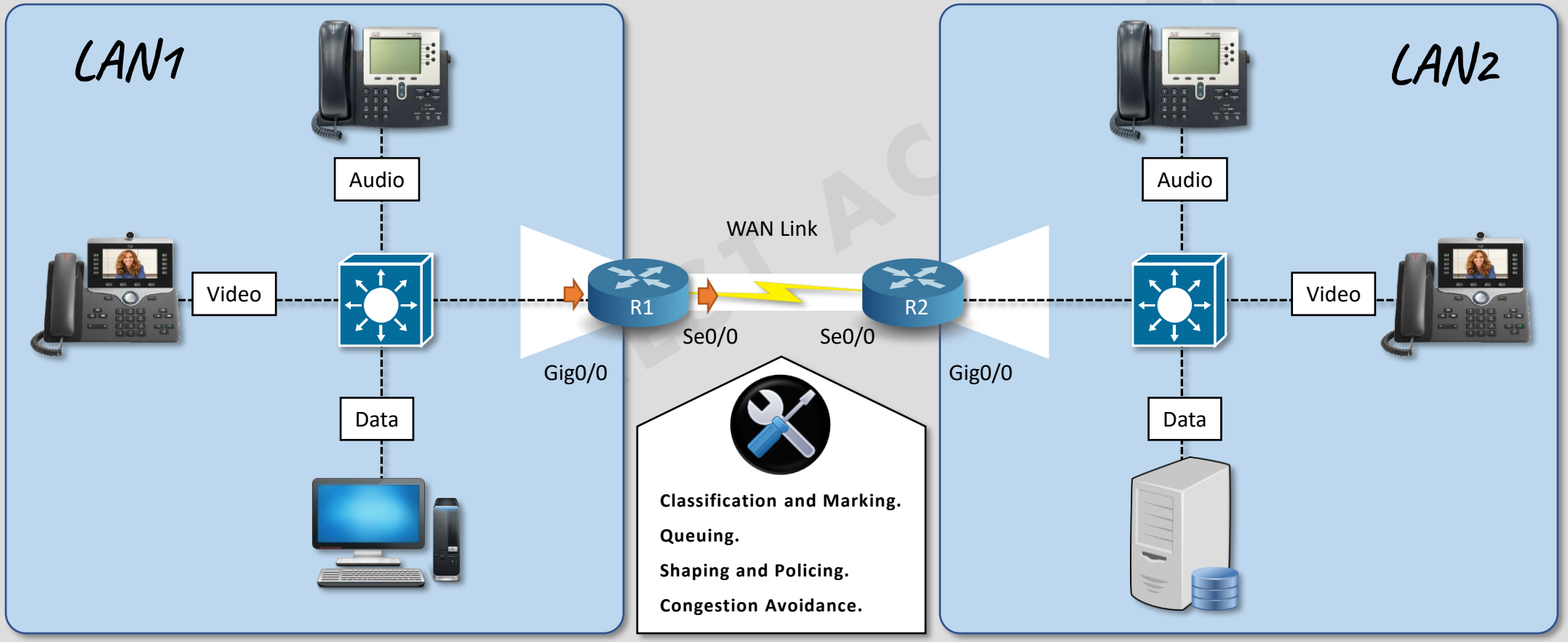
Quality of Service (QoS)

- **Quality of Service (QoS)** is a set of tools that network devices can use to manage four characteristics of network traffic (**Bandwidth**, **Delay**, **Jitter**, and **Loss**) .

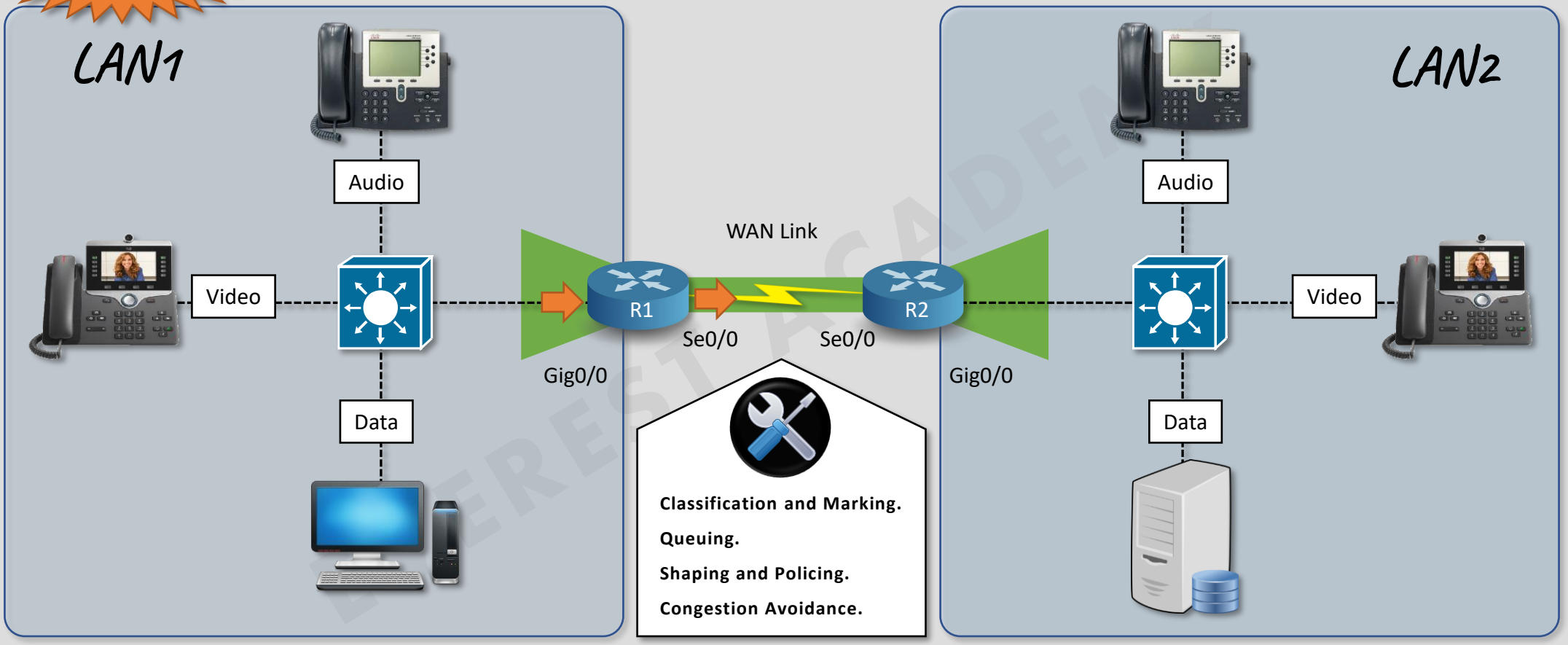


رابط دورة المدخل الى شبكات سيسكو CCNA 200-301 على موقع يودمي , هذه الدورة من إعداد المدرب عبد الرحمن العلوش

عربي

Quality of Service (QoS)

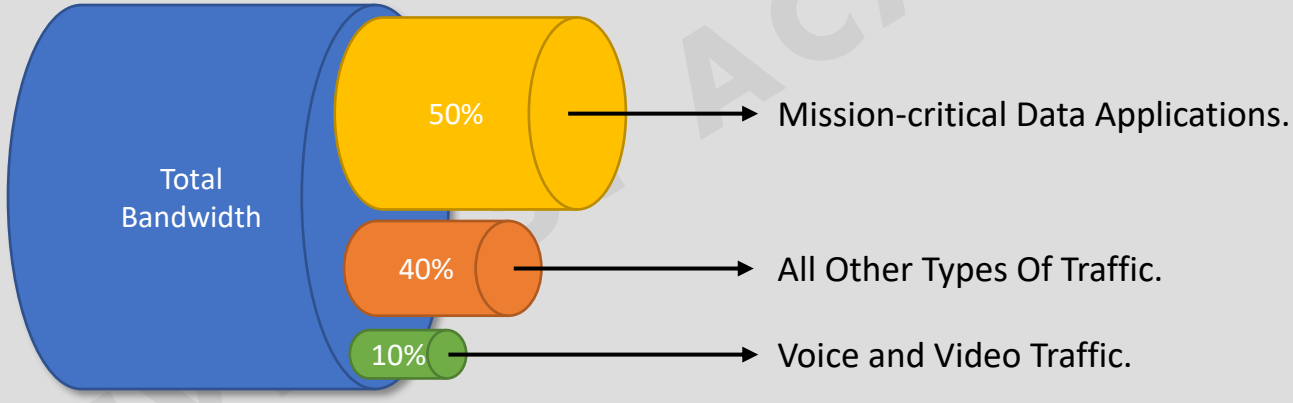
CCNA 200 -301



Quality of Service (QoS)

- **Quality of Service (QoS)** is a set of tools that network devices can use to manage four characteristics of network traffic (**Bandwidth**, **Delay**, **Jitter**, and **Loss**) .

  - **Bandwidth** (capacity of the link) refers to the amount of bits that can be sent over the link per second (Kbps, Mbps, Gbps, etc.). QoS tools determine how much of bandwidth each type of traffic can get over time.



Queuing tool

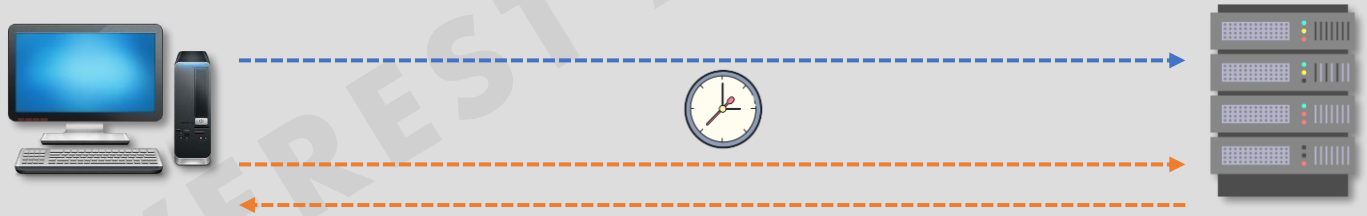
Quality of Service (QoS)

- **Quality of Service (QoS)** is a set of tools that network devices can use to manage four characteristics of network traffic (**Bandwidth**, **Delay**, **Jitter**, and **Loss**) .

  - **Delay:** one-way delay or round-trip delay.

    1. **One-way Delay** refers to the time it takes to send a packet from a source to a destination.

    2. **Round-trip Delay** refers to the time it takes to send one packet between two hosts and receive one back.

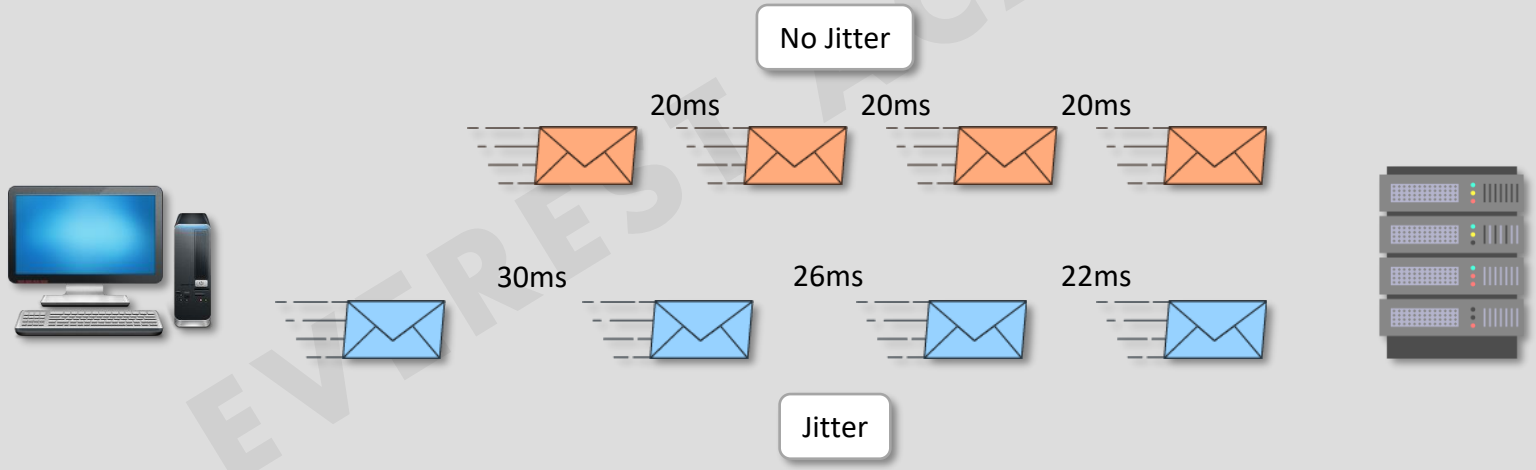


Queuing and shaping tool

Quality of Service (QoS)

- **Quality of Service (QoS)** is a set of tools that network devices can use to manage four characteristics of network traffic (**Bandwidth**, **Delay**, **Jitter**, and **Loss**) .

  - **Jitter** refers to the variation in one-way delay between consecutive packets sent by the same application.



Quality of Service (QoS)

- **Quality of Service (QoS)** is a set of tools that network devices can use to manage four characteristics of network traffic (**Bandwidth**, **Delay**, **Jitter**, and **Loss**) .

  - **Loss** refers to the number of lost messages.

Queuing tool

Quality of Service (QoS)

- **Cisco's** recommendation for interactive **voice** traffic **:**
  - Bandwidth: Bandwidth (30–128Kbps).
  - Delay (one-way): 150ms or less.
  - Jitter: 30ms or less.
  - Loss: 1% or less.

G.711, G.729, etc.

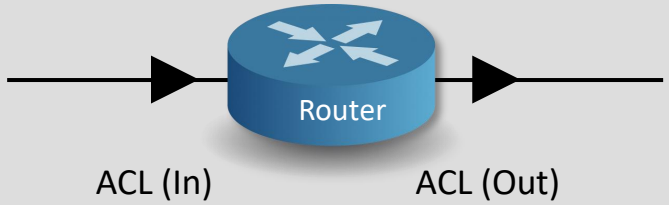
IP Header 20 bytes	UDP Header 8 bytes	RTP Header 12 bytes	Payload (Audio) Variable size depending on codec

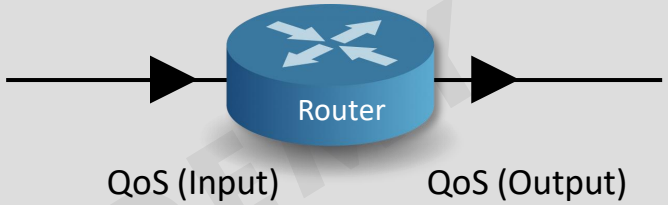
- **Cisco's** recommendation for **video** traffic **:**
  - Bandwidth: 384 Kbps to 20+ Mbps
  - Delay (one-way): 200–400ms
  - Jitter: 30–50ms
  - Loss: 0.1%–1%

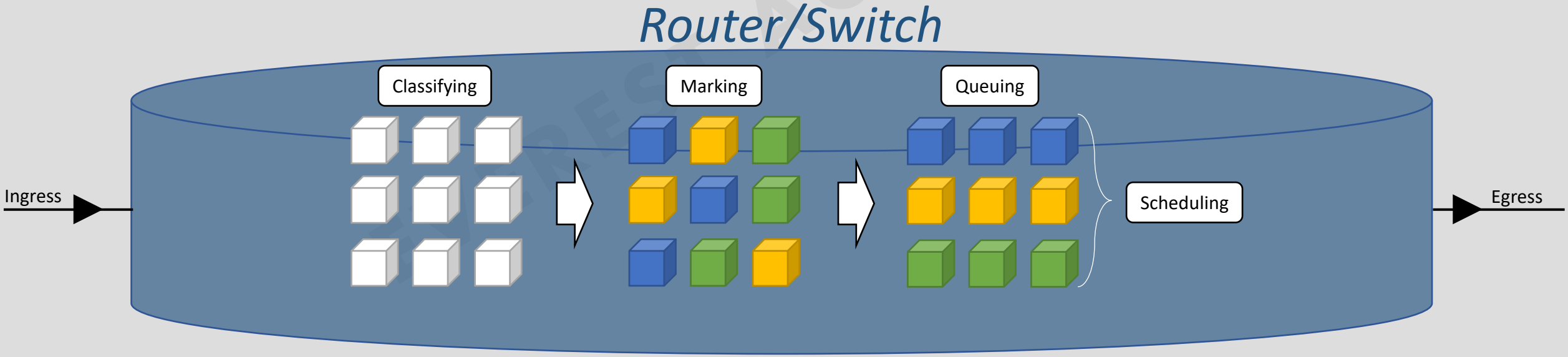
QoS tools

- Classification and Marking.
- Queuing.
- Shaping and Policing.
- Congestion Avoidance.

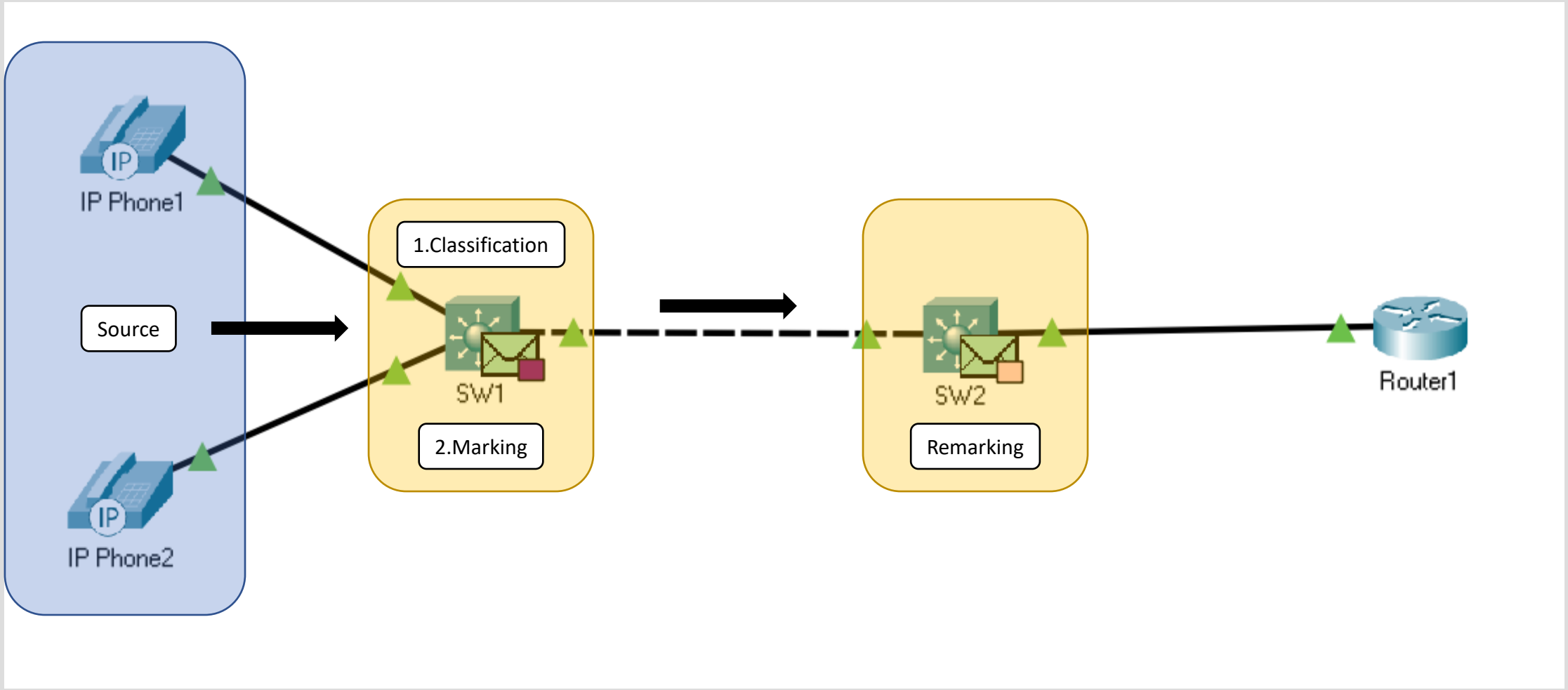
Classification and Marking





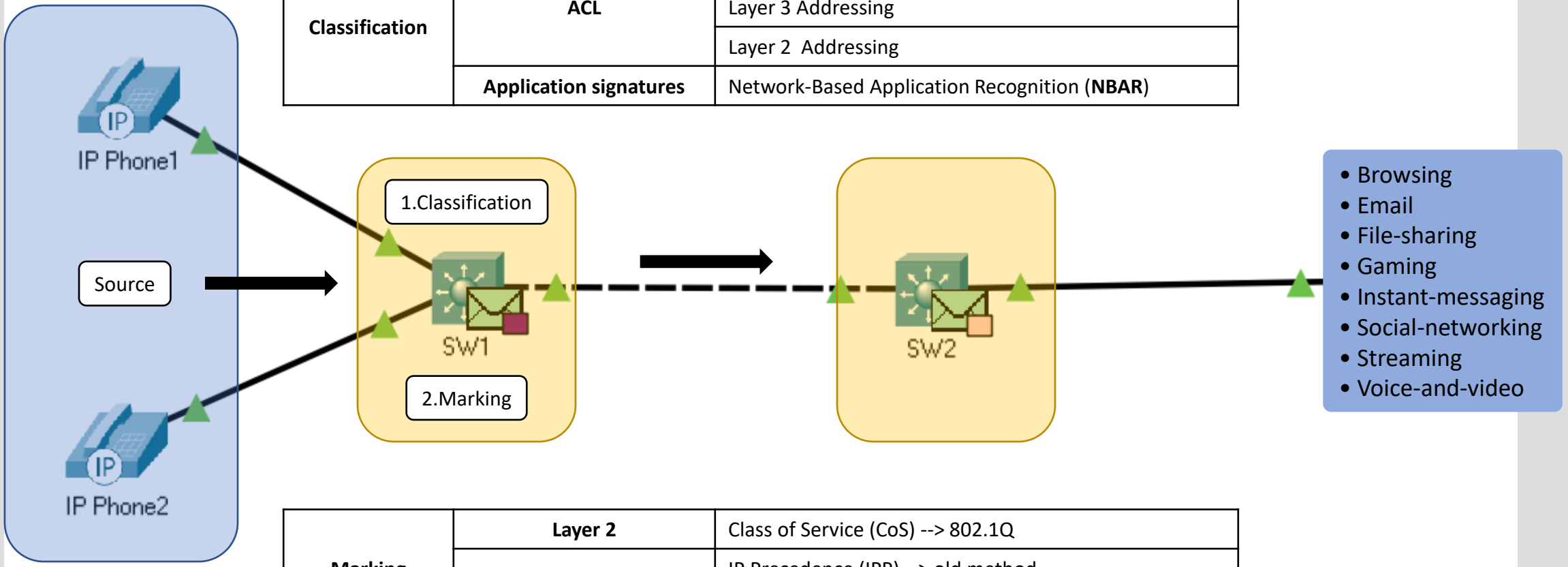


Classification and Marking



Classification and Marking

Classification	**ACL**	Layer 4 (source and destination port number)
		Layer 3 Addressing
		Layer 2 Addressing
	Application signatures	Network-Based Application Recognition (**NBAR**)



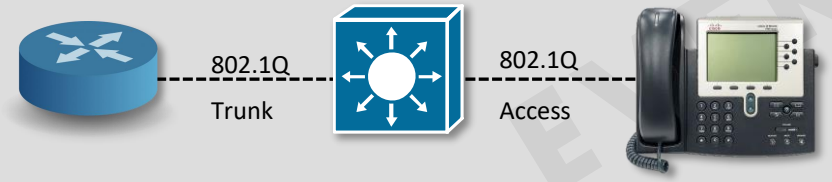
Marking	**Layer 2**	Class of Service (CoS) --> 802.1Q
	Layer 3	IP Precedence (IPP) --> old method
		Differentiated Services Code Point (DSCP)

Marking : Class of Service (CoS)

Ethernet 802.1Q Header

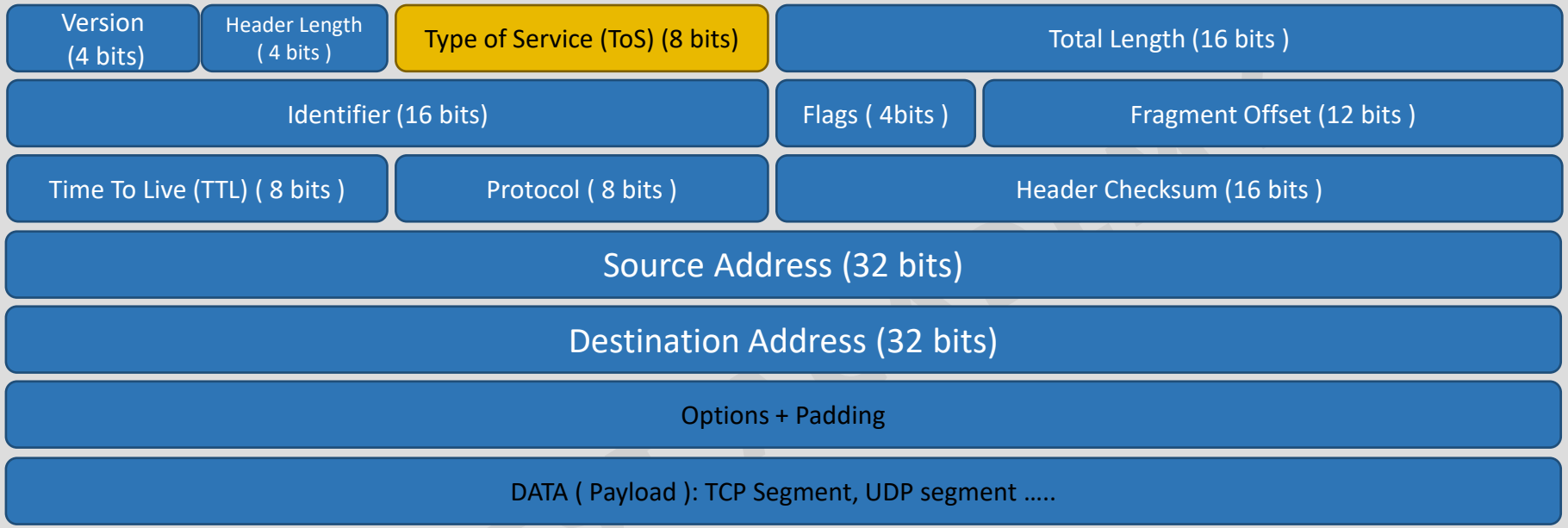
Tag Protocol Identifier (TPID)	**Priority Code Point (PCP)**	Drop Eligible Indicator	VLAN Identifier
(0x8100) 16 bits	**3 bits**	1 bit	12 bits

<<---------- Tag Control Information (TCI) ---------->>



Priority	Application
(000) --> **0**	**Best-effort data (Default)**
(001) --> 1	Medium-priority
(010) --> **2**	**High-priority (critical data application)**
(011) --> **3**	**Call signaling**
(100) --> **4**	**Video conferencing**
(101) --> **5**	**Voice**
(110) --> 6	Reserved
(111) --> 7	Reserved

Marking : Type of Service (ToS)



X	X	X					
IP Precedence (IPP)							

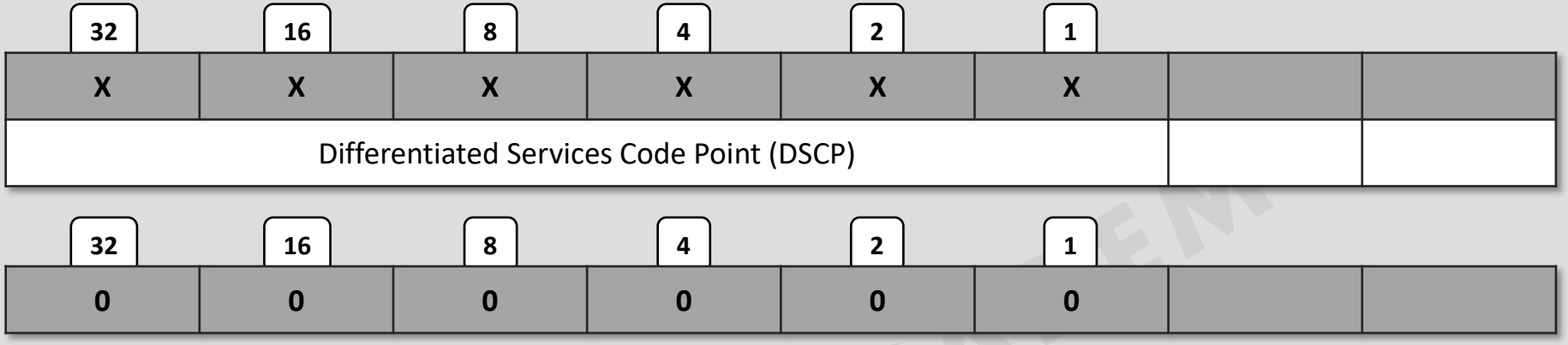
X	X	X	X	X	X		
Differentiated Services Code Point (DSCP)							

IP Precedence (IPP)

X	X	X					
IP Precedence (IPP)							

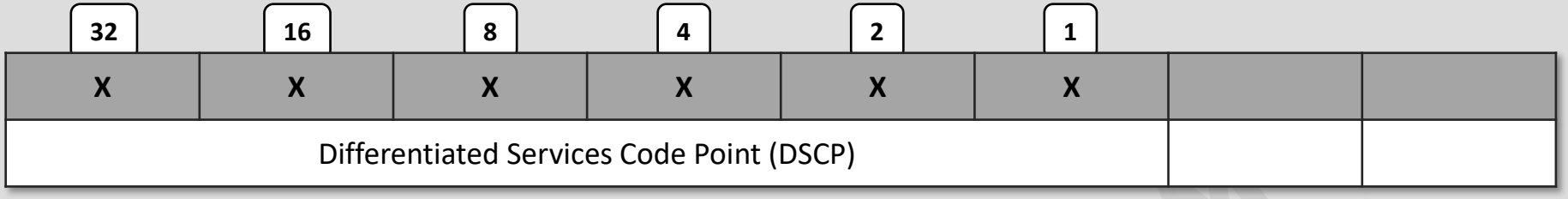
Values	Description
(000) --> **0**	**Routine or Best Effort**
(001) --> 1	Priority
(010) --> 2	Immediate
(011) --> **3**	**Flash (mainly used for Voice Signaling)**
(100) --> 4	Flash Override
(101) --> **5**	**Critical (mainly used for Voice RTP)**
(110) --> 6	Internetwork Control
(111) --> 7	Network Control

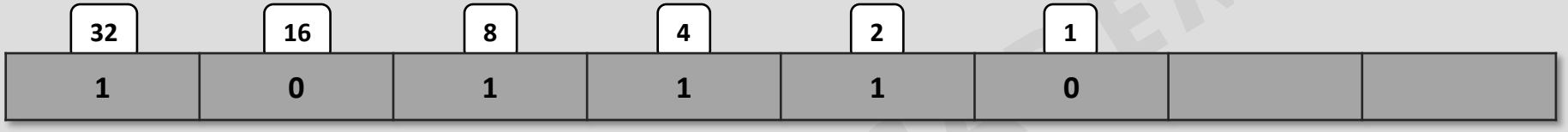
Differentiated Services Code Point (DSCP)



- **Default Forwarding (DF)** or **Best-Effort (BE)** : (000 000) --> 0

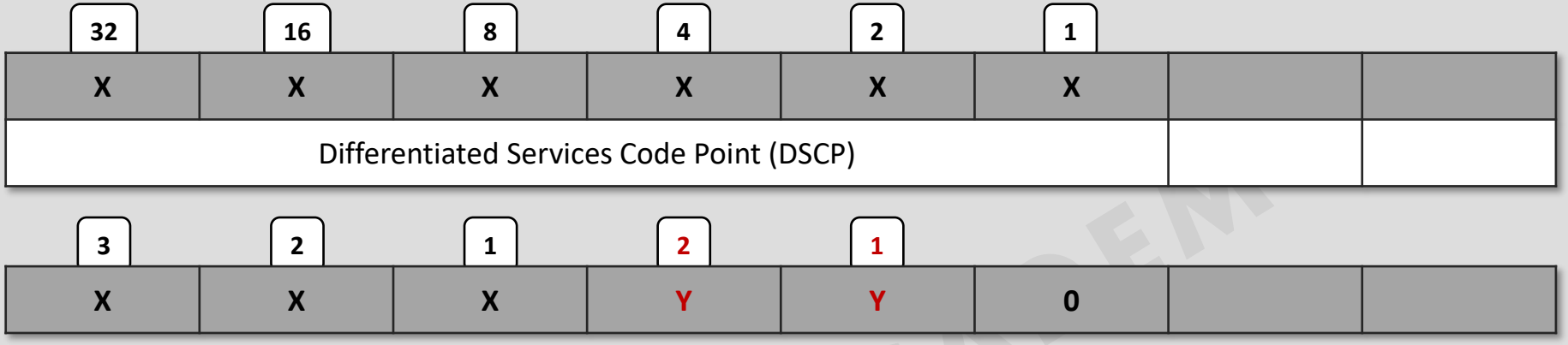
Differentiated Services Code Point (DSCP)





- **Expedited Forwarding (EF)** : (101 110) --> 46 = 32 + 8 + 4 + 2,
  - Is a single value used for packets that need low delay, low jitter, and low loss (Voice payload).
  - By default, Cisco IP Phones mark at layer 3 **voice payload** with **EF**, and mark **voice signaling** packets sent by the phone with another value called **CS3**.

Differentiated Services Code Point (DSCP)

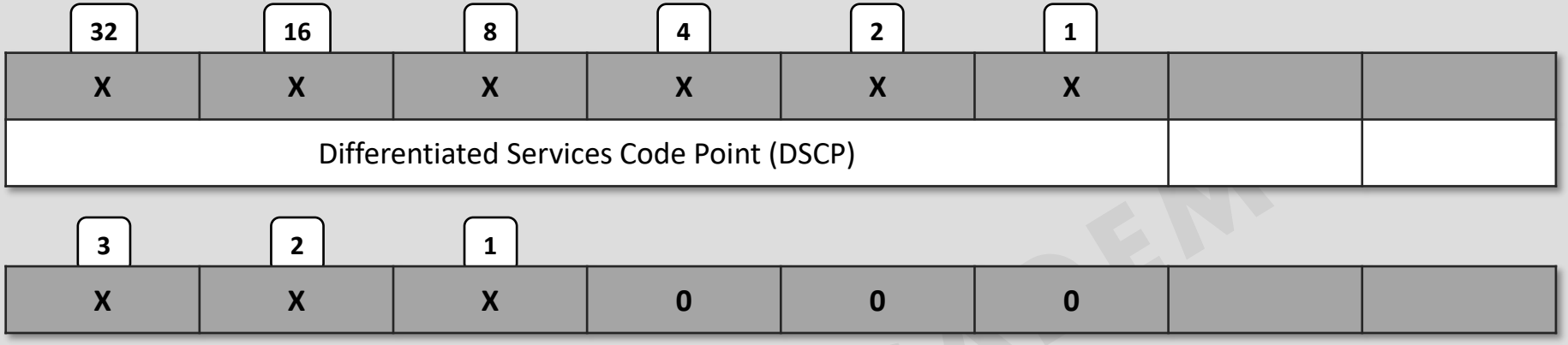


- **Assured Forwarding (AF)** :
  - defines **four** separate queues (classes) in a queuing system.
  - defines **three** levels of drop priority within each queue for use with congestion avoidance tools.

	Low Drop Probability	Medium Drop Probability	High Drop Probability
Highest Queue Priority ↑ Lowest Queue Priority	AF41 (34) --> 100 010	AF42 (36) --> 100 100	AF43 (38) --> 100 110
	AF31 (26) --> 011 010	AF32 (28) --> 011 100	AF33 (30) --> 011 110
	AF21 (18) --> 010 010	AF22 (20) --> 010 100	AF23 (22) --> 010 110
	AF11 (10) --> 001 010	AF12 (12) --> 001 100	AF13 (14) --> 001 110

❖ Formula for figuring out Decimal Values for DSCP: 8X + 2Y , X = Class Selector, Y = Drop Precedence.

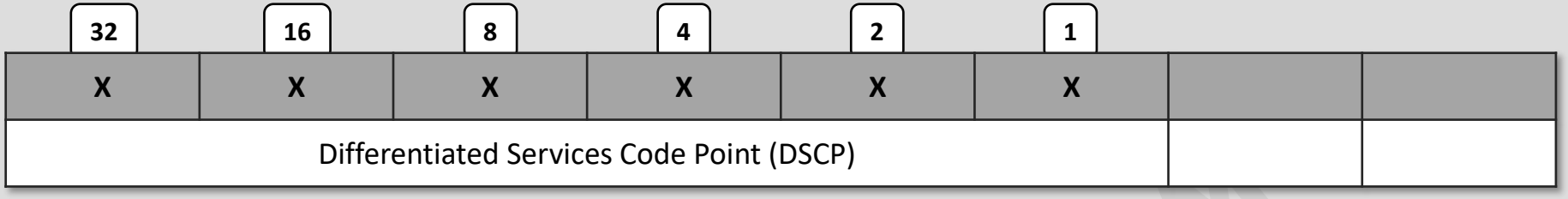
Differentiated Services Code Point (DSCP)



- **Class Selector (CS)**:
  - Defines eight DSCP values for backward compatibility with IPP values.

CS Value	IP Precedence Value	DSCP Value
CS0	0	0
CS1	1	8
CS2	2	16
CS3	3	24
CS4	4	32
CS5	5	40
CS6	6	48
CS7	7	56

Guidelines for DSCP Marking Values

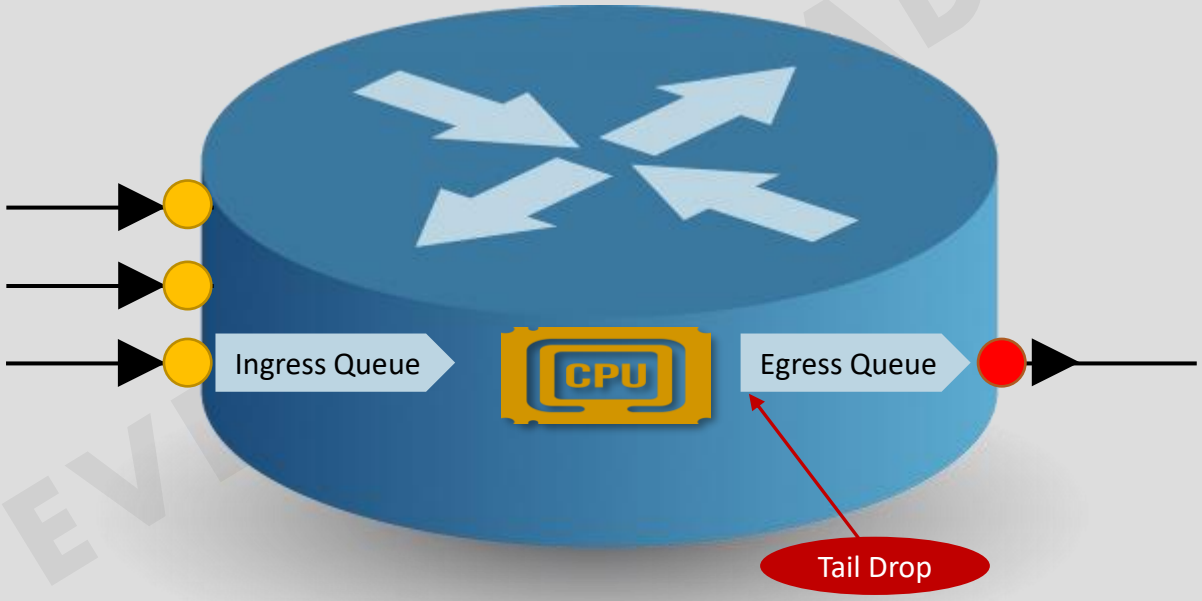


- **Standard Recommendations:**
  - **EF**: Voice payload.
  - **AF4x**: Interactive video (for example, videoconferencing).
  - **AF3x**: Streaming video.
  - **AF2x**: High priority data.
  - **CS0**: Standard data.

Congestion Management

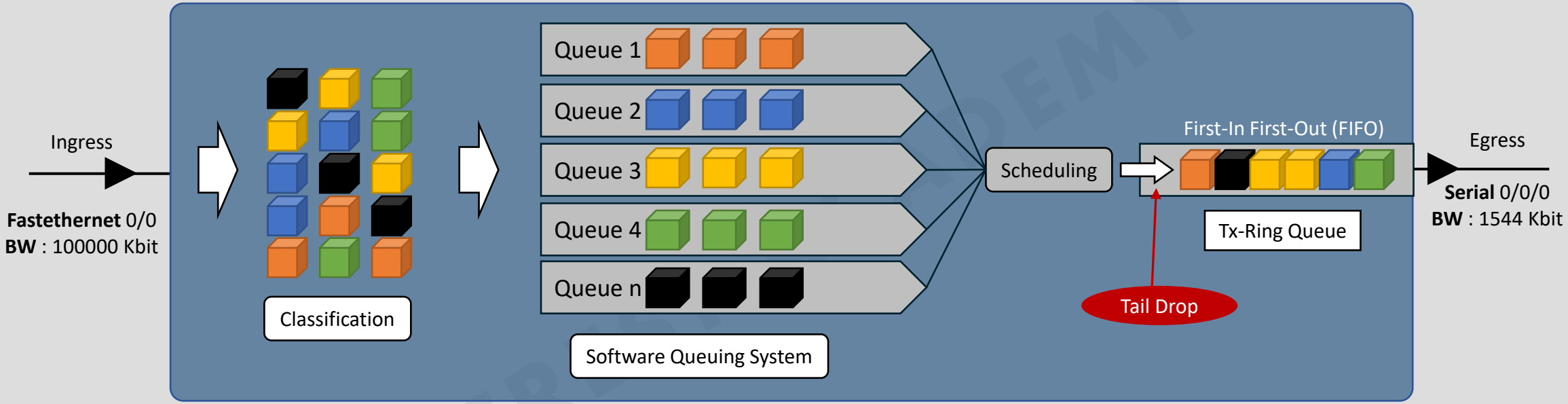
Congestion Management :

- Queuing.
- Scheduling.



- Hardware Queue (Tx-Ring Queue).
- Software Queue.

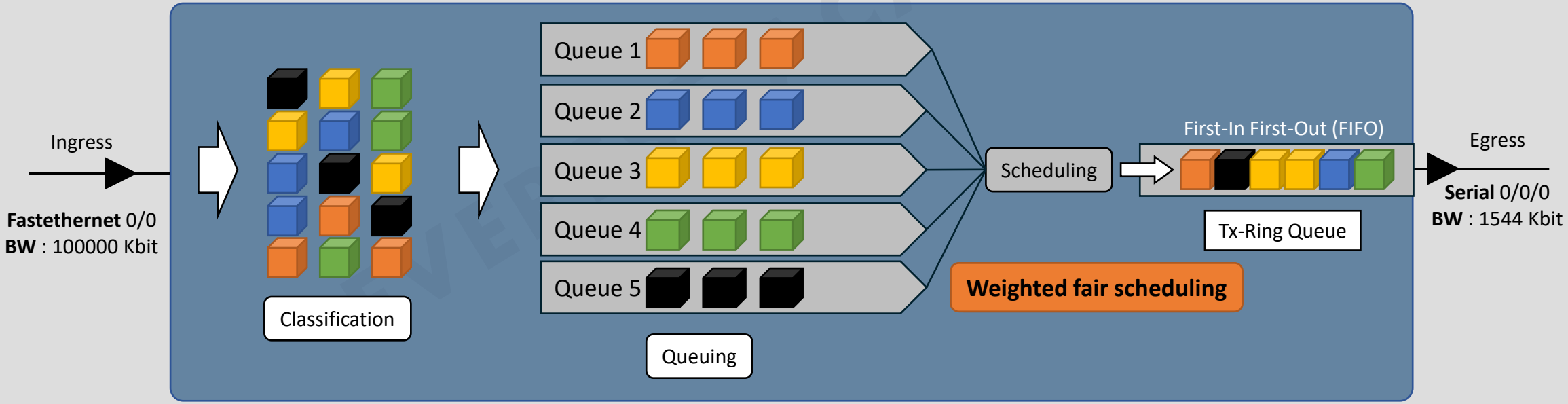
Congestion Management



Scheduling Mechanisms

❑ **Scheduling mechanisms :**

- Strict priority scheduling.
- Round-robin scheduling.
- Weighted fair scheduling.



Software Queuing Methods

1) First In First Out (FIFO) Queuing.

2) Priority Queuing (PQ).

3) Custom Queuing (CQ).

4) Weighted Fair Queuing (WFQ).

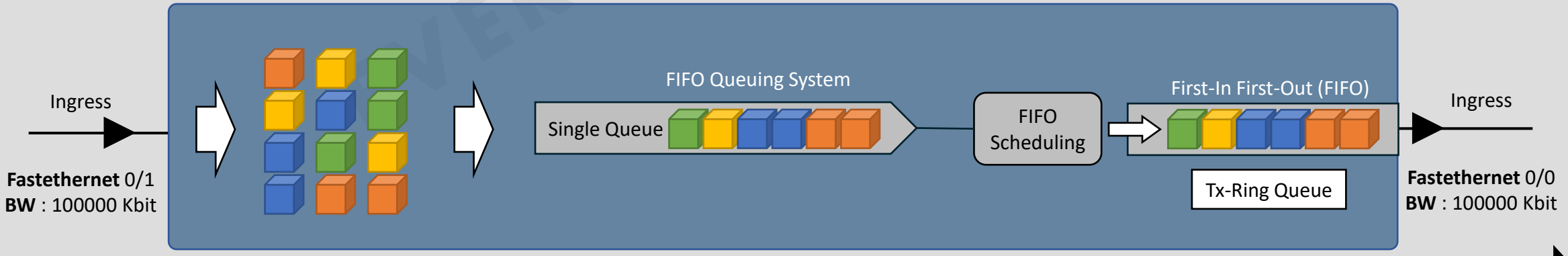
5) Class-Based WFQ (CBWFQ).

6) Low-Latency Queuing (LLQ) .

Software Queuing Methods

1) First In First Out (FIFO) Queuing.

```
R1#show interfaces fastEthernet 0/0
FastEthernet0/0 is up, line protocol is up (connected
  Hardware is Lance, address is 00e0.8f29.4b01 (bia 0
  Internet address is 192.168.1.1/24
  MTU 1500 bytes, BW 100000 Kbit, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation ARPA, loopback not set
  Full-duplex, 100Mb/s, media type is RJ45
  ARP type: ARPA, ARP Timeout 04:00:00,
  Last input 00:00:08, output 00:00:05, output hang r
  Last clearing of "show interface" counters never
  Input queue: 0/75/0 (size/max/drops); Total output
  Queueing strategy: fifo
  Output queue :0/40 (size/max)
  5 minute input rate 21 bits/sec, 0 packets/sec
  5 minute output rate 21 bits/sec, 0 packets/sec
     659 packets input, 26789 bytes, 0 no buffer
```

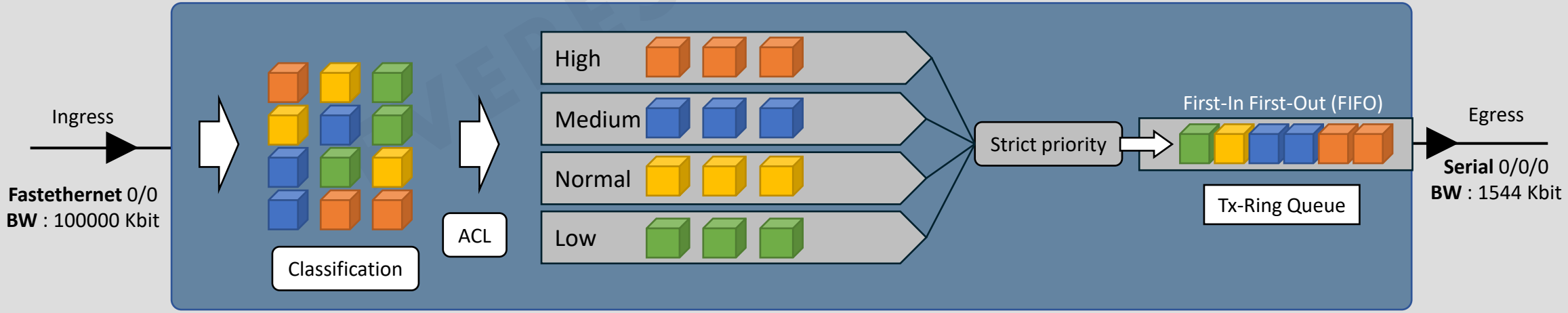


Software Queuing Methods

2) Priority Queuing (PQ).

- High
- Medium
- Normal (default)
- Low

```
access-list 101 permit tcp  any nay eq 80
access-list 102 permit tcp  any any eq 23
access-list 103 permit udp any any eq 53
access-list 104 permit ip     any any
!----------
priority-list 1 protocol ip high       list 101
priority-list 1 protocol ip medium list 102
priority-list 1 protocol ip normal   list 103
priority-list 1 protocol ip low         list 104
priority-list 1 default normal
priority-list 1 queue-limit 20 40 60 80
!-----------
interface Serial0/0/0
priority-group 1
```

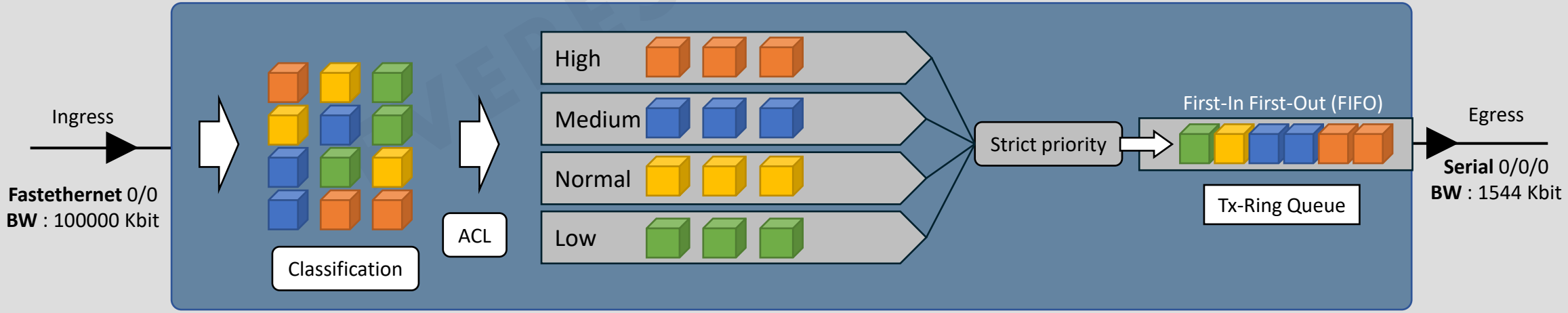


Software Queuing Methods

2) Priority Queuing (PQ).

- High
- Medium
- Normal (default)
- Low

```
R1#show interfaces serial 0/0/0
Serial0/0/0 is up, line protocol is up (connected)
  Hardware is HD64570
  Internet address is 200.1.1.1/24
  MTU 1500 bytes, BW 1544 Kbit, DLY 20000 usec,
     reliability 255/255, txload 1/255, rxload 1/255
  Encapsulation HDLC, loopback not set, keepalive set (10 sec)
  Last input never, output never, output hang never
  Last clearing of "show interface" counters never
  Input queue: 0/75/0 (size/max/drops); Total output drops: 0
  Queueing strategy: priority-list 1
  Output queue (queue priority: size/max/drops):
     high: 0/20/0, medium: 0/40/0, normal: 0/60/0, low: 0/80/0
  5 minute input rate 12 bits/sec, 0 packets/sec
  5 minute output rate 12 bits/sec, 0 packets/sec
     16 packets input, 516 bytes, 0 no buffer
     Received 0 broadcasts, 0 runts, 0 giants, 0 throttles
     0 input errors, 0 CRC, 0 frame, 0 overrun, 0 ignored, 0 abort
```

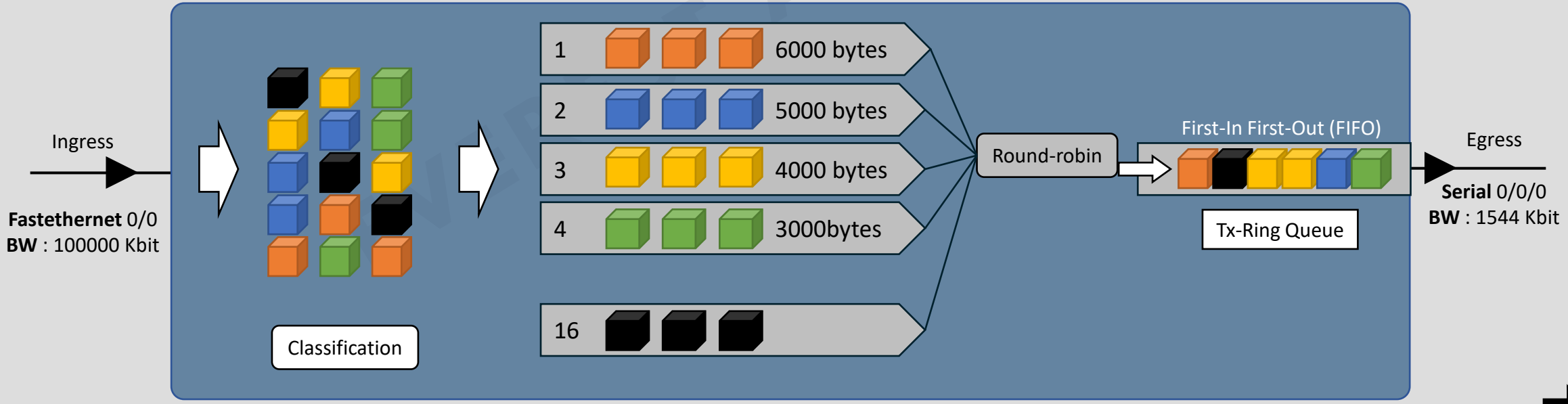


Software Queuing Methods

3) Custom Queuing (CQ).

- CQ supports a maximum of 16 queues.
- Each queue has different number.

```
queue-list 1 protocol ip 1 tcp 433
queue-list 1 protocol ip 2 tcp 80
queue-list 1 protocol ip 3 udp 53
queue-list 1 protocol ip 4 tcp 23
!---------------------------------------
queue-list 1 queue 1 byte-count 6000
queue-list 1 queue 2 byte-count 5000
queue-list 1 queue 3 byte-count 4000
queue-list 1 queue 4 byte-count 3000
!---------------------------------------
interface Serial0/0/0
custom-queue-list 1
```

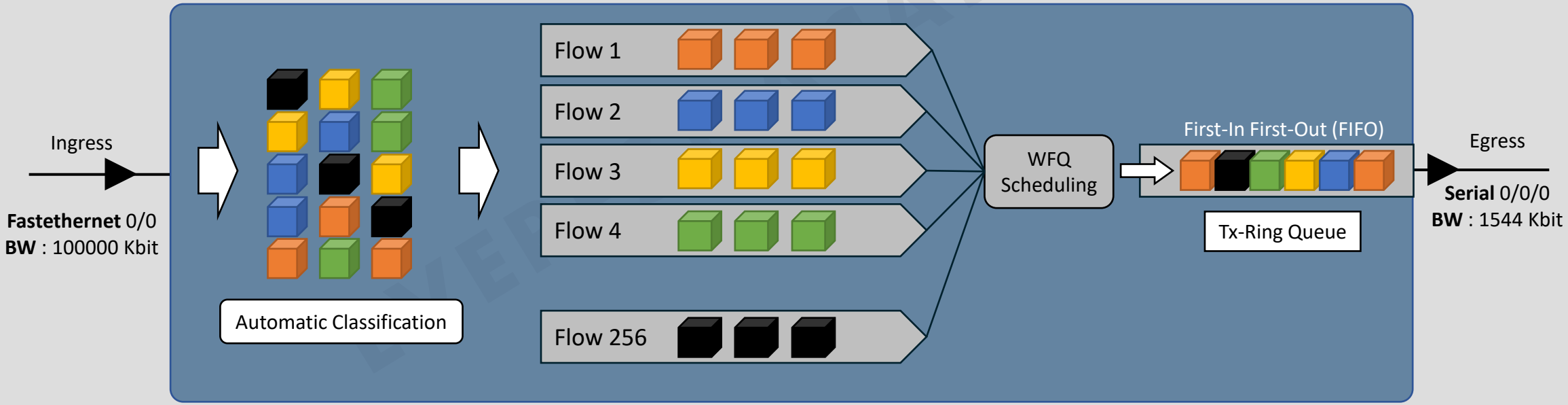


Software Queuing Methods

4) Weighted Fair Queuing (WFQ) ---> Serial Interface (2.048 Mbps or less) .

- Source and Destination IP address.
- Source and Destination TCP (or UDP) port.
- IP Protocol number.
- Type of Service value (IP Precedence or DSCP).

```
interface Serial0/0/0
fair-queue
```

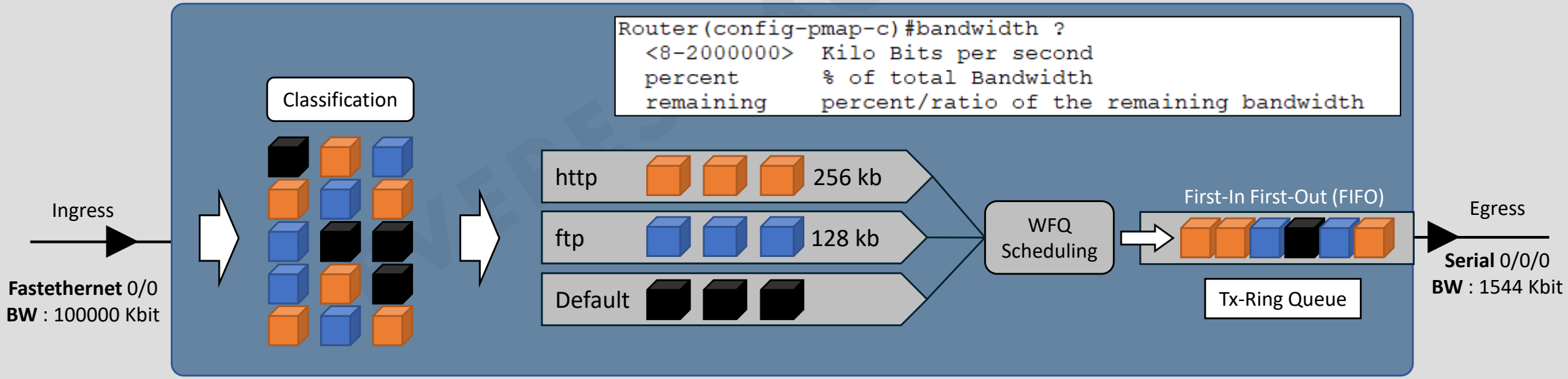


Software Queuing Methods

5) Class-Based WFQ (CBWFQ).

- CBWFQ provides up to 64 user-defined queues using ACLs or NBAR protocol.
- Each queue is provided with a configurable minimum bandwidth guarantee.

```
access-list 101 permit tcp any any eq 80
class-map HTTP
 match access-group 101
class-map FTP
 match protocol ftp
policy-map WEB
 class HTTP
  bandwidth 256
 class FTP
  bandwidth 128
interface Serial0/0/0
 service-policy output WEB
```

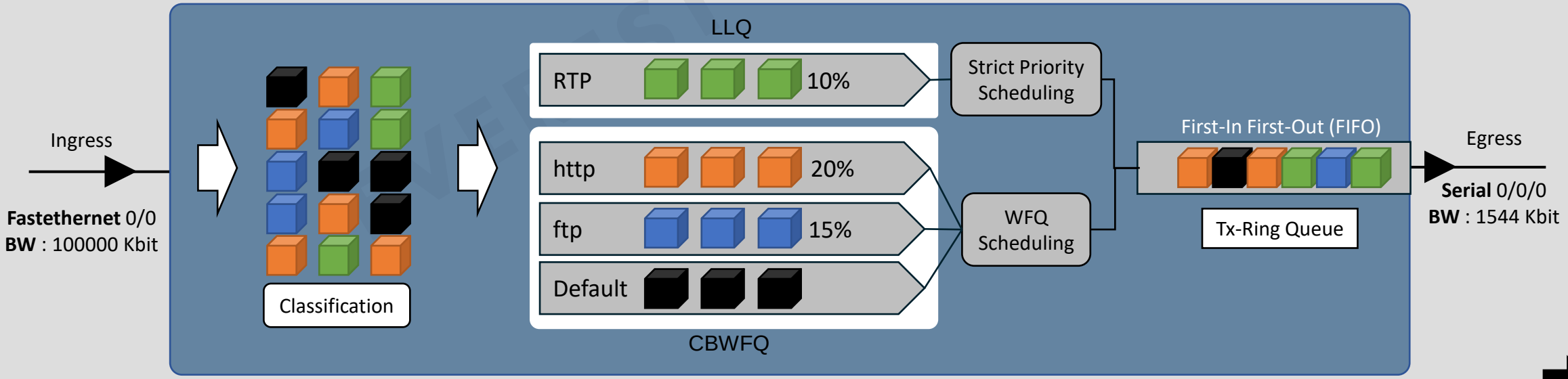


Software Queuing Methods

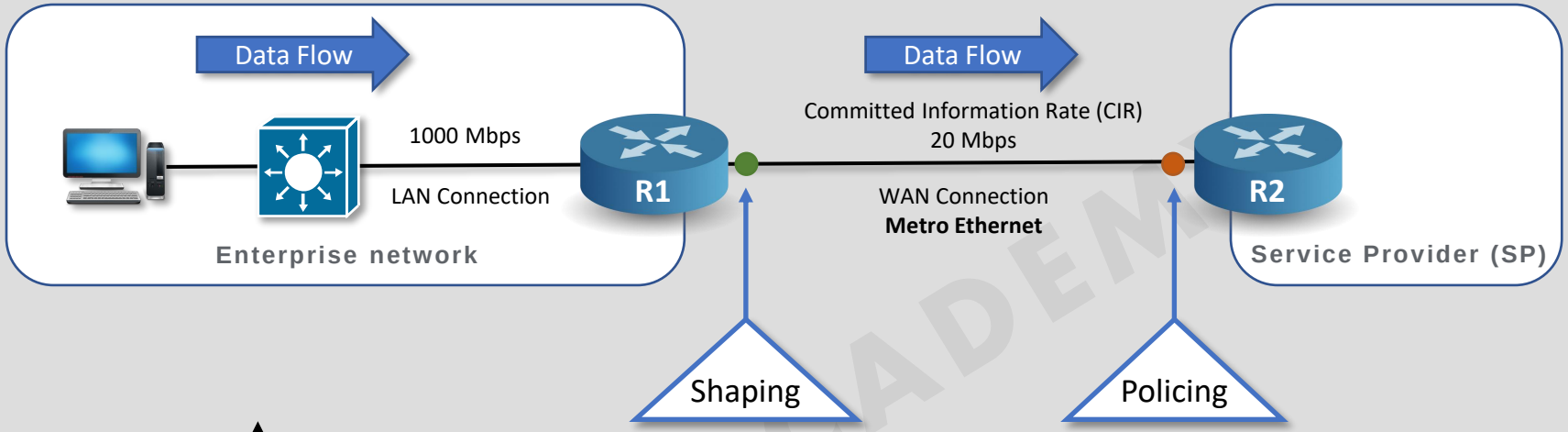
6) Low-Latency Queuing (LLQ) .

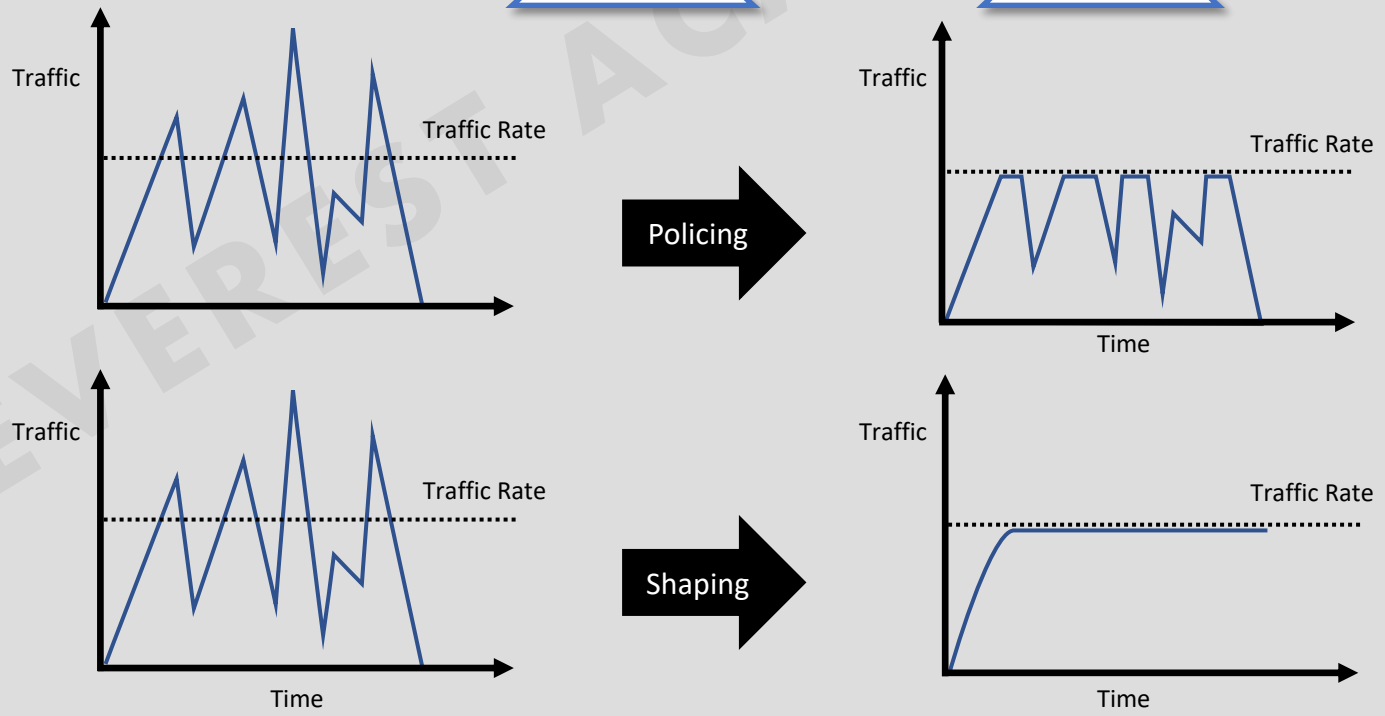
- LLQ is an improved version of CBWFQ that includes one or more **strict-priority** queues.
- **Strict-priority** queues are always serviced before standard class-based queues.
- The LLQ **strict-priority** queue is policed, either by bandwidth or a percentage of the bandwidth.

```
class-map HTTP
  match protocol http
class-map FTP
  match protocol ftp
class-map RTP
  match protocol rtp
policy-map MAP_A
  class HTTP
    bandwidth percent 20
   class FTP
     bandwidth percent 15
   class RTP
      priority percent 10
Interface  Serial0/0/0
   service-policy output MAP_A
```

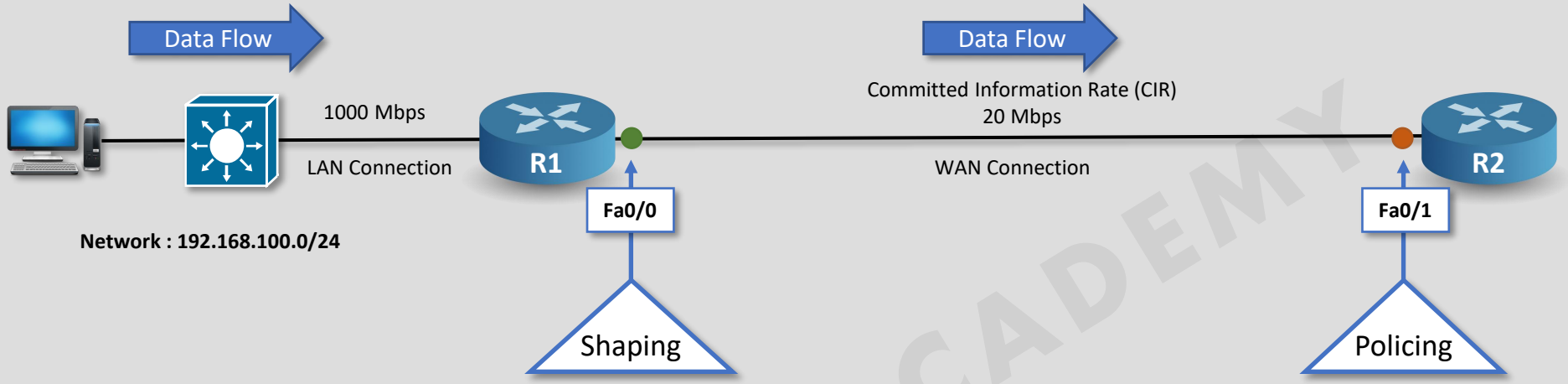


Traffic Policing and Shaping





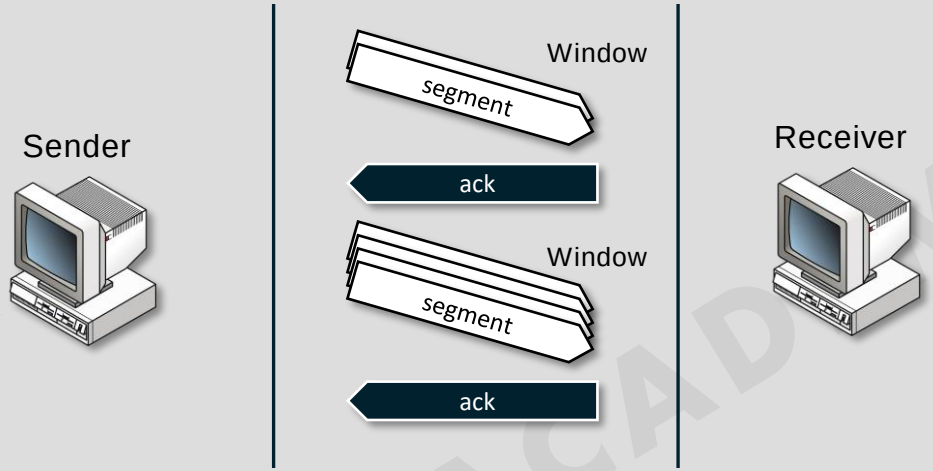
Traffic Policing and Shaping

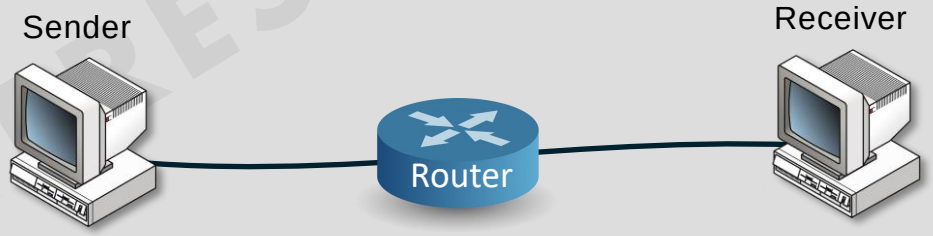



```
R1# conf t
R1(config)# access-list 1 permit 192.168.100.0 0.0.0.255
R1(config)# class-map class1
R1(config-cmap)# match access-group 1
R1(config-cmap)# exit
R1(config)# policy-map map1
R1(config-pmap)# class class1
R1(config-pmap-c)# shape average 20M
R1(config-pmap-c)# exit
R1(config-pmap)# exit
R1(config)# interface FastEthernet0/1
R1(config-if)# service-policy output map1
R1(config-if)# end
R1#
```

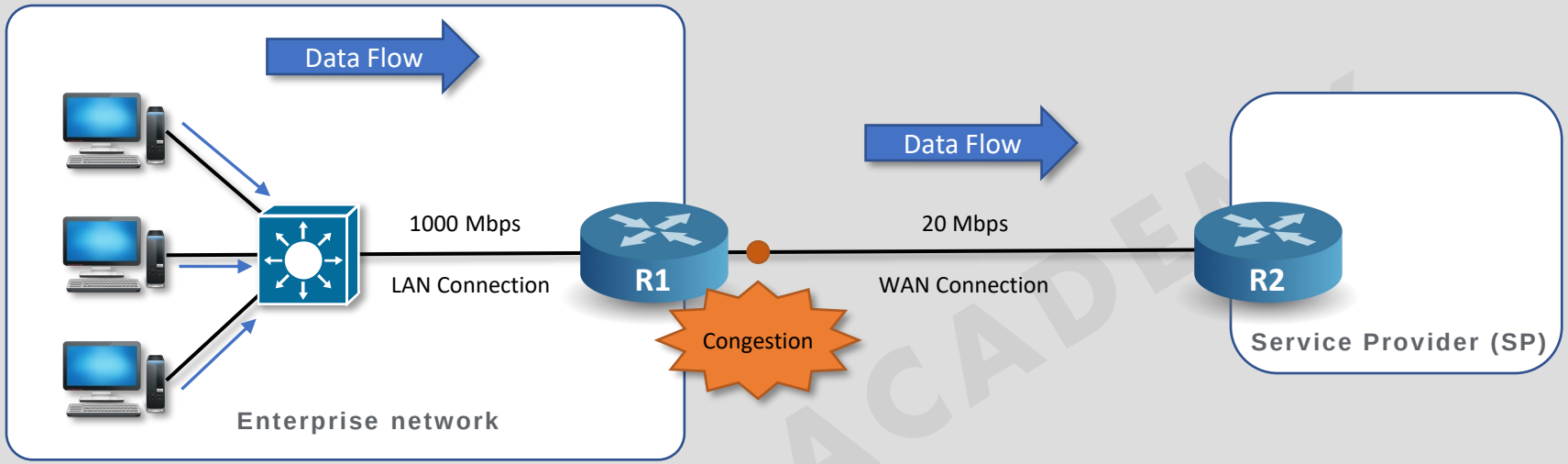
```
R2# conf t
R2(config)# access-list 1 permit 192.168.100.0 0.0.0.255
R2(config)# class-map class1
R2(config-cmap)# match access-group 1
R2(config-cmap)# exit
R2(config)# policy-map map1
R2(config-pmap)# class class1
R2(config-pmap-c)# police cir 20M
R2(config-pmap-c-police)# exit
R2(config-pmap-c)# exit
R2(config-pmap)# exit
R2(config)# interface FastEthernet0/1
R2(config-if)# service-policy input map1
R2(config-if)# end
R2#
```

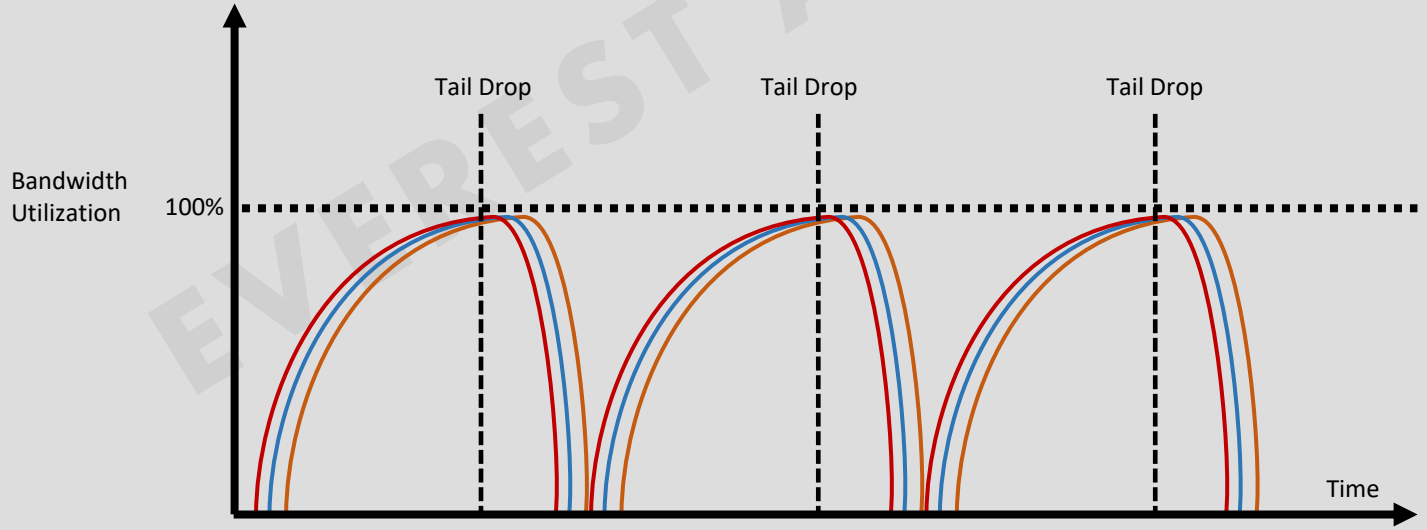
Congestion Avoidance Tools





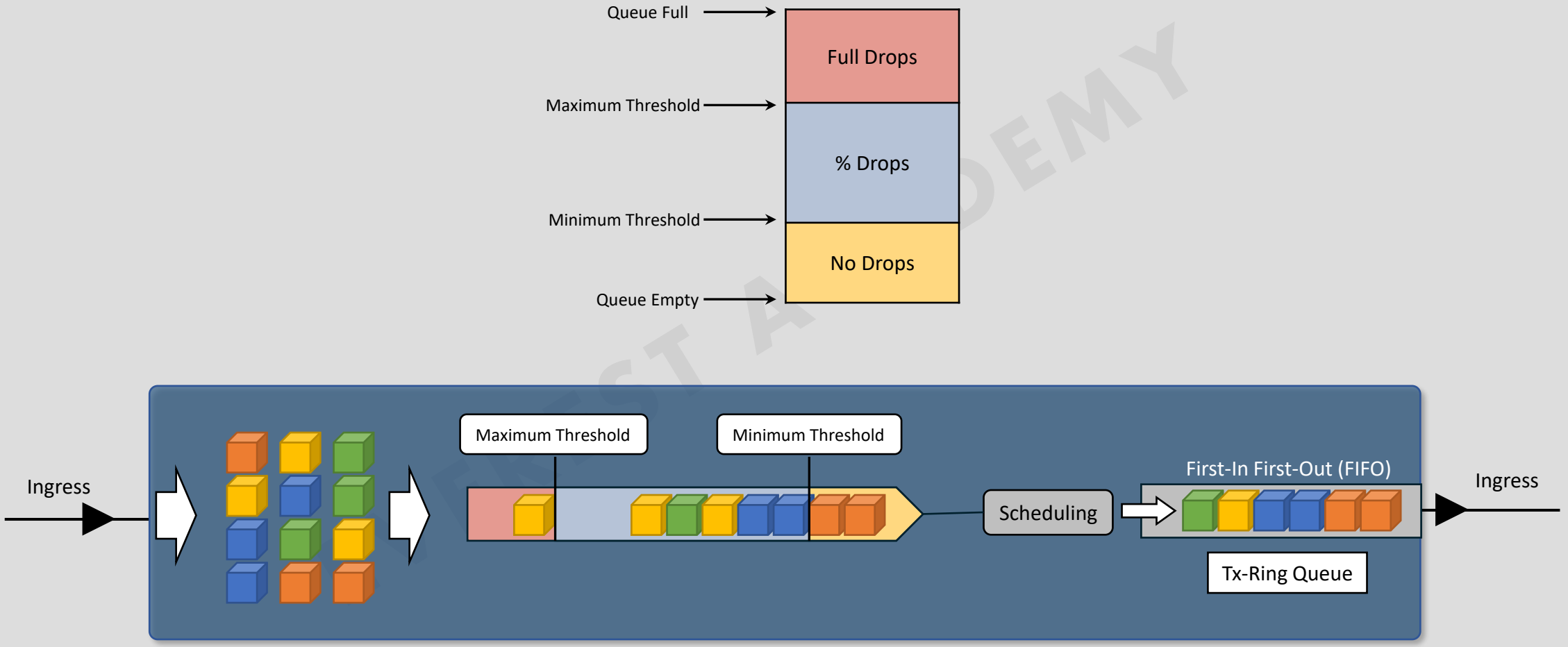
Congestion Avoidance Tools





TCP Global Synchronization

Random Early Detection (RED)



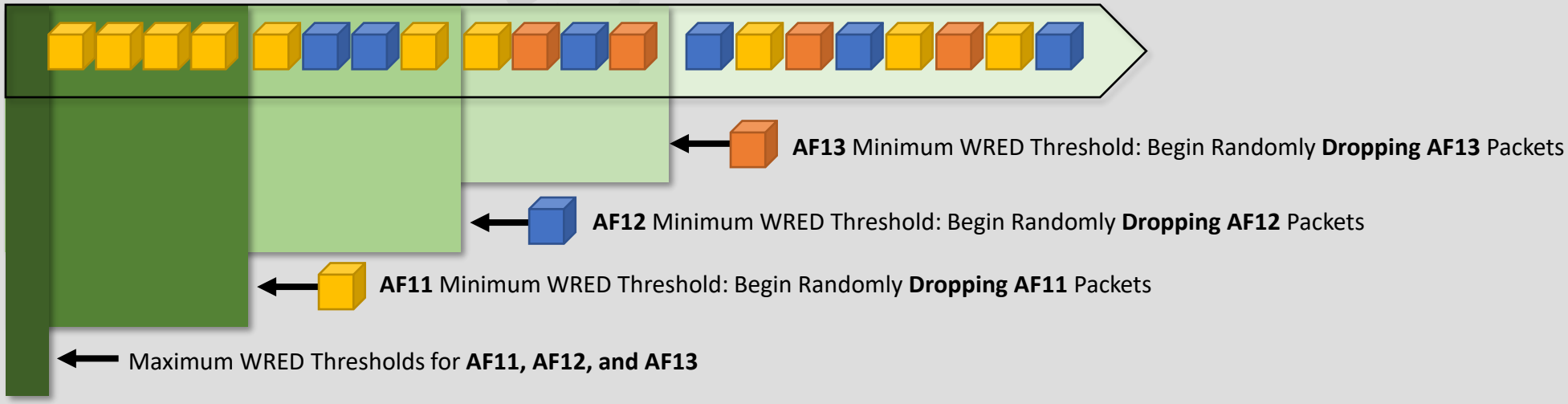
Weighted Random Early Detection (WRED)

Assured Forwarding (AF)

	Drop Probability		
	Low	Medium	High
Highest Queue Priority	AF41	AF42	AF43
⬆	AF31	AF32	AF33
	AF21	AF22	AF23
Lowest Queue Priority	AF11	AF12	AF13

IP Precedence (IPP)

Values	Description
0	**Routine or Best Effort**
1	Priority
2	Immediate
3	**Flash (mainly used for Voice Signaling)**
4	Flash Override
5	**Critical (mainly used for Voice RTP)**
6	Internetwork Control
7	Network Control



Classification and Marking	Congestion Avoidance	Congestion Management