Mobile Networks

Module C- Part 1

WLAN Performance Aspects

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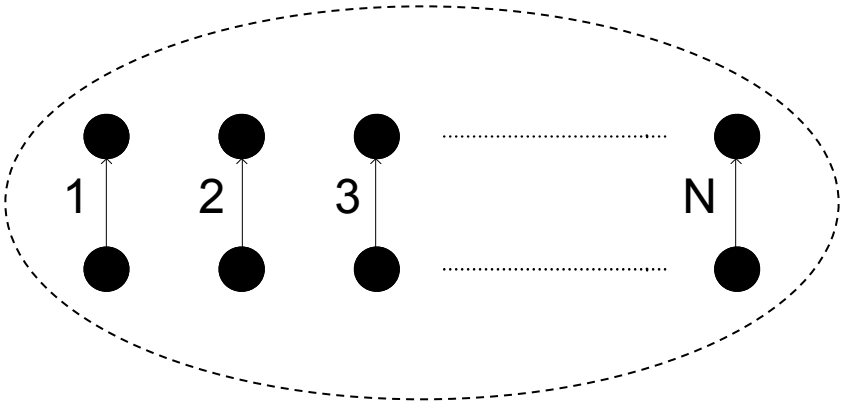
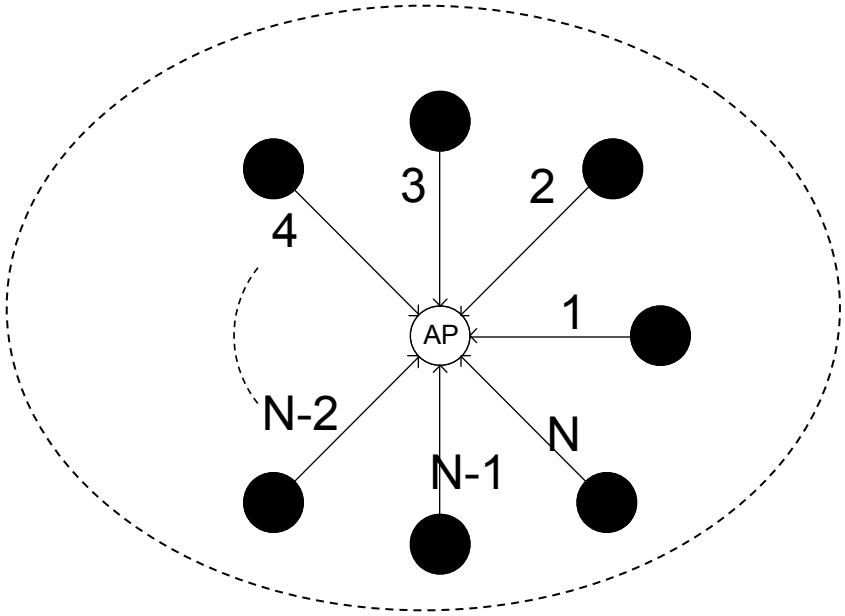
Performance Evaluation of IEEE 802.11(DCF)

- Real Experimentations
  - HoE on IEEE 802.11b
- Analytical Models
  - Bianchi's Model
- Simulations
  - HoE on ns-2

Bianchi's Model: Topology and Parameters

- N links with the same physical condition (single-collision domain):





We want to calculate the throughput of this network.

MAC Layer
PHY Layer

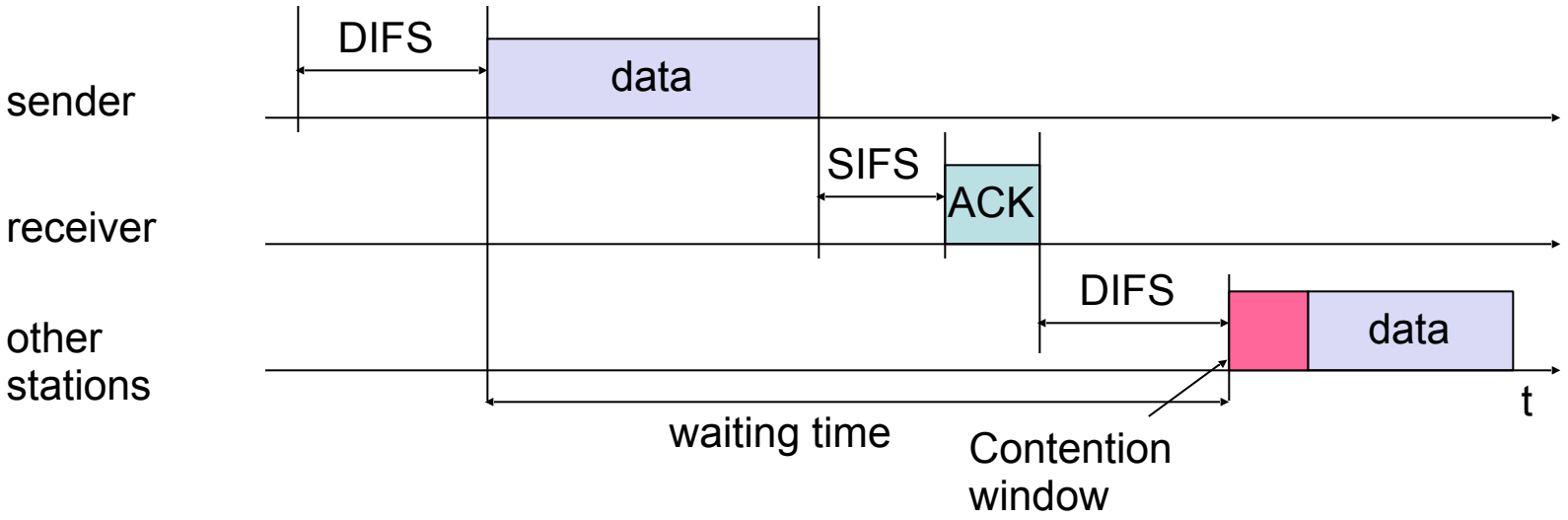
→ π = Probability of Transmission

↕

→ P = Probability of Collision
= More than one transmission at the same time
= $1 - (1- \pi)^{N-1}$

802.11 - CSMA/CA unicast (Review)

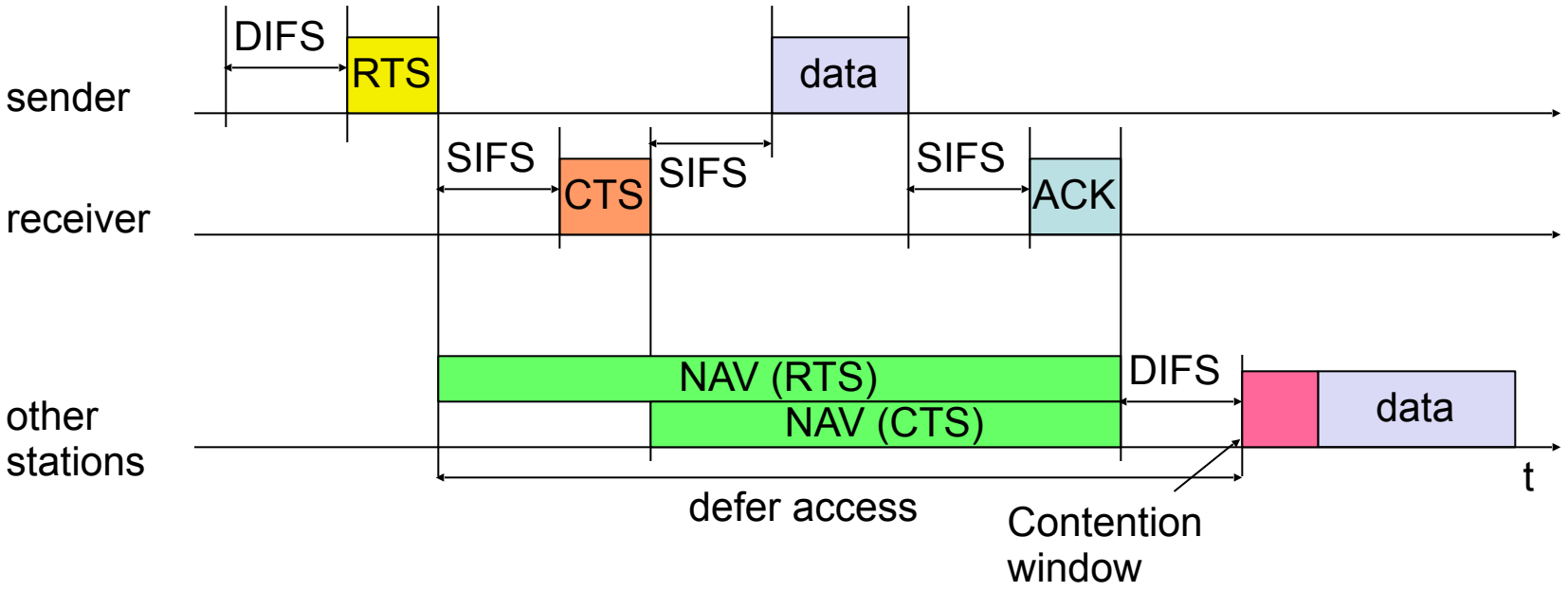
- Sending unicast packets
  - station has to wait for DIFS before sending data
  - receiver acknowledges at once (after waiting for SIFS) if the packet was received correctly (CRC)
  - automatic retransmission of data packets in case of transmission errors



The ACK is sent right at the end of SIFS (no contention)

802.11 – DCF with RTS/CTS (Review)

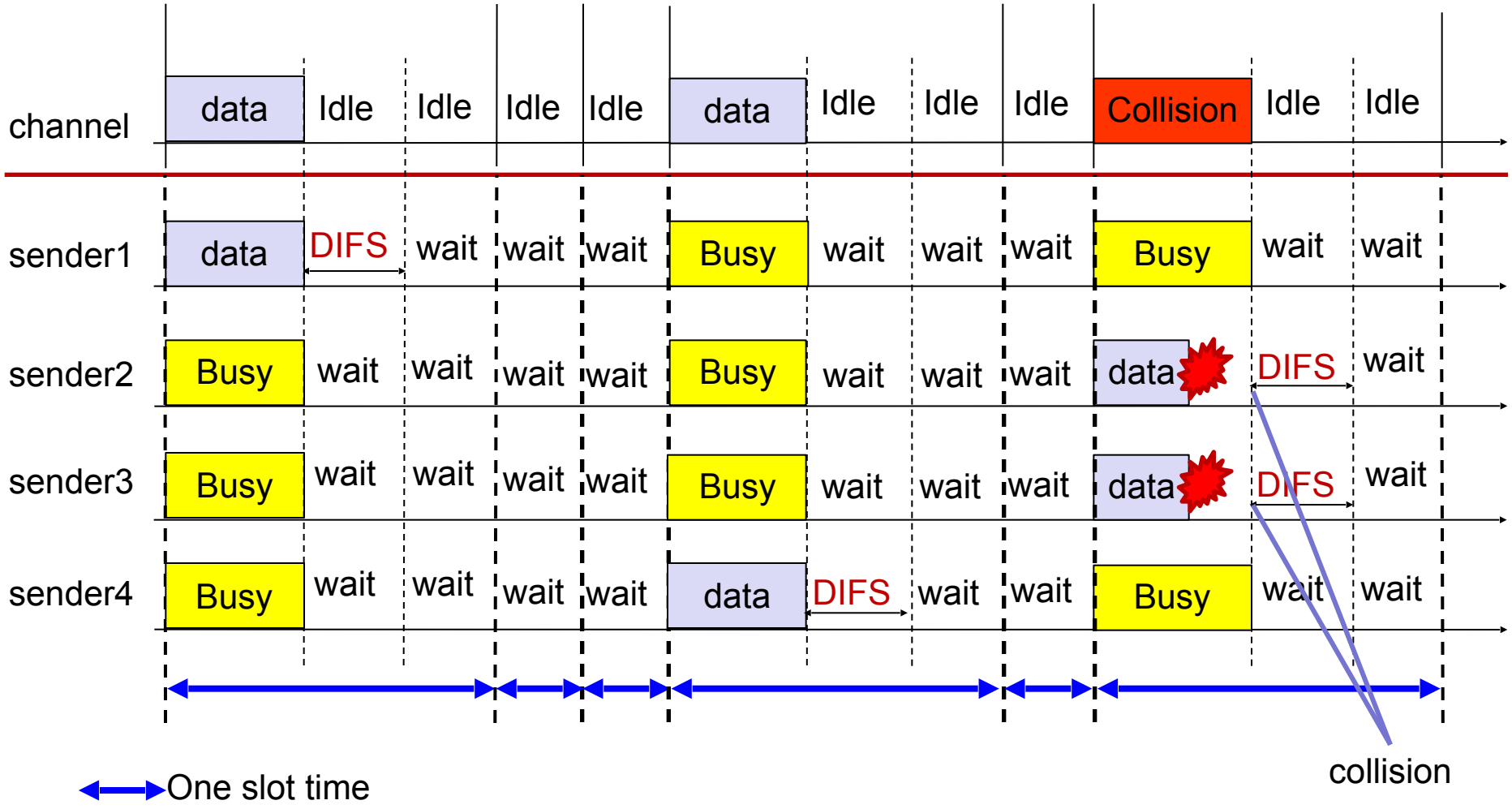
- Sending unicast packets
  - station can send RTS with reservation parameter after waiting for DIFS (reservation determines amount of time the data packet needs the medium)
  - acknowledgement via CTS after SIFS by receiver (if ready to receive)
  - sender can now send data at once, acknowledgement via ACK
  - other stations store medium reservations distributed via RTS and CTS



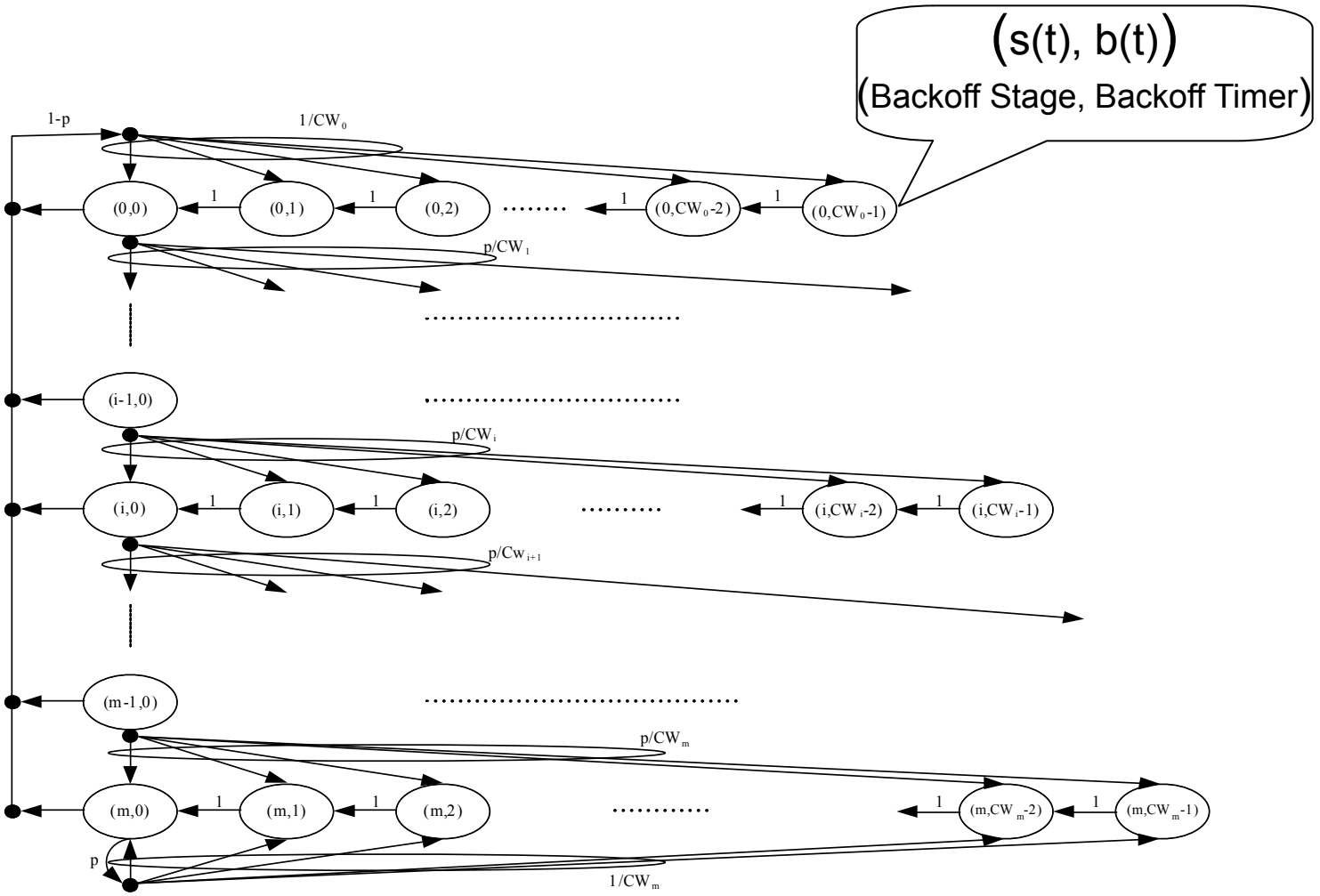
NAV: Net Allocation Vector

RTS/CTS can be present for some packets and not for other

802.11 – Slot Time in Bianchi's Model



Bianchi's Model: Two Dimensional Markov chain



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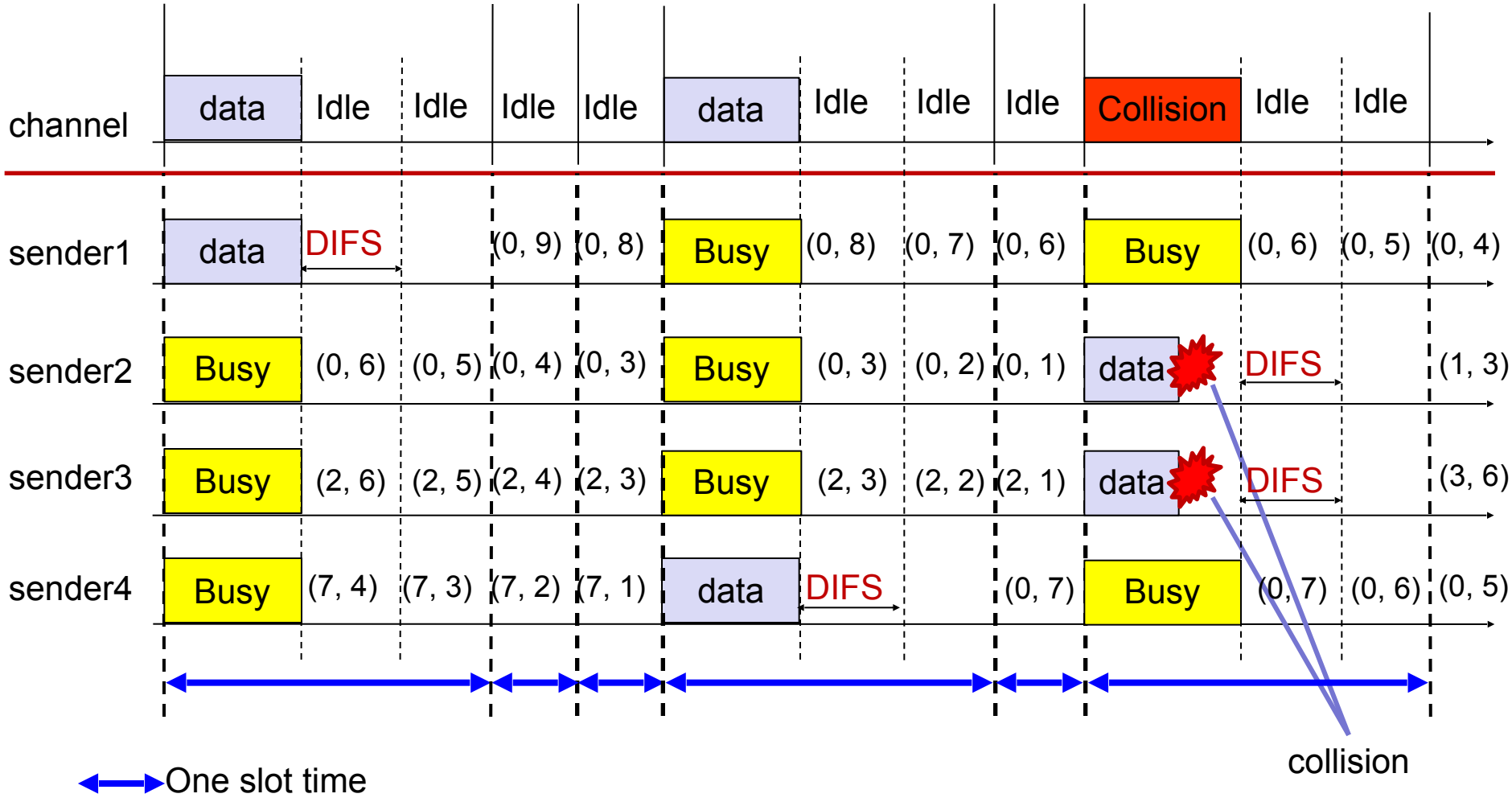
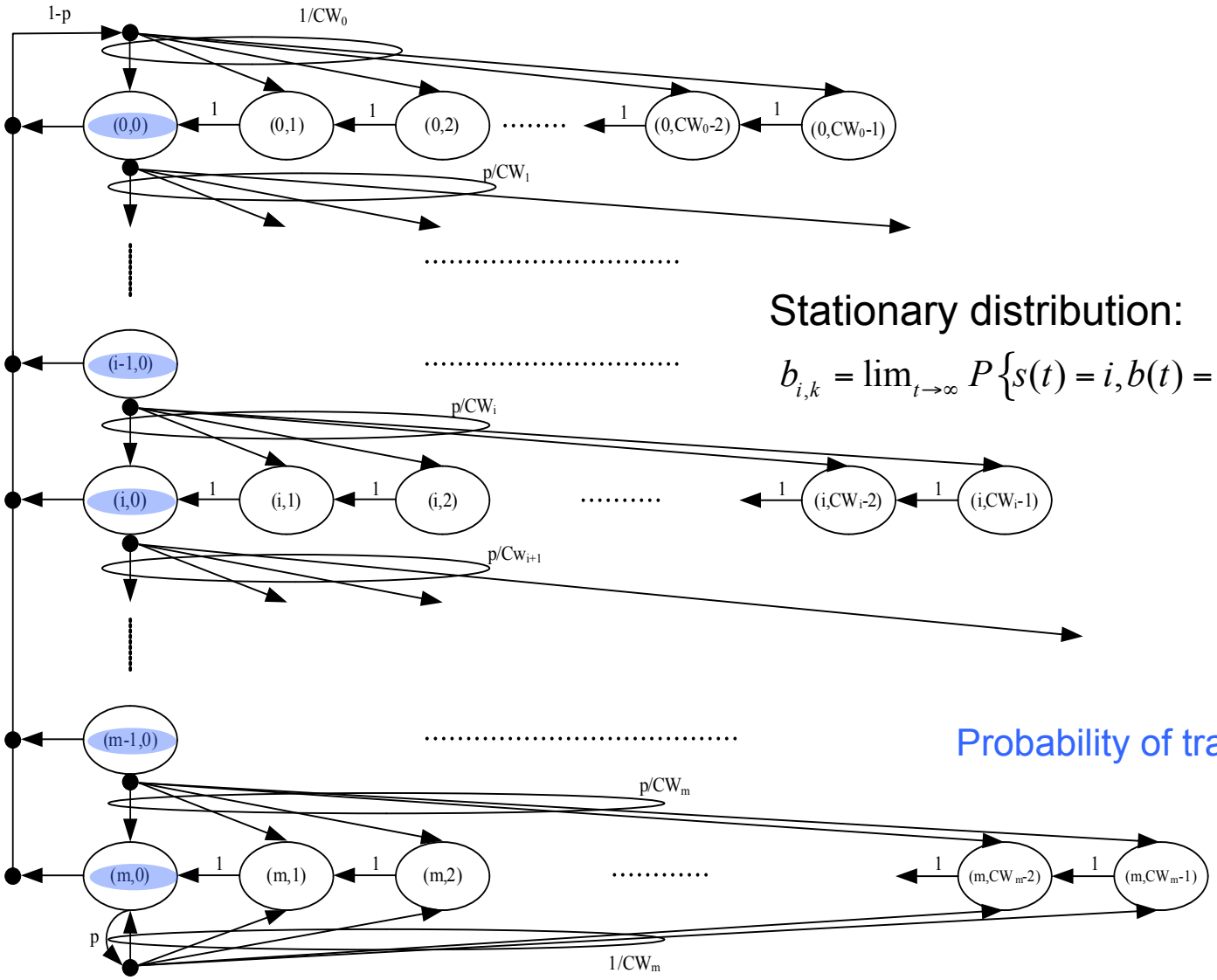


Bianchi's Model: Two Dimensional Markov chain

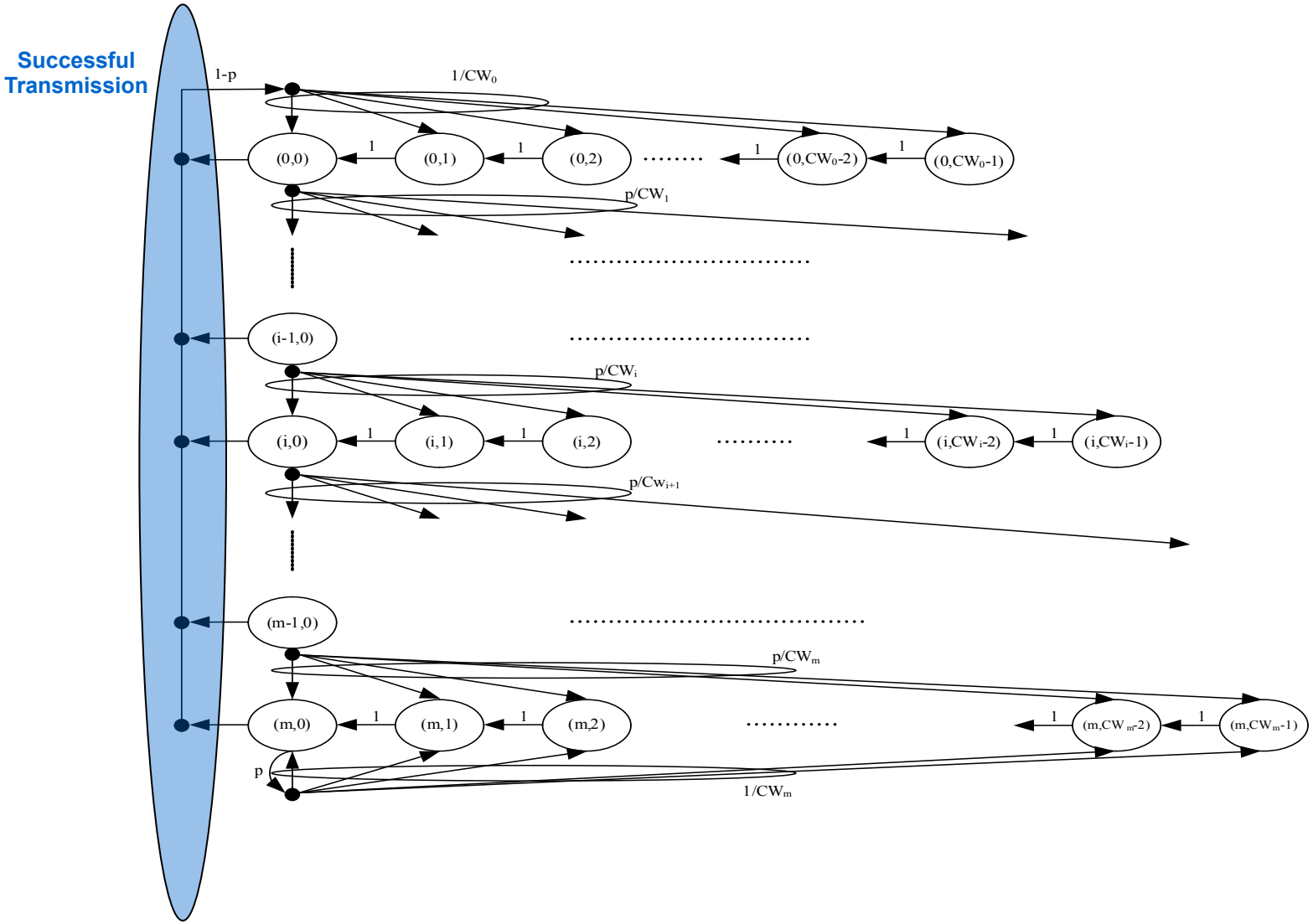


Stationary distribution:

$$b_{i,k} = \lim_{t\to\infty} P\{s(t)=i, b(t)=k\}, i\in(0,m), k\in(0,CW_i-1)$$

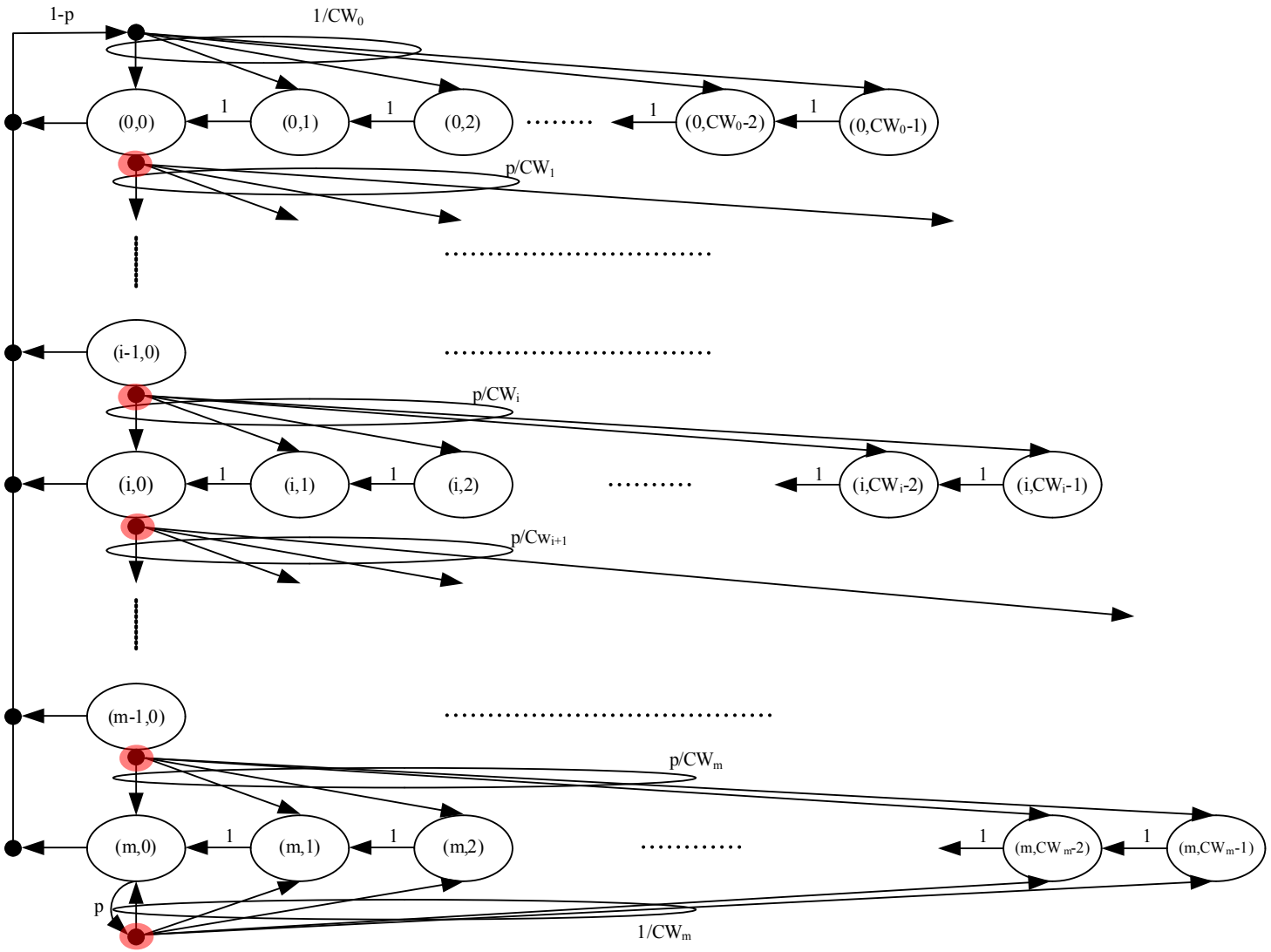
Probability of transmission: $\pi = \sum_{i=0}^{m} b_{i,0}$

Bianchi's Model: Two Dimensional Markov chain

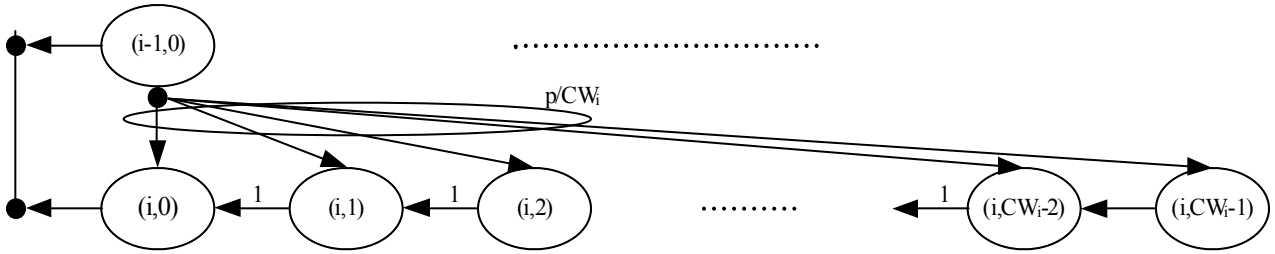


Bianchi's Model: Two Dimensional Markov chain

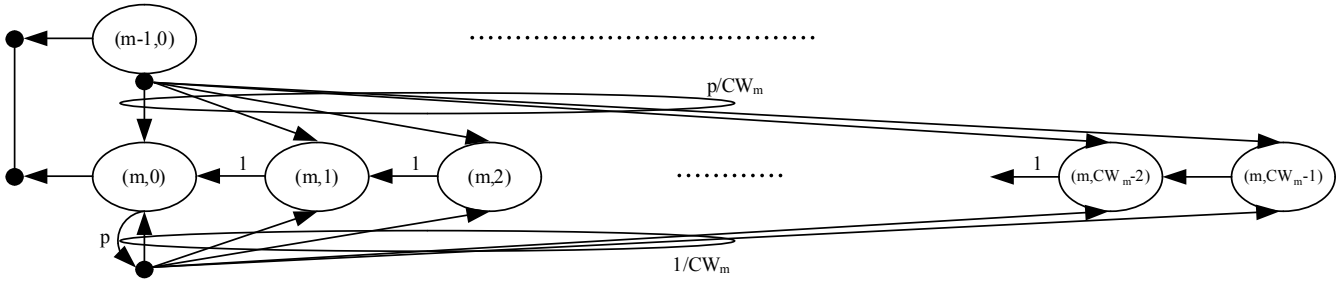
Collision



Bianchi's Model: Stationary Distribution of Chain



$$b_{i,0} = p\, b_{i-1,0}$$



$$b_{m,0} = p\, b_{m-1,0} + p\, b_{m,0}$$

Bianchi's Model: Solution for p and π

After some derivations → system of two nonlinear equations with two variables p and π:

$$\begin{cases} p = 1 - (1-\pi)^{N-1} \\ \\ \pi = \dfrac{2}{1 + W_{min} + pW_{min} \sum_{k=0}^{m-1} (2p)^k} \end{cases}$$

➔ Can be solved numerically to obtain p and π

Bianchi's model: Throughput Calculation

- Throughput of node i:

$$\tau_i = \frac{E[Payload\ Transmitted\ by\ user\ i\ in\ a\ slot\ time]}{E[Duration\ of\ slot\ time]} = \frac{P_s P_{tr} L}{P_s P_{tr} T_s + P_{tr}(1-P_s)T_c + (1-P_{tr})T_{id}}$$

  - P_{tr}: Probability of at least one transmission in slot time
  - P_s: Probability of successful transmission during a random time slot
  - L: Average packet payload size
  - T_s: Average time to transmit a packet of size L
  - T_c: Average time of collision
  - T_{id}: Duration of the idle period
  - t_{ACK}: ACK transmission time
  - t_H: Header transmission time
  - t_L: Payload transmission time

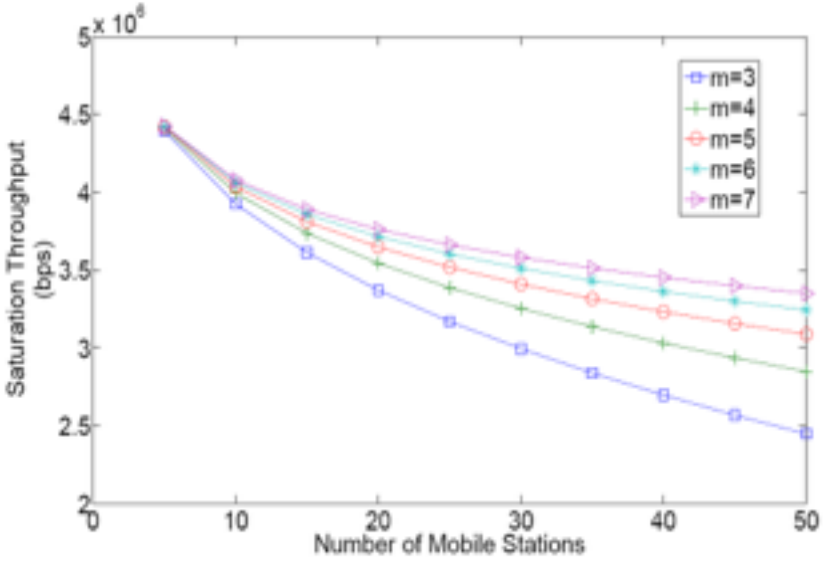
$$P_{tr} = 1-(1-\pi)^N$$

$$P_s = \frac{N\pi(1-\pi)^{N-1}}{1-(1-\pi)^N}$$

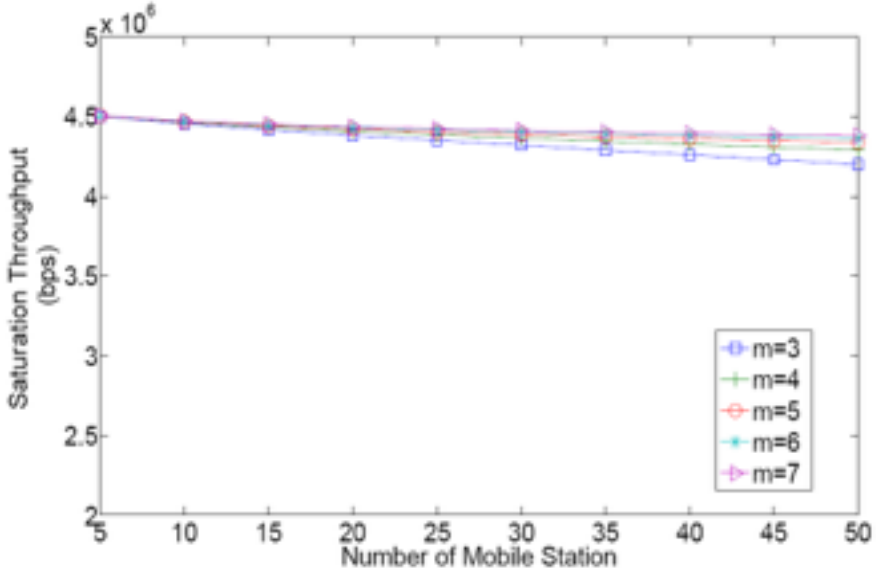
$$T_s = t_H + t_L + SIFS + \sigma + t_{ACK} + DIFS + \sigma$$

$$T_c = t_H + t_L + DIFS + \sigma$$

Numerical Results



Basic Mode



RTS/CTS

Conclusion

- Semi-analytical model to express the performance of IEEE 802.11 networks
- More sophisticated models have been developed since then
- Don’t forget checking the related write up: «Performance Analysis of the IEEE DCF: Bianchi Model»