Introduction

Part 1

CS-6777 Mobile Ad Hoc Networking

Memorial University of Newfoundland

What is an Ad Hoc Network?

- A mobile ad hoc network (MANET) is
  - Communication network
  - Wireless signaling
  - Multi-hop
  - Mobile

MANET Applications

- Tactical networks
- Disaster relief
- Rescue tasks
- Access extension
- Wireless sensor networks

Bit of History – A DARPA View

- Packet Radio Network (PRNet)
- Survivable Radio Network (SURAN)
- Global Mobile (GloMo) Program
- Tactical Internet (TI)
- Extending Littoral Battle-Space Advanced Concept Technology Demonstration (ELB ACTD)

Wireless Comm. Characteristics

- Higher interference + lower reliability
  - From other sources & self interference
- Lower bandwidth
- Shared medium
- Highly dynamic network structure
- Limited computing & energy resources
- Limited service coverage
- Weak Security

Categorization of Wireless Networks

By …

- Network architecture
- Communication coverage area
- Access technology
- Application domain

By Network Architecture

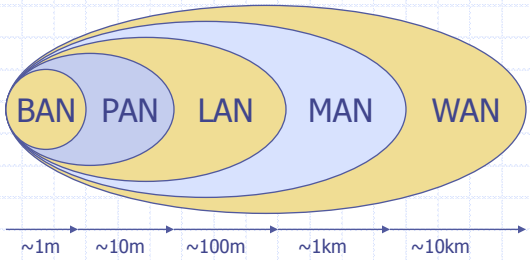
- Infrastructure-based
  - Cellular networks
  - Wireless local area networks
  - Satellite phones
- Infrastructureless (ad hoc)
  - Focus of this course

By Coverage Area

- Wireless Wide-Area Networks (Wireless WAN)
  - Cellular networks and satellite networks
- Wireless Metropolitan-Area Networks (Wireless MAN)
  - Fixed wireless, e.g. Nokia Rooftop Routers & IEEE 802.16
- Wireless Local-Area Networks (Wireless LAN)
  - IEEE 802.11 & HIPERLAN/2
- Wireless Personal-Area Networks (Wireless PAN)
  - Bluetooth & ZigBee

By Coverage Area (Cont'd)

- Wireless Body-Area Networks (Wireless BAN)



By Access Technology

- FDMA
- TDMA
- GSM
- CDMA
- Wi-Fi (802.11)
- Infrared

By Network Applications

- Enterprise networks
- Home networks
- Tactical networks
- Sensor networks
- Pervasive computing
- Wearable networks
  - Body-area networks (BAN)
- Automated vehicle networks

Evolution of Wireless Networks

Generation	1G	2G	2.5G	3G	4G
Time frame	1980s	1990s	Late 1990s	2000s	2010s
Signal type	Analog	Digital	Digital	Digital	Digital
Access technology	FDMA/ FDD	TDMA/FDD CDMA/FDD	GPRS EDGE	CDMA2000 W-CDMA TD-SCDMA	MC-CDMA OFDM
Media type	Voice	Mostly voice, low-speed data (10 ~ 70 kbps)	Mostly voice, high-speed data (10 ~ 384 kbps)	Voice, high-speed data (144 kbps ~ 2Mbps)	Converged voice, data and MM; all IP
Example systems	AMPS NMT TACS	GSM DCS1900 IS-54/95/136 CDMAOne	GPRS EDGE	CDMA2000 W-CDMA TD-SCDMA	

Foci of 4G

- Network integration
- All-IP networking
- Ultra-high speed and Multimedia
- Ubiquitous computing
- Support for ad hoc networking
- Location intelligence

Characteristics of MANETs

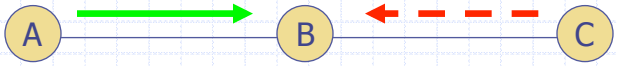
- Wireless
- Infrastructureless
- Multi-hop
- Dynamic structure

Design Issues and Challenges

- No existing infrastructure
- Mobile users
- PHY layer limitations
  - Bandwidth, quality, reliability and variance
- Energy conservation
- Security and cooperation
- Scalability
- Quality of Service (QoS)

Medium Access Control

- Share wireless channel
- Half duplex signaling
  - Self interference
- CSMA
- Collision avoidance
- Hidden terminal problem



Routing

- Most active area
- Primary objectives: correct and efficient
  - Simplicity and ease of implementation
  - Rapid route convergence
  - Distributed and light-weight
  - Bandwidth, computing power and energy
  - Scalable
  - Secure and reliable
  - QoS support

Classification of Routing Protocols

- Proactive
  - DSDV, CGSR, WRP, OLSR, FSR
- Reactive
  - AODV, DSR, TORA, ABR
- Hybrid
  - ZRP
- Hierarchical
- Location-based

Multicasting

- Unicasting
  - To unique destination
- Broadcasting
  - To all nodes in the network
- Multicasting
  - To subset of nodes
  - Tree-based
  - Mesh-based
- Geocasting
  - To nodes in specified geographic region

TCP Issues

- Assumption in Internet
  - Packet loss = network congestion
  - Reduce traffic flow by slowing down transmission
- Different interpretation of packet loss in wireless networks
  - Link layer error or network disconnection
- New treatment
  - Cellular networks
  - Ad hoc networks

Energy Conservation

- Save energy without compromising network performance
- PHY – Reducing transmission power
- MAC – putting air interface into *sleep* mode
- Energy efficient routing protocols
- Duty cycle sharing among clusters

Network Security

- Forms of attacks
  - Passive eavesdropping
  - Denial of service (DoS)
  - Signaling attacks
  - Flow disruption
  - Resource depletion
  - Data integrity attacks
  - Stolen device attacks

Cooperation

- Selfish behavior among nodes
  - "Since energy is scarce, why would I bother to forward other people's packets?"
- Economics models
  - Game theory

Quality of Service

- QoS model
  - Throughput/capacity
  - Delay
  - Delay jitter
  - Packet loss rate
- QoS routing
- QoS signaling
- QoS MAC

Performance Evaluation

- Analysis
- Computer Simulation
  - E.g. OPNET, ns2, GloMoSim, QualNet
  - Mobility models & networking modules
- Testbed measurement
  - APE – Uppsala University, Sweden
  - Project MART – Helsinki University, Finland
  - MONARCH – Carnegie Mellon University, USA
  - MOMENT – UC Santa Barbara, USA
  - DAWN – Trinity College in Dublin, Ireland

Future Research

- Routing protocol optimization
- QoS support
- Simulation
- Security
- Standardization and interoperability

Ubiquitous Computing

The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it.

— The late Mark Weiser
Father of Ubiquitous Computing