IEEE 802.11e
Dienstgüte in Wireless LANs (engl.)

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legacy 802.11 MAC protocol
limitations in QoS support
concepts for QoS support in Wireless LANs

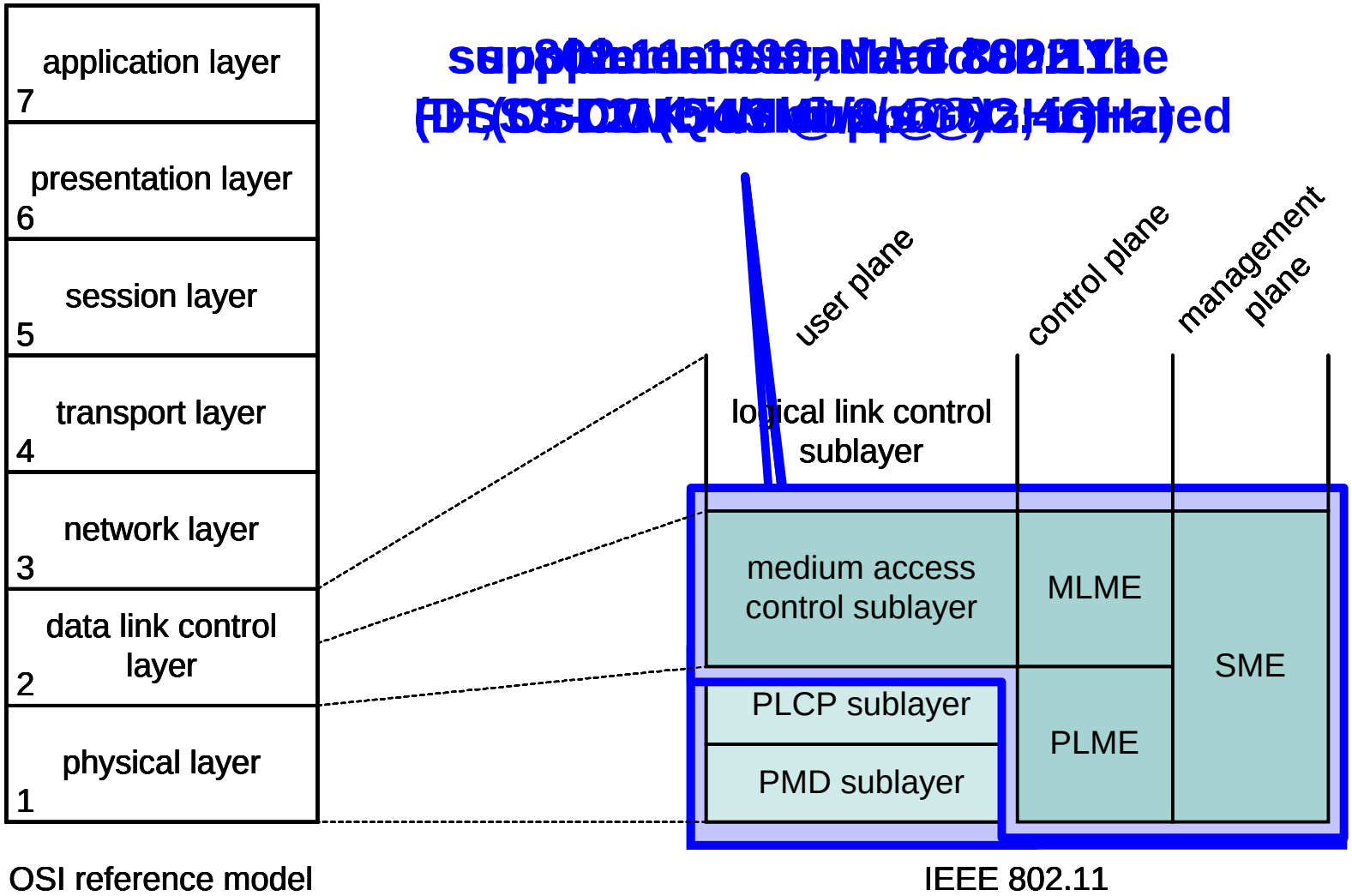
We present ...

- a brief overview over the 802.11 MAC protocol (as part of ISO/IEC8802-11, ed. 1999)
- limitations of the legacy 802.11 MAC protocol for the support of QoS
- (new) MAC enhancements for QoS support, per Task Group e: **IEEE 802.11e**
- remaining problems

Introduction: IEEE Working Group 802.11

- IEEE 802.11 Working Group (WG)
  - The 802.11 WG is comprised of all of the Task Groups together
- Task Group (TG)
  - The committee(s) that are tasked by the WG as the author(s) of the standard or subsequent amendments
    - **TGa**: the scope of the project is to develop a PHY to operate in the newly allocated UNII band.
    - **TGb**: the scope of the project is to develop a standard for a higher rate PHY in the 2.4GHz band
    - **TGe**: enhance the 802.11 MAC to improve and manage Quality of Service
- Study Group (SG)
  - Investigates the interest of placing something in the standard
    - **5GSG**: presently investigating the globalization and harmonization of the 5GHz band jointly with ETSI-BRAN, and MMAC

IEEE 802.11 Reference Model

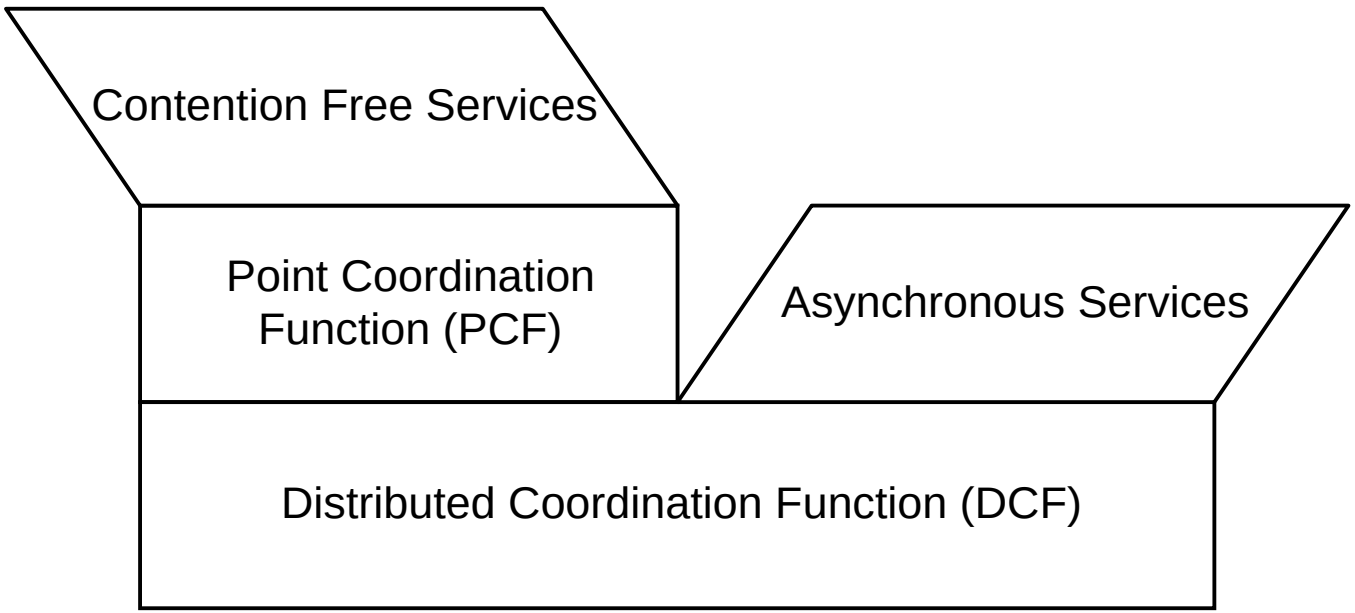


IEEE 802.11 Services

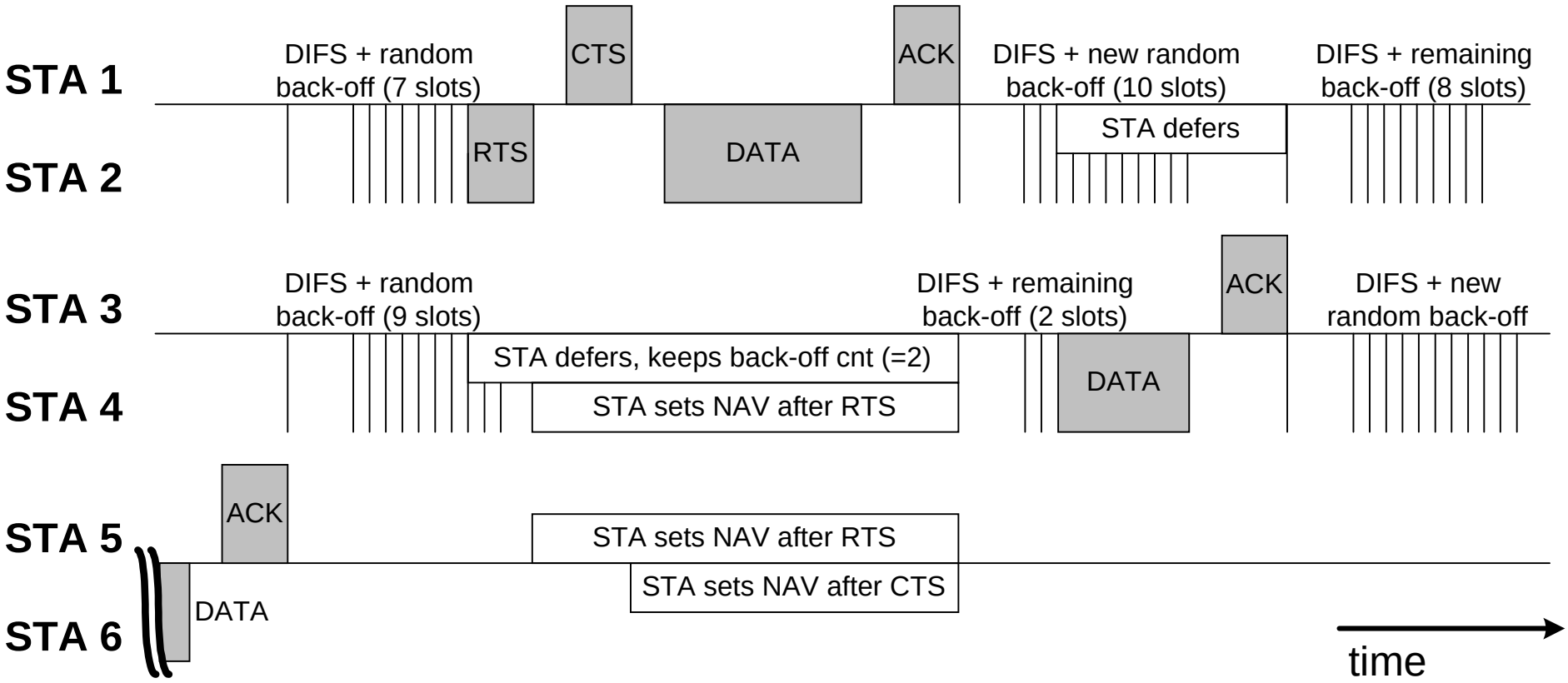
- Services are provided to upper layers by Basic Service Sets (BSSs), i.e. sets of communicating stations (STAs)
- The **MAC Service Data Unit (MSDU) Delivery** is the service we are interested here
- Within a BSS, MSDUs are delivered from STA to STA over the wireless medium
- A BSS is independent (IBSS), if it does not include a central coordinator and no Access Point (AP)
- Other services are
  - (de-)authentification
  - privacy
  - (re-/dis-)association
  - distribution

IEEE 802.11 MAC

- 802.11 performs distributed medium access, CSMA/CA
- Two types of MSDU Delivery Services
  - DCF: Asynchronous (no guarantee of successful transmission, best-effort)
  - PCF: Contention Free (time-bounded delivery)
- PCF is optional, but if implemented, it has highest priority



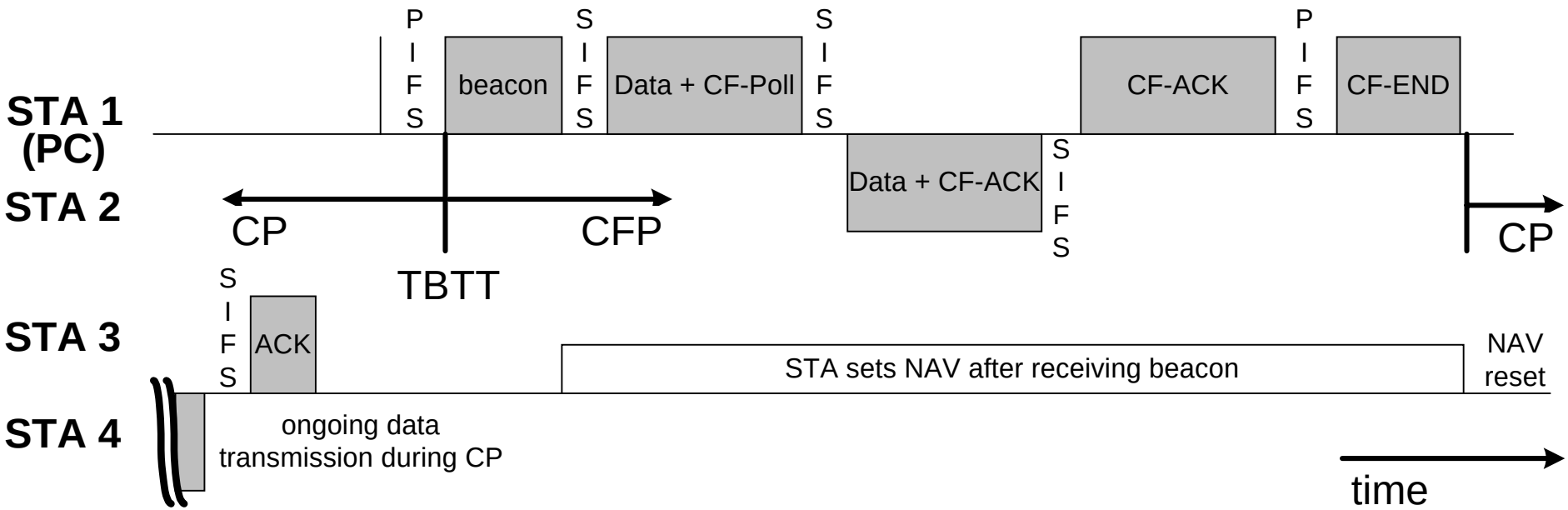
Legacy 802.11 – Distributed Coordination Function



- Basic access technique is the CSMA/CA
- Request to Send / Clear to Send for hidden station provision

Legacy 802.11 – Limited QoS with Point Coordination Function

- A management frame, the beacon, may periodically start a Contention Free Period (CFP) at target beacon transmission times
- During CFP, the point-coordinator polls STAs for MSDU delivery
- QoS-problem: Beacon defers at busy medium
- QoS-problem: hidden STAs may start frame exchanges during CFP



Problems with the legacy 802.11

- Errors in the normative text
- Errors in the normative SDL description
- PCF is very inefficient, has never been implemented
- Once a STA grabbed the channel, it may transmit for a long time
- Beacons may be delayed (up to 4.9ms in 802.11a)
- What if there are two overlapping BSSs, both with PCF implemented?
- Back-off wastes capacity
- Required:
  - classes of service for QoS
  - better security and authentication mechanisms

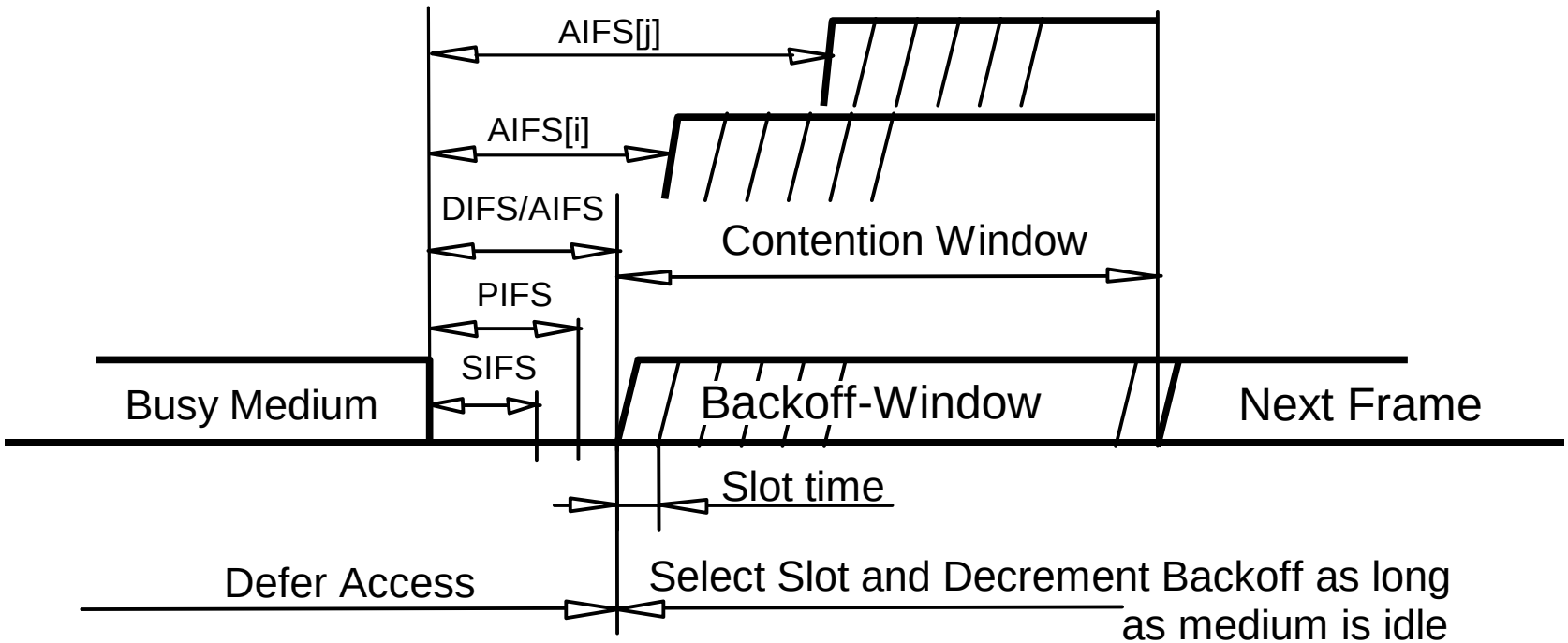
The new IEEE 802.11e MAC protocol (per draft 1.3, Oct. 2001)

DCF is replaced by EDCF

PCF is replaced by the HCF

Enhanced DCF (EDCF)

- The basic access method is the contention based EDCF
- A STA implementing the EDCF is called ESTA
- EDCF priority parameters are
  - DIFS now substituted by AIFS[i]
  - Contention window size CWmin[i], Persistence factor[i]

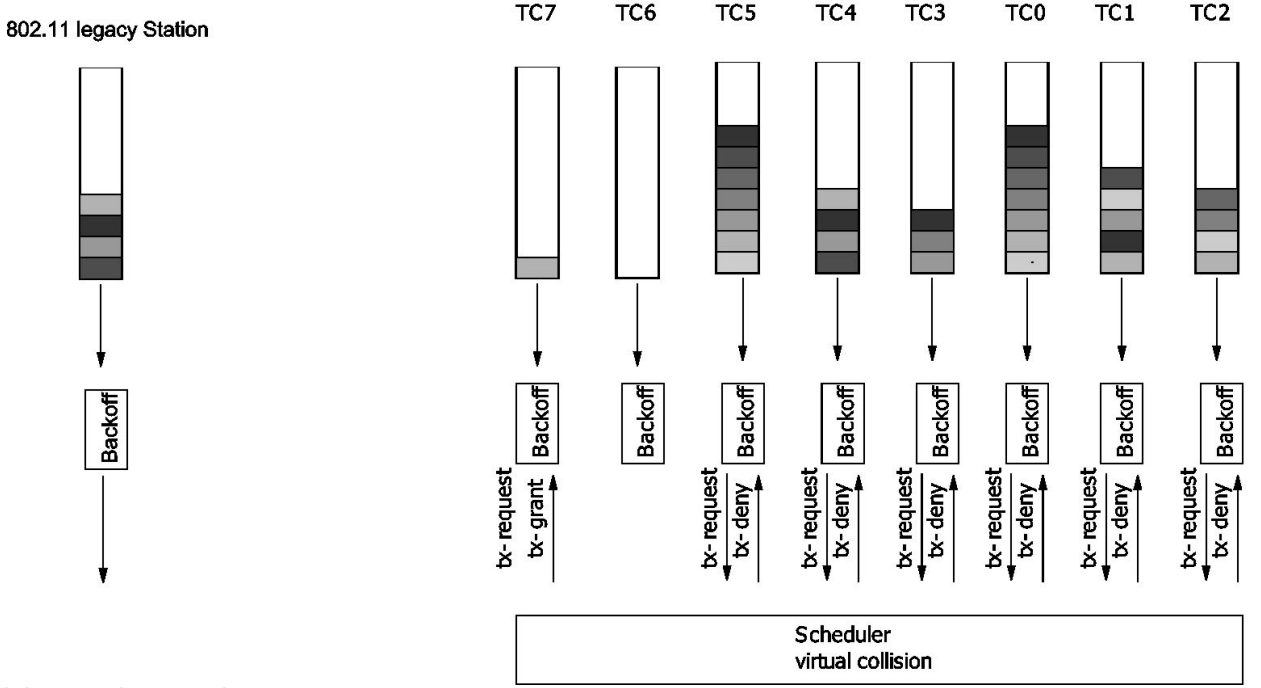


Priorities per traffic category, not per ESTA

- ESTAs operate with virtual back-offs
- up to 8 Traffic Categories (TCs)

before: DIFS=34us,
CWmin=15, PF=2

now: DIFS>=34us,
CWmin=0-255, PF=1-16

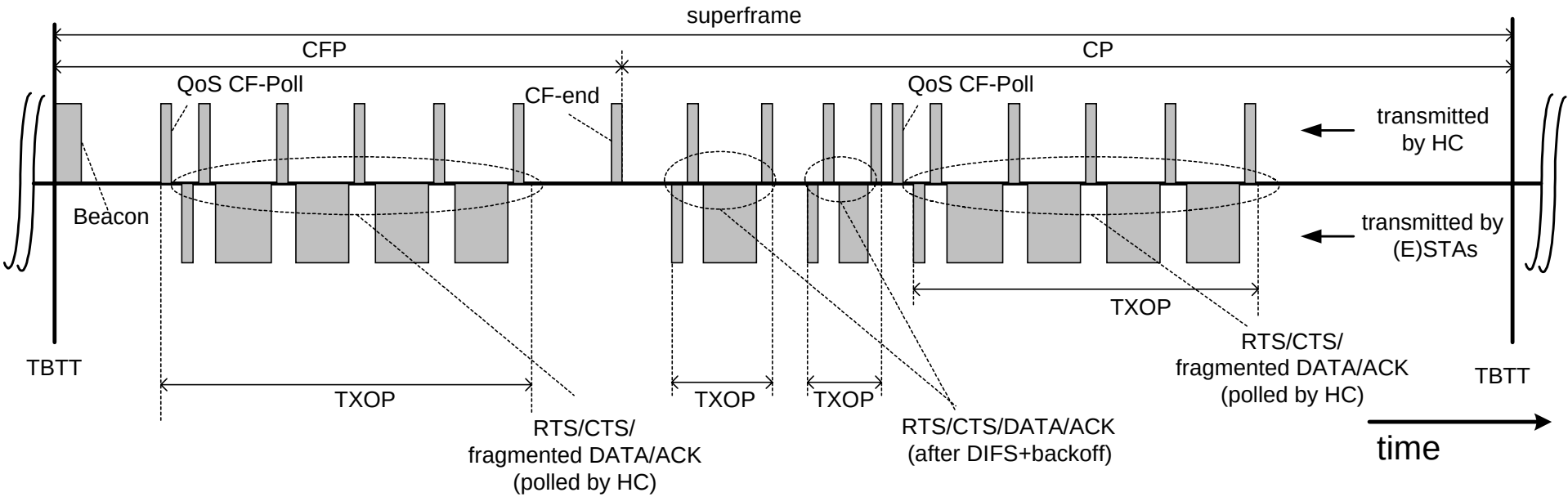


802.11 MAC Enhancement: Transmission Opportunities (TXOPs)

- TXOP is an interval of time when an ESTA has the right to initiate transmissions
- TXOP is defined by a starting time and a maximum duration
- Obtained via:
  - EDCF contention (EDCF-TXOP)
  - After being polled (polled TXOP)
- Limited duration:
  - The duration of an EDCF-TXOP is limited by a BSS-wide TXOP limit distributed in beacon frames
  - The duration of a polled TXOP is specified in the frame header that includes the poll function
- No TXOP, nor transmission within a TXOP, extend across TBTT → no beacon delays

802.11 MAC Enhancement: Hybrid Coordination Function (HCF)

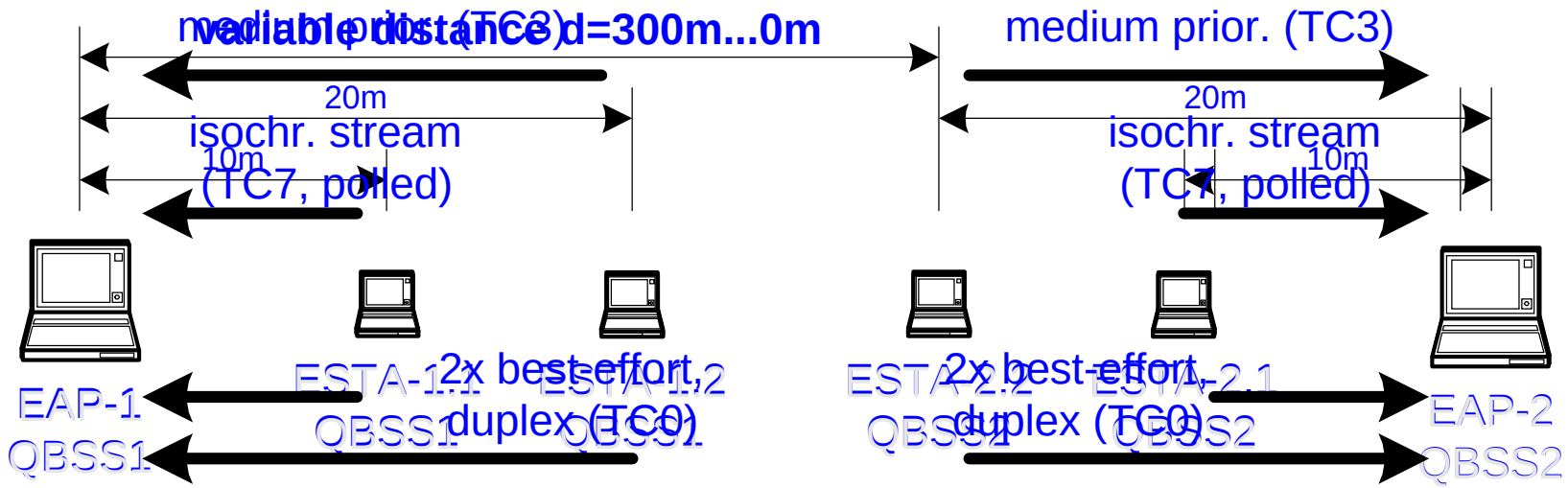
- HCF combines aspects of the DCF and PCF
- *"the EDCF is part of the HCF and is not a separate coordination function"*
- It is hybrid, because it polls during CFP as well as CP



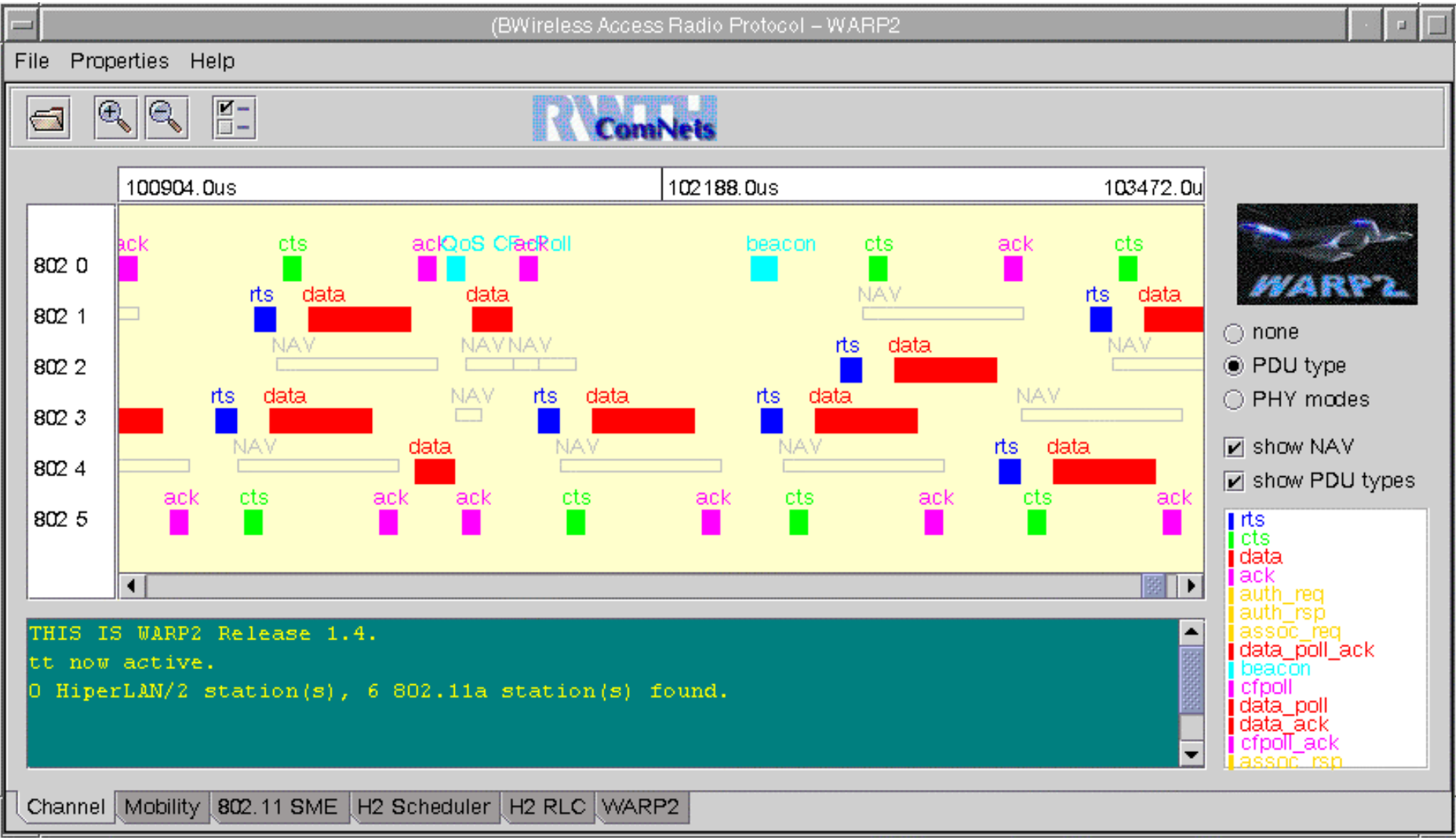
Simulation scenario: overlapping BSSs

- 2 QoS-supporting BSSs, 3 ESTAs each
- Isolated ... full overlap
- HCF or EDCF
- 3 streams each, priority 0,5,7

EDCF parameters:	TC0	TC5	TC7
AIFS[us]	79	52	34
CWmin[us]	135	90	63
CWmax[us]	1080	180	63
PF	2	2	2



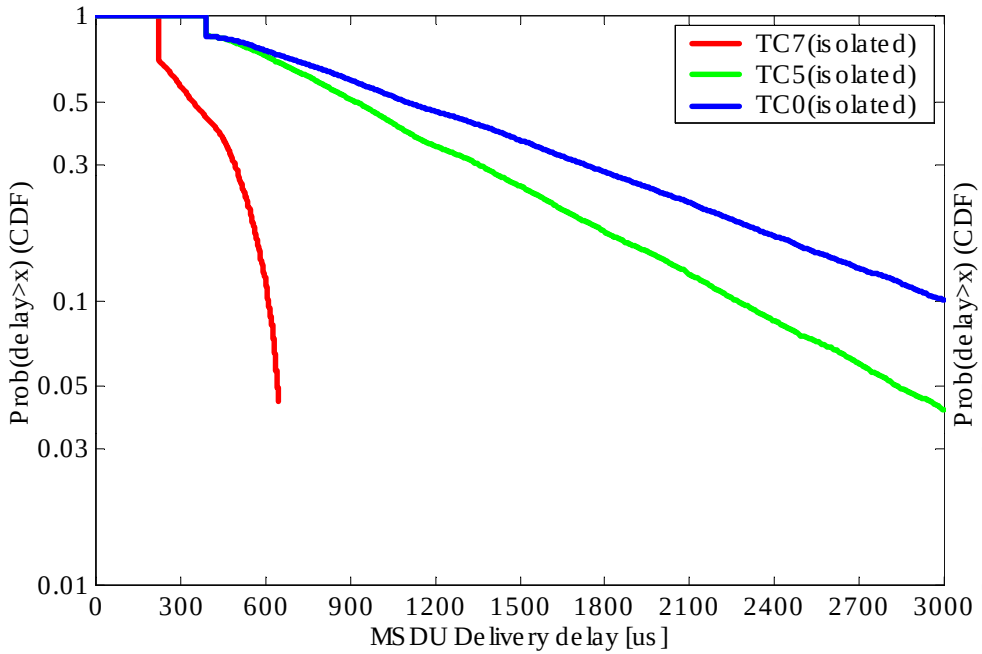
Isolated QBSSs: EDCF and HCF



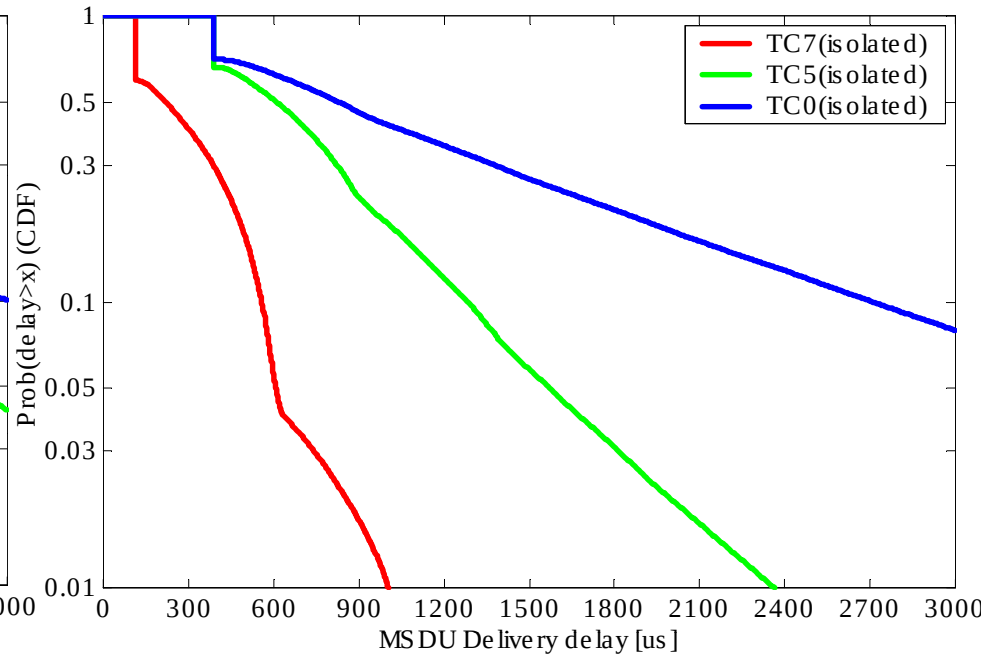
Results: Isolated QBSSs: EDCF and HCF

- Thrp=offer: *128kbit/s* isochr. stream – *1Mbit/s* per diff.&be streams
- Delay: TC7 < TC5 < TC0
- HCF: *QoS CF-Poll* wastes capacity
- HCF: max. delay of polled MSDUs depends on *EDCF-TXOPlimit*

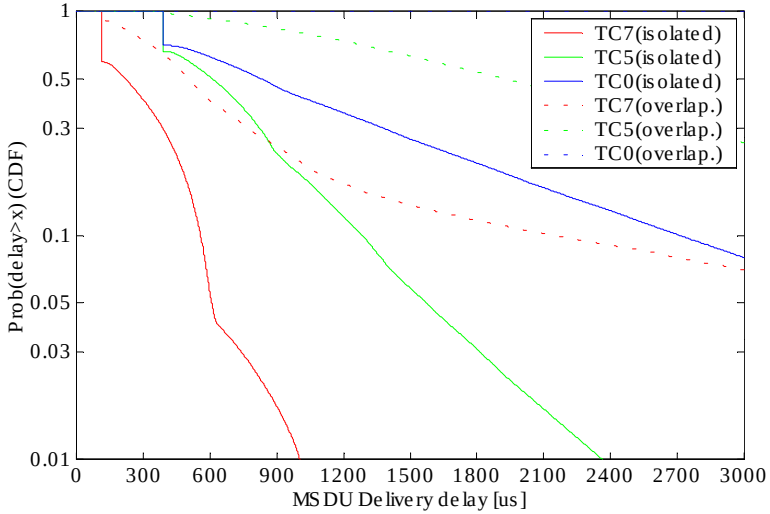
HCF:

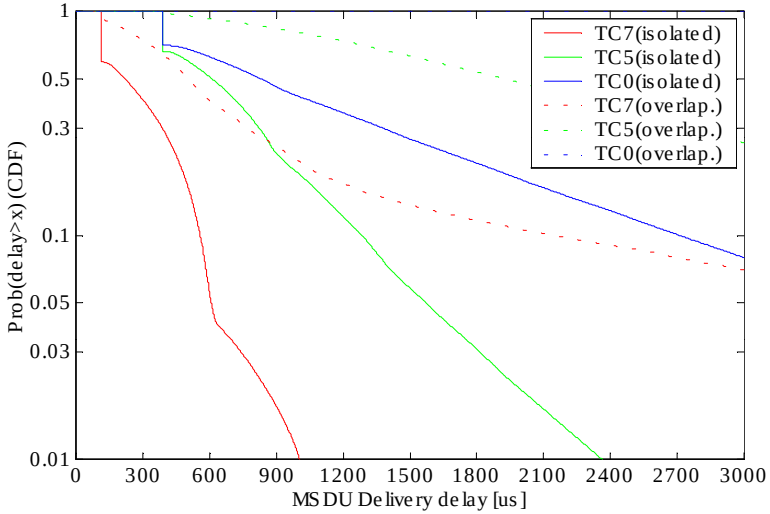


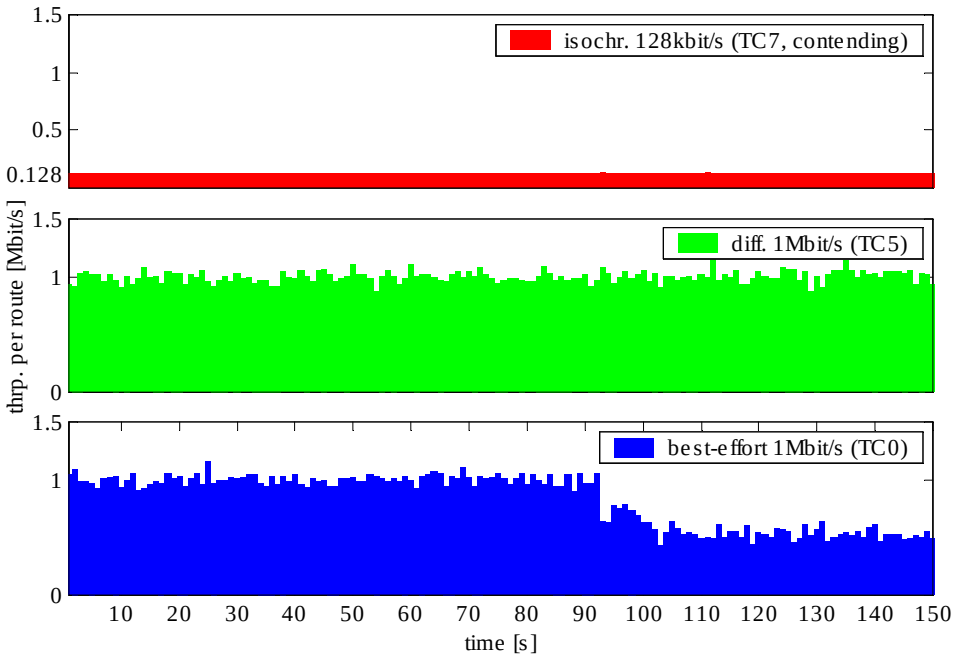
EDCF:

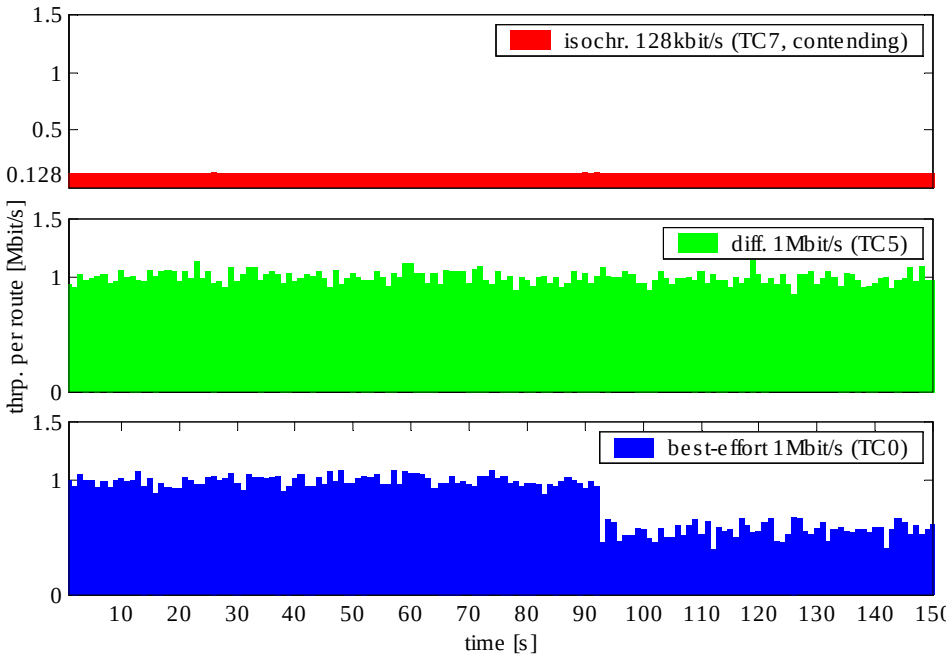


Results: Overlapping QBSSs: **EDCF-EDCF**

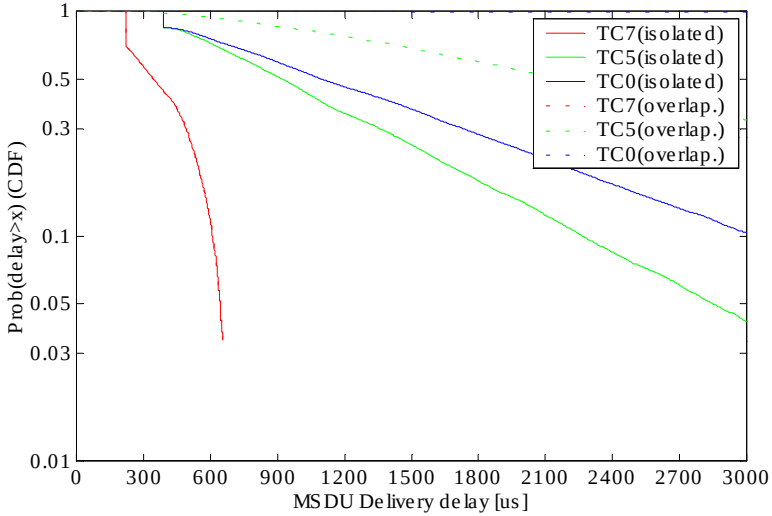


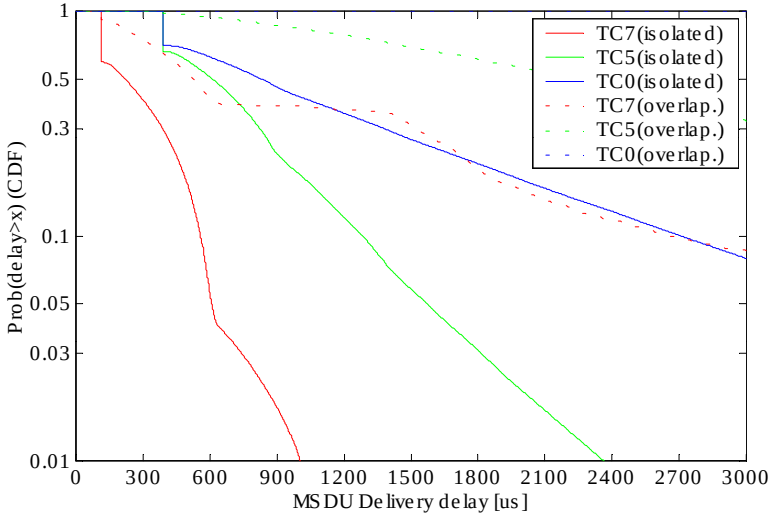


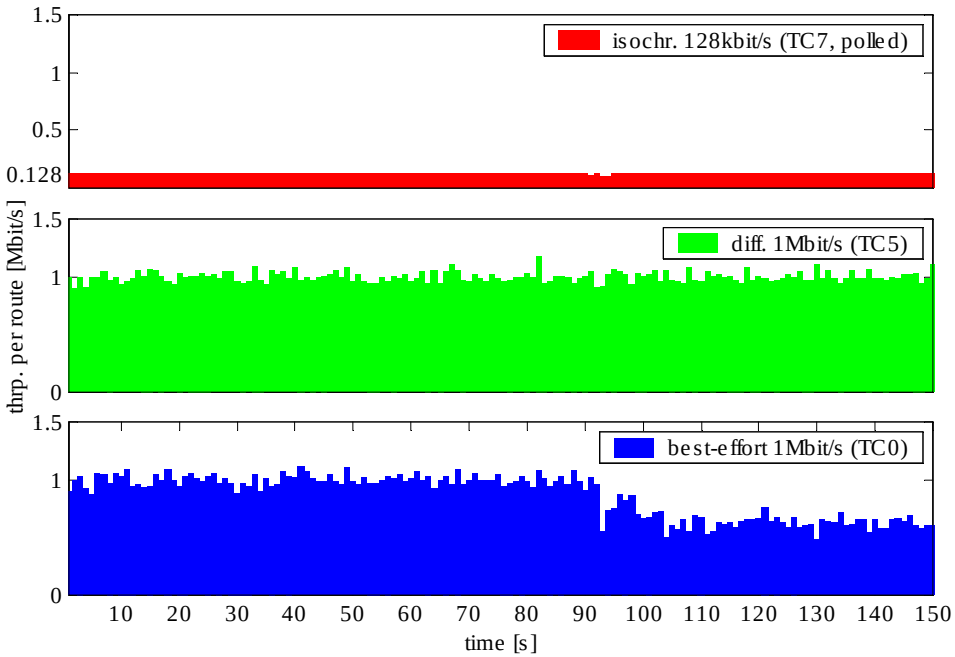


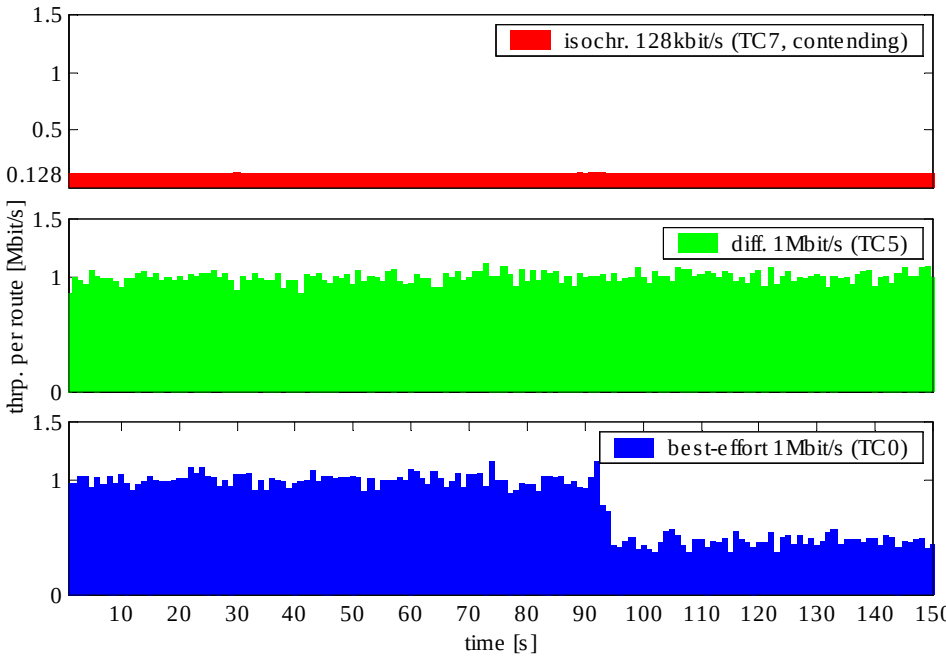


Results: Overlapping QBSSs: HCF - EDCF

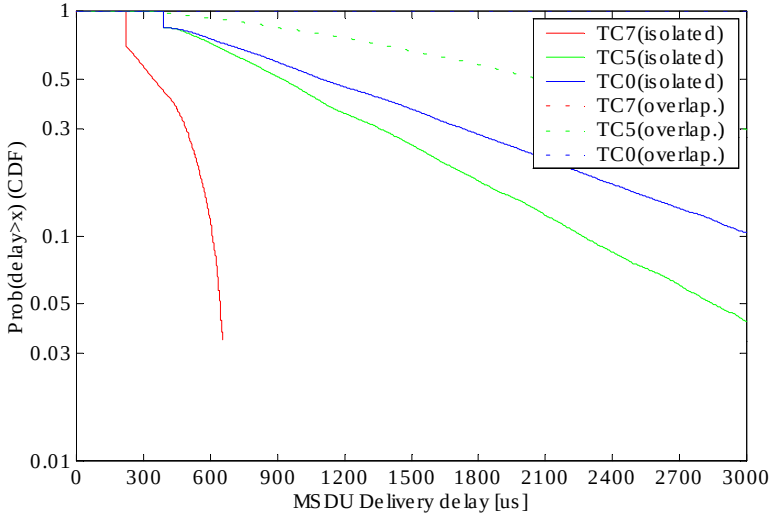


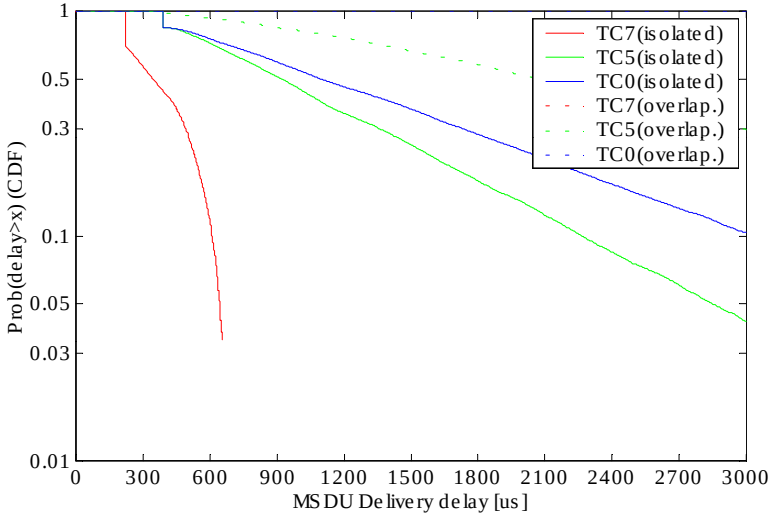


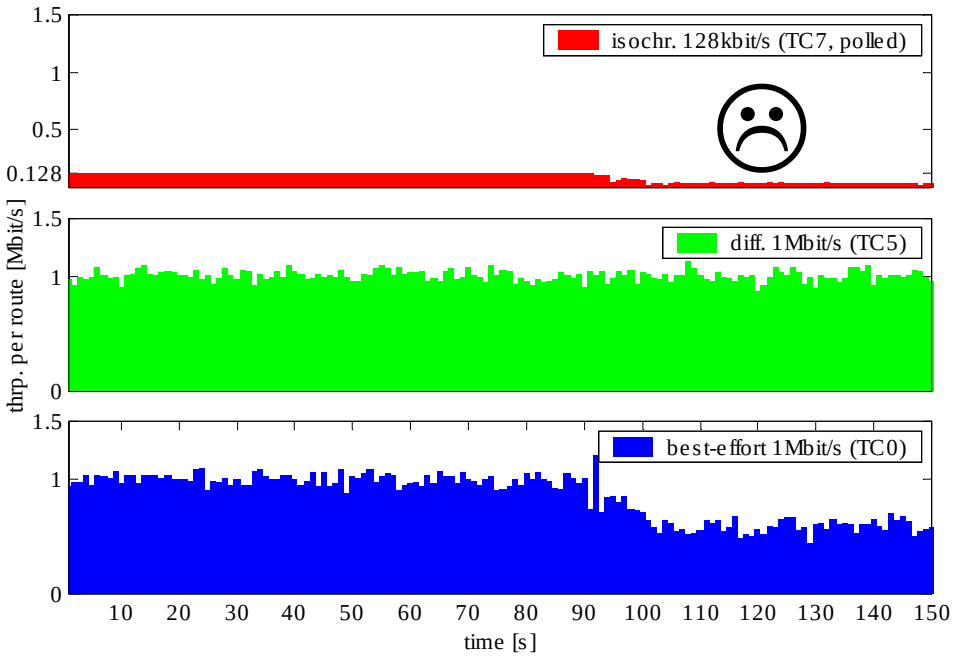


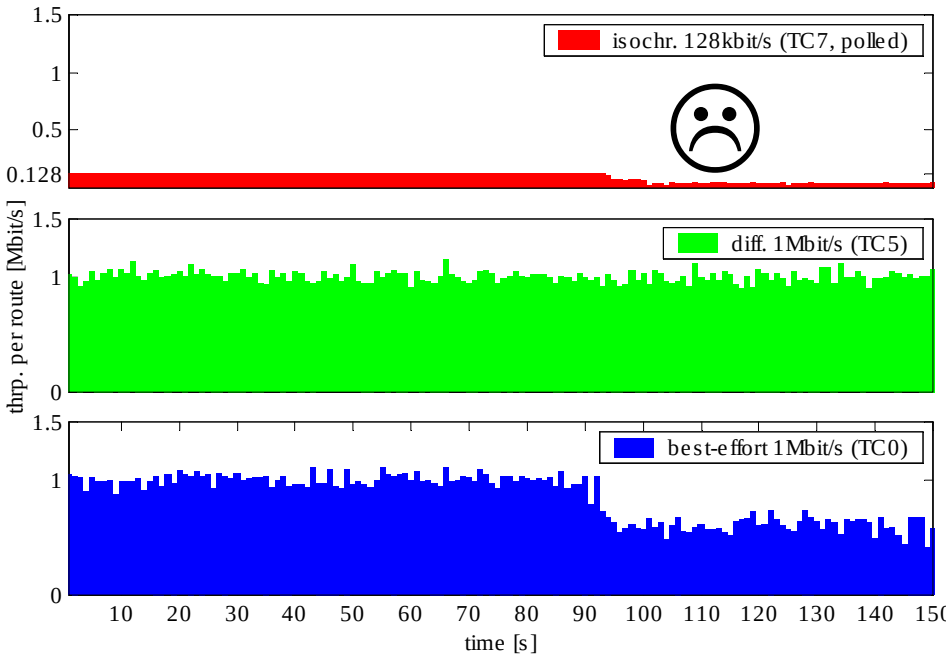


Results: Overlapping QBSSs: **HCF-HCF**









Conclusion, Remaining Problems

- Priority classes are defined
- DCF is enhanced for distributed QoS
- HCF replaces PCF

- Remaining problems
  - Overlapping BSSs with HCF cannot guarantee QoS
    - Dynamic Frequency Selection will be available as part of of TGh
    - Policies may help
  - Fairness problems if only one MSDU per TXOP is allowed
    - Bursting in EDCF-TXOPs