Physical Layer

radios, coaxial cable, optical fibers

bits "on the wire"

spread spectrum	reduces narrowband interference by spreading a signal's frequency to create a wider bandwidth
DSSS	direct sequence spread spectrum
FHSS	frequency hopping spread spectrum

DSSS and FHSS require time synchronization between sender and receiver.

Maximum (Data) Bandwidth

Shannon Channel Capacity

> data rate = $W\log_2(1 + S/N)$

(theoretical) maximum number of bits that can be transmitted per second by a physical channel

data rate = **bps**
W = frequency range = bandwidth = **Hz**
S/N = signal noise ratio = **no unit**

Variables

Signal	sending signal
Noise	thermal noise, background radiation (aka AWGN - additive white gaussian noise)
Interf-erence	signals from other transmitting sources
SINR or SNR	S/(N + I)

Path Loss Formulas

free space model

> --

two-ray ground reflection model

> --

Effects on Signal Propagation

path loss, shadowing, reflection, refraction, scattering, diffraction, fading

Multiplexing

space, time, frequency, code
TODO: pros/cons of each

Modulation

AM, FM, PM
amplitude modulation, frequency modulation, phase modulation
TODO:
pros/cons of each

Link Layer

WiFi, Ethernet

data transfer btwn neighboring network elements

IEEE 802.11 DCF CSMA/CA

CSMA/CA	carrier sensing medium access / collision avoidance
DCF	distributed coordi-nation function - appropriate for multi-hop ad hoc networks
RTS/CTS	request to send, clear to send
hidden terminal problem	A and C want to send to B but A and C cannot see each other. both send to B and msg collides. solved by RTS/CTS

Security

TODO WEP insecure as heck

Network Layer

IP, routing protocols

routing of datagrams from src to dest

knows addresses, routes from src to dest, elems = hosts and routers

LS	link state
DV	distance vector
types of networks	MANET (mobile ad hoc network), mesh network, sensor network, DTN (delay tolerant network)

Mobile IP

TO mobile system

> CN -> HA -> FA -> MN

FROM mobile node

> MN -> FA -> CN

CN = correspondent node (aka FN = fixed node??)
HA = home agent
FA = foreign agent
MN = mobile node

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DTN

ALGORITHM	WHO	WHEN
flood	all nodes	new contact
direct	src only	dest
simple replic-ation (r)	src only	new contact
history (r)	all nodes	new contact
erasure coding (ec-r)	src only	new contact

TODO: review history and erasure coding

Sensor Network

TOGPSR WHOM	greedy perimeter stateless routing
BVR	beacon vector routing

TODO: study implementation and write in chart in word or something

Mesh Networks

ETX	expected transmission count

= 1/(d_f * d_r) ... where d_f = fwd delivery rate, d_r = rev delivery rate

ETT	estimated transmission time TODO: this is some combo of SETT and something right???

MANET

DSR	destination source routing
AODV	ad hoc on-demand distance vector
DSDV	destination-sequenced distance vector

DSR can be used for wireless mesh networks

Transport Layer

TCP, UDP

host-host data transfer

UDP	user datagram protocol
TCP (wired)	transmission control protocol

Mobile TCP

TCP - not pipelined

Stop and wait

TCP - pipelined

GBN	go-back-N

selective repeat

Questions

Why can't we just use NACK?

Formulas

Transmission

$$T = L/R$$

Utilization - fraction of time sender is busy sending

$$U = (L/R) / (RTT + L/R)$$

Speed of light (to convert distance to propagation delay)

3E8 m/s

Don't forget to use proper units (convert)

T = transmission time in **seconds**

L = pack length in **bits**

R = transmission rate in **bps**

U = utilization **no unit**

RTT = round trip time **seconds** = propagation delay * 2

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