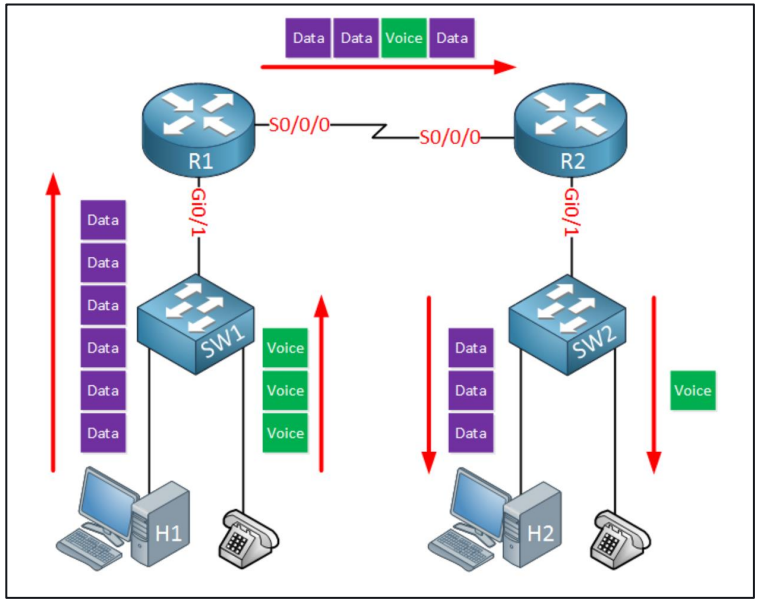
Quality of Service. Port Mirroring

Lecture 7



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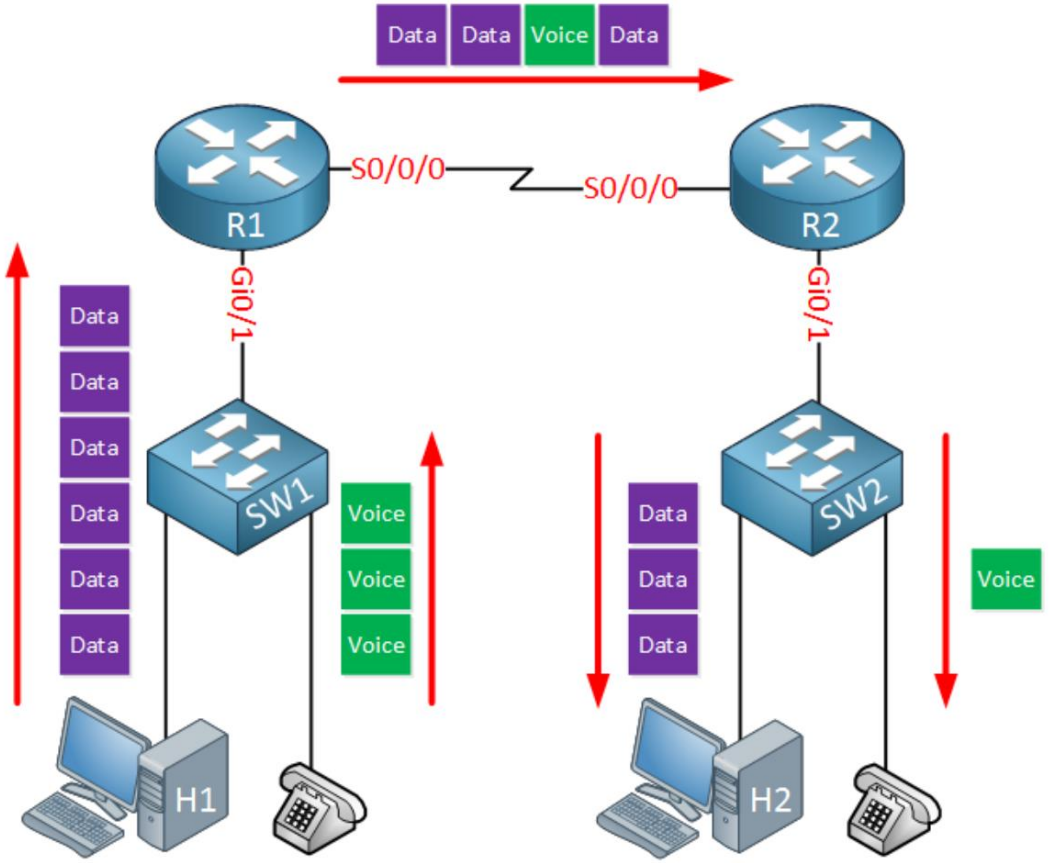
Quality of Service (QoS)

What is QoS?

- Network devices do NOT care about the type of traffic, they need to forward:
  - Switches use destination MAC
  - Routers use routing tables
- The logic in forwarding is simply FIFO (First In First Out)
- **QoS** is a way to prioritize



Characteristics of Network Traffic

- **Bandwidth** - the speed of the link
- **Delay** - the time it takes for a packet to get from the source to the destination (can be one-way or round-trip delay)
- **Jitter** - the variation of the one-way delay for each packet
- **Loss** - the amount of the lost data

Traffic and Application Types

- Non-interactive application (a.k.a. batch application), for example - downloading a file
  - bandwidth, delay, jitter, loss
- Interactive application, for example Telnet or SSH
  - bandwidth, delay, jitter, loss
- Voice and video application
  - bandwidth, delay, jitter, loss

QoS Tools

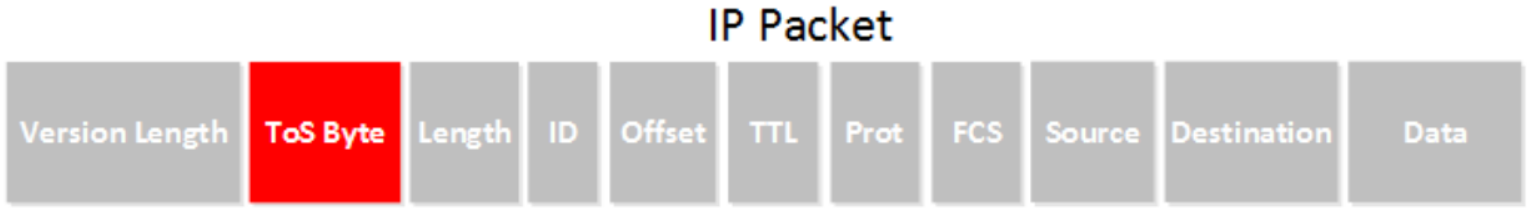
- Classification and marking
- Queuing
- Policing and shaping
- Congestion avoidance

Classification and Marking

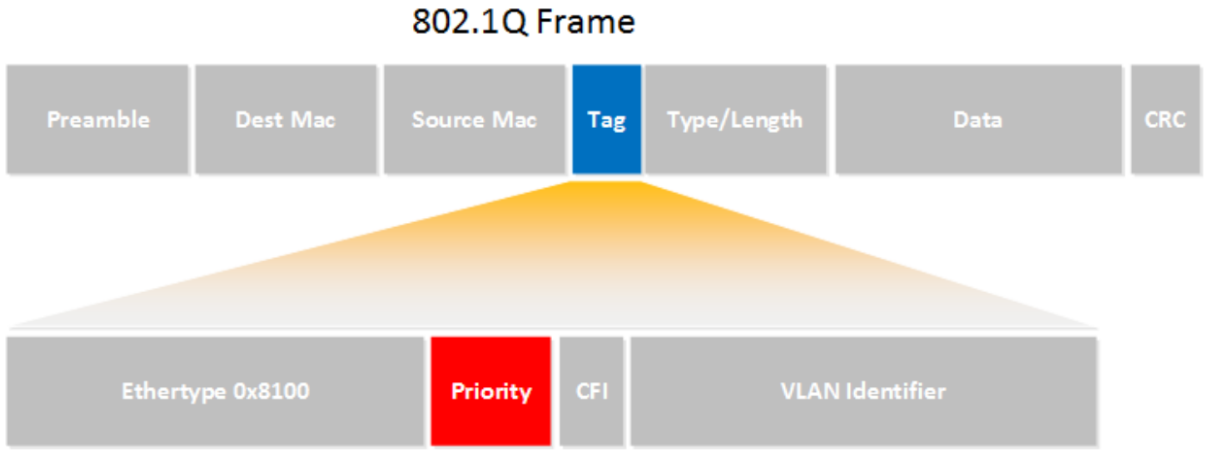
- For each packet to have different treatment, we have to first identify and mark them
- There are different methods to classify a packet:
  - Header inspection - looks for MAC, IP, port numbers
  - Payload inspection - looks inside the packet, making deep packet inspection.
  - On Cisco routers, this is done with **NBAR** (**N**etwork-**B**ased **A**pplication **R**ecognition)

Classification and Marking (2)

- Once classified, we need to mark the packet or frame
  - For L3 packets, we modify the ToS field:



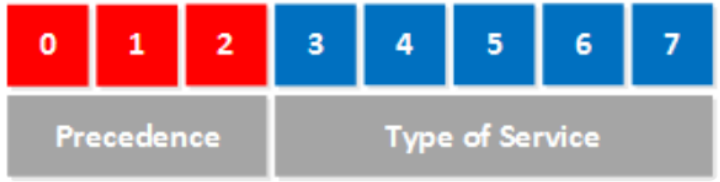
  - For L2 frames, we modify the Priority field (for trunks only):



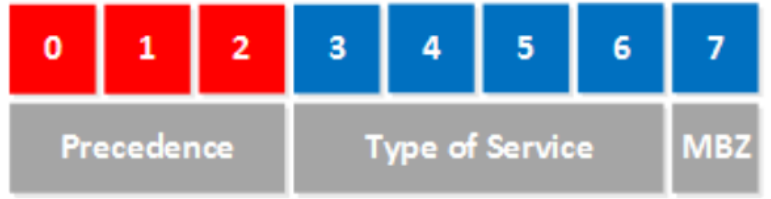
IP Precedence

- Originally, only the precedence in the ToS byte was used:

TOS Byte (back in 1981)



TOS Byte (back in 1992)

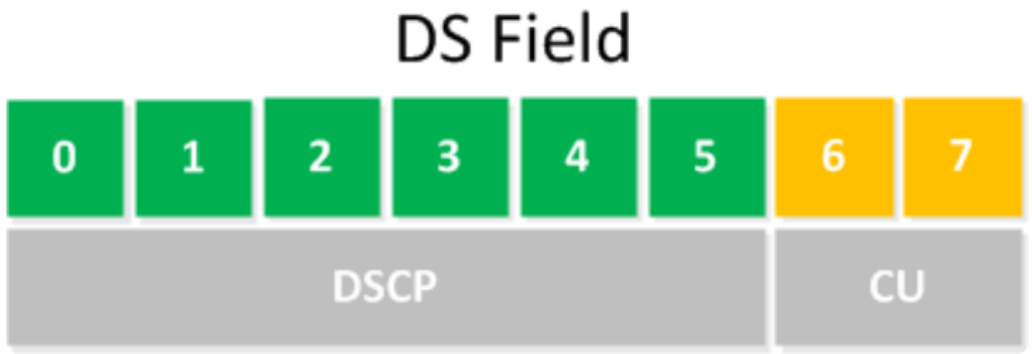


- The possible values for precedence:

IP Precedence	Decimal value	Bit pattern
Routine	0	000
Priority	1	001
Immediate	2	010
Flash	3	011
Flash Override	4	100
Critical	5	101
Internetwork Control	6	110
Network Control	7	111

Differentiated Services

- In 1998, the ToS filed gets a new name: DS field
- The first 6 bits set a **code point** which affects the Per Hop Behavior
- **DSCP**: **D**ifferentiated **S**ervices **C**ode **P**oint
- DSCP PHB (Per Hop Behavior) options:
  - Default PHB
  - Class-Selector PHB
  - Assured Forwarding PHB
  - Expedited Forwarding PHB



Default PHB

- The default PHB means that we have a packet that is marked with a DSCP value of **000000**
- This packet should be treated as "best effort"

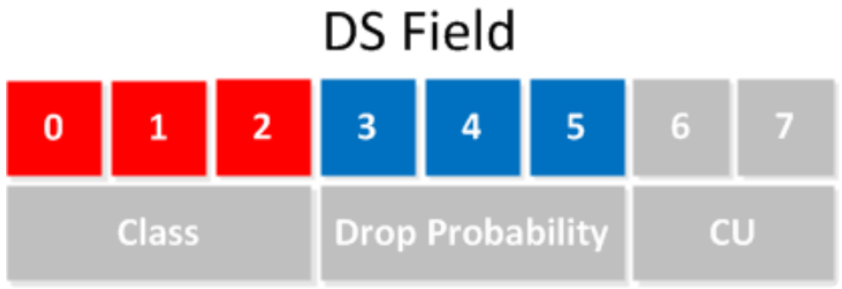
Class-Selector PHB

- Used for compatibility between precedence-capable devices and DSCP-capable devices (the only used bits are the first 3)

Class selector name	DSCP value	IP Precedence value	IP Precedence name
Default / CS0	000000	000	Routine
CS1	001000	001	Priority
CS2	010000	010	Immediate
CS3	011000	011	Flash
CS4	100000	100	Flash Override
CS5	101000	101	Critical
CS6	110000	110	Internetwork Control
CS7	111000	111	Network Control

Assured Forwarding PHB

- **AF** has two functions - queueing and congestion avoidance



Drop probability	Class 1	Class 2	Class 3	Class 4
Low	001010 AF11	010010 AF21	011010 AF31	100010 AF41
Medium	001100 AF12	010100 AF22	011100 AF32	100100 AF42
High	001110 AF13	010110 AF23	011110 AF33	100110 AF43

Expedited Forwarding PHB

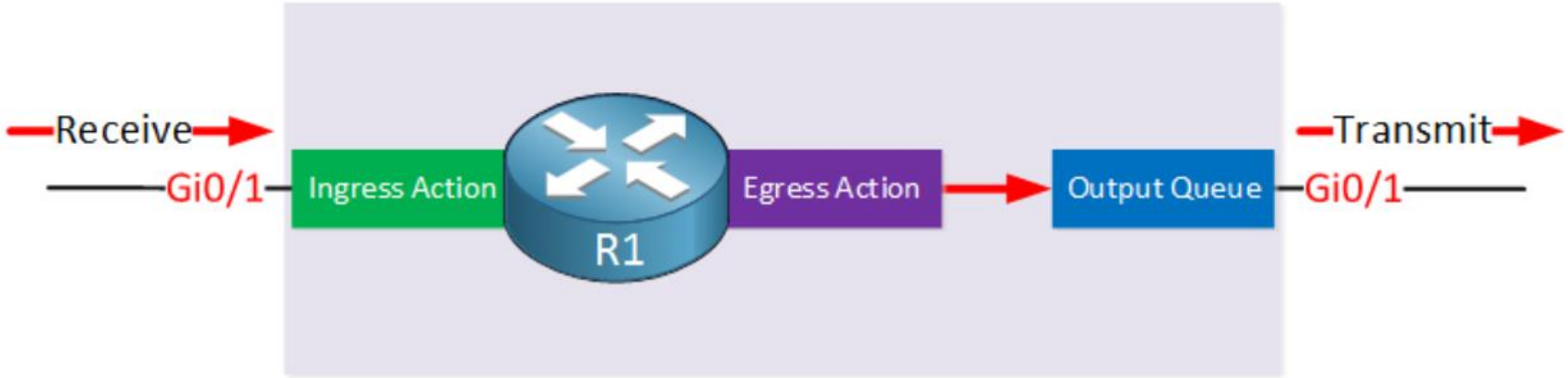
- The DSCP value is normally called "**EF**"
- **EF** has two functions - queueing and policing
- These packets experience minimum delay and packet loss
- We need to set a **rate limit** for this priority queue, because it can "eat" the entire bandwidth
- The real-time application packets (like VoIP) should be here
- In binary it is **101110**, the decimal value is **46**

QoS Tools

- Classification and marking
- Queuing
- Shaping and policing
- Congestion avoidance

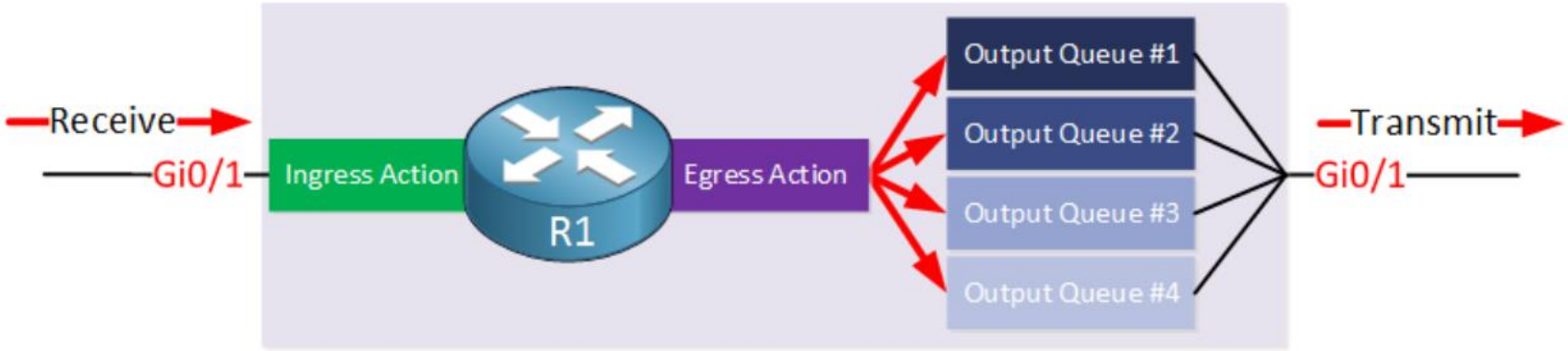
Queuing/Congestion Management

- In a router, after consulting with the routing table, the router will put a packet in an interface's queue
  (same applies for a switch, with frames)
- Queuing is needed only if there is congestion



Queuing/Congestion Management (2)

- Most network devices has multiple output queues



- Different **scheduling** options exist, for example:
  - FIFO
  - Priority Queuing
  - WFQ (Weighted Fair Queuing)
  - CBWFQ (Class Based Weighted Fair Queuing)

Queuing Mechanisms

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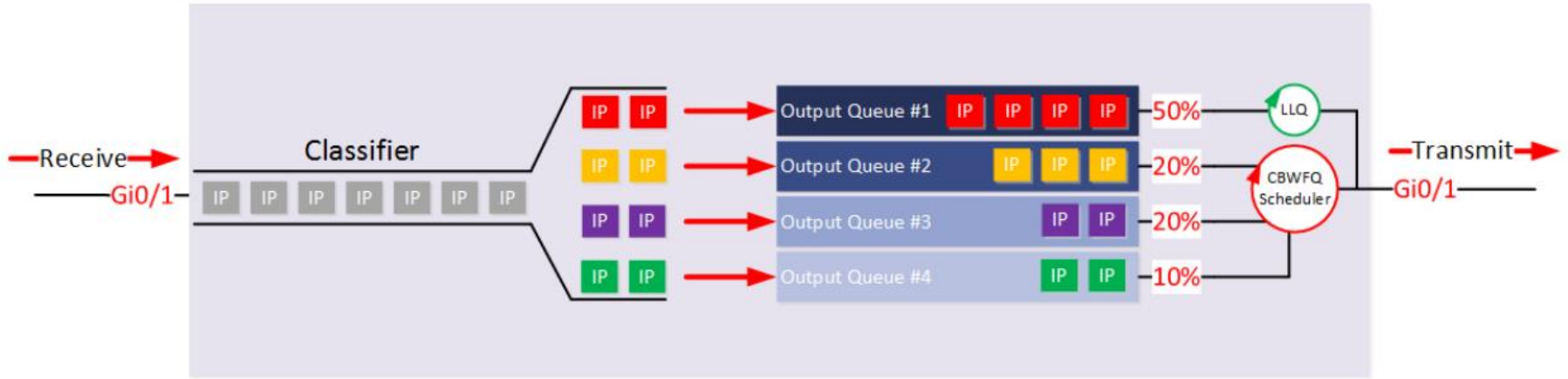
- FIFO (First In First Out)
  - Single queue, not good for voice and video
- PQ (Priority Queuing)
  - 4 queues, served in priority order (high, medium, normal, low)
  - The problem: lower priority queues are served only when higher are empty
- CQ (Custom Queuing)
  - Up to 16 queues, round-robin, provides bandwidth guarantees
  - The problem: the voice traffic has to always wait its turn (because of the round-robin), which results in delay

Queuing Mechanisms (2)

- WFQ (Weighted Fair Queuing)
  - The bandwidth is divided based on **flows** (source and destination IP, port, etc.)
  - A weight is added to the flow
  - Puts priority on small packets (for voice, for example) over large packets
  - The problem: not based on classes and does not provide bandwidth guarantees
- CBWFQ (Class-Based Weighted Fair Queuing)
  - Traffic classes get fair bandwidth guarantees (minimum bandwidth for each class)
  - The problem: provides no priority queue and therefore suitable only for data networks
  - The solution: Additional priority queue – LLQ (Low Latency Queue)

CBWFQ and LLQ

- Voice traffic can be attached to LLQ (Low Latency Queue) in order to be sent immediately
- It is important to limit the LLQ to ensure the other queues get served as well, otherwise **que starvation** will occur



QoS Tools

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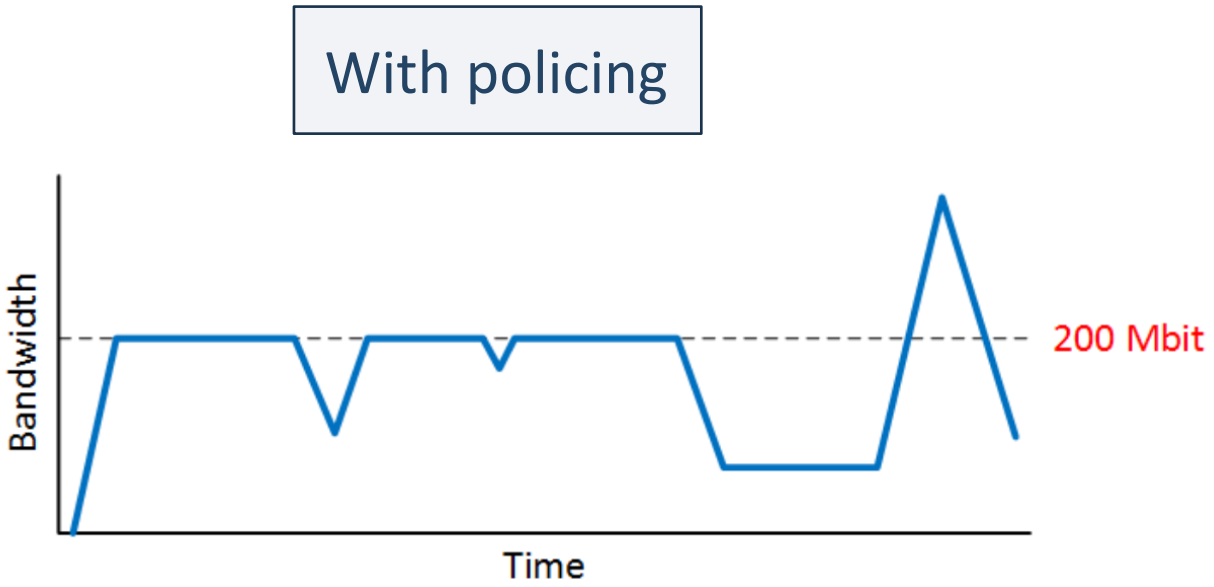
- Queuing
- Policing and shaping
- Congestion avoidance

Policing

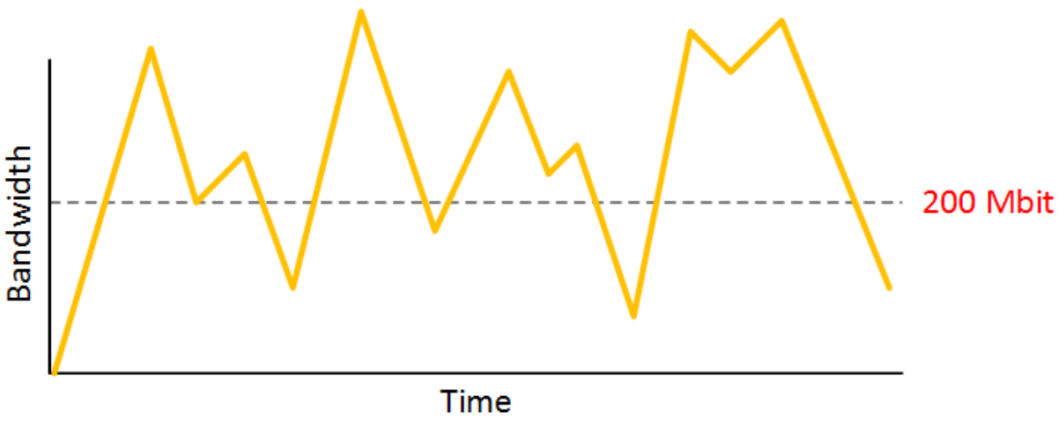
- Policers discard traffic in order to meet the CIR (Committed Information Rate)



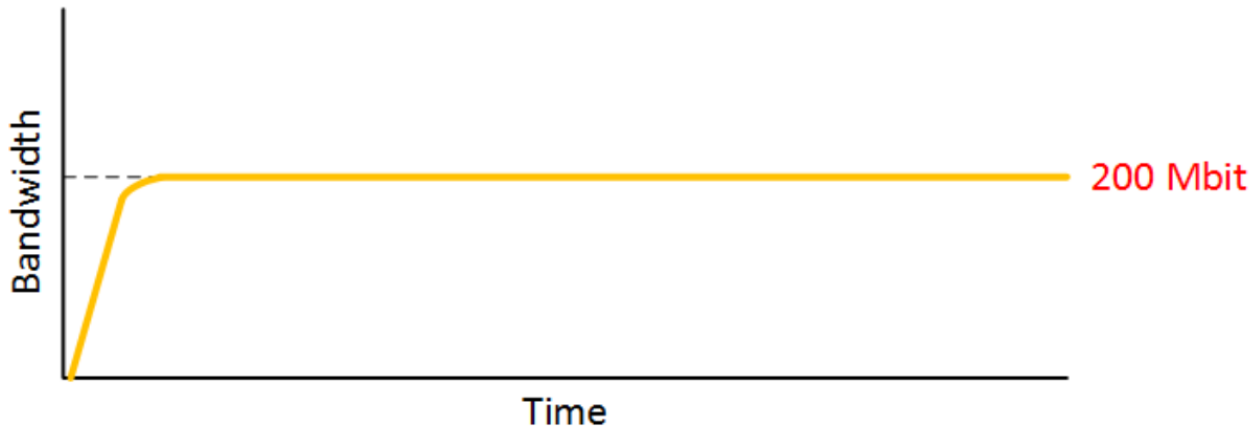
Shaping

- Shapers hold packets in a queue, causing delay
- This prevents the traffic from getting dropped at the other end

Before



After

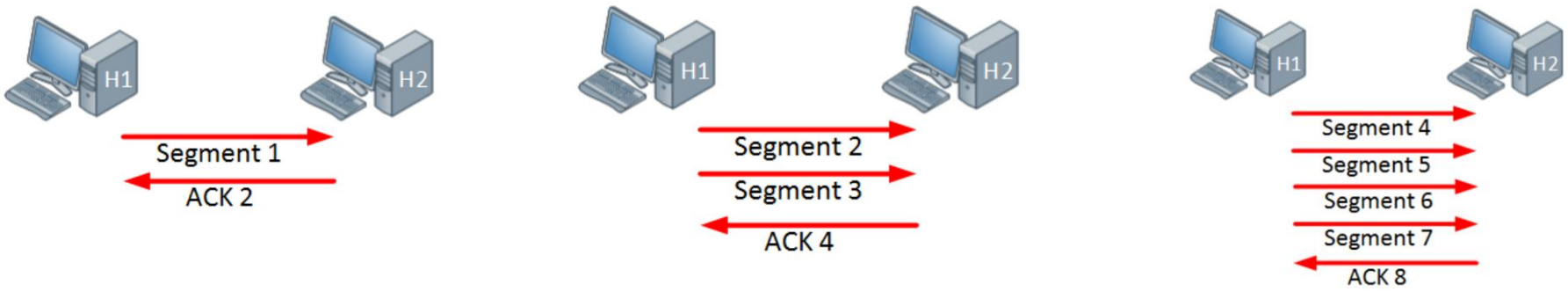


QoS Tools

- Classification and marking
- Queuing
- Shaping and policing
- Congestion avoidance

Congestion Avoidance

- Remember the TCP windowing?

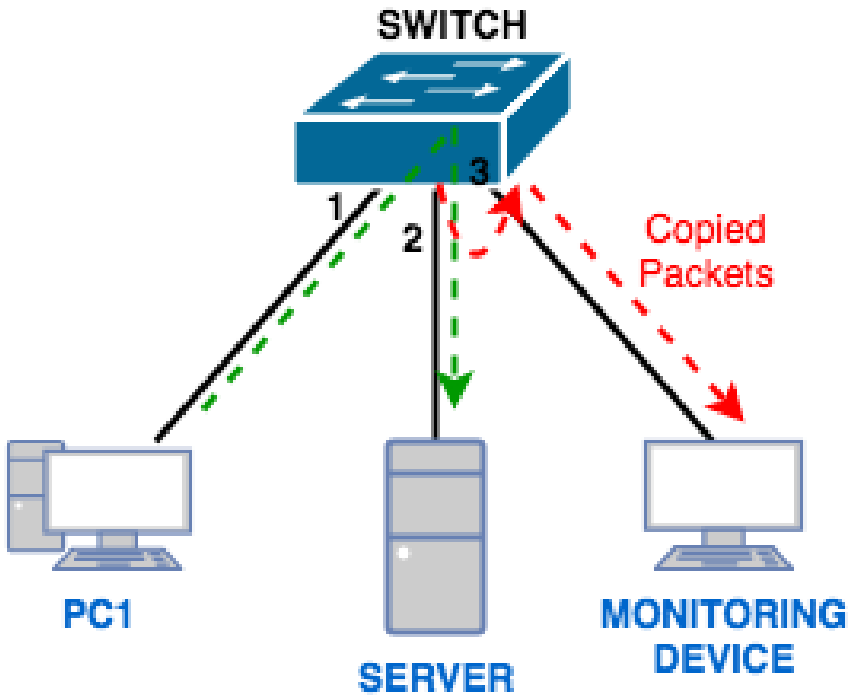


  - Tail drop – when congestion occurs, all packets at the end are dropped
  - This causes **TCP global synchronization**
- With congestion avoidance mechanisms, once the output queue is at certain level, it will drop (random) TCP segments in order to reduce the window size
  - Example: WRED (Weighted Random Early Detection)

Port Mirroring

What is Port Mirroring?

- Also called port monitor or SPAN (Switch Port Analyzer) in Cisco
- Let's you copy all traffic from a source port or source VLAN to a destination interface

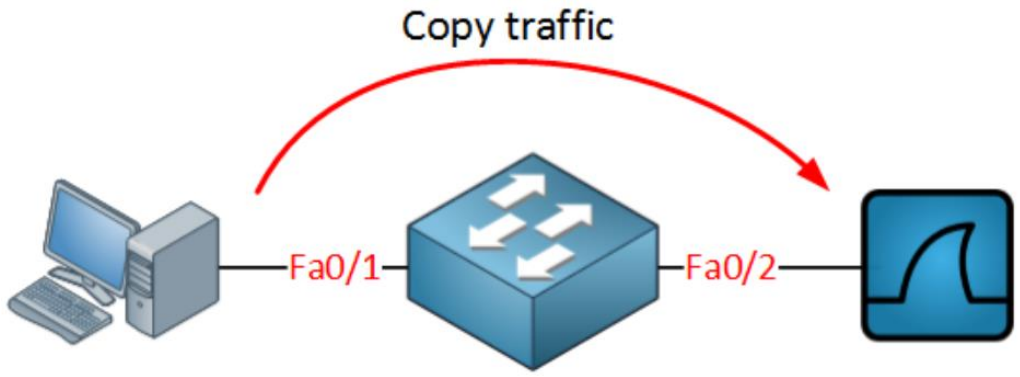


Why Port Mirroring?

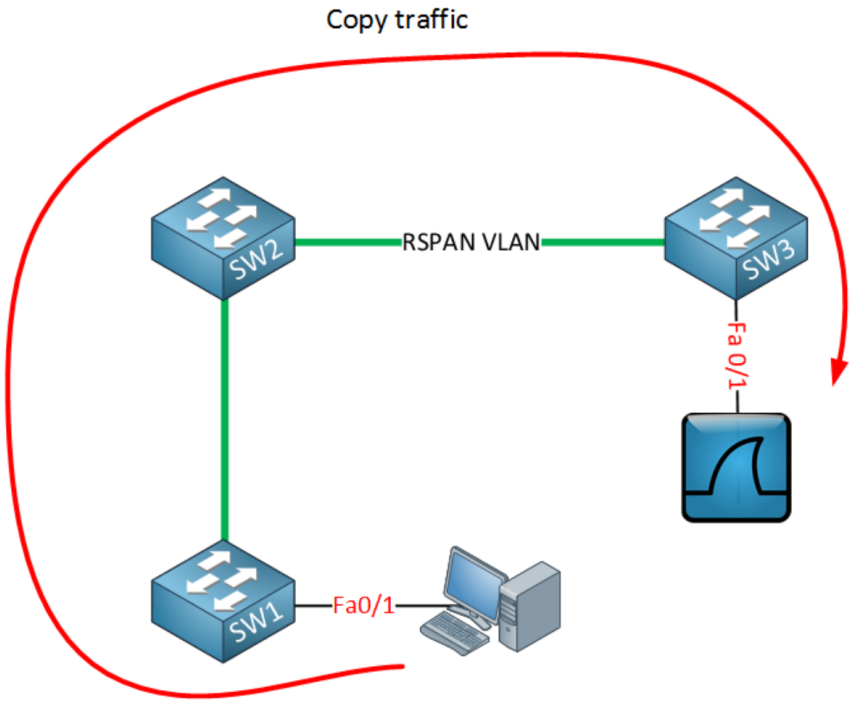
- SPAN can be useful for a number of reasons:
  - If you want to use Wireshark to capture a communication, you need to sniff
  - To redirect all traffic from a VLAN to an IDS/IPS
  - Redirect all VoIP calls from a VLAN so you can record the calls

Types of SPAN

- Local SPAN



- RSPAN - Remote SPAN



SPAN Specifics

- Both SPAN and RSPAN have some specifics:
  - Source interface can be anything - L2/L3 port, access/trunk port, Etherchannel
  - If the source is trunk, all VLANs are copied (no filtering)
  - As source, you can use either ports or VLAN, but cannot mix them
  - Be careful not to overload the destination interface (it is easy!)
  - Some L2 frames, like CDP and STP BPDUs are not copied by default

Demonstration

Summary

1. Quality of service
2. Port mirroring
3. Demonstration

Questions?

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