Lecture Two

Wireless Sensor Networks

2^{nd} class

Dr. Mehdi Ebady Manaa

WSN NETWORK ARCHITECTURES AND PROTOCOL STACK

Sensing is a technique used to gather information about a physical object or process, including the occurrence of events (i.e., changes in state such as a drop in temperature or pressure). An object performing such a sensing task is called a sensor. For example, the human body is equipped with sensors that are able to capture optical information from the environment (eyes), acoustic information such as sounds (ears), and smells (nose). These are examples of remote sensors, that is, they do not need to touch the monitored object to gather information.

A ***sensor*** is a device that translates parameters or events in the physical world into signals that can be measured and analyzed. Another commonly used term is transducer, which is often used to describe a device that converts energy from one form into another. A sensor, then, is a type of transducer that converts energy in the physical world into electrical energy that can be passed to a computing system or controller. Figure (1) shows a typical wireless sensor network setup with central monitoring.

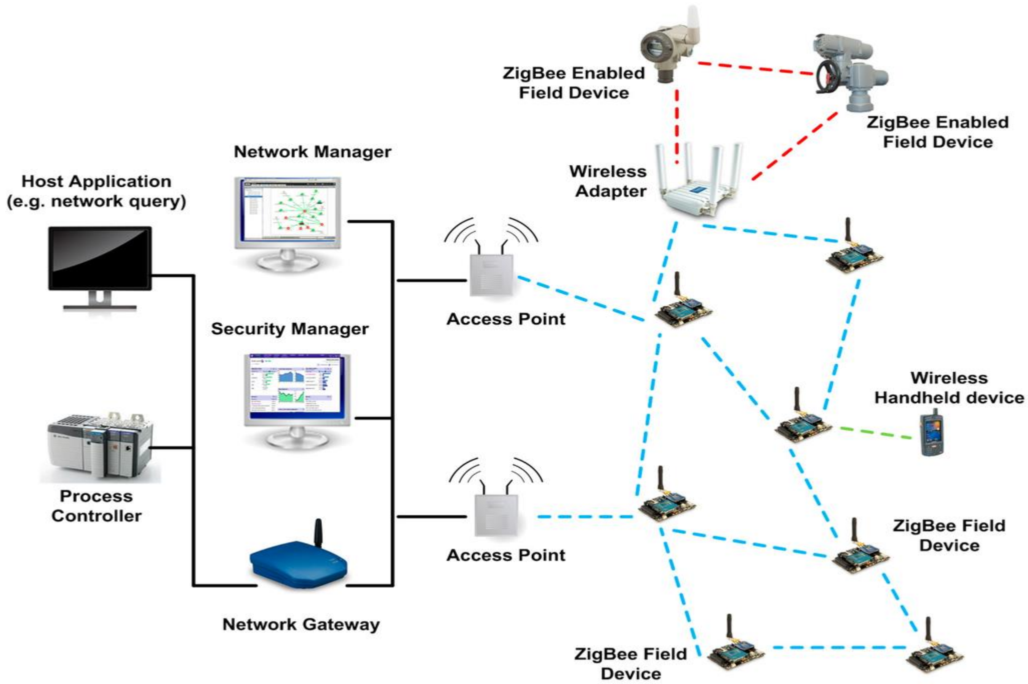


Figure 1: A typical view of WSN with central monitoring

The protocol stack for WSNs consists of five protocol layers: ***the physical layer***, ***data link layer***, ***network layer***, ***transport layer***, and ***application layer***, as shown in Figure 2 .

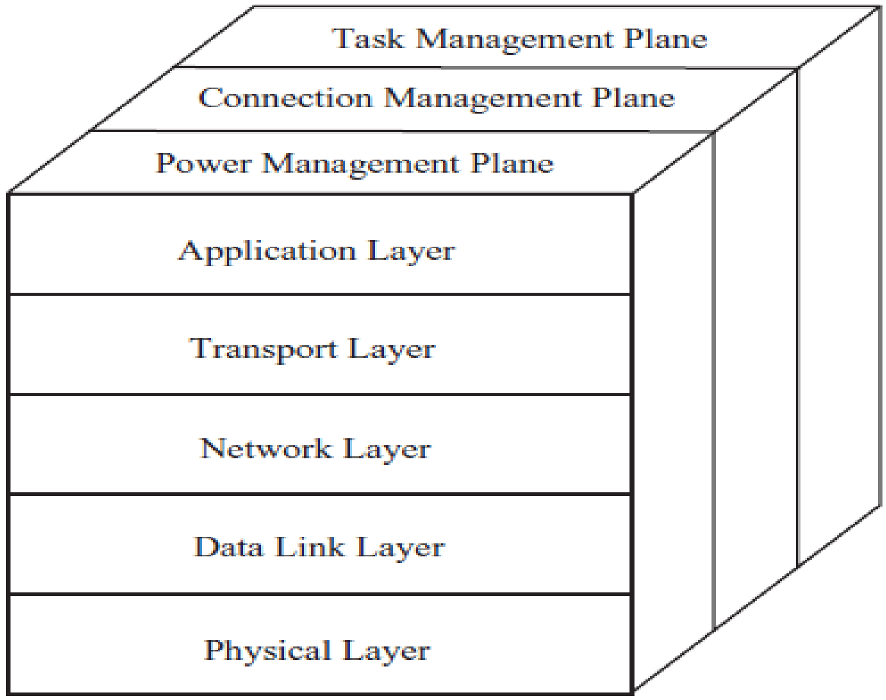


Figure 1: Protocol Stack for WSN

1. Application Layer

The application layer contains a variety of application layer protocols to generate various sensor network applications. This layer performs various sensor network applications, such as:

1. query dissemination.
2. node localization
3. time synchronization, and
4. network security.

For example, the **Sensor Management Protocol** (SMP) is an application – layer management protocol that provides software operations to perform a variety of

tasks, for example, exchanging location − related data, synchronizing sensor nodes, moving sensor nodes, scheduling sensor nodes, and querying the status of sensor nodes.

The Sensor Query and Tasking Language (SQTL) provides a sensor programming language used to implement middleware in WSNs

2. Transport Layer

The transport layer is responsible for reliable data delivery required by the application layer between sensor nodes and the sink(s). Due to the energy, computation, and storage constraints of sensor nodes, traditional transport protocols cannot be applied directly to sensor networks without modification.

For example, the conventional end − to − end retransmission − based error control and the window – based congestion control mechanisms used in the transport control protocol (TCP) cannot be used for sensor networks directly because they are not efficient in resource utilization.

In addition, data delivery in sensor networks primarily occurs in two directions:

1. **Upstream** in this type, the sensor nodes transmit their sensed data to the sink(s).
2. **Downstream**. In the downstream, the data originated from the sink(s), for example, queries and commands binaries, are sent from the sink(s) to the source sensor nodes. The data flows in the two directions may have different reliability requirements.

3. Network Layer

The network layer is responsible for routing the data sensed by source sensor nodes to the data sink(s).

In general, a source node can transmit the sensed data to the sink either directly via ***single − hop long – distance*** wireless communication or ***via multihop short − distance*** wireless communication.

In this case, to send the sensed data to the sink, a source node must employ a routing protocol to select an energy − efficient multihop path from the node itself to the sink.

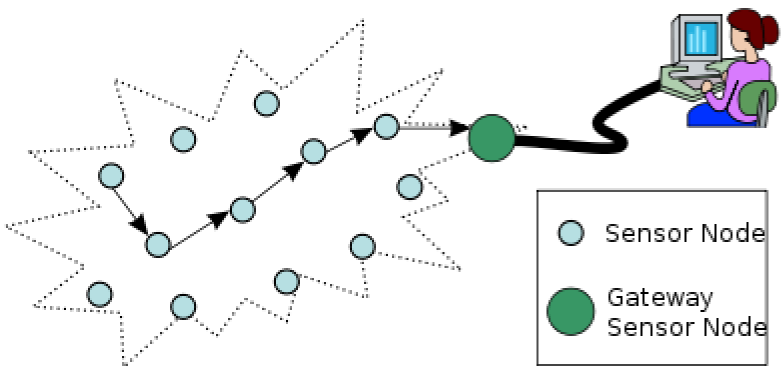


Figure 2: Finding an optimal path

Q/ Are the traditional routing protocols work with WSN?

1. Traditional wireless networks protocols are not suitable for sensor networks because they do not consider energy efficiency as the primary concern.
2. Also, data from the sensing region toward the sink exhibit a unique many − to − one traffic pattern in sensor networks. Thus, The combination of multihop (i.e., hop − by − hop) and many − to – one communications results in a significant increase in transit traffic intensity and thus packet congestion, collision, loss, delay, and energy consumption as data move closer toward the sink.

4. Data Link Layer

The data link layer is responsible for data stream multiplexing, data frame creation and detection, medium access, and error control in order to provide reliable point − to − point and point − to − multipoint transmissions.

One of the most important functions of the data link layer is medium access control (MAC). The primary objective of MAC is to fairly and efficiently share the shared communication resources or medium among multiple sensor nodes in order to achieve good network performance in terms of energy consumption, network throughput, and delivery latency.

Q/ are MAC protocols for traditional wireless networks work with WSN?

It cannot be applied directly to sensor networks without modification because they do not take into account the unique characteristics of sensor networks, in particular, the energy constraint.

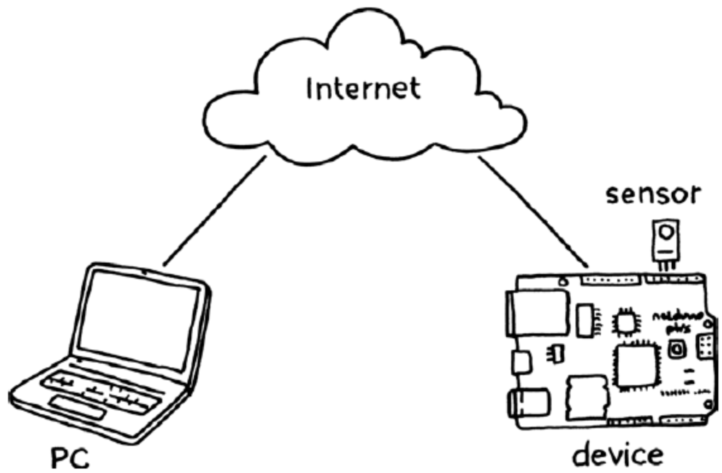
Another important function of the data link layer is ***error control*** in data transmission. In many applications, a sensor network is deployed in a harsh environment where wireless communication is error prone.

5. Physical Layer

The physical layer is responsible for converting bit streams from the data link layer to signals that are suitable for transmission over the communication medium. For this purpose, it must deal with various related issues, for example, transmission medium and frequency selection, carrier frequency generation, signal modulation and detection, and data encryption. In addition, it must also deal with the design of the underlying hardware, and various electrical and mechanical interfaces.

Link Layer determines how the data is physically sent over the network's physical layer or medium . (e.g copper wire, coaxial cable, or a radio wave).

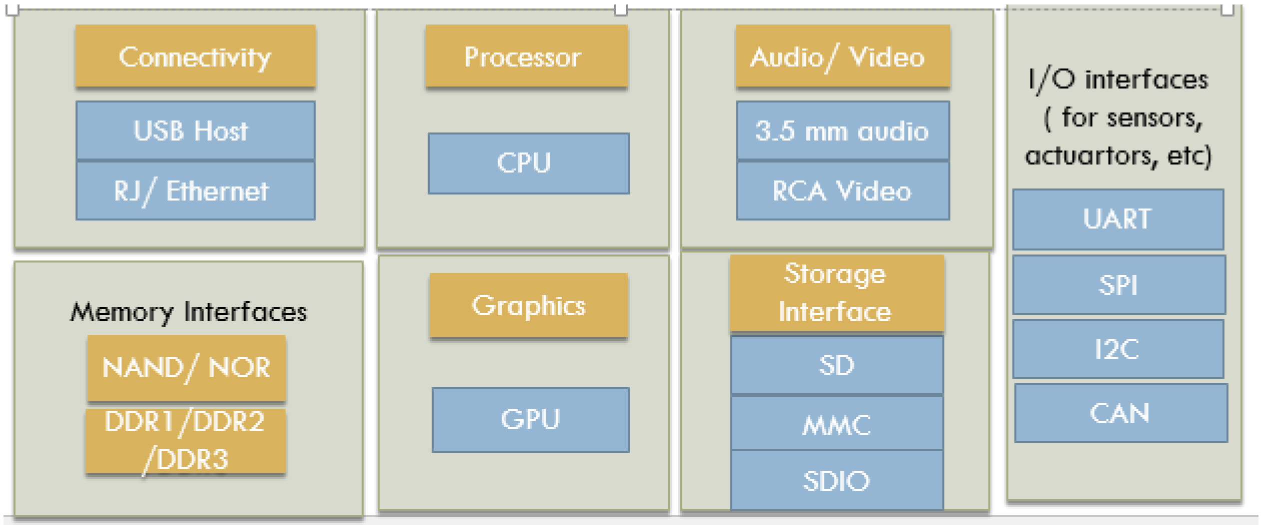
The term Internet of Things generally refers to scenarios where network connectivity and computing capability extends to objects, sensors and everyday items not normally considered computers, allowing these devices to generate, exchange and consume data with minimal human intervention. There is, however,no single, universal definition.



The Internet of Things (IoT) is an important topic in technology industry, policy, and engineering circles and has become headline news in both the specialty press and the popular media.

The term ***"Internet of Things" (IoT)*** was first used in 1999 by British technology pioneer Kevin Ashton to describe a system in which objects in the physical world could be connected to the Internet by sensors. Today, the Internet of Things has become a popular term for describing scenarios in which Internet connectivity and computing capability extend to a variety of objects, devices, sensors, and everyday items.

The "Things" in IoT usually refers to IoT devices which have unique identities and can perform remote sensing, actuating, and monitoring capabilities. Iot devices can exchange data with other connected devices and applications. (directly or indirectly) or collect data from other device and process data either locally or send the data to the other devices.



An IoT devices consists of several interfaces for connection to other devices:

1. I/O interfaces for sensors
2. Interfaces for Internet Connectivity
3. Memory and storage interfaces
4. audio/ video interfaces

Link layer has many protocols in Internet of Things Sensor.

- **802.3 Ethernet**

  IEEE 802.3 standard is collection of wired Ethernet standards for the link layer.

❖ IEEE 802.3 standard for the using of ***coaxial cable*** as shared medium.

❖ IEEE 802.3i standard for the using of copper ***twisted-pair connections*** .

❖ IEEE 802.3j standard for the using of copper ***fiber optic connections***.

❖ IEEE 802.3ae standard for the using of copper **10 Gbit/s over *fiber optic connections***.

- **802.11- Wi-Fi**

  IEEE 802.11 standard for LAN, for example.

- 802.11a operats in the 5GHz band,
- 802.11 b and 802.11 g operate in the 2.5 GHz
- 802.11n operates in the 2.41/5 GH
- 802.11 ac operates in the 5 GHz

These standards provide data rates from 1Mb/s up to 6.75 Gb/s

6. Management planes

On the other hand, the protocol stack can be divided into a group of management Planes across each layer: including power, connection, and task management planes.

a. ***The power management plane*** is responsible for managing the power level of a sensor node for sensing, processing, and transmission and reception, which can be implemented by employing efficient power management mechanisms at different protocol layers. For example, ***at the MAC layer***, a sensor node can turn off its transceiver when there is no data to transmit and receive. ***At the network layer***, a sensor node may select a neighbor node with the most residual energy as its next hop to the sink.

b. ***The connection management plane*** is responsible for the configuration and reconfiguration of sensor nodes to establish and maintain the connectivity of a network in the case of node deployment and topology change due to node addition, node failure, node movement, and so on.

c. ***The task management plane*** is responsible for task distribution among sensor nodes in a sensing region in order to improve energy efficiency and prolong network lifetime.