MODULE 3

CHAPTER 3

The Core IoT Functional Stack

Syllabus

Layer 1 - Things : Sensors and Actuators Layer, Layer 2 - Communications Network Layer, Access Network Sublayer, Gateways and Backhaul Sublayer, Network Transport Sublayer, IoT Network Management Sublayer, Layer 3 - Applications and Analytics Layer, Analytics Vs. Control Applications, Data Vs. Network Analytics, Data Analytics Vs. Business Benefits, Smart Services.

3.1 LAYER 1 : THINGS: SENSORS AND ACTUATORS LAYER

GQ. Explain things: Sensors and Actuators layer ? **(4 Marks)**

"**Smart Objects : The 'Things' in IoT,**" provides more in-depth information about smart objects. From an architectural standpoint, the variety of smart object types, shapes, and needs drive the variety of IoT protocols and architectures. One architectural classification could be :

(1) **Battery-powered or power-connected :** This classification is based on whether the object carries its own energy supply or receives continuous power from an external power source.

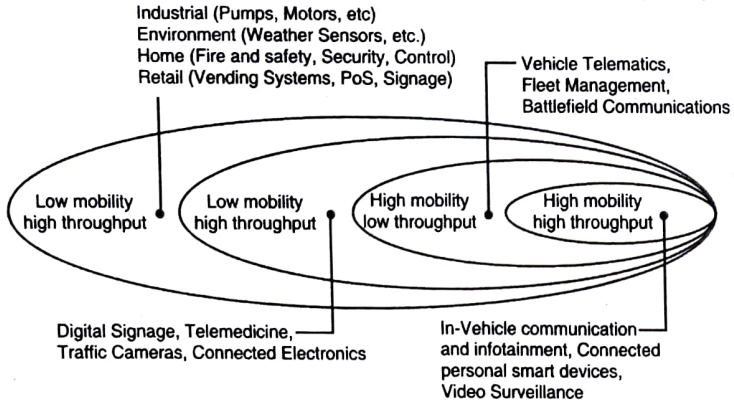
(2) **Mobile or static :** This classification is based on whether the "thing" should move or always stay at the same location. A sensor may be mobile because it is moved from one object to another or because it is attached to a moving.

(3) **Low or high reporting frequency :** This classification is based on how often the object should report monitored parameters. A rust sensor may report values once a month. A motion sensor may report acceleration several hundred times per second.

(4) **Simple or rich data :** This classification is based on the quantity of data exchanged at each report cycle.

(5) **Report range :** This classification is based on the distance at which the gateway is located. For example, for your fitness band to communicate with your phone, it needs to be located a few meters away at most.

(6) **Object density per cell :** This classification is based on the number of smart objects (with a similar need to communicate) over a given area, connected to the same gateway.



(1C1)**Fig. 3.1.1 : Example of Sensor Applications Based Mobility and Throughput**

Fig. 3.1.1 provides some examples of applications matching the combination of mobility and throughput requirements.

3.2 LAYER 2 : COMMUNICATIONS NETWORK LAYER

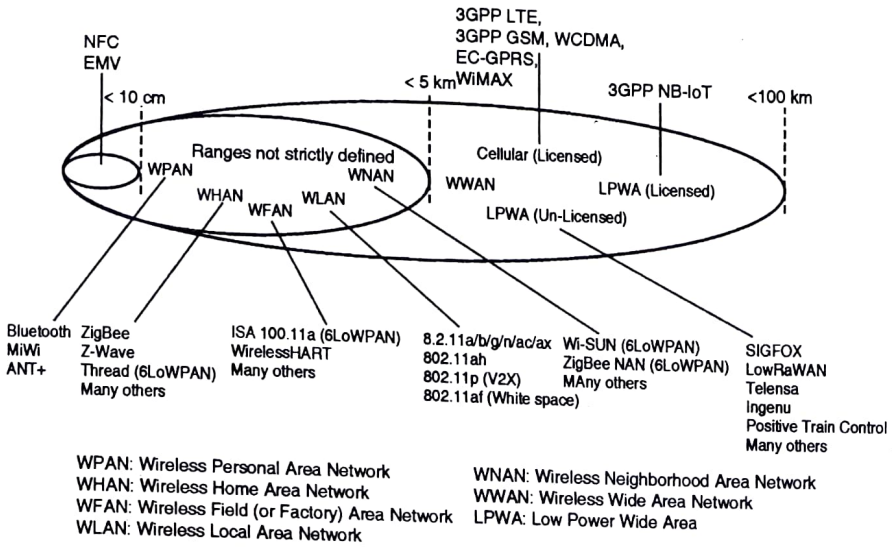
GQ. Explain Communication Network Layer. **(4 Marks)**

- Once you have determined the influence of the smart object form factor over its transmission capabilities (transmission range, data volume and frequency, sensor density and mobility), you are ready to connect the object and communicate.
- Compute and network assets used in IoT can be very different from those in IT environments. The difference in the physical form factors between devices used by IT and OT is obvious even to the most casual of observers.
- What typically drives this is the physical environment in which the devices are deployed. What may not be as inherently obvious, however, is their operational differences.
- The operational differences must be understood in order to apply the correct handling to secure the target assets.

☞ Access Network Sublayer

GQ. Explain Access Network Sublayer. **(4 Marks)**

- There is a direct relationship between the IoT network technology you choose and the type of connectivity topology this technology allows.
- Each technology was designed with a certain number of use cases in mind (what to connect, where to connect, how much data to transport at what interval and over what distance).
- These use cases determined the frequency band that was expected to be most suitable, the frame structure matching the expected data pattern (packet size and communication intervals), and the possible topologies that these use cases illustrate.
- One key parameter determining the choice of access technology is the range between the smart object and the information collector.
- Fig. 3.2.1 lists some access technologies you may encounter in the IoT world and the expected transmission distances.



(1C2)**Fig. 3.2.1 : Access Technologies and Distances**

Range estimates are grouped by category names that illustrate the environment or the vertical where data collection over that range is expected. Common groups are as follows :

(1) **PAN (personal area network) :** Scale of a few meters. This is the personal space around a person. A common wireless technology for this scale is Bluetooth.

(2) **HAN (home area network) :** Scale of a few tens of meters. At this scale, common wireless technologies for IoT include ZigBee and Bluetooth Low Energy (BLE).

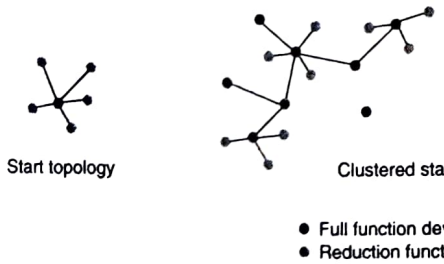
(3) **NAN (neighborhood area network) :** Scale of a few hundreds of meters. The term NAN is often used to refer to a group of house units from which data is collected.

(4) **FAN (field area network) :** Scale of several tens of meters to several hundred meters. FAN typically refers to an outdoor area larger than a single group of house units. The FAN is often seen as "open space" (and therefore not secured and not controlled).

(5) **LAN (local area network) :** Scale of up to 100 m. This term is very common in networking, and it is therefore also commonly used in the IoT space when standard networking technologies (such as Ethernet or IEEE 802.11) are used.

Similar ranges also do not mean similar topologies. Some technologies offer flexible connectivity structure to extend communication possibilities:

☞ **Point-to-point topologies Point-to-multipoint**



(1C3)**Fig. 3.2.2 : Star and Clustered Star Topologies**

☞ **Comparison of the main solutions from an architectural angle.**

Technology	Type and Range	Architectural Characteristics
Ethernet	Wired, 100 m max	Requires a cable per sensor/sensor group; adapted to static sensor position in a stable environment; range is limited; link is very reliable
Wi-Fi (2.4 3Hz, 5 GHz)	Wireless, 100 m (multipoint) to a few kilometers (P2P)	Can connect multiple clients (typically fewer than 200) to a single AP; range is limited; adapted to cases where client power is not an issue (continuous power or client battery recharged easily); large bandwidth available, but interference from other systems likely; AP needs a cable
802.1lah (Halo W, Wi-Fi in sub-1 GHz)	Wireless, 1.5 km (multipoint), 10 km (P2P)	Can connect a large number of clients (up to 6000 per AP); longer range than traditional Wi-Fi; power efficient; limited bandwidth; low adoption; and cost may be an issue
WiMAX(802.16)	Wireless, several kilometers (last mile), up to 50 km (backhaul)	Can connect a large number of clients; large bandwidth available in licensed spectrum (fee-based); reduced bandwidth in license-free spectrum (interferences from other systems likely) : adoption varies on location
Cellular (for example, LTE)	Wireless, several kilometers	Can connect a large number of clients; large bandwidth available; licensed spectrum (interference-free; license-based)

3.3 LAYER 3 : APPLICATIONS AND ANALYTICS LAYER

- Once connected to a network, your smart objects exchange information with other systems.
- As soon as your IoT network spans more than a few sensors, the power of the Internet of Things appears in the applications that make use of the information exchanged with the smart objects.

Analytics Versus Control Applications

Multiple applications can help increase the efficiency of an IoT network. Each application collects data and provides a range of functions based on analyzing the collected data. It can be difficult to compare the features offered. From an architectural standpoint, one basic classification can be as follows :

(1) Analytics application

- This type of application collects data from multiple smart objects processes the collected data, and displays information resulting from the data that was processed.
- The display can be about any aspect of the IoT network from historical reports, statistics, or trends to individual system states.
- The important aspect is that the application processes the data to convey a view of the network that cannot be obtained from solely looking at the information displayed by a single smart object.

(2) Control application

- This type of application controls the behavior of the smart object or the behavior of an object related to the smart object. For example, a pressure sensor may be connected to a pump.
- A control application increases the pump speed when the connected sensor detects a drop in pressure. Control applications are very useful for controlling complex aspects of an IoT network with a logic that cannot be programmed inside a single IoT object, either because the configured changes are too complex to fit into the local system or because the configured changes rely on parameters that include elements outside the IoT object.

Data Versus Network Analytics

Analytics is a general term that describes processing information to make sense of collected data. In the world of IoT, a possible classification of the analytics function is as follows:

(1) Data analytics

GQ. Short note on Data Analytics. **(2 Marks)**

- This type of analytics processes the data collected by smart objects and combines it to provide an intelligent view related to the IoT system. At a very basic level, a dashboard can display an alarm when a weight sensor detects that a shelf is empty in a store.
- In a more complex case, temperature, pressure, wind, humidity, and light levels collected from thousands of sensors may be combined and then processed to determine the likelihood of a storm and its possible path .

(2) Network analytics

GQ. Short note on Network Analytics. **(2 Marks)**

- Most IoT systems are built around smart objects connected to the network. A loss or degradation in connectivity is likely to affect the efficiency of the system. Such a loss can have dramatic effects. For example, open mines use wireless networks to automatically pilot dump trucks.
- A lasting loss of connectivity may result in an accident or degradation of operations efficiency (automated dump trucks typically stop upon connectivity loss). On a more minor scale, loss of connectivity means that data stops being fed to your data analytics platform, and the system stops making intelligent analyses of the IoT system.

Data Analytics Versus Business Benefits

- Data analytics is undoubtedly a field where the value of IoT is booming. Almost any object can be connected, and multiple types of sensors can be installed on a given object.
- Collecting and interpreting the data generated by these devices is where the value of IoT is realized.

☞ Smart Services

- The ability to use IoT to improve operations is often termed "smart services." This term is generic, and in many cases the term is used but its meaning is often stretched to include one form of service or another where an additional level of intelligence is provided.
- Smart services can also be used to measure the efficiency of machines by detecting machine output, speed, or other forms of usage evaluation.
- Smart services can be integrated into an IoT system. For example, sensors can be integrated in a light bulb. A sensor can turn a light on or off based on the presence of a human in the room

Chapter Ends...

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MODULE 4

CHAPTER 4

Application Protocols for IoT

Syllabus

The Transport Layer, IoT Application Transport Methods, Application Layer Protocol Not Present SCADA - Background on SCADA, Adapting SCADA for IP, Tunneling Legacy SCADA over IP Networks, SCADA Protocol Translation, SCADA Transport over LLNs with MAP-T, Generic Web-Based Protocols, IoT Application Layer Protocols – CoAP and MQTT.