EE 597
WIRELESS NETWORKS

- Phy Layer (~ 1/4 of the course)
  for more detailed coverage: EE 535
  (mobile comm.)

  - Radio propagation models
  - Digital modulation:
    tradeoffs between Rate, Power, & Error

  - Aspects of fading:
    - fast / slow
    - flat / freq. selective fading
  - CDMA & OFDM (TDMA)
  - MIMO & Diversity schemes
  - Coding

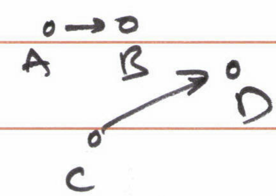
- Medium Access & Resource Allocation (40%)

- Randomized Access:
  - Aloha / Slotted Aloha
  - CSMA (IEEE 802.11x)

Throughput/Capacity Region & Saturation Throughput Analysis

(will make heavy use of EE 465 material here)

Power control over independent links



Power control over parallel channels - Waterfilling.

Channelized Access (TDMA/FDMA) in multihop settings & for cellular: Graph Coloring Applied

Multihop Wireless Networking.

25%

- Routing Protocols:
  AODV, OLSR, Backpressure Routing, Spray & Wait, etc.

- Routing Metrics for Wireless
  "ETX"

- Networked MIMO / Cooperative Routing: Anypath route computation

- NS-2 simulations of routing protocols

Transport Layer Congestion Control in Wireless Networks (10%)

- problems with traditional TCP in wireless
- Explicit Congestion Notification
- Problem of fair-rate allocation

WCP - a fix for this.

- Cross Layer Protocol Design using Backpressure Scheduling

- Assignments & Projects
  ~ 3 ~ 2 — 40%.

  can be done in <u>pairs</u>

- mid-term exam — 30%.
  (late Feb | early March)

- Final exam — 30%
  (during univ. appointed date & time)
  (NOT CUMULATIVE)

No "curve" for the final grade

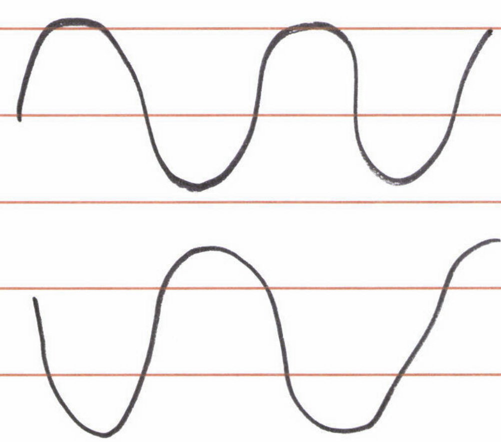
90 +	:	A	
80 - 90	:	B	− 88, + 86
70 - 80	:	C	− 78, + 76

Modulation

Additive White Gaussian
Noise Channel

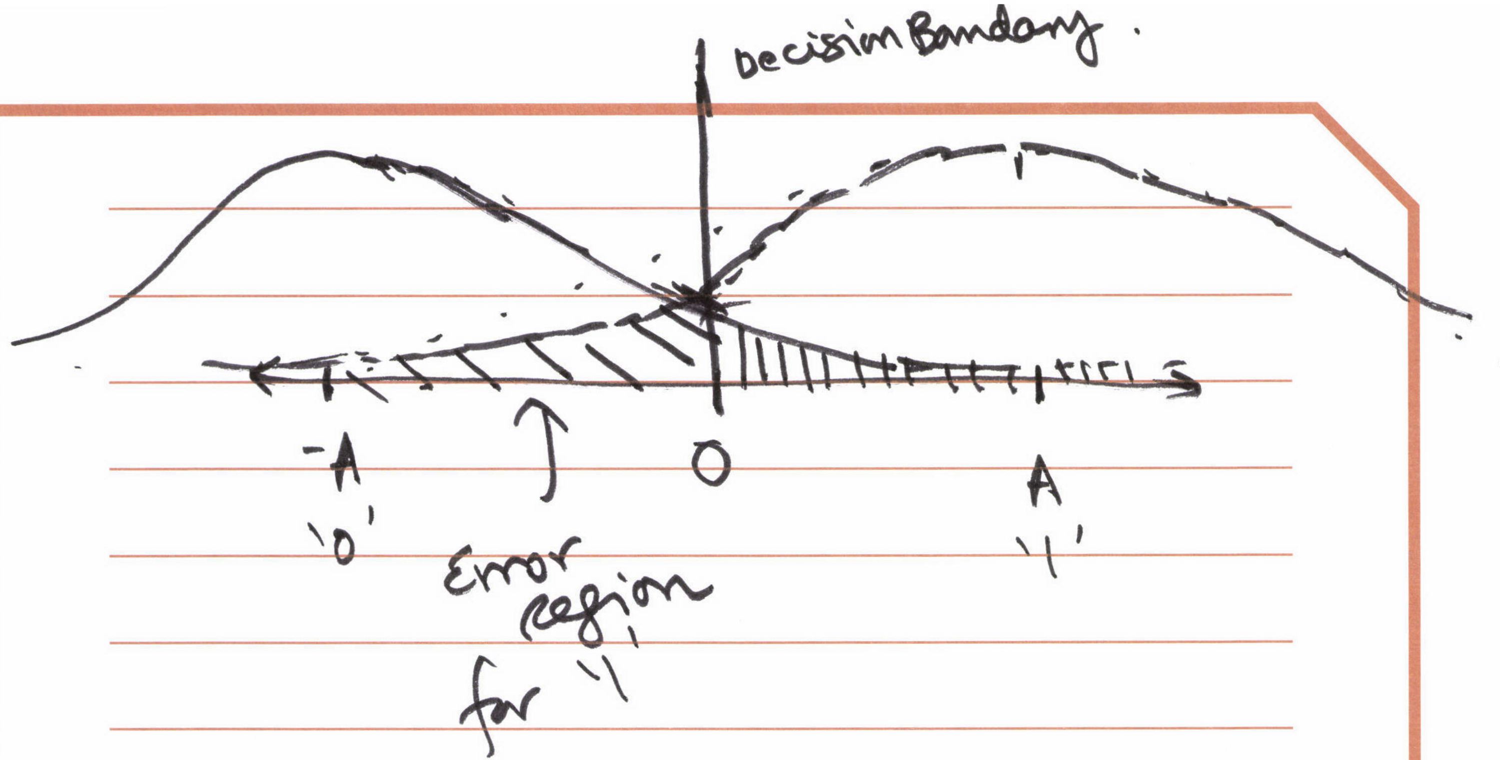
noise $\sim \mathcal{N}(0, \sigma^2)$

Binary Phase Shift Keying
Amplitude Shift Keying.



'1'

'0'



Prob. of Error : tail of the Gaussian distribution for the noise.

<u>Noise variance</u> : $N_0/2$

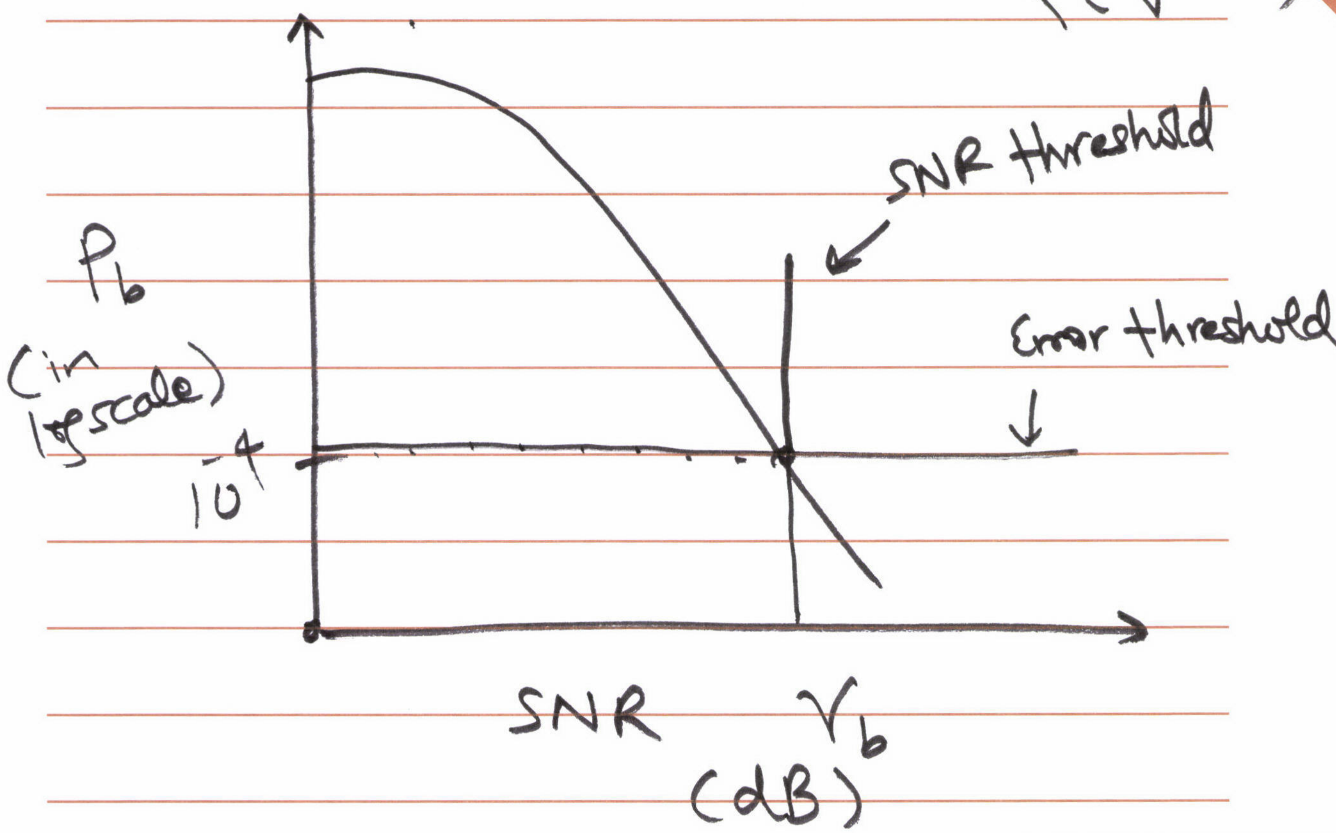
$$Q(z) \triangleq P(X > z)$$
for $X \sim \mathcal{N}(0,1)$

Prob of error for BPSK $= Q\left(\frac{A}{\sqrt{N_0/2}}\right)$

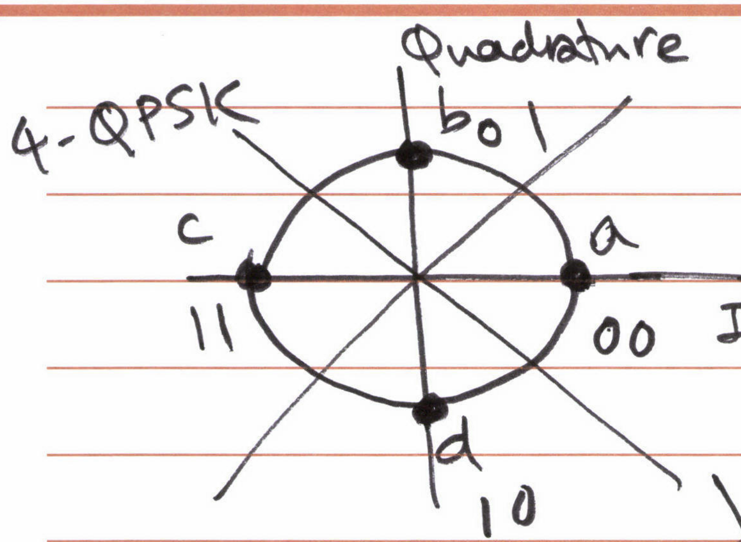
$$Q\left(\sqrt{\frac{2E_b}{N_0}}\right) = Q(\sqrt{2\gamma_b})$$

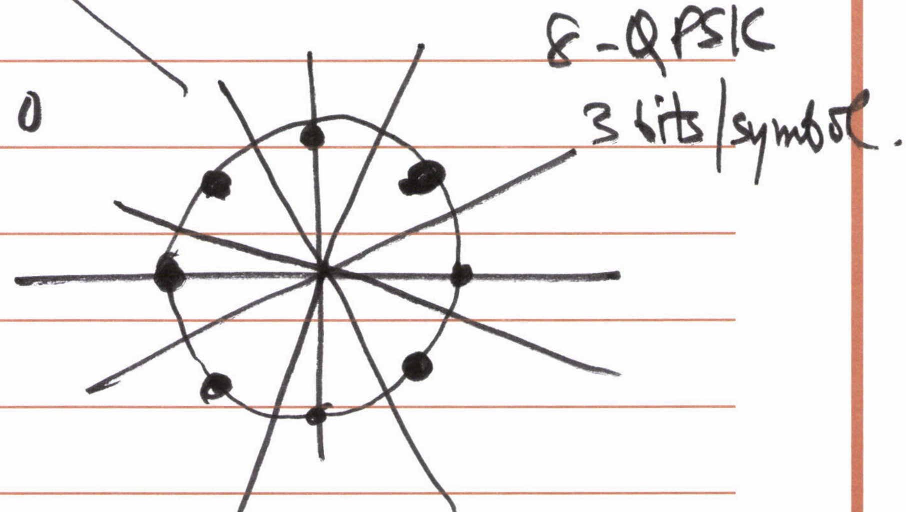
γ_b: SNR per bit.

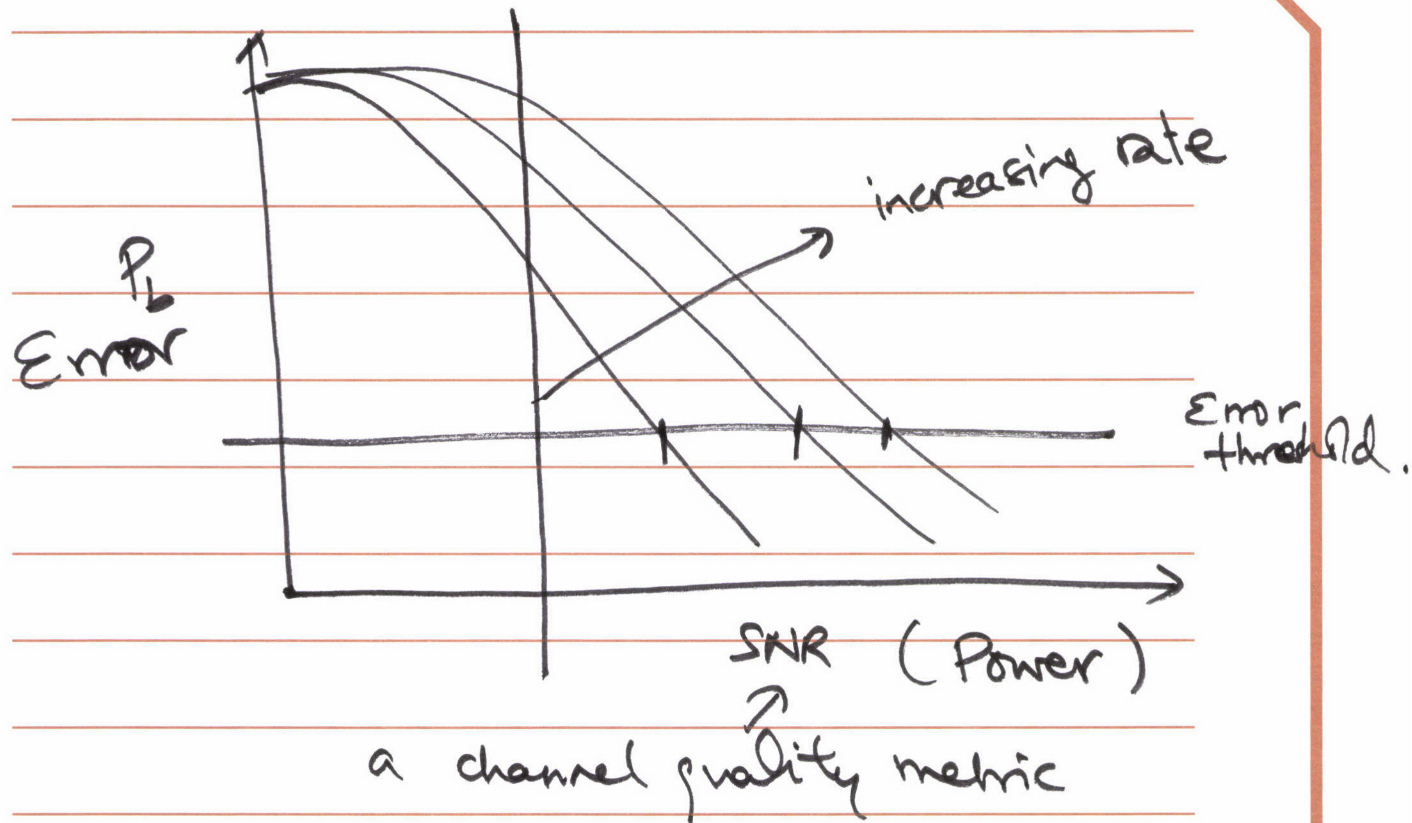
$Q(\sqrt{2\gamma_b})$



Constellation Diagram.

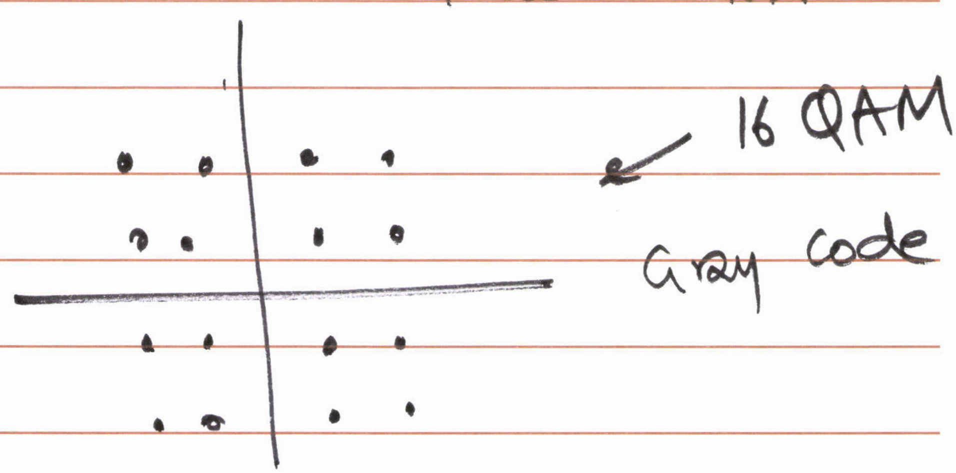




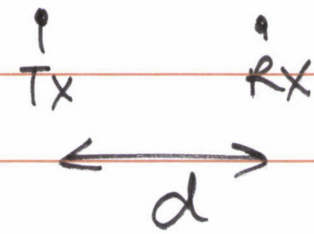


Rate - Power - Error Tradeoff.

QAM : Quadrature Amplitude Modulation



Radio Propagation.



As we vary d, what happens to the received power?

an omnidirectional antenna in ideal vacuum

~~received power ∝ ideal~~

$$\text{Received Power} \propto \frac{\text{Total Transmitted Power}}{\text{Surface Area at distance } d}.$$

$$P_r \propto c \cdot P_T \cdot d^{-2}$$

$$P_r \underset{\approx}{\propto} c\, P_t \cdot d^{-\underline{\underline{\eta}}}$$

η ← path loss exponent.

Simplified Path loss model

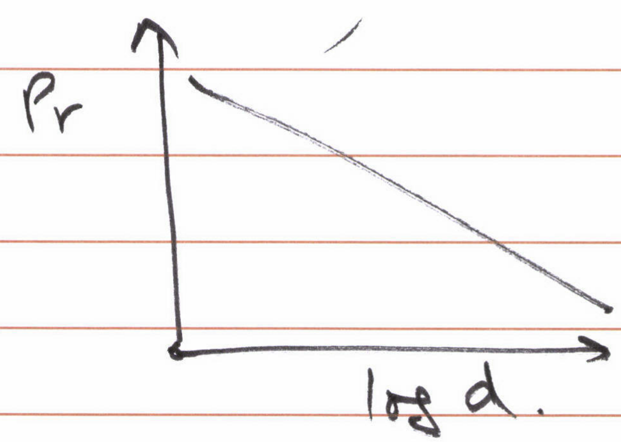
$$P_r = P_t K \left[\frac{d_0}{d}\right]^{\eta}$$

d_0 is a reference distance, such that, when $d = d_0$

$P_r = K \cdot P_t$.

in dB:

$$P_{r_{dBm}} = P_{t_{dBm}} + K_{dB} - \eta \, 10 \log_{10}\left[\frac{d}{d_0}\right]$$



Power is measured in Watts

1 mW in dB notation is called 0 dBm.

i.e: $10 \log_{10} 1\,mW = 0\,dBm.$

$P_r = 0.5 \times 100\,mW = 50\,mW$

unitless.

$$Pr_{dBm} = P_{t\,dBm} + K_{dB}$$

$$a_{dBm} + \bcancel{b_{dBm}} = c_{dBm}$$

$$(x\,mw)(y\,mW) = mW^2$$

$$x_{dB} = 10 \cdot \log_{10} x$$

$$x = 10^{\frac{x_{dB}}{10}}$$

SNR ⟷ dB.

Power ⟷ dBm

multiplicative constants ⟷ dB.

η ranges from 1 to 7

Indoor building : 1.6 – 3.5

Outdoor Urban : 3.7 to 6.5