M2M	IoT
* Point-to-point connection b/w machines of using wired/wireless	* IP network connections
* All about machines	* All about things.
* older protocols & communication techniques	* Varying new protocols specifically developed for IoT protocols such as 6LoWPAN.
* hardware-based.	* hardware & software.
* less built-in intelligence.	* more intelligent form of machine communications
* Limited scalability.	* High scalability.
* Internet connection is not required.	* Is required.
* Business-to-Business (B2B)	* B2B, B2C.

Chapter-3

Wireless Sensor Networks.

* Group of sensors that are deployed in a area with a purpose of collecting the data regarding the surrounding environment.
* Small network consisting of few nodes forming a large scale network that can monitor vast areas without human interventions.
* A node in WSN is self contained unit consisting of the sensor, trans-receiver, power supply & microcontroller.
* The data received by node is sent to the base station by routing through other sensors in multi-hop fashion.
* It also depends on topology of WSN.
* A bidirectional WSN used to control nodes & remotely interact & help for custom data acquisition.
* The cost & size of sensor nodes depends on the application it designed, on-board memory storage, power supply, frequency of sending & receiving the data.
* various sensors (visual, radar, seismic, magnetic, Infrared, thermal, acoustic) (VRSMITA) they have various constraints like computational capabilities, energy consumption among speed etc.
* Self organised is important characteristic of WSN which enables the nodes to configure the self based on the requirements of particular application where human intervention is not possible.
* Challenges of WSN are - power limitation, less memory, communication network constraints - No GUI/displays
* Categories of WSN services - Monitoring, Alerting, Information on Demand, Actuating.

① monitoring - WSN are deployed in order to monitor the surrounding environment
Ex- WSN is deployed for precision agriculture collects the data regarding the temperature wind speed & humidity.
- WSN is also deployed for water quality testing, measure various elements like dissolved Oxygen & sends information twice a day.

③ Alerting:
* WSN nodes are deployed in a drastic prone areas. These WSN nodes are subscribed to send alerts when the measured parameter, crossed a certain threshold value.
Ex: • alerts can be issued from Tsunami monitoring WSN deployed in ocean.
• WSN nodes deployed for preventing landslides. 10m threshold for flood monitoring

③ Information on demands:
* WSN can provide the information regarding the required information on features.
* soil moisture values can be quered at particular position.
* Arithmetic, boolean, logical operations can be performed on collected data.

④ Actuating:
* WSN system can send the signal & change the behaviour of external system based on the environment it displayed.
Ex: sensing weather conditions by WSN will trigger & GPS location can be shared.
* Activating a sensor inorder to capture the required data.

Characteristics of WSN:
• The WSN nodes can be used for monitoring unattended physical environment

① Energy efficient
② Low cost
③ Computational power
④ Communication capabilities.
⑤ Cross-layer design.
⑥ distributed sensing and processing
⑦ Security & privacy.
⑧ Dynamic network topology
⑨ multi-hop communication.
⑩ self-organisation
⑪ Application oriented.
⑫ Robust operation.
⑬ small size

① Energy efficient:
* If the power run out of sensor node then it can't monitor the surrounding.
* so efficient algorithms & protocols are used to designing the WSNs.
* Imp things for designing the WSN are-
- The power source of WSN are Battery oriented.
- Lifetime of sensor node depends upon battery lifetime. Sometimes a nearby station can also be used to charge the battery.
- Lifetime should be high.
- main utility of power is for sensing, communication & computation

② Low cost:
* many sensors are used in order to monitor a place. The cost be low as much as possible.

③ Computational capabilities:
* WSN have limited computational capabilities & decided by cost, size and energy.

④ Communication capabilities:
* Radio signals are used for communication, the communicational channel may be either unidirectional (or) bidirectional.

⑤ Cross layer Design:
* This type of design is recently used in wireless communication, it provides the data rate, energy efficient, QoS.
* In traditional layered approach -
- data can't be communicated among different layers leads to incomplete information.
- Dynamically changes environment can't be acquired by WSN.

⑥ Distributed Sensing & processing:
* To enable robustness & resilence, the sensor nodes in a WSN are distributed randomly & uniformly.
* A sensor node sends the data to Node which is capable of collecting, processing, aggregating & sending the data.

⑦ Security & privacy: should provide safety & security of the data.

⑧ Dynamic network topology:
* The capability of self-replacement with new ones (or) addition of new nodes.

⑨ Multi-hop communication:
* A node requires to communicate with other nodes, a base station, a multi-hop route is needed.

⑩ Self organisation:
* The sensor nodes should have the capability of self-organise to fit in a distributed topology to form a optical performance.
Ex: If node gets fail, then system should be itself replace with new one & it should adjust with the current topology & support communication.

⑪ Robust Operation:
* They nodes should have self testing, self-configurating, self-repairing.

⑫ Application oriented:
* depends on specific application.

Types of WSN:
* These are classified based on Application environment.
① multimedia ③ Terrestrial ⑤ Underground
② mobile ④ Underwater

① multimedia WSN:
* These WSNs are used when monitoring & tracking requires the multimedia.
* sensor nodes attached with camera & microphone. The nodes are connected with each other, form a network for data preprocessing like data retrieval, correction & compression.
* requires high bandwidth & energy.

② Mobile WSN:
* The collection of sensor nodes that can move on their own and interact with surrounding environment are called "mobile WSN"
* communication & computation capabilities. As sensors move, cover more surroundings, better energy, efficiency and channel capacity.

③ Terrestrial WSN:-

* These sensor nodes are capable of communication with base stations.
* Many large no of nodes are used to cover the terrain for effective mapping.
* The deployment structure requires 2D, 3D or grid for performance & efficiency.
* The nodes have the limited power for solar panels are used as additional source. The energy is managed by optimal routing, monitoring delays, low density cycles, etc.

④ Underwater WSN:-

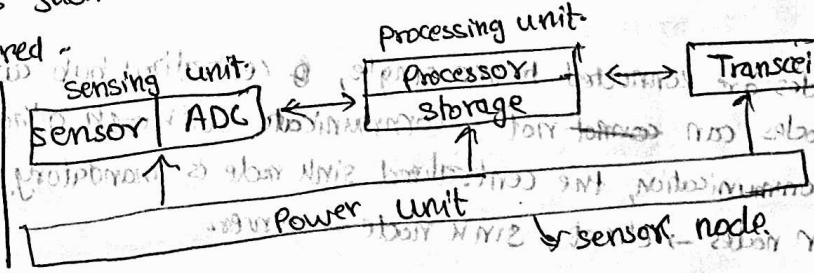
* WSN which is deployed under the water is known as "Underwater WSN".
* Limitations are propogational delay, bandwidth & sensor node failure.
* Main issue of designing is energy conservation.
* The data is collected from these nodes by using autonomous underwater vehicle.
* In marine system, drifting and moored buoys are used to measure various marine biological parameter.

⑤ Underground WSN:-

* mainly designed for subsurface region.
* main applications are precision agriculture, landslides.
* cost is high due to high maintenance, careful planning.
* for data transfering from underground additional nodes are also needed on surface in order to communicate with base station.
* Difficult to recharge them & signal from node may get attenuated.

Architectural Design of WSN:-

* WSN architecture is different than conventional communication architecture bcoz of resource limitations.
* Doesn't follow OSI model exactly.
* sensor node consists of the sensing unit, processing unit and power unit along with transceiver.
* key features such as low cost, fault tolerance & low energy consumption is considered.



Layers:-
Application,
Transportation,
Network, Datalink.

Sensing Unit:-

* It consists of sensor which is selected based on the application and the ADC.

Communication unit:-

* Transceiver — trasmitter + receiver.
* Communication done by network protocols. A suitable communication method is selected.

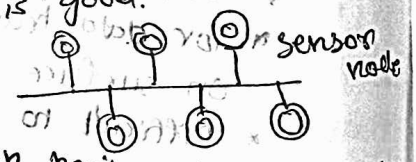
Processing Unit:
* It has operating system & timer. The microcontroller process the data & stores the data.

power unit:
* It provides the energy to the sensor unit. The sensor node life is dependent on life of battery.

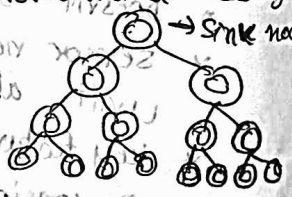
Key goals to be considered while designing the WSN are-
* requirement analysis of application for which WSN is designed
* Quantative analysis
* Understanding & selecting the required technologies that are shifted & required
* Best fit solution development
* Employing power optimal technologies.

Topologies in WSN:
* these are classified into 4 types - star, mesh, one way, Bidirectional
* Different types of WSN are - Bus, mesh, tree, Ring, star, circular, Grid.

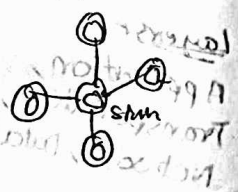
Bus:
* A sensor node sends a broadcast message to all nodes in a network and intended recipitent a message
* It is easy to install but more traffic & congestion
* If nodes number is small, then bus topology is good.



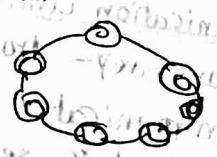
Tree:
* In this, the root node is central hub & acts as main router. The nodes are interconnected to each other.
* It is a combination of star & peer-peer topology.
* For distribution implementation, the tree topology is suitable.
* The intermediate nodes have more burden in order to forward a message & more power loss will happen.
* Leaf nodes → not in routing, load balancing is problem.



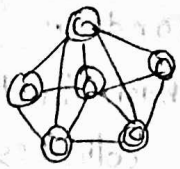
star:
* All nodes are connected to one single, centralized hub called as sink
* The nodes can ~~cannot~~ not communicate with each other.
* For communication, the centralized sink node is mandatory.
* other nodes → client, sink node → server.



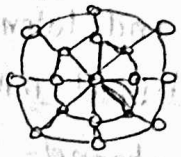
Ring:
* each node have exactly 2 neighbours
* only one direction communication is possible (clockwise/anticlockwise)
* If one node gets damaged, then connection would loss.
* The more congestion if we want to get bidirectional communication.



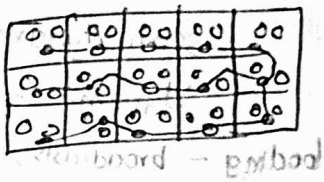
Mesh:
* every node is connected to every other node.
* many paths are possible b/w source & destination.
* It is used for load balancing, reliable



Circular:
* In a circular network, there is circular sensing area & every such sensing area has a single node. The event information is captured by sensor node and single node.
* More efficient, simple to implement.



Grid:
* In the grid network, sensor network field is divided into non-overlapping square grids of same size.
* In each grid, atleast one node should be in active state.
* By turns, the node become active. so life span increases, energy efficient.
* Head node is responsible for routing the information & transmitting the data packets.
* Avoids congestion, fast packet transfer.



WSN communication protocols:
* primary goal is to optimize the network to work in an energy efficient way so that WSN lifetime is increased.

Physical layer :- communication hardware, signal detection, data encryption, freq. generation, modulation.

Datalink layer :- MAC protocols are applied.

Transport layer:- data flow to WSN applications

Network layer:- manages routing of data coming from transport layer.

① Single channel MAC protocols: < Synchronous / Asynchronous

* Synchronization nodes.
S-MAC, T-MAC, RMAC, DW-MAC
* exchange of data happens only in the active time of the node, thus it saves energy.
* asynchronous approach, sender sends a preamble for a period of sleeping of receiver before transmitting the data.

② Asynchronous single channel MAC protocol:
* Each sensor node periodically checks the availability. If medium is busy, it waits further until become idle.
* Sender assumes receiver is not ready. All other consumes energy.
* WiseMAC protocol utilizes the preamble sampling to overcome this problem but buffering time of packet increases, broadcasts the packet.
* dynamic length preambles are used to reduce idle listening time.

(v) Pseudorandom Asynchronous Protocolr
* Uses hash function to decide next wakeup time. so saves energy also collisions reduced.

(iv) Medium Reservation MAC (MRMAC)r
* additional info like NPAT, MRI is present in beacon msg. To reduce end-end latency in msg delivery, collisons reduced.

(vi). Multi-channel MAC protocolsr
Single channel- One channel, capacity, throughput of network is less
multi channel- several channels, divides bandwidth.
* adjacent nodes use diff. channels. Hence collisions reduced.
Three methods for channel assignment.
fixed assignment - cluster approach.
semi-dynamic - each node is assigned to certain channel for transmission & reception.
dynamic - each node is assigned diff. channel after every wakeup schedule
→ Flooding - broadcasts, useless retransmissions, increased collision. not for dense WSN.
→ Gossiping ← non deterministic / probabilistic
* easy to implement, reduces energy loss.
* latency, prop. delay.

Routing protocols in WSNr
* wireless links are unreliable, also consequent node failure is possible

Category	Protocols for WSN
location-based protocol	- MECN, SMECN, GEAR, Span.
data-centric "	- SPIN, COUGAR, EAD, ACQUIRE
Hierarchial "	- LEECH, HEED, TEEN.
mobility-based "	- SEAD, TIDD, joint mobility routing
multipath-based "	- multipath discovery, braided multipath.
Heterogeneity based "	- CHR, CADR, IDSQ.
Qos-based "	- SAS, SPEED.

OS for WSNr less complex.
TinyOS - has event handlers and tasks with run-to-completion semantics, based on event-driven programming model.
Life Os - UNIX like environment, User C-programming language.
Contiki - supports advanced tech such as 6LoWPAN & Protothreads.
RIOT - real time Os & same as contiki
PreonVM - supports java programming, provides 6LoWPAN based on contiki.
* Simulation of WSN by simulators like NS, Opnet, Tes etc.

Security in WSNr
* care dropping, node outrage, msg corruption, node malfunction, denial of service, false node - threats encountered.
* Prone to threats due to infrastructure less architecture and unattended working environment.

Evolution of WSN towards IoT:

* has high heterogeneity bcz there are many proprietary and non-proprietary solutions for diff. applications
* Creating network of things web technologies like AJAX, Javascript, PHP, Ruby, to build applications & share using web mechanisms

Real world WSN applications:

① Healthcare monitoring:

* Sensors like wearable, implanted & environment-embedded devices.
* for body position measurement, finding location, monitoring patients in hospital
* environment embedded can be used for tracking a person for continuous health-diagnosis.
* authenticity & privacy are important.

Area monitoring:

* an appln of WSN wher WSN is deployed over a region as per the application.

Earth / Environmental sensing:

* monitoring physical environment around.

Ex: forest fire detection.

* sensors installed in forest. senses the outbreak of forest.
* sense temp, humidity, dryness, solar index, based on climatic conditions predicted

Air pollution monitoring:

* concentration of dangerous gases is to be monitored with certain frequency to decide air pollution level.
* done by adhoc wireless links. (adhoc wireless network can be made mobile)

Water quality monitoring:

* distributed wireless sensor node network senses diff parameters and decide water quality.
* With this, even unreachable remote places water quality can be checked.

Natural disaster management:

* WSN installed in disaster-prone areas for taking precautionary measures can save lives.

Landslide detection:

* WSN sensor nodes can detect slight movement of soil and changes environmental parameters to detect the possibility.

② Industrial Monitoring:

datacenter monitoring:

* wireless temp. sensors are fitted on racks as many possible to monitor intake & outtake temp. of racks
* mesh network is useful.

data logging:

* live data feed & its logging for useful (when design changes are needed).

Machine health monitoring:
* Some parameters made checked by the sensor network. will help in planning for best performance & long life of machinary.

Wastewater monitoring:
* produced by industrial waste Such water's quality to be monitored before recycling this water for any use.

Structural health monitoring:
* condition of any civil infrastructure can be monitored by WSN. By monitoring diff. geophysical processes in real time using sensor

Wine production:
* Using WSN for maintaining the desired quality of wine.

Chapter-1:

Multidisciplinary nature of IoTs:

* IoT is not related to particular domain. In order to make a single device, all branches are integrated with each other. Developed by multidomain researchers and development teams.

Challenges:

① Technological challenges:

(i) IoT system design considerations:
* variety of protocols are being used by various organisation/ entities to design, develop & implement IoT systems.
* Leading to non-interoperable systems whose integration & access is become very challenge

(ii) Maturity & integration with existing technology:
* Most of IoT technologies have not reached matured phase, but guaranteed to grow in particular direction.
* Integration with existing technologies & overhead due to constant requirement for upgradation of existing hardware.

(iii) Standard operating procedures (SOPs):
* Lack of well understood & standard operating procedures for IoT devices maintenance, response & incident management. These need to be strengthened to streamline the processes involved in IoT systems.

(iv) Security:
* crucial barrier for widespread acceptance of IoT.
* Malicious attacks & hacking of IoT devices can have security nightmare

(i) Authentication & authorization for secure communication:
* authentication enables to establish the identity of various IoT devices deployed in a shared environment, so maintain integrity of IoT device & data
* authorization determines whether an entity has access rights to resources & to what extent.

* Security protocols such as digital certificates & cryptography approaches requires amount of space. so ongoing effort.

(ii) Privacy:

* In case of IoT nodes that are collecting private information, there is a threat to privacy at
  - (↔) endpoints where each IoT node emits the data.
  - ↔ data obtained from networked IoT nodes which are collected, combined & analyzed.

② Connectivity:

* For enabling connectivity in IoT, many technologies are available. in unlicensed spectrum, (LPWPAN), cellular & satellite-based technologies
* connectivity solutions depend on the adaptability to vast array of IoT devices
* Requirement varies in terms of data capture rate, data transmission rate, latency, storage, etc.
* connectivity needs are based on device & its particular characteristics.

③ Societal drivers:

* Issues of privacy & trust are going to be main drivers for wide acceptance of IoT.
* Data captured by device may send only the summary & does not transmit the original raw data.

Privacy by design: starting from fundamental building blocks in IoT system development, privacy is given utmost importance & embedded in each process

④ Uncertain Returns on investment:

* Investment in IoT is very high.

Vision of IoT:

Things perceptive, Standards & Semantics perceptive, Internet perceptive, Social perceptive.