EEC 687/787 Mobile Computing (Spring, 2008)

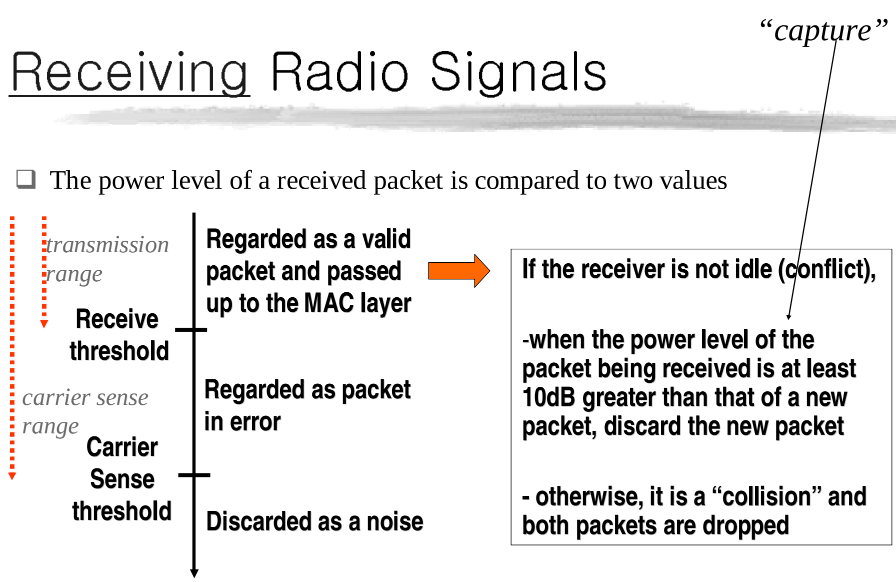
Ns-2 Laboratory #4

Chansu Yu

Cleveland State University

Receiving Radio Signals

- The power level of a received packet is compared to two values



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c.yu91@csuohio.edu

18.1 Free space model

The free space propagation model assumes the ideal propagation condition that there is only one clear line-of-sight path between the transmitter and receiver. H. T. Friis presented the following equation to calculate the received signal power in free space at distance d from the transmitter [12].

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L} \quad (18.1)$$

where P_t is the transmitted signal power. G_t and G_r are the antenna gains of the transmitter and the receiver respectively. $L(L \geq 1)$ is the system loss, and λ is the wavelength. It is common to select $G_t = G_r = 1$ and $L = 1$ in *ns* simulations.

18.2 Two-ray ground reflection model

A single line-of-sight path between two mobile nodes is seldom the only means of propation. The two-ray ground reflection model considers both the direct path and a ground reflection path. It is shown [29] that this model gives more accurate prediction at a long distance than the free space model. The received power at distance d is predicted by

$$P_r(d) = \frac{P_t G_t G_r {h_t}^2 {h_r}^2}{d^4 L} \quad (18.2)$$

where h_t and h_r are the heights of the transmit and receive antennas respectively. Note that the original equation in [29] assumes $L = 1$. To be consistent with the free space model, L is added here.

c.yu91@csuohio.edu

Configuration for PHY Layer

- Radio Propagation Model

Propagation/Shadowing	set	pathlossExp_	2.0
Propagation/Shadowing	set	std_db_	4.0
Propagation/Shadowing	set	dist0_	1.0
Propagation/Shadowing	set	seed_	0
Antenna/OmniAntenna	set	X_	0
Antenna/OmniAntenna	set	Y_	0
Antenna/OmniAntenna	set	Z_	1.5
Antenna/OmniAntenna	set	Gt_	1.0
Antenna/OmniAntenna	set	Gr_	1.0

- Where are they defined?

c.yu91@csuohio.edu

Configuration for PHY Layer

```
Phy/WirelessPhy   set   CPThresh_    10.0
Phy/WirelessPhy   set   CSThresh_    1.559e-11
Phy/WirelessPhy   set   RXThresh_    3.652e-10
Phy/WirelessPhy   set   bandwidth_   2e6
Phy/WirelessPhy   set   Pt_          0.28183815
Phy/WirelessPhy   set   freq_        914e+6
Phy/WirelessPhy   set   L_           1.0
```

- Where are they defined?
- Can you calculate
  - Carrier sense range?
  - Transmission range?

c.yu91@csuohio.edu

Specifying and Parameterizing the Propagation Model

- Three different radio propagation models.
  - Free space and two-way ground reflection models in fact comprise one model
  - Shadowing model is another
  - Shadowing model can be parameterized (beta and stdev values) => **must be defined before node configuration!!!**

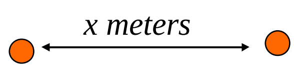
Check "tcl/lib/ns-default.tcl"

```
# first set values of shadowing model
Propagation/Shadowing set pathlossExp_ 2.0   ;# path loss exponent
Propagation/Shadowing set std_db_ 4.0        ;# shadowing deviation (dB)
Propagation/Shadowing set dist0_ 1.0         ;# reference distance (m)
Propagation/Shadowing set seed_ 0            ;# seed for RNG
```


c.yu91@csuohio.edu

Lab Exercise #4 (in class)

- Download prop.tcl
  - This script takes one command-line argument: the distance between two nodes.
  - ns prop.tcl -dist {x}

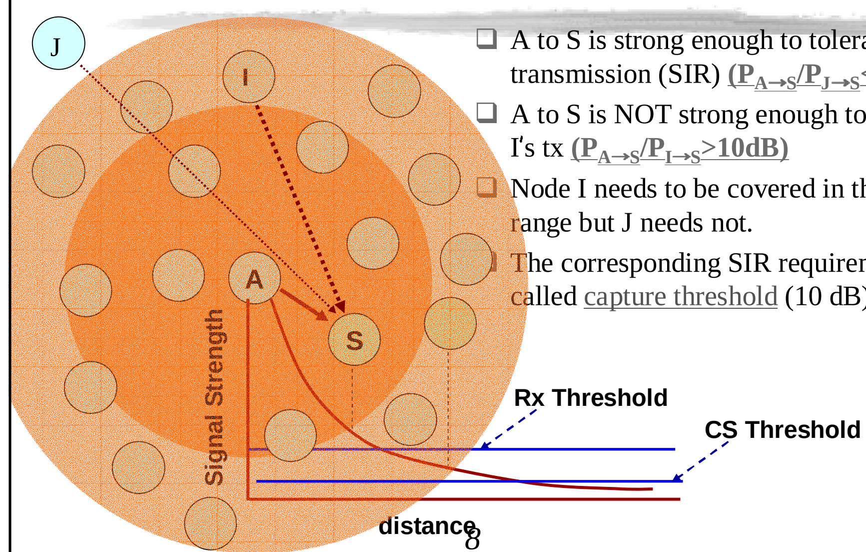


- Run the simulation for FreeSpace, TwoRayGround, and Shadowing (with different deviation values: 2, 4, and 8dB)
  - Vary x= 75m, 100m, 125m, 150m, 200m, 250m
  - Use linux commands (grep) to get pdr

c.yu91@csuohio.edu

Determining Carrier Sense Threshold

- A to S is strong enough to tolerate J's transmission (SIR) **($P_{A\to S}/P_{J\to S}<10dB$)**
- A to S is NOT strong enough to tolerate I's tx **($P_{A\to S}/P_{I\to S}>10dB$)**
- Node I needs to be covered in the CS range but J needs not.
- The corresponding SIR requirement is called capture threshold (10 dB)

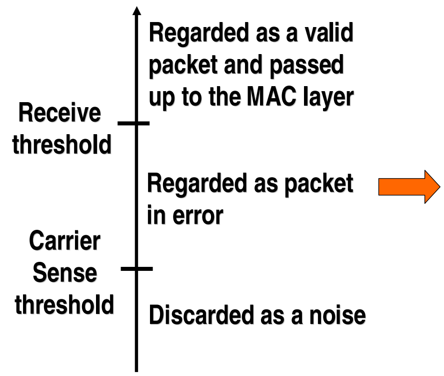


c.yu91@csuohio.edu

Receiving Radio Signals

"signal capturing"

- The power level of a received packet is compared to two values



If the receiver receives one signal while receiving another (conflict),

- P(old)/P(new)>10dB, can still receive the old one (new packet is dropped)

- Otherwise, it is a "collision" and both packets are dropped

c.yu91@csuohio.edu

Signal Capturing in ns-2

- mac/wireless-phy.cc

```
int WirelessPhy::sendUp(Packet *p) {
…
if (Pr < CSThresh_) pkt_recvd = 0;
if (Pr < RXThresh_) pkt_recvd = 1; hdr->error() = 1;
else pkt_recvd = 1; hdr->error() = 0;
```

- mac/mac-802_11.cc

```
void Mac802_11::recv(Packet *p, Handler *h) {
…
if (rx_state_ == MAC_IDLE) {
...
} else {
      if(pktRx_->txinfo_.RxPr / p->txinfo_.RxPr >= p->txinfo_.CPThresh) capture(p);
      else collision(p);
}
```

If medium idle, receive it

If medium is not idle, receive it if SINR>CPThresh. Collision, otherwise

c.yu91@csuohio.edu

Quiz: Packet capturing

- ❑ Investigate the effect of capture ratio.

  Phy/WirelessPhy set CPThresh_ 10.0

- ❑ What happens if
  - ➢ CPThresh_ = 1000.0: packet is successful when SIR>1000
  - ➢ CPThresh_ = 1.0001: packet is successful when SIR>1.0001

c.yu91@csuohio.edu

Multirate Control

- ❑ Multirate support
  - ➢ 802.11 supports 1 and 2 Mbps
  - ➢ 802.11b supports 1, 2, 5.5 and 11 Mbps
  - ➢ 802.11a supports 6, 9, 12, 18, 24, 36, 48 and 54 Mbps
- ❑ Advantages of high-rate communication
  - ➢ Faster delivery (less delay)
  - ➢ More throughput
  - ➢ Less energy
  - ➢ Issues ???

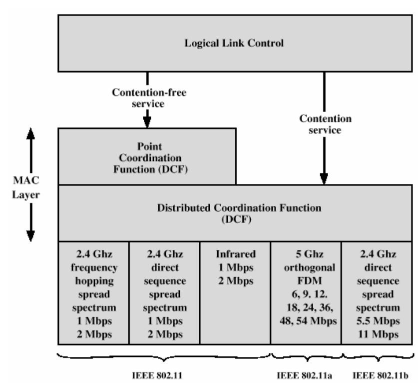


Figure 14.5 IEEE 802.11 Protocol Architecture

c.yu91@csuohio.edu

Multirate Control

- Signal-to-Interference Noise Ratio (SINR) required for successful reception at the receiver depends on the transmission rate being used.
- The ideal capacity of a channel with bandwidth B is given by Shannon's Equation: W=Blog(1+SINR), yielding SINR(reqd) >= (2^(W/B)-1).
- Recall that carrier-sense range (CSRange) is the distance from the transmitter upto which nodes assess the channel as busy, and thus CSThresh and CSRange possess an inverse relationship with each other.

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c.yu91@csuohio.edu

Multirate Control

- A small CSThresh implies that even nodes quite far away from a transmitting node shall detect the channel as busy, and defer.
- A larger CSRange implies more space is "reserved" by a transmission as a "guard zone" to avoid interference/collisions.

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c.yu91@csuohio.edu

Multirate Control

Data rate (Mbps)	Receive threshold (dBm)	Communication distance (m)	Capture threshold (dB)	Capture distance (m)	***Carrier sense distance (m)***
6	-82	238	6.02	337	***575***
9	-81	224	7.78	351	***576***
12	-79	200	9.03	336	***536***
18	-77	178	10.79	331	***509***
24	-74	150	17.04	400	***550***
36	-70	119	18.80	351	***470***
48	-66	95	24.05	389	***484***
54	-65	89	24.56	366	***455***

** Transmit power: 6 dBm*

** For a successful communication, when a node transmits a packet, other nodes should not send theirs. This can lead to capture distance.*

** CSThresh = -91 dBm*

c.yu91@csuohio.edu

Lab Exercise #4 (Lab report)

- This exercise is aimed at exploring how rate control and adaptation of carrier sense threshold can affect spatial reuse (and hence aggregate throughput) in a multi-hop network.
- Download rate.tcl
  - A simulation topology of 100 nodes arranged in a 10x10 grid with a grid-spacing of 150m.
  - 25 CBR conversations between randomly chosen source-destination pairs are set up.
- The script takes as arguments the TX-Rate (in bps), the RxThresh (in Watts), CPThresh (ratio; no units), and the CSThresh (-91 dBm). (see the table)
  - Usage: ns multi-hop.tcl -rate {rate (Mbps)} -rxthresh {rcv_threshold} -cpthresh {capture-threshold} -csthresh {carrier-sense threshold (W)}

c.yu91@csuohio.edu

Lab Exercise #4 (Lab report)

- Run the simulations for all combinations of TX-rate and RXThresh. Obtain the aggregate CBR throughput for each run.
- Draw a chart drawing throughput versus TX-rate for each value of RXThresh

- Discussion: What trends may be observed? For this simulation topology, what combination seems to yield the best performance?

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c.yu91@csuohio.edu