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Chapter Four: Internet of Things (IoT)

4.1. Overview of IoT

- important features of IoT:

- **AI**

- IoT essentially makes virtually anything “smart” with the power of data collection, artificial intelligence algorithms, and networks

- **Connectivity**

- IoT networking - networks between its system devices
- Networks are smaller and cheaper scale while still being practical

- **Sensor**

- transform IoT from a standard passive network of devices into an active system capable of real-world integration

- **Active Engagement**

- active content, product, or service engagement

- **Small Devices**

- Devices have become smaller, cheaper, and more powerful over time

- purpose-built small devices to deliver its precision, scalability, and versatility

4.1.1. What is IoT?

- IoT is the networking of smart objects, huge number of devices intelligently communicating in the presence of internet protocol that cannot be directly operated by human beings
- smart objects have some constraints such as limited bandwidth, power, and processing accessibility for achieving interoperability among smart objects
- IoT is a framework of all things that have a representation in the presence of the internet in such a way that new applications and services enable the interaction in the physical and virtual world in the form of Machine-to-Machine (M2M) communication in the cloud.

IoT= Services+ Data+ Networks + Sensors

Generally

- IoT is the network of physical objects or "things" embedded with electronics, software, sensors, and network connectivity, which enables these objects to collect and exchange data
- IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction

- IoT is a network of devices that can sense, accumulate and transfer data over the internet without any human intervention
- Simply stated, the Internet of Things consists of any device with an on/off switch connected to the Internet
- IoT systems allow users to achieve deeper automation, analysis, and integration within a system
- IoT utilizes existing and emerging technology for sensing, networking, and robotics. IoT exploits recent advances in software, falling hardware prices, and modern attitudes towards technology

4.1.2. History of IoT

Development necessary component for developing the Internet of Things:

- ✓ first radio voice transmission took place on June 3, 1900
- ✓ development of computers began in the 1950s
- ✓ The Internet, itself a significant component of the IoT, started out as part of DARPA in 1962 and evolved into ARPANET in 1969
- ✓ Global Positioning Satellites (GPS) became a reality in early 1993, Satellites and landlines provide basic communications for much of the IoT
- ✓ IPV6's remarkably intelligent decision to increase address space
 - The Internet of Things, as a concept, wasn't officially named until 1999. One of the first examples of an Internet of Things is from the early 1980s and was a Coca Cola machine
 - By the year 2013, the Internet of Things had evolved into a system using multiple technologies

- Kevin Ashton, the Executive Director of Auto-ID Labs at MIT, was the first to describe the Internet of Things, during his 1999 speech.
- Kevin Ashton stated that Radio Frequency Identification (RFID) was a prerequisite for the Internet of Things. He concluded if all devices were “tagged,” computers could manage, track, and inventory them
- To some extent, the tagging of things has been achieved through technologies such as digital watermarking, barcodes, and QR codes

4.1.3. IoT – Advantages

1. Improved Customer Engagement

- ✓ to achieve richer and more effective engagement with audiences.

2. Technology Optimization

- ✓ aid in more potent improvements to technology
- ✓ IoT unlocks a world of critical functional and field data

3. Reduced Waste

- ✓ IoT provides real-world information leading to the more effective management of resources

4. Enhanced Data Collection

- ✓ It allows an accurate picture of everything

4.1.4. IoT – Disadvantages

- 1) potential that a hacker could steal confidential information
- 2) likelihood of every connected corruption due to a bug in the system
- 3) difficult for devices from different manufacturers to communicate with each other

- 4) millions of IoT devices; collecting and managing the data from all those devices will be challenging.

4.1.5. Challenges of IoT

- list of some its major issues:

a. Security

- ✓ IoT creates an ecosystem of constantly connected devices communicating over networks
- ✓ The system offers little control despite any security measures
- ✓ It leaves users exposed to various kinds of attackers.

b. Privacy

- ✓ sophistication of IoT provides substantial personal data in extreme detail without the user's active participation.

c. Complexity

- ✓ complicated in terms of design, deployment, and maintenance

d. Flexibility

- ✓ Concern about IoT system to integrate easily with another because of several conflicting or locking systems

e. Compliance

- ✓ Its complexity makes the issue of compliance seem incredibly challenging

4.2. How does it work?

4.2.1. Architecture of IoT

- IoT device consists of hardware, software, network connectivity, and sensors
- four major components:

1. Sensing Layer

- It identify any phenomena in the devices' peripheral and obtain data from the real world
- It is consists of several sensors
- Sensors in IoT devices are usually integrated through sensor hubs
 - **sensor hub**: a common connection point for multiple sensors that accumulate and forward sensor data to the processing unit of a device
 - **Actuators**: intervene to change the physical conditions that generate the data.
 - ✓ Example: actuator might shut off a power supply, adjust airflow valve
- Sensors in IoT devices can be classified into three:
 - A.Motion Sensors**
 - measure the change in motion as well as the orientation of the devices
 - two types of motions
 - linear motion - refers to the linear displacement of an IoT device
 - angular motion - rotational displacement of the device
 - B.Environmental Sensors**
 - sense the change in environmental parameters in the device's peripheral
 - such as **Light sensors**, **Pressure sensors**, etc

- It help the devices to take autonomous decisions according to the changes of a device's peripheral

C.Position sensors

- deal with the physical position and location of the device
- The two common position sensors
 - Magnetic sensors - used as digital compass and help to fix the orientation of the device display
 - Global Positioning System (GPS) - for navigation purposes

2. Network Layer

- Act as a communication channel to transfer data, collected in the sensing layer, to other connected devices
- allow data flow between other devices within the same network
- implemented by using diverse communication technologies (e.g., Wi-Fi, Bluetooth, etc.)

3. Data Processing Layer

- takes data collected in the sensing layer and analyses the data to make decisions based on the result
- In some IoT devices it also saves the result of the previous analysis to improve the user experience
- It may share the result of data processing with other connected devices via the network layer

4. Application Layer

- implements and presents the results of the data processing layer to accomplish disparate applications of IoT devices
- It is user-centric layer that executes various tasks for the users
- Example: smart transportation, smart home, personal care, etc

4.2.2. Devices and Networks

- Every device talks to other related devices in an environment to automate home and industrial tasks, and to communicate usable sensor data to users, businesses and other interested parties
- devices can be categorized into three main groups: consumer, enterprise and industrial
 - Consumer connected devices - smart TVs, smart speakers, toys, wearables, smart appliances
 - industrial and enterprise IoT devices - smart meters, commercial security systems, smart city technologies
- IoT network typically includes a number of devices with constrained resources (power, processing, memory, among others) and some of those devices may be massively deployed over large areas whereas others may be deployed in hard-to-reach areas
- The efficient management of IoT networks requires considering both the constraints of low power IoT devices and the deployment complexity of the underlying communication infrastructure

- IoT landscape is depicted by an increasing number of connected devices characterized by their **heterogeneity** and the **presence of resources constrained networks**.
- **Developing an IoT network management solution** is not an easy task because of the intrinsic constraints of IoT networks (architecture, technologies, physical layer)
 - ✓ it is necessary to **take into account** several elements such as **scalability**, **interoperability**, **energy efficiency**, **topology control**, **Quality of Service (QoS)**, **fault tolerance**, and **security**
- **M4DN.IoT (Management for Device and Network in the Internet of Things)**
 - ✓ It is **platform** for IoT networks and devices management
 - ✓ integrates and controls the individual functionalities of the devices in an IoT network as well as the **status and characteristics of the network**
 - ✓ defines a management structure in two scopes
 - **local management** - the **platform** runs in the **same environment as the devices**
 - **remote management** – the **platform** controls the **devices in different networks**
 - ✓ structure of the platform is **expandable**, allowing the addition of new **types of network devices or applications**
 - ✓ the platform provides **standard web services**, such as **device discovery**, **data storage**, and **user authorities**, which are basic requirements for creating IoT applications

4.3. IoT Tools and Platforms

IoT Platform

➤ KAA

- Manage an unlimited number of connected devices
- Set up cross-device interoperability
- Perform real-time device monitoring
- Perform remote device provisioning and configuration
- Collect and analyze sensor data
- Analyze user behavior and deliver targeted notifications
- Create cloud services for smart products

➤ SiteWhere

- Run any number of IoT applications on a single SiteWhere instance
- Spring delivers the core configuration framework
- Add devices through self-registration
- Integrates with third-party integration frameworks such as Mule any point
- Default database storage is MongoDB
- Eclipse Californium for CoAP messaging
- InfluxDB for event data storage
- Grafana to visualize SiteWhere data

➤ ThingSpeak

- Collect data in private channels
- Share data with public channels
- MATLAB analytics and visualizations

- Alerts
- Event scheduling
- App integrations
- Worldwide community

➤ **DeviceHive**

- Directly integrate with Alexa
- Visualization dashboard of your choice
- It supports Big data solutions such as ElasticSearch, Apache Spark, Cassandra and Kafka for real-time and batch processing
- Connect any device
- It comes with Apache Spark and Spark Streaming support.
- Supports libraries written in various programming languages, including Android and iOS libraries
- It allows running batch analytics and machine learning on top of your device data

➤ **Zetta**

- Supports a wide range of hacker boards
- Zetta allows you to assemble smartphone apps, device apps, and cloud apps

➤ **ThingsBoard**

- Real-time data visualization and remote device control
- Customizable rules, plugins, widgets and transport implementations
- Allows monitoring client-side and provision server-side device attributes.
- Support multi-tenant installations out-of-the-box.

- Supports transport encryption for both MQTT and HTTP(s) protocols.

4.4. Applications of IoT

❖ Agriculture

- indoor planting
 - ✓ monitoring and management of micro-climate conditions
- outside planting
 - ✓ sense soil moisture and nutrients, in conjunction with weather data
 - ✓ better control smart irrigation and fertilizer systems
 - ✓ prevents wasting a precious resource

❖ Consumer Use

- ✓ in the form of wearables and smart homes
- ✓ make life easier
- Wearables – Fitbit, smartphones, smart watches, health monitors
- Smart homes
 - house is at peak comfort
 - Security is made more accessible
 - ✓ Ability to control to control appliances
 - ✓ activating a smart lock

❖ Healthcare

- ✓ wearable IoT devices let hospitals monitor their patients' health at home
- ✓ In hospitals, smart beds
- ✓ Putting IoT sensors on critical equipment means fewer breakdowns and increased reliability

- sensors can also determine if a patient has fallen or is suffering a heart attack

❖ Insurance

- ✓ Insurance companies can offer their policyholders discounts for IoT wearables such as Fitbit
- ✓ By employing fitness tracking, the insurer can offer customized policies and encourage healthier habits, which in the long run benefits everyone, insurer, and customer alike.

❖ Manufacturing

- ✓ RFID and GPS technology can help a manufacturer track a product from its start to its placement in the destination store, the whole supply chain
- ✓ Sensors attached to factory equipment can help identify bottlenecks in the production line, thereby reducing lost time and waste
- ✓ track the performance of the machine, predicting when the unit will require maintenance, thereby preventing costly breakdowns

❖ Retail

- ✓ Online and in-store shopping sales figures can control warehouse automation and robotics, information gleaned from IoT sensors; Much of this relies on RFIDs
- ✓ IoT can help analyze mall traffic so that stores located in malls can make the necessary adjustments that enhance the customer's shopping experience while reducing overhead
- ✓ IoT helps retailers target customers based on past purchases
- ✓ a retailer could craft a personalized promotion for their loyal customers

❖ **Transportation**

- ✓ The GPS is being utilized to help transportation companies plot faster and more efficient routes for trucks hauling freight, thereby speeding up delivery times
- ✓ city planners can also use that data to help determine traffic patterns, parking space demand, and road construction and maintenance

❖ **Utilities**

- ✓ IoT sensors can be employed to monitor environmental conditions such as humidity, temperature, and lighting
- ✓ The information provided by IoT sensors can aid in the creation of algorithms that regulate energy usage and make the appropriate adjustments
- ✓ With IoT-driven environmental control, businesses and private residences can experience significant energy savings
- ✓ On a larger scale, data gathered by the Internet of Things can be used to help run municipal power grids more efficiently
- ✓ sensors can help pinpoint outages faster, thereby increasing the response time of repair crews and decreasing blackout times

4.4.1. IoT Based Smart Home

- Smart Home initiative allows subscribers to remotely manage and monitor different home devices from anywhere via smartphones or over the web with no physical distance limitations
- These “smart” devices have the potential to share information with each other given the permanent availability to access the broadband internet connection

- **Remote Control Appliances:**
 - ✓ Switching on and off remotely appliances
 - ✓ avoid accidents and save energy
- **Weather:**
 - ✓ Displays outdoor weather conditions with the ability to transmit data over long distances
- **Smart Home Appliances:**
 - ✓ Refrigerators - telling what's inside, food that's about to expire and with all the information available on a smartphone app
 - ✓ Washing machines - monitor the laundry remotely
 - ✓ Kitchen - allowing remotely adjustable temperature control and monitoring the oven's self-cleaning feature
- **Safety Monitoring:**
 - ✓ cameras, and home alarm systems
- **Intrusion Detection Systems:**
 - ✓ Detection of window and door openings and violations to prevent intruders
- **Energy and Water Use:**
 - ✓ Energy and water supply consumption monitoring to obtain advice on how to save cost and resources, & many more

4.3.2. IoT Based Smart City

- ✓ In cities, the development of smart grids, data analytics, and autonomous vehicles will provide an intelligent platform to deliver innovations in
 - energy management

- traffic management
- security
- **Structural Health:**
 - ✓ Monitoring of vibrations and material conditions in buildings, bridges and historical monuments
- **Lightning:**
 - ✓ intelligent and weather adaptive lighting in street lights
- **Safety:**
 - ✓ Digital video monitoring
 - ✓ fire control management
 - ✓ public announcement systems
- **Transportation:**
 - ✓ Smart Roads and Intelligent High-ways with warning messages and diversions according to climate conditions and unexpected events like accidents or traffic jams.
- **Smart Parking:**
 - ✓ Real-time monitoring of parking spaces
 - ✓ residents able to identify and reserve the closest available spaces
- **Waste Management:**
 - ✓ Detection of rubbish levels in containers to optimize the trash collection routes
 - ✓ Garbage cans and recycle bins with RFID tags allow the sanitation staff to see when garbage has been put out

4.3.3. IoT Based Smart Farming

➤ **Green Houses:**

- ✓ Control micro-climate conditions to maximize the production of fruits and vegetables and its quality

➤ **Compost:**

- ✓ Control of humidity and temperature levels in alfalfa, hay, straw, etc
- ✓ prevent fungus and other microbial contaminants

➤ **Animal Farming/Tracking:**

- ✓ Location and identification of animals grazing
- ✓ Study of ventilation and air quality in farms
- ✓ detection of harmful gases from excrements

➤ **Offspring Care:**

- ✓ Control of growing conditions of the offspring in animal farms to ensure its survival and health

➤ **Field Monitoring:**

- ✓ Reducing spoilage and crop waste