Part B

21. What are the Merits and demerits of energy harvesting systems?

Table 2 Merits and demerits of energy harvesting systems

Type	Source	Power density	Advantage	Disadvantage
Solar energy	Sunlight	mW/cm^2	Limitless availability	Not available during night time
Wind energy	Wind	mW/cm^2	High power received	Availability depends on weather conditions
Piezoelectric energy	Vibration	$\mu W/cm^2$	Both indoor and outdoor applications	Small life span of device
Thermal energy	Heat	$\mu W/cm^2$	Easy to implement	Less power density
RF energy	EM waves	$\mu W/cm^2$	Freely available during day and night	Distance is the limitation

22. What are the challenges in IoT in terms of security?

Security:

- IoT faces some security challenges which are Privacy, Authentication, Trust, Confidentiality, Policy enforcement, Access control, etc.
- Security challenges encountered at different layers of IoT architecture are:

a. Perception Layer: As the perception layer focuses on data collection, security challenges at this layer are Node Capture, Eavesdropping and Interference, False Data Injection, Cryptanalysis and Side Channel, Malicious Code Injection, Replay Attacks, Sleep Deprivation Attacks, etc.

Network Layer: As the network layer focuses on data transmission, security challenges at this layer are related to availability of network resources and wireless networks. These are Denial-of-Service (DoS) Attacks, Man in the Middle Attack, Wormhole Attacks, Sinkhole Attacks, Spoofing Attacks, Routing Information Attacks, Sybil Attacks, Unauthorized Access, etc.

c. Application Layer: As the application layer focuses on service support, challenges faced are related to software attacks. These are Phishing Attack, Malicious Scripts and Virus/worm, etc.

2. Standardization: there is no standard framework, even though many standards for IoT like Zigbee, Wireless Hart, M2M, NFC, ROLL, etc. are evolved.

23. Identify which schemes schedule node state based on the network activity to understate idle listening and explain the same.

Duty Cycling:

Duty cycle of a node is fraction of time for which node remains active during its lifetime.

These schemes schedule node's state based on the network activity to understate idle listening.

These schemes can be divided into three categories: synchronous, asynchronous and semi-synchronous
These approaches have high sleep latency as node has to wait for the receiver to be in active state. Moreover, in some cases, a node cannot broadcast information to all of its neighboring node because they are not awake simultaneously.

24. What algorithm you could suggest if you wanted to distribute the traffic among the pool of available server

The requests from the users contain the details of the resources required.

All the requests are kept in the queue and maintained by the controller.

Ant Colony Optimization algorithm helps to allocate and maintain the cloud services in systematic way.

25. What are the benefits of energy-efficient smart health care system?

- An efficient monitoring and diagnosis can be performed by IoT-enabled healthcare devices.
- The data collected from the sensors will provide doctors a very clear idea about the nature of diseases and lead them to accurate diagnosis.
- Through these efficient IoT devices, a doctor can monitor his patient even remotely.
- Similarly, by utilizing the readings from the IoT sensors, we can regulate the energy usage in a hospital environment.
- By effectively combining the insights from the IoT sensors, we can have an efficient energy usage pattern in a hospital, so as to minimize energy wastage and leap toward energy efficiency

26. How duty cycling could be done for energy optimization?

- Synchronization between various uplink and downlink message slots for different messages in the transmission queue is important to avoid disruption in transmission and intermixing, leading to a corrupted communication.
- we use frequency time division for bandwidth allocation for physical transmission channel known as physical random access channel (PRACH) here.
- This allows us to establish a radio resource control (RRC) that ultimately serves the goal of bandwidth division.
- Connected nodes in this network are informed of availability of PRACH resources through a broadcast or other downlink channels by the evolved node-B (eNB)

PART-C

1. 27.a.i. Is the IoT platform has standard architecture? Justify.
   - Depending upon different application areas of Internet of Things, it works accordingly as per it has been designed/developed. But **it has no standard defined architecture** of working which is strictly followed universally. The architecture of IoT depends upon its functionality and implementation in different sectors.

   b. Describe in detail about the different types of IoT architecture and its comparison

Three-Layer Architecture:

- The three layers in this architecture are: the perception, network and application layers

  Perception Layer: This layer is similar to physical layer in OSI model and also known as “Device Layer”.

- The aim of this layer is identification, tracking, information acquisition, and processing from the environment.
- various types of physical devices and sensors such as Zigbee, Infrared, RFID, QR code, etc. are used to monitor physical world and collect the data.
- Information collected is transmitted to network layer for secure communication

2. Network Layer:

- This layer provides the facility to connect with other smart objects. This layer is also responsible for routing and secure data transmission through Wi-Fi, 3G, infrared, Bluetooth, UMTS, Zigbee, RFID, Satellite, WiMAX, etc.
- IEEE 802.15.4, 6LoWPAN, Zigbee, Z-Wave, etc., are some protocols for secure and reliable communication in IoT.

3. Application Layer:

- The information received from the lower layer is managed by respective management system and services specific to application are delivered to the user

Four Layer Architecture:

- The four layers are enlisted as 1. Perception Layer 2. Network Layer 3. Service Layer 4. Application Layer

Service Layer

- In service layer, various enabling technologies are exploited to ensure the efficient service provision. These technologies are interface, resource management and sharing, middleware and service management

Five-Layer Architecture

- The five layers are enlisted below. 1. Perception Layer 2. Transport Layer 3. Processing Layer 4. Business Layer 5. Application Layer.

1. Transport Layer:

- This layer transmits the collected data from lower layer to upper layer securely and vice versa via 3G, 4G, LAN, Bluetooth, NFC, RFID, etc.

2. Middleware Layer:

- Middleware layer is also known as "Processing Layer". This layer performs service management and data storage
- This layer is capable of making decision based on the results of computational automatically.
- Technologies like databases, big data processing, and cloud computing are employed by this layer.

Business Layer:

- it can make business models, reports, flowcharts, graphs, etc.
- Depending on analysis, it also helps in making more precise decisions about the roadmaps and strategies of business

(OR)

b. Discuss in detail about the different types of antennas

The different types of sensing antenna can be

- Monopole
- dipole
- folded dipole
- Fractal
- Bowtie
- Slot
- and microstrip patch antenna

The antenna must have high gain and multiple radiating band characteristics

Log Periodic Dipole Antenna

- It is an array of dipoles with variation in size and the last dipole is considered as the largest element whereas the first dipole at the front end is the smallest element.

- The antenna elements are connected in parallel to each other and with feedline and it is very commonly used for the purpose of broadcasting.

Bowtie Antenna

- Bowtie Antenna also called as butterfly antenna acts as a high pass filter in the rectenna systems.

Wire Antenna or short dipole antenna

- the size of wire antenna is completely dependent upon the wavelength.
- A short dipole antenna is a very common and simple type antenna with feeding line connected in the center and its length should be less than the one-tenth of the wavelength.
- This antenna is omnidirectional with 90° half-power beamwidth and shows a linear polarization radiation characteristic.

- Dipole Antenna
  - A dipole antenna is an extension of the short dipole and in this antenna, the length of each conductor must be chosen as the quarter wavelength of the operating frequency

Compared to short dipole antenna, the dipole antenna is directional and has a large bandwidth

- Monopole Antenna
  - with single pole and consists of a single conductor generally connected in the perpendicular or vertical direction.
  - antenna size is the half wavelength of the simple dipole antenna
  - The directivity of the monopole antenna is roughly double the length of the antenna.
- Loop Antenna
  - The circumference of the loop determines the antenna efficiency similar to monopole where the conductor length measures the efficiency of the antenna.
- Helical Antenna
  - The helical antenna is having the shape of a helix and is popularly called as traveling wave antenna.
  - Here, D is the diameter of the single turn,

N is the number of turns, H is the height of antenna,
and S is the distance between two consecutive turns

Yagi–Uda Antenna

- This antenna is the most popular antenna type and can be easily seen on the rooftop of the small and large building used mainly for the purpose of broadcasting.

Spiral Antenna

- small size and good sensing capability
- wide bandwidth
- High frequency range of 1–18 GHz is popularly used in lightweight fighter aircraft.

Spiral antennas are derived from dipole antenna by turning its arm either in a circular shape or rectangular shape and their feeding element is present in the center of the antenna

Slot Antenna

- Slot antenna operates well within the frequency range of 300 MHz to 24 GHz.

A slot is basically a cut of any shape or size present on the surface of the antenna

a rectangular slot of dimension a × b is cut from the conducting plane.

Horn Antenna
Mainly, three types of Horn antennas are in practice:

(a) E-plane Horn antenna: the antenna shape is flared in the E-plane axis.

(b) H-plane Horn antenna: the antenna shape is flared in the H-plane axis

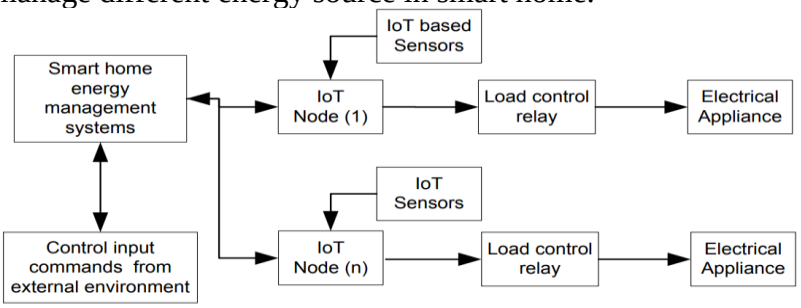
(c) Pyramidal Horn antenna: when the flare is in both E-plane and H-plane axis and this type are most commonly used.

Microstrip Antenna

- The microstrip antenna comprised of a metallic patch on the top, a dielectric substrate beneath the radiating patch and a conducting layer at the bottom known as a ground plane

29. a Design a smart home system and explain the required components for reducing the energy conservation.

- The challenges in smart home solution are automation, effective utilization of sensor data, communication technology and protocols.
- Automation techniques in smart home are the key component in exchanging the data between various end nodes and central control unit.
- Transferring data/command to its destination should reach timely without delay.
- The home automation has various activities such as acquiring data from various sensors, controlling appliance using end nodes on appliance, and exchanging command/messages between various nodes in the network
- As home automation systems do not have smart algorithms to control, they are just a medium to control the appliance.
- Home automation systems are managed by energy management devices
- Smart energy management devices use the services/automation network to control the electrical appliance in a better way to contribute in energy conservation.
- Home automation provides better control to end user in terms of security, energy management, access control, lighting, environment, surveillance.
- When it is managed by energy management device, it provides data to energy management device and energy management device has various algorithms to manage different energy source in smart home.



- **Fig. 4** Smart home overview

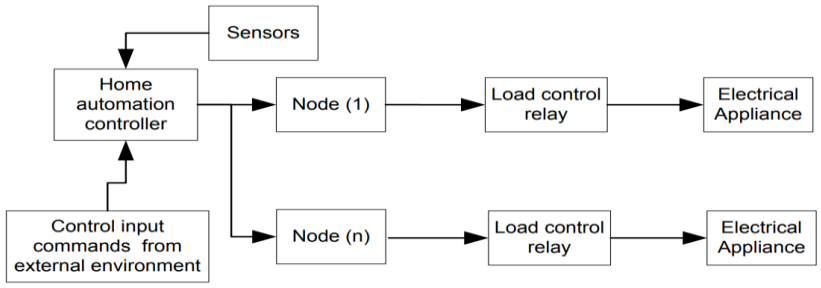


Fig. 3 Home automation overview

(OR)

b. Describe in detail about the energy conservation technique in detail

Energy conservation which focus on the reduction of energy consumption in IoT devices. There are many schemes to conserve the energy like duty cycling, data reduction, etc.

1. Sleep/Wake-up:

- There are some state slots when these nodes do not communicate. These are called idle states.
- Nodes also consume energy in these states. Thus, idles states are the main reasons of energy consumption in the nodes.
- During the idle states, nodes can go to sleep state so that they require less power.
- Switching between the sleep and wake-up states is the main concept of sleep/wake-up schemes.
- The node is switched On when it communicates and goes to Off during inactive period.
- These techniques adjust the radio state of the node to cut down the energy requirement of the node
    - These techniques can be categorized as follows:
        - Duty Cycling:
            - Duty cycle of a node is fraction of time for which node remains active during its lifetime.
            - These schemes schedule node's state based on the network activity to understate idle listening.
            - These schemes can be divided into three categories: synchronous, asynchronous and semi-synchronous
            - These approaches have high sleep latency as node has to wait for the receiver to be in active state. Moreover, in some cases, a node cannot broadcast information to all of its neighboring node because they are not awake simultaneously.

Passive wake-up radios:

- In the duty cycling, node switches between inactive and active states according to their duty cycle.
- There can be unnecessary wake-up calls even though there is no communication.
- To resolve this issue, passive wake-up radio are used to reduce the energy consumption.
- Passive wake-up radios are low power consuming radio which awake the node when data transmission is required.

Topology control:

- To find out the optimal subset of nodes which guarantee connectivity is known as the topology control.

- Then it is possible to deactivate some node at a time and active them later to prolong the life of network.
- topology control focuses on adapting network topology dynamically according to the application requirement

4. MAC Protocol:

- Collision and control packet overheads are also reasons for the energy deficiency in the sensor networks.
- Thus, several MAC protocols have been proposed with low energy consumption.
- MAC protocols can be classified into three categories given as: Contention based, TDMA based and hybrid protocols.

Data Driven: These approaches aim at the data reduction to be communicated for saving the energy.

data driven approaches are used to limit sensing tasks and the unneeded sampling because both the data acquisition and transmission are expensive in terms of energy.

Such approaches can be divided into two classes: data reduction and data acquisition schemes.

1. Data Reduction: These approaches address the issue of redundant data samples. Such schemes aim at reducing the data to be communicated to sink node.

- a. Data Compression: Data compression is the process of modifying, converting or encoding the data in such a way that the new representation requires less space than the original.
- b. Data Prediction: these techniques assist in reduction of energy consumption by decreasing the number of communication between sink and source node. Data prediction approaches can be divided further into stochastic, time series forecasting and algorithmic approaches.

. Data Aggregation:a node receives data from several sources. But it forwards only aggregated value. An intermediate node between the sources and sink node performs the data aggregation.

2. Data Acquisition:

Only reducing the data communication is not sufficient, energy saving schemes also need to focus on the data sampling rate.

focuses on the reduction of energy consumption of node's sensing unit.

a. Adaptive Sampling:This group of techniques exploit the temporal and spatial correlation of data to reduce the data sampling rate.
b. Hierarchical Sampling:These schemes select which sensor class to activate dynamically to find out a trade off between energy conservation and accuracy.

C. Model-based Active Sampling: These schemes are based on prediction. These techniques exploit this model to cut down the frequency of data sampling which assist in reduction of energy consumption

30.a. To determine a feasible solution to the problem present in the cloud, suggest the best algorithm to rectify and explain the same.

Particle Swarm Optimization (PSO) is used to find the fitness of each individual particle leads to a feasible solution to the problem present in the cloud.

Each particle consists of velocity and position

The algorithm starts with the initialization of a group of particles randomly, finding the optimal solution by performing iterations.

Every particle in the group changes its position with a specified velocity by searching the local best position Xlbest,i and the global best position Xgbest,i.

- The velocity of each particle along with the positions are updated by the following equations.
- Vt i and Vt+1 I are the velocity before updated and after updated respectively, Xt i , Xt+1 I are the before and after updated position respectively.

$$V_i^{t+1} = pV_i^t + c_1 r_1 (X_{lbest,i}(t) - X_i^t) + c_2 r_2 (X_{gbesti}(t) - X_i^t) \quad (3)$$

$$X_i^{t+1} = X_i^t + V_i^{t=1} \quad (4)$$

Addition Operation

Multiplication Vector

(OR)

b. Explain in detail about the different static energy efficient algorithm and its steps to reduce the energy consumption in the cloud

Exact Allocation Algorithm

- The Pack is a set of VMs(virtual machine) for a set of nodes
- If n is the requested VMs and m are the available servers at data center, they are denoted by Pj,max, where j = 1,2,...m.
- The j is the VMs number which is given by the current energy consumption Pj,current . Pj,current = Pj,idle + ∑k pk with VMk host
- Consider a decision value ej for every server where j will be 1 if j is selected by host VM otherwise it will be 0.
- If the VMi is placed in j server then it is expressed by xij = 1 else it will be assigned as 0.

Best Fit Heuristic Algorithm

- This is used to save energy and it is of two steps.
- It sorts the requested VMs from higher to lower order of energy consumption to build the ordered stack.
- The next step involves, the VMs are always handled from the top of the stack.
- The most energy consuming servers are packed with least energy until the remaining servers of VM down the stack fits the target server.
- This process is repeated until all the VMs are packed with the most occupied servers.
- This will allow the servers to enter into sleep mode or switch off when they are in free or idle state

31. a. If one wanted to create awareness of their energy usage and current energy need to the users, what are the techniques are the best suitable one.

- Creating Awareness Through Prototyping: A Green IoT-Based Smart Home Model
- Monitoring Energy Consumption
- A Robust Information Management and Automation System
- User Feedback and User Involvement for Energy Savings

(OR)

c. Describe in detail about the Green IoT and its techniques

- Green IoT comprises methods for reducing energy consumption and how sensors can be efficiently used as an indication of energy conservation
-

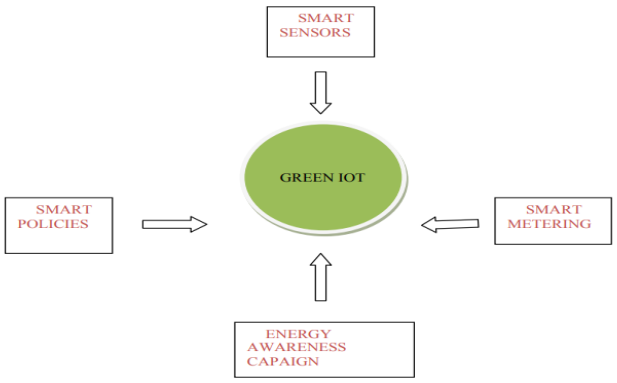


Fig. 3 An overview of green IoT

- As shown in the picture, smart sensors and usage of smart metering are leading to the implementation of green IoT
- Implementation of effective energy usage policy and energy awareness campaigns are also leading to the concept of green IoT
- Green IoT also includes the concept of how IoT can be utilized to reduce energy consumption.
- Using the IoT sensors, electric devices can be disconnected from power supply or convert into power saving mode if being unused

32.a. Explain about the intelligent transport systems

- ITS may be considered as a holistic transportation management and service system which aims to provide innovative and user-friendly services relating to different modes of transport
- ITS uses a network of IoT sensors as the underlying basis for these innovative solutions to transport management. These sensors help in capturing data in a real time and feed the data to various networked subsystems of communication channels and data processors.
- ITS through the implementation of its subsystems, collects relevant data, processes it, and hands out the solutions to problems and concerns at hand in various aspects that might be encountered during travel, ranging from road safety, congestion management, traffic rules implementation, to catering to ever-evolving needs of passengers
- Apart from segmental energy optimization, power harnessing at macro-level may be planned to achieve energy efficiency of the ITS systems.
- Like any other systems, ITS also has some operational issues which need to be addressed to make it highly productive and efficient.
- Some typical issues associated with communication process like congestion, clashes, and resource allocation may be resolved by employing various methods like use of routing algorithms with optimized duty cycle and latency determination, resource time scheduling, unsynchronized intelligent learning based resource management, etc.

(OR)

d. Describe the motivation for vehicle to everything (V2X) and V2G technology.

- Vehicle to everything is a partnership project using 4G LTE, C-V2X, or 5G network to support communication between vehicles to infrastructure (V2I), vehicle to network (V2N), vehicle to vehicle (V2V), vehicle to pedestrian (V2P), vehicle to device (V2D), and vehicle to grid
- The cellular V2X (C-V2X) demands improved infrastructure capable of delivering economic and societal impact in terms of safe driving experience, reduced

accidents, predictive travel, less greenhouse gas emission, and better traffic efficiency

- It enables a growing set of applications such as forward collision warning, do not overtake, blind intersection at crossroads, queue warning, curve speed warning, road user alerts, discover parking and charging, optimal speed for traffic signal priority, emergency vehicle alert, etc..
- The communication may be within the device to device (direct) for out of coverage area or via a network within coverage area
- The gap between demand and supply may be filled with the ancillary services (reserves). Frequency regulation is the process of maintaining the system frequency to its predetermined value either by injecting a little power or by withdrawing power from the grid.
- The power flow from vehicle to grid (V2G) may provide better frequency regulation as it is believed that at any instance, more than 90% of vehicles are parked. A vehicle battery can be viewed as a source of energy in between 10 and 30 kWh depending upon the size of the vehicle.
- To exploit the potential of plug-in-electric vehicle (PEV), it needs to be connected to grid to supplement the generation.
- This may relieve the utility from excess generation during peak hours and benefit the consumer in terms of reduced electricity charges due to saving in transmission cost.

e.