

# **CMPE 150: Introduction to Computer Networks**

**Dr. Chane L. Fullmer**  
**chane@cse.ucsc.edu**

# Class Information

- Class web site:  
[www.soe.ucsc.edu/classes/cmpe150/Spring03/](http://www.soe.ucsc.edu/classes/cmpe150/Spring03/)
- Class Newsgroup
  - ucsc.class.cmpe150
- TA Section
  - Mondays @ 5:00PM – Thursdays @10:00AM
    - Baskin ***White Boards*** area

# (Optional) Class Project

- Network programming project
  - In lieu of taking final examination
- Goal:
  - Build an FTP client/server from scratch
  - Using 'C' language
- Details on web page.. now...
  - Due by June 4<sup>th</sup>...

# Homework Assignments

Homework assignment #2

Due by May 1.....

# Homework Assignments

Late Homework Rules:

-10% reduction first day

-5% each additional day

**Not accepted after one week**

Solutions handed out at one week

# **CMPE 150: Introduction to Computer Networks**

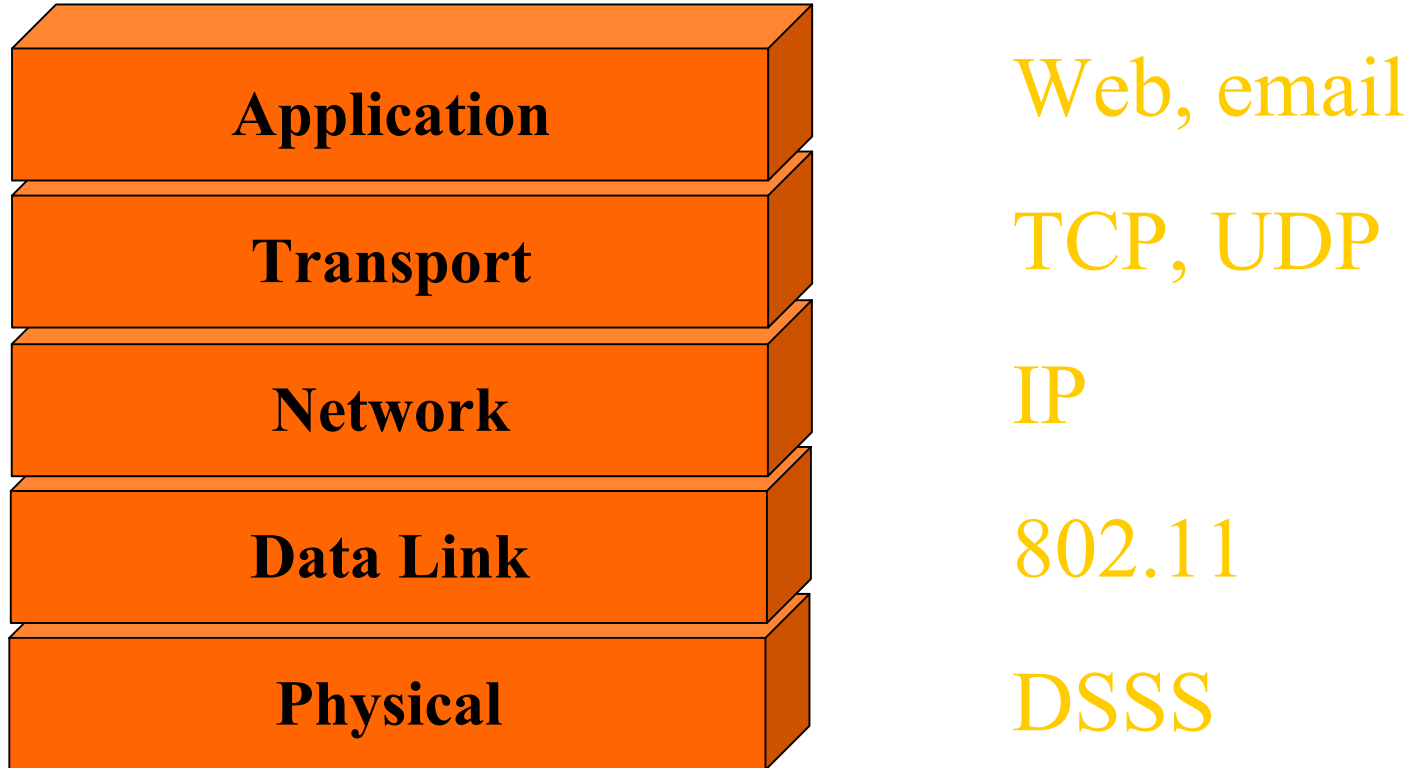
## **LECTURE 6:**

### ***MAC, Part IV***

### ***Issues in Wireless Networks***

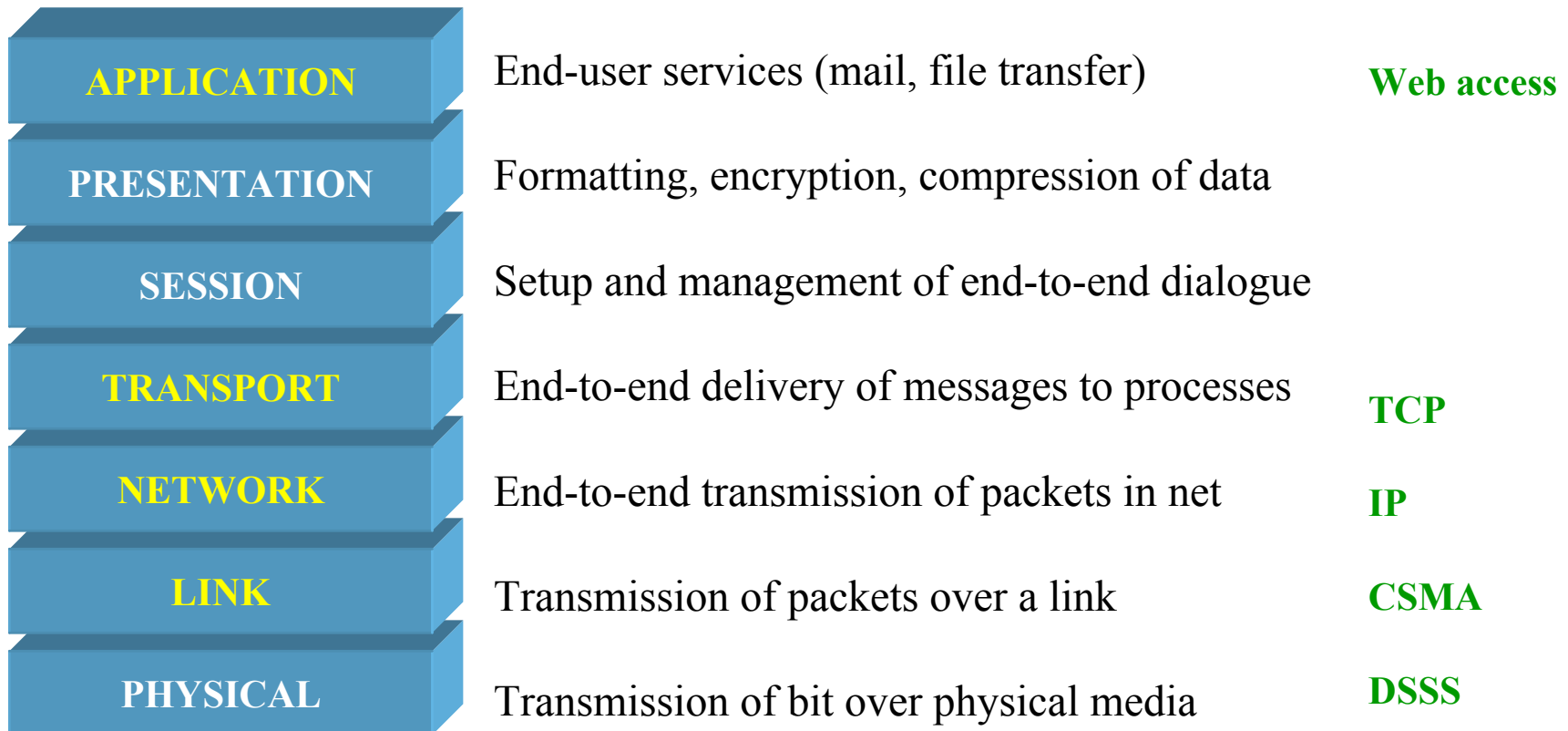
# The Protocol Stack

- Berkeley (Internet) Stack



# (OSI) Stack

- Proposed by the International Standards Organization
- Specifies the functions at each layer, not the protocols that implement them



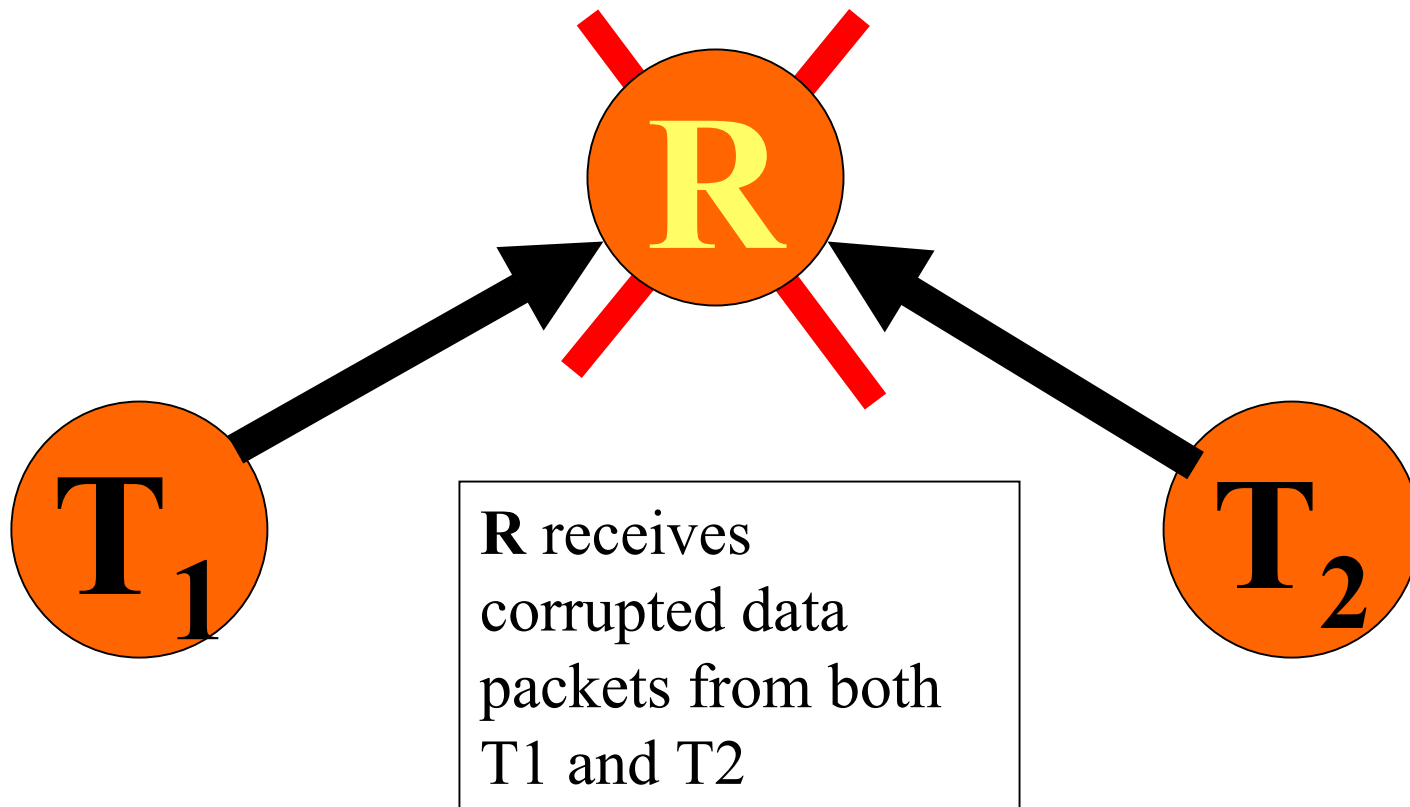
# Physical Layer Constraints

- Line of Sight
  - Fresnel Zone clearance...
- Multipath reception
  - Reflection from objects
- Interference Prone
  - Co-channel interference
  - Self interference
- Near-Far problem

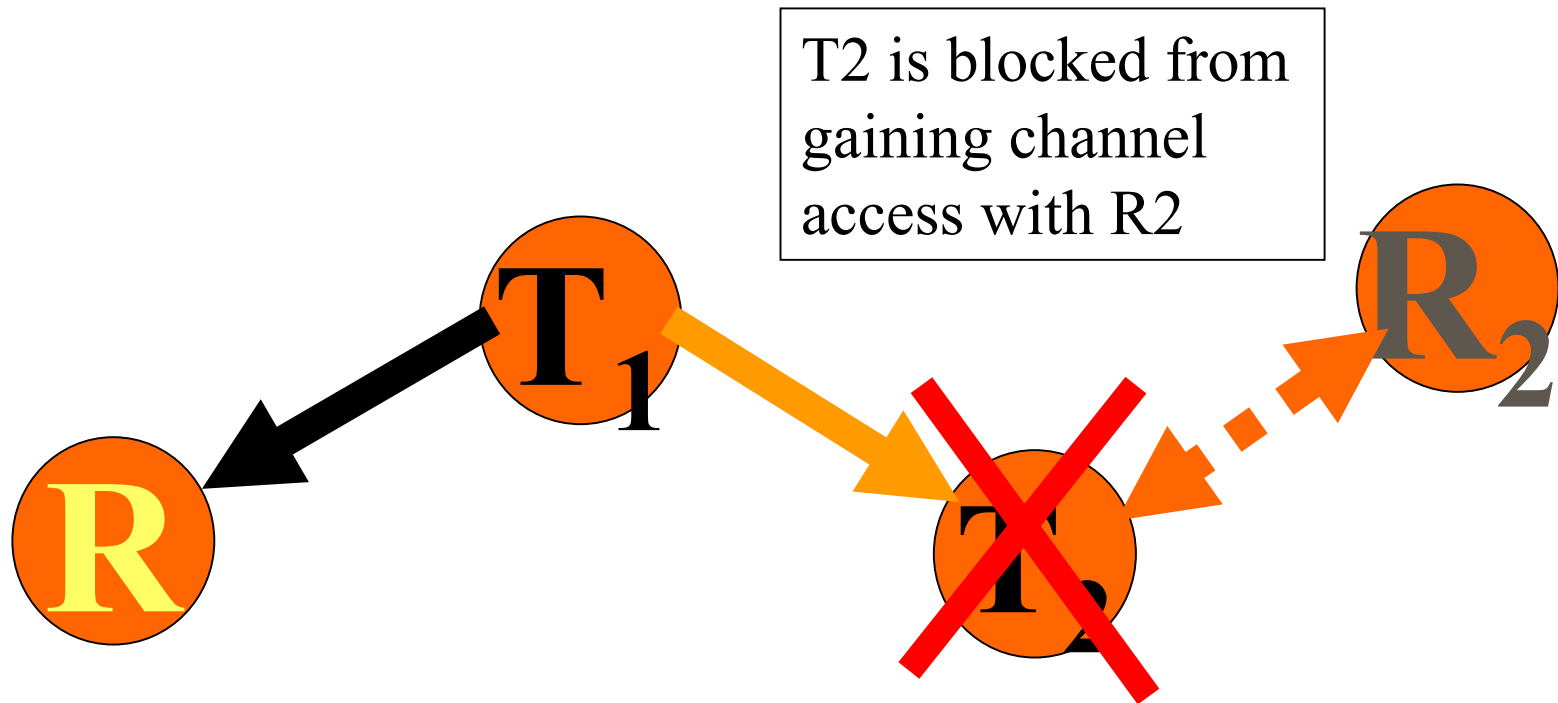
# MAC Issues

- Hidden/Exposed Terminals
  - Hidden Terminal (transmitter)
  - Hidden Receiver
  - Exposed Transmitter
  - Exposed Receiver
- Unidirectional links
- Marginal links

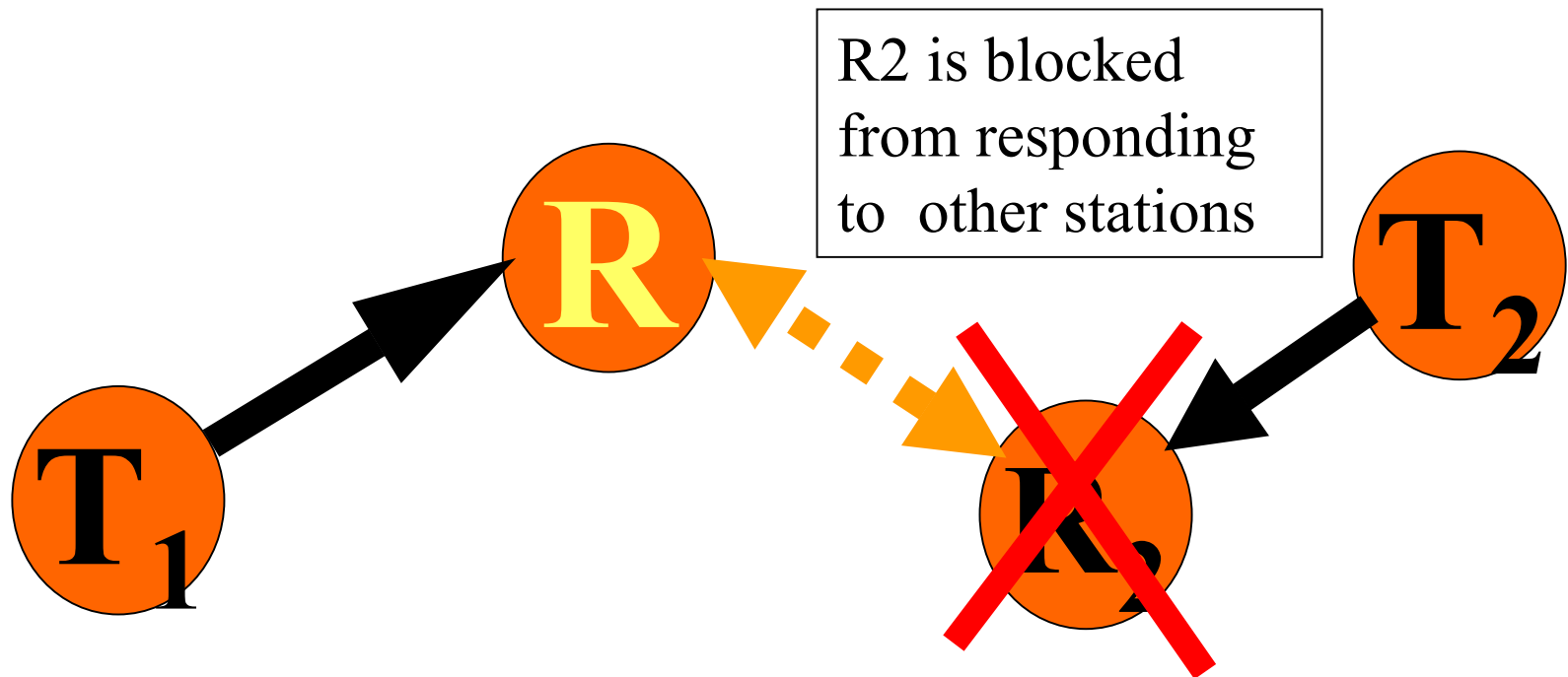
# Hidden Terminal Problem



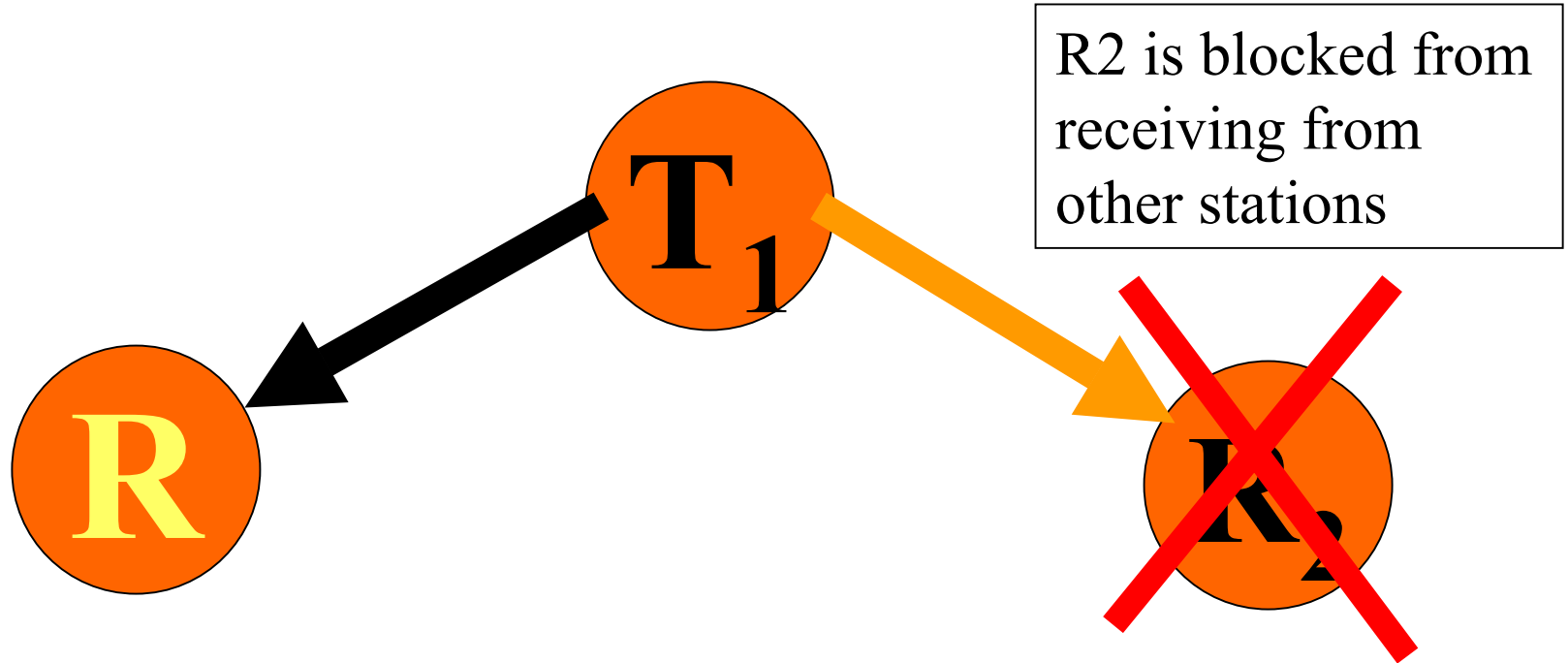
# Exposed Transmitter Problem



# Hidden Receiver Problem



# Exposed Receiver Problem



# Routing Issues

- Mobility
  - Causes topology changes...
- Address space
  - Flat address space
  - Opaque subnet...
- IP Forwarding out the same interface..
  - Multicast..

# Transport Layer Issues

- High loss rate
  - TCP reacts poorly
- High delay variance
  - TCP reacts poorly

# Early Work

- The DARPA Packet Radio Network
  - ▣ Initiated in 1973
  - ▣ 1987 – 50 node network, some mobility
- Barry M. Leiner, Donald Nielson and Foud Tobagi, “Issues in Packet Radio Network Design”, *Proceedings of the IEEE*, Special Issue on Packet Radio Networks, Vol. 75, No. 1, January 1987.

# Issues in Packet Radio Network Design

- Methods for efficient sharing of the radio channel
- Methods for determining connectivity and routing data through the network
- Methods for reliable communication
- Methods for controlling the network

# Issues in Packet Radio Networks

- Three areas to consider for design decisions
  - Physical aspects of the network
    - Connectivity, channel sharing
  - Management of the network
    - Routing, link management
  - Network operation

# Physical Connectivity

- Link connectivity
  - The ability to correctly receive the information
    - Propagation characteristics
      - Radio Frequency
      - Distance
      - Terrain
      - Xmit power

# Physical Connectivity

- Given:
  - Terrain, user locations, user requirements (traffic, mobility, etc..)
- Select:
  - Radio frequency and bandwidth
  - Signaling, encoding, modulation schemes
  - Network topology

# Frequency & Bandwidth

- Frequency choices
  - Low frequencies propagate longer distances
    - Lower data rates
    - Increased self interference
  - High frequencies (Above 1GHz)
    - Propagation is short and line-of-sight (LOS)
      - May require *repeater nodes* for connectivity
    - Higher data rates

# Bandwidth Time/Space Management

- Choices for bandwidth time/space
  - FDMA (Frequency Division Multiple Access)
  - TDMA (Time Division Multiple Access)
  - CDMA (Code Division Multiple Access)
  - Random access protocols
  - Spatial Reuse

# Channel Access

- Narrow Band
  - FDMA, TDMA
    - Inefficient with bursty traffic..
  - Random access protocols
    - ALOHA (no sensing – packet sensing)
    - CSMA (activity/carrier sensing)

# Wideband Channel Access

- Wideband (spread spectrum) modulation
  - CDMA
    - Uses a preamble
    - Uses orthogonal spreading codes
      - Allows concurrent transmission
    - Time-capture
      - Allows time overlap on same codes
  - Frequency Hopping Spread Spectrum (FHSS)
  - Code assignment...
    - Fixed, Receiver/transmitter oriented; Bit-by-bit code changing
  - Protocols
    - ALOHA, CSMA....

# Data Link Control

- Goal is to provide reliable communication
  - Acknowledgements – ARQ
    - Suffers in high bit-error channel
  - FEC (forward error correction)
    - Significantly increases packet size (lowers throughput)
  - Balance must be achieved between FEC and ACK mechanism
  - ACKS
    - Explicit – short packet, or header based
    - Echo – listen for rebroadcast

# Network Management

- Link determination and control
- Routing and packet forwarding
- Monitoring status, etc..

# Link Determination and Control

- ***How should two packet radio units determine the existence of a link between them and pass that information to the network management algorithms?***
  - Determining connectivity
    - SNR, BER, Packet error rate
- ***When does a set of links constitute an acceptable network?***
  - Network partitions, disjoint clusters...

# Routing & Pkt Forwarding

- Goal: *To get packets from source to destination efficiently.*
- *How should routes be established based on the link connectivity?*
- *What type of routing algorithm should be used?*
- *How should the routing information be disseminated?*

# Routing & Forwarding

- Forwarding mechanisms
  - Flooding
    - Every node gets every packet, at least once
  - Point-to-point
    - Virtual circuit (Tag info in header)
    - Connectionless (traditional IP forwarding)
  - Mobility creates problems
    - Link control, routing updates,...

# Routing

- How should routing information be disseminated..
  - Central routing server
    - Latency is an issue
  - Distributed algorithms
    - Local connectivity flooded to all nodes (Link State)
    - Local info sent to neighbors only (Distance Vector)

# Forwarding

- ***What information should be passed from node to node in the process..***
  - ▣ Src, dst, sequence id, chksum...
- ***What strategies should be used to correct for rapid local changes in topology..***
  - ▣ Attempt to reroute – ask neighbors for info
  - ▣ Drop and inform source..

# Other Network Management

- Congestion and flow control
  - *How can traffic be limited at entry to the network so that congestion is controlled?*
    - Virtual circuits
    - Connectionless approaches are limited..
      - Delay characteristics...needs more research..
  - *How can the association of a user device be maintained throughout the network?*
    - Mobile IP...??

# Network Operation

- Network deployment and maintenance
- Connecting the PRN to external networks
- Impact on the RF spectrum

# Deployment & Maintenance

- Where to put nodes & repeaters
- How much automation to use
- Whom and how should parameters be allowed to be set and changed
- How should upgrades be disseminated
- How much redundancy
- How to detect operational failures...

# Connecting to external networks

- PRN Gateways
  - Network access administration
  - Addressing and naming conventions
  - Security issues

# RF Spectrum Impact

- Electromagnetic Compatibility
  - *How should a given system be accommodated within the existing spectrum?*
    - Narrow band vs. wideband bandwidth impact to other RF devices/networks
- Counter counter-measures & noise immunity
- Efficiency
  - User densities – how many can be handled
  - What resources should be allocated to network overhead

# Network Performance Evaluation

## ■ Metrics for evaluation

### □ User perspective

Availability	Delay	Priority	Throughput
Coverage	Mobility		Accuracy

### □ Operator perspective

#### □ User concerns, plus...

- costs, fault tolerance, efficiency...

#### □ Cost of creation vs cost of operation

# Next Week

- Logical Link Control