulu	1.29%	Hulu	1.15%
	Top 10	66.00%	Top 10	76.23%	Top 10	73.35%

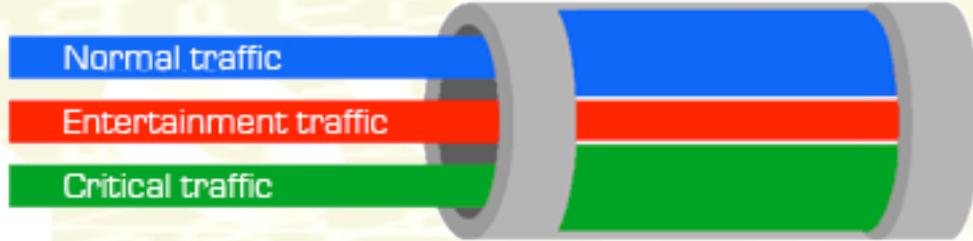


QoS in the Internet

Bandwidth Use without QoS control



Bandwidth Use with QoS control

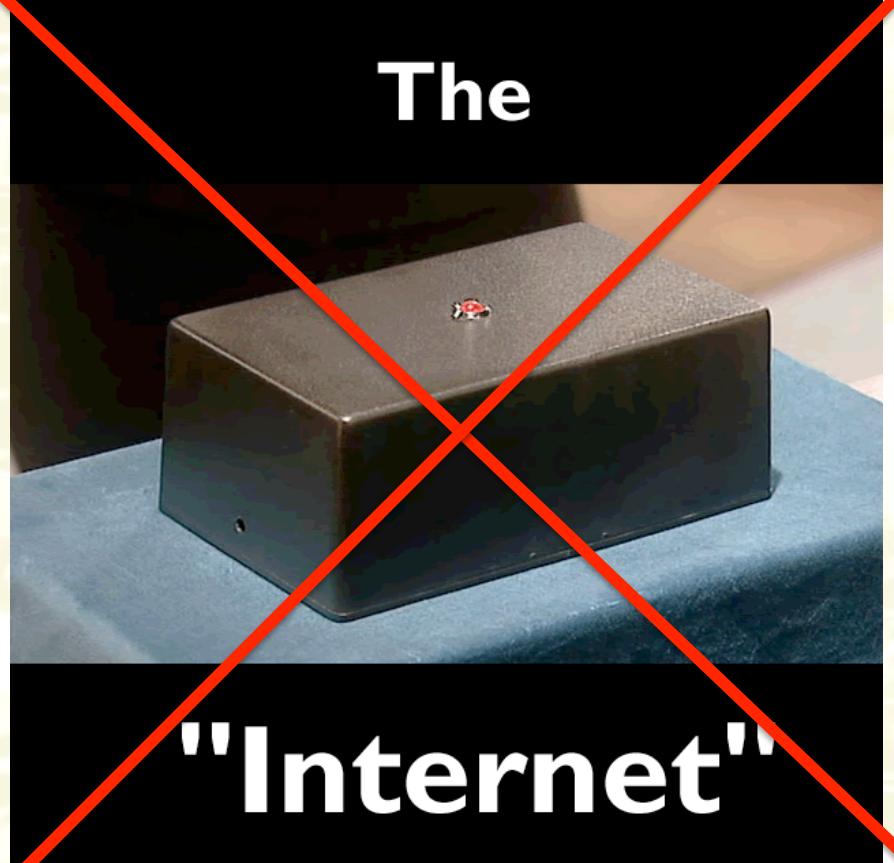


E.g. VoIP requires packets to be delivered with a delay which is in the worst case in the order of 150ms one-way





Infrastructure QoS support



Cisco IOS: Basic commands

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Basic commands

- Show current configuration:
 - show running-config
- Save permanently configuration:
 - copy running-config startup-config
- Reboot a router:
 - reload



Interface configuration

- Configuration:
 - configure terminal
- Configure an interface:
 - interface Ethernet0/0
 - ip address 192.168.1.1 255.255.255.0
 - no shutdown
- Set DHCP server:
 - ip dhcp pool localnetwork
 - network 192.168.1.0 255.255.255.0
 - default-router 192.168.1.1



RIP configuration

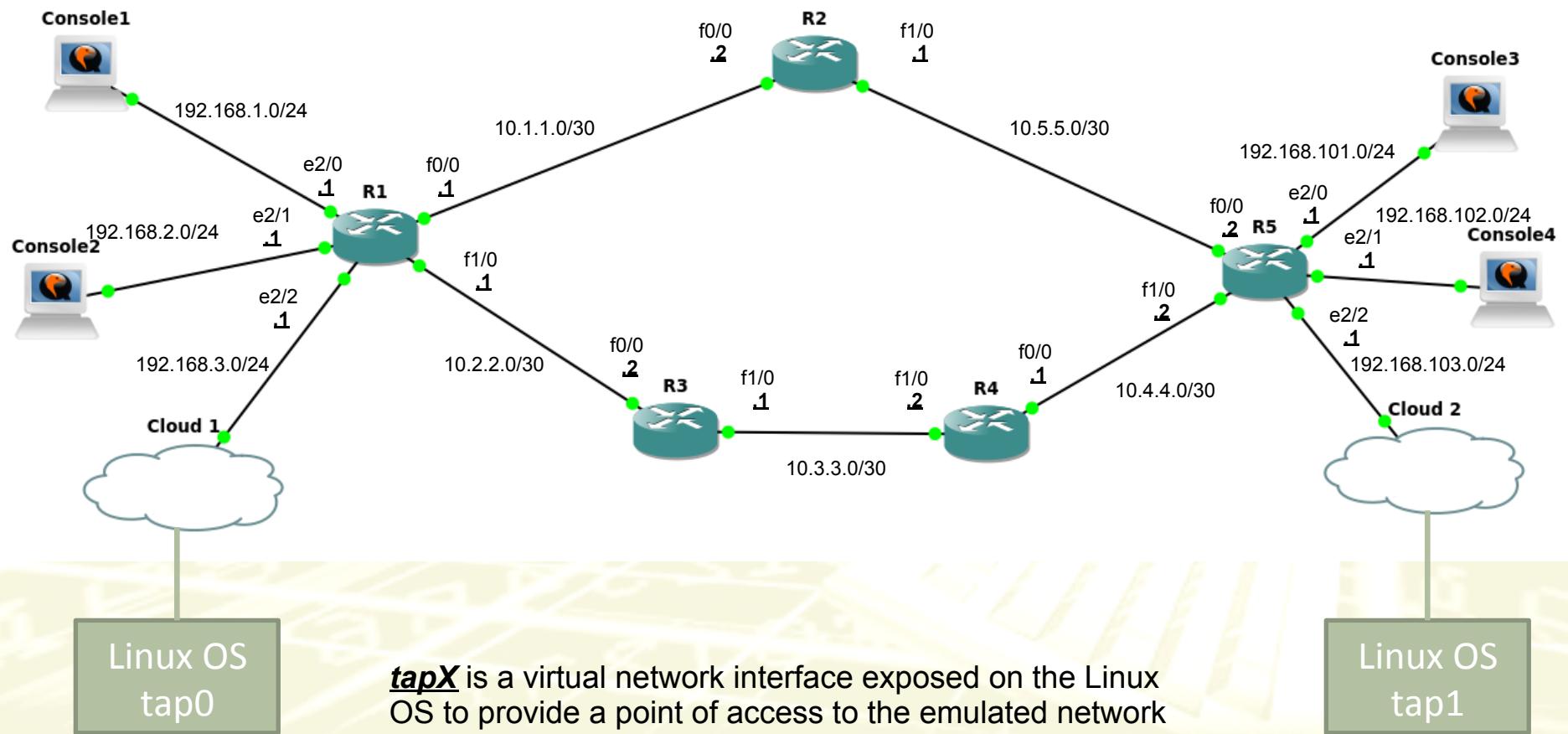
- Configuration:
 - router rip
 - network 10.0.0.0
 - network 192.168.1.0
- Show routing-table:
 - show ip route

Basic Network

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Network Architecture

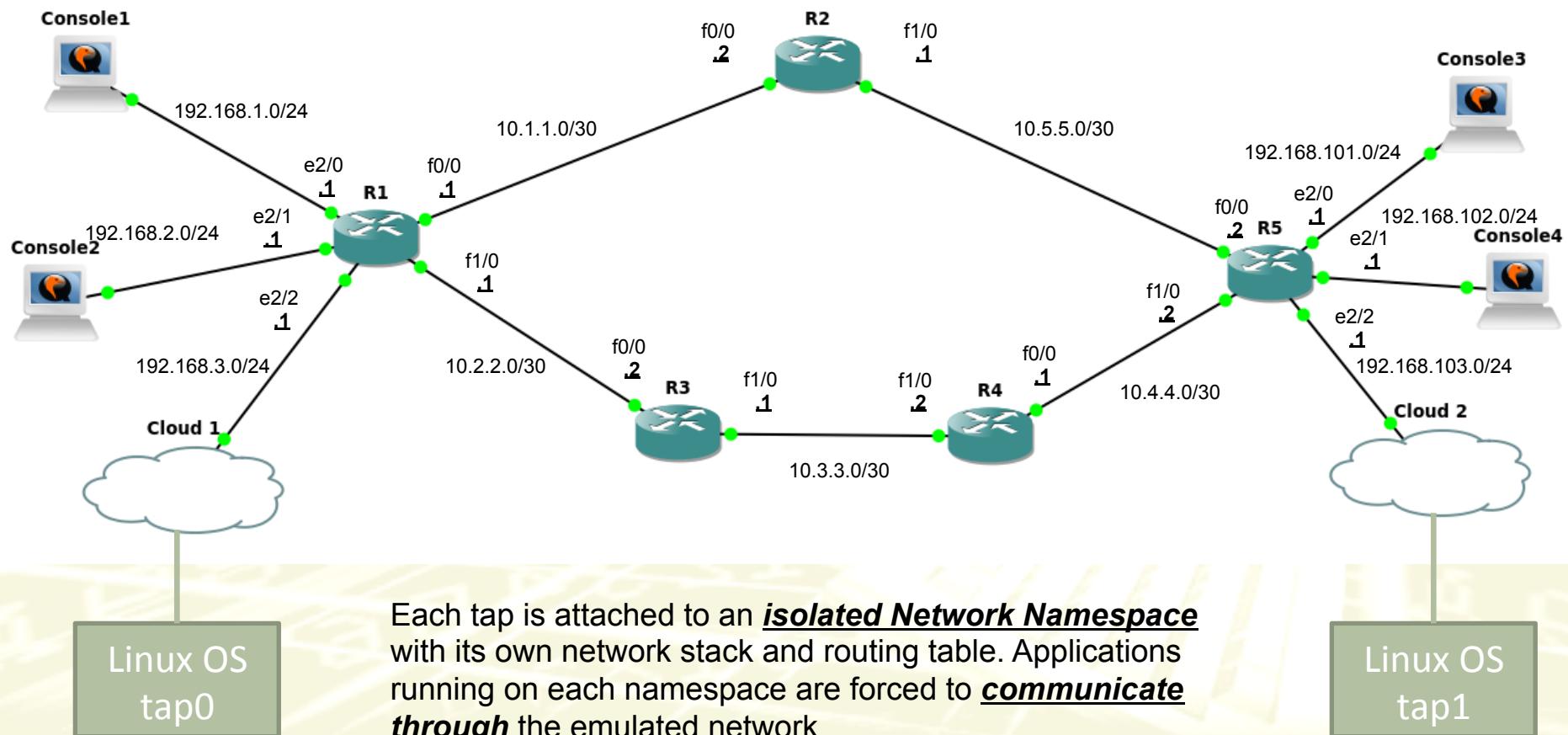


Linux OS
tap0

Linux OS
tap1



Network Architecture



Linux OS
tap0

Linux OS
tap1

IPv6 Configuration

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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!



6to4 Tunneling Configuration

- On R1 create a new tunnel interface :
 - interface Tunnel0
 - no ip address
 - no ip redirects
 - ipv6 address 2002:a01:101:1::1/64
 - tunnel source 10.1.1.1
 - tunnel mode ipv6ip 6to4
- Add manually routing information:
 - ipv6 route 2001:bbbb:bbbb:cccc::/64 2002:a05:502:1::1
 - ipv6 route 2002:a05:502:1::1/64 Tunnel0
- Replicate configuration on R5

a01:101 corresponds
to 10.1.1.1

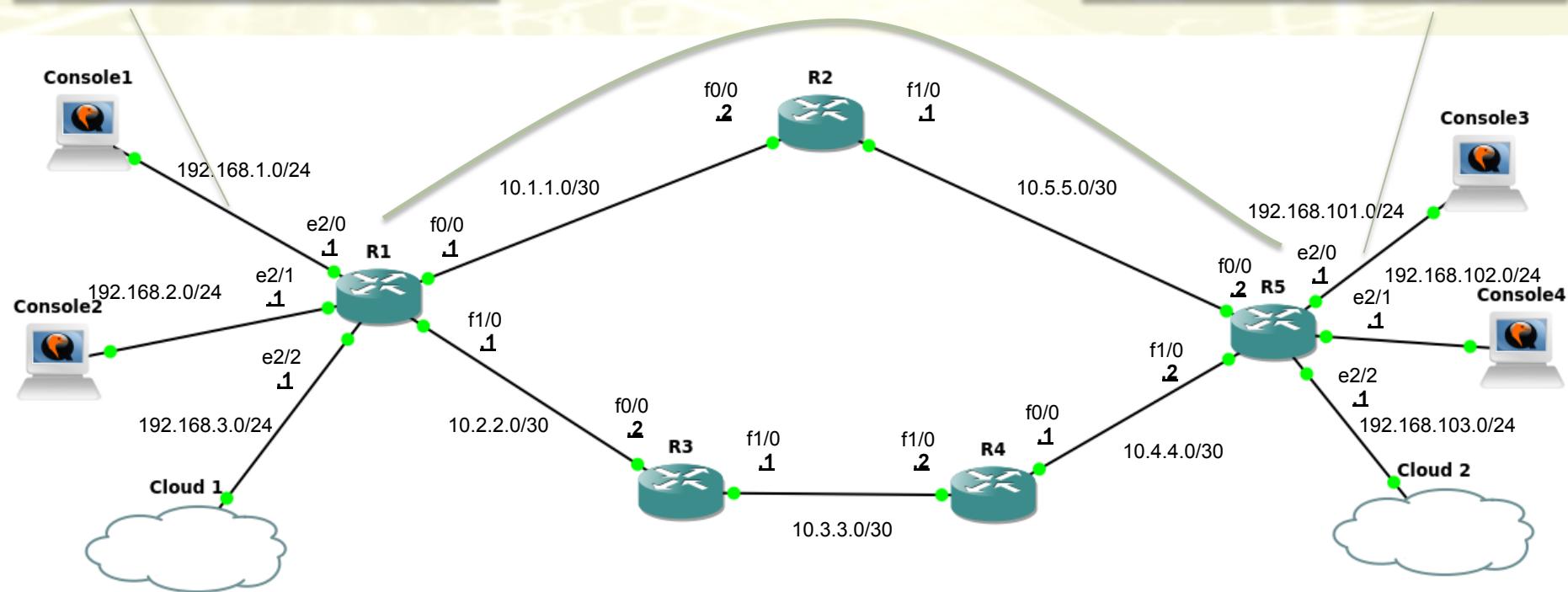
Tunnel IPv6



IPv6/IPv4 link
2001:aaaa:bbbb:cccc::/64

6to4 Tunnel

IPv6/IPv4 link 2001:bbbb:bbbb:cccc::/64

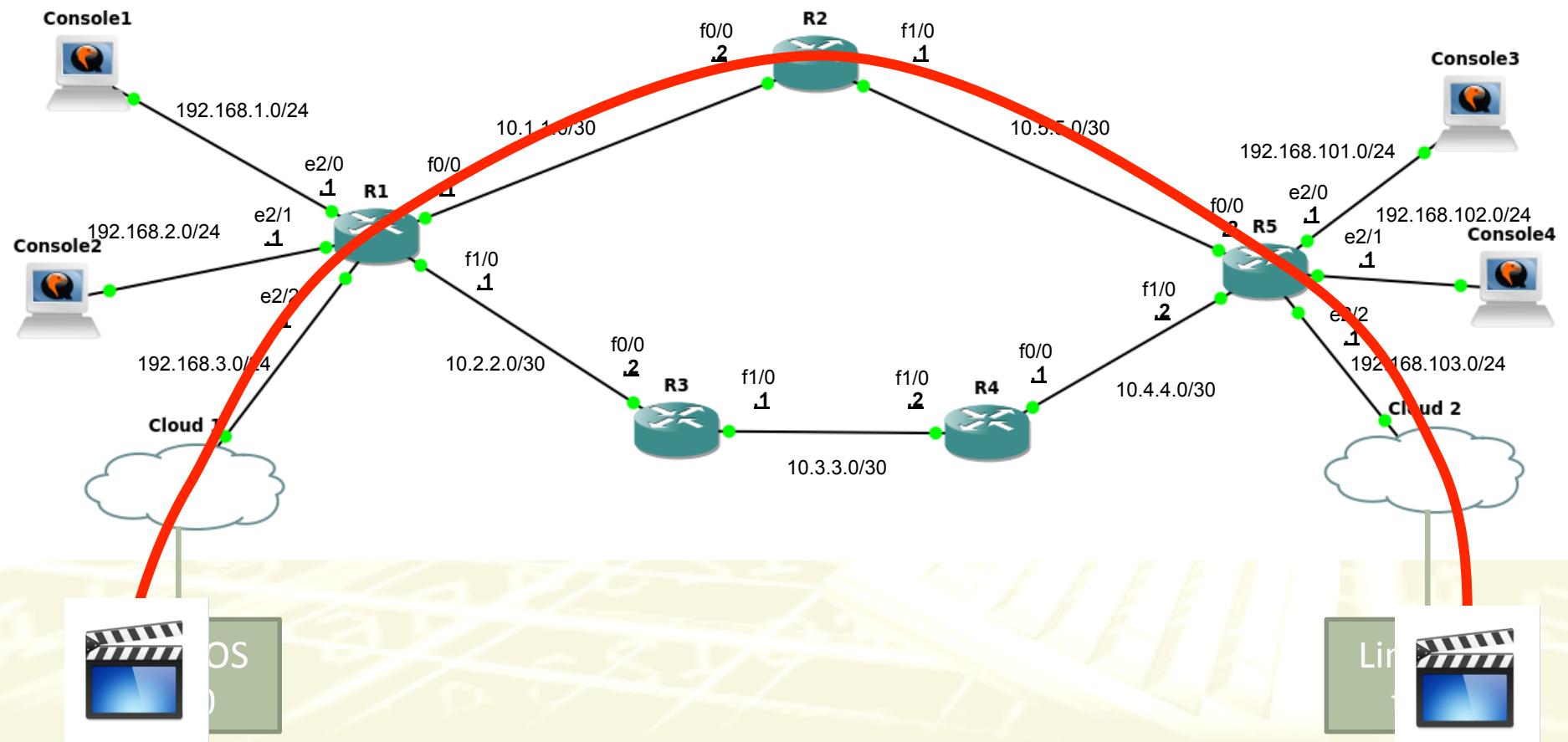


Best Effort

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Network Architecture





Soft real-time traffic – Video

- Initialize Linux Namespaces:
 - http://www.sample-videos.com/video/mp4/240/big_buck_bunny_240p_50mb.mp4
- Install vnc on the virtual machine if needed
 - sudo apt-get install vlc vlc-nox



Soft real-time traffic – Video

- Download video from:
 - cd streaming
 - ./init.sh
- Verify Server IP address:
 - sudo ip netns exec server ifconfig
 - inet addr:192.168.103.2
 - Modify the file server.sh and client.sh accordingly
- Start Server:
 - sudo ip netns exec server ./server.sh
- Start Client:
 - sudo ip netns exec client ./client.sh



Soft real-time traffic – Video

- Video is flowing
- Start UDP traffic
- Open Console3:
 - iperf3 -u -c 192.168.1.2 -b 100M
- Open Console1:
 - iperf3 -s

Differentiated Services Architectures

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Intro

- Network Boundary
 - Classification & Marking
 - Shaping and Policing
- Per-Hop Behavior
 - Scheduling and Resource Allocation
 - Congestion Avoidance and Packet Drop Policy

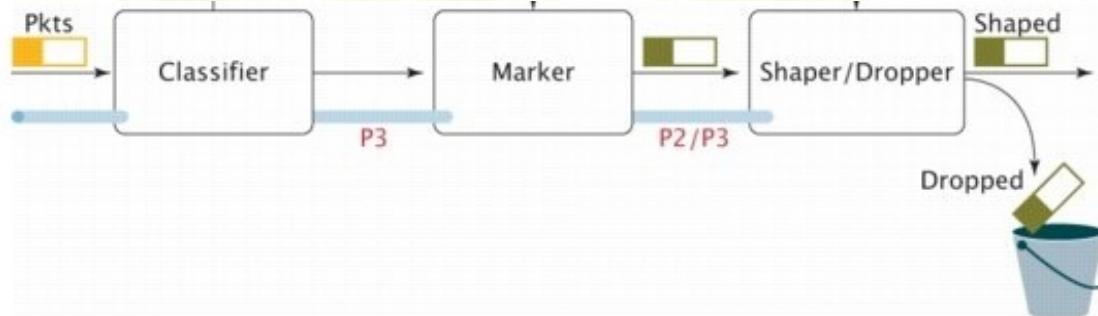
Network Boundary

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Network Ingress

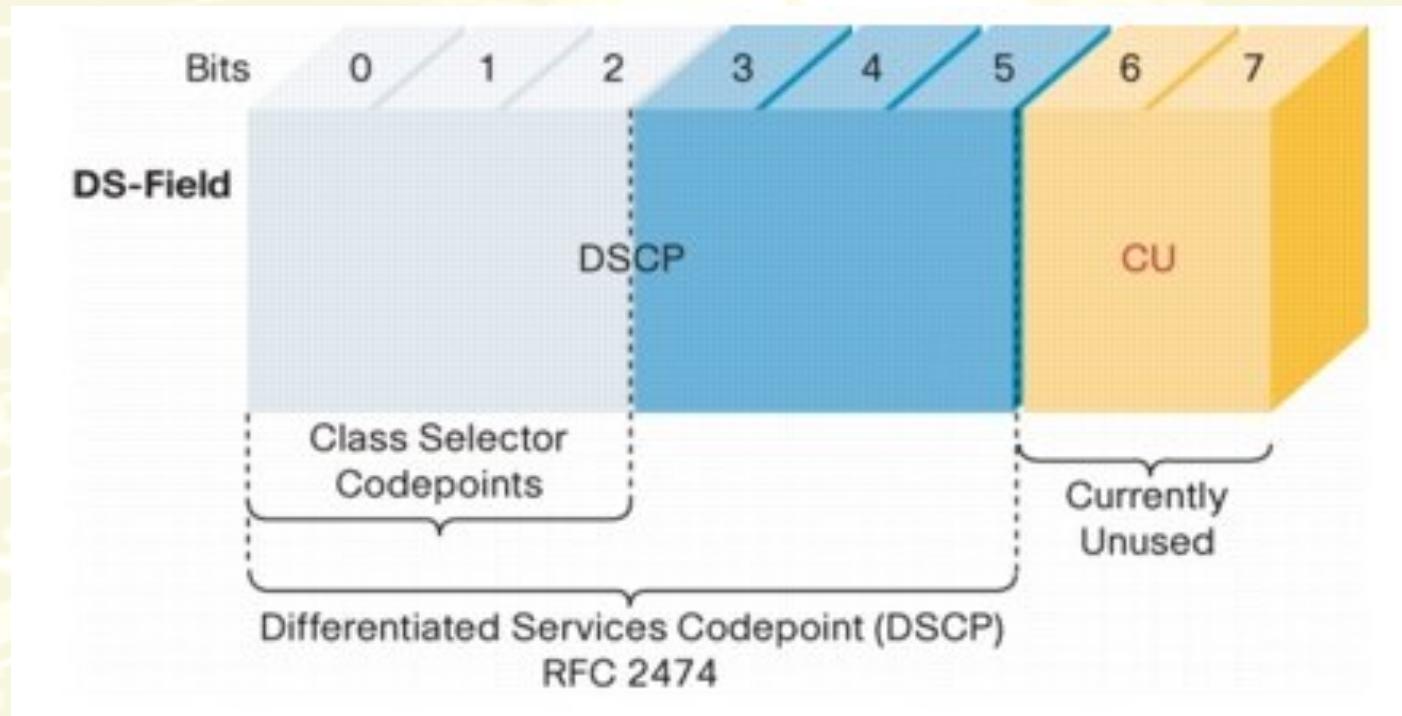
- Routers at the network boundary perform **Classifier** functions to identify packets belonging to a certain traffic class based on one or more TCP/IP header fields
- A **Marker** is used to color the classified traffic
- A **Shaper** or **Traffic Policing** is used to regulate ingress rate





Packet Marker

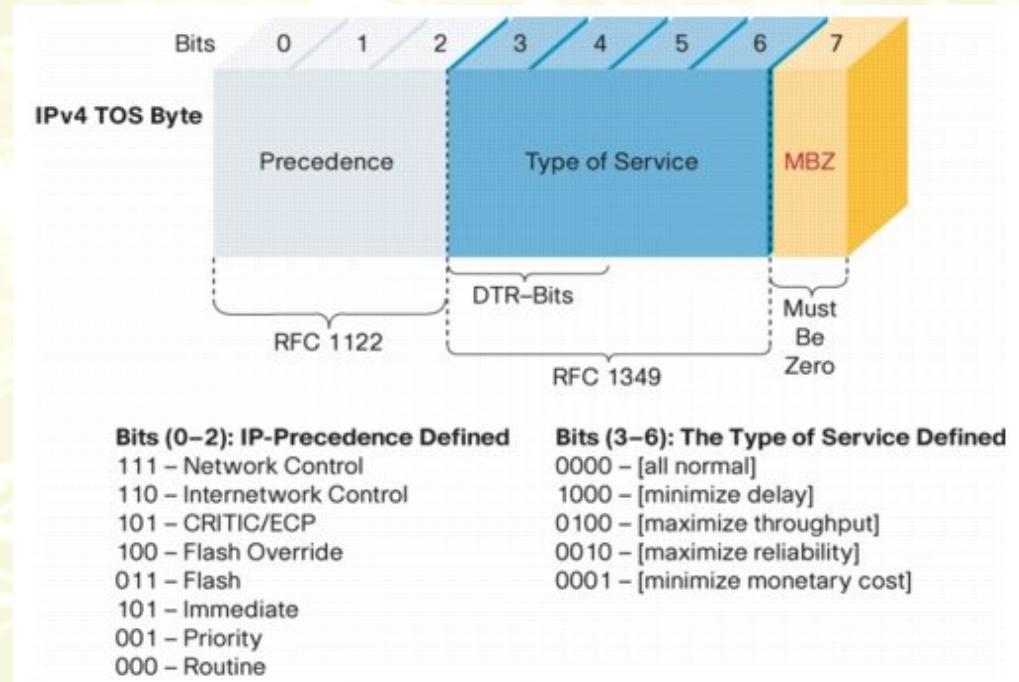
- The marker set the Differentiated Services Code Point (DSCP) field





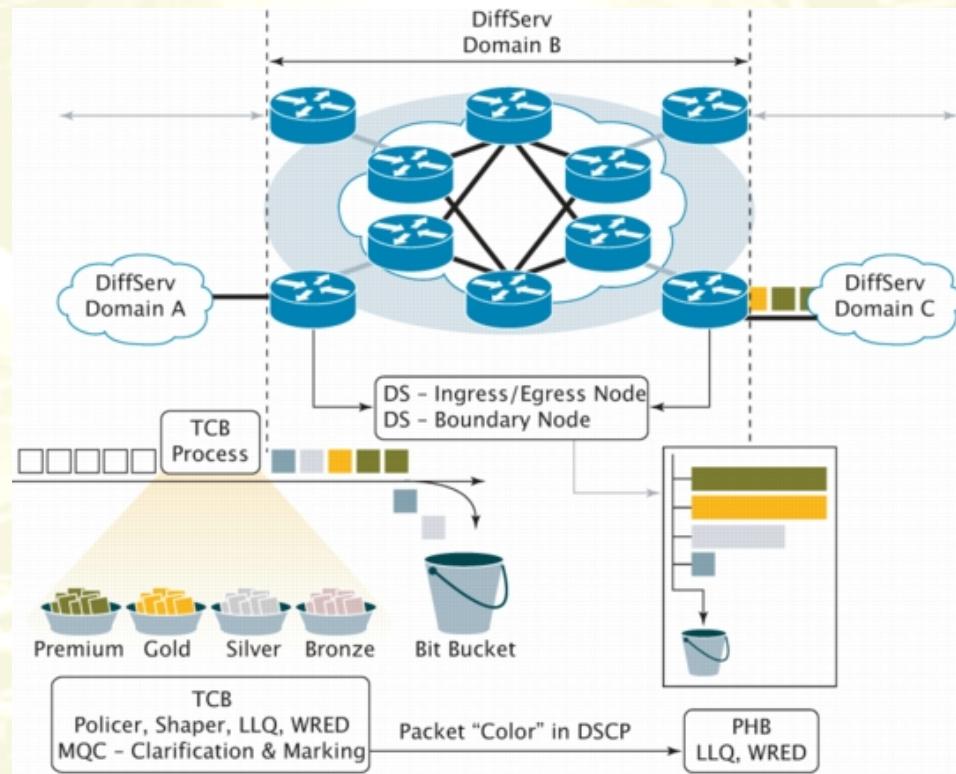
Warning

- The IOS version adopted is old, it is not compliant with latest Diffserv specifications. Only the precedence field can be marked
- Hence, it only support PHB based on Class Selector
- In the following, packets will be marked using the command “`set ip precedence`” to mark the precedence field (first 3 bits of DSCP), to mark the DSCP field instead use the command “`set ip dscp`” (it can be used only on new routers)



Per-Hop Behavior

- Within the network core, a per-hop behavior (PHB) is applied to the packets based on either the IP Precedence or the DSCP field marked in the packet header



Packet C&M using PBR (Policy Based Routing)



- Define Classification
 - access-list 1 permit 192.168.1.2 0.0.0.0
- Define Marking:
 - interface Ethernet 0/0
 - ip policy route-map prio
 - route-map prio permit 10
 - match ip address 1
 - set ip precedence 5
 - route-map prio permit 40
 - set ip precedence 4
- To disable
 - no ip policy route-map prio



Test

- Test with ping and check that the precedence bit on the IP header is set correctly using wireshark!

3 5.373284000 192.168.1.3 192.168.100.2 ICMP 98 Echo (ping) request id=0xd106, seq=0/0, ttl=63 (reply in 4)

```
> Frame 3: 98 bytes on wire (784 bits), 98 bytes captured (784 bits) on interface 0
> Ethernet II, Src: c8:01:0b:2b:00:10 (c8:01:0b:2b:00:10), Dst: c8:02:0b:3e:00:10 (c8:02:0b:3e:00:10)
└ Internet Protocol Version 4, Src: 192.168.1.3 (192.168.1.3), Dst: 192.168.100.2 (192.168.100.2)
    └ Version: 4
    └ Header Length: 20 bytes
    └ Differentiated Services Field: 0xa0 (DSCP 0x28: Class Selector 5; ECN: 0x00: Not-ECT (Not ECN-Capable Transport))
        └ 1010 00.. = Differentiated Services Codepoint: Class Selector 5 (0x28)
            .... ..00 = Explicit Congestion Notification: Not-ECT (Not ECN-Capable Transport) (0x00)
    └ Total Length: 84
    └ Identification: 0x0000 (0)
    > Flags: 0x02 (Don't Fragment)
    └ Fragment offset: 0
    └ Time to live: 63

0000  c8 02 0b 3e 00 10 c8 01  0b 2b 00 10 08 00 45 a0  ...>.... .+....E.
0010  00 54 00 00 40 00 3f 01  54 b3 c0 a8 01 03 c0 a8  .T..@.?.. T.....
0020  64 02 08 00 76 46 d1 06  00 00 34 eb 7b c7 00 00  d...vF.. .4.{...
0030  00 00 00 00 00 00 00 00  00 00 00 00 00 00 00 00  ..... .......
```



Classification based on protocol

- Classify traffic based on transport protocol or application:
 - access-list 101 permit tcp any any
 - access-list 102 permit udp any any
- Define Marking:
 - interface Ethernet 0/0
 - ip policy route-map prio
 - route-map prio permit 20
 - match ip address 101
 - set ip precedence 6
 - route-map prio permit 30
 - match ip address 102
 - set ip precedence 3



Test with iperf

- Iperf is a tool to generate traffic
- Generate TCP flow (data is generated from client to server)
 - iperf -s (to create the server)
 - iperf -c 192.168.100.2 (to start the flow)
- Generate UDP flow (data is generated from client to server)
 - iperf -u -s (to create the server)
 - iperf -u -c 192.168.100.2 -b 1M (to start 1Mbps flow)



Test!

- Start two flows, one UDP and one TCP and check with wireshark the precedence value



References

- IPv6 configuration:
[http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6/configuration/12-4t/ipv6-12-4t-book/ip6-addrg-
bsc-con.html](http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6/configuration/12-4t/ipv6-12-4t-book/ip6-addrg-bsc-con.html)
- Tunnel 6to4:
[http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6/configuration/12-4t/ipv6-12-4t-book/ip6-
tunnel.html#GUID-26B4E1CE-B36F-4C82-8A38-78199FBCA0DF](http://www.cisco.com/c/en/us/td/docs/ios-xml/ios/ipv6/configuration/12-4t/ipv6-12-4t-book/ip6-tunnel.html#GUID-26B4E1CE-B36F-4C82-8A38-78199FBCA0DF)
- DSCP values:
[http://www.cisco.com/c/en/us/support/docs/quality-of-service-qos/qos-packet-marking/10103-
dscpvalues.html](http://www.cisco.com/c/en/us/support/docs/quality-of-service-qos/qos-packet-marking/10103-dscpvalues.html)
- http://www.cisco.com/en/US/technologies/tk543/tk766/technologies_white_paper09186a00800a3e2f.html
- Policy Based Routing:
http://www.cisco.com/c/en/us/td/docs/ios/12_2/qos/configuration/guide/fqos_c/qcfpbr.html