EE597 [NOTE: NO CLASS ON FEB 9!]

Lecture 9 Feb 7, 2012

Medium Access & Resource Allocation

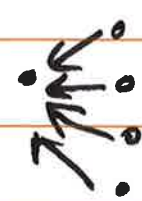
So far : Phy layer

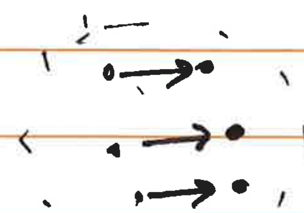
Tradeoffs between power, rate, delay, error performance etc.

many possible phy layer mechanisms, which must be considered & taken into account when designing any given network for a particular environment, usage pattern, mobility, etc.

next : Medium access & resource allocation


downlink parallel channels


uplink parallel channels

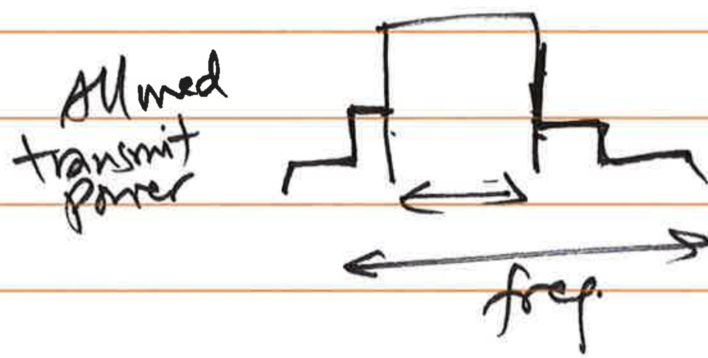

independent channels

assumption : omnidirectional antennas

In a wireless environment
all links potentially share
the same medium

Sharable
Resources : • Bandwidth / Time
• Power

| Power Allocation & Power Control |



Two mathematical models pertaining to power allocation:

$$R = W \cdot \log(1 + SNR) \quad (1)$$

R ↑ Rate

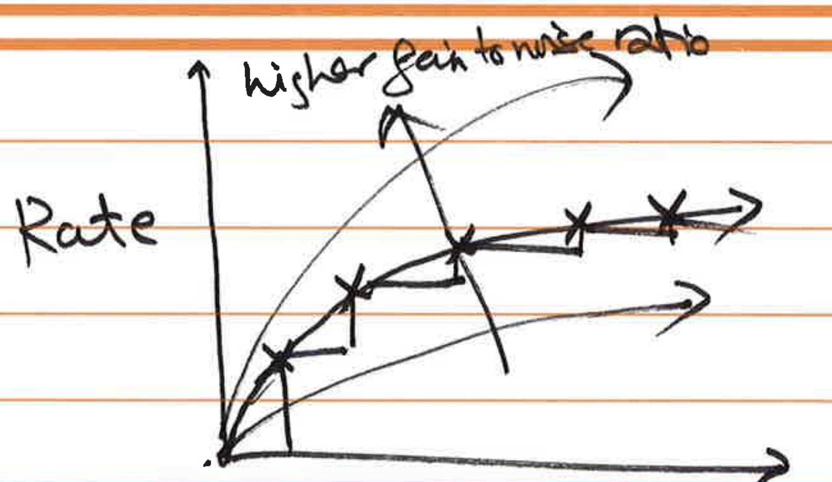
$$SNR = \frac{P_T \cdot g}{N}$$

P_T – transmit power

g – channel gain

N – receiver noise

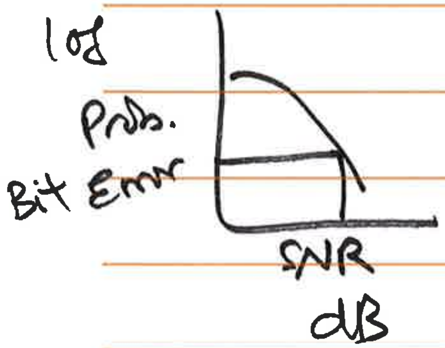
$\frac{g}{N}$ – gain to noise ratio

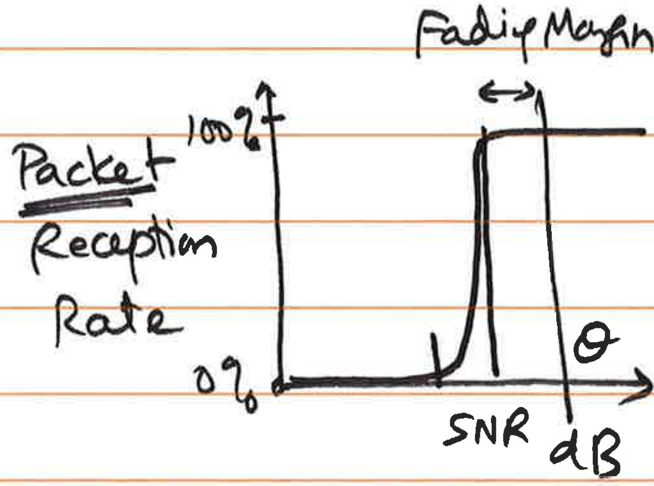


Rate is a concave function of power

Rate-adaptive model for a transmitter

Fixed-rate model for a transmitter





If SNR > Θ, then transmission is successful

$$\frac{P_T\, g}{N} > \Theta$$

When interference is present,

SINR > Θ

$$\frac{P_{T_i}\, g_{ii}}{\sum_{j \neq i} P_{T_j}\, g_{ji} + N_i} > \Theta$$

g_{ii} ← signal gain

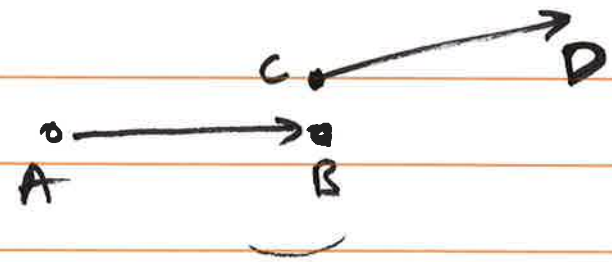
g_{ji} ← interference gain term

Two optimization/ decision problems.

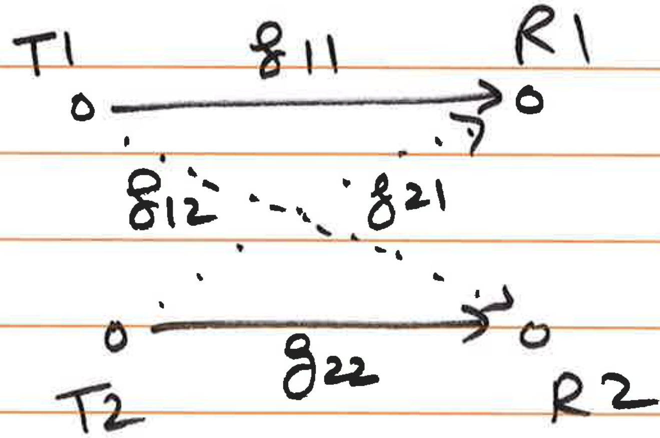
① maximize the sum rate over parallel channels, subject to a total power constraint, assuming a rate-adaptive model. (multiuser OFDM)

② Identify whether it is possible to allocate transmit powers to a set of independent links, assuming a fixed-rate model. (multiuser CDMA)

CDMA system Near-Far effect



Near interferer can overwhelm a far transmitter.



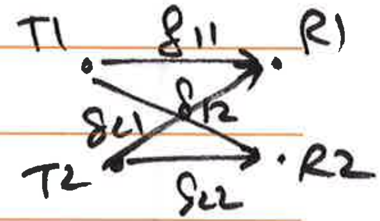
Assume slow fading, i.e. all the gains are static & known.

Fixed-rate model.

$SINR_1 \geq \Theta$ $\quad$ $SINR_2 \geq \Theta$

$P_1 \leftarrow$ transmit power for T1

P_2 " " T2



① — $$\frac{P_1 \cdot g_{11}}{P_2 \cdot g_{21} + N} \geq \Theta$$

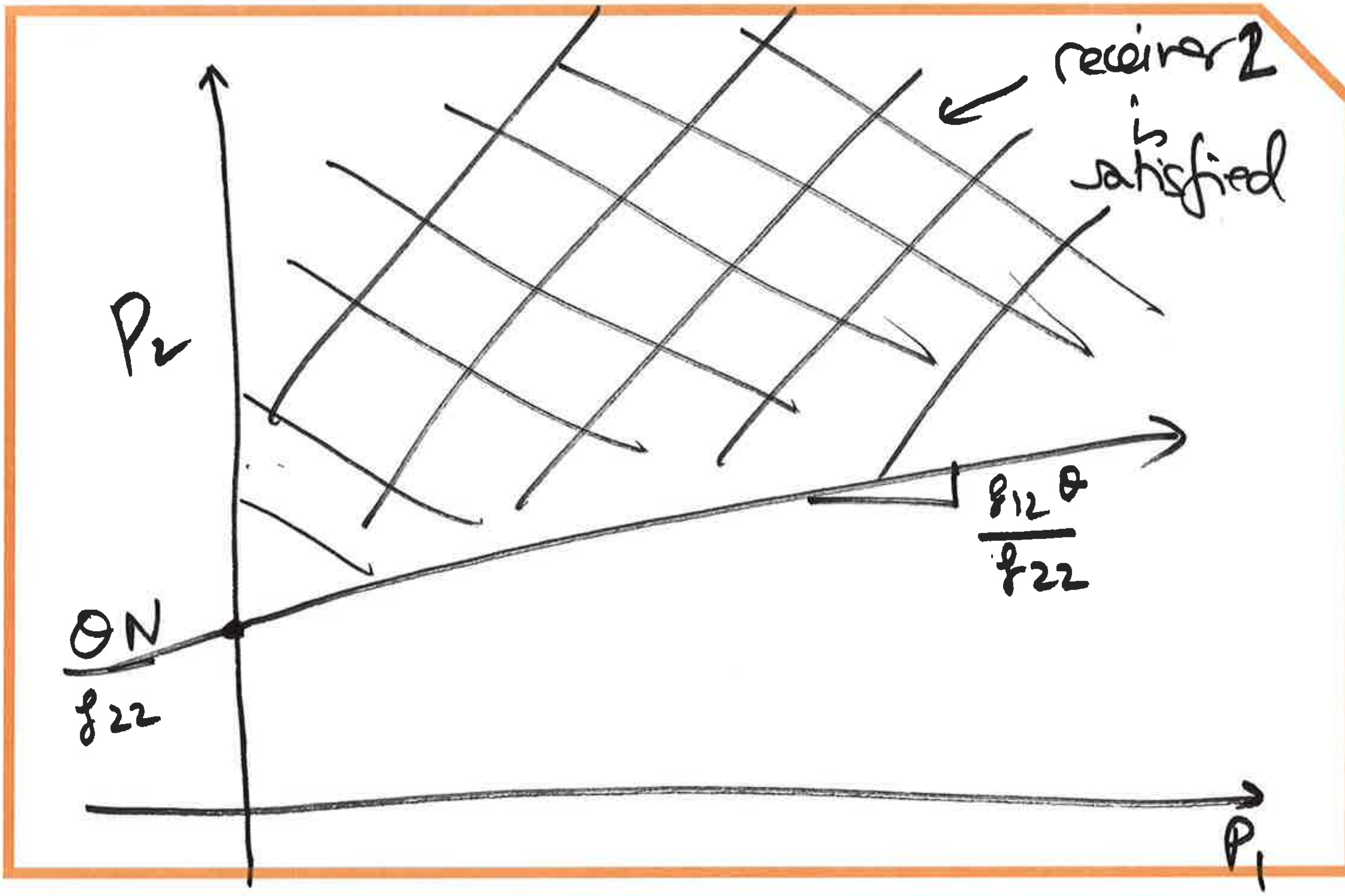
② $$\frac{P_2 \cdot g_{22}}{P_1 \cdot g_{12} + N} \geq \Theta$$

Both must hold for both receivers to receive successfully.

P_1, P_2 are the design variables

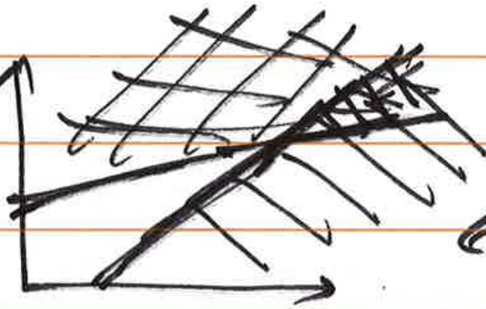
$$P_1 g_{11} \geq \Theta \cdot P_2 \cdot g_{21} + \Theta \cdot N \quad \text{— ①}$$

$$P_2 g_{22} \geq P_1 g_{12} \Theta + \Theta \cdot N \quad \text{— ②}$$



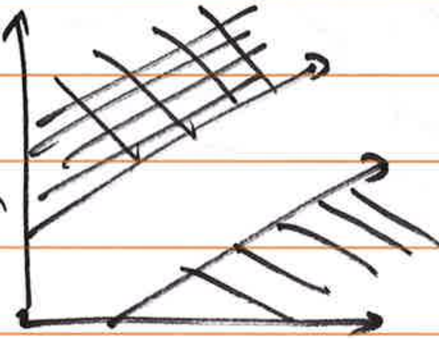
② $$P_2 \geq P_1 \frac{g_{12}\theta}{g_{22}} + \frac{\theta N}{g_{22}}$$

∃ a feasible set of powers for both ① & ② to hold



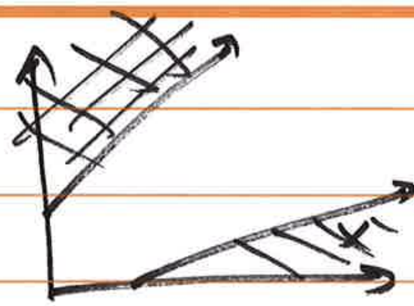
I

3 possibilities

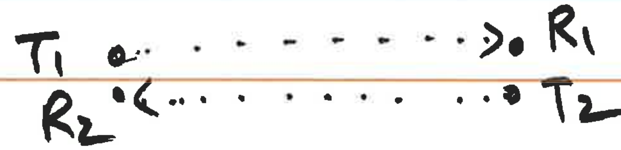


II

Infeasible



III



Case II happens (parallel lines) when the slopes are the same.

$$\frac{g_{11}}{\theta \cdot f_{21}} = \frac{f_{12}\theta}{f_{22}}$$

no solution

Case I

$$\frac{f_{11}}{\theta \cdot f_{21}} > \frac{f_{12}\theta}{f_{22}}$$

feasible solution exists

Case III

$$\frac{f_{11}}{\theta \cdot f_{21}} < \frac{f_{12}\theta}{f_{22}}$$

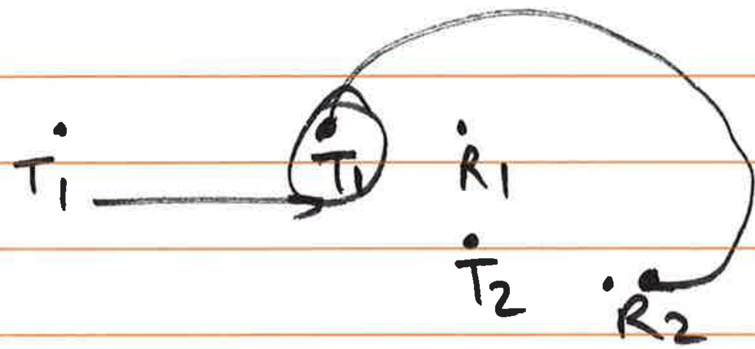
no solution

$$\frac{g_{11}}{\theta\, g_{21}} > \frac{g_{12}\,\theta}{g_{22}}$$

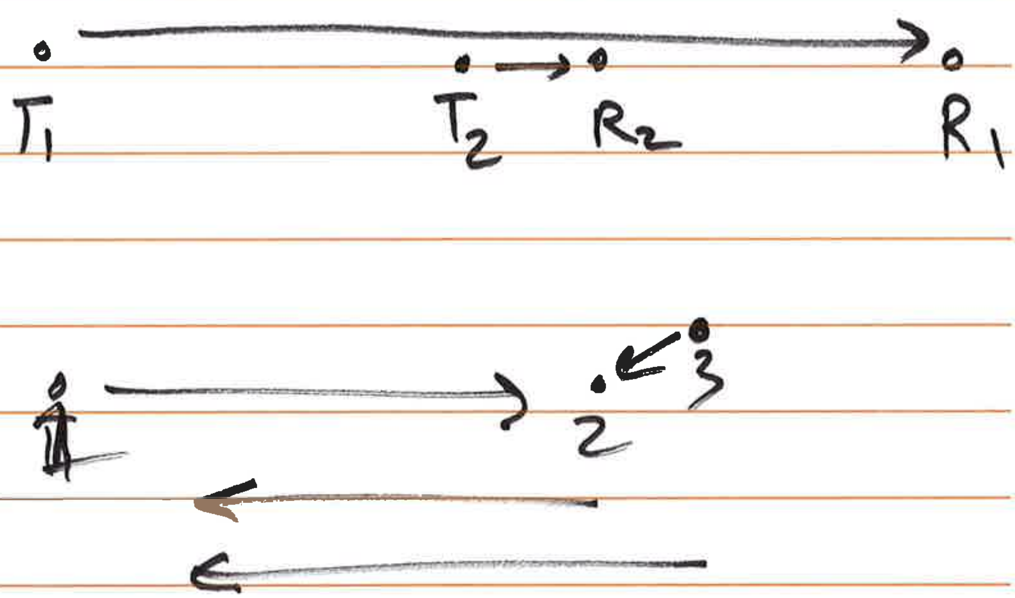
is necessary & sufficient for solution to exist.

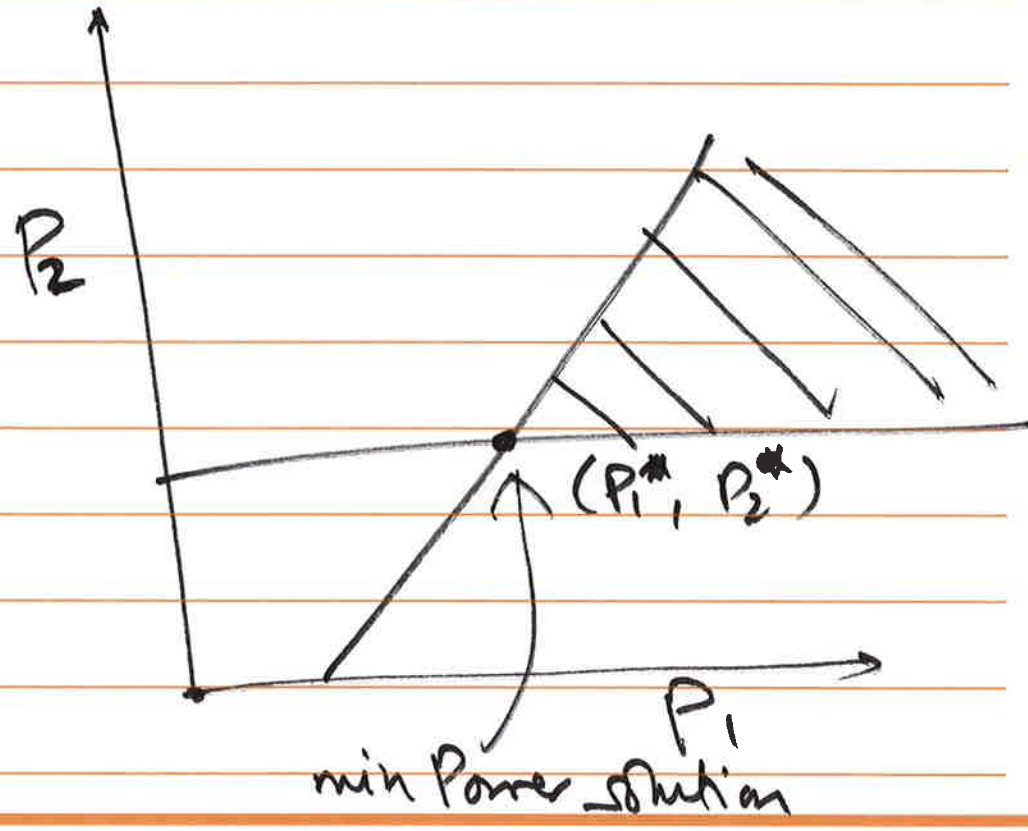
$$\underbrace{g_{11} \cdot g_{22}}_{\text{signal gains}} > \theta^2 \cdot \underbrace{g_{12} \cdot g_{21}}_{\text{interference gains}}$$

Some configurations in space:



Could this have a feasible solution?





solve for this by equating the two expressions

$$\frac{P_1 f_{11}}{\theta \cdot f_{21}} - \frac{N}{f_{21}} = \frac{P_1 f_{12}\theta}{f_{22}} + \frac{\theta N}{f_{22}}$$

$$P_1 \left[\frac{f_{11}}{\theta \cdot f_{21}} - \frac{f_{21}\theta}{f_{22}} \right] = \frac{N}{f_{21}} + \frac{\theta N}{f_{22}}$$

$$P_1^* = \frac{\frac{N}{g_{21}} + \frac{\theta N}{g_{22}}}{\left[\frac{g_{11}}{\theta g_{21}} - \frac{g_{21}\theta}{g_{22}}\right]}$$

can solve for P_2

$$P_2^* = \frac{\frac{N}{g_{12}} + \frac{\theta N}{g_{11}}}{\left[\frac{g_{22}}{\theta g_{12}} - \frac{g_{12}\theta}{g_{11}}\right]}$$

next class will be: on Tuesday the Feb 14.

↳ generalize to N ind. links