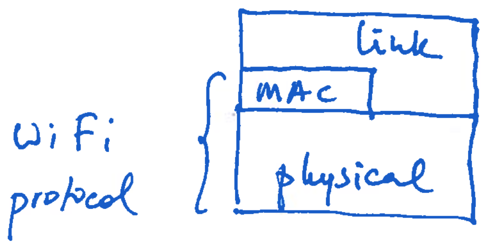
TIAA CREF

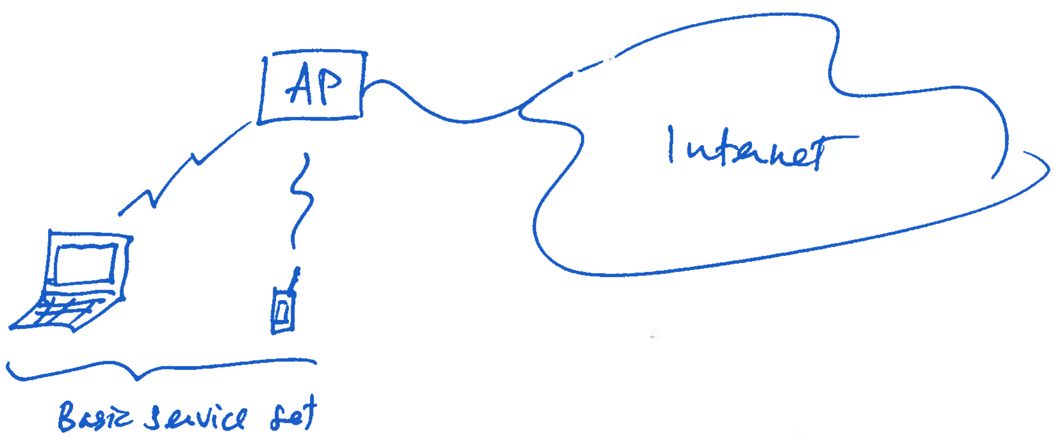
Nov 29, 2018 ①

Ch4 WiFi (Walrand & Parekh)

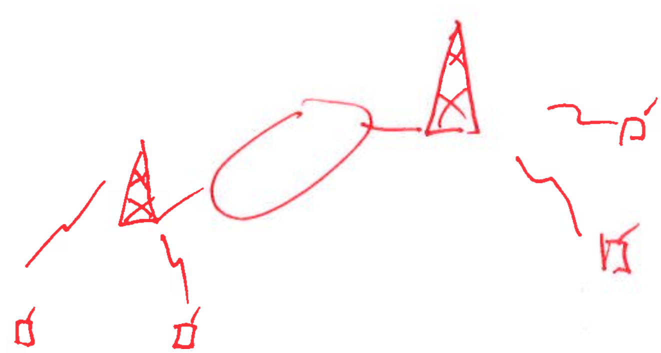
Protocol layer :



Infrastructure mode :



Cellular



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4.2 MAC

Table 4.1 MAC protocol parameters

CSMA/CA:

1. On receiving correct WiFi pkt, wait for SIFS (short I.F.S.) and send ACK

2. To send a WiFi pkt,
   - wait for channel to idle for DIFS (DCF IFS)
   - wait for random backoff delay of z slot times
     z uniform in $\{0, 1, .., CW_n\}$

     where $CW_n = \min(CW_{max}, (CW_{min}+1)2^n - 1)$, $n = 0, 1, ..$

     n: # previous attempts — Binary exp. back off

     e.g. 802.11b: $CW_0 = 31$,
     $CW_1 = 63$
     $CW_2 = 127$

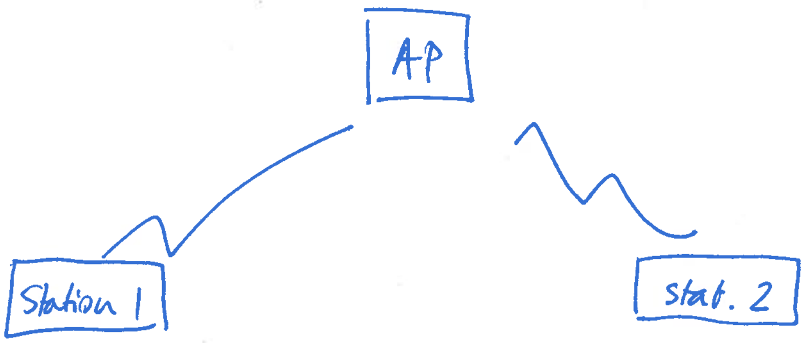
   - Decrement backoff counter by 1 every slot time.
     If another station transmits, it freezes backoff counter, & resume dec. after channel idle for DIFS again.
   - Transmit when backoff counter == 0.
   - Since DIFS > SIFS, transmission will not collide with any ACK.

3. If a station receives an incorrect packet, it must wait for EIFS (extended IFS) before attempting to transmit in order for the intended recvr to receive ACK.

After ~~waiting~~ for EIFS, resume dec ~~the~~ residue backoff counter.
(channel has idle)

Illustration: Fig. 4.1, p. 50.

Enhancement: Hidden terminal problem



Stat 1 & stat 2 do not hear (interfere with) each other.
but their transmission can collide at AP!

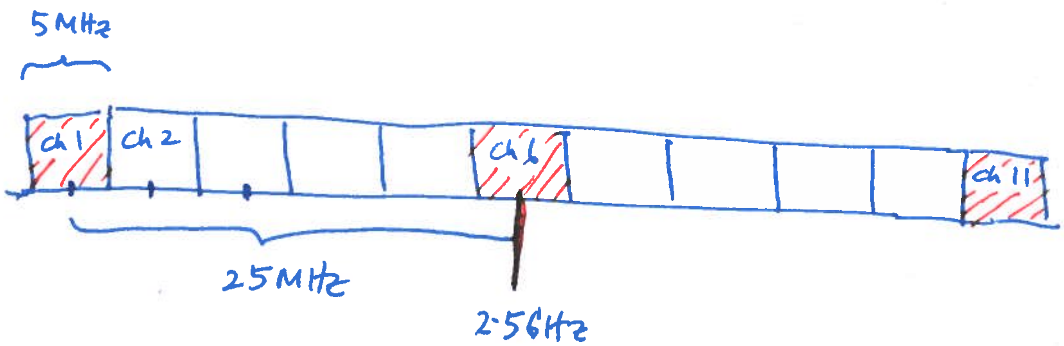
Solution:

- Sender (stat 1) sends RTS (request to send)
- AP replies with CTS (clear .. ..). This silences stat 2.
- Stat 1 sends data, AP replies with ACK.

RTS - SIFS - CTS - SIFS - DATA - SIFS - ACK

4.3 PHY layer

E.g. 802.11 b :
- spectrum around 2.4 GHz unlicensed.
- 11 channels with 5 MHz % consecutive center freq
- Commonly use channels 1, 6, 11, giving channel separation of 25 MHz



4.4 Efficiency

Single device

Fig 4.3 Channel usage

Single station always sending to AP.

802.11b:

data ~~efficiency~~ throughput := $\frac{\text{\# bits (data)}}{\text{time period inc. overheads}}$ = 6.38 Mbps

channel bit rate = 11 Mbps

∴ efficiency := $\frac{6.38}{11}$ = 58 %

Multiple devices : n devices always have pkts to send

Markov chain $(s(k), b(k))$

$s(k)$: # previous attempts for the pending pkt at time k

$b(k)$: backoff counter at time k.

Transition probabilities Fig 4.4. p. 55

Key assumption :

when a stat transmits, it is successful with prob $1-p$
and collides " " p
independent of state $(i,0)$ or other events or history.

∴ Can analyze network efficiency by analyzing 1 stat. in isolation.

Here, p is to be determined as follows.

MC analysis
$\pi = \pi P$

1. Given p, we can compute the stationary distribution of the Markov chain, and determine

$$\alpha(p) := \text{prob}(\text{stat. in state } (i,0) \text{ and stat. transmits})$$

attempt probability

2 Assume all n station behaves similarly and has the same attempt prob. $\alpha(p)$. Then

$$\text{prob of success} = (1-p) = (1-\alpha(p))^{n-1}$$

3. This is a nonlinear eqtn in one unknown p.
Solve for $p \Rightarrow \alpha(p) =: \alpha$

4. Let T := avg. duration b/w two successful transmission.

$$= \begin{cases} \text{idle slot time} & \text{if no transmission} \\ \text{trans. time of 1 pkt + SIFS + ACK + DIFS} & \text{if 1 (successful) transmission} \\ \text{longest trans. time of colliding pkts + DIFS} & \text{if multiple transmissions} \end{cases}$$

See [17] for detailed calculation of T

5. Let $\beta := n\alpha(1-\alpha)^{n-1}$ ← Prob(exactly 1 transmission)

In an avg. duration of T:

B data bits are transmitted (successfully) w.p. β

0 " " " " " w.p. $1-\beta$

$\therefore$ network throughput (efficiency) $:= \frac{\beta B}{T}$

$$= \frac{n\,\alpha(p)\,(1-\alpha(p))^{n-1}}{T}$$

Fig 4.5: 802.11b