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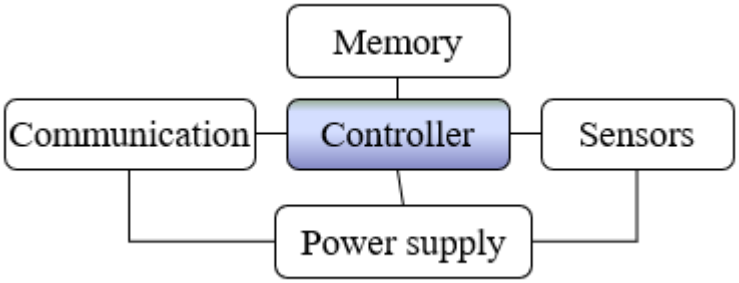
Sub:	IoT & WSN					Sub Code:18EC752
Date:	/12/2021	Duration:	90 Minutes	Max Marks:	50	Sem / Sec:

Answer any FIVE FULL Questions

1 Explain the single node architecture with necessary hardware components. [10] M



Main functionality

- It is core of a wireless sensor network.
- It collects data from the sensors, processes this data, decides when and where to send it, receives data from other sensor nodes and decides on actuator's behavior.
- It is CPU of sensor node as it executes various programs ranging from time critical signal processing and communication protocols to application protocols.

Main options:

- **MCUs (Microcontrollers)**
- **DSPs (Digital Signal Processors)**
- **FPGAs (Field Programmable Gate Arrays)**
- **ASICs (Application-Specific Integrated Circuits**)

Communication Module:

- The communication module of a sensor node is called "Radio Transceiver".
- The essentially tasks of transceiver is to "transmit" and "receive" data between a pair of nodes.
- Depends upon the a) Choice of transmission medium b) Transceivers
- Both wired and wireless communication can be used.
- Wired communication:
  It can be carried out by using field buses like LON, CAN etc.
- Wireless communication
  - ✓ It can be radio frequencies, light, ultrasound etc
  - ✓ It provides relatively high data rate and does not require the
  - ✓ line of sight between sender and receiver.
  - ✓ It uses communication frequency between 433 MHz to 2.4 GHz

Sensor's main categories

A sensor is a device that detects and responds to some type of input from the physical environment. It can be categorized as Passive vs. Active, Directional vs. Omidirectional.

	Some sensor examples are: Passive & Omnidirectional , light, thermometer, microphones, hygrometer, … Passive & Directional,electronic compass, gyroscope, Passive & Narrow-beam, CCD Camera, triple axis accelerometer, infar sensor, Active sensors, Radar, Ultrasonic,
	
	Actuator:
	A device or mechanism capable of performing a physical action for example motor, light bulb, LEDs etc
	
	Memory:
	✓ Memory is required to store programs and intermediate data; usually, different types of memory are used in WSN for programs and data.
	✓ Random Access Memory (RAM) to store intermediate sensor readings, packets from other nodes, and so on. RAM is fast, its main disadvantage is that it loses its content if power supply is interrupted.
	✓ Read-Only Memory (ROM) Program code can be stored in Read-Only Memory (ROM) or in Electrically Erasable Programmable Read-Only Memory (EEPROM) or flash memory.
	✓ Flash memory is similar to EEPROM but data can be erased or written in blocks instead of only a byte at a time. It can also serve as intermediate storage of data in case RAM is insufficient or the power supply of RAM should be shut down.
	
	Power supply:
	• They store energy and provide power.
	• A normal battery store about 2.2-2.5 ampere hour at 1.5 V
	• Traditional batteries
	  • Primary batteries – not rechargeable
	  • Secondary batteries – rechargeable, only makes sense in combination with some form of energy harvesting
	• Requirements include
	  • Low self-discharge
	  • Long shelf live
	  • Capacity under load
	  • Efficient recharging at low current
	  • Good relaxation properties (seeming self-recharging)
	  • Voltage stability (to avoid DC-DC conversion)

2	What is geographical routing and explain about Greedy Perimeter Stateless Routing for Wireless Networks with proper figure [5+5] M Geographic routing • **Geographic routing** (also called **georouting**[1] or **position-based routing**) is a routing principle that relies on geographic position information. • It is mainly proposed for wireless networks and based on the idea that the source sends a message to the geographic location of the destination instead of using the network address. • Geographic routing requires that each node can determine its own location and that the source is aware of the location of the destination. With this information, a message can be routed to the destination without knowledge of the network topology or a prior route discovery. Geographic routing without positions – GEM ➢ Apparent contradiction: geographic, but no position? ***virtual coordinates:***

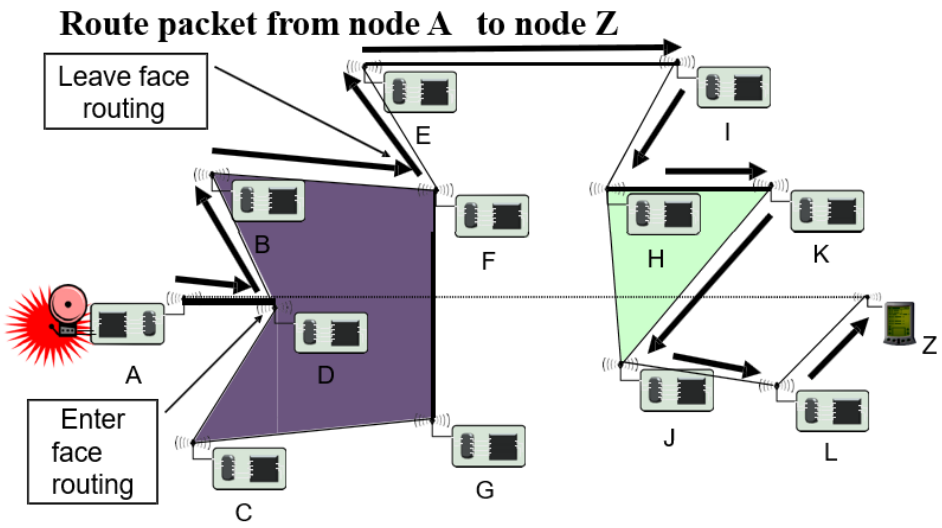
- GEM does not require actual position determination.
- But preserve enough neighborhood information to be useful in geographic routing.

Essential parts:

- ✔ Use polar coordinates from a center point (like given an radius and angle from center).
- ✔ Assign "virtual angle range" to neighbors of a node.
- ✔ Construct a spanning tree with the center point as the root.
- ✔ Define the radius of a node by the number of hops (in spanning tree)

GPSR: Greedy Perimeter Stateless Routing for Wireless Networks

- GPSR forward the packet as long as possible using greedy forwarding with "most forward rule".
- If no progress possible: Switch to "perimeter" routing
- **Perimeter: Set of nodes defining the face**
- **Face:** it is largest possible region of the plane that is not cut by any edge of the graph; can be exterior or interior.
- Perimeter sends the packet around the face using right-hand rule.
- For this the packet carries information that where it has to enter a given face.
- The node and the connecting line between it and the destination decides whether the packet should leave the face and proceed to the next one.
- Also packet can, switch back to greedy routing

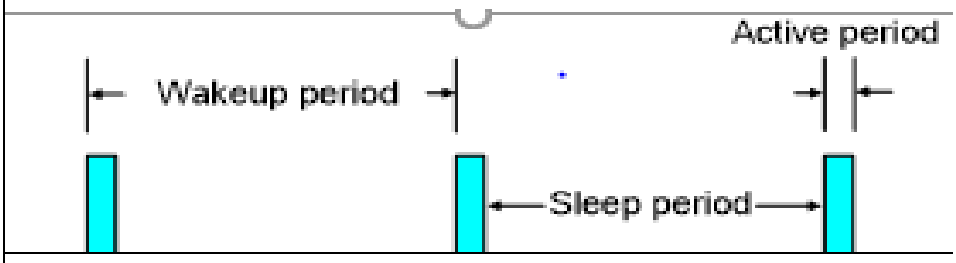


- A packet is routed from node A to node Z where node A is the source and node Z is the destination.
- The packet can be greedily forwarded to node D
- But at node D the dead end is there, hence is avoided.
- Hence the packet has to be routed around the perimeter of the interior face defined by BFGCD
- Now the packet is forwarded from node B to F.
- And from F it will be routed around perimeter of exterior face i.e. Via node E to I to H and then to node K to J and feom J to L then to destination node Z.
- Faced based procedure is applied to planer graphs.

3 Q) 3. Write a short note on low duty cycle protocols and wake up concepts and explain the S-MAC protocol with necessary figure [5+5].

Low duty cycle protocols and wakeup protocols

Wake up channel time 'T': (sleep period + active period)
It is divided into sleep period and listen period 'Trx' (T>>> Trx) and these together are called wake up period.



Duty cycle:
Ratio of active and wakeup period

- **Low duty cycle:**
  - As the active period is very less as compared to wakeup period.
- **Periodic wakeup scheme:**
  - The Node uses periodic wakeup scheme.
  - Here the node spend most of time in sleeping state and wakeup periodically in **'listen period'** to receive packets from other nodes.
  - The sleep state is left only when node is about to transmit and receive packets.

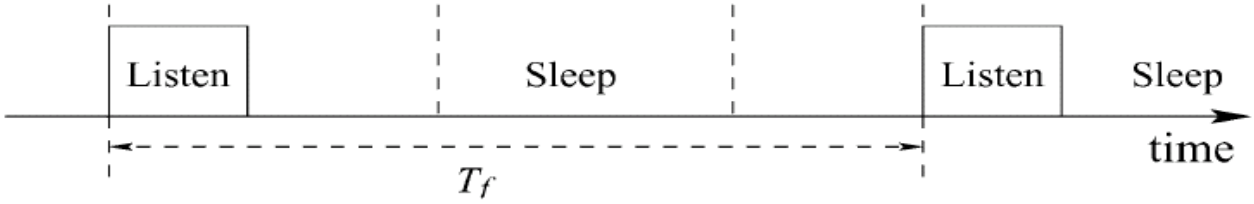
All the nodes must be synchronized to this wakeup period.

S-MAC protocol

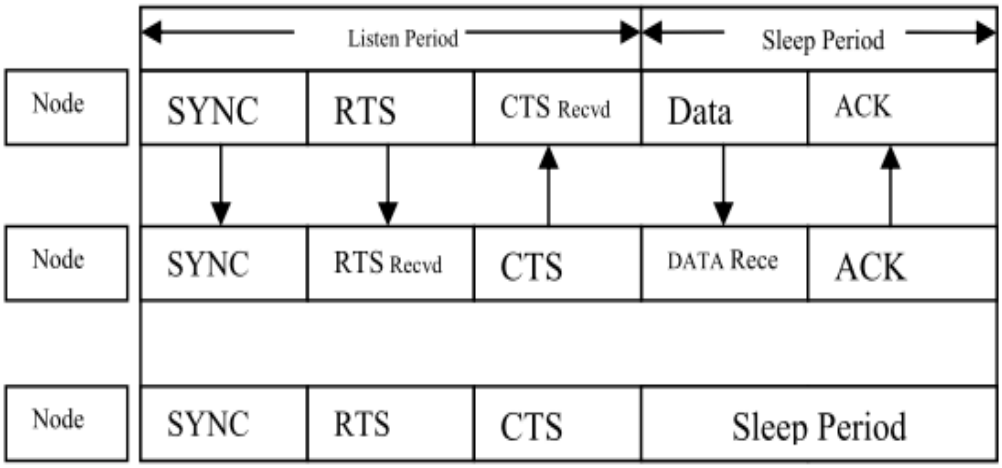
- Stands for **Sensors Medium Access Control**
- Also called as **S-MAC or Scheduled MAC.**
- Specifically designed for Ad hoc wireless sensor networks
- Primary goal: Energy Efficiency

Main features of SMAC include

- Periodic Listen and sleep
- Collision Avoidance
- Overhearing Avoidance
- Message Passing



- **A periodic wakeup schedule is exchanged between the neighboring nodes with a fixed length listen period and sleep period.**
- Neighboring nodes are synchronized together and their listen period should start at same time.
- During sleep mode turn off radio and set a timer to awake later
- Reduce duty cycle to ~10%



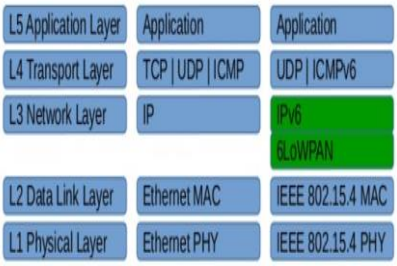
4 Explain HTTP and 6LoWPAN protocols.[5+5] M

HTTP PORT

- HTTP uses port number 80.
- A WEB HTTP Server listens to port number 80 only and respond to port number 80 only.
- The port number is specified after TLD (Top level Domain) like **http://www.vtu.ac.in:80/test.html**
- Important features of HTTP:
- **HTTP is an web's application-layer protocol**: Used for transmitting various forms of data between sever and client like plaintext, hypertext, image and sound.
- **HTTP is an client server protocol:** It allows two machines to communicate using a reliable, connection oriented transport service such as TCP.
- **HTTP is flexible and connectionless:** The HTTP client (browser) initiates an HTTP request and after a request is made, the client disconnects from the server and waits for a response. The server processes the request and re-establishes the connection with the client to send a response back.
- **HTTP is media independent:** Any type of data can be sent by HTTP as long as both the client and the server know how to handle the data content.
- **HTTP is a very light protocol**: It has a **small format and is fast.**
- **HTTP is based on Object Oriented Programming System (OOPS): T**he objects are identified by URL.
- **HTTP is stateless**: The server and client are aware of each other only during a current request

6LoWPAN

- **6LoWPAN** is an acronym of *IPv6 over Low -Power Wireless Personal Area Networks (WPAN).*
- 6LoWPAN concept originated from the idea that *"even the smallest and the low-power devices (operating in LR-WPAN) with limited processing capabilities can participate in the Internet of Things*
- 6LoWPAN sits between network layer and data link layer hence called as **adaptation-layer protocol** for the IEEE 802.15.4 network devices.
- Features of 6LoWPAN are **header compression, fragmentation and reassembly**.
- The devices are the **WPAN** nodes having low power and low speed and forms a mesh network.



Features of 6LoWPAN

- **6LoWPAN adopts the physical (PHY) and Media Access Control (MAC) layer protocols** defined in IEEE 802.15.4 standard as its lower layer protocols which **gives a total device node frame size of (i.e. MTU) 127B**.
- **The IPv6 protocol is us**ed as the network layer protocol in 6LoWPAN and have **Maximum Transmission Unit (MTU) of 1280B**.
- Therefore when the packet is forwarded from network layer to link layer, the packet is fragmented to frames having length of 127B each and when it reaches to another node then frames from the device of 127B are reassembled into IPV6 frame.

5 Write a short note on Optimization goals and figure of merit. [10] M

- **Optimization goals and figures of merit:**
  - The main challenge for a network is how to optimize a network.
  - Optimization and figures of merit depend upon certain parameters like:
    - Quality of service
    - Energy efficiency
    - Scalability
    - Robustness

    - **Quality of service involves**:

A) Low level networking device observable attributes like: Bandwidth, delay, jitter, packet loss rate
B) High level, user observable also called as subjective attributes like: Quality of voice communication or video transmission.
In WSNs, the high level attribute depends upon the application.

- ✓ **Event detection/reporting probability :**

Means the event that actually happened is detected or not or reported or not to the information sink.

- ✓ **Event classification error-** If events are not only to be detected but also to be classified, the error in classification must be small
- ✓ **Event detection delay -**It is the delay between detecting an event and reporting it to any/all interested sinks

Quality of service: Some generic possibilities are

- ✓ **Missing reports -**In applications that require periodic reporting, the probability of undelivered reports should be small.
- ✓ **Approximation accuracy-** It defines what is the average/maximum absolute or relative error with respect to the actual function.
- ✓ **Tracking accuracy** Tracking applications must not miss an object to be tracked, the reported position should be as close to the real position as possible, and the error should be small.

Energy efficiency:
The Energy efficiency of the WSN can be increased by considering various aspects.
1)Energy per correctly received bit:
It defines the average energy consumed in transporting and receiving one bit of information, after considering all possible intermediate hops from source to destination.
2) Energy per reported event:
It defines the average energy consumed in reporting one event. Since same event can be reported from various sources. Hence redundant information can be reduced.

1) Delay/Energy trade-off:

In case of reporting of urgent events a huge amount of energy is consumed. Here a trade-off (balance) between Delay/Energy is an important aspect.
4) Network lifetime:
It is the time for which network is operational. Possible definitions are:

a) Time to first node death:.
b) Network half-life:
c) Time to partition:

Scalability:

- ❖ With WSN potentially consisting of thousands of nodes, the ability to maintain performance characteristics irrespective of the size of the network is referred to as scalability.
- ❖ The need for extreme scalability has direct consequences for the protocol design as the complexity will increase and can effect the performance.

Robustness:

- ✓ Wireless sensor networks should also exhibit an appropriate robustness
- ✓ They should not fail just because a limited number of nodes run out of energy, or because their environment changes and severs existing radio links between two nodes

If possible, these failures have to be compensated by finding other routes

6 Write a short note on 1) Network gateway 2) Event based programming 3) Process based programming. [4+4+3] M

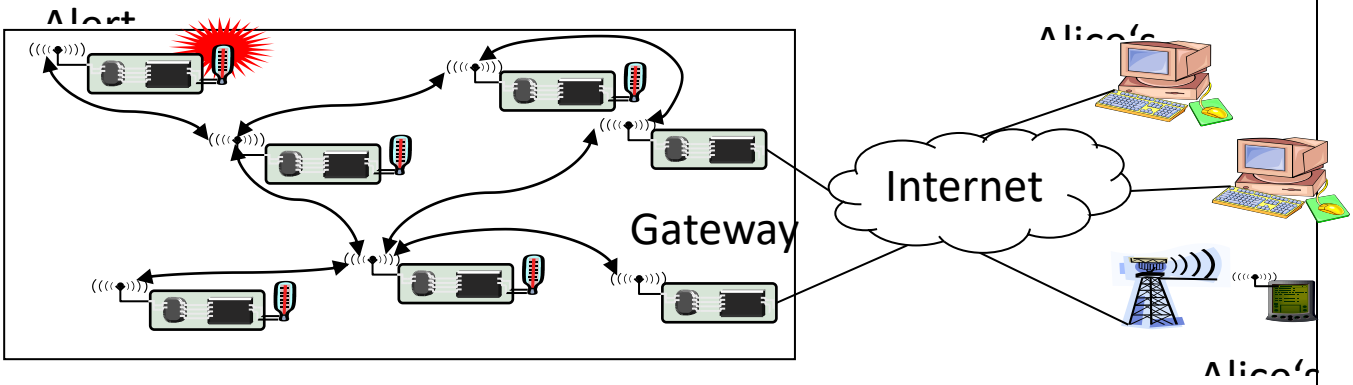
Network Gateway:

A gateway is a network node used in **telecommunications that connects two networks with different transmission protocols together**. Gateways serve as an entry and exit point for a network as all data must pass through or communicate with the gateway prior to being routed.

Let an sensor node 'ALICE 'wants to deliver an alarm message to some Internet host.
But here occurs some issues like

- ➢ How to handle the several gateways.
- ➢ Choose "best" gateway (integrates routing & service discovery)

Finding the host IP address to which it has to be forwarded



Internet to WSN communication

- ➢ Let internet based entity tries to access the services of WSN.
- ➢ If requesting terminal can directly communicate like mobile then no particular treatment is necessary, but if this is not the case then complexity increases.

There also occur many complexities like:

a) Gateway node is required.
b) How to find the right WSN in desired location is another problem.
c) Addressing of the right sensor in network.
d) How to translate from IP protocols to WSN protocols, semantics?
e) How to make WSN services accessible from standard web browser.

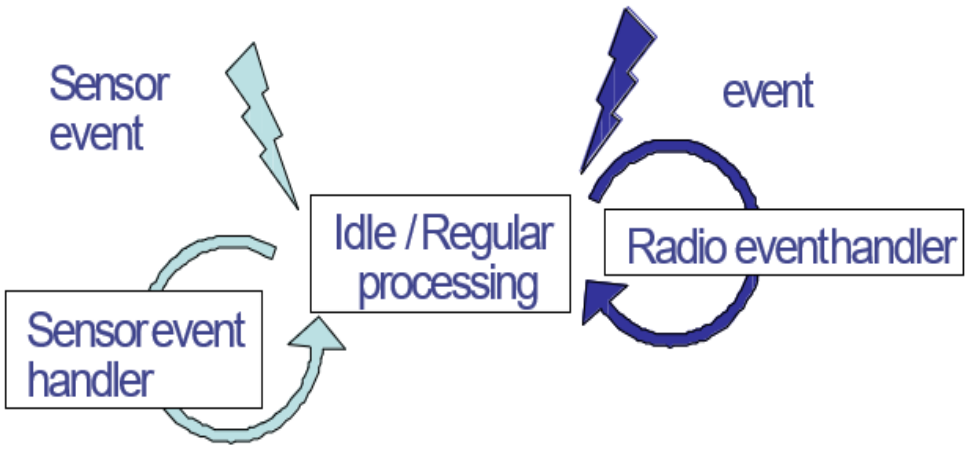
➢ **Event-based programming:**

✓ In **Event-driven programming** the flow of the program is determined by events such as

- User actions (mouse clicks, key presses)
- Sensor outputs
- Arrival of packets
- Expiration of a timer or messages from other programs/threads.

✓ **Event handler**: These events are handled by a set of instructions that store the necessary information about the occurrence of event are called Event handler.

Consider the event handler model



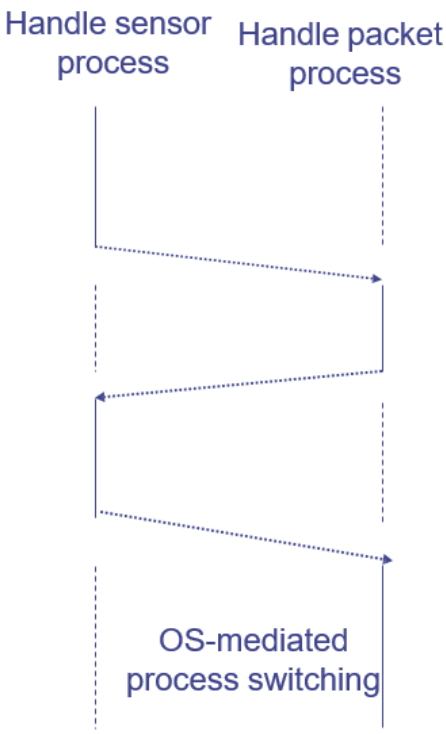
➢ **Process-based concurrency**:

✓ It is concurrent (parallel) execution of multiple processes at the same time on a single CPU.

✓ Processes communicate using messages

✓ Disadvantage:

Equating individual protocol or layer to individual process leads to high overhead.

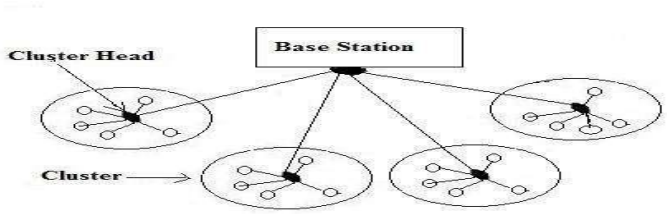


7 Explain the LEACH protocol in WSN with necessary figures [10] M

LEACH (Low-Energy Adaptive Clustering Hierarchy)

- **It is self-organizing, adaptive clustering protocol that uses dynamic clustering method.**
- Base station (sink) is fixed and away from sensors.
- LEACH conserves energy

through:
Aggregation
Adaptive Clustering

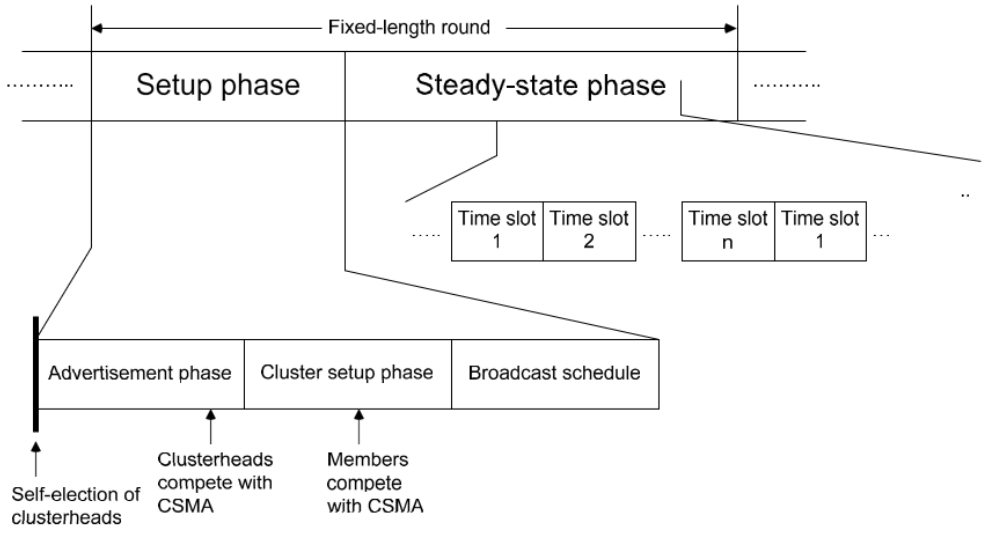


Nodes in LEACH

1) All the nodes in the network are homogeneous.
2) The LEACH partitions the nodes into '**clusters** ' (**round**) and in each cluster elects a dedicated node called **'Cluster head '** to avoid excessive energy consumption.
3) Cluster head assigns a **TDMA** schedule to all member nodes which is used to exchange the data between members and cluster head.
4) Cluster head **aggregates** the data from member nodes and transmit it to the sink node.
5) If transmission are not there for that time slots, nodes can spend time to sleeping state.
6) There is **no peer to peer communication**.
7) LEACH is ***dynamic*** because the job of cluster-head rotates

LEACH rounds

- The protocol is organized in the rounds and each round is divided into
  - Setup phase , Steady- state phase



The Set-Up Phase

- Advertisement
- Election of cluster-heads
- Membership of nodes
- Schedule creation

The Steady-State

- The cluster-head is maintained
- When data is transmitted between nodes

Weakness inLEACH

LEACH assumes that

- All nodes can communicate with each other and are able to reach the sink (therefore, it is only suitable for small size networks).
- All nodes have data to send and so assign a time slot for a node even though some nodes might not have data to transmit.
- All nearby nodes have correlated data which is not always true.
- All nodes are continuously listening (this is not realistic in a random distribution of the sensor nodes).

8	Explain CSMA protocol with flow diagram.[10] M

- CSMA protocols are contention-based, where

  neighbors try their luck to transmit their packet.

- The node sense the channel before transmitting.

- If the channel is busy then the node selects other random channel, repeats the carrier sensing and after a number of unsuccessful trials it just backsoff.

- And if the channel is idle then it start transmitting.

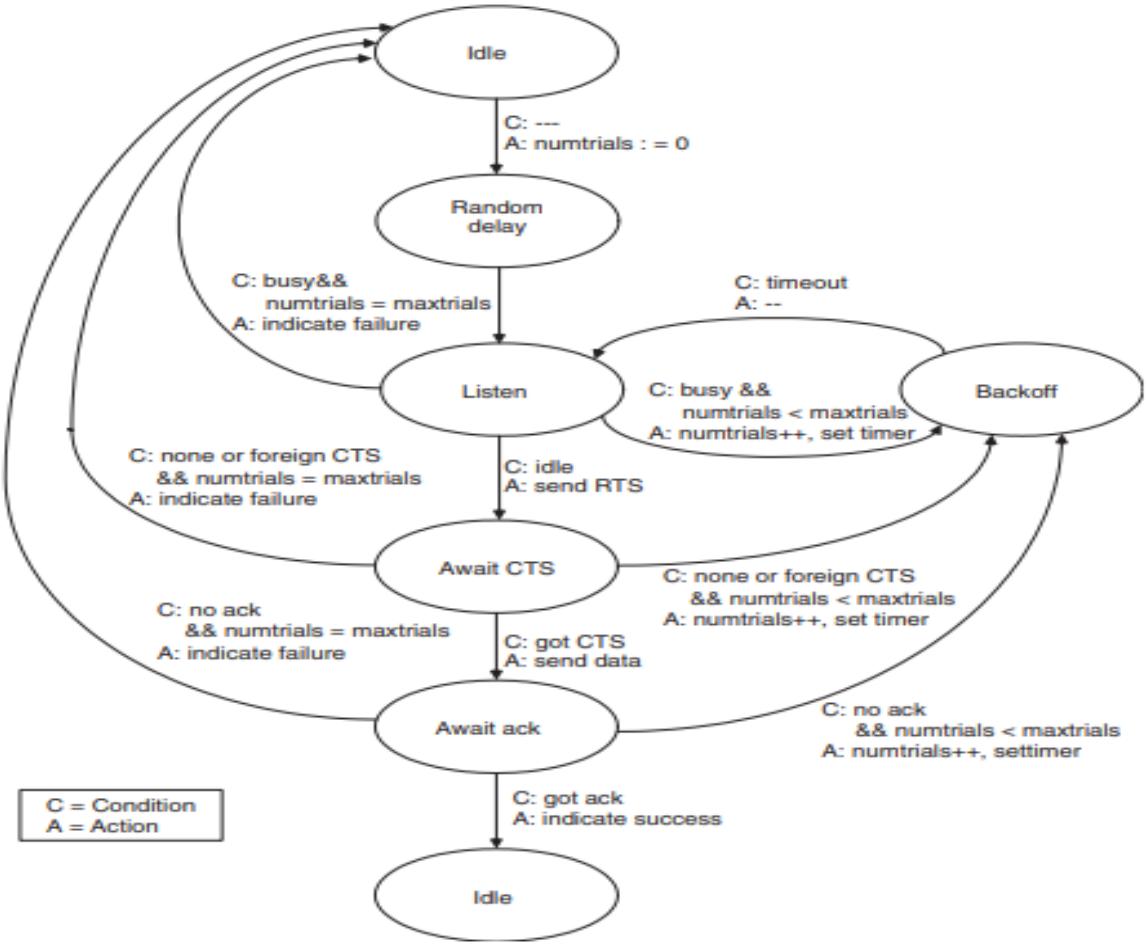


Figure 5.9 Schematic of the CSMA protocol presented in reference [888]

Working: (Finite state automation)

Step1: ["Idle state"]

- Normally the nodes are in "idle state".

Step 2: ["Random delay"]

- When it receives the packet from upper layer for transmission to lower layer (called as downstream node), it restarts the "Random Delay".
- Counter "numtrials" is =0;
- ***The purpose of "Random delay" is to desynchronized the nodes if initially synchronized by the external event.***

Step3: ["Listen"]

- The nodes perform carrier listening for some time
- If the medium is found busy, it goes to **"Backoff"** mode.
- If the medium is found free, the node transmits "**RTS"** packet and enters **"Await CTS state"**.

Step4: ["Backoff"]

- Here nodes wait for a random amount of time for the channel to be free and then goes to sleep state.
- **"Backoff"** period is used by application layer for the **"phase change" i.e.** ***to desynchronize the periodic traffic of different nodes***.
- **After the "Backoff"** period nodes listens again.

Step5: ["Await CTS state"]

- Here the node waits for CTS packet.
- If CTS packet arrives in time then node sends its data packet and waits for
- Acknowledgement and enter into **"Await ack"** state.
- Otherwise go back to **"Backoff"** state or drop the packet depending upon

"numtrials" values.

Step6: ["Await ack state"]

- It can be explicit ack or parent node piggybacks the ack on packet and then forwarded to grandparent.
