Wireless Mobile Ad-hoc Networks and Modeling of Wireless Channels

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Outline

- Mobile Ad Hoc network behavior
- MANET routing and power saving algorithms
- Modeling the wireless channel
  - A TIOA model and simulation output

Mobile Ad-hoc Wireless Networks

- MANET: a network without a wired infrastructure.
  - No cable, no wired hub, switch, router or access point
  - Wireless nodes may move.
- Easy to deploy
- Useful for disaster rescue, battle field communication and sensor network, etc.

Limitations of MANET

- Power: network life limited by battery life
- Short radio range
- Packet Collisions
- Network topology changes
- Address allocation

Power

- Network life limited by battery life
- Wireless transmission eats power
  - One third of a laptop's power
  - Over half of a PDA's power
- Power aware
  - forwarding
  - routing

Short Radio Range

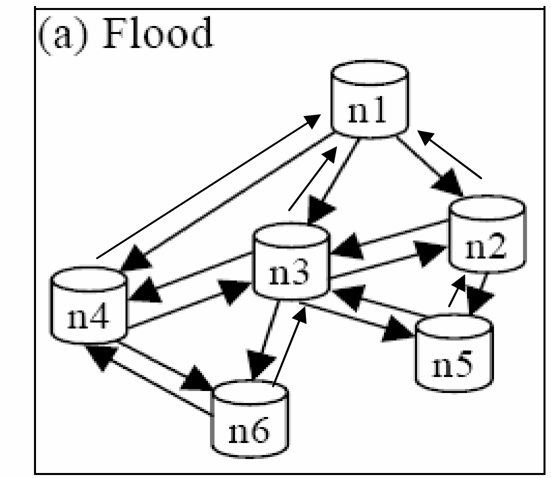
- Radio fades quickly and subjects to interference
- Trade-off between power consumption and range
  - Result: Typical Radio Range on the order of a few hundred meters
- Problems:
  - Denser network needed
  - More forwarding hops
    - More routing overhead
    - More end to end packet loss

Packet Collision

- Sending and receiving can’t happen at the same time
- No two transmissions can happen at the same time on the same channel

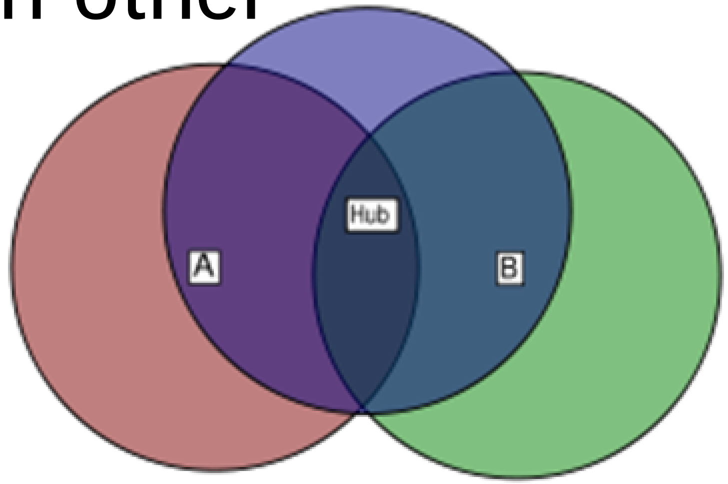
Broadcasting

- Unlike wired network, every hop is broadcasting
- Every packet can reach every node in the radio range of the sender
  - As in Ethernet
- Flooding messages m m even worse
  - Wasted bandwidth
  - High collision rate



Hidden Terminal Problem

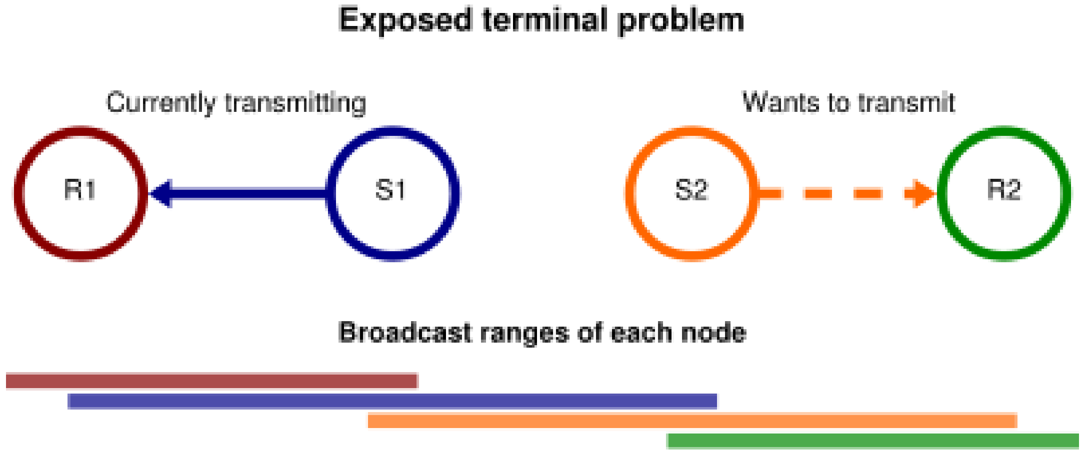
- Node A tries to send a packet to the hub, Node B tries to send at the same time
- They can't sense each other
- Collision happens
- Solution
  - RTS-CTS
    - Request to send
    - Confirm to send



Picture from Wikepedia.org

Exposed Terminal Problem

- S1 tries to send a packet to R1, S2 tries to send a packet to R2
- Suppose S1 sends first
  - By carrier sensing, S2 won't send although this transmission won't collide with S1's transmission
- Solution: an RTS without a following CTS



Picture from Wikepedia.org

Node movement

- Node may move around
- Network topology may change rapidly
  - Network converges slowly
- Dynamic address allocation needed

Address Allocation

- Difficulties
  - No central entity offering DHCP service
  - Networks may partition and merge
  - Address Duplication and Leakage
- Necessity
  - Large number of nodes may come and go

MANET Routing

- Traditional Routing doesn’t work well in MANETs
  - No subnet
  - Network topology changes quickly
  - Address allocation
- High routing overhead with low channel bandwidth

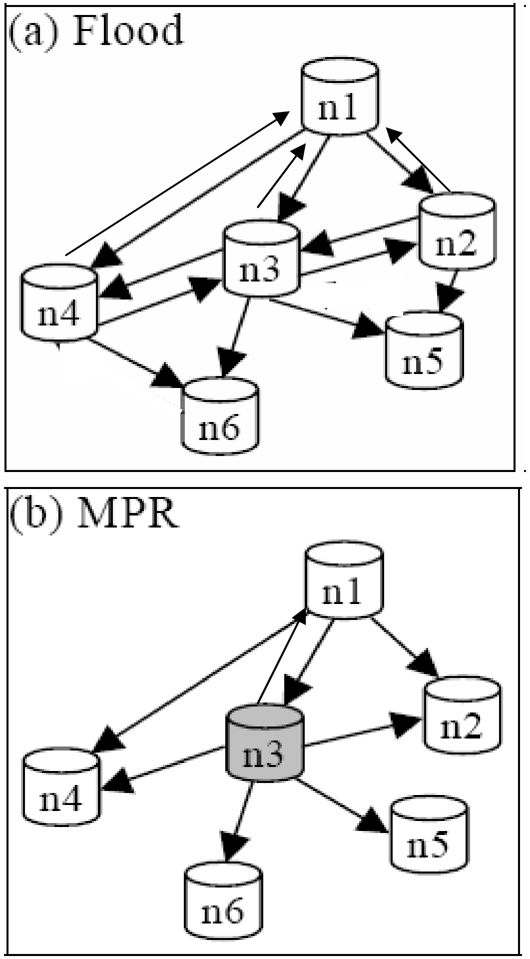
MANET algorithms

- Multi-Point Relaying
  - Reducing routing overhead and conflicts
- JAVeLEN
  - Power management by duty cycling

We assume that the wireless nodes already got addresses assigned somehow.

Multi-Point Relaying

- Part of OLSR protocol, RFC 3626. Widely used.
- Multi-Point Relaying
  - On a node (n1)
    - Use Hello messages to collect 2-hc topology
    - Select a minimal set of 1-hop neighbors to cover all 2-hop neighbors (MPR set)
  - Only nodes in MPR set forward Link State Routing messages fo the selector



MPR cont.

  - Only nodes picked by some node as MPR nodes generate LSR messages
  - A LSR message only contains the nodes who pick the sender as an MPR node (MPR selectors)
- MPR can
  - Reduce routing overhead
  - Alleviate packet collisions
- Packet collisions still happen

Joint Architecture Vision for Low Energy Networking (JAVeLEN)

- BBN technologies, 2006
- Power Management
  - 2 Channels, High/Low Power (data/control)
  - Divide time into slots
    - Unique receiving schedules based on Pseudo Random Number sequences and thresholds.
    - A node exchanges schedules with neighbors.
    - Using the schedule, a node turns on low power channel
    - Upon receipt of a hail message, turn on high power channel
  - To send a data message, a node
    - Checks receiver's schedule,
    - If it is scheduled for receiving, send Hail message, then send data.

JAVeLEN cont.

- Routing, a modified version of OLSR
  - A power efficient MPR set
  - Forward LSR messages with different probabilities.
- Advantages: power efficient, collision avoidance
- Problems
  - Complicated Power control
  - Need network wide clock synchronization

Modeling Ad Hoc Channel

- Packet format
- Wireless channel
  - Send: input
  - Read: output
  - Discard: internal
  - Register: input
- Node Movement
  - Waypoint model

Packet Format

- seq: the sequence number of the packet
- source, dest: the source and destination of a packet
- pos_x, pos_y: the position the packet comes from

```
vocabulary Packet
 types Packet tuple[seq: Nat, source, dest:
  Nat, pos_x, pos_y: Int]
```

Wireless channel

- A single common channel

```
signature
   input send(p:Packet)
   internal discard(p:Packet)
   input register(id: Nat, pos_x, pos_y: Int)
   output read(p:Packet, id:Nat)
```

- A buffer of short-lived packets
- Definition: packet position
  - The location of the packet sender

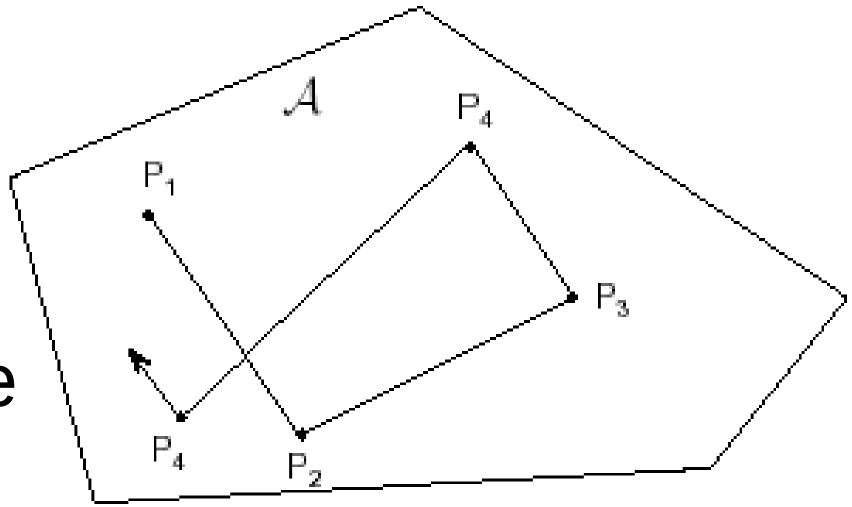
Wireless Channel Cont. (1)

- Transitions:
  - Send: get a packet from a node. Record the time when the packet is received.
  - Discard: discard outdated messages from the channel.
    - Only way a packet can be removed
    - Assume packets are outdated fast enough, so that no collision will happen between two packets that come at times far apart

Wireless Channel Cont. (2)

- Register: node registers position to the channel before receiving a packet
- Read: a node reads a packet from the channel
  - For every packet buffered, check the distance
    - ThresholdR: The channel checks if any packet can reach the node
  - And there is no collision from other packets in the channel
    - ThresholdC: Even if a second packet is not close enough to be received, it can still cause collision.
    - ThresholdD: If two sending nodes' distance to the receiving node are very different, the farther one will be drown out.

Random Waypoint Model



- Randomly pick
  - Waypoints
  - Speed
  - Pause Time
- Move-Pause-Move
- A problem
  - Average speed decreasing
  - Slow moving nodes get trapped
    - Solution: non-zero minimum speed
    - Other solutions?

Thank you!