Enabling technologies for wireless sensor networks

The technologies used in WSN.

- Building such wireless sensor networks has only become possible with some fundamental advances in enabling technologies.

Miniaturization of hardware

- First and foremost among these technologies is the miniaturization of hardware.
- Smaller feature sizes in chips have driven down the power consumption of the basic components of a sensor node.
- This is particularly relevant to microcontrollers and memory chips as such, but also, the radio modems, responsible for wireless communication, have become much more energy efficient.
- Reduced chip size and improved energy efficiency is accompanied by reduced cost, which is necessary to make redundant deployment of nodes.

Sensing Equipment

- The actual sensing equipment is the third relevant technology.
- However, it is difficult to generalize because of the vast range of possible sensors.
- The basic parts of a sensor node have to accompanied by power supply.
- This requires, depending on application, high capacity batteries that last for long times, that is, have only a negligible self-discharge rate, and that can efficiently provide small amounts of current.
- Ideally, a sensor node also has a device for **energy scavenging**, recharging the battery with energy gathered from the environment - solar cells or vibration-based power generation.
- Such a concept requires the battery to be efficiently chargeable with small amounts of current, which is not a standard ability.
- Both batteries and energy scavenging are still objects of ongoing research.
- The counterpart to the basic hardware technologies is software.
- The division of tasks and functionalities in a single node is done by the architecture of the operating system or runtime environment.
- This environment has to support simple retasking, cross-layer information exchange, and modularity to allow for simple maintenance.
- This software architecture on a single node has to be extended to a network architecture, where the division of tasks between nodes, not only on a single node and also to structure interfaces for application programmers.

Applications of sensor networks

The applications of WSN in detail.

Some of the most important applications of WSN include:

Disaster relief applications

- A typical scenario is wildfire detection: Sensor nodes are equipped with thermometers and can determine their own location.
- These sensors are deployed over a wildfire, for example, a forest, from an airplane.
- They collectively produce a "temperature map" of the area or determine the perimeter of areas with high temperature that can be accessed from the outside by firefighters equipped with Personal Digital Assistants (PDAs).
- Similarly control of accidents in chemical factories.
- In military applications, where sensors should detect enemy troops rather than wildfires.
- In such an application, sensors should be cheap enough to be considered disposable since a large number is necessary; lifetime requirements are not particularly high.

Environment control and biodiversity mapping

- WSNs can be used to control the environment with respect to chemical pollutants - a possible application is garbage dump sites.
- Another example is the surveillance of the marine ground floor; an understanding of its erosion processes is important for the construction of offshore wind farms.
- Also to gain an understanding of the number of plant and animal species that live in a given habitat (biodiversity mapping).

Intelligent buildings

- Buildings waste vast amounts of energy by inefficient Humidity, Ventilation, Air Conditioning usage.
- A better, real-time, high-resolution monitoring of temperature airflow, humidity, and other physical parameters in a building by means of a WSN
- It can increase the comfort level of inhabitants and reduce the energy consumption.
- In addition, such sensor nodes can be used to monitor mechanical stress levels of buildings in seismically active zones.
- By measuring mechanical parameters like the bending load of girders, it is possible through WSN whether it is still safe to enter a given building after an earthquake. It is a considerable advantage for rescue personnel.
- Similar systems can be applied to bridges. Other types of sensors might be geared toward detecting people enclosed in a collapsed building and communicating such information to a rescue team.

Facility management

- In the management of facilities larger than a single building, WSNs also have a wide range of possible applications.
- Simple examples include keyless entry applications where people wear badges that allow a WSN to check which person is allowed to enter which areas of a larger company site.
- This example can be extended to the detection of intruders.
- Vehicles that pass a street outside of normal business hours. A wide area WSN could track such a vehicle's position and alert security personnel - this application shares many

commonalities with corresponding military applications.

- WSN could be used in a chemical plant to scan for leaking chemicals.

Machine surveillance and preventive maintenance

- One idea is to fix sensor nodes to difficult to- reach areas of machinery where they can detect vibration patterns that indicate the need for maintenance.
- Examples for such machinery could be robotics or the axles of trains. Other applications in manufacturing are easily conceivable.
- The main advantage of WSNs here is the cable free operation, avoiding a maintenance problem in itself and allowing a cheap, often retrofitted installation of such sensors.

Precision agriculture

- Applying WSN to agriculture allows precise irrigation and fertilizing by placing humidity/soil composition sensors into the fields.
- Similarly, pest control can profit from a high-resolution surveillance of farm land.
- Also, livestock breeding can benefit from attaching a sensor to each pig or cow, which controls the health status of the animal (by checking body temperature, step counting, or similar means) and raises alarms if given thresholds are exceeded.

Medicine and health care

- The use of WSN in health care applications is a potentially very beneficial.
- Possibilities range from post operative and intensive care, where sensors are directly attached to patients.
- The advantage of doing away with cables is considerable to the long-term surveillance of (typically elderly) patients and to automatic drug administration (embedding sensors into drug packaging, raising alarms when applied to the wrong patient, is conceivable).
- Also, patient and doctor tracking systems within hospitals can be literally life saving.

Logistics

- In several logistics applications, it is possible to equip goods (individual parcels, for example) with simple sensors that allow a simple tracking of these objects during transportation or facilitate inventory tracking in stores or warehouses.

Telematics

- Partially related to logistics applications are applications for the telematics context, where sensors embedded in the streets or roadsides can gather information about traffic conditions. Such a so called “intelligent roadside”

It could also interact with the cars to exchange danger warnings about road conditions or traffic jams ahead.