Sensor networks and applications

Mobility in sensor networks. Transport and application layers.

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Mobility in sensor networks

Mobility in sensor networks

- Typically, the nodes in a sensor network are static, but...
  - in certain cases mobility can be useful, or
  - the movement of the nodes cannot be avoided.

- In a WSN, can move...
  - the base station (BS), and/or
  - the sensors, and/or
  - the „events”, tracked objects.

Mobility in sensor networks

- The aim of mobility can be..
  - energy efficiency,
  - provide coverage,
  - topology-control,
  - quality improvement of monitoring.

- A mobile sensor network can react physically to its environment of changing surroundings.

Mobility in sensor networks

- The movement of a base station/sensor node can be…
  - controlled (e.g., controlled (micro-)robots)
  - uncontrolled (e.g., sensors floating on water surface)

- The (active) movement of sensors is energy consuming, and special hardware is needed..

Base station mobility

- The aim/cause of base station mobility can be…
  - The user is moving within the area of WSN
    - E.g., military staff of vehicles on the field
  - The sink (randomly) roaming within the area
    - E.g., data collector units mounted on animals or tourists
  - The sink nodes are controlled by the network/user
    - E.g., energy-efficient operation,
    - assuring connectivity (topology control).

Base station mobility

- Question arise when the BS is moving:
  1. „How can the BS announce its new position to the nodes?”
  2. „How can the nodes set their new paths towards the BS?”
  3. „How BS mobility affects the other energy-efficiency solutions (e.g., clustering, data aggregation)?”

Base station mobility

- Altough it is not typical for sensor nodes, for the BS we can assume that it is no problem to provide mobility.
- The primary task for the BS (sink) is to collect sensory data.

- Idea: *The BS can „go for the data" and collect them locally where the sensors measure them!*
- Advantage:
  - Long-distance data transmission can be avoided, either using direct or multi-hop communication.
  - There is no need to construct routes towards the BS BS-hez, if it comes for the data to fetch it.
    - (E.g., semi-smart metering)

Base station mobility

- BS mobility can be…
  - random,
  - predictable,
  - controlled,
  - adaptive.

- The BS can move…
  - on its own, or
  - with the help of some carrier.

BS random mobility

- In case of **random mobility**, it is not possible to follow an optimal routes and routing strategy.
  - E.g., „**data-mule**”: Environmental monitoring in a wild reserve, where the BSs are mounted on animals within the monitored habitat.
  - By the random roaming of the animals, the BSs sooner or later reach every part of the monitored area.
- The sensors either…
  - detect, if the BS comes close, and hand over all of their collected data, or…
  - the BS sends pilot signals to wake-up and query the sensors for the data.
- Typically, the transfer delay is very large, random, and data delivery is not always guaranteed.

BS predictable mobility

- In case of **predictable BS mobility**, data collection can be planned in advance.
  - E.g., the BS follows a given trajectory, going around periodically, covering the whole area.
- Advantages:
  - Sensor nodes do not have to communicate with a far away BS.
  - Delay can be big, but can be controlled, quality guarantee can be given (e.g., max D < lap time)
  - Few (~1) BS is enough to cover the whole network.

BS adaptive mobility

- The best network operation can be achieved by using **adaptive BS mobility** if possible.
  - E.g., The BS goes to the area where and when it is most needed.
- Advantage:
  - Energy efficient operation can be assured.
  - Load sharing can be achieved by using network resources evenly.
    - IMPORTANT: *In many cases the BS must be relocated just because its neighboring nodes start to deplete their battery (in multi hop communication)!*
  - Can follow up the changing network topology can be adaptively.
  - The BS can collect additional data when reaching the area of interes.

BS controlled mobility

- Using **controlled BS mobility**, the trajectory and timing can be planned using a preferred strategy.
  - E.g., the BS is moved to the area that is interesting for us.
- Advantage:
  - total control → more options to choose from
  - More BSs can be controlled together.
  - Data quality can be guaranteed (QoS).
- Note: The cost of BS mobility must be taken into account!

Sensor mobility

- In contrast to BS mobility, moving sensor nodes can be critical from energy and cost point of view!

- Sensors can move randomly, or in a controlled way.

- **Random mobility** for the sensors is typical, when they move along with the environment or medium, in a passive way.
  - E.g., Sensors in rivers, on the surface of water, underwater, in air, on glaciers, etc.
  - E.g., Sensors mounted on animals or vehicles…

Sensor mobility

- Using **controlled mobility** for sensors, it is possible to …
  - increase coverage,
  - provide connectivity,
  - ensure energy efficiency.
- In many cases the sensor can be moved only once, just after deployment to reach the desired topology.
  - E.g., uncovered areas, uneven node density, communication „holes” (=topology control).
- Sometimes only a small subset of the sensor nodes are mobile.

Sensor mobility

- In event-driven networks, sensors can **move adaptively** towards more „interesting” areas.
- The strategy for sensor mobility can be…
  - **reactive**: sensors move by reacting to events
    - E.g., they move closer to the events
  - **proactive**: sensors try to spread out optimally (evenly).
- A possible group of algorithms for sensor mobility is based on **potential fields**.
  - E.g., electrostatic field emulation, where same charges push themselves apart.

„Virtual” mobility in sensor networks

- **Mobile agents**: Agents are code segments, that can move within the network and executed on some network nodes.

- It can be useful to process the data within the network right where the data was collected.

- The network can be reconfigured by **virtually move (relocate) the BS(s)**.

Transport and application layers

Transport and application layers

Sensor network architecture

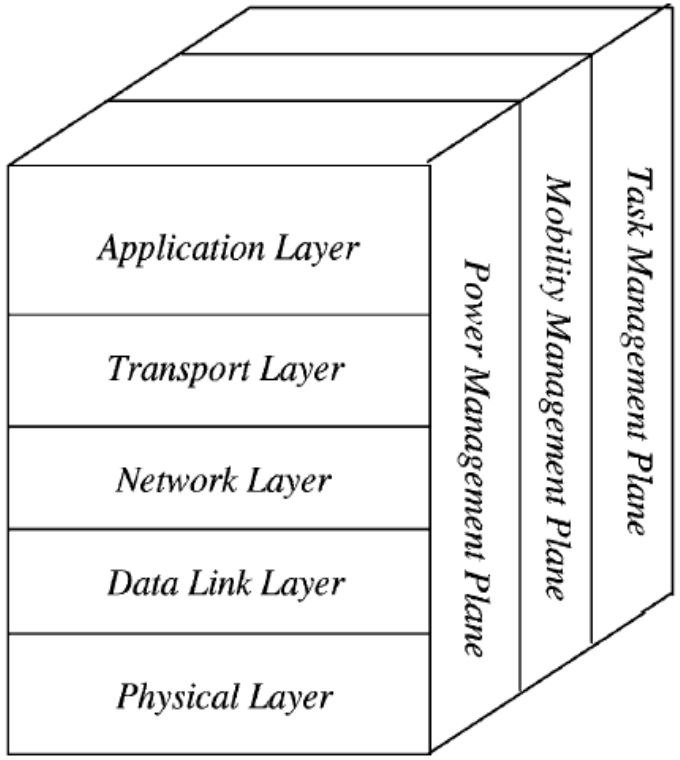
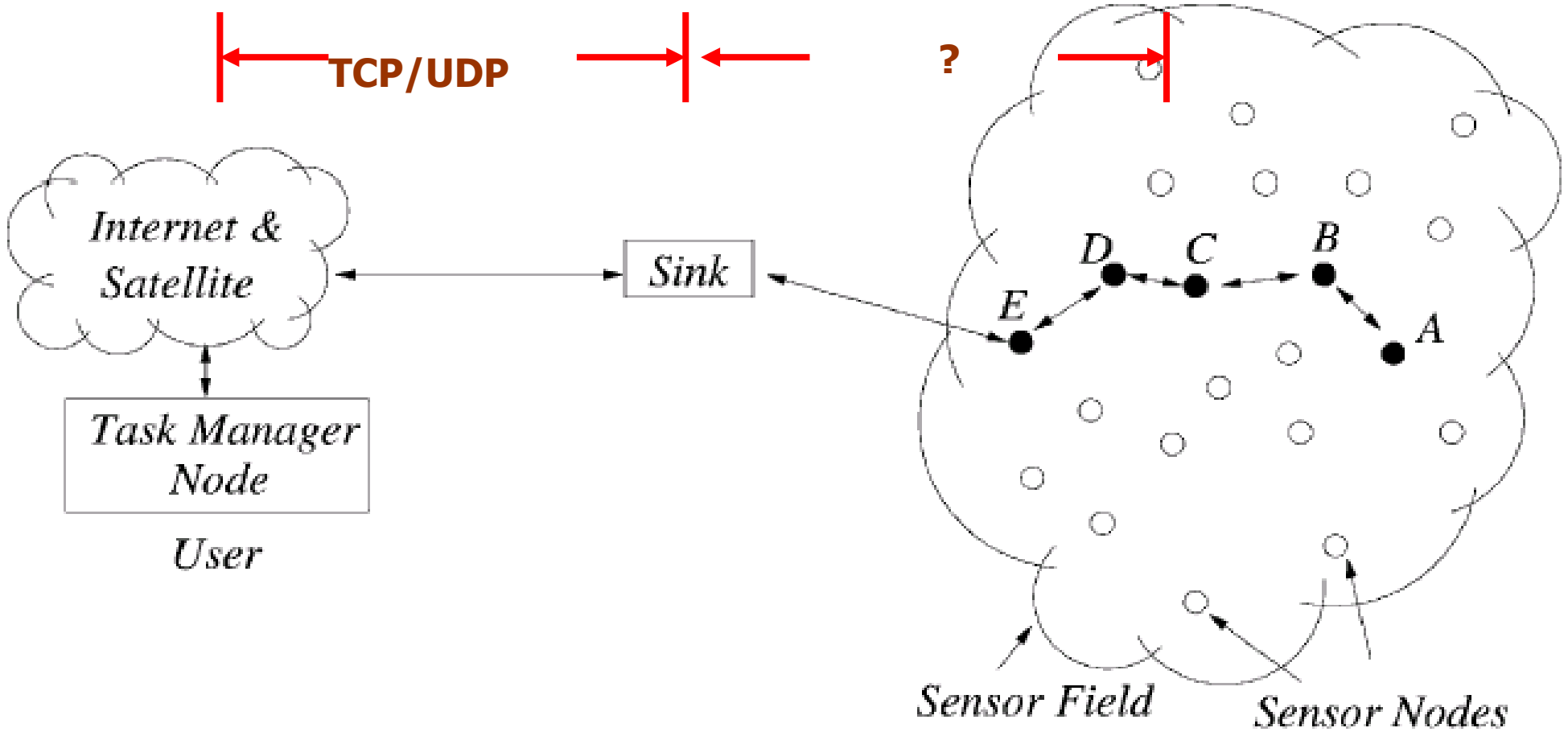


Fig. 3. The sensor networks protocol stack.

ISO OSI

Transport layer

- The transport layer solution is necessary when the sensor network is accessed via the Internet.



Transport layer

- The TCP-like solutions can not be directly applied to WSNs
  - Unique addresses are not always available.
  - There is not enough memory in the nodes.
  - TCP handshaking and acks can be a huge overhead.
  - Congestion management is not necessary, and is too complex.
- UDP-like solutions are more preferable in WSNs.
- „TCP-splitting”: The TCP connection is terminated at the BS, and only datagrams are used within the sensor network.

Application layer

- In contrast to the wide range of applications, there are no universal application layer protocols in WSNs.
- Possible management protocols:
  - **SMP – Sensor Management Protocol**
  - **TADAP – Task Assignment and Data Advertisement Protocol**
  - **SQDDP – Sensor Query and Data Dissemination Protocol**

- Note: These protocols are not yet defined and standardised!

SMP – Sensor Management Protocol

- The **network and sensor management** is an important task.
- The task for an application-layer management protocol is to make the lower (software and hardware) layers transparent to the application.
- The system administrators can use SMP to interactively manage the network.
- Without global addressing, SMP has to deal with attribute- and location-based addressing as well.

TADAP – Task Assignment and Data Advertisement

- An important task is to query and get useful data from the network.
- Possibilities:
  - The user commands the sensors and tells what information is needed.
  - Sensors advertise the available data to the user. The user only asks for the data that is interesting to him/her.

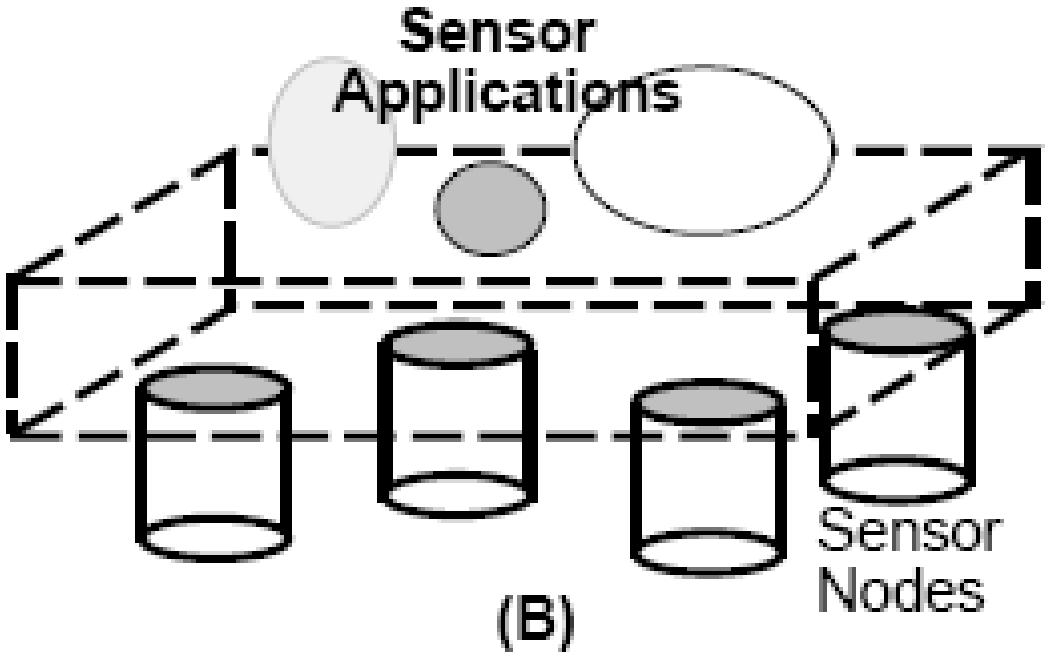
- An application layer protocol for task assignment or data advertisement can be a great help for the operation of lower layers (e.g., routing).

SQDDP – Sensor Query and Data Dissemination Protocol

- The SQDDP provides an interface towards the applications for
  - sending queries,
  - disseminating the data,
  - collecting the answers.
- It uses attributum- and location-based addressing
  - E.g., „Where are those sensors that measure temperature values higher than 70 degrees?”
  - E.g., „What is the temperature in the North-West sector?”
- There can be different SQDDP variants depending on the applications.

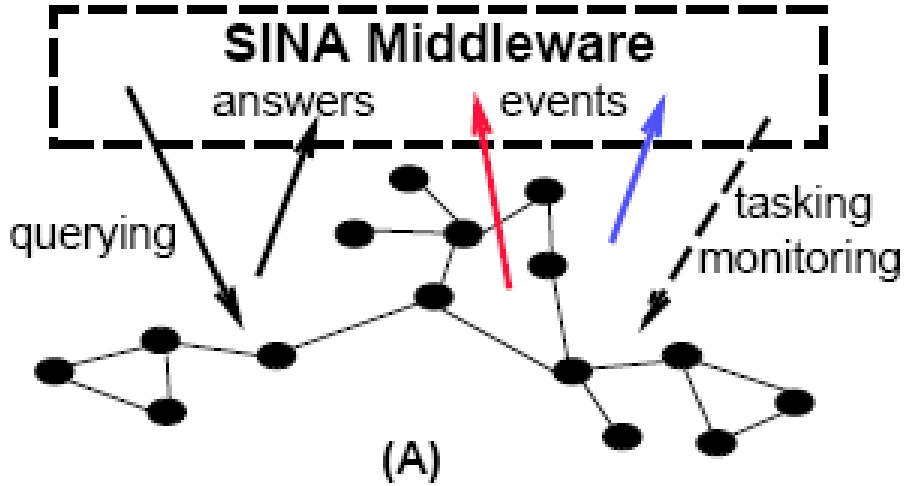
SINA and applications

- SINA = Sensor Information Networking Architecture
- Abtraction: The sensor network is seen as the collection of distributed objects (database!).
- SINA middleware



SINA architecture

- The role of SINA middleware: it makes possible for the applications to...
  - initiate queries,
  - distribute tasks,
  - collect answers and results,
  - monitor the network state.



SINA, SQTL

- SINA = Sensor Information Networking Architecture
  - SINA middleware
  - SINA architecture
  - SINA components
  - SINA query
- SQTL = Sensor Query and Tasking Language
  - SINA is part of the architecture