Mesh Deterministic Access (MDA) Optional IEEE 802.11s MAC scheme Simulation results

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Some animations may not be displayed correctly in PDF format.

Please see http://802wirelessworld.com for the original version in PowerPoint format.

Abstract

Mesh Deterministic Access (MDA) is a new Coordiation Function (CF) introduced by [4]. To provide simulation results on the efficiency of MDA we use the same simulation tool as in [1]. Our simulation results indicate that MDA operates efficiently in Mesh topologies and avoids congestion without additional means. However, MDA is vulnerably by legacy entities that are not MDA-aware. Traffic segregation is important therefore. Additional means may help to support coexistence of MDA with legacy entities when a single channel needs to be shared.

Simulation set-up

Simulation tool	WARP2
	Event-driven simulator, based on SDL, implements original 802.11 code [5]
Channel model	See [1, 2]
Set-ups	See [1, 3]
MDA implementation	According to [4]
MDA parameters	According to [4]
IEEE PHY	802.11a, 5GHz, OFDM
TX power	20dBm

Pages 6-10 taken from [1]

Simulation Environment – Propagation model

$$P_{Rx} = \frac{P_{Tx}}{d^{\gamma}} \cdot \left(\frac{c}{f_c \cdot 4\pi} \right)$$

- **Path loss model**
  - P_{Tx}: transmission power
  - d: distance between transmitter and receiver
  - γ: damping factor, depending on scenario, incorporating antenna gains, reflection, scattering
    - γ = 2: Free space attenuation
    - γ > 2: More realistic path loss, LOS/NLOS, indoor/outdoor environments
    - **Here: γ = 3.5**
  - f_c: center frequency
    - **Here: f_c = 5GHz**
  - Antenna gains can be included (Rx & Tx)

Simulation Environment – Channel model

- **Additional obstacles (e.g. walls, doors)**
  - Attenuation is subtracted from P_{Rx} (in dB)
- **Signal to Interference plus Noise Ratio (SINR)**
  - Signal (S) = $P_{Rx, wanted}$
  - Interference (I) = $P_{Rx, unwanted, i}$
    - i interferer, $i \geq 0$
  - Noise (N)
    - Thermal environment noise, **Here: N = -95 dBm**

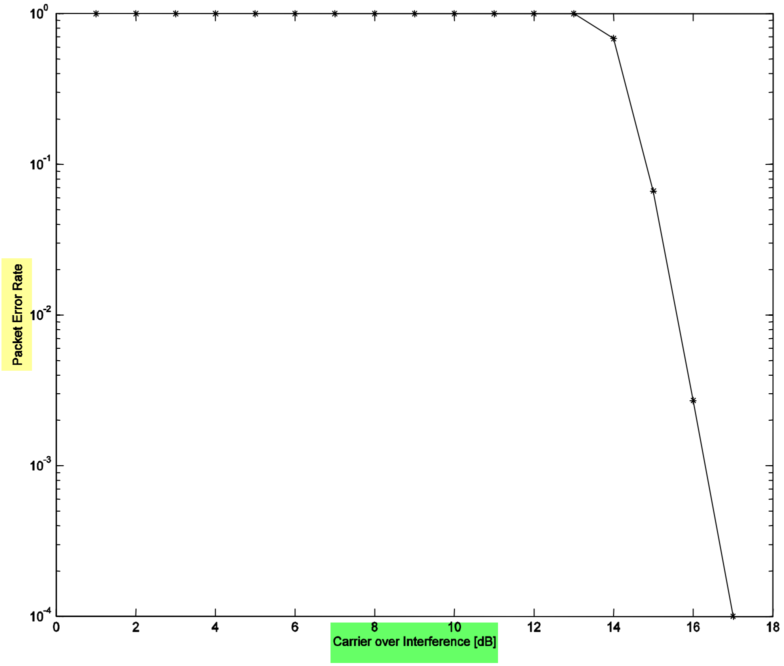
$$SINR = \frac{P_{Rx,wanted}}{N + \sum_i P_{Rx,unwanted,i}}$$

Simulation Environment – PHY layer model

- **Modeling packet error probability**

$$p(error) = f\,(P_{Rx,wanted}\,, SINR, Packetlength, MCS)$$

- Minimal $P_{Rx,\ wanted}$
  - Sensitivity (see .11a standard)
  - Depending on Modulation and Coding Scheme (MCS)
- Link level mapping (Packet Error Rate vs. SINR)
  - Tables derived from real hardware measurements
  - Parameterized by
    - MCS
    - Packet length
  - Complementary PER, see example figure



Simulation Environment – PHY layer

- **IEEE 802.11a**
  - Clear Channel Assessment
  - 5GHz, OFDM PHY
  - Busy detection for
    - Any Rx signal > -62 dBm
    - Valid OFDM preamble, Rx level > -82 dBm

Simulation scenario set-up

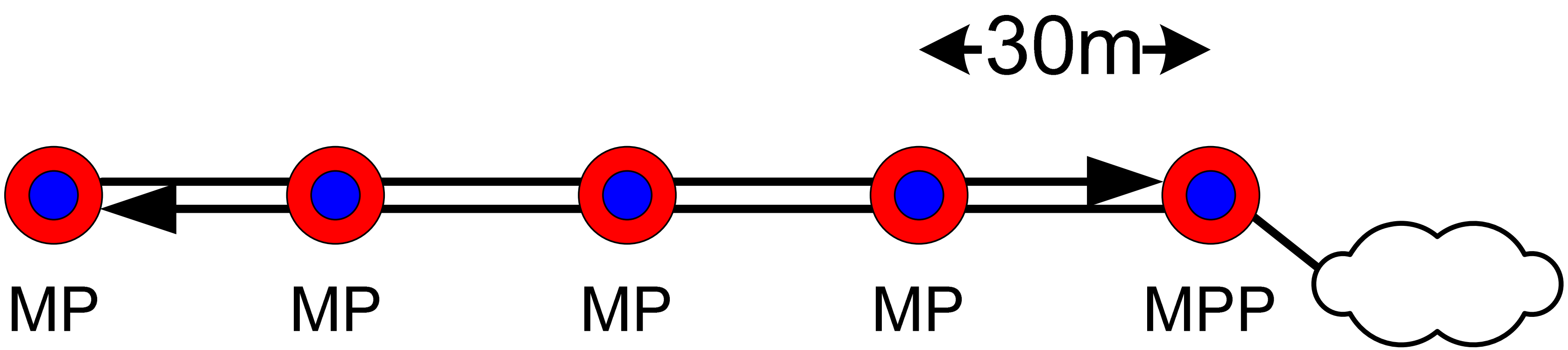
- **Single radio, single frequency channel Mesh WLAN**
  - 20dBm transmission power
- **Offered traffic: Constant Bit Rate (CBR)**
- **EDCA parameters**
  - TxOP duration = 2048 µs
  - Backoff settings, see 802.11e values for 802.11a OFDM PHY

Priority	CWmin	CWmax	AIFS/µs
0 (Best Effort)	15	1023	43
7 (Voice)	3	7	34

Simulation results

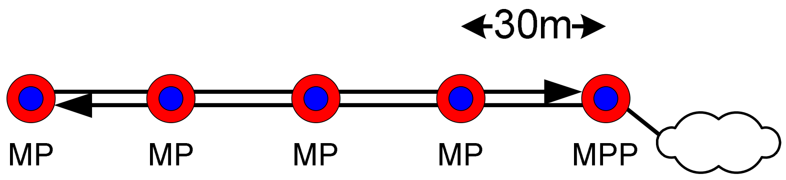
Basic scenario – Straight multi-hop route

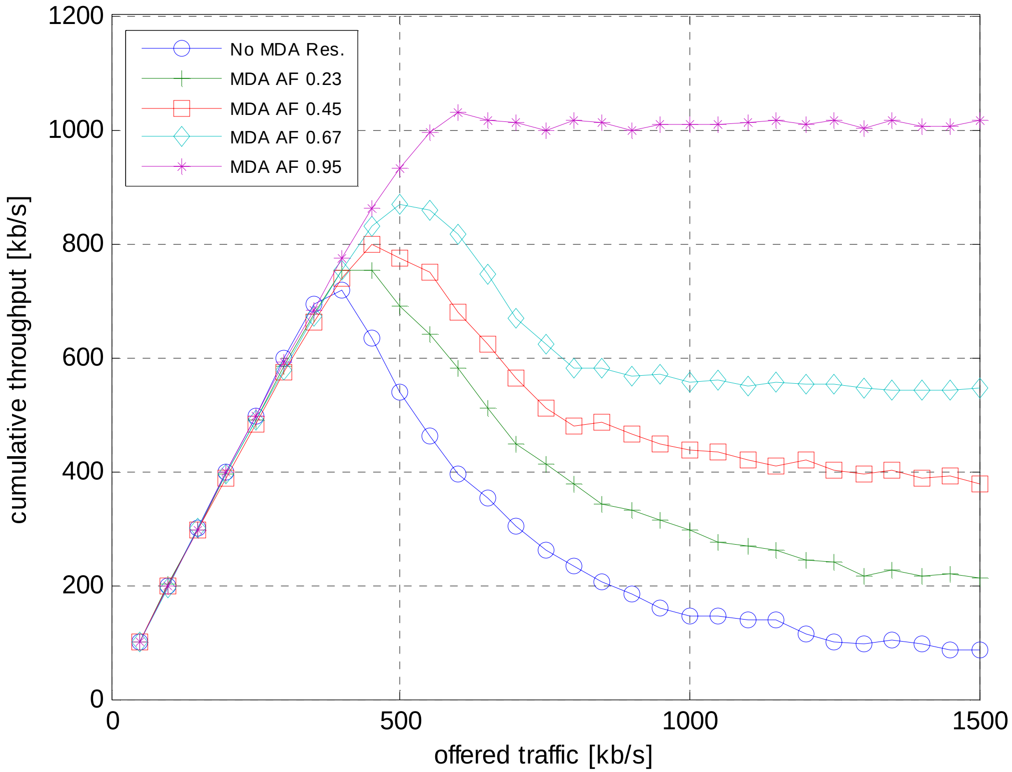
- **4 hop route**
  - Duplex data transmission
  - Up- & Downlink traffic
  - All MPs MDA capable
  - MCS: QPSK½ (12Mb/s)
  - 80 B packet size
  - MP is sink & source of traffic
  - MPP as gateway to Internet



4 hop route – Simulation results

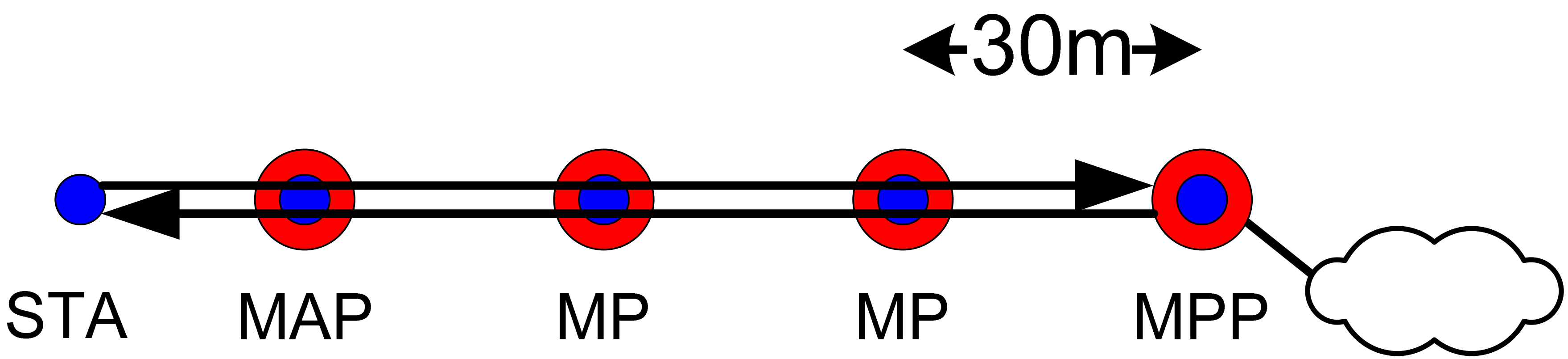
- **MDA more efficient than EDCA**
  - Lack of Congestion Control limits performance with low MDAF
  - For EDCA only compare to [1]
- **Low MDAF values limit efficiency**





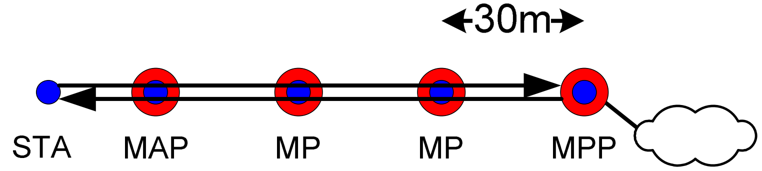
Basic scenario – Straight multi-hop route

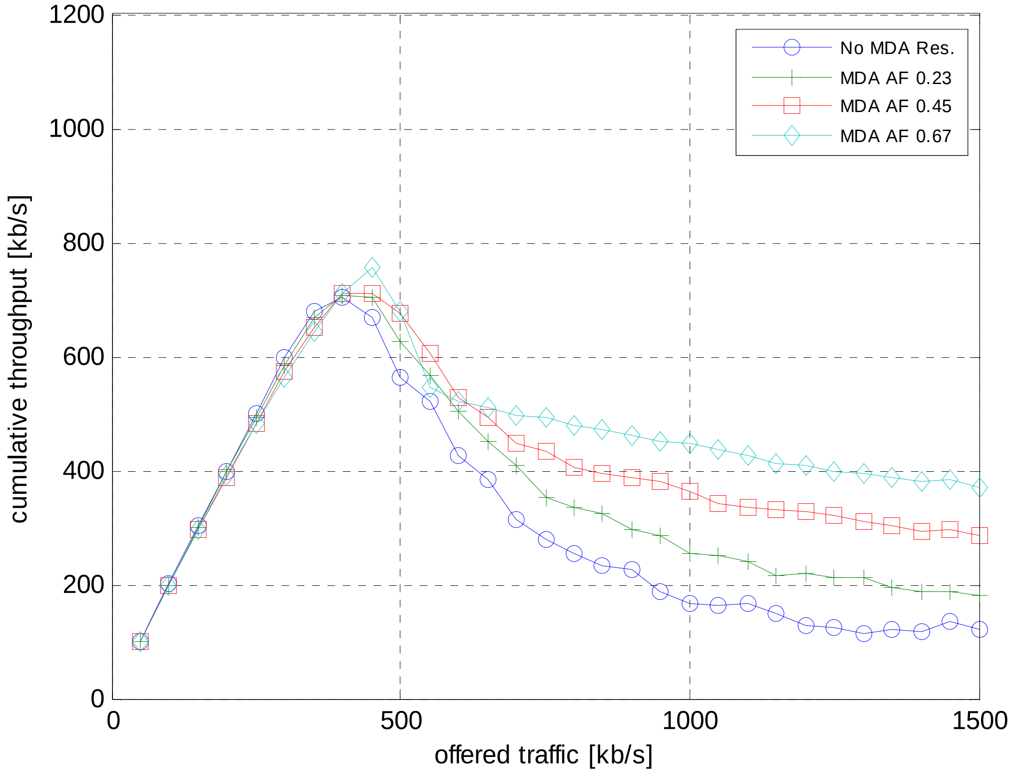
- **4 hop route**
  - Duplex data transmission
  - Up- & Downlink traffic
  - All MPs MDA capable
  - MCS: QPSK½ (12Mb/s)
  - 80 B packet size
  - STA attached to MAP
  - STA is sink & source of traffic
  - MPP as gateway to Internet



4 hop route – Simulation results

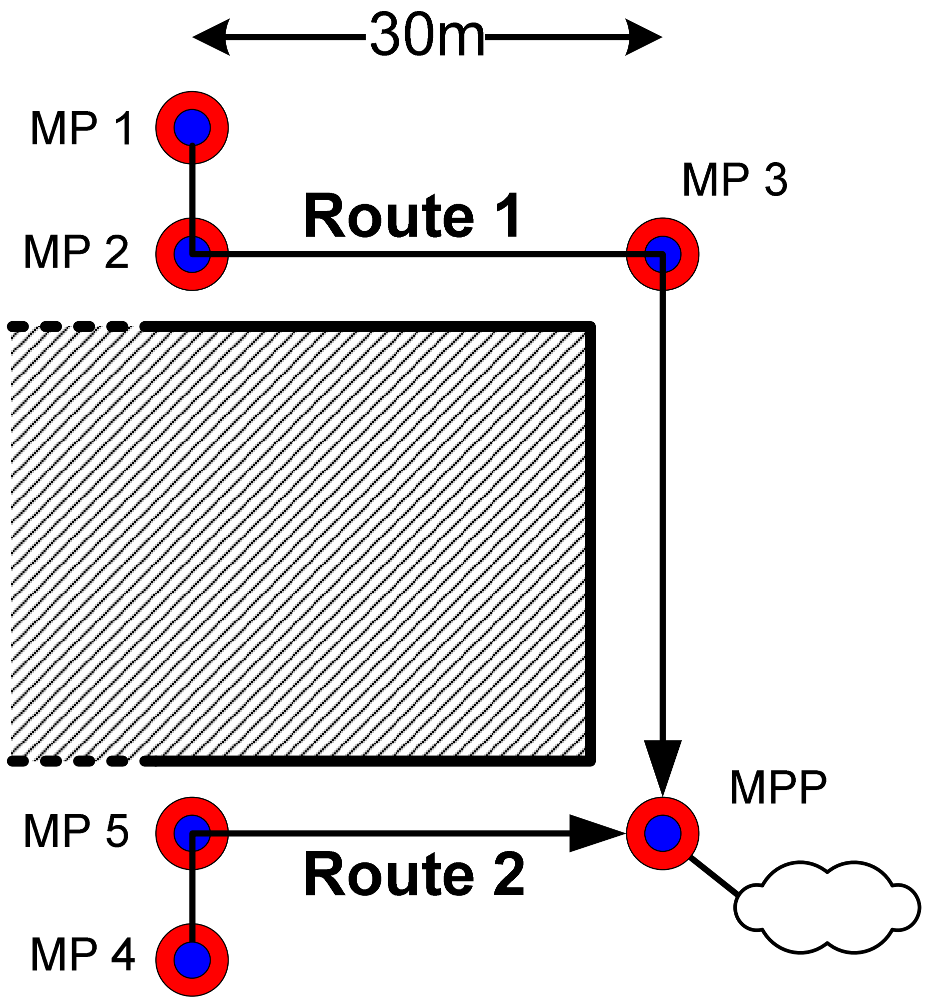
- **MDA unaware station**
  - Interference for MDA MPs
  - No congestion control at station
  - Limits system performance
  - No traffic segregation possible



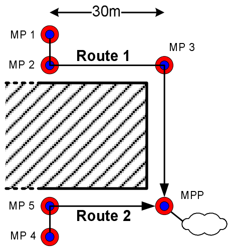


Public access scenario

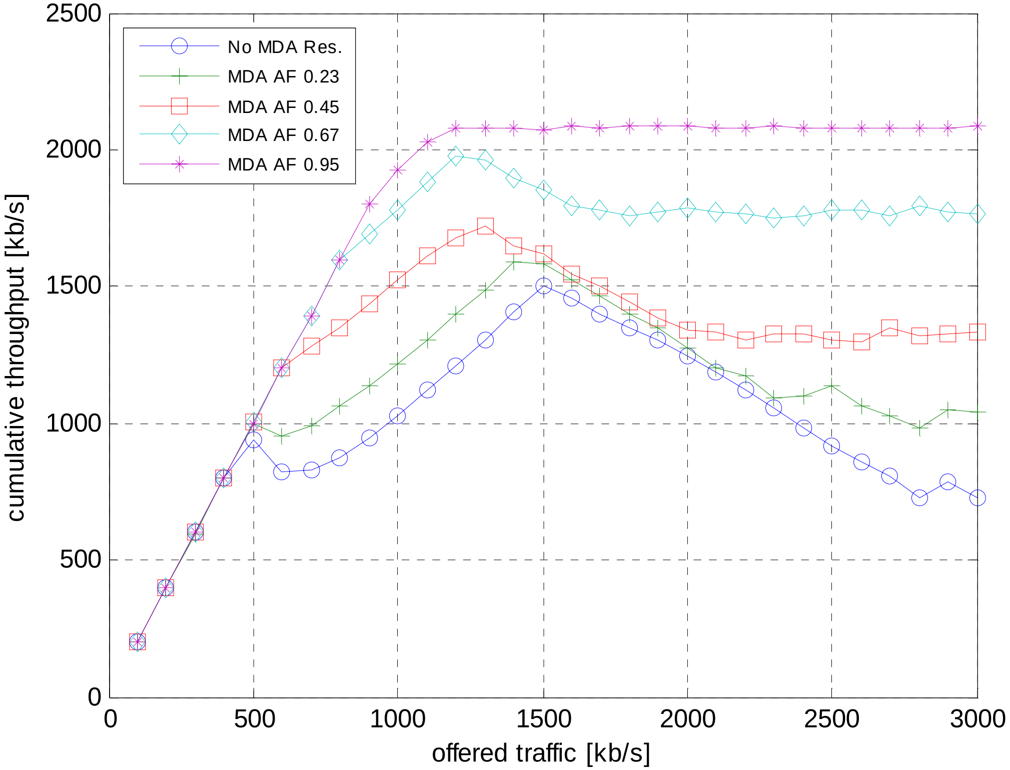
- **Building attenuates signal: 100 dB**
- **Uplink traffic sent from MPs to Internet**
  - 3 hop route
    - MP 1 → MP 2 → MP 3 → MPP
  - 2 hop route
    - MP 4 → MP 5 → MPP
  - MCS: QPSK½ (12Mb/s)
  - 80 B packet size



Public access scenario – Simulation results

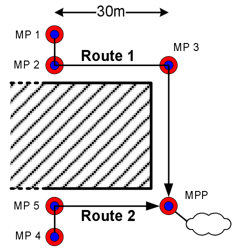


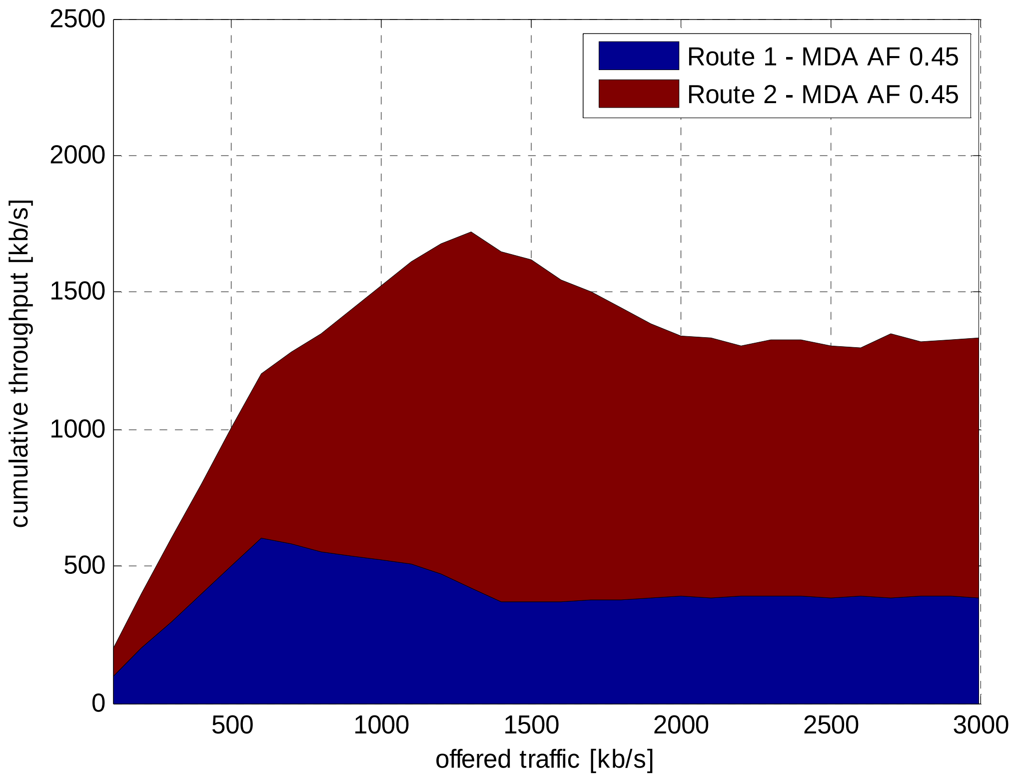
- **High MDAF provides efficient medium usage**
- **Low MDAF limited by EDCA**
  - EDCA efficiency decreases without congestion control
  - MDA performance = 1.4 EDCA performance



Public access scenario – Simulation results

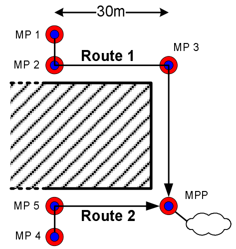
- Low MDAF cannot guarantee fairness
- Route 2 dominates
- MDA limits starvation of Route 1

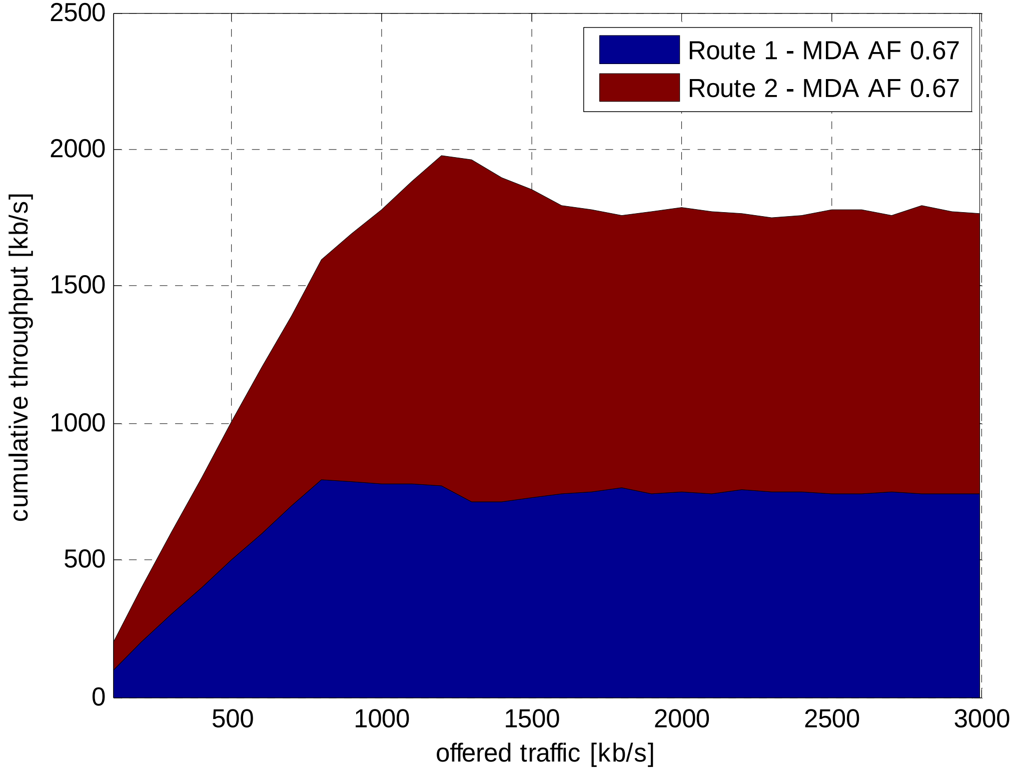




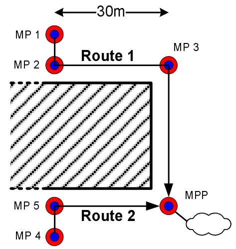
Public access scenario – Simulation results

- **Fairness increases with higher MDAF**
- **Route 2 dominates**
- **MDAF defines capacity left for Route 1**

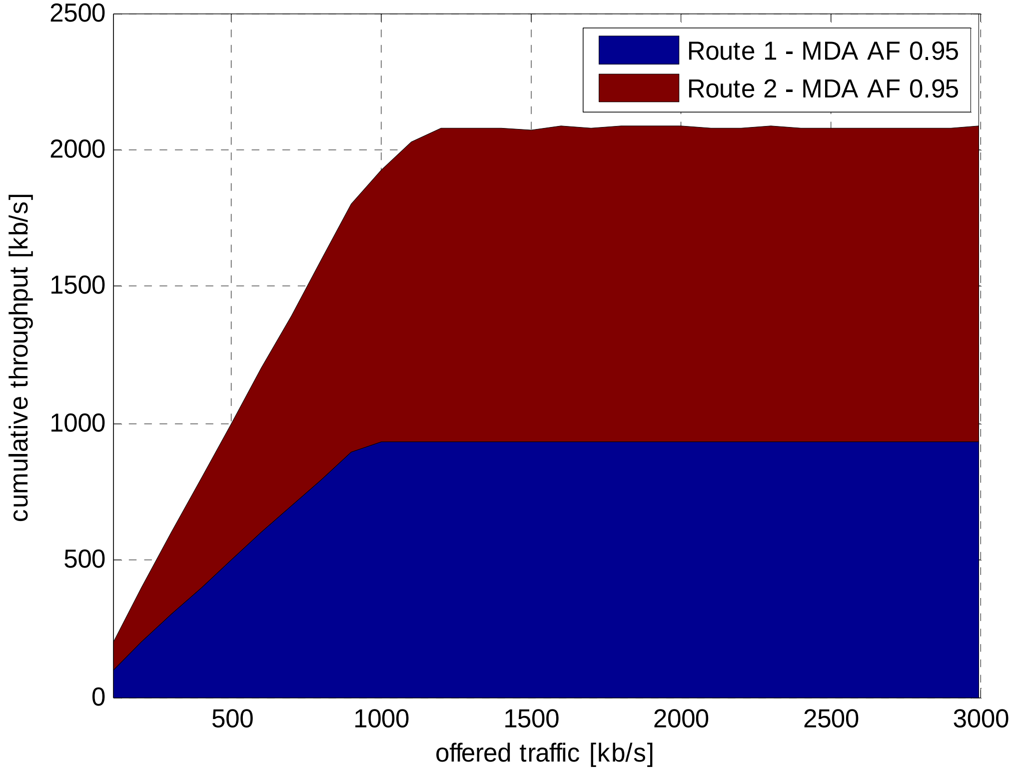




Public access scenario – Simulation results

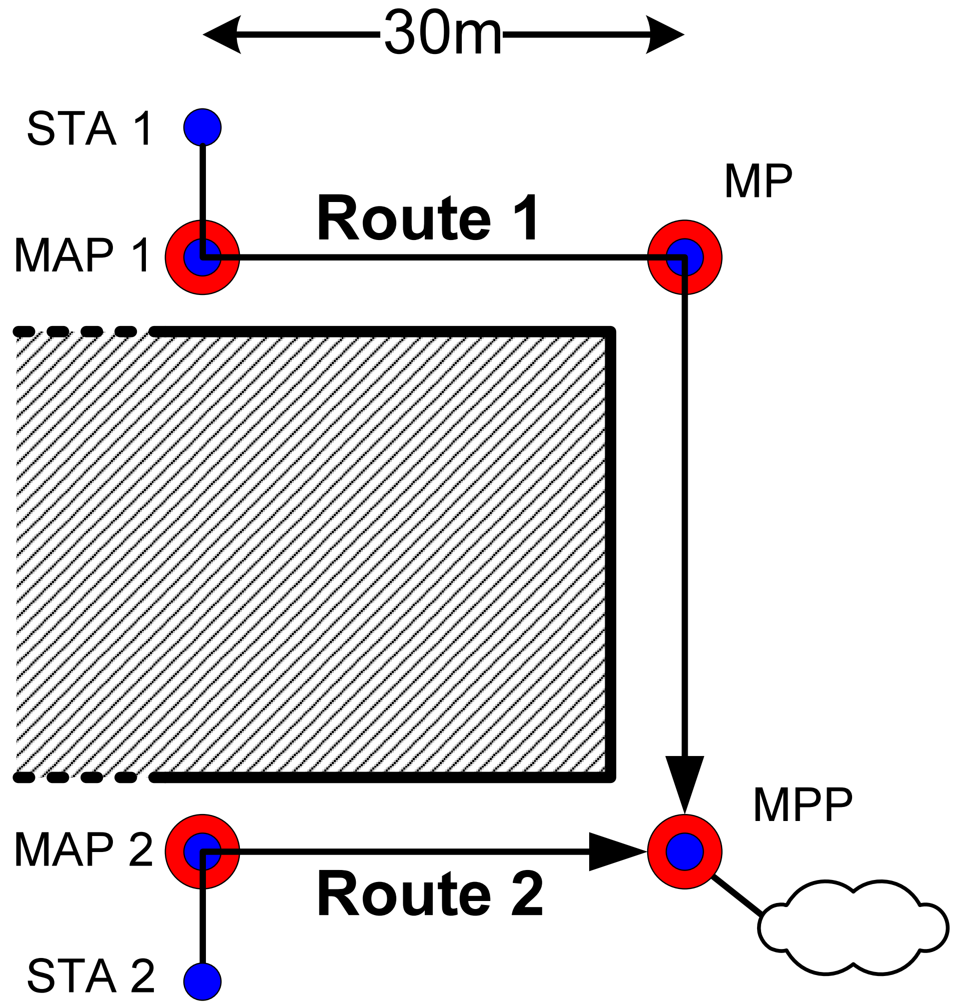


- High MDAF achieves fair sharing
- Capacity of the wireless medium can be equally used
- No differences in hop count

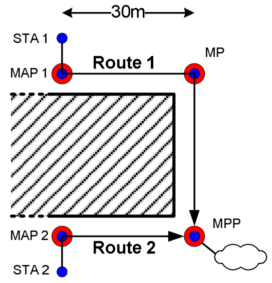


Public access scenario

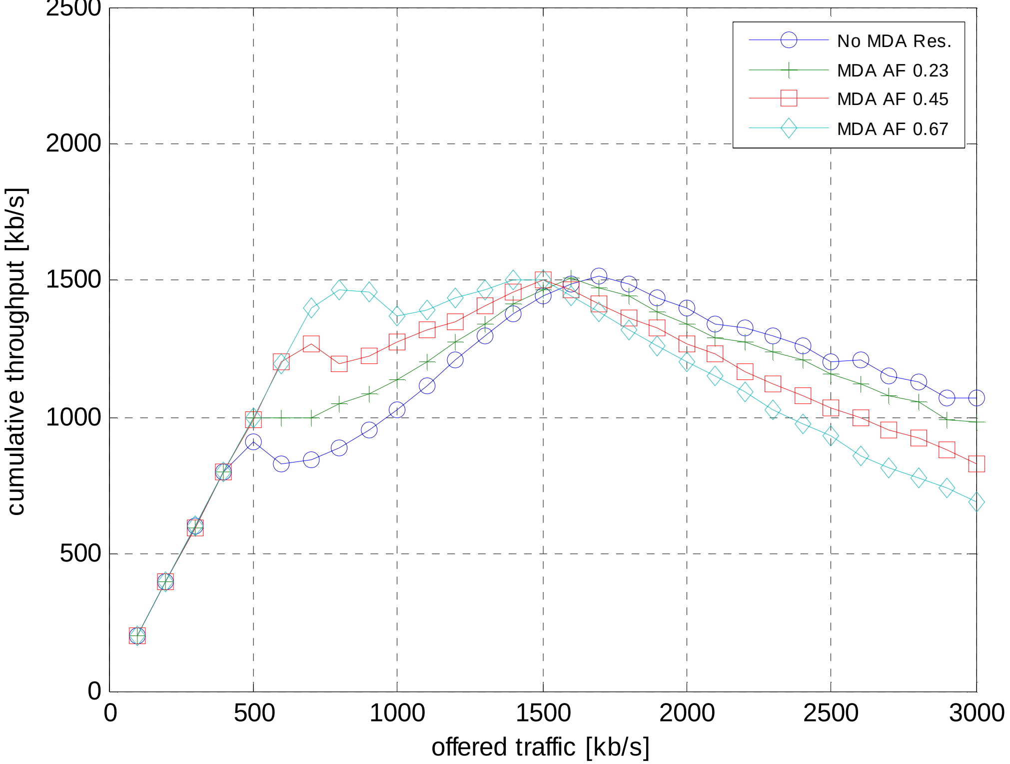
- **Building attenuates signal: 100 dB**
- **Uplink traffic sent from STAs to Internet**
  - 3 hop route
    - STA 1 → MAP 1 → MP → MPP
  - 2 hop route
    - STA 2 → MAP 2 → MPP
  - MCS: QPSK½ (12Mb/s)
  - 80 B packet size



Public access scenario – Simulation results

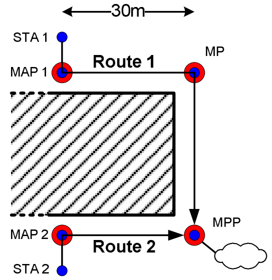


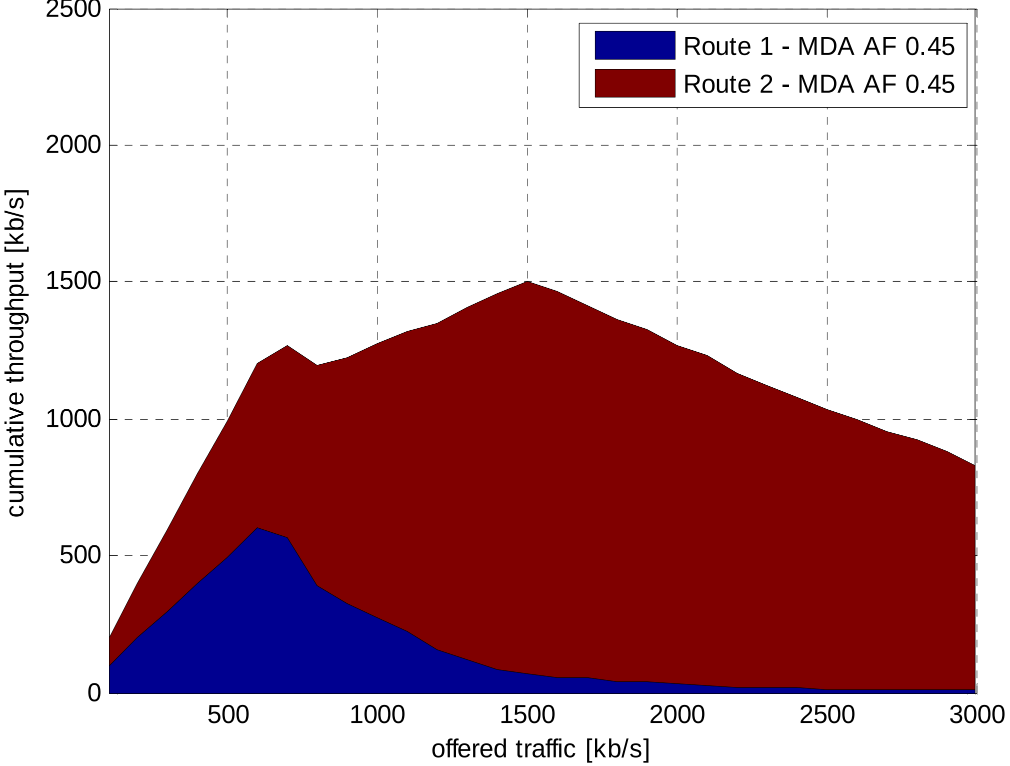
- Stations limit overall performance
- No congestion control at stations possible
- MDA MPs compete with EDCA stations on capacity



Public access scenario – Simulation results

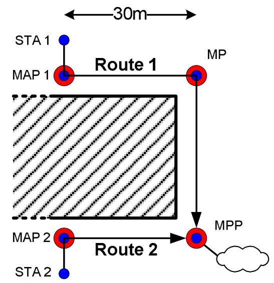
- APs flooded by their associated stations
- Route 2 totally dominates Route 1
- High amount of offered traffic leads to starvation of Route 1

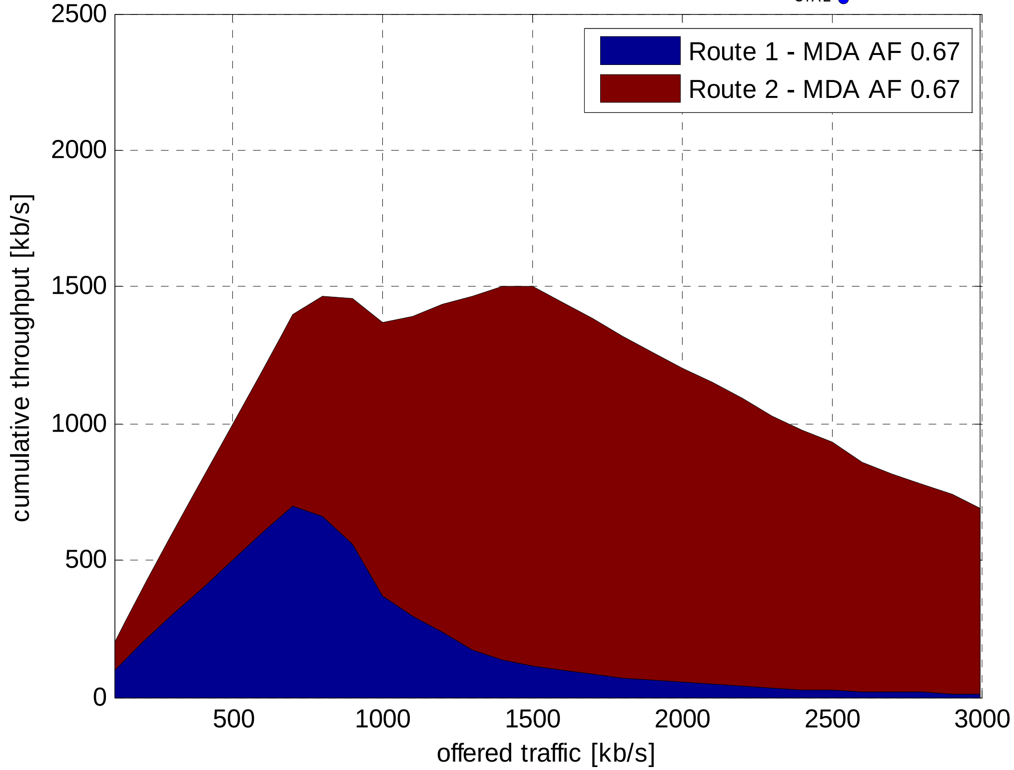




Public access scenario – Simulation results

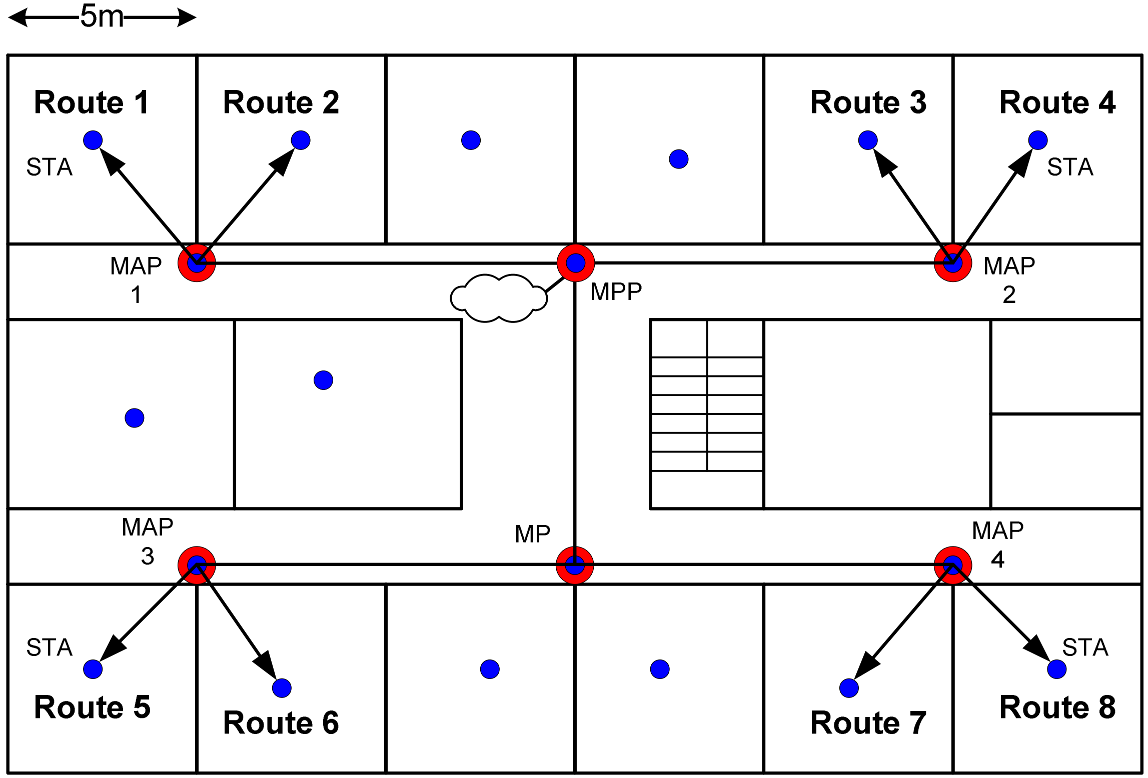
- Increased MDAF cannot prevent starvation in presence of MDA unaware stations
- Traffic segregation impossible
- Limited performance of Mesh WLAN





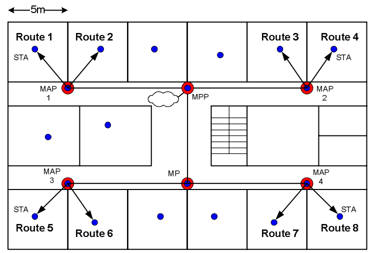
Office scenario

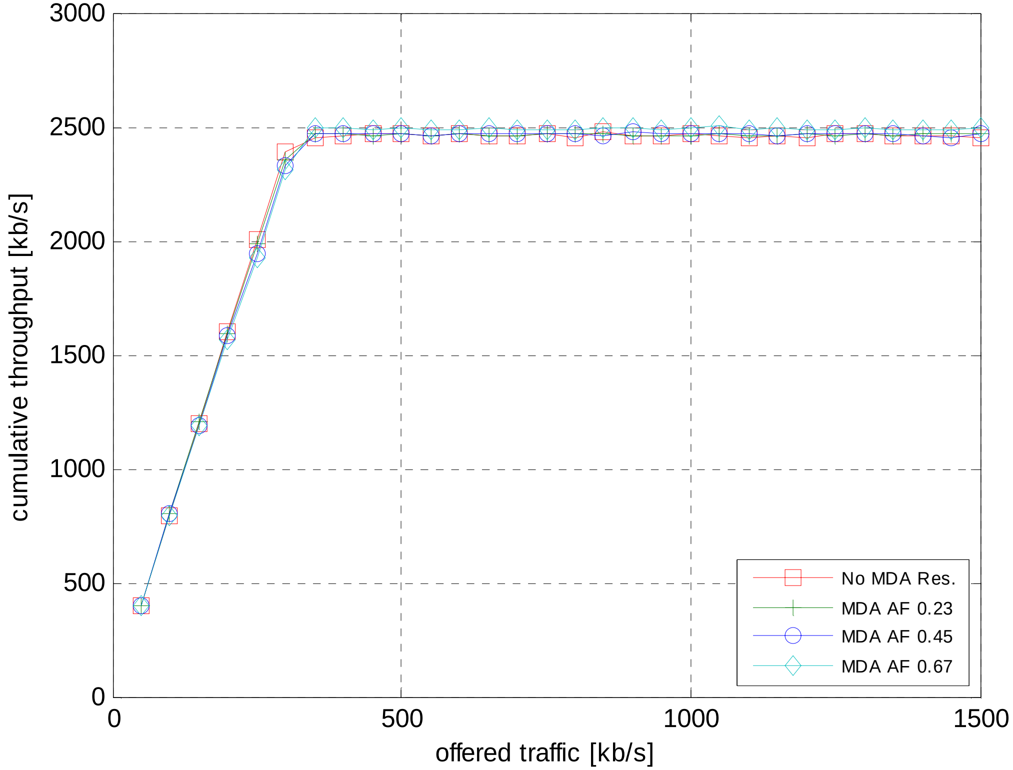
- **Offered traffic: CBR**
  - Downlink routes
- **MCS: 64QAM¾ (54Mb/s)**
- **Attenuation**
  - Walls: 13 dB
- **80B packet size**



Office scenario – Simulation results

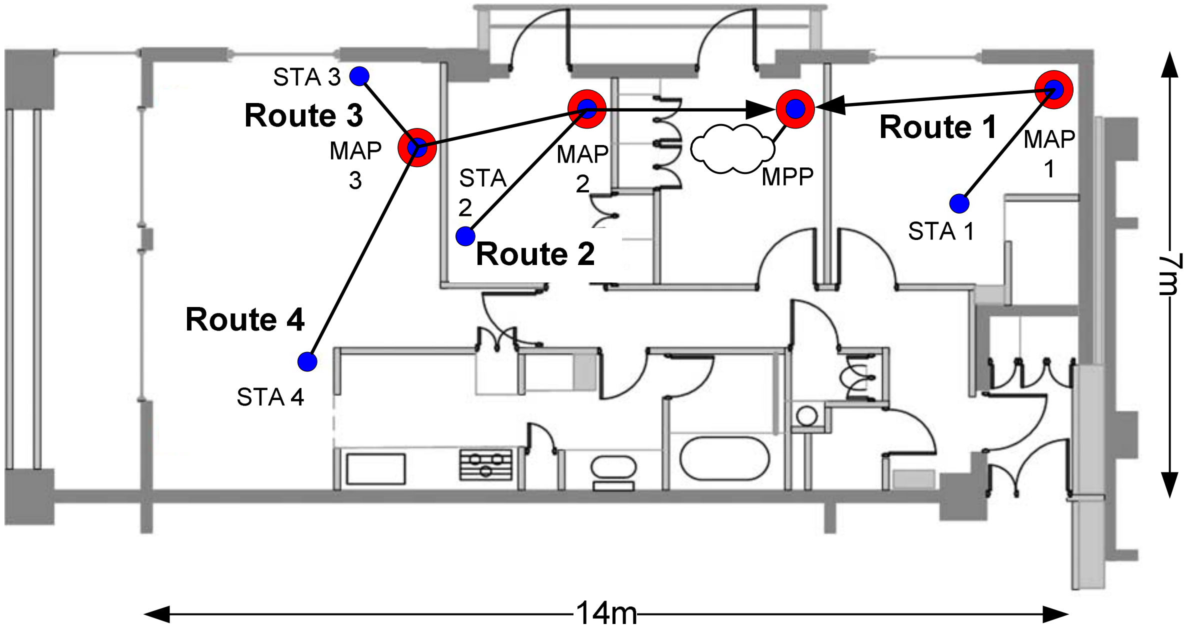
- **Single source of traffic**
  - Downlink only
  - Contention on forwarding hop only
- **Performance limited by lack of spatial frequency reuse**
- **MDA and EDCA perform equal**



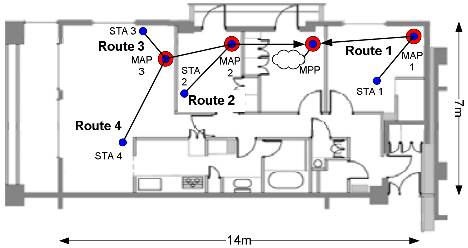


Residential scenario

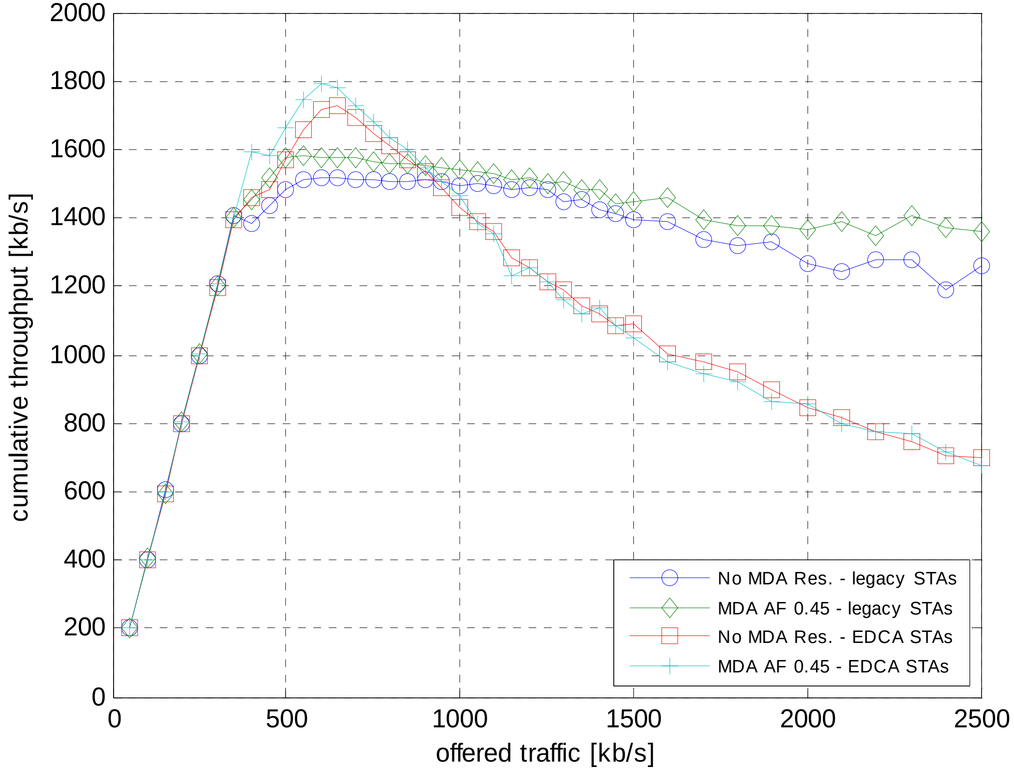
- **Offered traffic: CBR**
  - Uplink routes
- **MCS: 64QAM¾ (54Mb/s)**
- **Attenuation**
  - Walls: 10 dB
  - Doors: 3.5 dB
- **80B packet size**



Residential scenario – Simulation results



- **DCF stations send single frame per contention**
- **EDCA stations send several frames limited by EDCA TXOP duration**
  - Long EDCA TXOP limit MDA performance



Conclusion

- **EDCA & DCF operate with low performance**
- **Congestion Control not sufficient to provide good Mesh WLAN performance**
- **High performance with MDA possible**
- **MDA needs protection from EDCA & DCF entities**

→ Additional methods to silence stations needed

References

[1] 11-05-0600-03-000s-mesh-networks-alliance-proposal.ppt

[2] 11-05-0605-02-000s-mesh-networks-alliance-proposal.doc

[3] 11-05-0788-02-000s-mna-5min-statement-to-tgs.ppt

[4] IEEE P802.11s/D0.03

[5] ANSI/IEEE Std. 802.11, 1999 Edition, Annex C (normative), “Formal description of MAC operation”