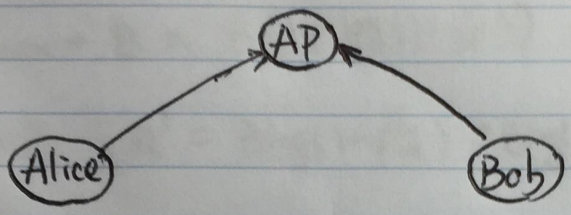
Lecture 6: Interference Management

TX ⟶ RX

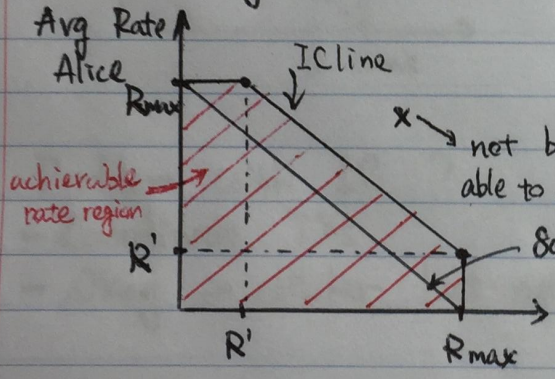
$Rate_{max} \leq C = B \log(1+SNR)$

$= B \log\left(1 + \frac{P_{RX}}{N}\right)$ — P_{RX}: received power; N: noise



- Total Rate = $Rate_{Alice} + Rate_{Bob}$
- $P_{RX}^{Alice} = P_{RX}^{Bob} = P$

Rate Region



$R_{max} = B \log(1+\frac{P}{N})$

$R' = B \log(1+\frac{P}{P+N})$

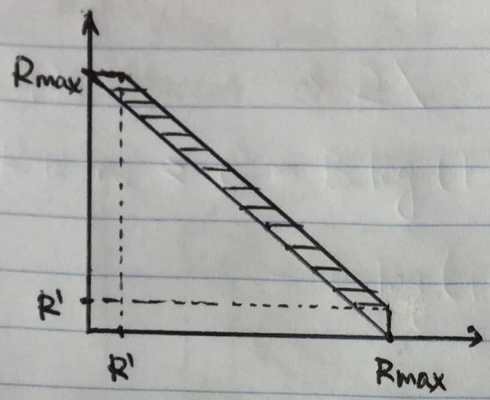
x → not be able to decode

802.11 TDMA / CSMA

$y(t) = y_A(t) + \underbrace{y_B(t) + n(t)}_{n'(t)}$

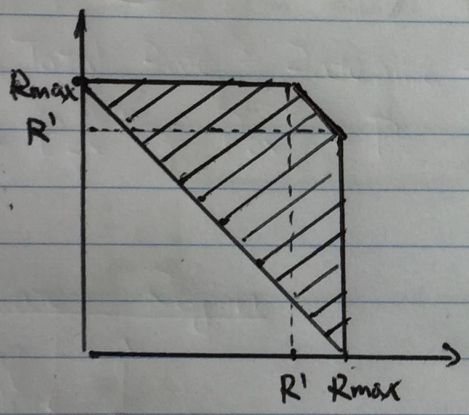
① Treat Bob as noise
② Decode Alice
③ Subtract $y_A(t)$ from $y(t) \Rightarrow y_B(t) + n(t)$
④ Decode Bob $\Rightarrow y_B(t)$
⑤ Iterate subtract Bob $\Rightarrow y_A(t) + n(t) \Rightarrow$ Decode Alice

$P \gg N$ $\quad R' = B\log\left(1+\frac{P}{P+N}\right) \approx B\log 2 = B$



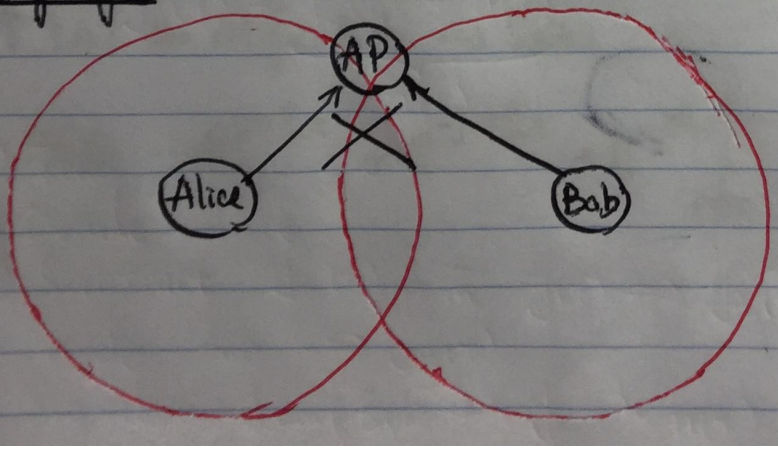
$$R_{max} + B = B\left(1 + \log\left(1+\frac{P}{N}\right)\right)$$

$N \gg P$ $\quad R' = B\log\left(1+\frac{P}{P+N}\right) \approx B\log\left(1+\frac{P}{N}\right) \approx R_{max}$



Problem with IC ?
- Coordinate TXs
- Okay in cellular but not in WiFi

ZigZag :

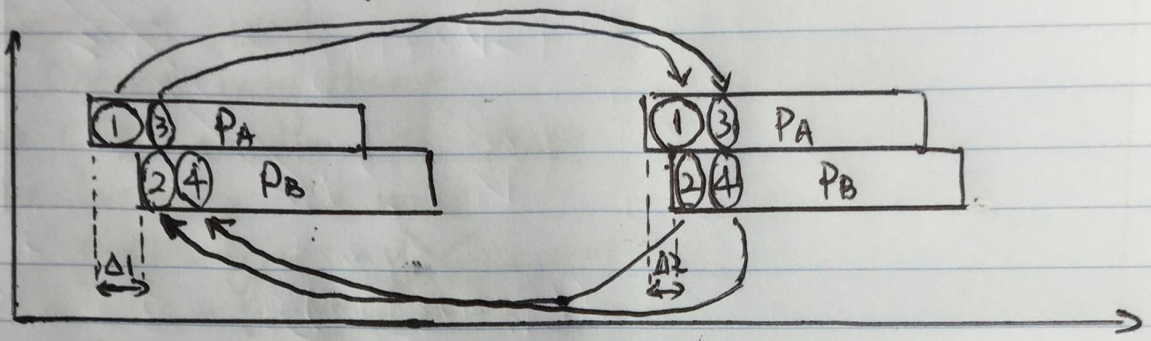


802.11 : RTS/CTS

ZigZag : Observation

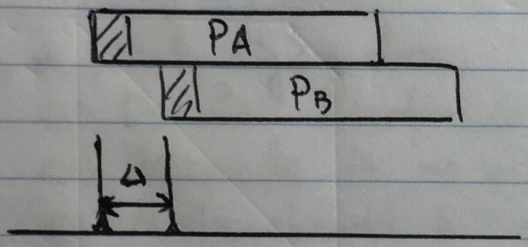
① If Alice and Bob collide, they will collide again

② Different offset of collision (CSMA: Wait Random # of slots)



ZigZag:

① How do you know there is a collision?



$x(t)$

$$y(t) = h_A x(t) + h_B x(t-\Delta) + n(t)$$

$$\Gamma(\Delta) = \sum_n y(t)\, x^*(t)$$

$$= h_A \sum_n x(t)\, x^*(t-\Delta) + h_B \sum_n x(t-\Delta)\, x^*(t-\Delta) + n(t)$$

$$\sum_n x(t)\, x^*(t-\Delta) = 0$$

$$= h_B \sum |x(t-\Delta)|^2 e^{-j2\pi\Delta f_c t}$$

$\Gamma(0) \Rightarrow$ Align Alice $\Rightarrow$ Spike

$\Gamma(\Delta) \Rightarrow$ Align Bob $\Rightarrow$ Spike

CFO $\quad e^{j2\pi f_c t} \times e^{-j2\pi f_c' t} = e^{-j2\pi\Delta f_c t}$

Δf_c ↑ CFO

② What does it mean to subtract a chunk?

- Subtract inteference free signal obtained first collision from second collision ⇒ complex numbers

Does not work

<1> Channel may change

<2> CFO accummulate phase

<3> Increase the noise

$$y(t) = y_A(t) + y_B(t) + n(t)$$
$$= y_A(t) + n(t)$$
$$y'(t) = y_A(t) + y_B(t) + n'(t)$$
$$y'(t) - y(t) = y_B(t) + n(t) + n'(t)$$

- What ZigZag does:

<1> Decode interference free chunk

<2> Re encode it ⇒ noise free signal

<3> Apply channel h, CFO, $e^{j2\pi\delta f c t}$ to it

<4> Sample it with sampling offset of 2 collisions

<5> Subtract it

• Error can propagate!!!