Adaptive IEEE 802.11 MAC Protocol for high efficiency MC-CDMA WLANs

15. FFV Workshop

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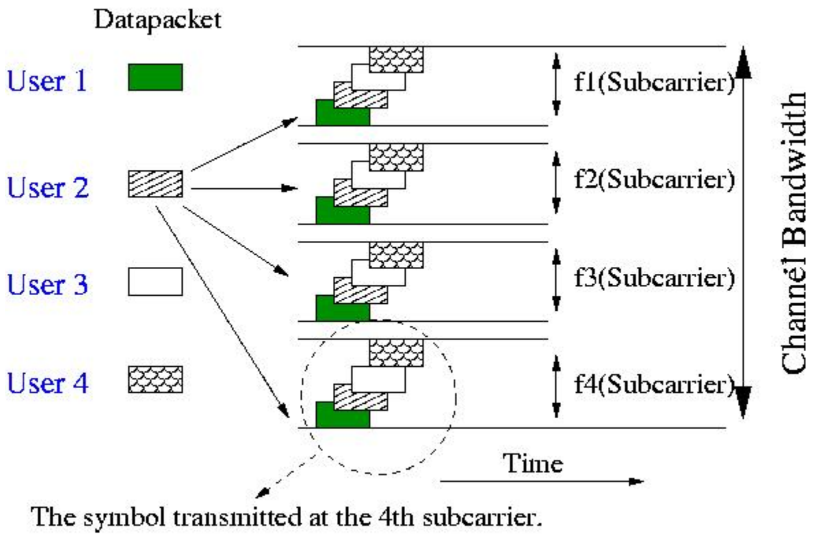
Overview

- MC-CDMA
- C-DCF Main protocol
- C-DCF OFDM/MC-CDMA capacity comparison
- Smart Backoff
- Frequency adaptation
- Crosslayer optimisation
- Multihop extension
- Centralized mode
- Conclusions

MC-CDMA (I)

- Combination of SS and OFDM
- Frequency spreading
- Frequency diversity
- IFFT / FFT realization of multicarrier modulation
- Simultaneous transmissions in the same frequency, through division of the spectrum in parallel channels => codechannels

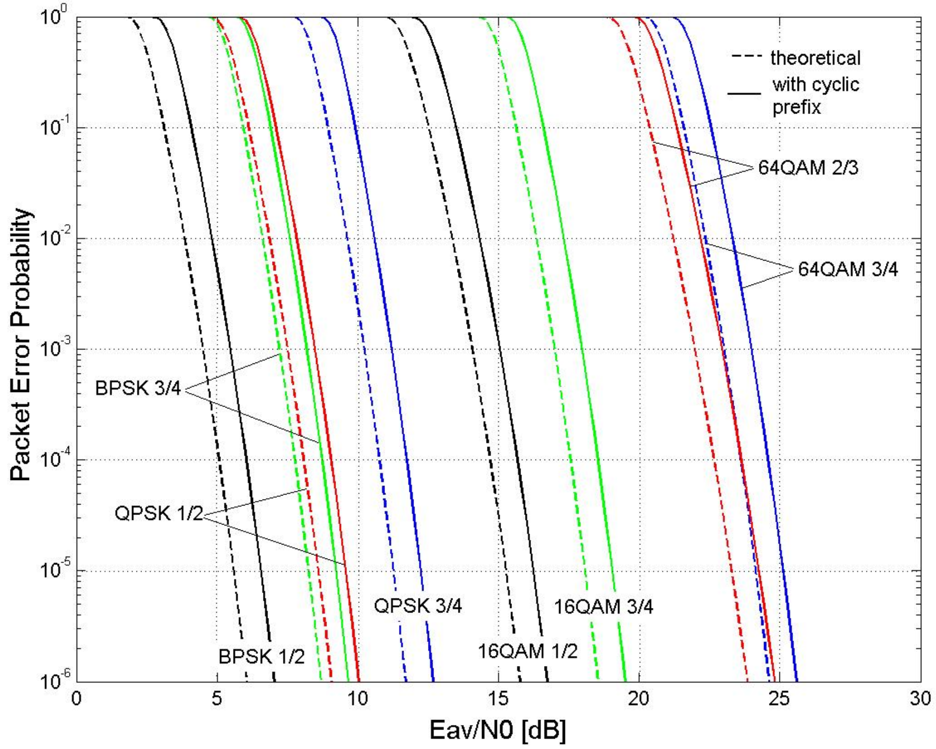
- Major advantages for MAC protocol design:
  - Effective protocol overhead reduction
  - Contention reduction
  - Multichannel structure: higher complexity, more degrees of freedom for optimization



MC-CDMA (II)

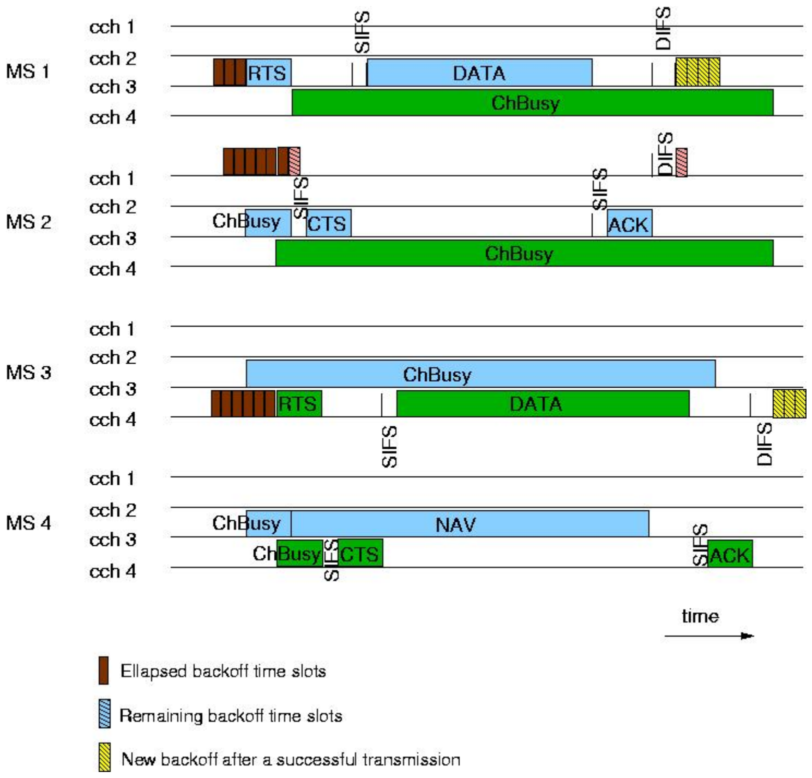
Link Level Performance of MC-CDMA

- PHY modes from IEEE 802.11a/e
- Convolutional encoder K=7
- Packet length: 1514 Bytes
- a_{CP} = 80%



C-DCF Main protocol

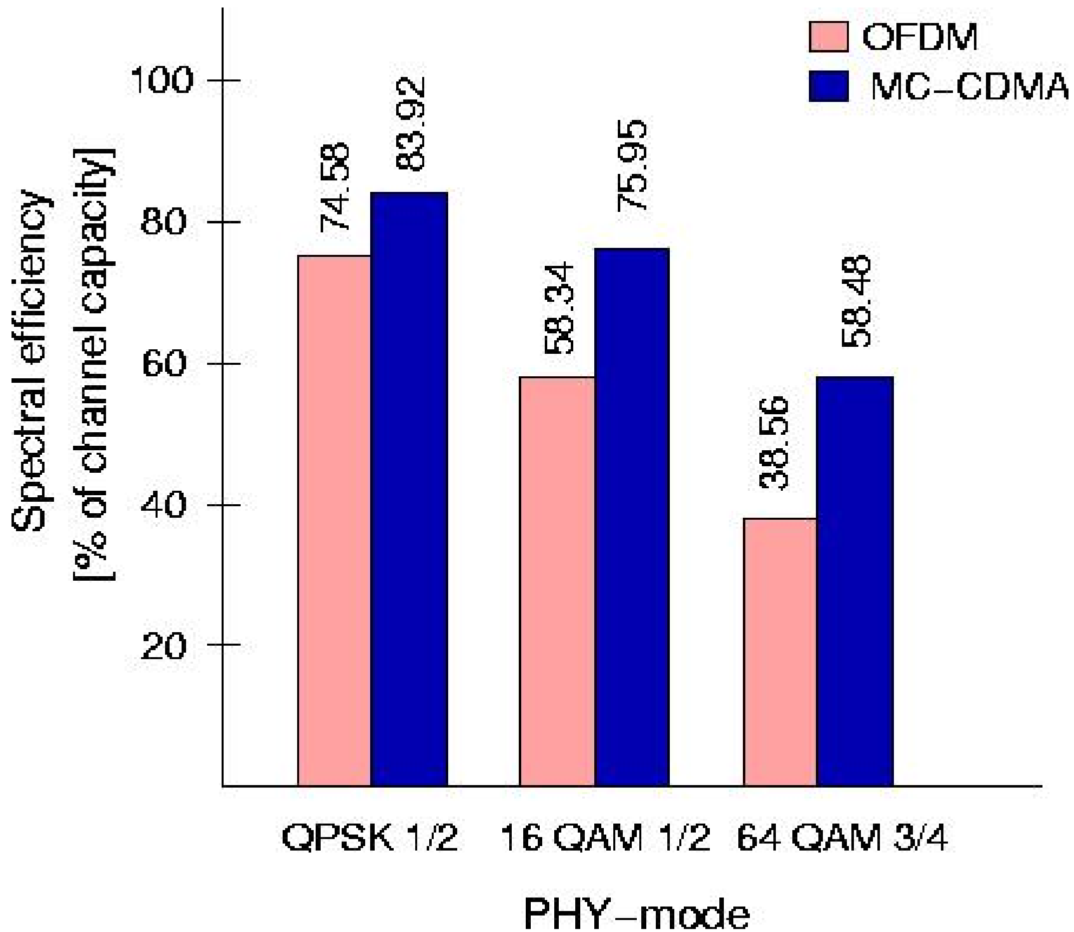
- CSMA / CA with 4 parallel codechannels
  - multichannel system
- Selection of codechannel
  - random
  - first transfer on cch1
- Data transfer: DCF
- NAV per codechannel
  - each station monitors optionally one or all codechannels
- Power control over RTS / CTS
  - for all data frames



C-DCF

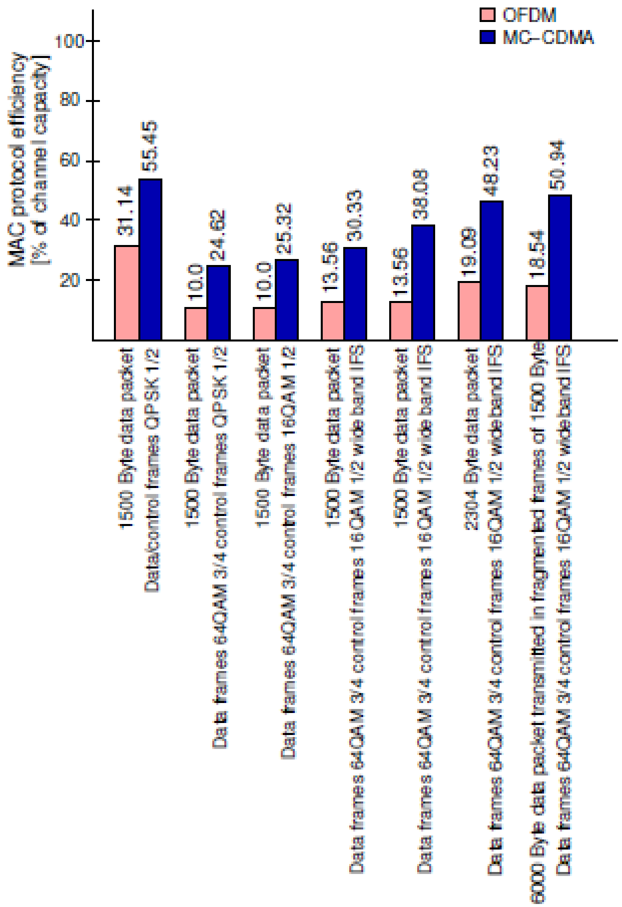
OFDM/MC-CDMA capacity comparison

- 1024 Bytes MAC SDUs



C-DCF

OFDM/MC-CDMA capacity comparison
WigWam AP3 high speed PHY-layer parameters

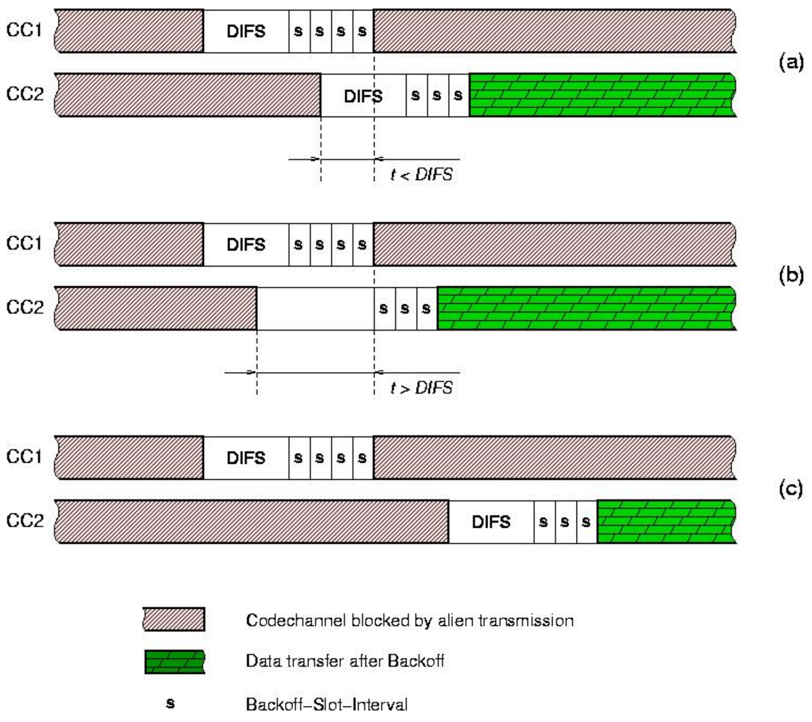


- F = 5.25 GHz
- BW = 100MHz
- Nsubcarriers = 596
- Δf = 0.15625 MHz
- Tsymbol = 6.8µsec
- aSlotTime, SIFS, Preamble = 4µsec
- DIFS = 8µsec
- PHY-rate Data packets: 64QAM3/4

- PHY-layer capacity: 330Mbit/sec

Smart Backoff (I)

- Backoff procedure spanning over many cchs
- Backoff Time = Random · aSlotTime
  - Another cch seems idle
  - Another cch is determined idle
  - No cch is idle



Smart Backoff (II)

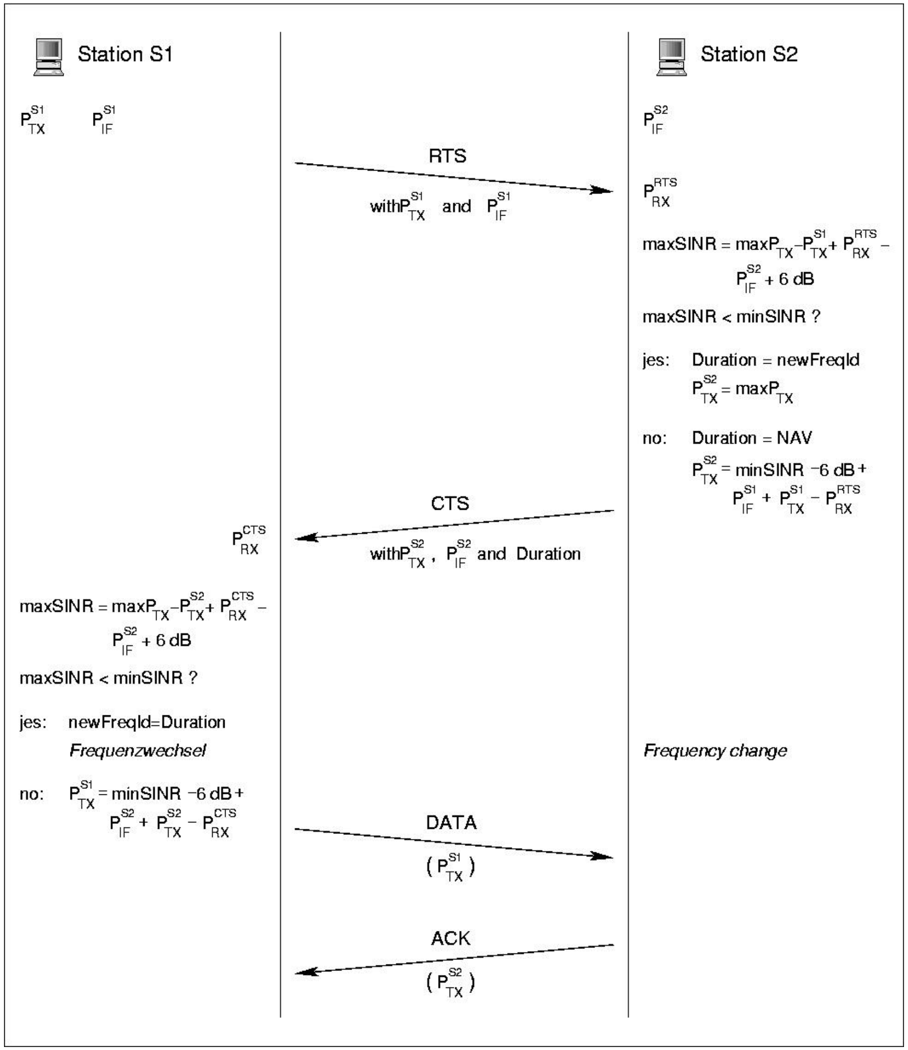
Smart Backoff discussion

+ Load balance among cchs
  - smothing interference
- Fair resource utilization
  - same competition in each cch
- Easy to implement with CDMA
- Priorization for MSs
- Enable parallel transmission

\- Static codechannel allocation:
  - better optimization

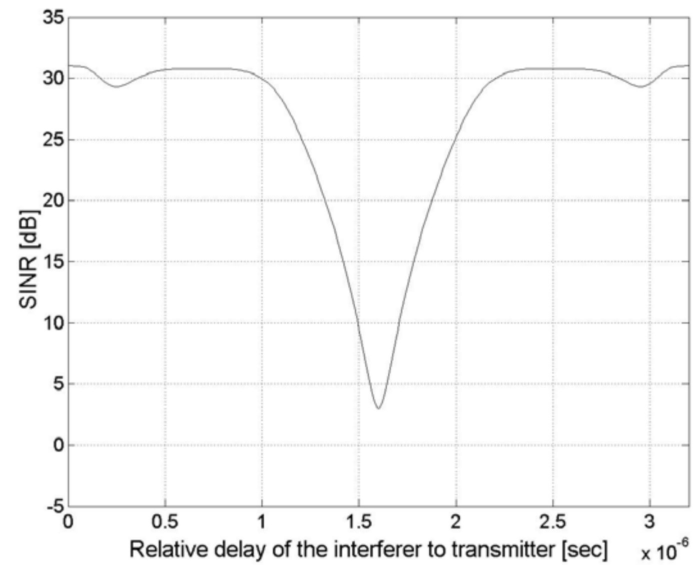
Frequency adaptation

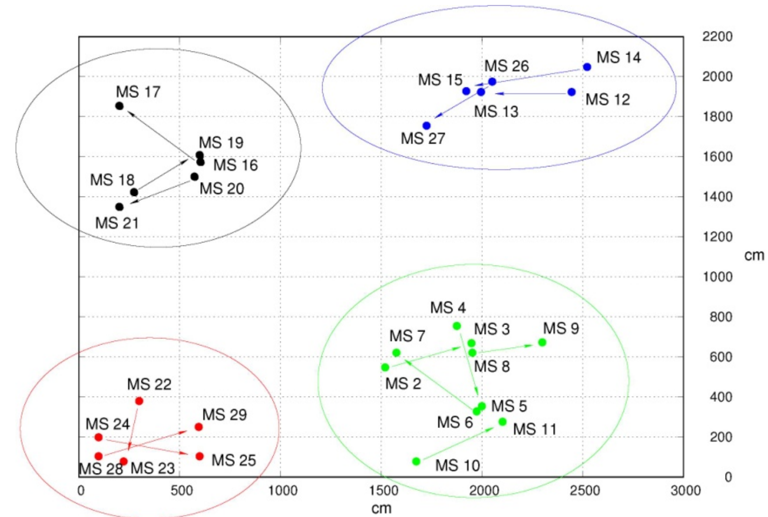
- Based on MUD and PC
- Solution for Near-Far Effects with higher PHY-modes
- Calculate link balance as in PC
- Change frequency band if needed Tx-Power exceeds threshold
- Alternatively change set of subcarriers



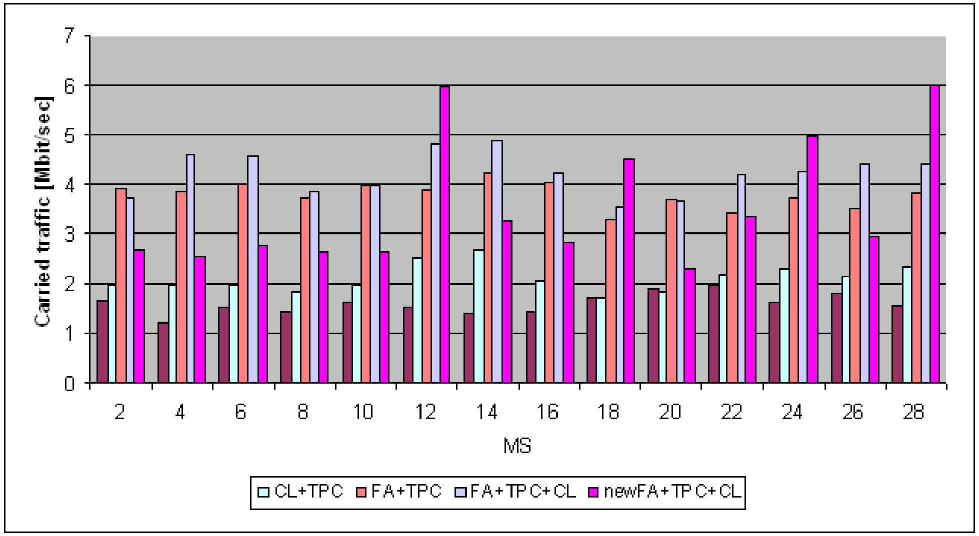
Crosslayer optimization (I)

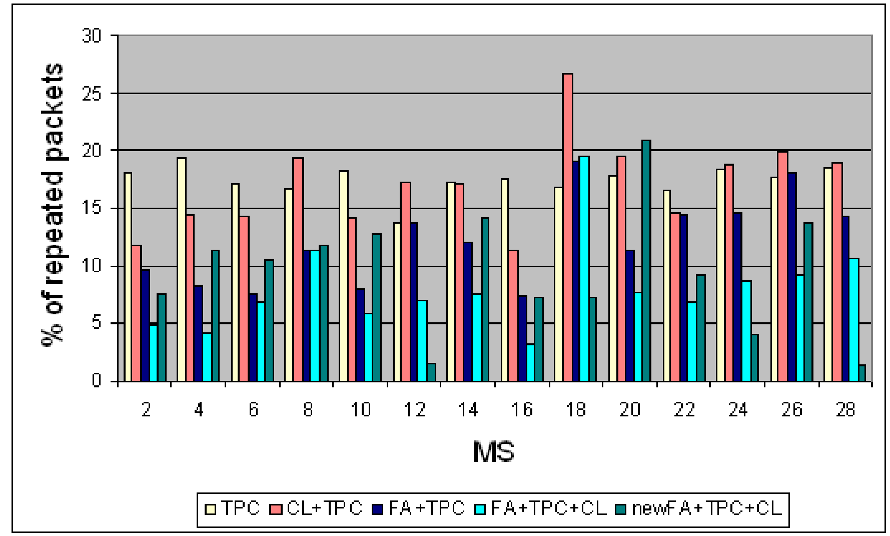
- Operation on MUD high efficiency area
- Reduction of relative delay among concurrent transmissions
- Synchronization on multicarrier symbol level
  - Adaptation of all timing parameters to multiples of a multicarrier symbol duration
- Isochronous operation due to:
  - Imperfect clocks at stations
  - Propagation delay of decentralized system





Crosslayer optimization (II)

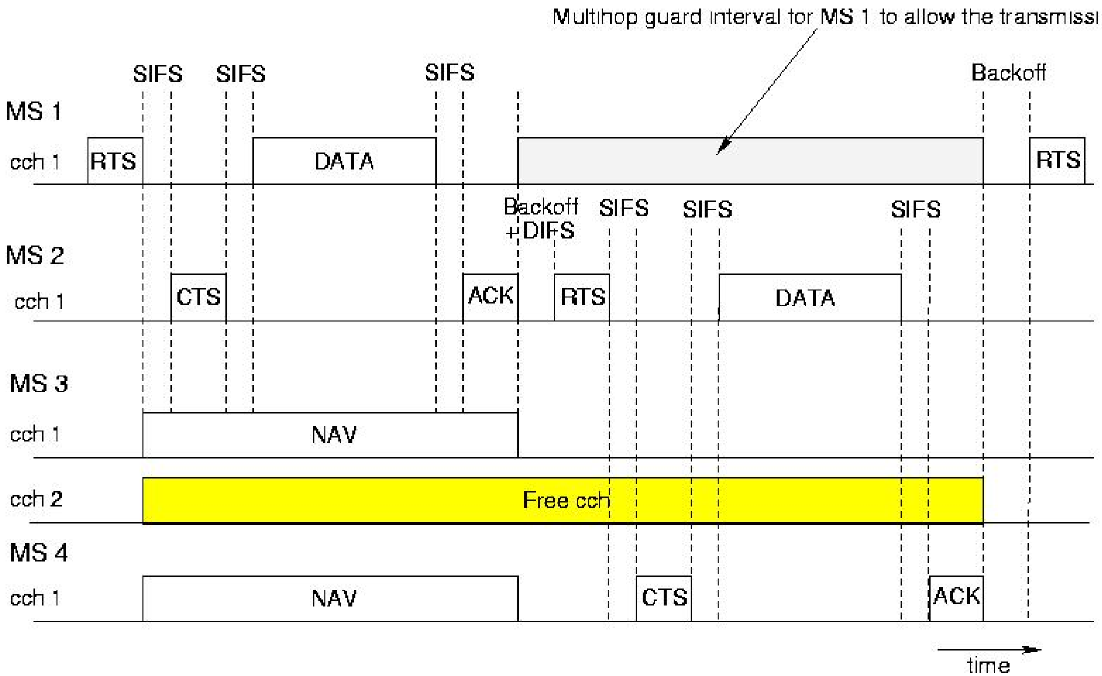


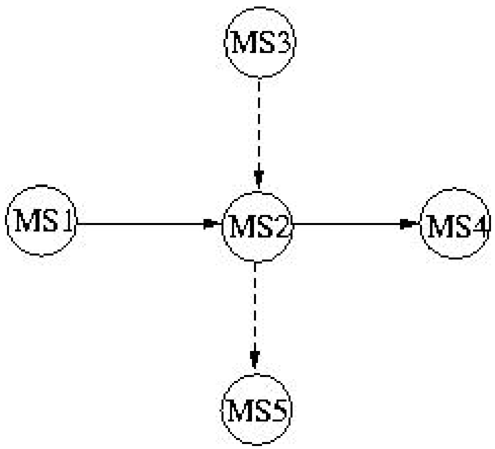


- 2 available frequency channels
- Synchronization accuracy: 10% multicarrier symbol duration
- Superiority of crosslayer adaptation towards other methods

Multihop extension (I)

Multihop guard interval, extended NAV

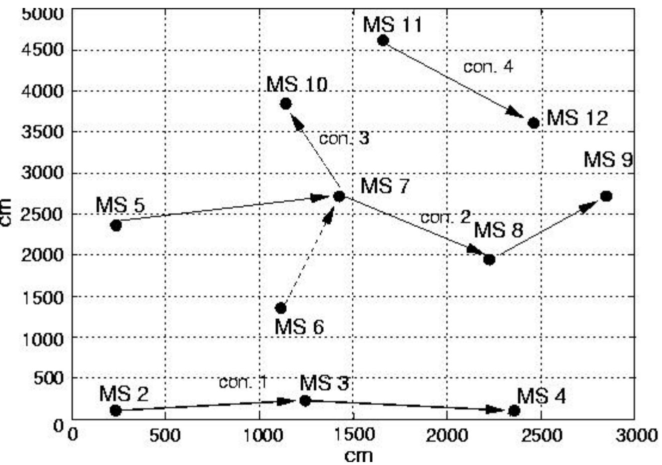


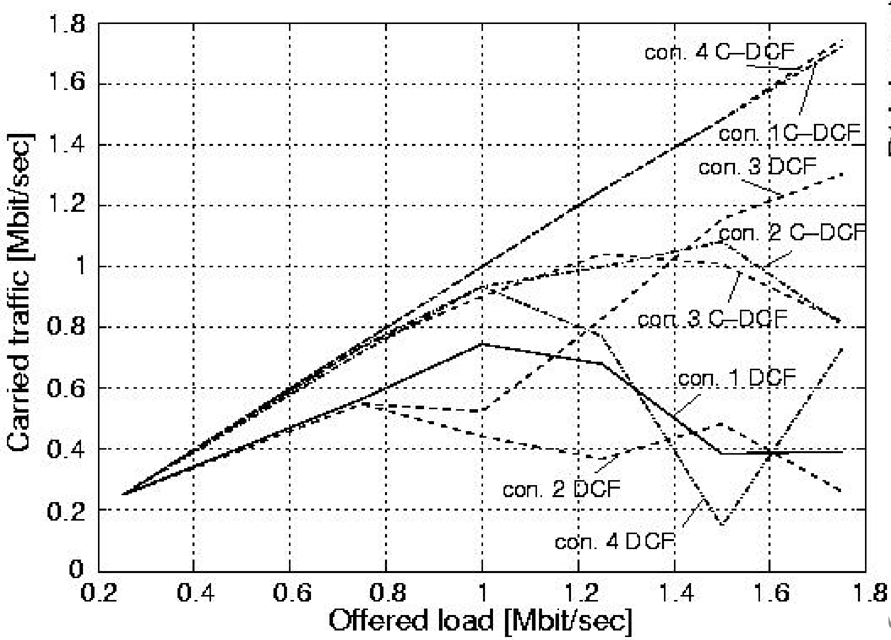


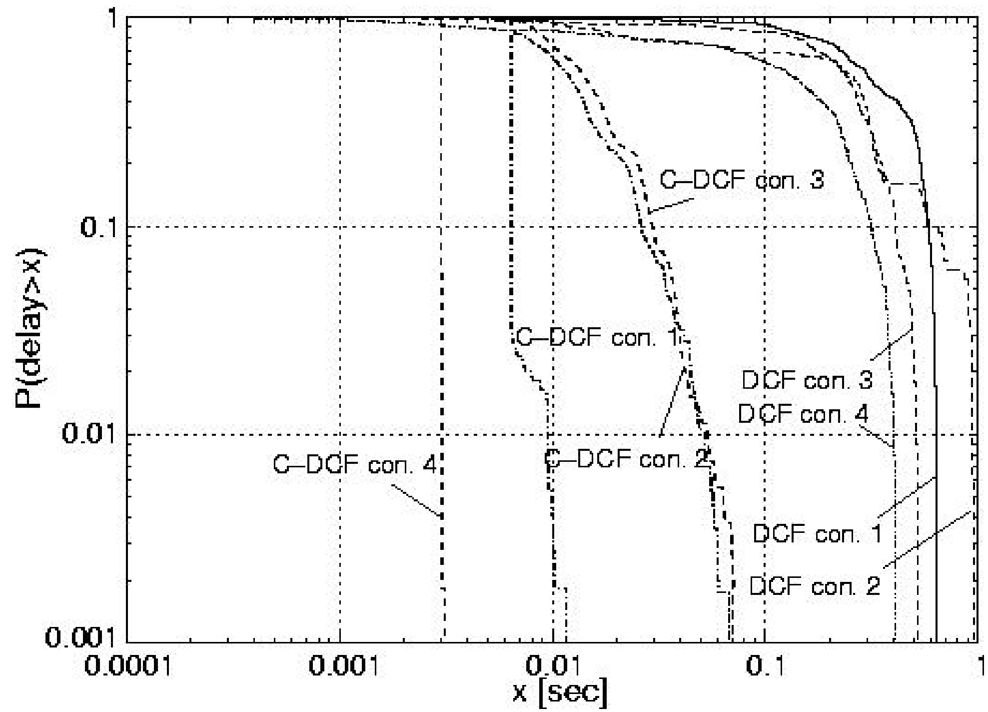
- Multihop guard interval to prioritize forwarder
  - Duration of one complete transmission window
- Smart Backoff at forwarders for bottleneck avoidance
  - Combined with parallel transmission
- Extended NAV
  - Duration, cch, MSs

Multihop extension (II)

Typical scenario and comparative simulation results

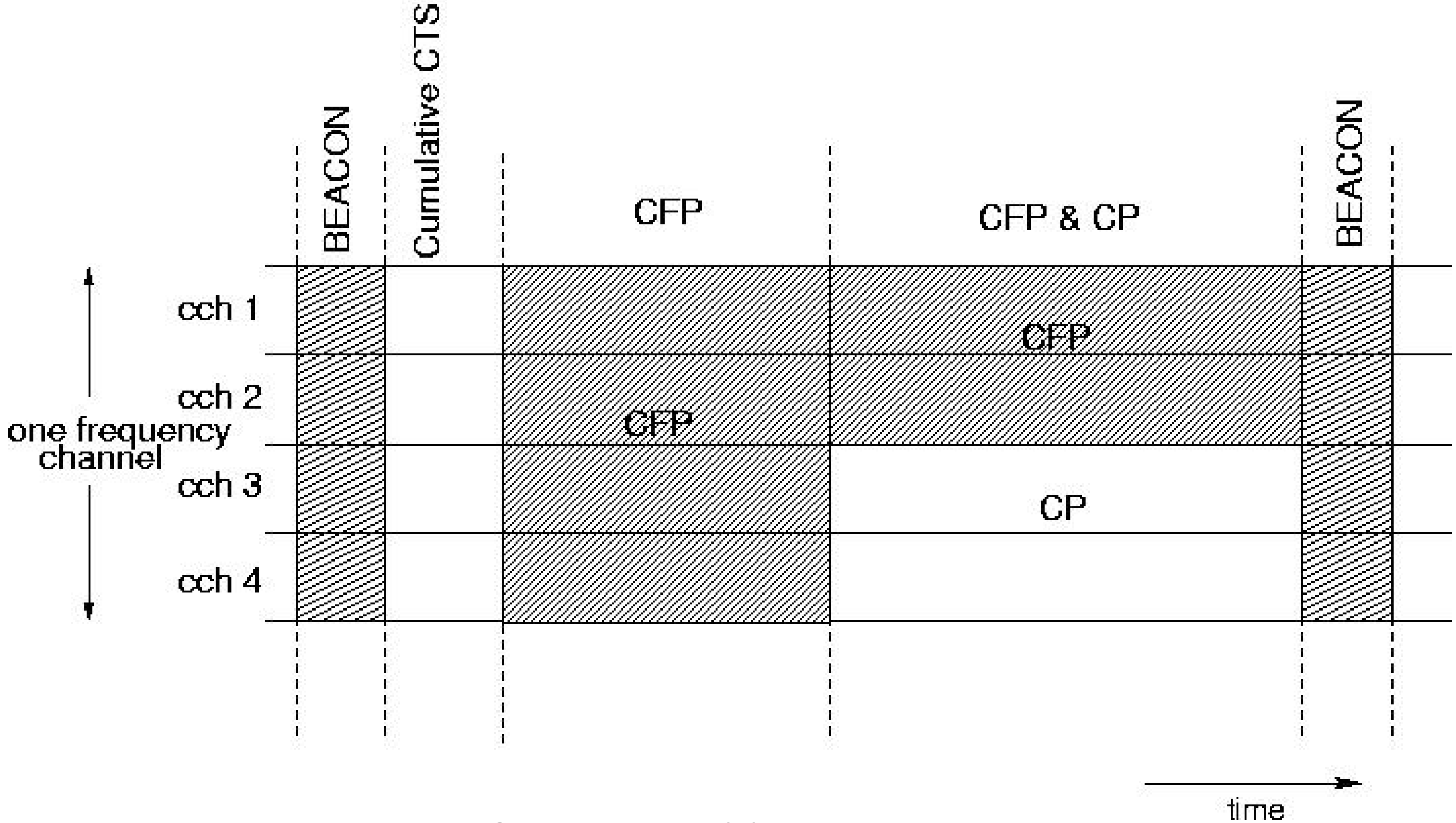






Centralized mode (I)

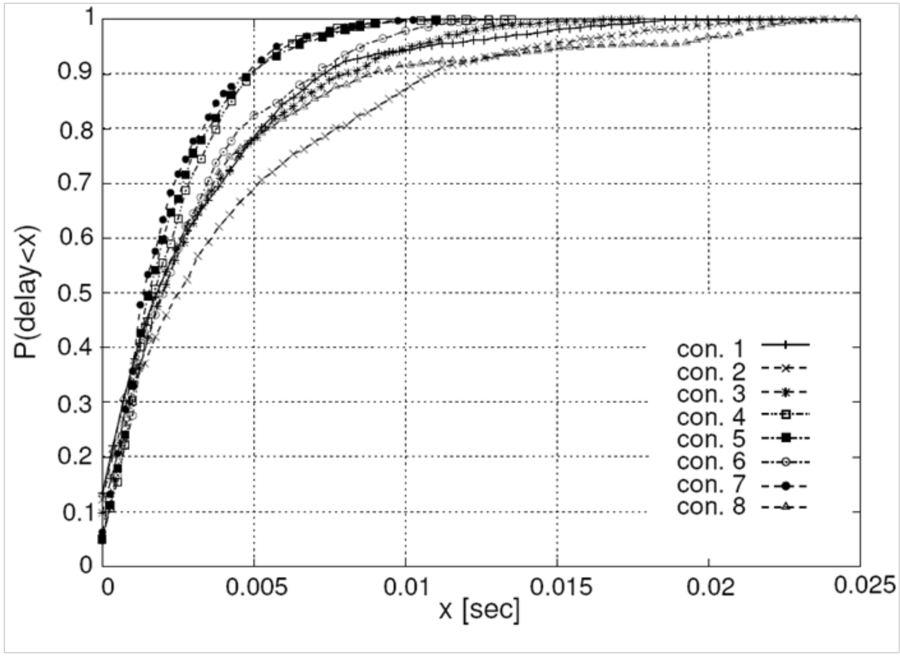
- Support for Aps and high throughput /low delay applications
- Optimum CP/CFP separation in time and code domain
  reduces initialization delay
  avoids strict timing arrangements between MSs operation in two modes.



Centralized mode (II)
performance

Superframe length	C-DCF Max. theoretical throughput on 4 cchs	IEEE 802.11e
20 msec	40.96 Mbit/sec	25.39 Mbit/sec
40 msec	40.96 Mbit/sec	25.80 Mbit/sec
100 msec	41.61 Mbit/sec	26.05 Mbit/sec

1KByte
100% CFP



CDF of queueing delay per MS with 2.8 Mbit/sec/MS Poisson distributed offered load. Mixed operation.
P(delay<11.5msec)=90%
Delay_max=18msec (prio 1)
=25msec (prio 2)

Conclusions

- MC-CDMA reduces overhead, leading to high capacity
- Smart Backoff for priorization and load balance
- Adaptation function to exploit high capacity and avoid near-far-effects
- Cross layer optimization boosts performance and improves fairness
- Multichannel structure allowing good separation of users (codechannels)
  - Essential since one user seldom demands whole Gbit capacity

- Reservation of cch for QoS guaranty when higher SF is applied

Thank you for your attention!

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