Unit 4 20

Q1. Illustrate diff issues & needs with standardization of IoT protocol.

ans. Standardization is an effort to bring conformity with an established way of doing something especially in order to ensure consistency & regularity.

needs:

1. Interoperability: biggest pro of standardisation is interoperability with other IoT products & existing devices & protocols.
Ex: based on whether both geyser & AC could work.

2. Avoid vendor lock in: ensures you're not stuck with a vendor that uses proprietary tech or protocols such that it is hard to move away from it w/o incurring big expenses.
Ex: ~~we~~ shouldn't have to replace your previous appliances from with the appliances from new vendor whose home automation sys you purchased.

3. Economy to scale: Choosing std components could provide economies of scale for IoT device manufacturers
Ex: : supplies of bluetooth & WiFi's h/w components do not need to customise components for matching the IoT device's requirement, overall cost reduces

4. Focus on application: IoT developers & device manufacturers can just focus ~~of~~ on app" & purpose of device. Instead worrying bout interoperability of device
Ex: you don't worry about connectivity & just assume that it would be available over ethernet, cellular / WiFi

5. Quality & certainity: standardisation provides a sense of quality & certainity to user bgn buying IoT device.
Ex: seeing ISO hallmark gives a sense of satisfaction

Issues / Challenges:

1. Insufficient existing standards: Quite a few stds around IP addressing, M2M, SCADA, etc existed before IoT existed. ∴ they were established w/o considering impacts & requirements of IoT domain ∴ they are not sufficient for all various use cases.

2. lack of a standard body: No single standard body has been established to define stds for all levels of & layers of IoT. Several SDOs (std development orgs.) around the world have published stds only for their chosen scope. but they also don't interoperate fully.

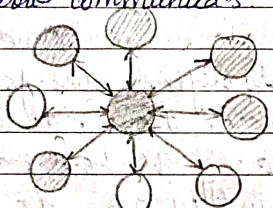
3. Uncertain nature of evolving field: IoT is an evolving & experimenting field & defining stds for it is a bit overwhelming. There might be a lag between what IoT could do & what aspects are covered.

4. Multi dimensional nature of evolving field: IoT involves multiple dimensions - devices, communica" & applica". It makes stdisa" more challenging ∵ you are not only dealing w/ 3 layers but also other factors such as configura", management & performance, resiliency security & privacy.

Q2 Classify diff topology of IEEE 802.15.4 & explain with suitable diagram.

ans: IEEE 802.15.4 LR-WPAN operates in either the

star topology	peer to peer topology
1. communication established between devices & a single central controller aka PAN coordinator	1. Any device can communicate with any other device on PAN w/o going through PAN coordinator
2. device has some associated app & is either the initiation point / termination point for network communication	2. PAN coordinator carries out regular coordinating & manage



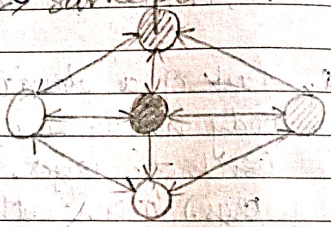
PAN coordinator — Primary controller of PAN

Full function device (FFD)

Reduced function device (RFD)

- all devices on network have unique address aka extended address, device can be assigned a short address during association process
- device will use either of these addresses for communication with PAN.

3. Star topology – usually over small areas.
4. Used – home automation, PC peripherals, games & personal healthcare.



3. Peer to peer allows more complex network formation such as tree / mesh
4. Spans over large area & is suitable for app"s such as industrial control & monitoring, wireless sensor networks, asset & inventory tracking etc.
5. allows multiple hops to route messages from any device to any other device on network.

Q.3. Show use of LoRa using any suitable app dev - smart irrigation - then mention the most appropriate protocol for it w/ explanations

Ans: Use case:

1. Smart irrigation app can utilise ~~Low~~ LoRa wireless communication to control water flow based on soil moisture, temp. & weather data
2. Sensors placed in field collect data & a µC communicates with app to adjust irrigation schedules.

Workflow:

1. sensors gather data & send it to a controller via LoRa (Low range) / BLE (Bluetooth Low Energy)
2. µC processes this data & relays info to the app over Wifi or GSM.
3. app provides real time control & monitoring allowing users to turn water sys on/off & set automated schedules.

Most appropriate protocol for smart irrigation - LoRaWAN

1. low power consumption - perfect for battery powered sensors.
2. long range: covers 15-20 km in rural areas.
3. Scalability: supports multiple nodes (sensors) in same network.
4. Cost effective - no dependency on cellular networks uses unlicensed ISM bands.
5. Data transmission: perfect for low bandwidth apps like sending & moisture readings.

w working principles, applicans

Q4. Classify RFID & SCADA, M2M, WSN protocol (w advs & disadvs)

ans: aspect	RFID	SCADA	M2M	WSN
1. working principle	Uses Electromagnetic field to read/write data from RFID tags	Centralized monitoring via sensors & RTUs	Direct communica" betw machines using networks	distributed sensors collect & transmit data wirelessly.
2. applica"	Asset tracking, inventory management, access control	Industrial automation, power grids, oil & gas monitoring	IoT devices, smart homes, healthcare monitoring	Environmental monitoring, disaster management, agriculture
3. Range	Short range (a few meters)	Wide Area networks	Variable - dependes on communica" channel	limited range per node, but scalable via multiple nodes
4. Power consump"	Low (passive tags) Moderate (active tags)	moderate - high (sensors sys)	medium - high (depend on appl & control)	very low for individual nodes, higher for gateways
5. Security	vulnerable to eavesdropping & skimming	requires strong cyber- to avoid hacking	Faces challenges like data interception	Prone to jamming, spoofing & interception
6. standards	-ISO/IEC 18000 (RFID air interface) -EPCglobal for supply chain	-IEC 60870 for telecontrol -IEC 62351 (security)	- ETSI TS 102690 & 3GPP stds - focuses on standardization like ONEM2M	-IEEE 802.15.4 for low rate Wireless PAN (LoRaWPAN) -Zigbee & 6LoWPAN for WSN communica"
7. advs	- contactless communica" - fast, efficient & durable - Works w/o line of sight	- Real time data proc" - centralized control - scalable for large sys.	- Enables automa" - reduces human intervention - Uses diverse channels	- cost effective & scalable - Low power usage - flexible for large scale deployments
8. disadvs	- limited range - high setup cost - affected by metal/liquids	-high cost - vulnerable to cyber attacks - complex integration	- high power usage - security issues - lack of standiza"	- limited range & bandwidth - vulnerable to attacks - signal interference
9. Best use case	Inventory tracking, toll sys.	Industrial process, Utilities management	smart homes, Industrial IoT	agriculture, disaster managemen & EVS.

Q5. Illustrate various IoT apps devcd using IP based protocol.

ans: 1. Smart home app:
Ex: smart lighting, smart thermostats, voice assistants
Protocols used:
HTTP/HTTPS: communicn with cloud services.
CoAP: resource constrained devices like sensors.
MQTT: light weight messaging devices.
features: remote control via apps
real time notifications
Energy optimizn

2. Smart Healthcare:
Ex: wearable devices, remote patient monitoring sys
Protocols used:
HTTP/HTTPS: secure data transmission to healthcare portals.
MQTT: reliable light weight telemetry data transfer
Web socket: real time monitoring dashboards
features: tracks health metrics
alerts healthcare professionals for critical conditions
improves patient care efficiently.

3. Smart agri
Ex: precision farming, automated irrigan sys
Protocols used:
CoAP: resource constrained soil & water sensors
LoRaWAN-IP: long range communicn
MQTT: telemetry data from farm devices
features: monitors soil health & weather conditions.
optimizes water usage.
increases crop yield using data analytics

4. Industrial IoT (IIoT)
Ex: predictive maintenance, smart factories
Protocols used:
OPC UA over IP : industrial communica"
HTTP/HTTPS: cloud integration
MQTT : real time machine telemetry
features: reduces downtime through predictive analysis
real time M2M communica"
Enhances produc" efficiency.

5. Smart Cities:
Ex: smart parking sys, waste management using IoT, smart traffic lights
Protocols used:
IPV6 : scalability for large sensor network
CoAP : energy efficient communica" for sensors.
Websocket: real time traffic updates & dashboard control.
features: reduces traffic congestion
optimizes waste collect ~~cost~~ schedules.
Enhances public safety.

Q.6. Show with suitable reasons why zigbee is popular than WiFi & Bluetooth in IoT.

ans: Zigbee - very low cost, very low power consuming, 2-way, wireless communican stds based on IEEE 802.15.4 std.

Reasons why zigbee is more popular.

1. Low power consumption:
   - consumes less power compared to WiFi & Bluetooth making it ideal for IoT devices requiring long battery life.
2. Mesh networking:-
   enables seamless communica" among multiple devices over large areas which WiFi & Bluetooth struggle with.
3. Scalability: Zigbee can handle upto 65000 devices in single network, far exceeding Bluetooth & WiFi capabilities for IoT ecosys.
4. Cost effective: lowers implementa" & maintenance cost makes zigbee more economical for large scale IoT apps.
5. Reliability in low data rate:
   optimized for low data rate apps such as sensors & smart home devices where WiFi's high throughput is unnecessary.
6. Interference management: operating on less crowded channels, it experiences minimal interference compared to WiFi & Bluetooth ensuring stable connec".
7. Designed for IoT: created for IoT apps, it excels in ~~this~~ where energy efficiency & scalability are paramount

Q7. Classify all 8 network layer protocols used in IoT & explain in brief.

Ans

Protocol	frequency range	range	data rate	topologies	applications
1. Bluetooth	2.4 GHz	10m - 100m	upto 1MBPS	point to point & mesh	to send small amt of data to smart/personal devices like speaker, earphones, smart watches etc & Home automat
2. Zigbee	2.4 GHz	100m	250 KBPS	star, mesh, cluster tree	transmit small amt of data within small ranges. & smart homes, industries
3. 6LoWPAN IPv6 low Power PAN	900 - 2400 MHz	~~25~~	250 KBPS	star, mesh	
4. Wireless LAN - WiFi		50m - 30 km (outdoor & private antennas)	54 MBPS - 600 MBPS	mostly bus.	smart home, cities, offices
5. LoRaWAN Long Range WAN		2.5 km - 15 km	0.8 - 50 KBPS		smart city, supply chain management
6. LTE-M Long term Evolution for Machines	1.4 - 5 MHz		4 MBPS		
7. Sigfox	900 MHz	3 - 50 km	max - 1 KBPS.		min power consumption
8. cellular / mobile network 2G, 3G, 4G, 5G	900 Hz - 1.8/1.9/2.1 GHz	35 km - 200 km	35 - 170 KBPS		used when wide area coverage req with consumes high power - not for IoT. only used with IoT connected cars.

Q8. What is 6LoWPAN & its EPC standardization

Ans: 1. IPv6 over Low Power Wireless Personal Area Network
2. It is an open std defined in base IETF std RFC 4944 & updated in several RFCs such as 6282, 6775, 8025, 8066.
3. It was originally designed to support IEEE 802.15.4 low power wireless networks in 2.4 GHz band. It now supports wide range of networking media
4. features:
IPv6 support:
Adaption layer compresses IPv6 headers & fragments packets to fit the limited MTU of IEEE 802.15.4
Mesh networking: ∴ wide coverage & multihop communication
Energy efficiency

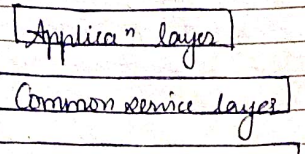
Electronic Product Code (EPC) standards:
1. They are mainly related to RFID & supply chain management but interact with 6LoWPAN in IoT where tracking & communication are integrated

Object Naming Service (ONS): links EPC data to internet resources.
EPC Info Services (EPCIS): manages & shares data collected via EPC enabled devices

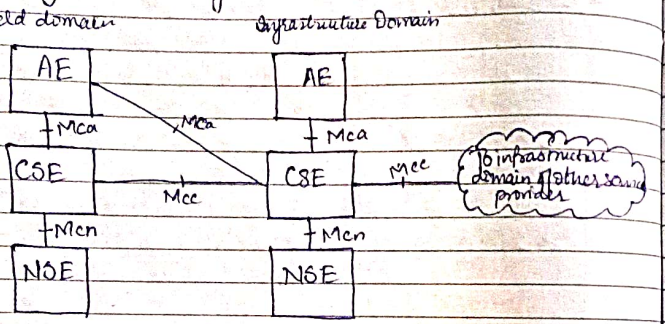
Q.9 Explain RFID, SCADA, M2M, WSN protocol standards

1. M2M protocol standards :

ONEM2M technical specifica" describes the funcal archi for oneM2M



layered model for End to End (E2E) M2M services.



High level oneM2M funcal archi

AE = Applican Entity = Entity in applica" layer that implements an M2M applica" logic can be resident in no. of M2M nodes &/or ≥ one on single M2M node.

Ex: fleet tracking, remote blood sugar trending app.

CSE = common service Entity = represent instantiation of set of 'common service funcs' of M2M envis. Such service funcs are exposed to other entities through Mca & Mcc ref points

Ex: data management, device management

Underlying Network Service Entity (NSE): provides services from underlying network to the CSEs

Ex: device management, location services, device triggering

Reference points: consist of ≥1 interfaces of any kind.

1. Mca = communica" flows btwn AE & CSE across M2M communica" applican interface Mca: enable AE to use services provided by CSE & CSE communicate with AE.

2. Mcc = M2M communica" service interface communica" flows btwn 2 CSEs, enable CSE to use services supported by another CSE

3. Mcn = M2M communica" network service interface communica" flows btwn CSE & NSE - enables CSE to use supported devices provided by NSE

4. Mcc' = M2M communica" service interface communica" flows btwn 2 CSE in Infrastructure nodes that are 1 M2M compliant & resides in diff M2M service provider domain

WSN protocol standards:

std name	usage
ISA 100	Traditional industrial envis
Wireless HART	"
Bluetooth low Energy	Scientific, user space IoT or medical envis
Zigbee	"
WiFi direct	"
EnOcean	"

SCADA protocol stds:

1. C37.1-2007 - IEEE std for SCADA & Automation sys.
   - defines process of substation integration as the design process that is foundation for substation automation
   - funcnal & envi reqs are provided for all Intelligent Electronic Devices (IEDs) located in sys.
   - purpose is to provide guidance to engineers responsible for the design & specifica" of SCADA & automation sys
2. International Society of Automation (ISA):
   - helps automation projectionals streamline process & improve industry safety, efficiency & portability.
   - since 1949, ISA has been recognised as expert source for automation & control sys consensus.

RFID protocol stds:

std. development org	RFID stds.
ISO (International Standards Org)	- ISO/IEC 29160 - RFID for item management (item level)
	- ISO/IEC 15961 - data protocol for RFID management
	- ISO/IEC 24791 - RFID for item management - sfw sys infrastructure
	- ISO 17367 - supply chain apps for RFID - prod. tagging
	- ISO 24631 - RFID for animals.

EPC global:
- Identifican
- Tag Data std (TDS)
- Tag Data Transla" (TDT)
- RFID Air interfaces
- UHF gen2 Air interfaces
- HF Air interface
- RFID sfw interfaces
- low level reader protocol (LLRP)
- Discovery configura" & Initialisa" (DCI)
- Reader management (RM)
- Applica" level event (ALE)
- Implementation guidelines
- GS1 RFID identifica" of pulp prods guidelines
- RFID based Electronic Article Surveillance (EAS) data
- Technical implementa" guide
- RFID based EAS - strategic overview
- Tagged item performance protocol (TIPP) guidelines

Q10. What is MQTT (in detail).

ans: Message Queuing Telemetry Transport (MQTT)
- is an open OASIS & ISO std.
- client server publish/subscribe messaging transport protocol
- light weight, open, simple & designed to be easy to implement
- ideal for: M2M & IoT where small footprint is req. & network bandwidth is a challenge.
- protocol runs over TCP/IP / over other network protocols that provide ordered, lossless, bi-directional

It provides:
1. Pub-Sub capabilities
2. Messaging transport that doesn't depend on content of payload
3. 3 qualities (levels) of service of message delivery
   - At most once: delivered du to best efforts of operati
   - At least once: messages are sure to arrive but duplicates
   - Exactly once: messages are assured to arrive exactly on
4. A small transport overhead & protocol exchanges minimised to reduced network traffic
5. A mechanism to notify interested parties when an abnormal disconnect occurs.

Q11. Explain MODBUS protocol in detail:- features, funcns, communicaⁿs modes in Industrial IoT apps.

ans: MODBus is an applicaⁿ layer messaging protocol.
It provides a standardized way to communicate between devices on diff types of networks.

Features:
1. Master-slave archi: master device communicates with multiple slave devices (SCADA sys)
2. Interoperability: Works across various diff ~~form~~ devices from diff manufacturers
3. Data simplicity: uses simple read/write commands for data exchange.
4. Multiple variants: Modbus RTU, ASCII & TCP/IP.
5. Supports for diff data types: handles discrete & analog data like coils, regis & i/o statuses.

Functions:
1. read coils/discrete ips: retrieves binary data.
2. read IO regis: reads analog i/o values.
3. Write single/multiple coils: sets binary o/ps.
4. Write single/multiple regis: sets analog values in regis
5. Diagnostics: provides error detection & status reporting

Transmission / Communication modes:

attribute	RTU mode	ASCII mode
1. Every device must support	yes (mandatory)	no (optional)
2. default mode	yes	no
3. Performance	High	low
4. Each byte	Has 2 hex-chars	needs 2 ASCII chars.
5. max frame size.	256 bytes	255 bytes.
6. diagram:	Slave address | Func code | data | CRC 1byte | 1byte | 0-252byte | 2bytes	Slave address | Func code | data | LRC 1byte | 1byte | 0-252byte | 1byte.
	Binary representation Uses CRC for error checking Efficient for slow serial links	Human readable format Uses longitudinal Redundancy Check (LRC) for error checking

Importance / use of Modbus in Industrial IoT / anywhere:

1. Device integration: seamlessly connect sensors, actuators, PLCs etc
2. Data collection: collects real time data from sys.
3. Remote monitoring: ~~facilitates~~ facilitates remote operation in SCADA & IoT
4. Energy management: monitors energy usage in smart grids
5. Predictive maintenance: retrieves machine health data to predict failure
6. Interoperability: connects legacy sys to IoT via gateways