Telecommunication Services Engineering (TSE) Lab

UNIVERSITÉ Concordia UNIVERSITY

Chapter IV –
Mobile Ad Hoc Networks and Wireless Sensor Networks

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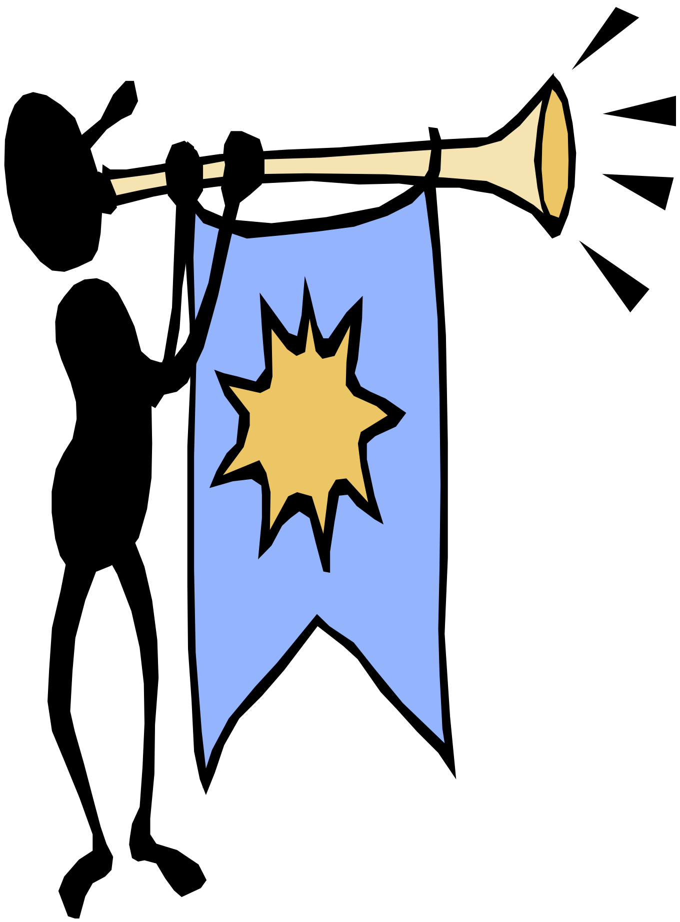
Engineering and Computer Science
Concordia Institute for Information Systems Engineering

Outline



1. Mobile Ad Hoc Networks (MANET)
2. Wireless Sensor Networks (WSN)

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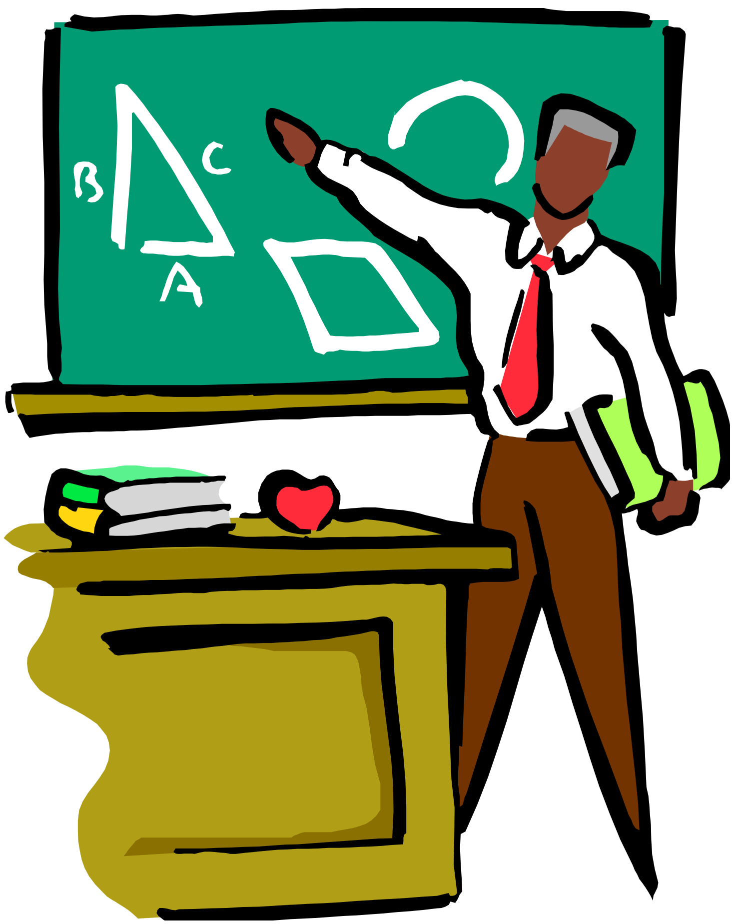
Mobile Ad Hoc Networks



1. General concepts
2. Below IP
3. IP Layer: Routing
4. Transport Layer
5. Applications layer challenges

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Mobile ad hoc networks

Networks that can be deployed, anywhere, any time

Some of the characteristics:

- Infrastructure-less
- Dynamically changing network topologies
- Physical layer limitations
- Variation in link and node capabilities
- Energy constraints

(Mobile) ad hoc networks

Categorization

- Stand alone

Or

- Connected to a fixed infrastructure (e.g. 3G, 4G, Internet)

(Mobile) ad hoc networks

Key application areas

- Natural disasters (e.g. earthquake)
- Battlefield.

Below IP: The Off-the-shelf building blocks

Wireless PANs -

BlueTooth

1 Mbps

- PHY (RF Layer)
  - Fast frequency hopping
- MAC (Baseband Layer)
  - Basic structure:
    - point to point
    - Master / slave
  - Piconet
    - Point to multipoint
    - 1 master controlling several slaves
  - Scatternets
    - 2 or more overlapping Piconets
    - Nodes which are part of more than one Piconet act as bridges

Below IP: The Off-the-shelf building blocks

Wireless PANs -

BlueTooth (The most popular)

Scatternets can be used as basis for multihop ad hoc networks

However:

- Few implementations of BlueTooth support scatternets
- Many open research issues
  - Efficient inquiry
  - Scatternet / piconet scheduling
- No working BlueTooth multihop ad hoc network test bed
- But simulators

Below IP: The Off-the-shelf building blocks

Wireless LANs -

1. IEEE 802.11 (a, b, c, d, e, f and g) – WiFi

- Most popular Off-the-Shelf building block
- 1 – 54 Mbps
- Two modes:
  - Infrastructure Mode Basic Service Set (IM-BSS)
    - Access points
    - Connections to a fixed network (e.g. 3G, Internet)
  - Independent Basic Service Set (IBSS)
    - No access point
    - Stand alone mode

Below IP: The Off-the-shelf building blocks

Wireless LANs –

IEEE 802.11 (a, b, c, d, e, f and g) - WiFi

- PHY
  - Most popular
    - Direct Sequence Spread Spectrum (DSS)
    - Orthogonal Frequency Division Multiplexing (OFDM)
      - More recent
      - Enable high rates

Below IP: The Off-the-shelf building blocks

Wireless LANs -

IEEE 802.11 (a, b, c, d, e, f and g) - WiFi

- MAC
  - Distributed Coordination Function (DCF)
    - Work in both IM-BSS and IBSS mode
    - Carrier Sense Multiple Access – Collision Avoidance (CSMA/CA)
    - Most popular
  - Point Coordination Function (PCF)
    - Polling scheme
    - Work only in the IM-BSS mode
    - Has lost momentum

IP Layer: Routing

Pro-active approaches -

- Each node maintains the route to every other node
- Periodic updates
- Derived from wireline traditional routing approaches
- Examples
  - Distance sequenced distance vector (DSV)
  - Optimized link state routing (OLSR)

IP Layer: Routing

Reactive approaches -

- On-demand (built when needed)
- Some examples
  - Ad hoc On Demand Vector Routing (AODV)
  - Dynamic Source Routing (DSR)

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Transport Layer

Examples of reasons for which TCP does not perform well in MANETs

Misinterpretations

- Interpret "wrongly" as congestion:

Packet loss

frequent path breaks

Network partitioning and re-merging

- Due to randomly moving nodes

Two categories of solutions:

Enhanced TCP

Brand new transport protocols

Application Layer Challenges: The case of Multimedia Sessions

Examples of challenges common to signaling and media handling

1. No centralized entity
2. Optimal usage of resources
3. Lightweigtht
4. Independence of lower layer protocols (e.g. Routing)
5. Scalability

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Application Layer Challenges: The case of Multimedia Sessions

Signaling specific challenges

Dynamic propagation of conferencing information (e.g. who has joined, who has left)

Very challenging in MANETs due to the frequent changes in topology

- Voluntary departure (easy to handle)
- Forced departure (trickier)

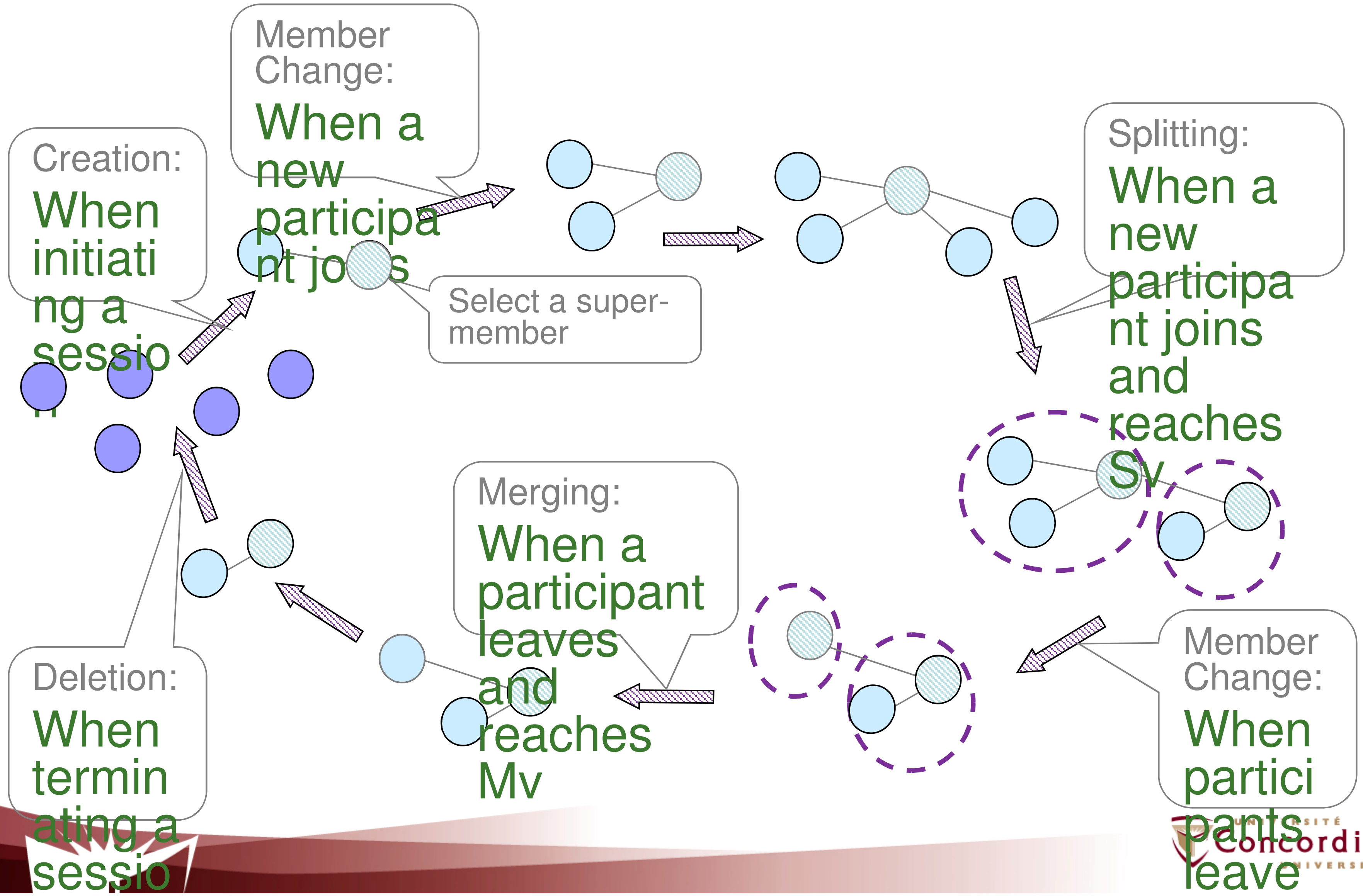
Application Layer Challenges: The case of Multimedia Sessions

Media handling specific challenges

- Limited quantity of streams
- Synchronization (streams delivery with proper ordering and timing)
- Attendance with different media compression format

Very challenging in MANETs because there is no possibility to have a centralized mixer

Potential solution: clustering



To probe further …

1. **S. Basagni et al., editors, Mobile ad hoc networking, IEEE / Wiley Press, 2004**
2. C. Fu, R. Glitho and F. Khendek, Signaling for Multimedia Conferencing in Stand Alone Mobile Ad Hoc Networks, *IEEE Transactions on Mobile Computing*, Vol. 8, No7, July 2009, pp. 991 – 1005

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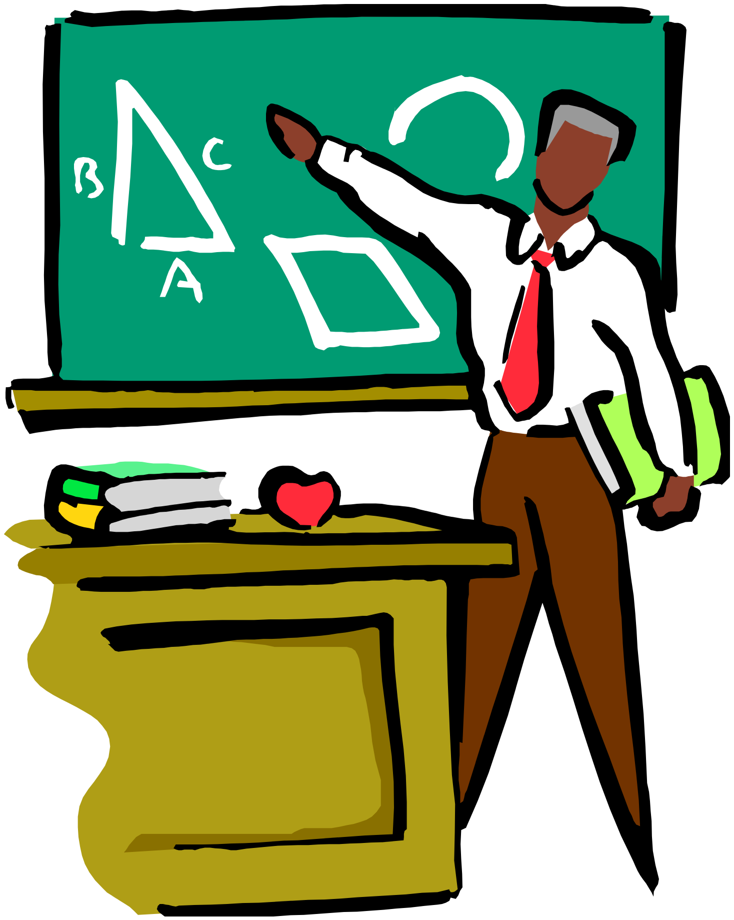
Wireless Sensor Networks



1. General concepts
2. Transport, network, MAC and PHY
3. Middleware

Wireless Sensors

Small scale autonomous devices that can sense, compute and communicate ambient information

- Ambient information
  - Space
    - e.g. location, velocity
  - Environment
    - e.g. luminosity, level of noise
  - Physiology
    - E.g. blood pressure, heartbeat

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Wireless Sensors

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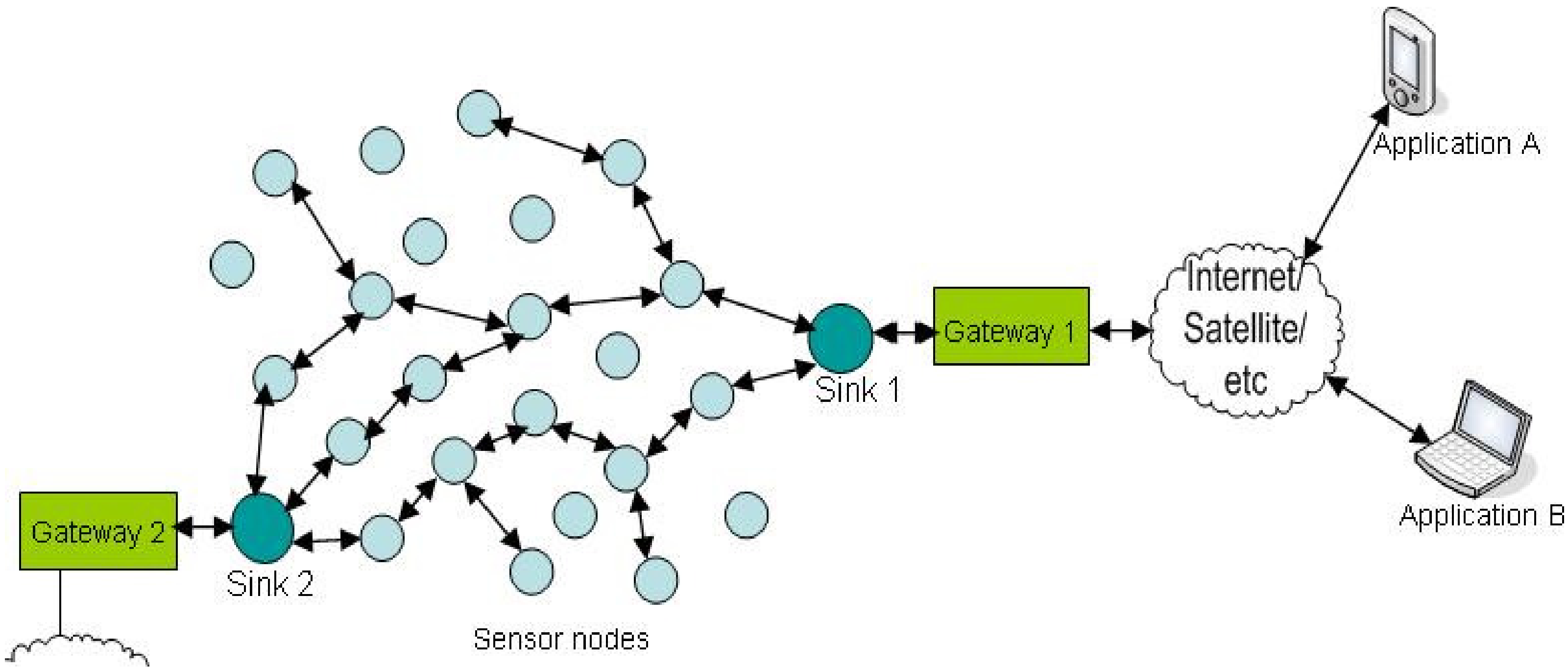
Wireless Sensor Networks (WSNs)

- Sensors
  - Do the actual sensing
- Aggregators
  - Logical representatives of regions of interest
    - Summarize data for regions
- Sinks
  - Collect data from all sensors / aggregators
    - Interact with end – user services / applications via gateways
- Gateways
  - Dual interfaces
    - Bridge WSNs and outside world

Wireless Sensor Networks

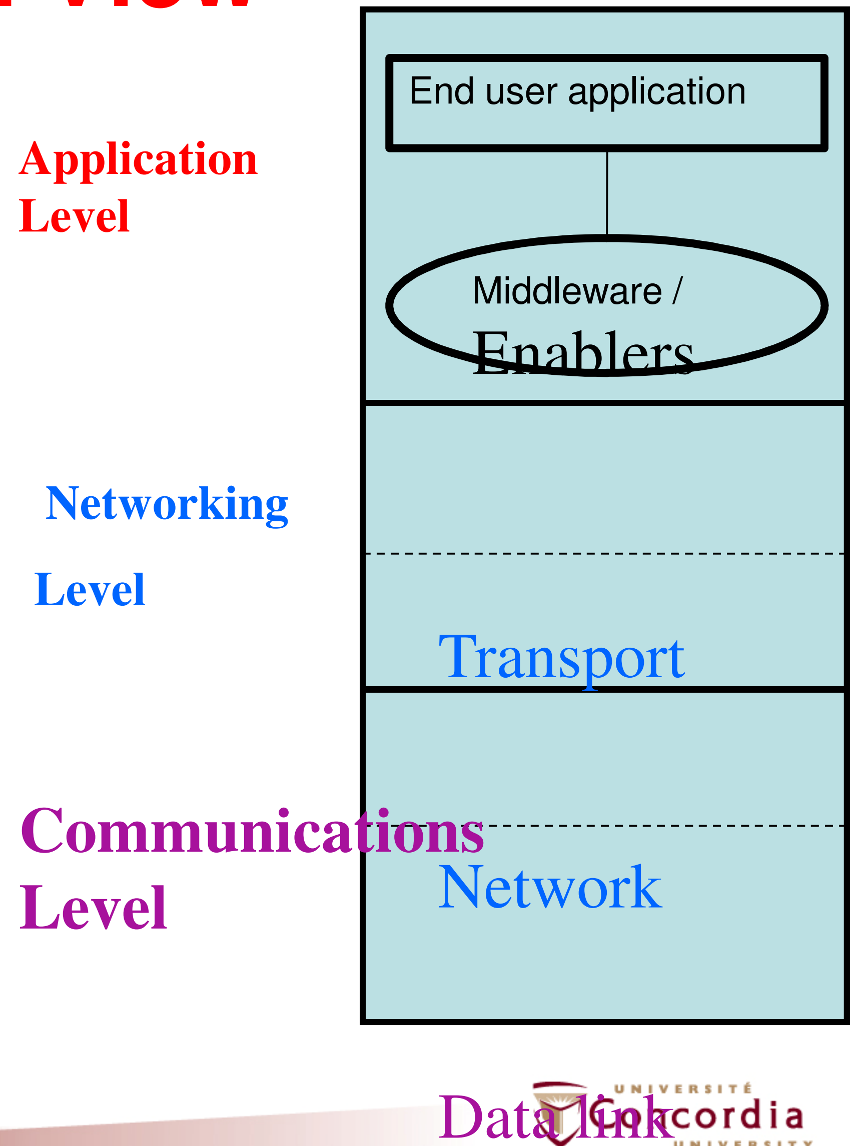


Applications areas

Numerous

- Military
- Environment
- Health
- Home
- Industry

A Layered View



Transport

- Transport layer in general
  - Bridge between network layer and application layer
    - Multiplexing / de-multiplexing
  - End to end data delivery with reliability required by application
    - Connection-less vs. connection oriented
  - Traffic regulation
    - Flow control / congestion control

Transport

- Unsuitability of classical Internet transport protocols
  - TCP
    - Overhead due to 3 way handshaking, wireless nature of WSN
  - UDP
    - Lack of flow and congestion control mechanisms

Transport

- Requirements for transport in WSN
  - Reliability (Transmission of event features from sensors to sink and transmission of commands / programming tasks from sink to sensors)
  - Congestion control (Avoid event detection impairment at sources such as aggregators)
  - Self configuration (adaptations to mobility, temporary failure, power down)
  - Energy awareness
  - Biased implementation (Fair usage of resources – heavier burden on sinks)
  - Constrained routing / addressing (No end to end global addressing)

Transport

- Two groups of protocols
  - Event to sink transport
  - Sink to sensors transport

Network layer (Routing)

- Data centric
  - Sensors do not usually have specific IDs
    - Data centric protocols
      - Route based on data description
        - Attribute naming (e.g. area where temperature > 20 degrees)
      - Data aggregation / fusion
      - Some examples
        - Flooding
        - Gossiping

MAC

- Requirements specific to WSNs
  - Energy efficiency
  - Topology awareness
  - Spatial correlation
- Categorization
  - Contention based protocols
  - Hybrid medium access

PHY

- Examples of technologies
  - Ultra wide band
    - Low energy level
    - Short range
    - Broadband (XXX Mbits)
  - Infrared

Middleware challenges

- Limited power and resources
- Scalability, mobility, dynamic network topology
- Heterogeneity
- Dynamicity (e.g. energy, processing power)
- Real world integration (e.g. on volcanoes)
- Quality of service
- Security

Examples of middleware technologies

- Low level commands
- Data bases
- Web services

-Low level commands

- Low level commands
  - Used for debugging/configuring/upgrading firmware/retrieving data readings
  - Commands sent by a proprietary client / standard text interfacing application (i.e telnet)
  - Requires a full understanding of the particular instance of WSN (algorithms or technology)

Slide 36

t3 give desc of appraoch
what reasearch work uses this
MAIN drawback

APIS
- low level: specifying ip/port, special flags, programming construct, following a sequence of prog operations

tt, 13/12/2005

-Low level APIs

APIs

- Based on high level programming languages or specialized languages (i.e. NesC)
- Relatively low level of abstraction
- Some security features, no publication/discovery
- Ex: MIT crickets, Sensoria sGate, EmberNet

t4

give desc of appraoch
what reasearch work uses this
MAIN drawback

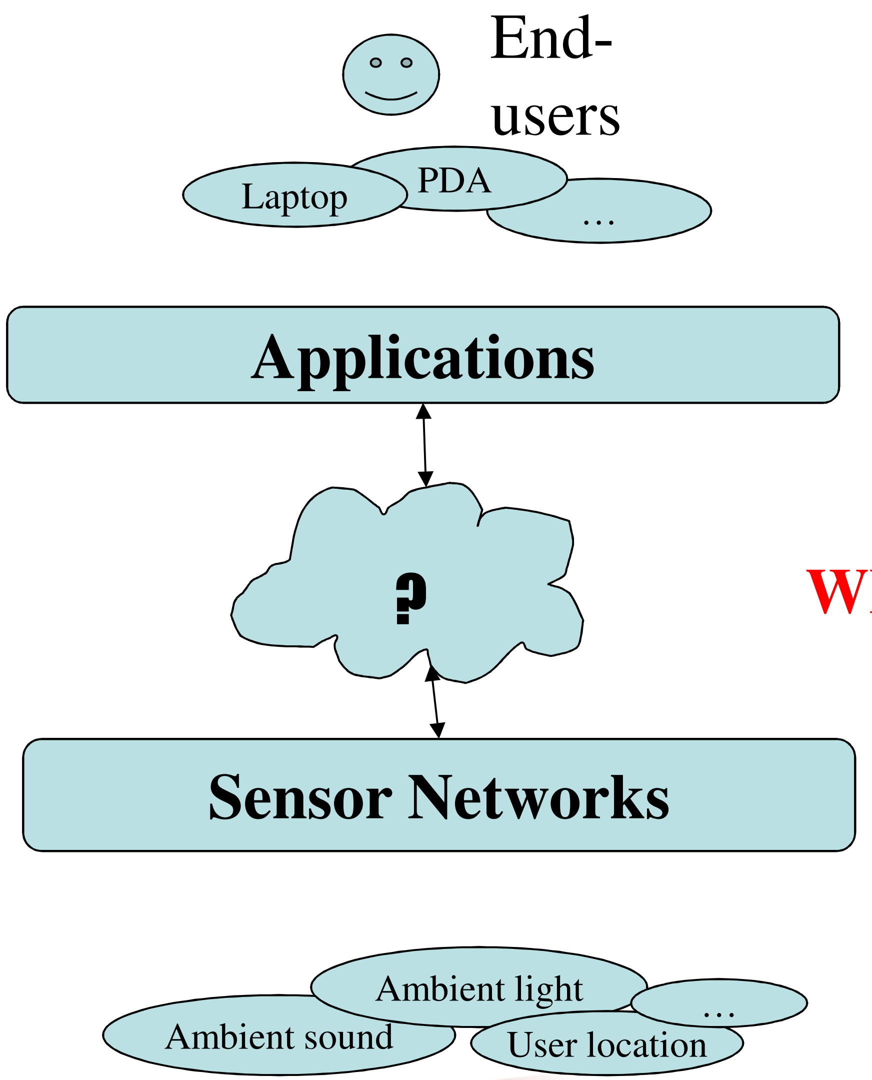
APIS
- low level: specifying ip/port, special flags, programming construct, following a sequence of prog operations

tt, 13/12/2005

Data Base approaches

- Treat the WSN as a data base
  - May use a standard query language or an extension
  - Queries are sent to the sink
  - Can be used with most programming languages
  - Some examples
    - TinyDB
    - MICA2
    - COUGAR

Web Services



WEB SERVICES !!!

To probe further

1. I. Akyildiz, W. Su, Y. Sankarasubramaniam, Wireless Sensor Networks: A Survey. Computer Networks Journal (Elsevier), Vol. 38, No4, pp. 393 – 422, March 2002
2. S. Hadim and N. Mohamed, Middleware: Middleware Challenges and Approaches for Wireless Sensor Networks, IEEE Distributed Systems OnLine, 1541 – 4922, Vol. 7, No3, March, 2006

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