Seminar Introduction

Ad hoc networks (1/3)

- An ad hoc wireless network is a collection of two or more devices equipped with wireless communications and networking capability
- Such devices can communicate with another node that is immediately within their radio range (peer-to-peer communication) or one that is outside their radio range (remote-to-remote communication) using intermediate node(s) to relay or forward the packet from the source (sender) toward the destination (receiver)

Ad hoc networks (2/3)

- An ad hoc wireless network is self-organizing and adaptive. This means that a formed network can be de-formed on-the-fly without the need for any system administration
- The ad hoc network can be heterogeneous, i.e., the nodes can be of different types (palmtop, laptop, mobile phone...) with different computation, storage and communication capabilities

Ad hoc networks (3/3)

- As an ad hoc wireless network does not rely on any fixed network entities, the network itself is essentially infrastructureless
- Since ad hoc networks rely on forwarding data packets sent by other nodes, power consumption becomes a critical issue

Packet radio networks

- In the 1970's, a multihop multiple-access packet radio network (PRNET) was developed under the sponsorship of ARPA (DARPA)
- In those days, the mobile devices were quite heavy and not very mobile, which means that the routing protocols used are not directly valid in very mobile cases

Mobile ad hoc networks

- MANET = mobile ad hoc network
- Applications in military, emergency rescue, classrooms and information sharing in conventions etc.
Wireless sensor networks

- A particular type of ad hoc wireless networks
- Can be stationary or mobile
- Applications in military, health-care, environmental observation, meteorology, agriculture and food industry etc.

Wireless network layers

- Physical layer
- Medium access layer
- Network layer
- Transport layer
- Application layer
- TCP/IP-layers: Network Access, Internet, Transport, Application (4)
- OSI-layers: Physical, Data link, Network, Transport, Session, Presentation, Application (7)

Differences from wireline networks

- Mobility causing frequent changes in topology
- Lower capacity of links
- Security problems due to wireless transmission
- Higher loss rates and higher delays
- Energy constraints due to batteries

Some terminology

- MAC (media access control) protocols are concerned with per-link communications
- Routing = find path from source to destination
- Clustering = group nodes (often so that each node belongs to a cluster)

Some “cast” terminology

- Unicast = send packet from source to one node
- Multicast = send packet from source to many nodes
- Broadcast = send packet from source to all nodes
- Geocast = send packet from source to all nodes inside a region
- Anycast = access nearest of any of receivers sharing the same service
- Gossiping = all-to-all broadcasting = every node has a message and the goal is to get all messages to all nodes

Routing

- Routing protocols in ad hoc networks need to deal with the mobility of nodes and constraints in power and bandwidth
- Current transport protocols (e.g. TCP) are not designed for wireless ad hoc networks
Routing protocols

- **Table-driven** routing = proactive protocols: DSDV, WRP, CSGR (hierarchical routing), STAR
- **On-demand-driven** routing = reactive protocols: ABR, DSR, TORA, AODV, CBRP, RDMAR, SSR, LAR
- **Hybrid** protocols: ZRP

Two standard problems

- Hidden terminal problem: 2 nodes out of signal range try to send to the same receiver. Some relief of this can be achieved with control messages (Request-to-Send and Clear-to-Send)
- Exposed node problem: C is transmitting to D, B overhears this and is blocked. B wants to transmit to A, but is being blocked. Thus wasted bandwidth

Performance evaluation terms

- **Delivery rate** = ratio of messages received by the destination and sent by sender
- **Latency** = end-to-end data delay = queuing delay + propagation delay
- **Communication overhead** = average number of control and data bits transmitted per data bits delivered (often not taken into account)

Observations for empirical analyses

- Note that routing algorithms perform differently on sparse and dense graphs (usually: average number of neighbors for each node)
- Also, static networks are different from mobile ones
- Node mobility needs to be modeled properly (see Stojmenovic’s Handbook p. 467); also taking into account possible moving together

Some relevant computer science areas

- NP-completeness and approximation algorithms
- Graph algorithms
- Optimization, linear programming
- Probability theory, random algorithms
- Distributed and on-line algorithms
- Game theory
- Information theory

Important NP-complete graph problems

- In the following 3 cases, we are given a graph \( G=(V,E) \) and a positive integer \( k \in \mathbb{N} \):
  - **Graph k-colorability**: Is there a function \( f:V \to \{1,2,\ldots,k\} \) s.t. \( f(u) \neq f(v) \) whenever \( \{u,v\} \in E \)?
  - **Dominating set**: Is there \( V' \subseteq V \) with \( |V'| \leq k \) s.t. for all \( u \in V-V' \) there is a \( v \in V' \) for which \( \{u,v\} \in E \)?
  - **Independent set**: Is there \( V' \subseteq V \) s.t. no two vertices in \( V' \) are joined by an edge in \( E \)?
- **Steiner tree**: Given \( G=(V,E) \), non-negative integer weight \( w(e) \) for each \( e \in E \), a subset \( R \subseteq V \), and a positive integer \( B \), is there a subtree of \( G \) that includes \( R \) and with sum of weights of the edges \( \leq B \)?
Contact information

- Email preferable: patrik.floreen@cs.helsinki.fi
- If you really have to call, use 09-4518115 = 050-3841514
- At the department: office B430, but usually not available
- Another office in HIIT / High Tech Center (Ruoholahti)