MŰEGYETEM 1782

BME

Mobile self-organizing networks

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Trends: Internet of Things

Smart Cities - M2M applications everywhere

Source: Eurotech - Smart City – Many Applications and Devices








Logistics
Smart Buildings
Remote Monitoring
Automatic Vehicle Location
Signage
Waste Management
Transportation
Air Conditions
Sports Medical Application
Elderly Living
Reverse Vending
Ticketing
Retail
Smart City
Industrial
Medical
Cool Chain Monitoring
Rail
Environmental
Value Transport
Energy Monitoring
Irrigation
Vending
Green Houses
Public Transport
Metering
Smart Grid
First Responders



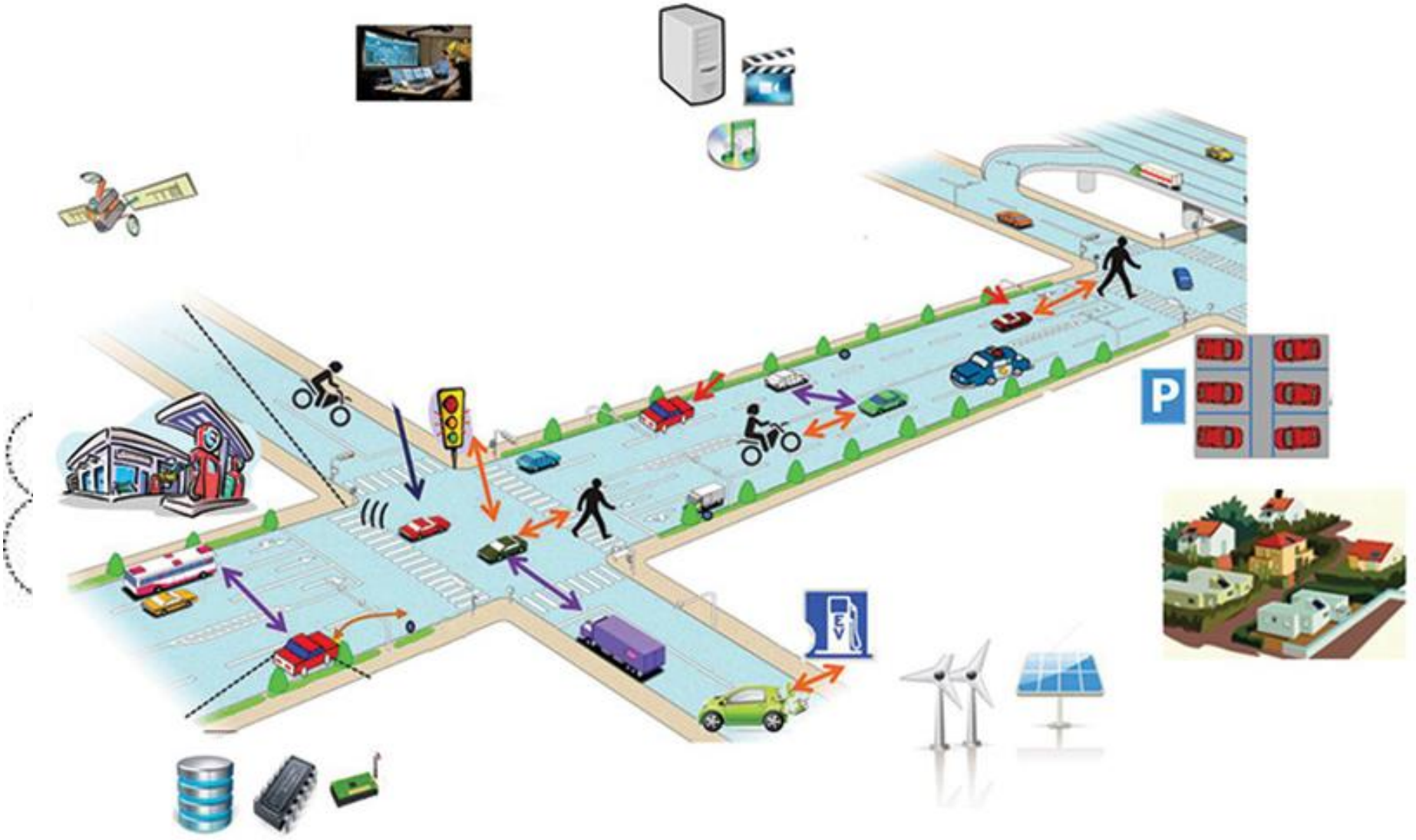






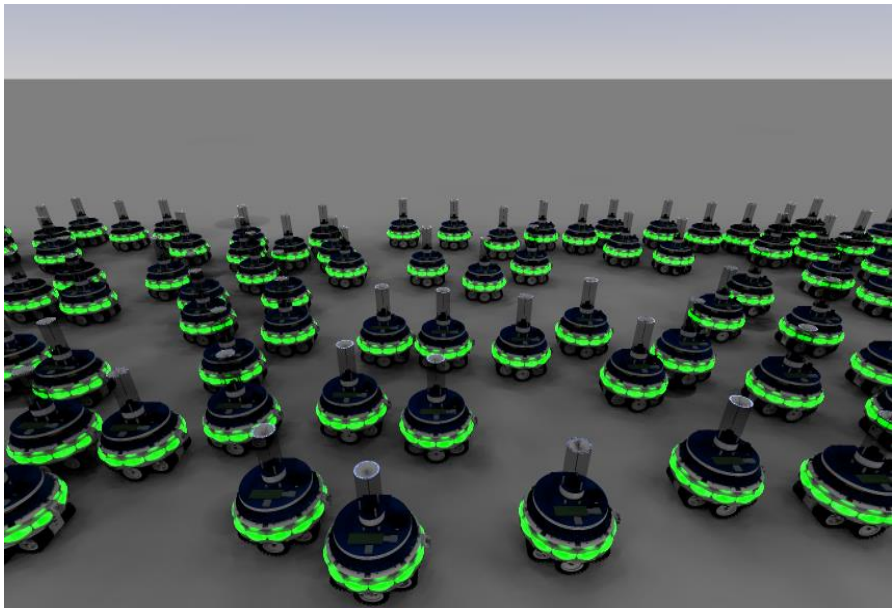


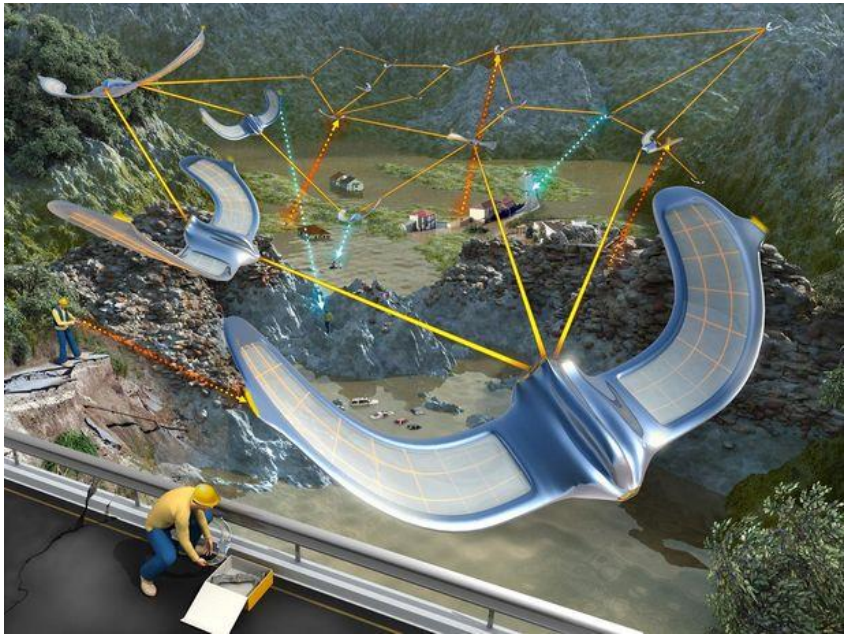

Trends: V2X communication



Trends: self-organized flocking

- Mobiles users moving in autonomous groups: flocks
  - UAVs, robots, cars
- Novel research: patrolling, autonomous task allocation

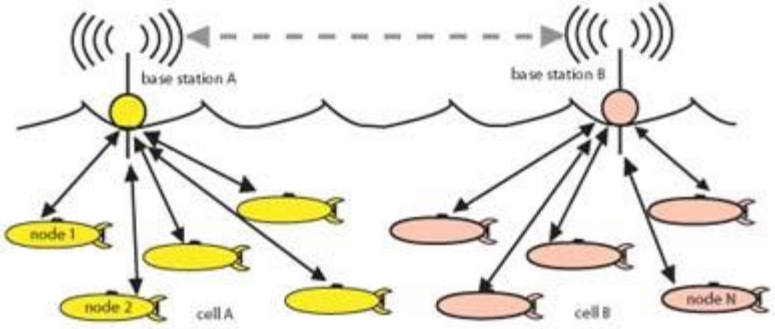




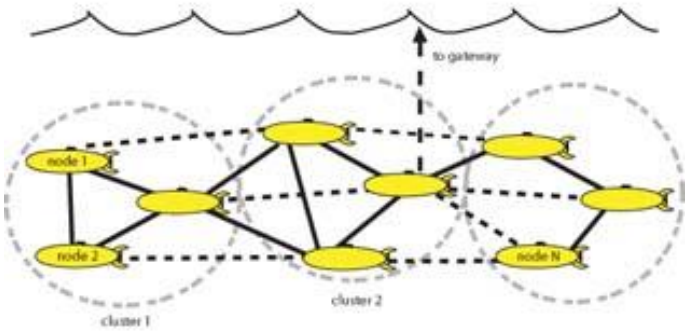
Network topologies

- Types of network topologies
  - Centralized
  - Decentralized (peer-to-peer)
  - Hybrid

Centralized



Decentralized



Centralized topology

- Communication from one node to another goes through a hub or base station (BS)
- Hub station controls nodes and monitors transmissions from each node
- Hub manages access by nodes to network's allocated bandwidth
- Configuration for cellular mobile and WLAN networks

Advantages of centralized topology

- Efficient use of transmit power
- Optimized placement of Hub/BS: minimizing obstruction
- Hub/BS: provides connection to backbone network
- Power control
  - a central point can determine required power for nodes to minimize interference and conserve battery

Disadvantages of centralized topology

- Single point of failure
- Can not deal with unpredictable propagation environments
- Cannot cover wide areas
  - where connections exceed range of single link
- **Not suitable for self-organizing networks**
- Requires significant infrastructure setup

Decentralized topologies

- Fully-connected network
  - All nodes can communicate directly
  - Requires nodes to be co-located
- Multi-hop network
  - If nodes can not directly reach the destination: intermediate nodes must relay messages to destination
  - Widely used in ad-hoc and mesh networks
    - Not possible to guarantee connectivity of all nodes

Fully-connected peer-to-peer network

- Advantages
  - No single point of failure
  - No store-and-forward delay
  - A node can be designated as a gateway to backbone network
- Disadvantages
  - Performance degradation in large networks
  - Near-far problem

Multi-hop peer-to-peer

- Advantages
  - Only solution if no infrastructure available
  - Widely used in military applications
  - Gaining popularity in other types of wireless networks
    - Ad hoc networks
    - Sensor networks
- Disadvantages
  - Multiple store-and-forwards
  - Increase delay
    - for users separated by multiple hops
  - No central timing or power control authority

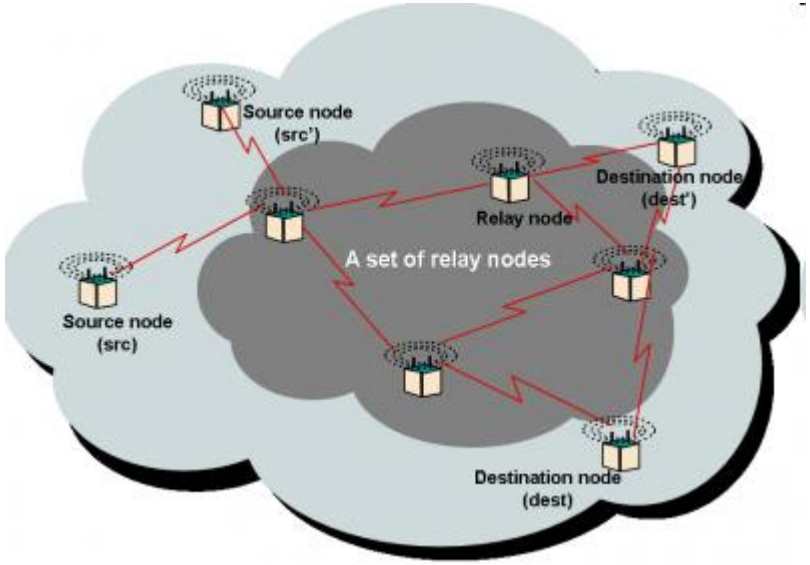
Types of networks

- WiFi/ 802.11
  - Two modes
    - Centralized: wireless local area data network
    - Peer-to-peer: MAC/PHY for ad hoc networks
- Self-organized networks
  - Multi-hop peer-to-peer networks
  - Hybrid networks
  - Unicast, multicast and broadcast networks
- Wireless sensor networks

Self-organizing networks

- Dynamic topology
  - nodes enter and leave the network continuously
- No centralized control or fixed infrastructure

- Application areas:
  - Meetings
  - Emergency or disaster relief
  - Military communications
  - Wearable computers
  - Sensor networks



Self-organizing networks

- Limited communication range of the mobile nodes
  - Enables spatial reuse of limited bandwidth: increased network capacity
- Each mobil node is a
  - Packet source
  - Packet sink
  - Router
- Problem: how to determine where a destination node is located relative to a sending node

„Routing” in self-organizing networks

- Route-finding is a current area of much research
  - Want to determine an “optimal”way to find “optimal”routes
- Dynamic links
  - Broken links must be updated
  - New links must be formed
  - Based on this new information: routes must be modified

- Frequency of route changes a function of node mobility

Issues in self-organizing networks

- Routing performance
  - Routes change over time
    - due to node mobility
  - To avoid long delays when sending packets
  - But also to avoid lots of route maintenance overhead

- MAC
  - Broadcast communication channel
  - Neighbor nodes change over time
  - Sleep mode: to reduce energy drain
  - No coordination/cooperation among nodes?

Issues in self-organizing networks

- Quality of service
  - Link variability
  - Collisions
  - Congestion
- Security
  - New vulnerabilities and complexities
  - Routing denial of service
    - Nodes may agree to route packets
    - Nodes may then fail to do so
    - Broken, malicious, selfish nodes
  - Key distribution and trust issues

MAC protocols

- No centralized control therefore:
  - Nodes independently determine access
  - Local nodes elected to control channel access

- Goals for MAC protocols
  - High channel efficiency
  - Low power
  - Scalable
  - Support for prioritization (QoS)
  - Distributed operation
  - Low control overhead

MAC: Channel separation

- Common channel vs. multiple channels

- Typical use of channel
  - Data transmission
  - RTS/CTS handshake
  - Carrier sensing

- **Common**: single channel for all packets
- **Multiple**: some packets (overhead) on one channel, while other packets (data) on others
  - allow more simultaneous users

Single channel

- Data and control messages on the same channel
- Collisions and contention
  - Handshake protocol
  - ACKs
  - Backoff protocol

Multiple channels

- Typically, one channel for control, others for data

- **TDMA-based**
  - Time slots + synchronization
  - Best with real-time, periodic data

- **FDMA-based**
  - Allows multiple nodes to transmit simultaneously

Multiple channels (cont.)

- **CDMA-based**
  - Simultaneous transmissions via code separation
- **SDMA-based separation**
  - Directional antennas to transmit in particular direction
- **Hybrid schemes**
  - Combine channel separation methods

Topologies: Flat

- **Flat**
  - Nodes make independent decisions to access the channel
    - Local coordination via handshaking, carrier sensing
  - **Single-hop**: concerned only with immediate neighbors
    Scalability issues
  - **Multi-hop**: some notion of nodes outside local neighborhood
    - Most use multiple channels

Topologies: Clustered

- **Clustered**
  - Elect local cluster head (CH) to perform control/management of network resources
  - Reduces burden on nodes, increases burden on cluster head
    - Good for heterogeneous networks
    - Bluetooth: elect CH (Master) as node that initiated cluster (piconet)

Reducing energy consumption

- Radio operates in 3 modes: transmit, receive, standby
- Reduce transmit power
  - Use “just enough” to reach intended destination
- Place nodes in standby mode as much as possible
  - Nodes do not need to be on when not receiving data
  - Requires nodes to know when they must listen to the channel and when they can “sleep”
  - MAC protocols cannot use “promiscuous” mode to listen to other conversations
  - Node must know when other nodes have data to transmit to it

Reducing energy consumption (cont.)

- Collisions should be minimized
  - Retransmissions expend energy
  - Introduce delays (e.g. Random Assessment Delay)
  - Reduce number of ACKs required
  - Use contention for reservations and contention-free for data transmission
- Allocate contiguous slots for transmission/reception
  - Avoids power/time in switching from Tx to Rx
- Have node buffer packets and transmit all packets at once
  - Allows node to remain asleep for long time
  - Trade-off in delay to receive packets and buffer size

Reducing energy consumption (cont.)

- Make protocol decisions based on battery level
  - Choose cluster head to have plenty of energy
  - Give nodes with low energy priority in contention

- Reduce control overhead
  - Need control to avoid collisions, but reduce as much as possible