Machine Learning for Networking

Wi-Fi performance

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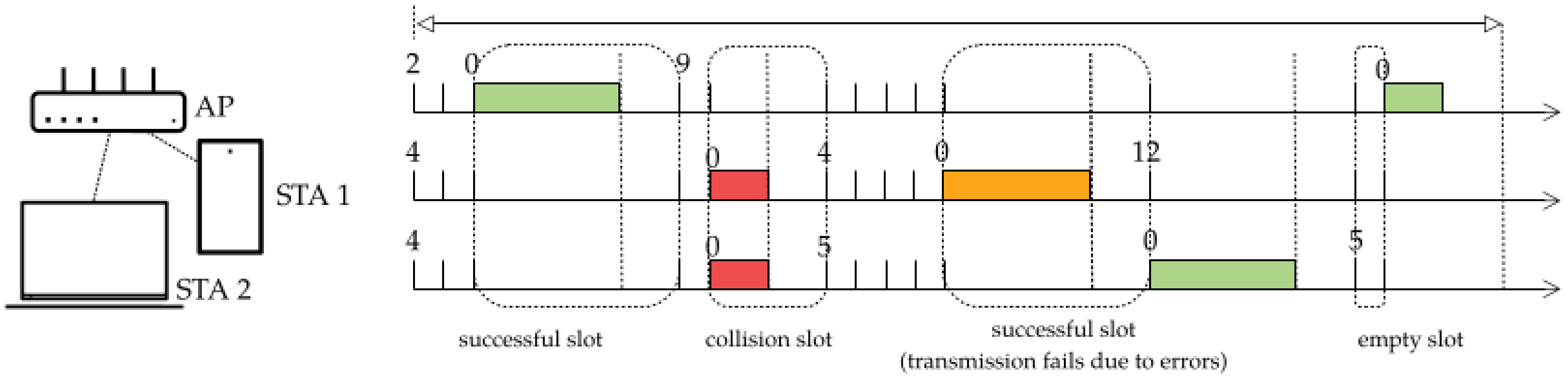
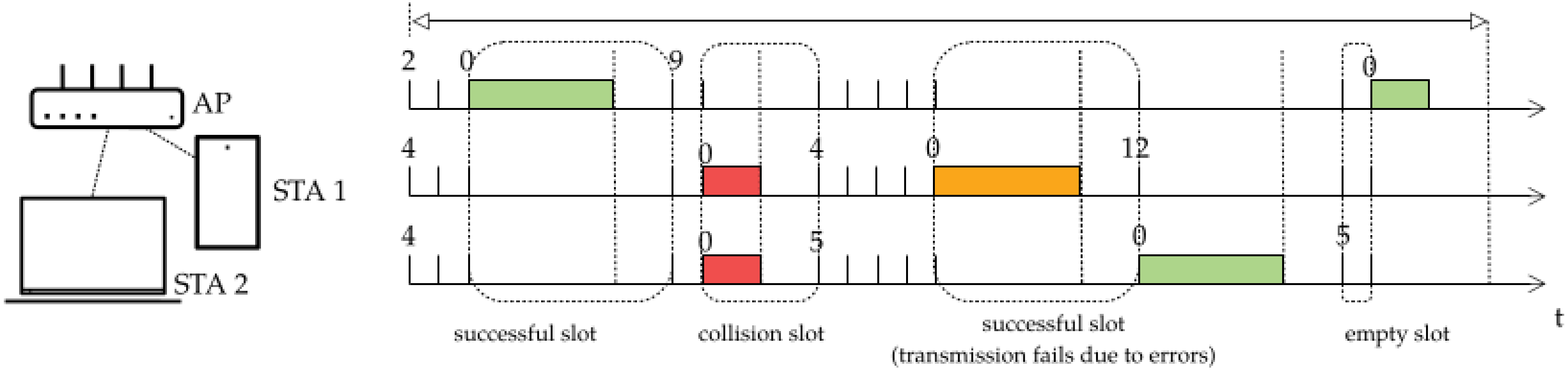
Initial considerations

- Full-buffer traffic model: all devices have always packets ready for transmission.
- All devices are contending all the time to access the channel.
- Implicit synchronization is achieved: all devices decrease their backoff counter at exactly the same instant of time.
- The ‘network’ evolves at discrete times instants. We will call a slot as the time between



Transmission Probability



$$\tau_{\mathrm{AP}} = \frac{1}{2+1+9+1} = \frac{1}{\frac{2+9}{2}+1} = \frac{1}{\mathbb{E}[Y_{\mathrm{AP}}]+1}$$

Collision & Failure Probability

- Frames can be lost due to collisions and transmission errors
- Collision probability

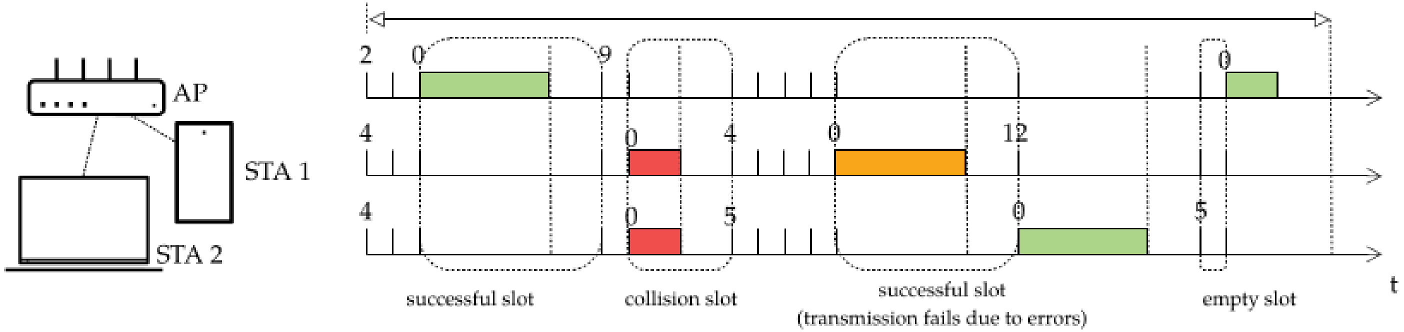
$$p_n = 1 - \prod_{\forall m \neq n} (1 - \tau_m)$$

- Failure probability

$$p_{f,n} = p_n + (1 - p_n) p_{e,n}$$

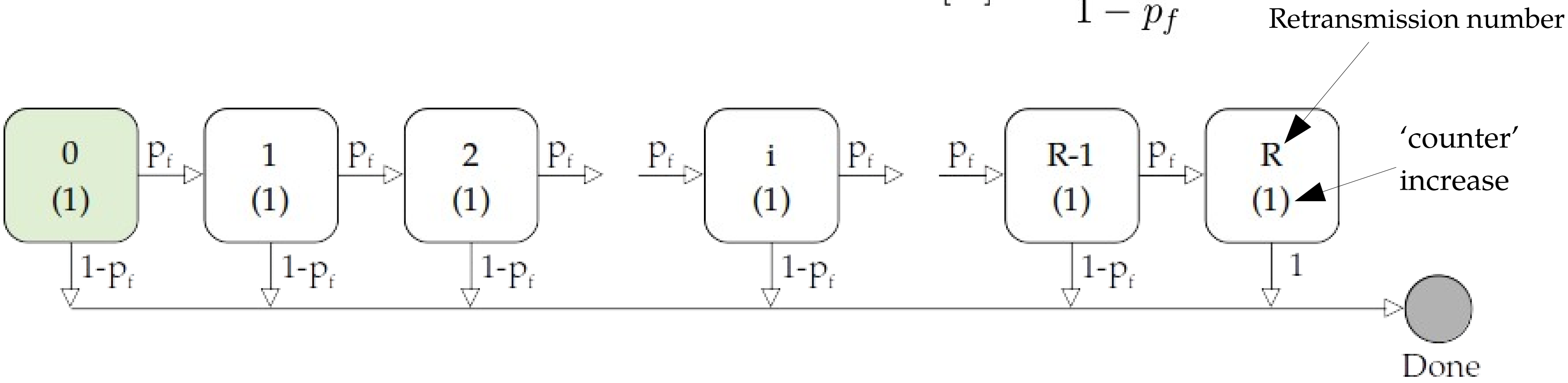
Example

- Write the collision probability for each device in terms of the transmission probability of the others



Expected Number of Transmissions

- The maximum number of retransmissions per frame is R.
- Mean number of retransmissions per frame $$\mathbb{E}[V] = \frac{1 - p_f^{R+1}}{1 - p_f}$$



Mean number of slots per transmission

- Single stage (m=0)

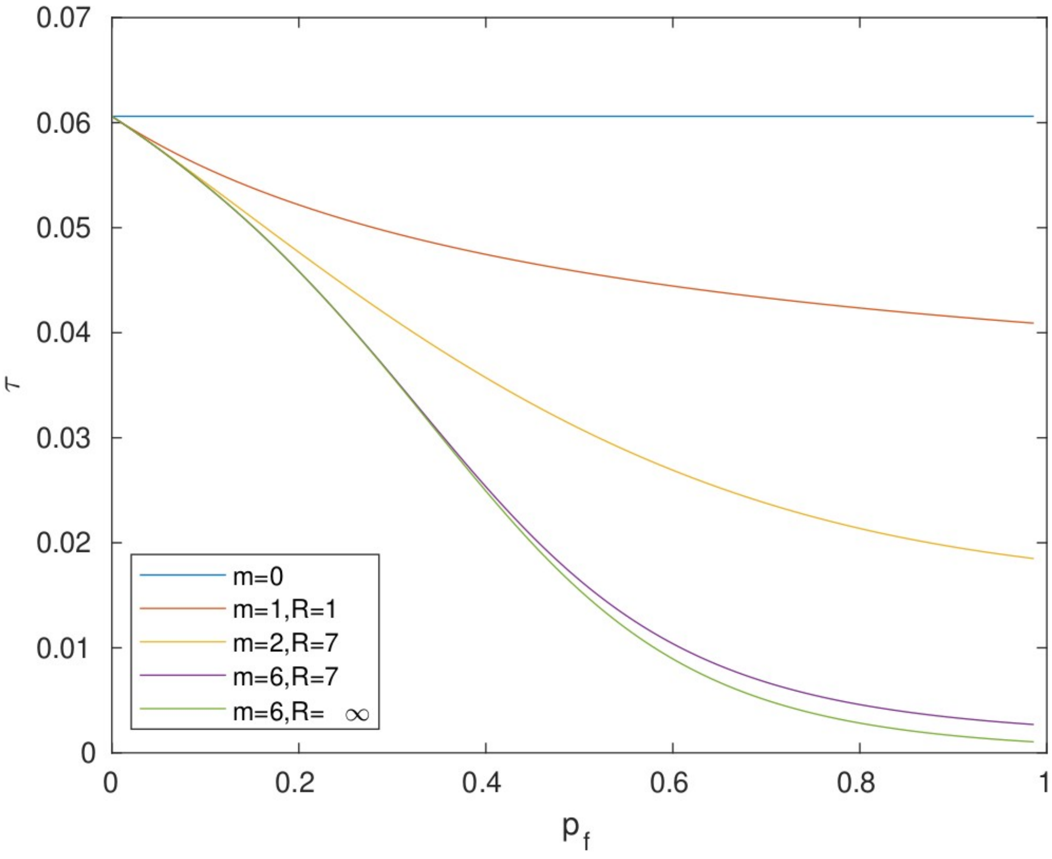
$$\mathbb{E}[Y] = \frac{0 + CW}{2} = \frac{\mathrm{CW}_{\min}}{2}$$

- Multiple stages

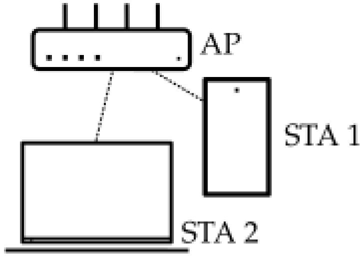
$$\mathbb{E}[Y] = \frac{\frac{(\mathrm{CW}_{\min}+1)}{2}\left(\frac{1-(2p)^m}{1-2p} + \frac{(2p)^m}{1-p} - \frac{2^m p^{R+1}}{1-p}\right) - \frac{1}{2}\left(\frac{1-p^{R+1}}{1-p}\right)}{\frac{1-p^{R+1}}{1-p}} =$$

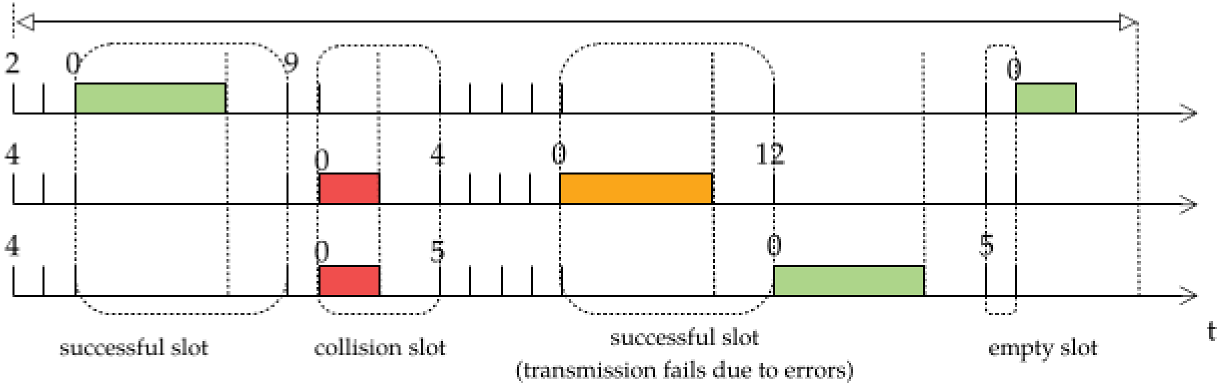
$$= \frac{(\mathrm{CW}_{\min}+1)}{2}\left(\frac{1-p}{1-p^{R+1}}\right)\left(\frac{1-(2p)^m}{1-2p} + \frac{(2p)^m}{1-p} - \frac{2^m p^{R+1}}{1-p}\right) - \frac{1}{2}$$

Backoff and Transmission probability



Slot Probabilities





$$p_0 = \prod_{\forall n} (1 - \tau_n)$$

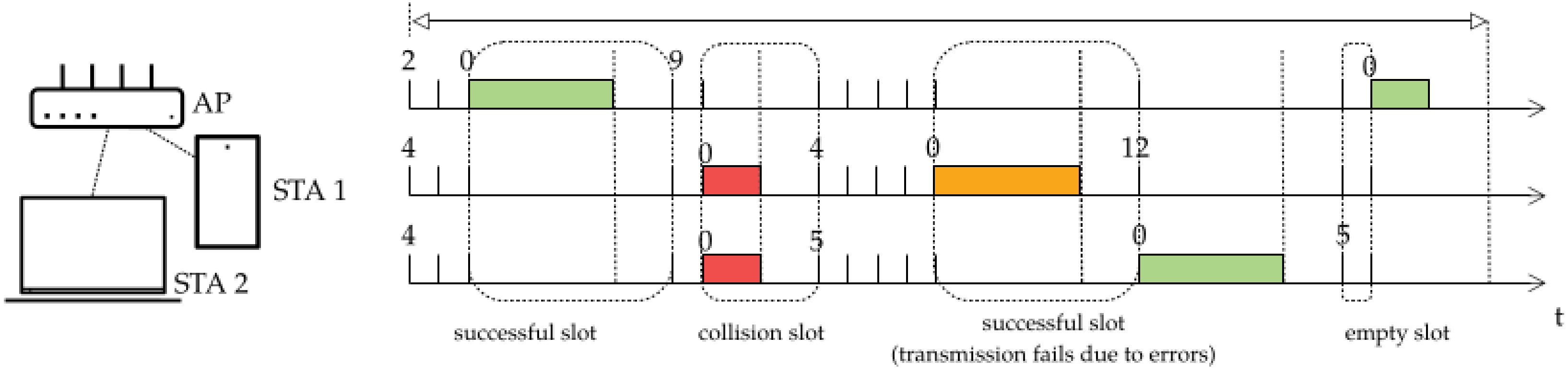
$$p_1 = \sum_{\forall n} \tau_n \prod_{\forall m \neq n} (1 - \tau_m).$$

$$p_+ = 1 - p_0 - p_1$$

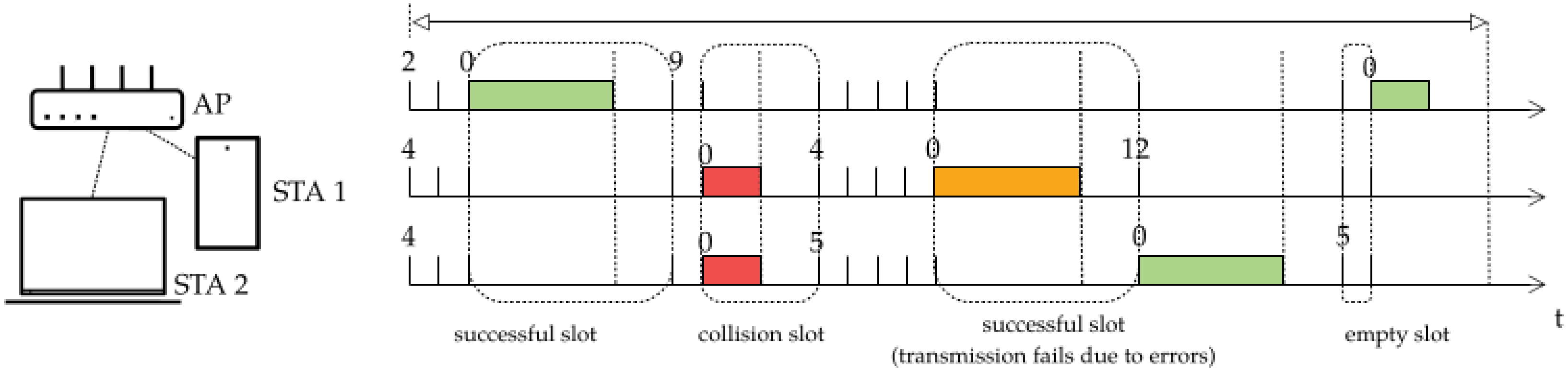
$$p_{n,1} = \tau_n \prod_{\forall m \neq n} (1 - \tau_m)$$

Example

- Find the exact expression of p_+ in this example

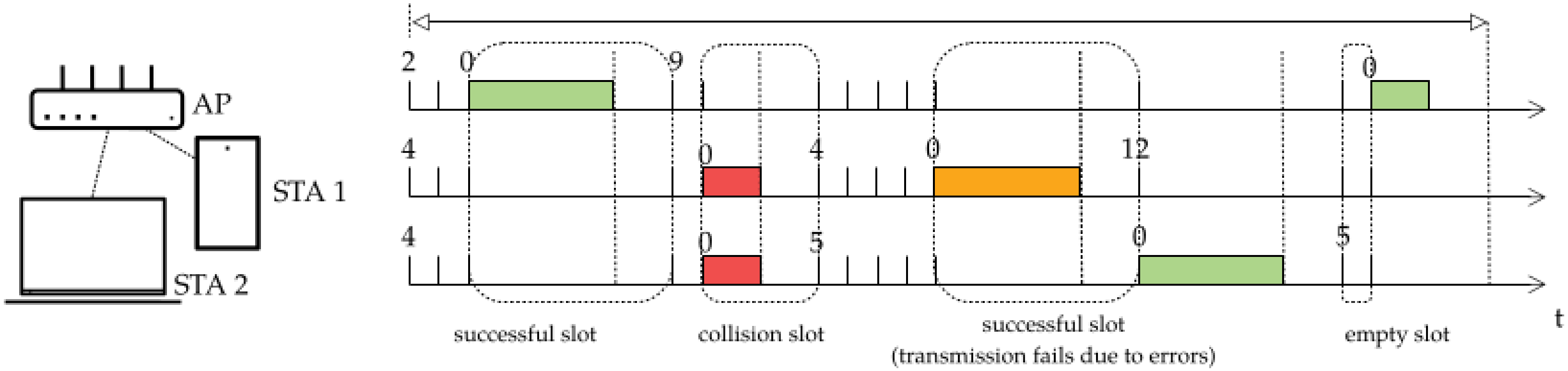


Average backoff slot duration



$$\mathbb{E}[\sigma] = \sigma_0 p_0 + \sum_{\forall n} p_{s,n} T_n + T_c p_+$$

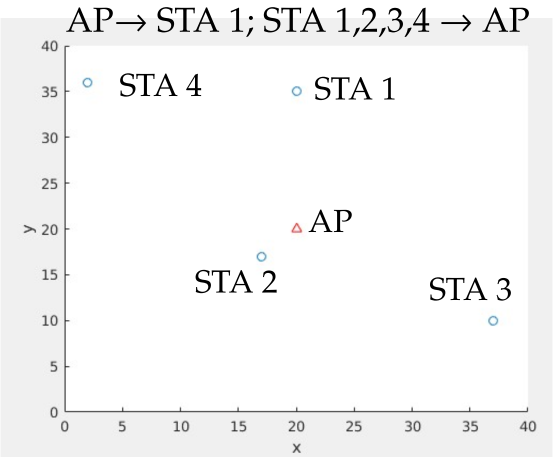
Throughput



$$\mathrm{Th}_n = \frac{p_{n,1} L_n (1 - p_{e,n})}{\mathbb{E}[\sigma]}.$$

Exercise

- Download Example3.zip.
- There are two files. Execute *Test_NetworkCentricDCFmodel.m*

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Distance between the AP and each STA
    15.1327e+000    15.1327e+000     4.6904e+000    19.8242e+000    24.1661e+000
Received Power (dBm)
   -69.0891e+000   -69.0891e+000   -50.5639e+000   -75.1191e+000   -80.2354e+000
---- Packet Durations ----
   539.0000e-006   539.0000e-006   491.0000e-006   603.0000e-006   875.0000e-006
   163.0000e-006   163.0000e-006   163.0000e-006   163.0000e-006   163.0000e-006
     9.0000e-006
Convergence!!
   101.0000e+000
 ----------- Resuts -----------
   117.6471e-003   393.8650e-003    71.3100e-003     3.3900e+006     3.5398e-003
   117.6471e-003   393.8650e-003    71.3100e-003     3.3900e+006     3.5398e-003
   117.6471e-003   393.8650e-003    71.3100e-003     3.3900e+006     3.5398e-003
   117.6471e-003   393.8650e-003    71.3100e-003     3.3900e+006     3.5398e-003
   117.6471e-003   393.8650e-003    71.3100e-003     3.3900e+006     3.5398e-003
```

AP → first result row; STA 1 → second result row; STA 4 → last result row

Tx prob. | Failure prob. | p_0 1 device | Throughput | Service time

Exercise

- 1) Explain what happens when (compare versus default values, 15)
  - Increase the CWmin and CWmax of all devices to 127
  - Decrease the CWmin and CWmax of all devices to 3
  - Is there any optimal CWmin and CWmax?
- 2) Explain what happens if CWmin = 7 and CWmax = 1023
- 3) How can we give to the AP 4 times more transmission opportunities than a station?