3. Overview for final exam

2. Localization in wireless networks
   1. Low-power operation

Wireless Sensor Networks
Low power wireless personal area network
LOWPAN

IEEE 802.15.4 PHY/MAC standard
Zigbee Alliance - Industry alliance for LOWPAN's.

- Devices typically consume mW of power
- Short range: a few feet max 10's of feet
- Low power radio, processor, on-board sensor

Low rate: 250 kbps for 15.4 radio
If a device is kept on all the time — will use up 2 AA batteries in about 4 days.

Leaving the processor & radio on even in idle mode uses about the same energy.

Radio is the primary source of energy usage.

Solution for a long lifetime system must be to put nodes to sleep when they are not needed (to sense, compute or communicate). Sleep/wake-up process must be automated.
Synchronous Sleep: Periodic sleep wake cycles on all nodes.

Challenge: maintaining synchronization.

Clock errors typically on the order of 40 ppm.

86,400 seconds per day.

~ 100,000 s

50 µs/s. ~ 5 s/day.

Needs to have a time sync protocol to do better.

Typically 20 plets/node every 2 hours is needed for synchronization.
Asynchronous sleep

Receiver-initiated
Transmitted-initiated.

The receiver adopts a sleep-wake cycle.

The transmitter, when it has a packet to send, transmits a beacon signal (or series of small probe packets) to catch the receiver's attention.
This was the Transmitter-initiated approach.

Receiver-initiated approach.

R  sleep  W  sleep  Prise  Awake  ACK  Pkt  Ack
**Wireless Localization (Indoor)**

- GPS doesn't work indoors

**Course-grained Location**

Simplest: reverse MAC ID lookup based on database of WiFi AP addresses & locations.

**Time of Arrival (measure distances based on propagation delay, used in GPS)**

doesn't work in indoor settings because ps-scale time sync could be very costly.
Time difference of arrival.

\[ \text{RF signal} \rightarrow \text{Acoustic signal} \]

Estimate distance not based on absolute propagation delay, but the relative delay in receiving RF & acoustic signals.

Sub-meter (10cm) accuracy.
(Ultrasound can be used)

Problem: Ultrasound needs line of sight, dense deployments & too expensive for mass deployment.
RF-only localization

Database of Signal Strength

→ Fingerprinting: from all reachable early 1990's (MIT) AP's & location

→ Maximum Likelihood Estimation:
  (early 2000's) based on a RF model of the environment
  Michigan

→ Sequence-based Localization
  (mid 2000's) USC

CSS

distance

all approaches fine ≤ 2m accuracy
Every region obtained from intersecting perpendicular bisectors yields a unique permutation in order of distances to the access point.

1 2 3 4
2 1 4 3

At a \( n \) possible permutations, only \( O(n^4) \) are geometrically feasible in 2D.
UWB-based localization techniques
10cm-scale accuracy.

Scope of the final exam &cheerios.

Network Layer:

- ETX as a metric &
  shortest path routing using
  existing protocols with
  this metric
- Any path routing
- On-demand routing for MANETS:
  AODV, DSR
- Backpressure scheduling
  MaxWeight Algorithm
- BCP - Backpressure-based routing protocol
- Barage Relay (diversity for explicit transmit)
- Epidemic Routing (broadcast)
- Spray & Wait
- Deterministic routing for WMNs

Transport Layer

Congestion control
- Loss Differentiation & the use of ECN
- Congestion sharing for fairness
  - Backpressure-based MAC (as a way to address fairness)
- Explicit & precise rate allocation
- Utility optimization as a way to do rate allocation.
  - Linear & log utilities
  - Over slotted Aloha
  - Saturation throughput region

- Backpressure based rate control
  - Utility optimization over stability region
  - Provides for a tradeoff between utility & delay.

- Combines rate allocation based on local utility & local queue
  - with max-weight algorithm

- Sleep scheduling & Localization
Recommended additional reading:
Browse through papers for
(BCP, ADDV, Anypath Routing, WCP, Barrage Relay, Spray & Wait)