QoS in Wireless Networks

Instructor: Dr.Hanal ABUZANAT

Introduction
QoS

- Supports services for the applications that are time-sensitive.
  - ex. Multimedia (video and voice), real-time, VoIP, etc.

- QoS guarantees can be characterized by:
  - Delay.
  - Delay jitter.
  - Bandwidth.
  - Packet losses.
- QoS managed:
  - Scheduling, Buffering, congestion control, Administration control

Introduction
QoS

- Service for the applications that are time-sensitive.
  - ex. multimedia, real-time, video and voice, etc.
- QoS guarantees can be characterized by:
  - Delay, delay jitter, bandwidth and Packet losses.
- A QoS architecture introduces tools to treat packets differently (ex. DiffServ):
  - Separate flows

Introduction
WLAN

- **What is IEEE802.11(e)?**
  - 802.11 standards can not provide any QoS guarantees due to poor performance.
  - 802.11e offers QoS support to time-sensitive applications.

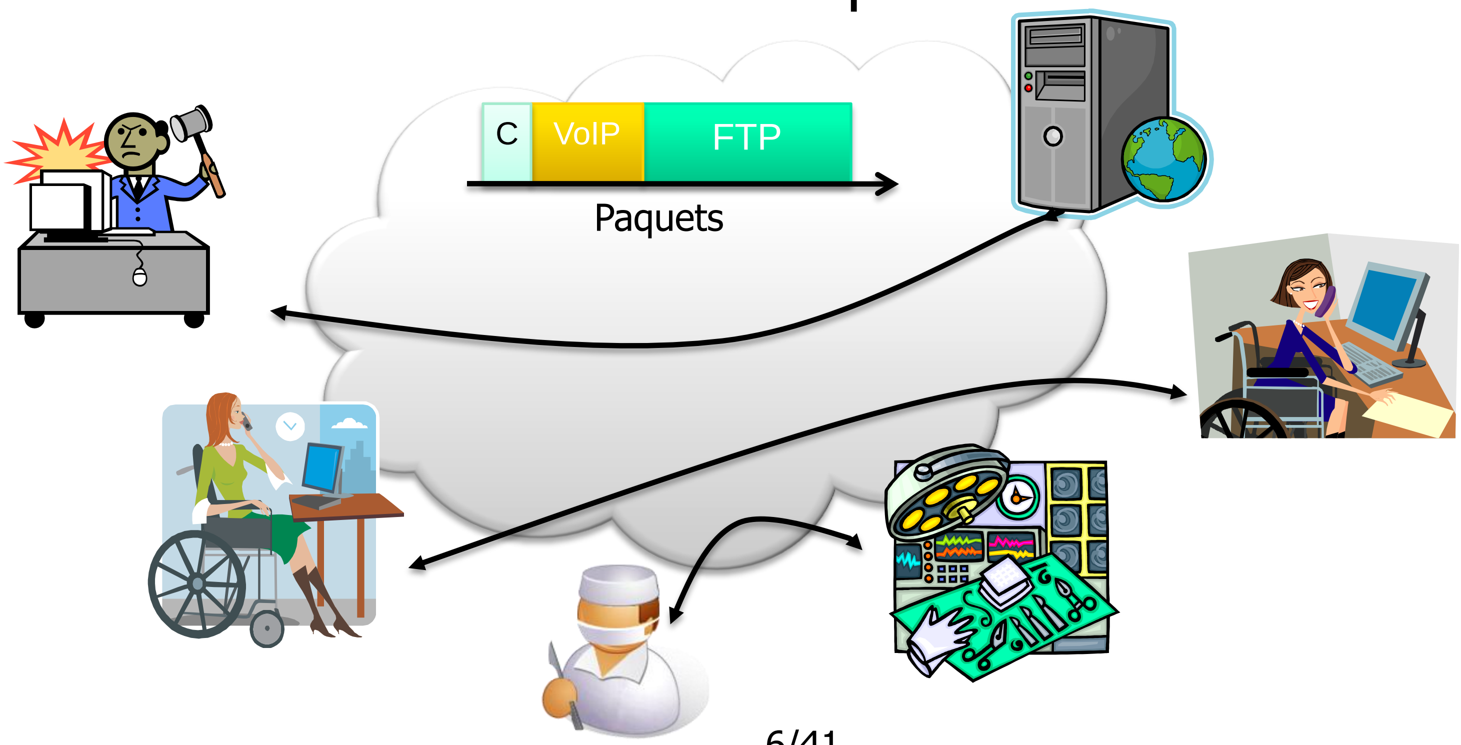
- Ad-hoc network
  - An autonomous wireless network
  - Can be formed without the need of any infrastructure or centralized administration.
  - QoS can be administrated by each station:
    - Enhanced DCF channel access (EDCA).
  - QoS hard challenge.

Introduction
WLAN Features

- High error rate and bursty error
  - Excessive amount of interference and higher error rates are typical
- Location-dependent
- Time-varying wireless link capacity and quality
- Scarce bandwidth
  - needs to be used efficiently
- User mobility
  - Mobility complicates resource allocation.
- Power constraint

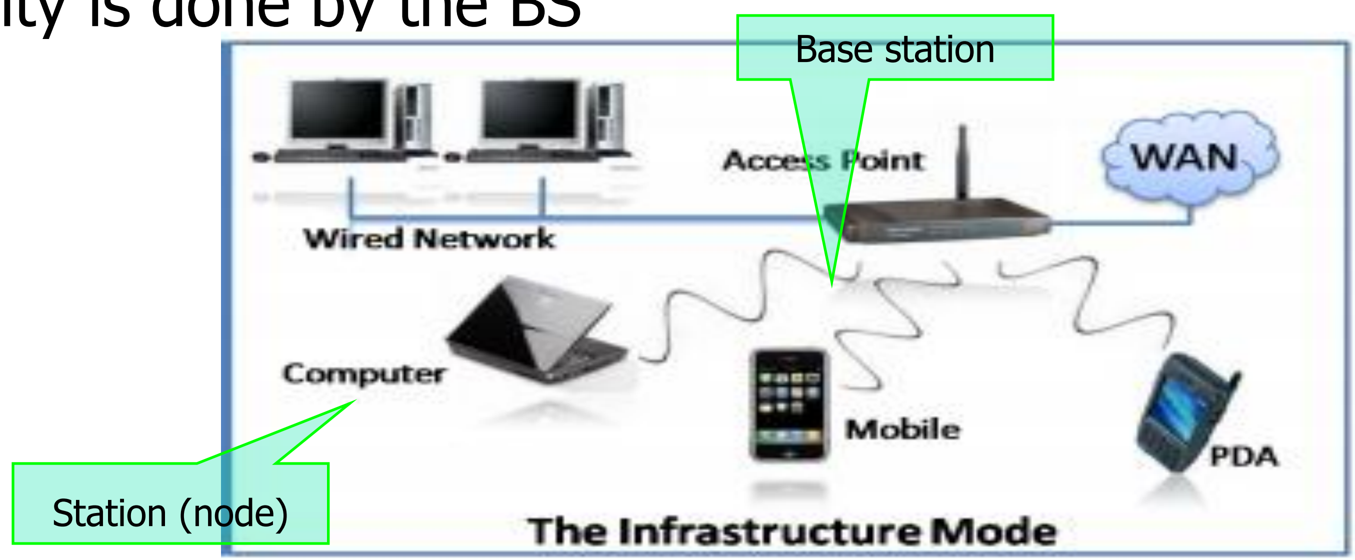
Why we need QoS?

- A user need to send (FTP) packets of size 1500B.
- A user need to send VoIP packets of size 512B.
- A user need to send control packets of size 64B.



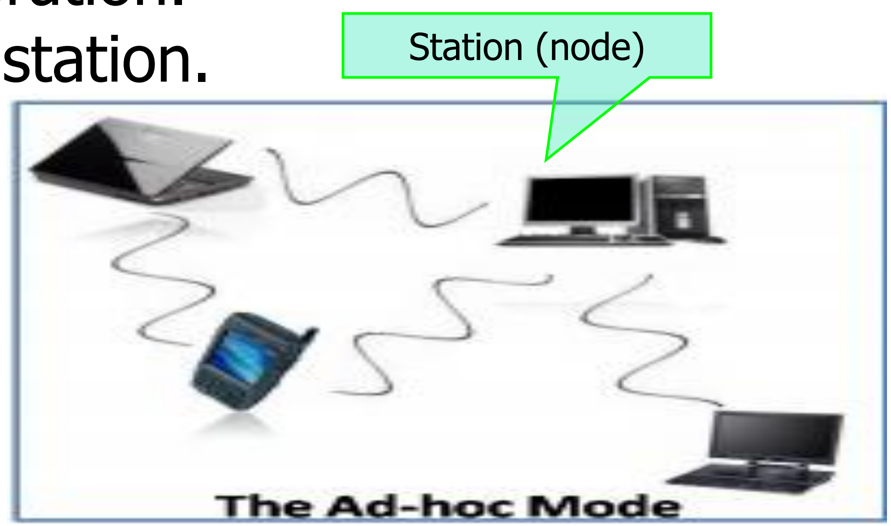
Introduction
WLAN (1)

- Infrastructure Networks:
  - Centralized administration.
  - QoS administrated by Base-stations (AP).
  - Connectivity is done by the BS



Introduction
WLAN (2)

- Ad-hoc Networks:
  - Autonomous network.
  - Distributed administration.
  - No need to Base station.
  - Connectivity is done collaboration.
  - QoS administrated by each station.
  - QoS is a hard challenge.



State of the art
Medium Access Control (MAC) in Ad-hoc

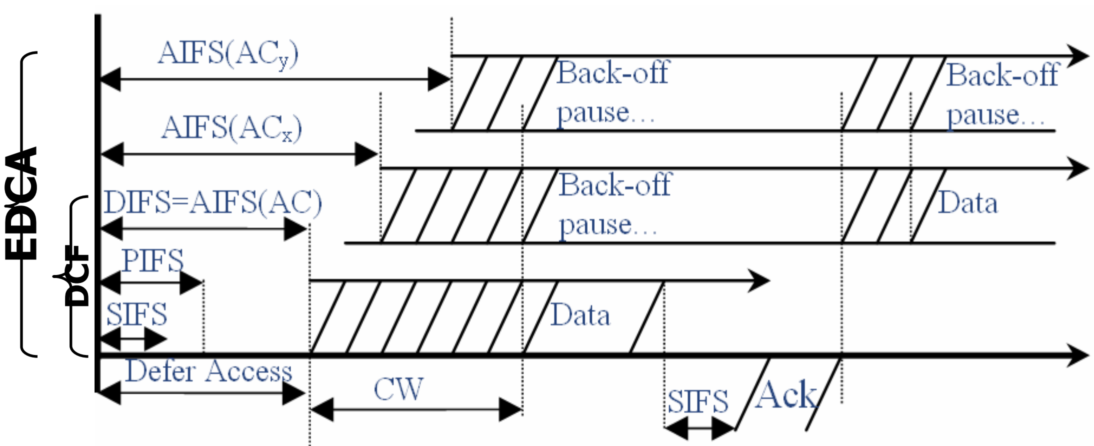
- **Standard IEEE 802.11:**
  - Distributed Contention Function (**DCF**).
  - No QoS (equal priorities)
  - Station may keep the medium busy.

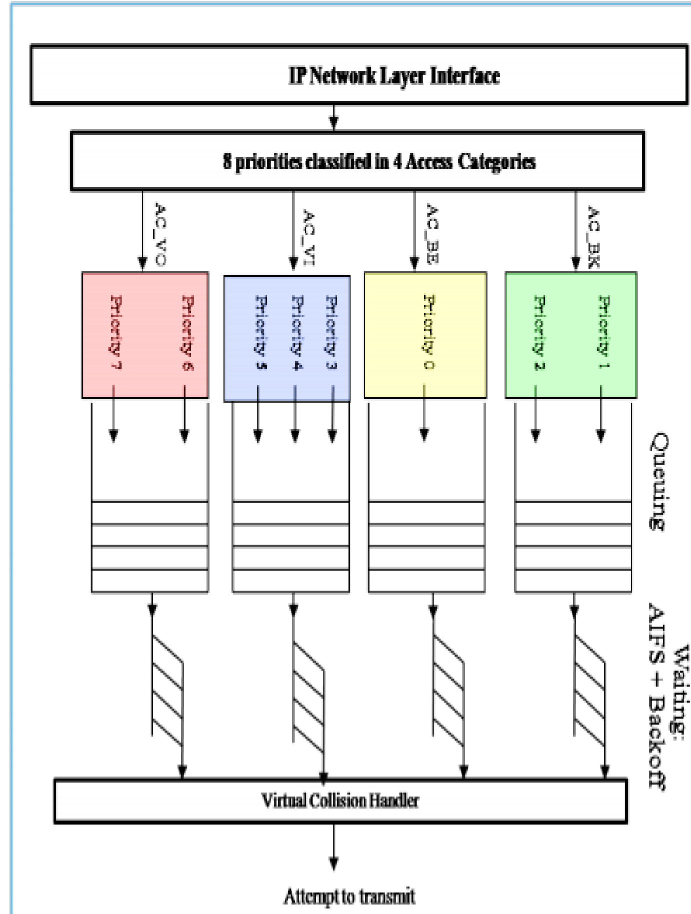
State of the art
Medium Access Control (MAC) in Ad-hoc

- **Standard 802.11e**
  - Enhanced DCF channel access **(EDCA)**.
  - Enhances IEEE 802.11 MAC layer.
  - Queue-based enhancement scheme.
  - Offers QoS (administrated in each node)

State of the art
EDCA access channel

- Each AC in EDCA can access the channel after waiting time = AIFS(AC) + backoff :
  - Arbitrary InterFrame Slot (**AIFS**)
  - Backoff is a random countdown [0, CW]:
- The parameters of EDCA:
  - CWmin, CWmax, AIFSN





State of the art
EDCA problematic

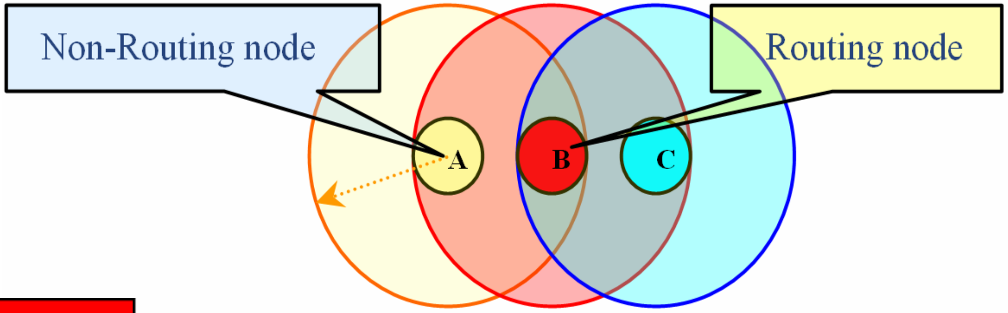
- No management control
- An extension is needed to be applied in EDCA to support fairness.

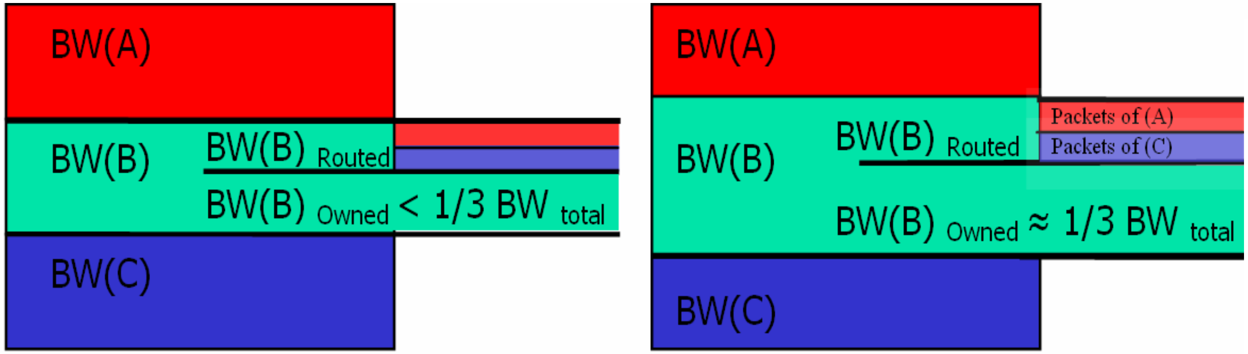
State of the art
F-EDCA [Hanal08]

- Fairness model for EDCA.
- Local solution between the node and its neighbors.
- DCF-based access channel enhancement.
- Differentiating between routing and non-routing nodes.

State of the art
F-EDCA [Hanal08]

- Routing node can access channel more frequently than non-routing node.

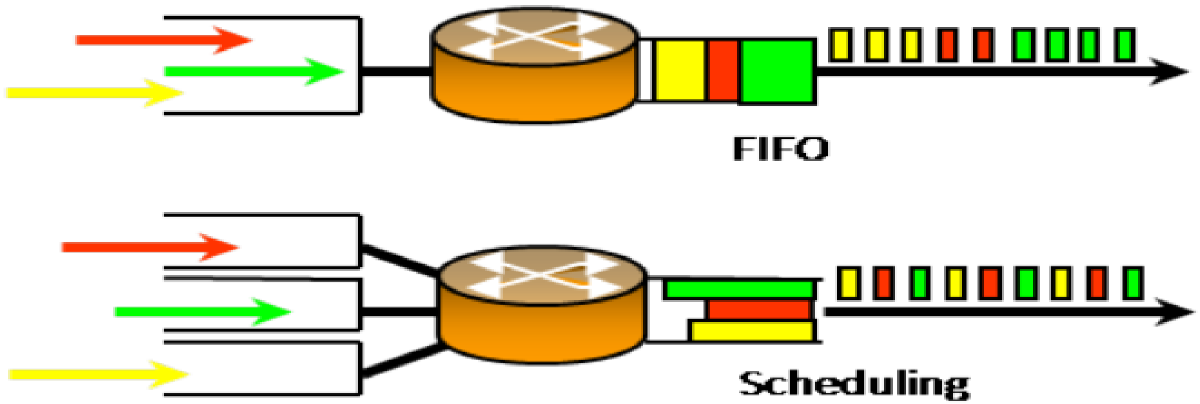




a) BW allocation without Fairness
$\{ BW(B)_{Owned} < (BW(C)_{Owned} \approx BW(A)_{Owned}) \}$

b) Wanted BW allocation with Fairness
$\{ BW(B)_{Owned} \approx BW(C)_{Owned} \approx BW(A)_{Owned} \}$

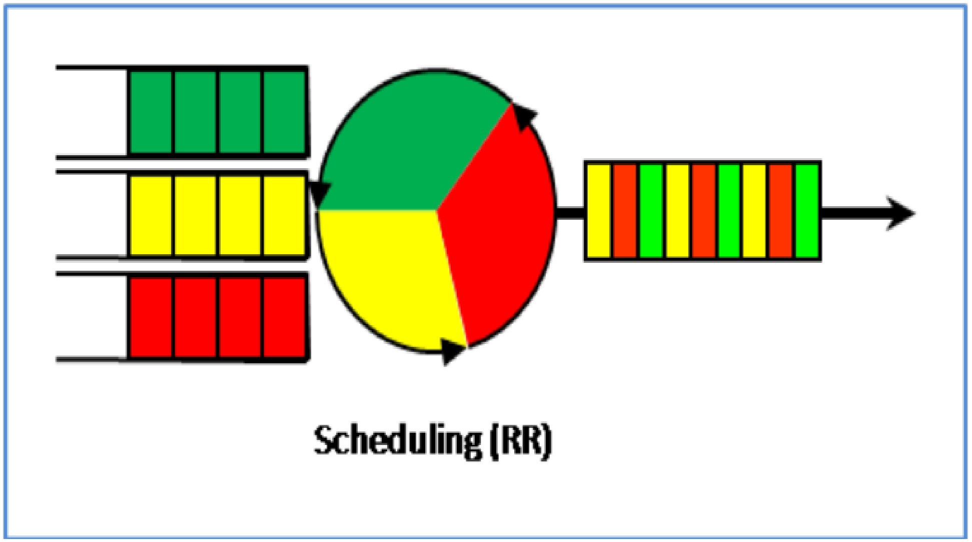
State of the art
Scheduling

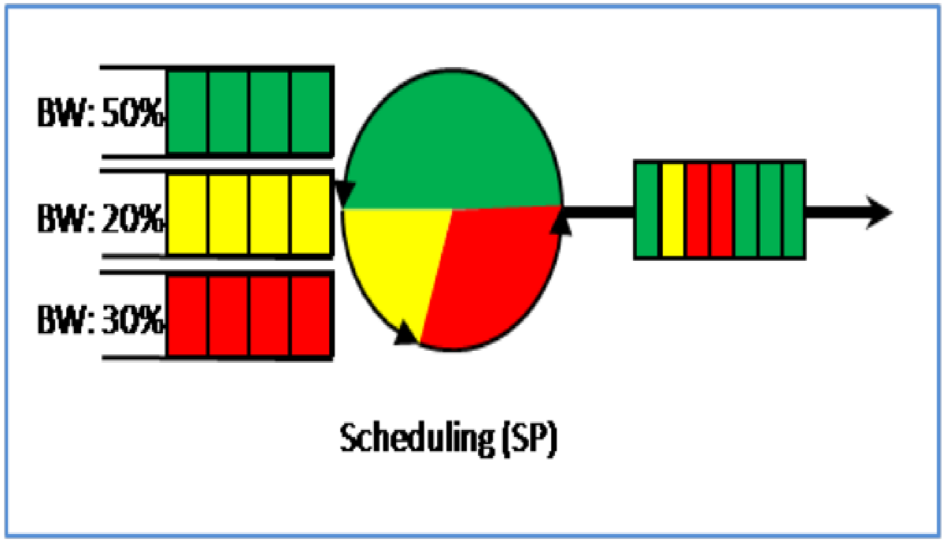


- Which packets should be given preference?
- How many packets should be transmitted from a flow?
- Scheduling (Queuing):
  - GPS, WFQ, WF2Q, RR, SP, VC, etc.

State of the art
Scheduling

- GPS is the fluid flow Ideal scheduling.
- WFQ is an emulation of GPS





Outline

- **Introduction**
- **State of the Art:**
- Our proposition
- Conclusion & Future works
- References

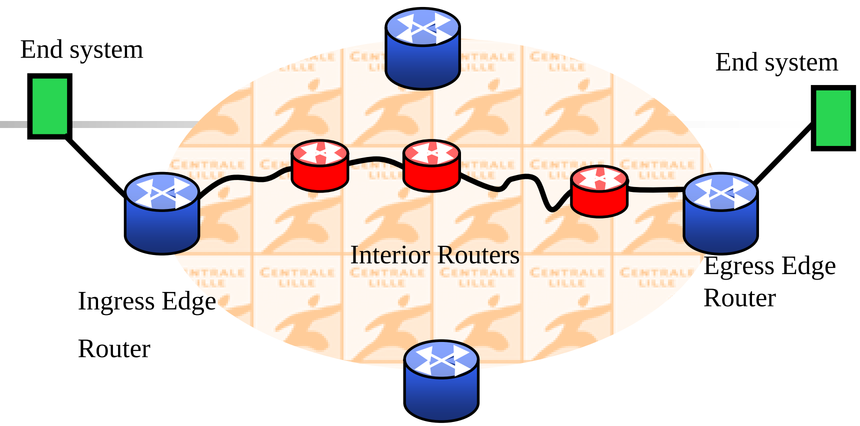
QoS in wired networks

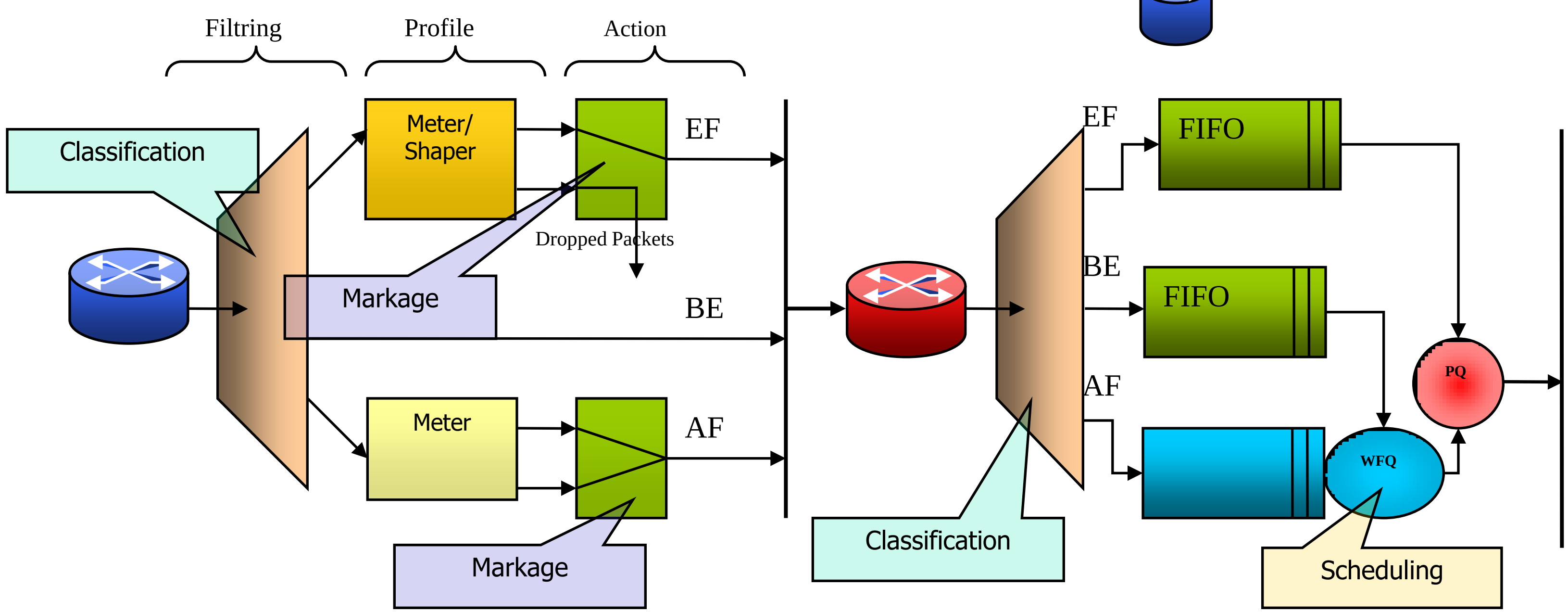
QoS Architectures

- IntServ:
  - Resource reservation per flow using **RSVP**.
  - Similar to ATM virtual connections.
  - Problems with scalability.
- DiffServ:
  - Aggregation of flows into per-hop behavior groups.
  - *Expedited* forwarding and *Assured* forwarding.

QoS in wired networks

Diffserv Model

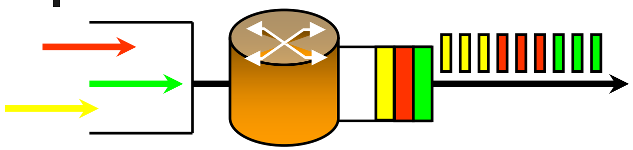


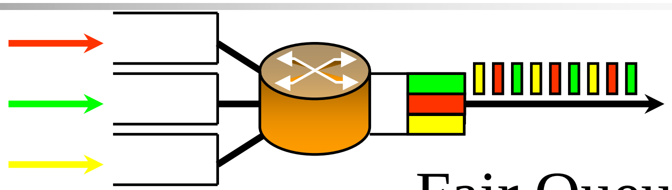


(a) Edge Router Interface

(b) Interior Router Interface

QoS in wired networks
Scheduling Goals


FIFO


Fair Queueing

- Congestion avoidance
- Sharing bandwidth
- Fairness of competing flows
- Resource allocation, bandwidth guarantees
- End-to-end bounded delay

QoS in WLAN
Scheduling in Wireless

- Simple:
  - FIFO or **[FCFS]**
- Multiplexing:
  - Round-robin
- Based on virtual finishing time:
  - WFQ or WF^2Q
  - time-stamping as Virtual-Time **[VT]**
    - is based on the resource reservation instead of an equal share to all users like WFQ
  - Self-clocked Fair Queuing **[SCFQ]**

QoS
Adapting algo from wired to wireless

- *Note: It's not simple to adapt a model that is designed for wired networks:*
  - burst channel errors: it's assumed in wired scheduling that is error-free channel
  - location-dependent channel capacity and errors (Bandwidth Variation)
  - Adapting Techniques of scheduling is <u>*Open Issue*</u>

QoS
WLAN access control schemes

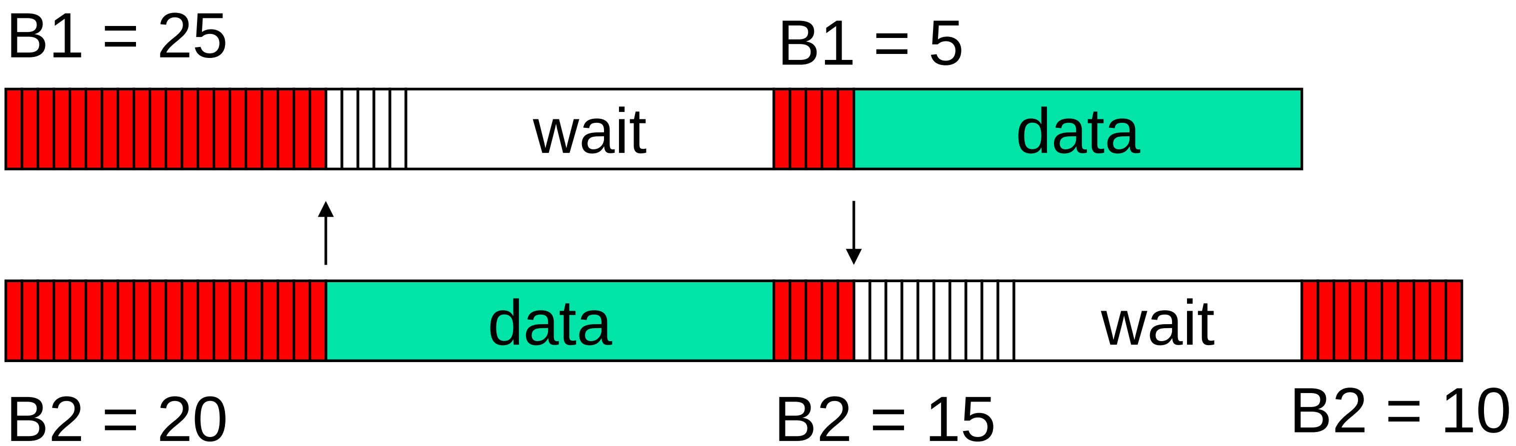
- 802.11 medium access control schemes (MAC):
  - Distributed Coordination Function (DCF).
  - Point Coordination Function (PCF).
- 802.11e medium access control schemes (MAC):
  - It enhances IEEE 802.11 MAC sublayer.
  - Hybrid Coordination Function (HCF):
    - Enhanced DCF channel access (EDCA).
    - HCF controlled channel access (HCCA).

QoS
DCF

- Ex. Ad-hoc
- to share the medium between multiple stations
  - Fairness needed *open issue*.
- Contention-Based (CW).
- Based on CSMA/CA.
- Uses a Contention window (Back-off interval).
  - Control CW for QoS is *open issue.*
- Designed for a best-effort service.
- Supports Asynchronous transmission.
  - No base station.

QoS

DCF example



B1 and B2 are backoff intervals for nodes 1 and 2

State of the ART of QoS

Limitation of DCF

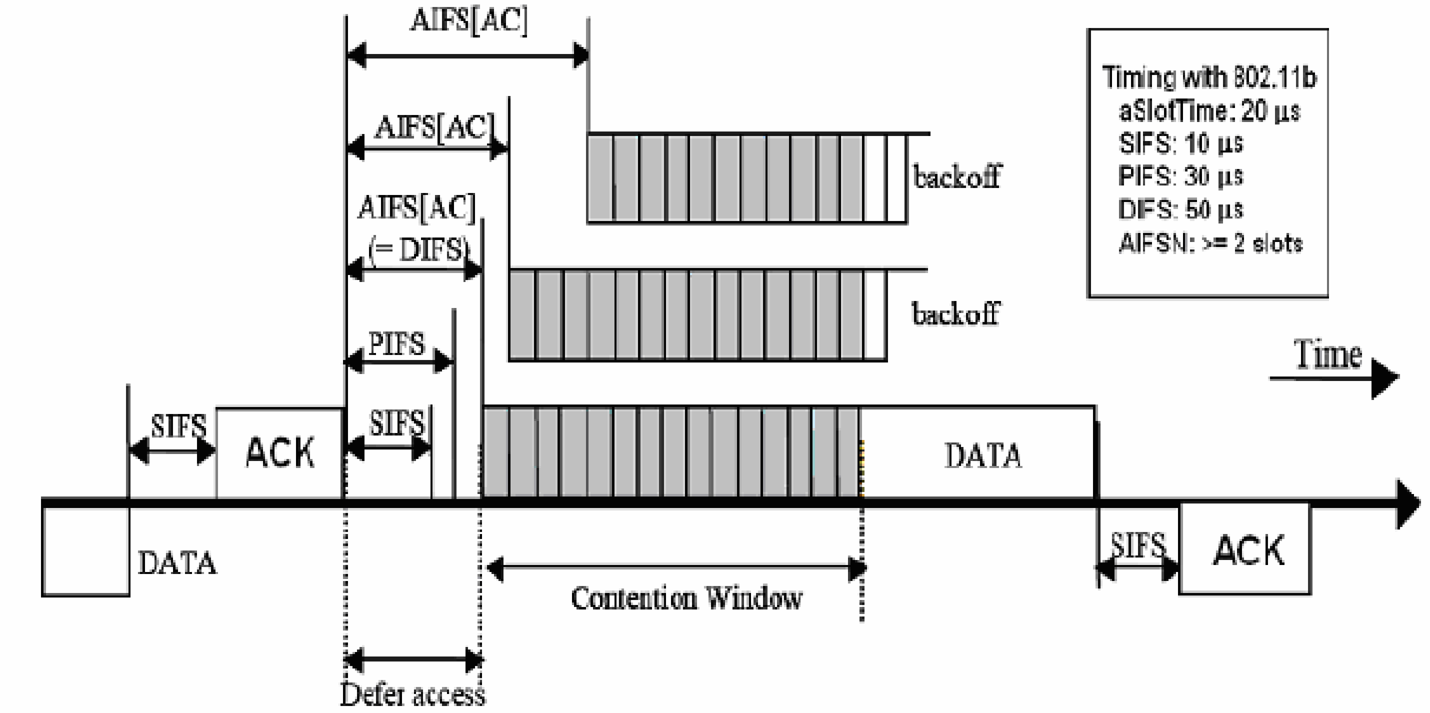
- No QoS guarantees.
- Does not support real-time application.
- Designed for equal priorities, there is no notion of high or low priority traffic.
- Station may keep the medium for as long as it chooses
- Does not support the concept of differentiating frames with different user priorities. (*open issue*)

State of the ART of QoS
EDCA

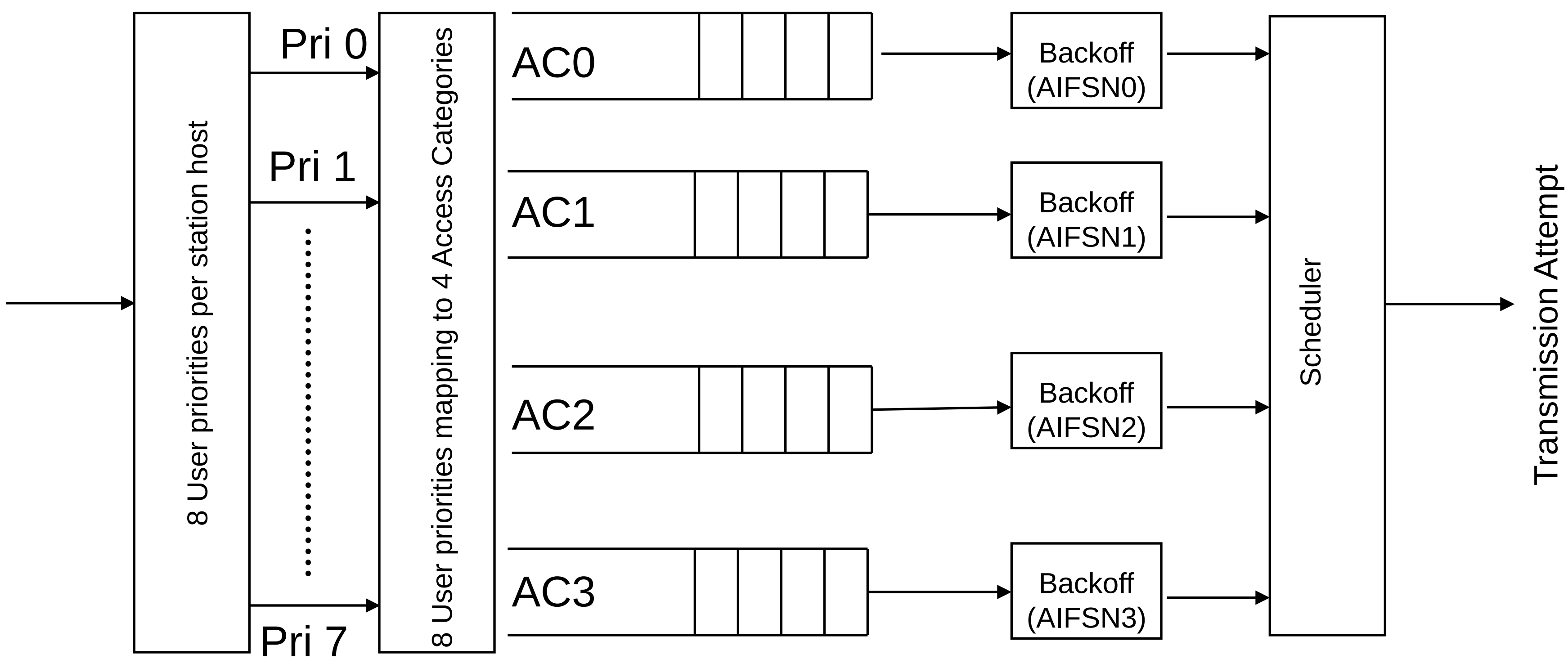
- Contention-Based channel access.
- Provides service differentiation.
- Differentiate the traffic into 8 different priorities.
- Each station has 4 access categories to provide service differentiation.
- Implementing an arbitrary interframe space:
  - **AIFS**: is number of slots to back off before the beginning countdown of backoff procedure
  - To accelerate backoff countdown
  - AIFS number is bigger or equal 2

State of the ART of QoS
EDCA

- **AIFS (AC) = SIFS + AIFSN (AC) * aSlotTime**



QoS
EDCA architecture



QoS
IEEE802.11e (EDCA) architecture

- Contention-Based channel access.
- Provides service differentiation.
- Implementing an arbitrary interframe space:
  - **AIFS**: is number of slots to back off before the beginning countdown of backoff procedure

Access Category (AC)	**Designation (Informative)**	**Priority**	AIFSN	CWmin	CWmax
AC3	Best Effort	0	7	31	1023
	Best Effort	1			
	Best Effort	2			
AC2	Video Probe	3	3	15	1023
AC1	Video	4	2	7	31
	Video	5			
AC0	Voice	6	2	3	15
	Voice	7			