Analysis of a simplified CSMA/CA protocol

- Consider a multiple access link with n nodes all in transmission range of each other (no hidden/exposed nodes; only 1 successful transmission at a time)
- Assume infinite backlogs at all nodes, fixed data rate r & fixed packet length L
- Let T_0 be the packet transmission overhead time (includes any handshaking, ACKs, interframe spaces), & T_c the average collision duration
- protocol follows 802.11 CSMA/CA except that the backoff durations are chosen from an exponential distribution with fixed mean $\frac{1}{\beta}$, $f(x) = \beta e^{-\beta x}$ (instead of the uniform distribution over adaptively chosen discrete sets)
  - → since the exponential distribution is memorylyess, we have a renewal reward process
    - each renewal interval starts upon the completion of a successful transmission or a collision period
    - at the start of each renewal interval, the residual or newly chosen backoff durations of all nodes are exponentially distributed with mean $\frac{1}{\beta}$
- the time until the first backoff completes is exponentially distributed with mean $\frac{1}{n\beta}$ (min of independent exponential r.v.s)
- a collision occurs if a second backoff completes within a timeslot δ of the first (δ is chosen s.t. all nodes can sense a transmission within 1 timeslot)
  - → the probability of a collision is

$$\gamma = 1 - e^{-(n-1)\beta\delta} \quad -(1)$$

(CDF of exponential distribution with mean $\frac{1}{(n-1)\beta}$)

- mean renewal interval duration is

$$\underbrace{\frac{1}{n\beta}}_{\text{backoff}} + \underbrace{(1-\gamma)\left(\frac{L}{r} + T_0\right)}_{\text{success}} + \underbrace{\gamma T_c}_{\text{collision}}$$

- by the renewal reward thm, the network throughput is

$$\frac{(1-\gamma)L}{\frac{1}{n\beta} + (1-\gamma)\left(\frac{L}{r} + T_0\right) + \gamma T_c}$$

(which goes to 0 as $\beta \to 0$ or $\beta \to \infty$)

- dividing by r gives the fraction

of time that the network is carrying data packets

- by setting $\frac{1}{\beta}$ equal to the average backoff duration for 802.11 (obtained in terms of γ by Markov analysis, then solved simultaneously with (1)), this approach gives a reasonably accurate prediction of the performance of the 802.11 MAC protocol (Bianchi 00)

Switching

- a switch interconnects 2 or more links, & forwards data received on one link out on one or more outgoing links
- unlike a physical layer hub or repeater, which joins 2 or more physical segments into a single broadcast domain, a switch isolates different links' traffic (i.e. packets can be transmitted on different links simultaneously without colliding) → scalability
- since a switch isolates different links, they can use different underlying technologies
- routers are network layer packet switches; bridges & switches are link layer packet switches
  - routers process packets up through the network layer, & use network-layer addresses to forward packets
  - bridges & switches process packets up through the link layer, & use MAC addresses to forward packets

Switch functions

- Data plane functions : fast timescale , per pkt fxns
  - demultiplexing flows on incoming links
  - identifying the appropriate output links
  - forwarding /switching from inputs to outputs
  - multiplexing flows onto each output link
- Control plane functions : slow timescale
  - reservations
  - updating switch / routing tables