

The IEEE 802.11 Protocol

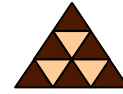
WLAN QoS
802.11e and WMM

Realtime Problems with 802.11



- Available BW is shared among clients
- No traffic priorities
- Once a station gains access it may keep the medium for as long as it chooses
 - ◆ Low bitrate stations (e. g. 1 Mbit/s) will significantly delay all other stations
- No service guarantees
- PCF does not support traffic classes
 - ◆ However, the PCF is typically not implemented in APs and client adapters

Specific PCF Problems



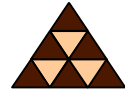
- **Irregular Beacon delays**
 - ♦ Stations may finish each transmission even if TBTT already expired
 - ♦ Up to 2304 bytes (2312 bytes if encrypted, new: even 2342 bytes allowed)
 - ♦ Station may even send all fragments of a L2-fragmented packet
- **Hidden station and interferences**
- **No traffic classes means: All applications have equal TX opportunity**

802.11e – EDCF and HCF



- **New coordinate functions relying on Traffic Classes (TCs)**
- **Enhanced DCF (EDCF)**
 - ♦ Better CHANCES for high-priority classes
 - ♦ But NO GUARANTEES ("best effort QoS")
 - ♦ Performed within CP
- **Hybrid Coordination Function (HCF)**
 - ♦ Is an enhanced PCF
 - ♦ Allows precise QoS configurations on the HC:
 - BW control
 - Guaranteed throughput
 - Fairness between stations
 - Classes of traffic
 - Jitter limits
 - ♦ Performed within CFP

802.11e – HCF Details



- Stations announce their TC queue lengths
- The Hybrid Coordinator (HC=AP) does not need to follow round robin but any coordination scheme
- Stations are given a Transmit Opportunity (TXOP)
 - ♦ They may send multiple packets in a row, for a given time period
- During the CP, the HC can resume control of the access to the medium by sending CF-Poll packets to stations
- Also allows to send multiple data frames followed by single ACK

802.11e – Facts



- **Concept Summary**
 - ♦ CP allows to prioritize certain TCs instead stations
 - More important traffic classes will be preferred—statistically
 - ♦ CFP allows bandwidth reservation by stations and non-round-robin polling
 - Not yet implemented (Fall 2004)
- **Hybrid Controller (HC) required**
 - ♦ Controls all other "enhanced stations"
 - ♦ Typically implemented within AP (not necessarily)
 - ♦ "QBSS" instead of BSS
- **Main driver for QoS is "Voice over Wireless IP" (VoWIP)**

802.11e – Algorithm (1)

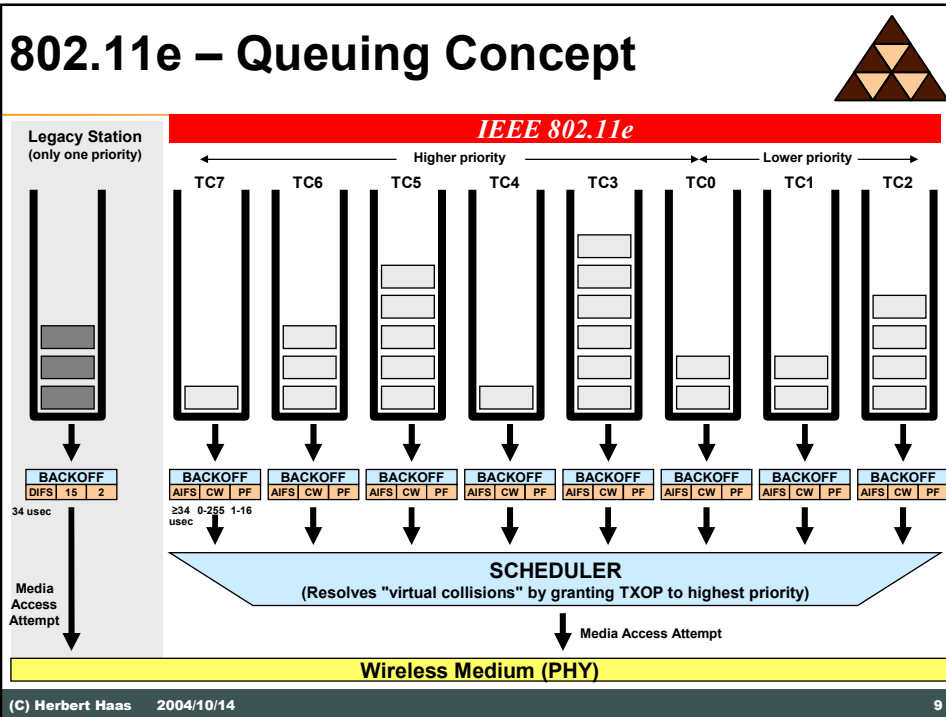


- All traffic is separated into TCs
 - ♦ Enhanced stations must maintain a separate back-off timer for each TC
- Up to 8 priority queues for each TC
 - ♦ "Virtual Stations" inside enhanced stations
- Each TC has different priority value
 - ♦ To avoid collisions if the counters of two TCs expire
- TCs compete within Arbitration Interframe Space (AIFS)
 - ♦ Different AIFS for each TC possible
 - ♦ At least one DIFS long
- Persistence factor (PF) solves collision
 - ♦ Used to calculate new back-off values
 - ♦ PF=1..16
- Legacy stations must have a CWmin=15 and PF=2

802.11e – Algorithm (2)

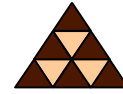


- Transmission Opportunity (TXOP)
 - ♦ Time slot during a station may send
- EDCF-TXOP
 - ♦ Issued by EDCF algorithm
 - ♦ Limited by system-wide TXOP-limit announced in beacon frames
- Polled-TXOP
 - ♦ Issued by HCF
 - ♦ Limited by parameter announced in poll-frame
- HCF can redefine TXOP at each time
 - ♦ And finish the CP earlier
- HC also supports controlled contention
 - ♦ Polling frames announce sending desire of other stations
 - ♦ Legacy stations must wait until end of controlled contention period



- ## WiFi Multimedia – WMM
- WMM implements a subset of 802.11e to satisfy urgent QoS needs
 - ◆ Certification start: 09/2004
 - Only supports prioritized media access:
 - ◆ 4 access categories per device: voice, video, best effort, and background
 - ◆ Does not support guaranteed throughput
- (C) Herbert Haas 2004/10/14 10

Legacy QoS



- **Most legacy (no 802.11e) APs only support downstream QoS**
 - ♦ On the AP, create QoS policies and apply them to VLANs
 - ♦ If you do not use VLANs on your network, you can apply your QoS policies to the access point's Ethernet and radio ports
- **Note: APs do not classify packets!**
 - ♦ Only already classified packets are prioritized (DSCP, client type, 802.1p)
 - ♦ EDCAF-like queuing is performed on the Radio port; only FIFO on Ethernet egress port
 - ♦ Only 802.1Q tagging supported – no ISL !!!

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802.1x and WAN Congestion



- Congestion on WAN links: prioritize 802.1x packets
- Classify and mark RADIUS packets using the Cisco Modular QoS Command Line (MQC)
 - ◆ Method to determine the appropriate queue size for the 802.1x/RADIUS packets
 - ◆ And to determine how to enable queuing on router interfaces

```
ip access-list extended LEAPACL                               !!! Create ACL for interesting traffic
permit udp any host 172.24.100.156 eq 1645

class-map match-any LEAPCLASS                               !!! Classify
match access-group name LEAPACL

policy-map MARKLEAP                                        !!! This is a policy group
class LEAPCLASS                                           !!! Corresponds to AF31 (Class=3, 1=low drop)
set ip dscp 26

interface FastEthernet0/0.100                             !!! Attach marker on interface
encapsulation dot1Q 100
service-policy input MARKLEAP                             !!! Mark inbound (input) packets only

policy-map LEAPQUEUEUE                                    !!! 8kb/s if needed (dynamical management)
class LEAPCLASS
bandwidth 8

interface Serial3/0:0                                     !!! Attach policy-map on WAN interface
ip address 172.24.100.66 255.255.255.252
load-interval 30
service-policy output LEAPQUEUEUE
```