A DiffServ transport network to bring 3G access to villages in the Amazon forest: a case study

based on the EC FP7 project "Wireless Technologies for isolated rUral communities in developing countries based on CellulAr 3G femtocell deploymeNts (TUCAN3G)"

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GDEE GLOBAL DIMENSION IN ENGINEERING EDUCATION

CONTEXT

Context analysis…

Rural isolated areas of developing countries **all over the world**:

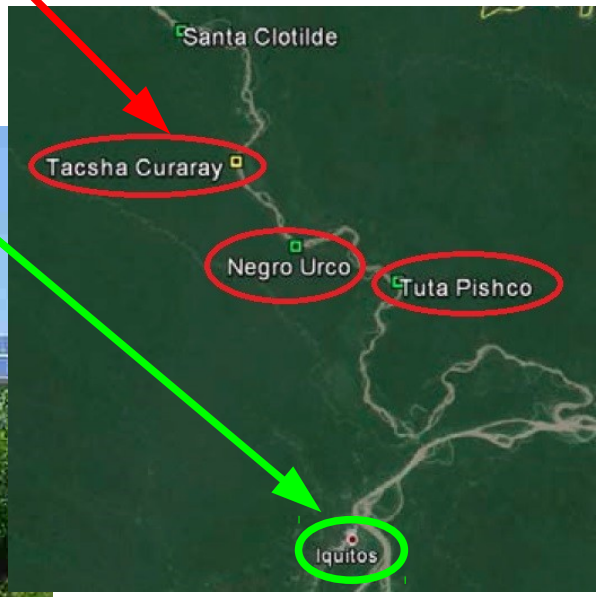
- 40% of the world population live in rural and remote areas (ITU).
- Two main features: geographical isolation (lack of infrastructures) and political isolation.

In Latin America (EHAS)…

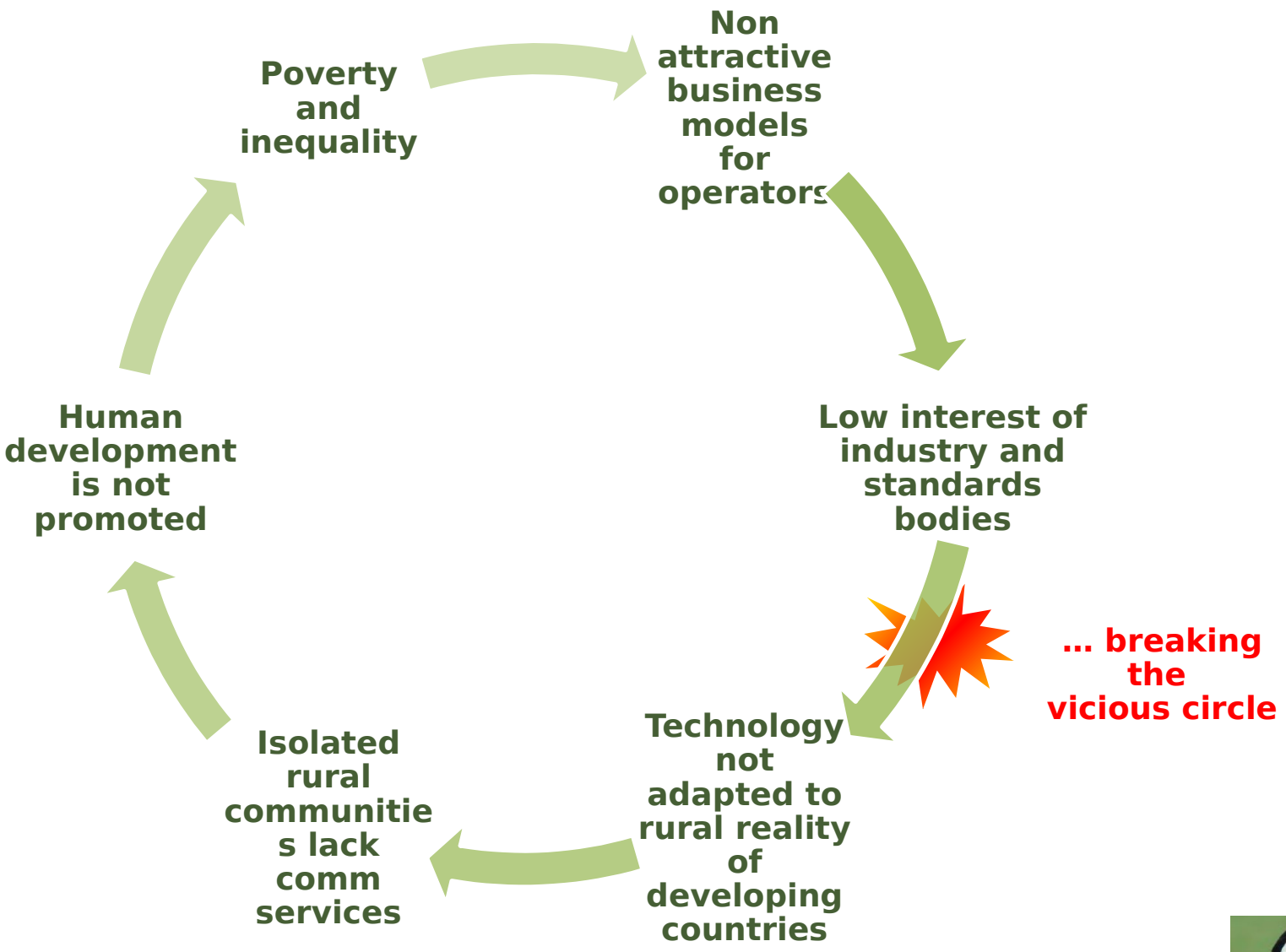
- 21% of rural population: 126 million of people.
- Rural areas: numerous small spots, low density scenarios and long distance between populated areas.
- Indigenous population: demographic transition with mortality reduction, progressive increase of fertility control and the emigration.
- Economic inequalities: 12% of the GDP provided by rural areas; 53% of rural incomes come from agriculture; big dependence form public sector.
- Lack of infrastructures: water, energy, transportation and telecommunication services.
- Inequalities on health, education, gender and political participation.

CONTEXT

- Small rural communities in developing countries suffer from a lack of communication services, sometimes replaced by an expensive and difficult-to-maintain public satellite phone, usually subsidized by Government, without data services.
- Cities have successfully deployed mobile phone services and use to have acceptable capacity for broadband communications.



CONTEXT


Poverty and inequality
Non attractive business models for operators
Low interest of industry and standards bodies
… breaking the vicious circle
Technology not adapted to rural reality of developing countries
Isolated rural communities lack comm services
Human development is not promoted

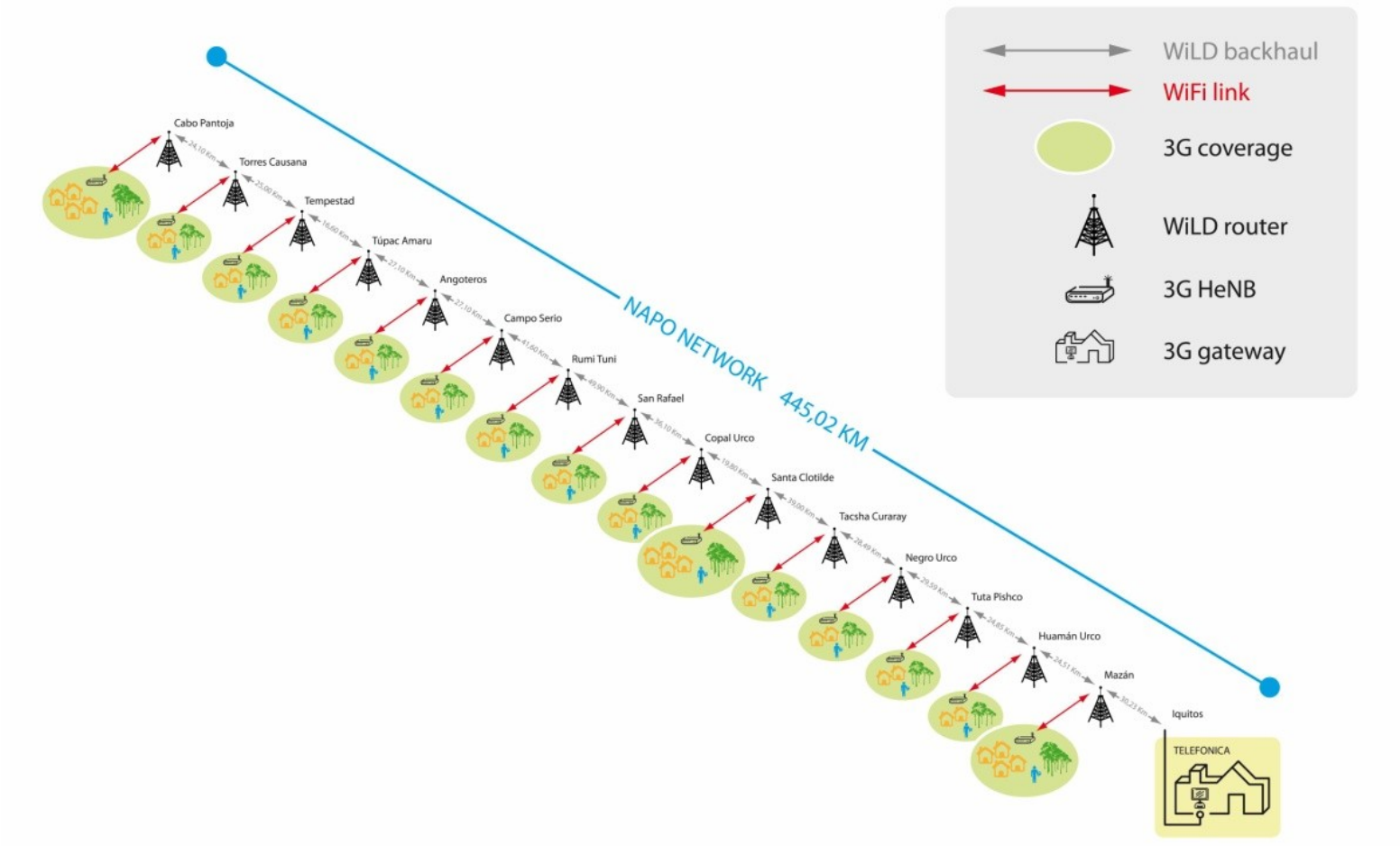
CONTEXT: Objectives of TUCAN3G

Obtain a technologically feasible and yet economically sustainable solution for the progressive introduction of voice and broadband data services in rural communities of developing countries, using commercial cellular terminals, 3G femtocells (and its possible evolution to 4G) and heterogeneous backhauling (WiLD-WiMAX-VSAT)

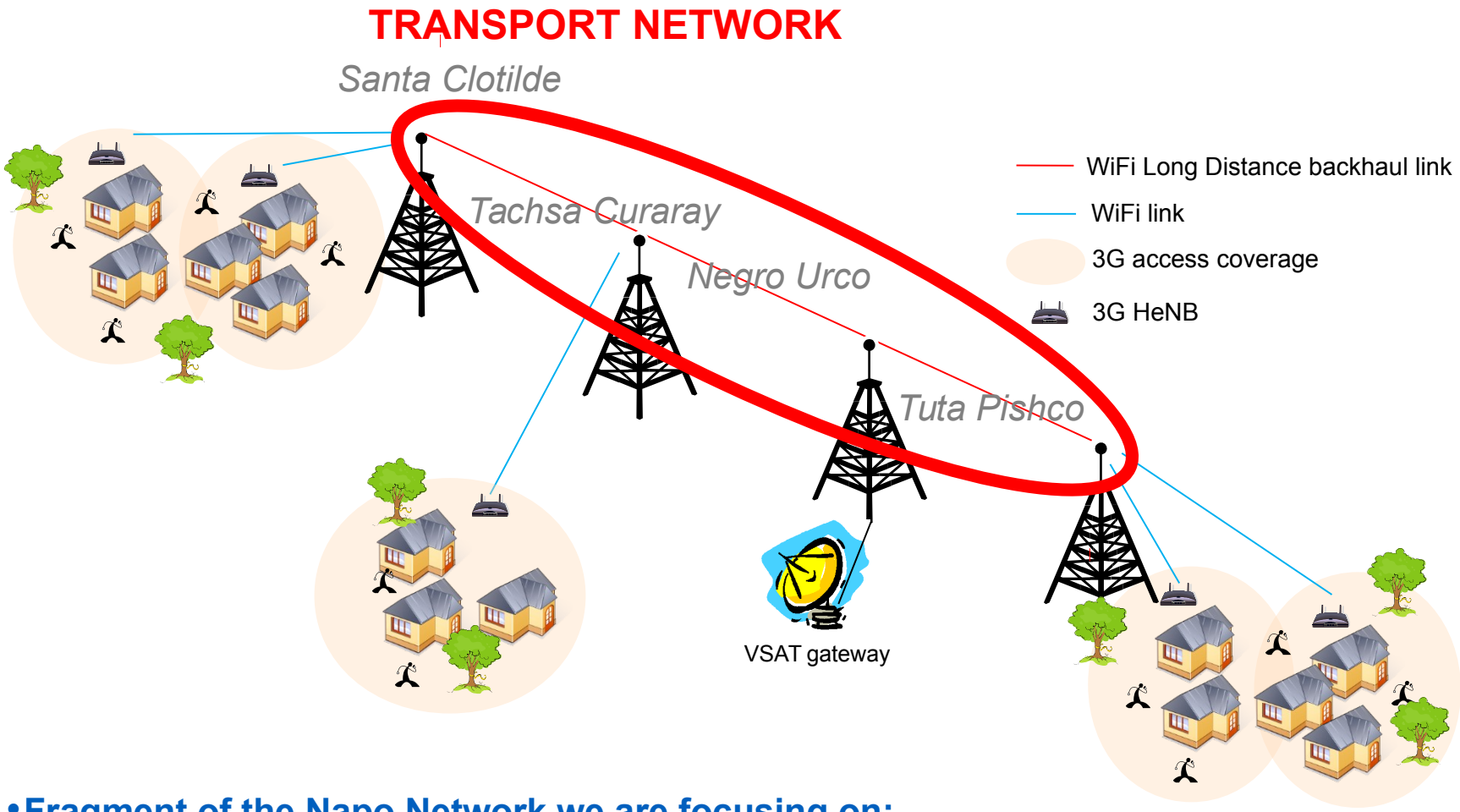
1. Finding a suitable business model
2. Enhancing the access network using femtocells
3. Enhancing the transport network using WiFi-WiMAX-VSAT backhauling
4. Checking the viability through demonstration platform

Scenario for the case study: the Napo network

- **Napo network**



Scenario for the case study: the Napo network



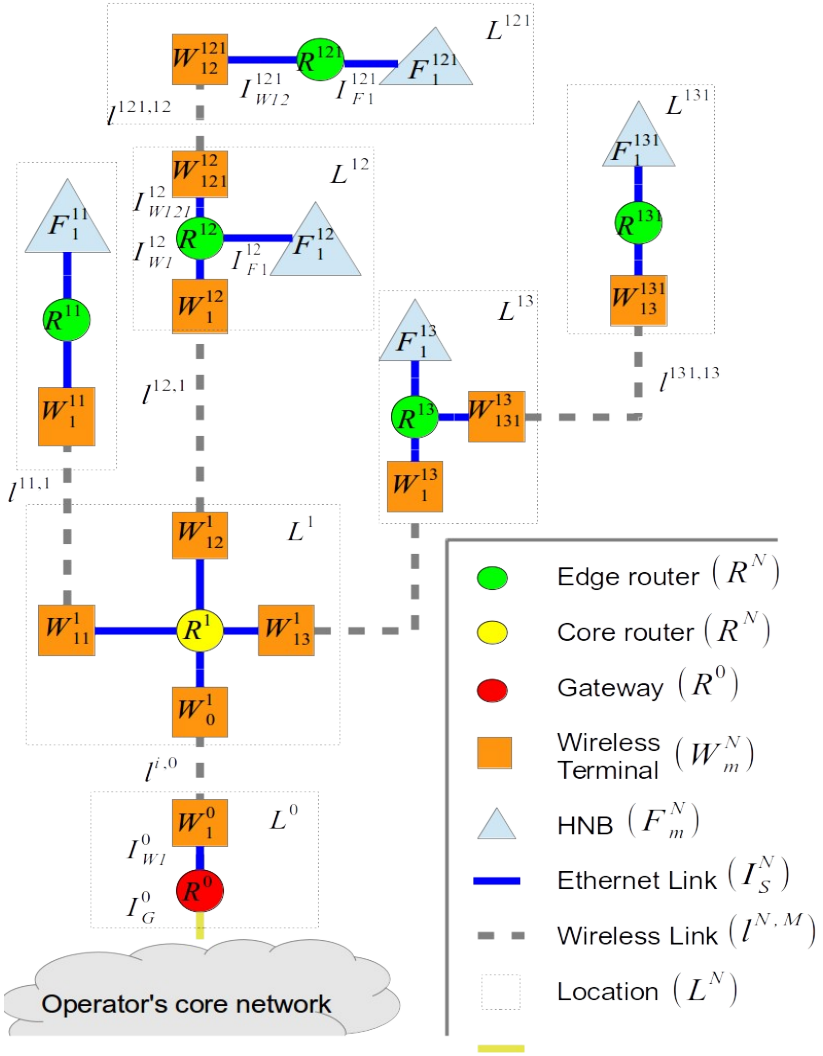
- **Fragment of the Napo Network we are focusing on:**
  - **We use the towers of the Napo network in four villages**
  - **We install 3G femtocells in this villages**
  - **We deploy a parallel transport network in this segment**

Scenario for the case study: network topology

WiLD and WiMAX are used for wireless links between routers.

Routers must control the traffic in every hop for

- Traffic differentiation
- Traffic shaping
- QoS monitoring



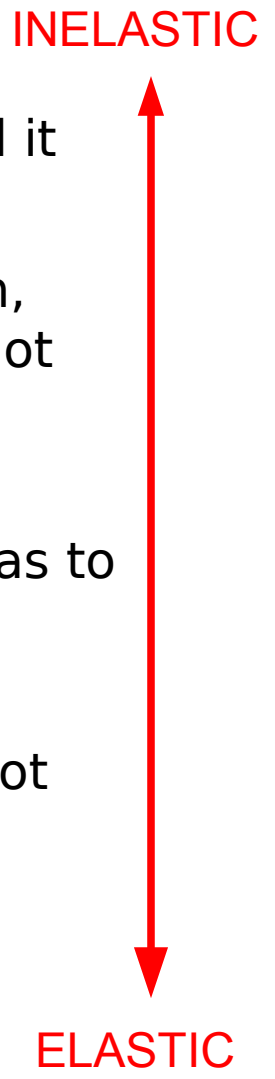
QoS

- ***QoS = Quality of Service***
  - *The concept appeared when packet-switched networks started to be used for real-time communications that traditionally used circuit-switched networks.*
  - ***QoS**: user requirements of throughput, delay, variation of delay and packet-loss*
  - *QoS-support: the network technology may ensure certain maximum or minimum values for the performance indicators experienced by each traffic class.*
    - *Parametric: per-class guarantees for the performance indicators.*
    - *Statistic: some traffic classes receive more priority than others, but there is not an absolute guarantee of maximum delay, minimum throughput, etc.*

Performance indicators

- **Throughput:** Bits per second of information transmitted and successfully received.
- **Packet-loss probability:** probability for a sent packet to be lost due to collisions, channel errors, buffer overflow, etc.
- **Delay:** Time elapsed between the instant in which the user starts to send a packet and the instant for the receiver to pass the packet to the destination.
- **Variation of delay:** (sometimes called 'jitter'): typical deviation of the delay.
- Other: system availability, packets ordered, ...

QoS



- Control traffic: maximum priority, low traffic load. We need it to give this traffic the maximum guarantees and priority
- Hard real-time traffic (telephony, VTC): required bandwidth, low delay, low jitter. <2% packet-loss may be supported, not more.
- Soft real-time traffic (audio-streaming, video-streaming): accepts high delays but low jitter values. The bandwidth has to be ensured on average.
- Best-effort traffic: it supports a lot of elasticity in the performance indicators, but the acceptable delay should not go beyond the “seconds” in order of magnitude
- Background traffic: maximum elasticity

DiffServ

- DiffServ = Differentiated Services (RFC 2475)
- Solution introduces QoS support in IP networks in a scalable way
- DiffServ may be used in any IP network, but it can be realistically applied in IP networks under the control of a single administrator, because all nodes must have a coordinated behavior.
- Traffic is classified in aggregated classes
- Each traffic class gets a SLA (Service Level Agreement).
- Each router implements a PHB (Per-Hop Behaviour).
- Users or edge routers mark packets to associate them to traffic classes.
- Edge routers do policy control and may perform admission control.

IPv4 header in a common packet

Version	Head. L.	TOS	Total Length			
Identification			X	D F	M F	Fragment offset
Life time	Protocol		Checksum			
Source address						
Destination address						
Options						

IPv4 header in DiffServ (RFC2474, 12/1998)

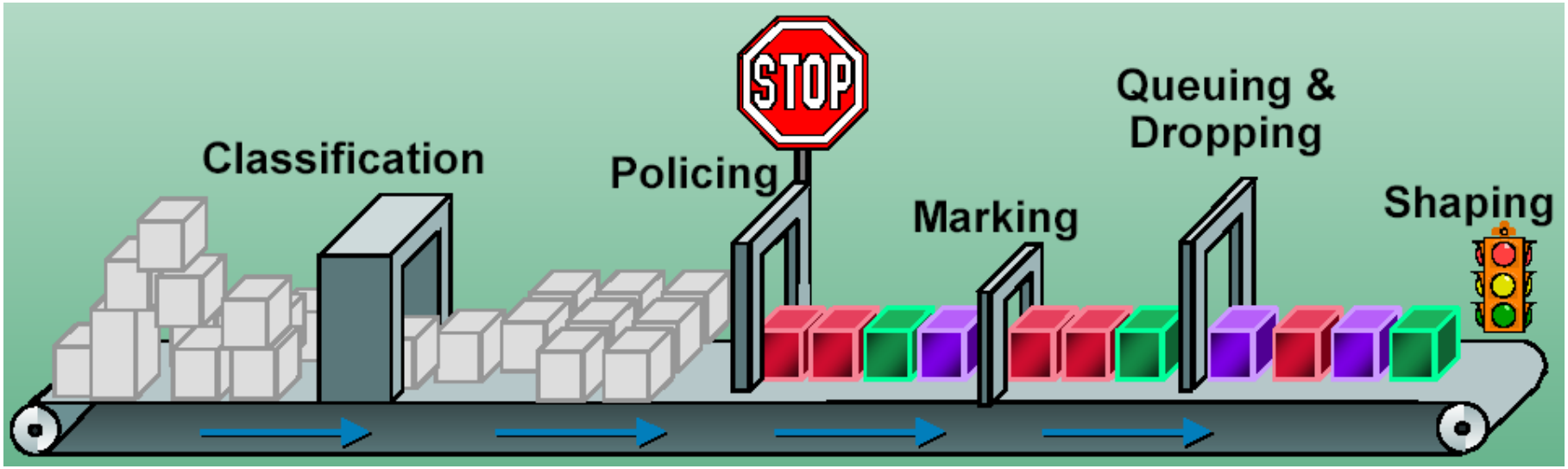
Version	Head. L.	DS	Total Length			
Identification			X	D F	M F	Fragment offset
Life time	Protocol		Checksum			
Source address						
Destination address						
Options						

- DSCP: Differentiated Services CodePoint. Six bits indicating what class the packet belongs to.
- CU: Currently Unused (reserved). These bits are more and more used for explicit congestion control (ECN)

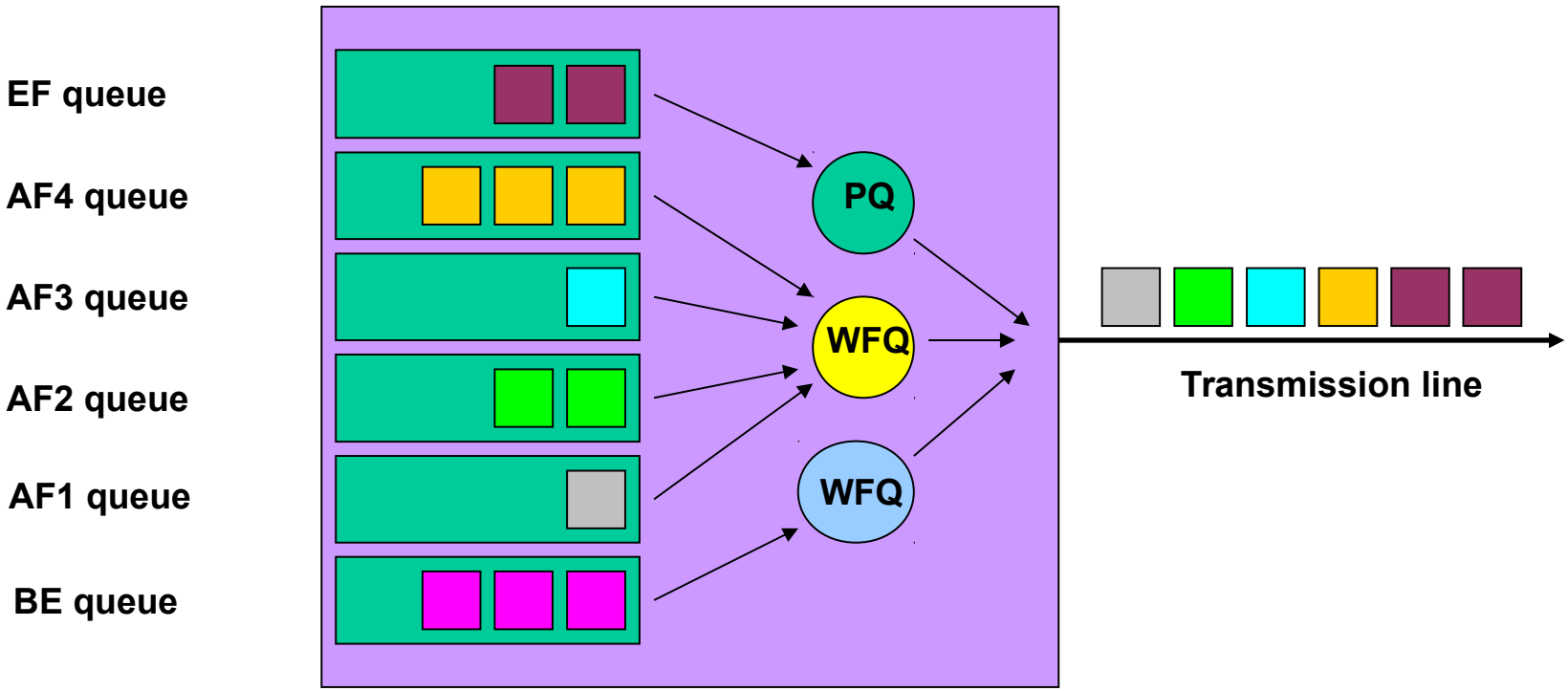
Types of services (PHB)

Service	Characteristics
'Expedited Forwarding' or 'Premium'	•A SLA may be defined. Maximum priority.
'Assured Forwarding'	•Priority, but no SLA •Four classes defined, each with three levels of packet-drop probability
'Best Effort' with priority	•No guarantees, but more priority than the next one
'Best Effort' without priority	•No guarantees

Edge router


STOP
Classification
Policing
Marking
Queuing &
Dropping
Shaping

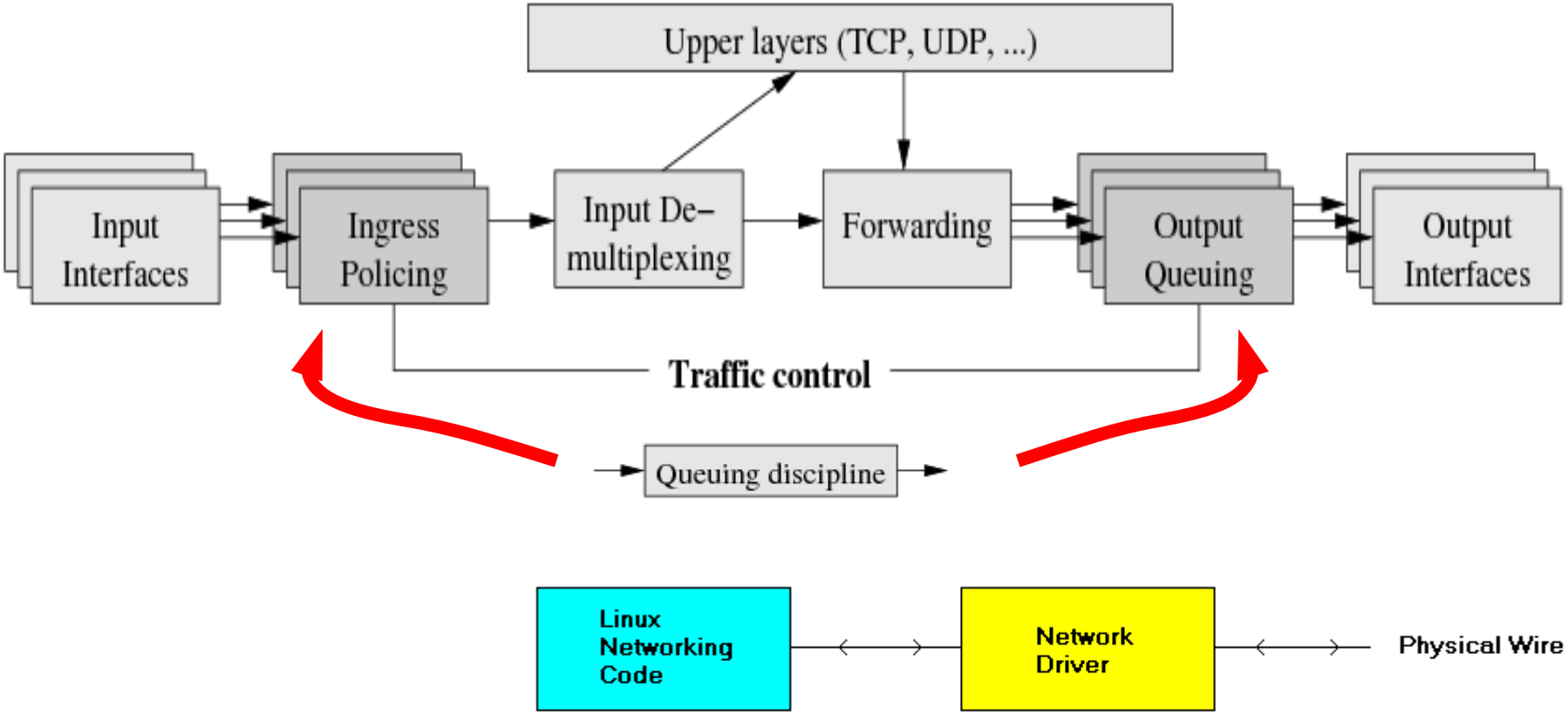
How packets are queued in a DiffServ router



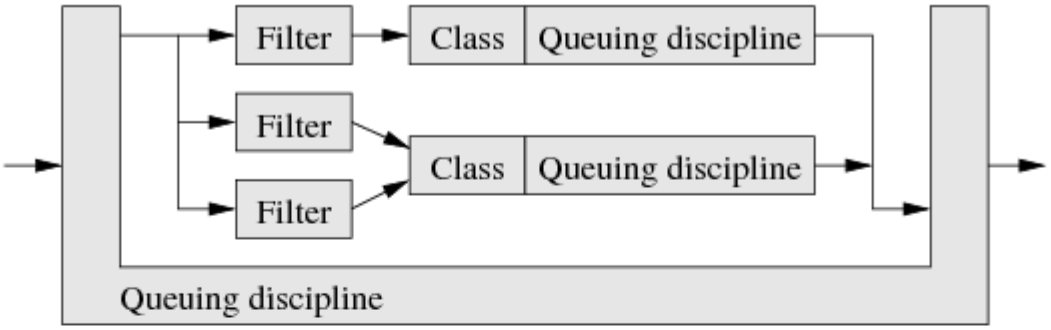
PQ: priority queue, CB-WFQ: class based weigthed fair queueing

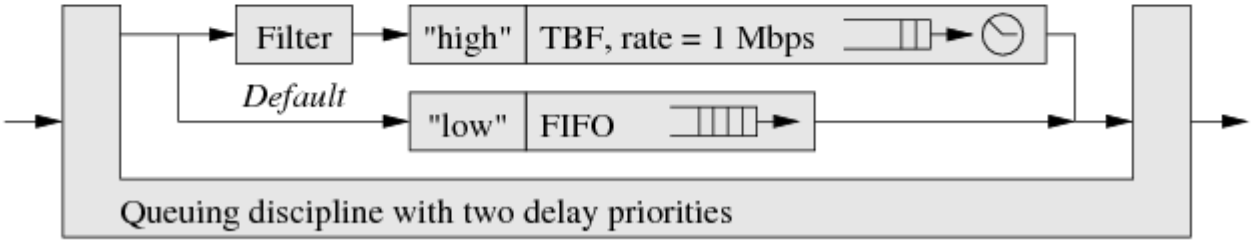
Queuing disciplines

For how qdiscs are used in Linux, see: http://www.lartc.org



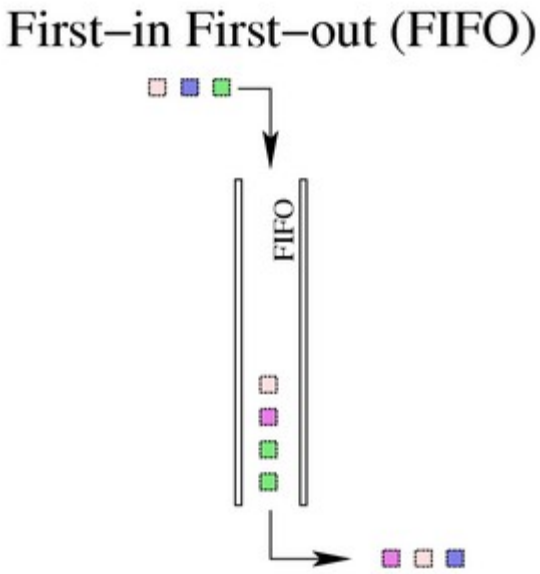
Queuing disciplines





Simple qdiscs

- **PFIFO**: fist in first out
  - Size in packets: pfifo_limit
  - Alternate qdisc with size in bytes: BFIFO




```
# tc qdisc add dev eth0 root pfifo limit 10
```

```
# tc qdisc show dev eth0
qdisc pfifo 8001: dev eth0 limit 10 p
```

```
# tc qdisc del dev eth0 root
```

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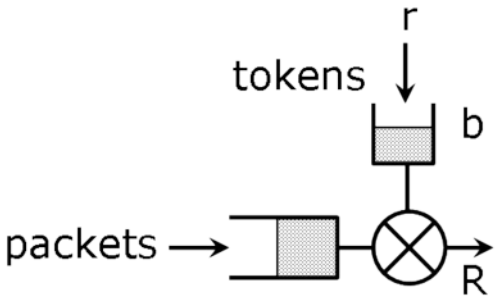
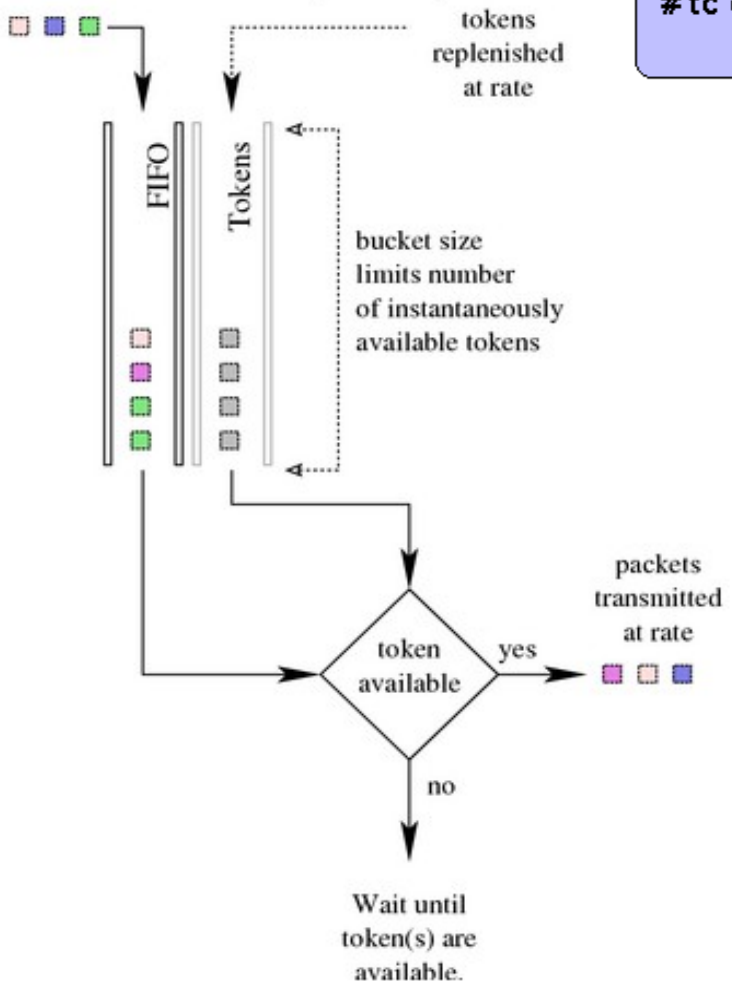
Simple qdiscs



- **TBF (Token Bucket Filter)**:
  - Bitrate limited to ***R***
  - Short bursts are permitted
  - How it works:
    - Tocket bucket with ***b*** tokens. The number of tokens is automatically incremented at a rate ***r***
    - Each time a byte is sent, a token is eliminated.
    - If a packet of B bytes is to be sent and the bucket contains less than B tokens, the packet stays in the queue
  - *Main parameters:*
    - *Limit* or *latency*: size of queue or maximum time for a packet to wait
    - *bust/buffer/maxburst*: bucket size <S>
    - *Rate*: <R>

Queuing disciplines

Token Bucket Filter (TBF)




```
# tc qdisc add dev eth0 root tbf rate 0.5mbit burst 5kb \
      latency 70ms peakrate 1mbit minburst 1540
```

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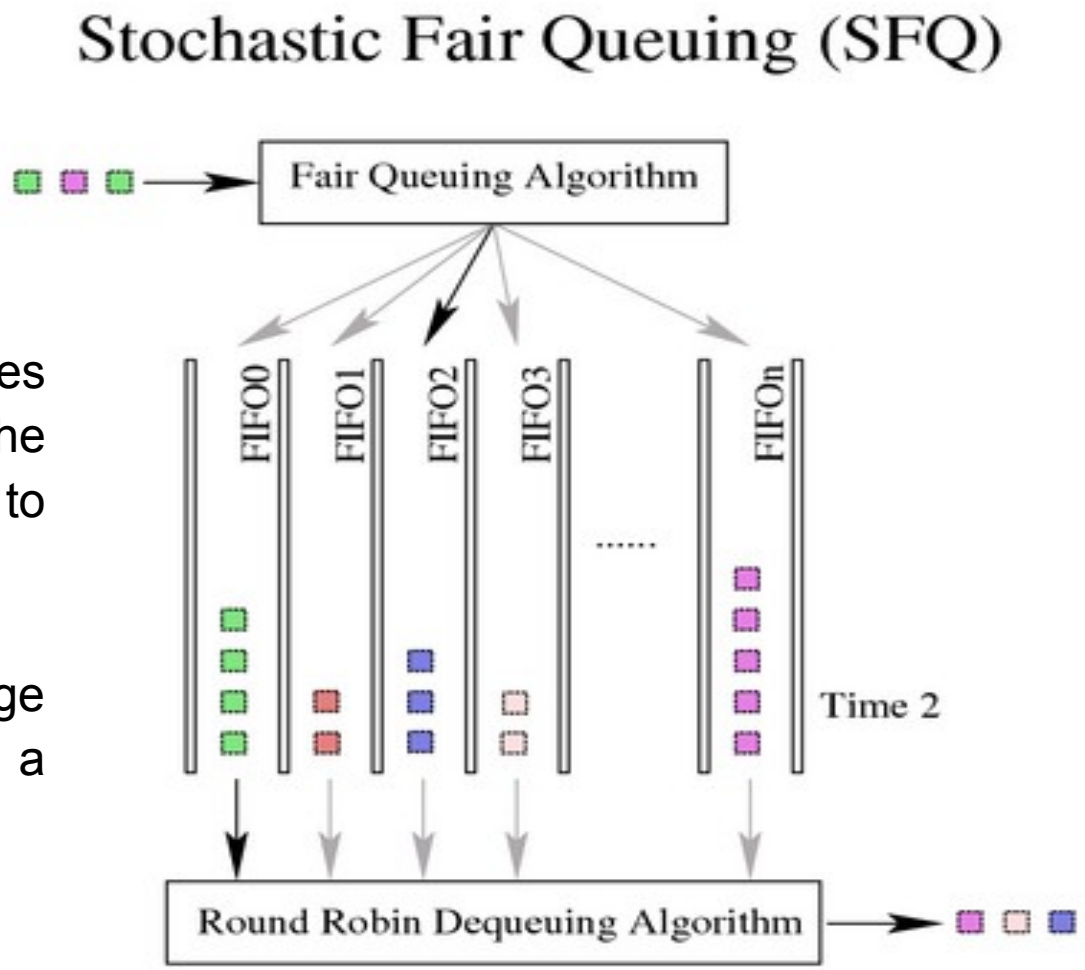
Simple qdiscs

- **SFQ**
  - Per-flow virtual FIFO
  - Round-Robin scheduler
  - Actually, several virtual queues are grouped in a real queue. The groups are changed very often to avoid blockings.
  - Main parameters:
    - Perturb: How often hash change
    - Quantum: # bytes pulled from a queue before RR-ing



Queuing disciplines

Qdisc with classes: **PRIO**

- Several bands (variable; defaults to bands = 3)
- We choose what qdisc manages each band.
- Absolute priority! Risk: resources starvation if there is always traffic of priority classes.

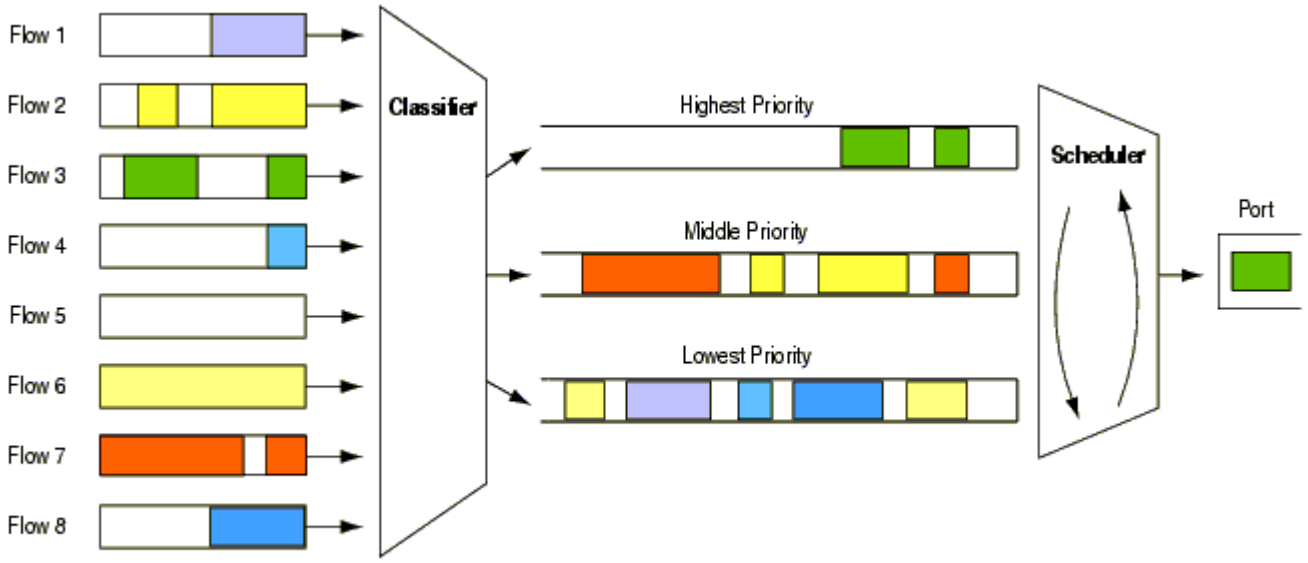


Figure 2.3.1

Queuing disciplines

PRIO

- Example:

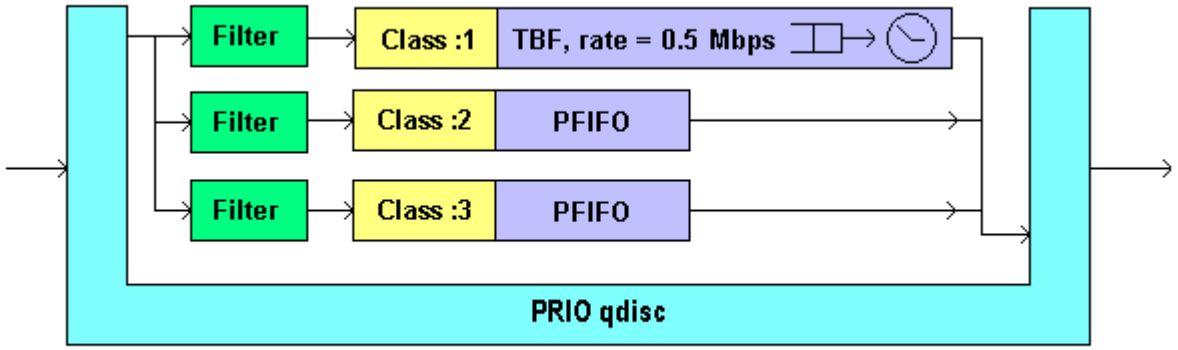


Figure 2.4.1

```
# tc qdisc add dev eth0 root handle 1: prio
# tc filter add dev eth0 parent 1:0 prio 1 protocol ip u32 \
          match ip tos 0x28 0xff flowid 1:1
# tc filter add dev eth0 parent 1:0 prio 2 protocol ip u32 \
          match ip tos 0x48 0xff flowid 1:2
# tc filter add dev eth0 parent 1:0 prio 3 protocol ip u32 \
          match ip tos 0x58 0xff flowid 1:3
# tc qdisc add dev eth0 parent 1:1 handle 10: tbf rate 0.5mbit burst 5kb \
           latency 70ms peakrate 1mbit minburst 1540
```

cm-09

Queuing disciplines

Qdiscs with classes:

HTB (Hierarchical Token Bucket)

- Defines how to share the bandwidth among traffic classes
- Defines guarantees
- Defines who heritates the resources not used by a class

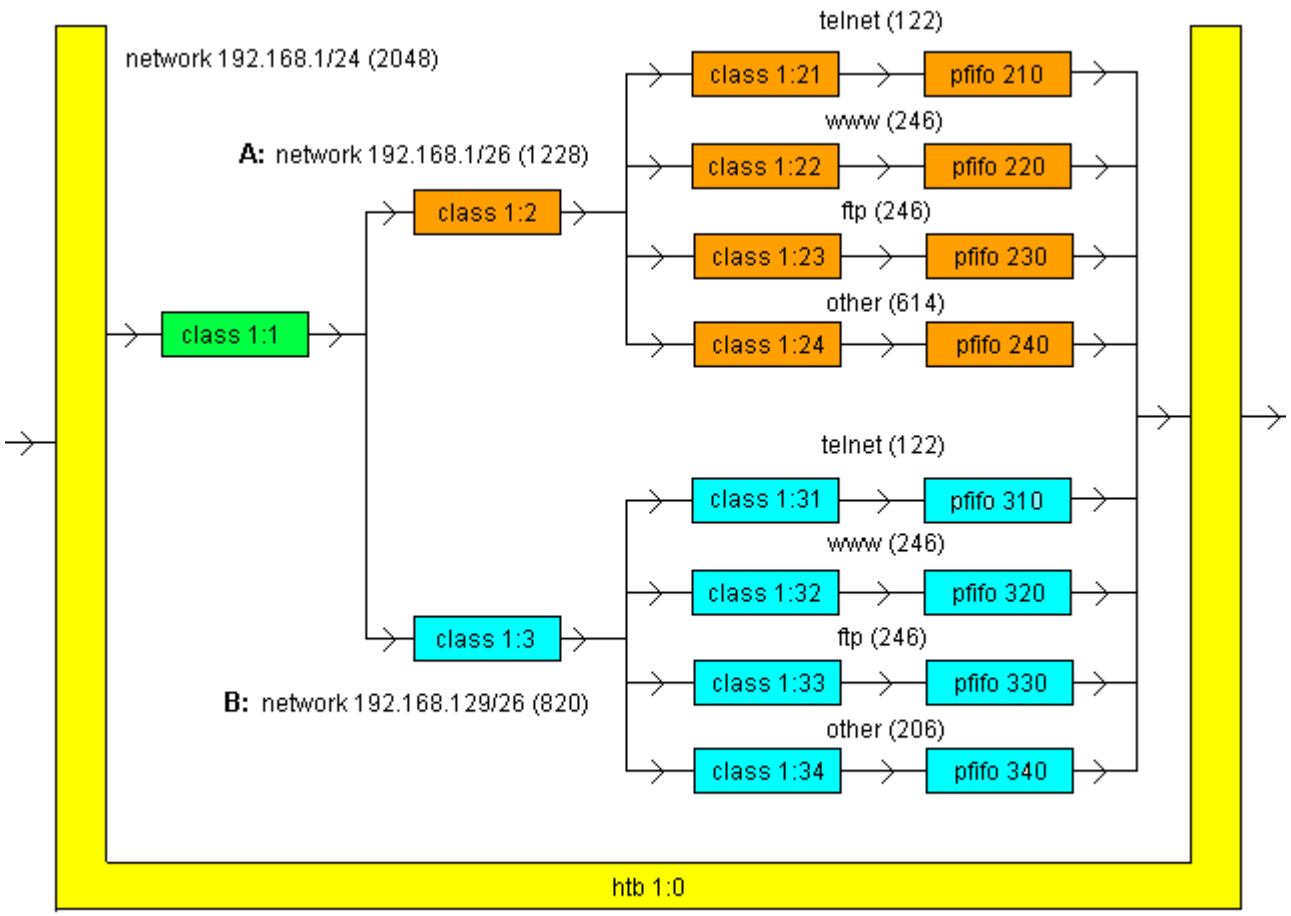


Figure 2.8.4