Introduction to Internet of Things

Week 3

Presented By: Riya Tapwal

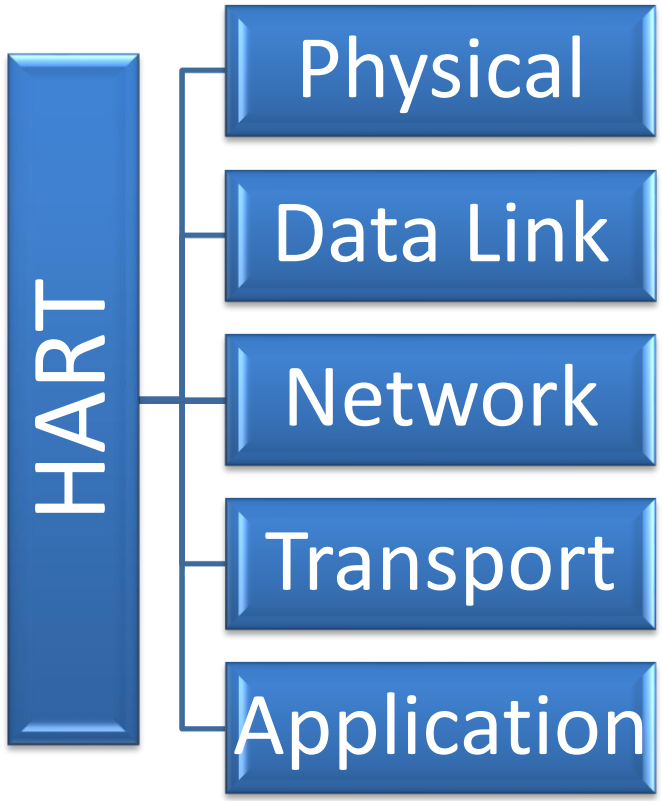
Under the supervision of

Prof. Sudip Misra

Indian Institute of Technology, Kharagpur, India

HART and Wireless HART

- ✓ WirelessHART is the latest release of **Highway Addressable Remote Transducer** (HART) Protocol.
- ✓ HART standard was developed for **networked smart field devices**.
- ✓ The wireless protocol makes the implementation of HART **cheaper and easier**.
- ✓ HART encompasses the most number of field devices incorporated in any field network.
- ✓ Wireless HART enables device placements more accessible and cheaper– such as the top of a reaction tank, inside a pipe, or at widely separated warehouses.
- ✓ Main difference between wired and unwired versions is in the physical, data link and network layers.
- ✓ Wired HART lacks a network layer



HART and Wireless HART

HART Physical Layer

✓ Derived from IEEE 802.15.4 protocol.
✓ It operates only in the 2.4 GHz ISM band.
✓ Employs and exploits 15 channels of the band to increase reliability.

HART Network & Transport Layers

✓ Cooperatively handle various types of traffic, routing, session creation, and security.
✓ WirelessHART relies on **Mesh networking** for its communication, and each device is primed to forward packets from every other devices.
✓ Each device is armed with an updated network graph (i.e., updated topology) to handle routing.
✓ **Network layer (HART)=Network + Transport + Session layers (OSI)**

HART Data Link Layer

✓ Collision free and deterministic communication achieved by means of super-frames and TDMA.
✓ Super-frames consist of grouped 10ms wide timeslots.
✓ Super-frames control the timing of transmission to ensure collision free and reliable communication.
✓ This layer incorporates channel hopping and channel blacklisting to increase reliability and security.
✓ Channel blacklisting identifies channels consistently affected by interference and removes them from use

HART Application Layer

✓ Handles communication between gateways and devices via a series of **command and response messages**.
✓ Responsible for **extracting** commands from a message, **executing** it and generating responses.
✓ This layer is seamless and does not differentiate between wireless and wired versions of HART

HART and Wireless HART

HART Congestion Control

- ✓ Interference-prone channels avoided by using channel switching post every transmission.
- ✓ Transmissions synchronized using 10ms slots.
- ✓ During each slot, all available channels can be utilized by the various nodes in the network allowing for the propagation of 15 packets through the network at a time, which also minimizes the risk of collisions.

WirelessHART Network Manager

- ✓ The network manager **supervises each node** in the network and guides them on **when and where** to send packets.
- ✓ Allows **for collision-free** and **timely delivery** of packets between a source and destination.
- ✓ The network manager **updates** information about neighbors, **signal strength**, and information needing delivery or **receipt**.
- ✓ Decides who will send, who will listen, and at what frequency is each time-slot.
- ✓ Handles **code-based network security** and prevents unauthorized nodes from joining the network

NFC

- ✓ **Near field communication**, or NFC for short, is an offshoot of radio-frequency identification (RFID).
- ✓ NFC is designed for use by devices within **close proximity** to each other.
- ✓ FeliCa is commonly found in Japan

NFC Types

- ✓ **Passive devices** contain information which is readable by other devices, however it cannot read information itself.
- ✓ NFC tags found in supermarket products are examples of passive NFC.
- ✓ **Active devices** are able to collect as well as transmit information.
- ✓ Smartphones are a good example of active devices.

Working Principle

- ✓ Works on the principle of **magnetic induction**.
- ✓ A reader emits a small electric current which creates a magnetic field that in turn bridges the physical space between the devices.
- ✓ The generated field is received by a similar coil in the client device where it is turned back into electrical impulses to communicate data such as identification number status information or any other information.
- ✓ 'Passive' NFC tags use the energy from the reader to encode their response while 'active' or 'peer-to-peer' tags have their own power source.

NFC

Peer-to-peer	Lets two smartphones swap data
Read/Write	One active device picks up info from a passive one
Card emulation	NFC device can be used like a contactless credit card

NFC

Smartphone based payments.

Low-power home automation systems.

Information tags in posters and advertisements.

Computer game synchronized toys.

Parcel tracking.

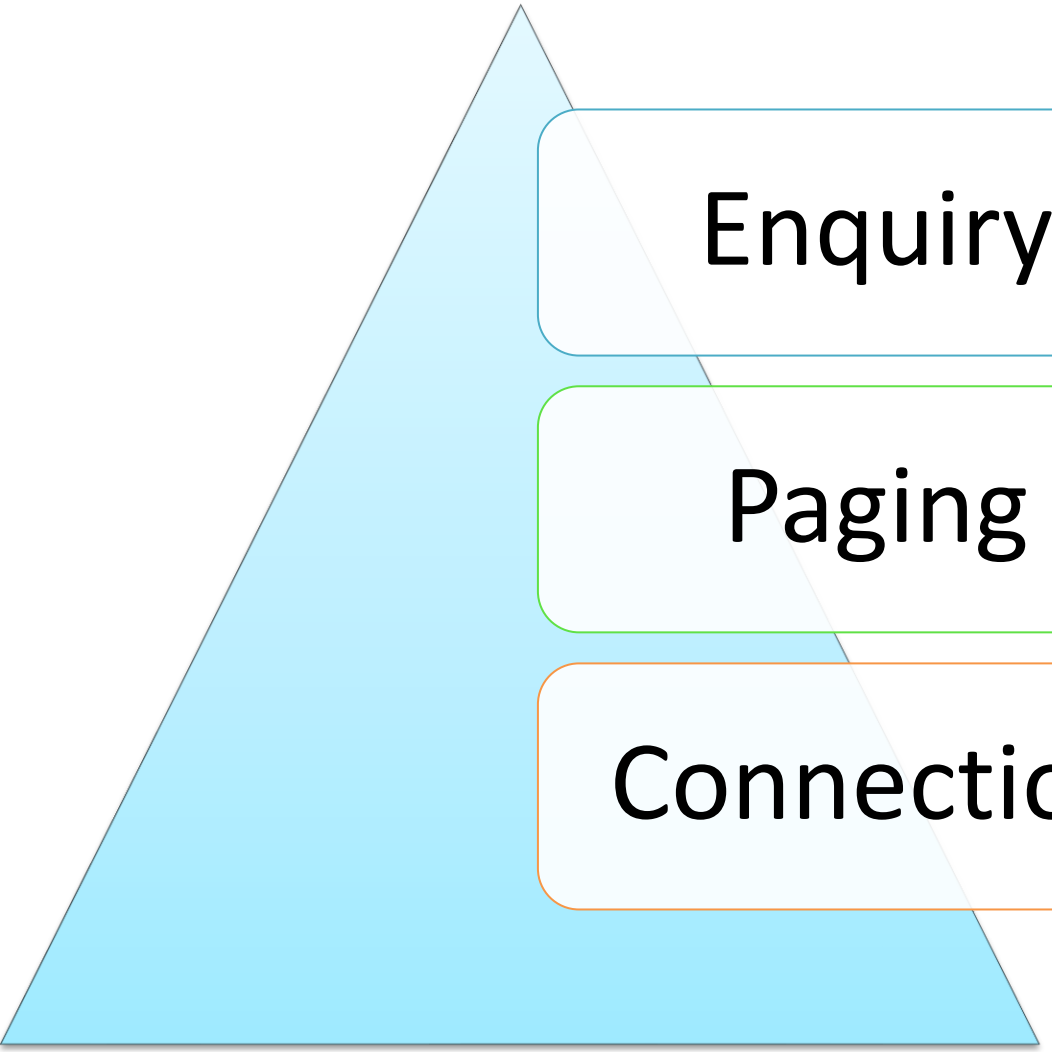
Bluetooth

- ✓ Bluetooth wireless technology is a short range communications technology.
- ✓ Intended for replacing cables connecting portable units
- ✓ Maintains high levels of security.
- ✓ Bluetooth technology is based on **Ad-hoc technology** also known as **Ad-hoc Piconets**
- ✓ Bluetooth technology operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHZ.
- ✓ Uses spread spectrum hopping, full-duplex signal at a nominal rate of 1600 hops/sec.
- ✓ Bluetooth supports 1Mbps data rate for version 1.2 and 3Mbps data rate for Version 2.0.

- ✓ Bluetooth operating range depends on the device:

  - **Class 3** radios have a range of up to 1 meter or 3 feet
  - **Class 2** radios are most commonly found in mobile devices have a range of 10 meters or 30 feet
  - **Class 1** radios are used primarily in industrial use cases have a range of 100 meters or 300 feet

Bluetooth : Connection Establishment



Enquiry

Inquiry run by one Bluetooth device to try to **discover other devices near it.**

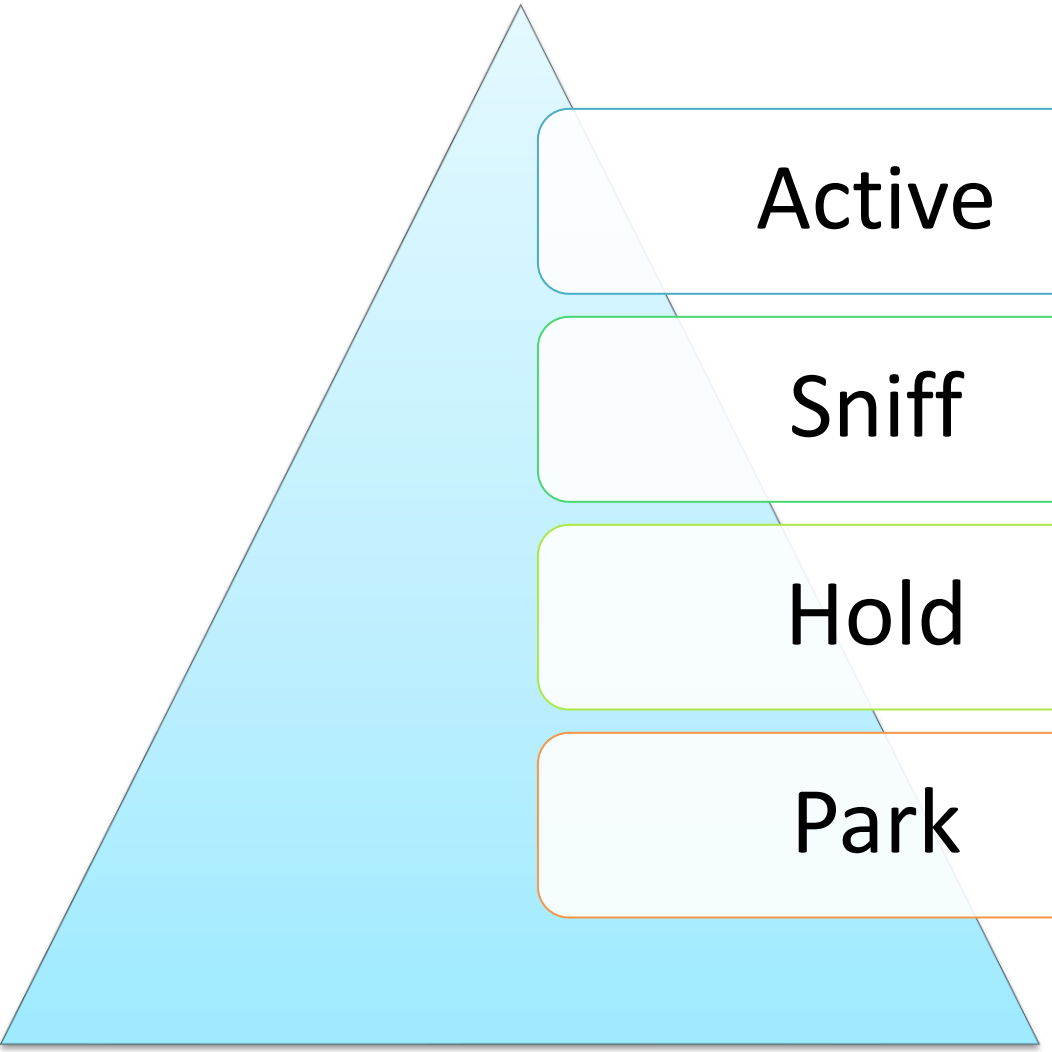
Paging

Process of **forming a connection** between two Bluetooth devices

Connection

A device either actively **participates** in the network or enters a low-power sleep mode

Bluetooth Modes



Active	Actively transmitting or receiving data.
Sniff	Sleeps and only listens for transmissions at a set interval
Hold	Power-saving mode where a device sleeps for a defined period and then returns back to active mode
Park	Slave will become inactive until the master tells it to wake back up.

Bluetooth

Baseband

- ✓ Physical layer of the Bluetooth.
- ✓ Manages physical channels and links.
- ✓ Other services include:
  - Error correction
  - Data whitening
  - Hop selection
  - Bluetooth security
- ✓ Manages asynchronous and synchronous links.
- ✓ Handles packets, paging and inquiry.

L2CAP

- ✓ The Logical Link Control and Adaptation Protocol (L2CAP).
- ✓ Layered over the Baseband Protocol and resides in the data link layer.
- ✓ Used to multiplex multiple logical connections between two devices.
- ✓ Provides connection-oriented and connectionless data services to upper layer protocols.
- ✓ Provides:
  - Protocol multiplexing capability
  - Segmentation and reassembly operation
  - Group abstractions

Bluetooth

RFComm

- ✓ Radio Frequency Communications (RFCOMM).
- ✓ It is a cable replacement protocol used for generating a virtual serial data stream.
- ✓ RFCOMM provides for binary data transport.
- ✓ Emulates EIA-232 (formerly RS-232) control signals over the Bluetooth baseband layer, i.e. it is a serial port emulation.
- ✓ RFCOMM provides a simple reliable data stream to the user, similar to TCP.
- ✓ Supports up to 60 simultaneous connections between two BT devices.

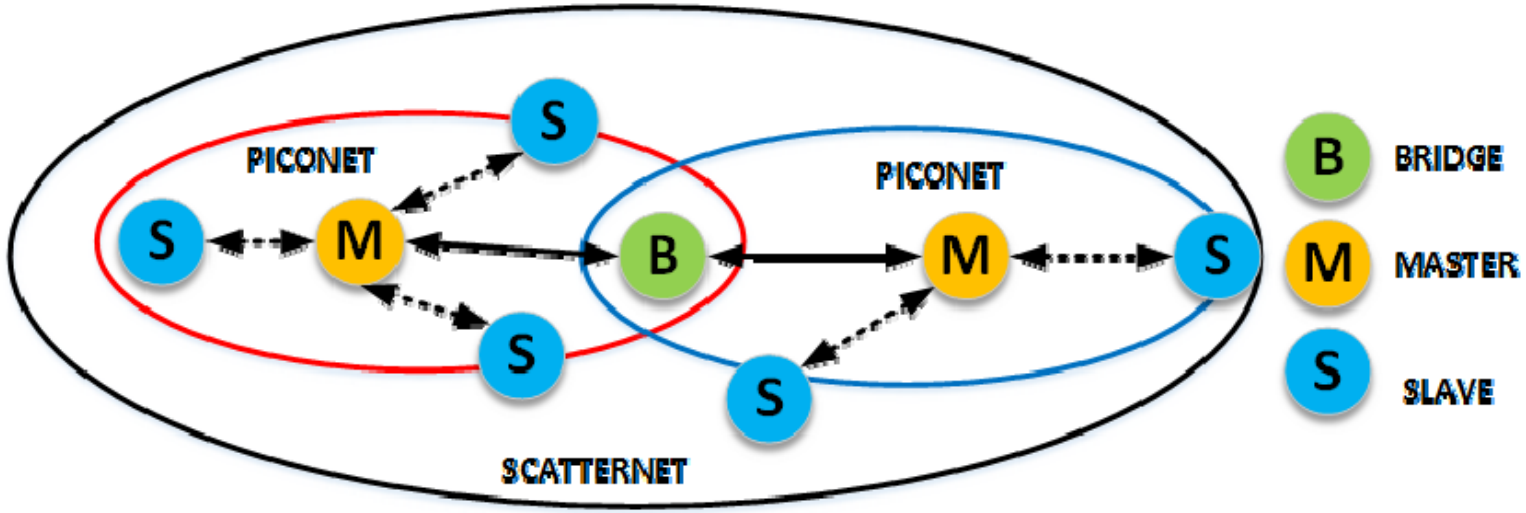
Service Discovery Protocol (SDP)

- ✓ Enables applications to discover available services and their features.
- ✓ Addresses the unique characteristics of the Bluetooth environment such as, dynamic changes in the quality of services in RF proximity of devices in motion.
- ✓ Can function over a reliable packet transfer protocol.
- ✓ Uses a request/response model

Bluetooth

Piconets

- ✓ Bluetooth enabled electronic devices connect and communicate wirelessly through short range networks known as **Piconets**
- ✓ Bluetooth devices exist in small ad-hoc configurations with the ability to act either as master or slave.
- ✓ Provisions are in place, which allow for a **master** and a **slave** to switch their roles.
- ✓ The simplest configuration is a point to point configuration with one master and one slave.
- ✓ When more than two Bluetooth devices communicate with one another, it is called a **PICONET**.
- ✓ A Piconet can contain up to seven slaves clustered around a single master.
- ✓ The device that initializes establishment of the Piconet becomes the **master**.
- ✓ The master is responsible for transmission control by dividing the network into a series of time slots amongst the network members, as a part of **time division multiplexing** scheme.



Bluetooth

Features of Piconet

✓ Within a Piconet, the clock and unique **48-bit address** of master determines the timing of various devices and the frequency hopping sequence of individual devices.

✓ Each Piconet device supports 7 simultaneous connections to other devices.

✓ Each device can communicate with several piconets simultaneously.

✓ Piconets are established dynamically and automatically as Bluetooth enabled devices enter and leave piconets.

✓ There is no direct connection between the slaves.

✓ All connections are either master-to-slave or slave-to-master.

✓ Slaves are allowed to transmit once these have been polled by the master.

✓ Transmission starts in the slave-to-master time slot immediately following a polling packet from the master.

✓ A device can be a member of two or more Piconets.

✓ A device can be a slave in one Piconet and master in another. It however cannot be a master in more than once Piconets.

✓ Devices in adjacent Piconets provide a bridge to support inner-Piconet connections, allowing assemblies of linked Piconets to form a physically extensible communication infrastructure known as **Scatternet**

Bluetooth

Applications

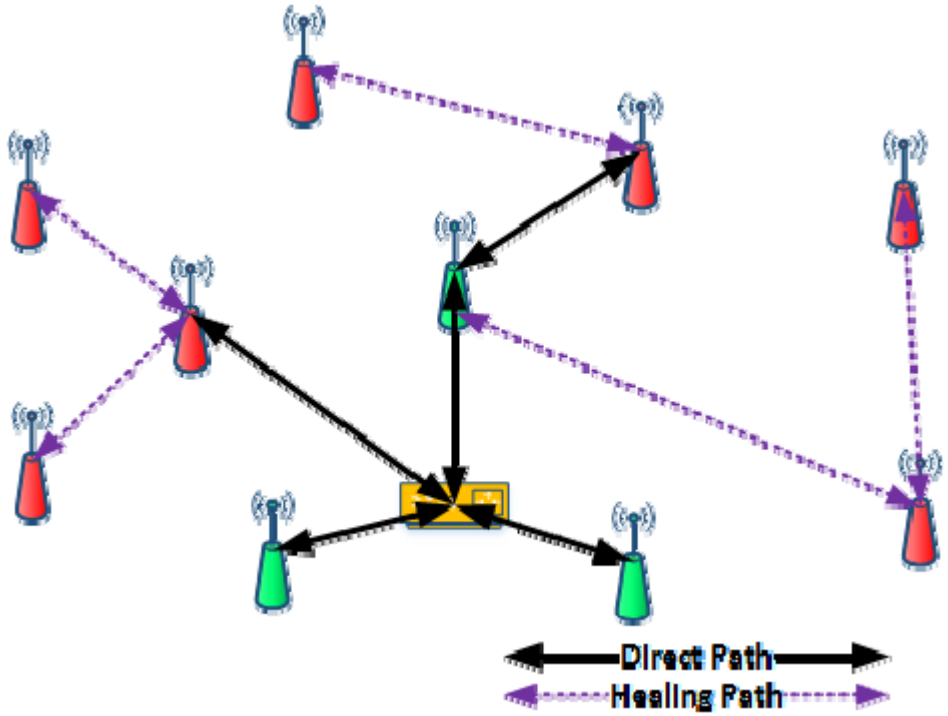
- ✓ Audio players
- ✓ Home automation
- ✓ Smartphones
- ✓ Toys
- ✓ Hands free headphones
- ✓ Sensor networks

Z Wave

- ✓ Zwave (or Z wave or Z-wave) is a protocol for communication among devices used for home automation.
- ✓ It uses RF for signaling and control.
- ✓ Operating frequency is 908.42 MHz in the US & 868.42 MHz in Europe.
- ✓ Mesh network topology is the main mode of operation, and can support 232 nodes in a network.
- ✓ Zwave utilizes GFSK modulation and Manchester channel encoding.
- ✓ A central network controller device sets-up and manages a Zwave network.
- ✓ Each logical Zwave network has 1 Home (Network) ID and multiple node IDs for the devices in it.
- ✓ Nodes with different Home IDs cannot communicate with each other.
- ✓ Network ID length=4 Bytes, Node ID length=1 Byte.

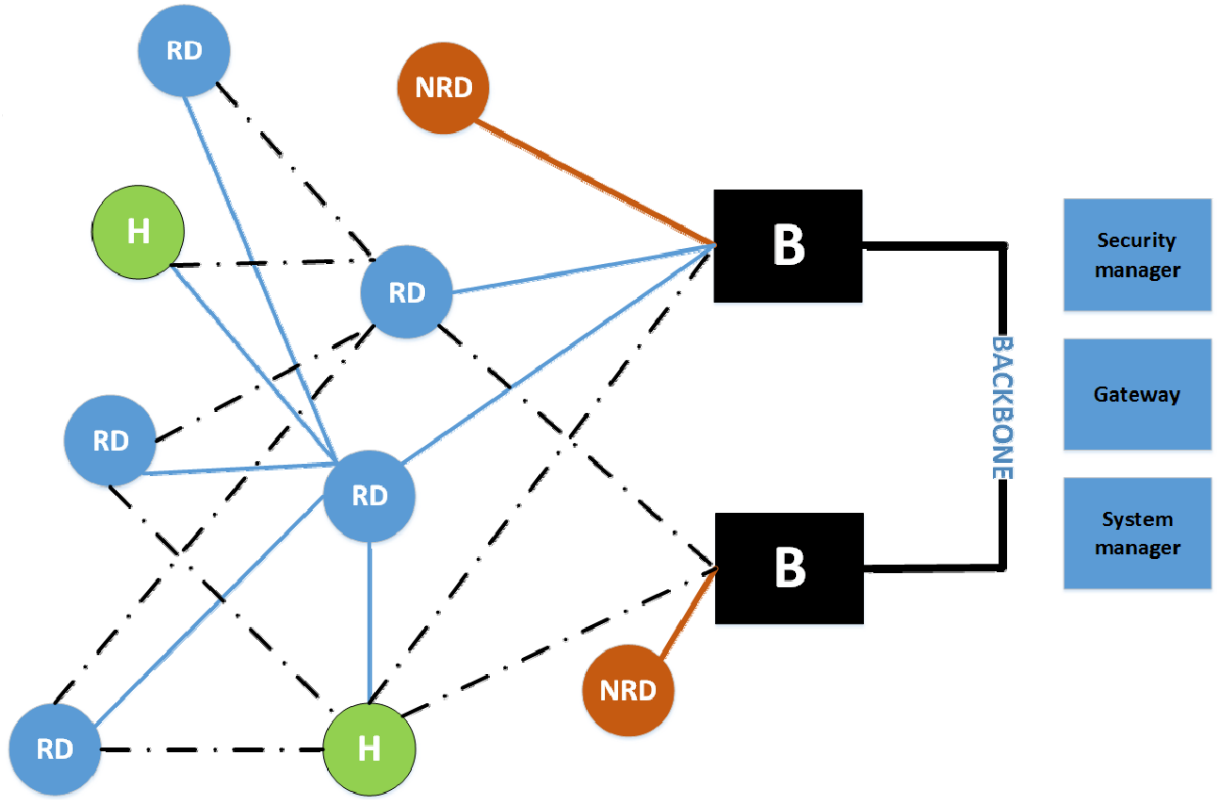
Z Wave

- ✓ Uses source routed network mesh topology using 1 primary controller.
- ✓ Devices communicate with one another when in range.
- ✓ When devices are not in range, messages are routed through different nodes to bypass obstructions created by household appliances or layout.
- ✓ This process of bypassing radio dead-spots is done using a message called **Healing.**
- ✓ As Zwave uses a source routed static network, mobile devices are excluded from the network and only static devices are considered.



ISA 100.11A

- ✓ International Society of Automation.
- ✓ Designed mainly for large scale industrial complexes and plants
- ✓ More than 1 billion devices use ISA 100.11A
- ✓ ISA 100.11A is designed to support native and tunneled application layers.
- ✓ Various transport services, including ‘reliable,’ ‘best effort,’ ‘real-time’ are offered.
- ✓ Network and transport layers are based on TCP or UDP / IPv6.
- ✓ Data link layer supports mesh routing and Frequency hopping.
- ✓ Physical and MAC layers are based on IEEE 802.15.4
- ✓ Topologies allowed are:
  - Star/tree
  - Mesh
- ✓ Permitted networks include:
  - Radio link
  - ISA over Ethernet
  - Field buses



RD=routing device
H=Handheld device

NRD=Non-routing device
B=backbone device

ISA 100.11A

Features

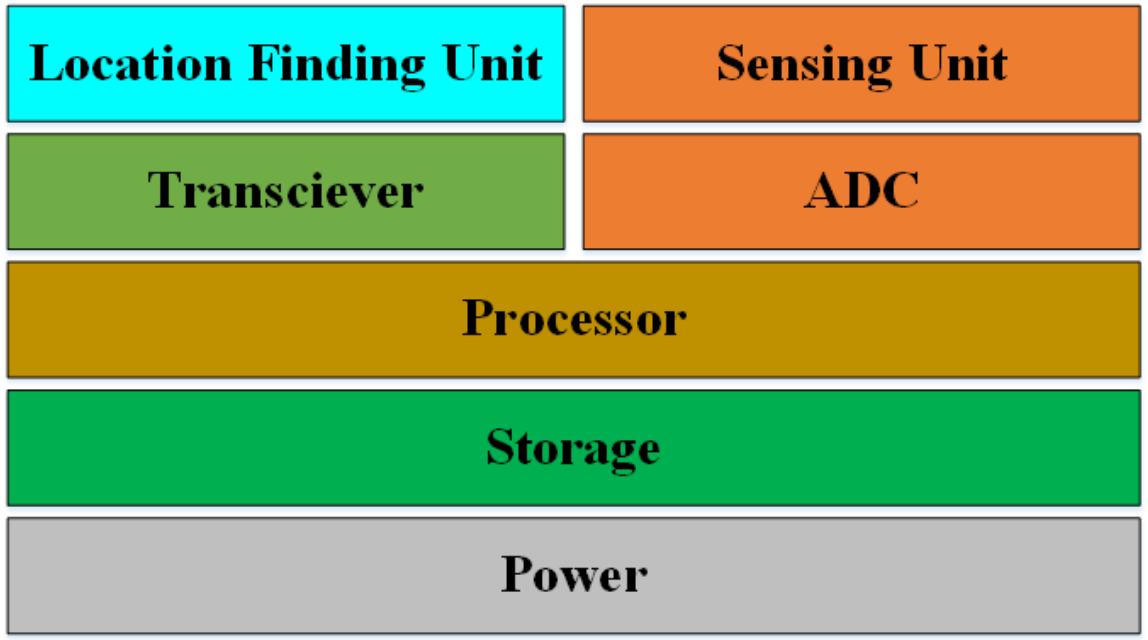
- ✓ Flexibility
- ✓ Support for multiple protocols
- ✓ Use of open standards
- ✓ Support for multiple applications
- ✓ Reliability (error detection, channel hopping)
- ✓ Determinism (TDMA, QoS support)
- ✓ Security

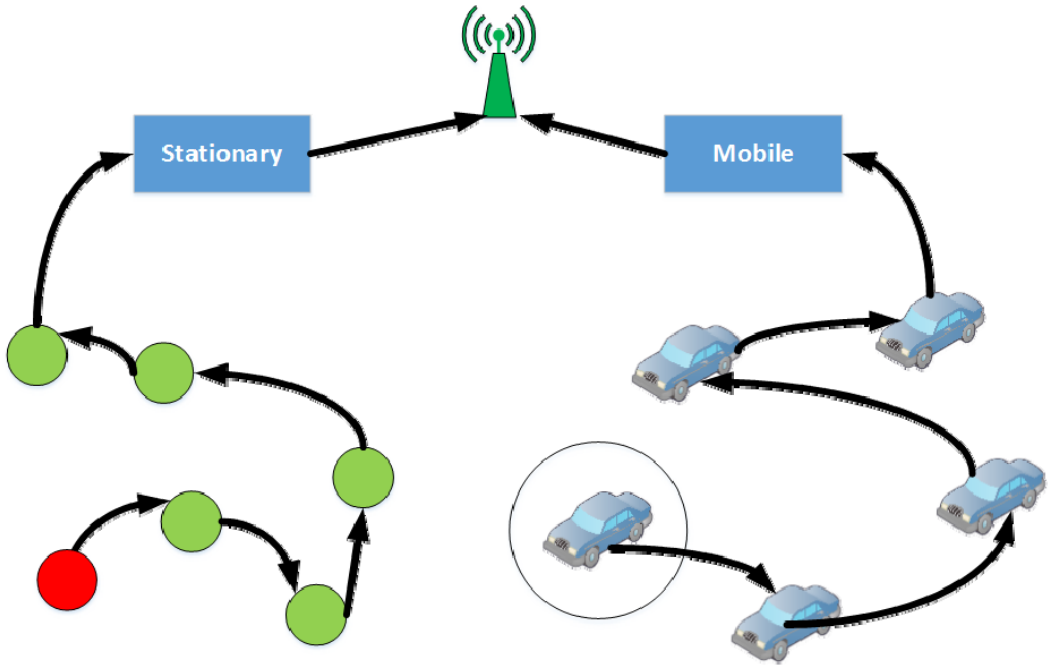
Security

- ✓ Security is fully built-in to the standard.
- ✓ Authentication and confidentiality services are independently available.
- ✓ A network security manager manages and distributes keys
- ✓ Twin data security steps in each node:
  - Data link layer encrypts each hop.
  - Transport layer secures peer-to-peer communications.

Wireless Sensors Networks

- Consists of a large number of sensor nodes, densely deployed over an area.
- Sensor nodes are capable of collaborating with one another and measuring the condition of their surrounding environments (i.e. Light, temperature, sound, vibration).





- The sensed measurements are then transformed into digital signals and processed to reveal some properties of the phenomena around sensors.
- Due to the fact that the sensor nodes in WSNs have short radio transmission range, intermediate nodes act as relay nodes to transmit data towards the sink node using a multi-hop path.

Sensors Nodes

- **Multifunctional**
- The number of sensor nodes used depends on the application type.
- **Short transmission ranges**
- **Have OS** (e.g., TinyOS).
- **Battery Powered** – Have limited life.

Constraints on Sensor Nodes

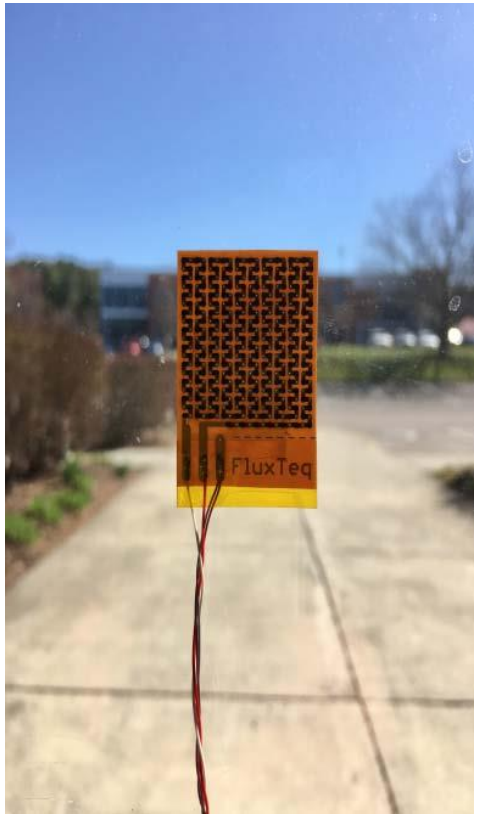
- Small size, typically less than a cubic cm.
- Must consume extremely low power
- Operate in an unattended manner in a highly dense area.
- Should have low production cost and be dispensable
- Be autonomous
- Be adaptive to the environment

Sensors Nodes

Applications

- Temperature measurement
- Humidity level
- Lighting condition
- Air pressure
- Soil makeup
- Noise level
- Vibration

a) Soil sensor node



b) Temperature Flux sensor node

c) Weather sensor node

Sensors Nodes

Challenges

Scalability

- Providing acceptable levels of service in the presence of large number of nodes.
- Typically, throughput decreases at a rate of , N = number of nodes

Quality of service

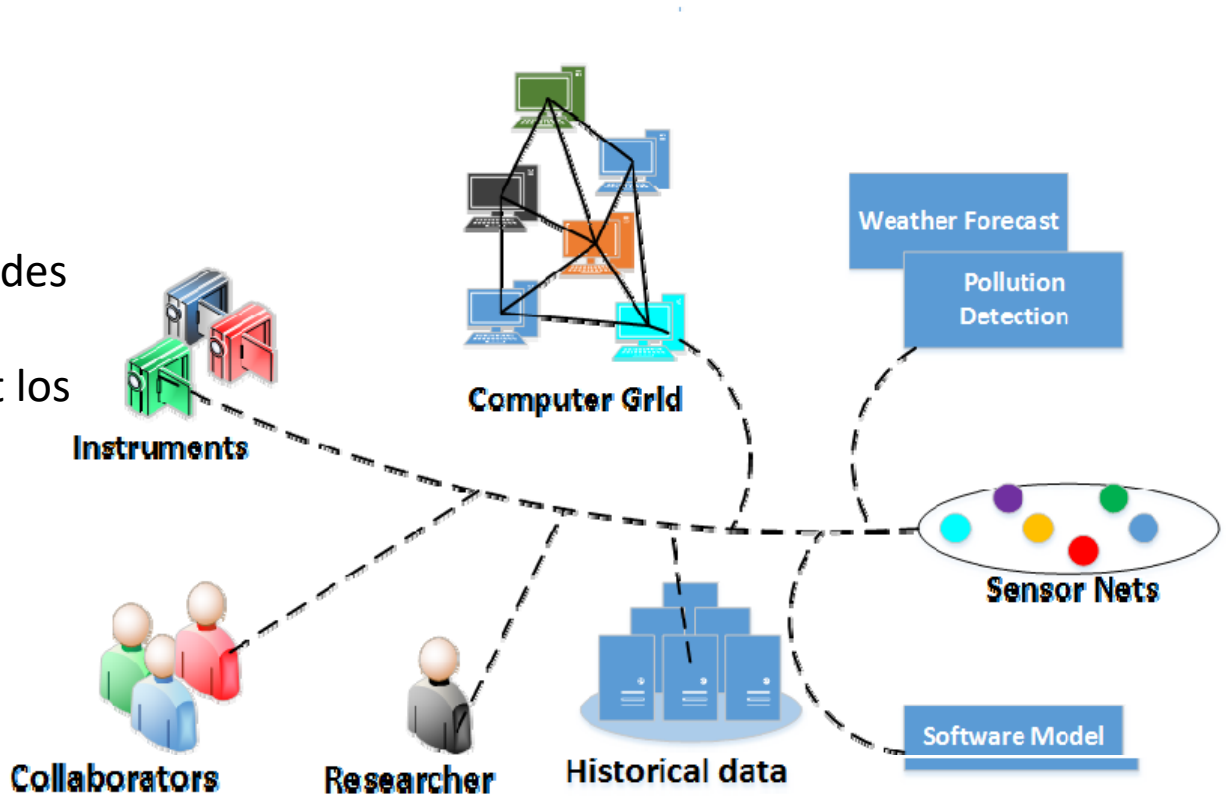
- Offering guarantees in terms of bandwidth, delay, jitter, packet los probability.
- Limited bandwidth, unpredictable changes in RF channel characteristics.

Energy efficiency

- Nodes have limited battery power
- Nodes need to cooperate with other nodes for relaying their information.

Security

- Open medium.
- Nodes prone to malicious attacks, infiltration, eavesdropping, interference.



Sensors Web

Cooperation in Wireless Ad Hoc and Sensor Networks

- Nodes communicate with other nodes with the help of intermediate nodes.
- The intermediate nodes act as relays.
- Wireless nodes are energy-constrained.
- Nodes may or may not cooperate.

- Two extremities:
- **Total cooperation:** if all relay requests are accepted, nodes will quickly exhaust limited energy.
- **Total non-cooperation:** if no relay requests are accepted, the network throughput will go down rapidly.

Issues:

- Selfishness, self-interests, etc.
- Symbiotic dependence
- Tradeoff: individual node's lifetime vs. Throughput.

Node Behavior in WSN

- Normal nodes work perfectly in ideal environmental conditions
- Failed nodes are simply those that are unable to perform an operation; this could be because of power failure and environmental events.
- Badly failed nodes exhibit features of failed nodes but they can also send false routing messages which are a threat to the integrity of the network.
- Selfish nodes are typified by their unwillingness to cooperate, as the protocol requires whenever there is a personal cost involved. Packet dropping is the main attack by selfish nodes.
- Malicious nodes aim to deliberately disrupt the correct operation of the routing protocol, denying network service if possible.

Dynamic Misbehavior: Dumb Behavior

- Detection of such temporary misbehavior in order to preserve normal functioning of the network – coinage and discovery of dumb behavior
- In the presence of adverse environmental conditions (high temperature, rainfall, and fog) the communication range shrinks
- A sensor node can sense its surroundings but is unable to transmit the sensed data
- With the resumption of favorable environmental conditions, dumb node work normally
- Dumb behavior is temporal in nature (as it is dependent on the effects of environmental conditions)

Detection and Connectivity Re-establishment

- The presence of dumb nodes impedes the overall network performance
- Detection, and, subsequently, the re-establishment of network connectivity is crucial
- The sensed information can only be utilized if the connectivity between each dumb node with other nodes in the network could be re-established.
- Before restoration of network connectivity, it is essential to detect the dumb nodes in the network.
- CoRD and CoRAD are two popular schemes that re-establish the connectivity between dumb nodes with others.

Event-Aware Topology Management in Wireless Sensor Networks

- Timely detection of an event of interest
- Monitoring the event
- Disseminating event-data to the sink
- Adapting with the changes of event state
- Event location
- Event area
- Event duration

Detection and Connectivity Re-establishment

Information Theoretic Self-Management of Wireless Sensor Networks

- A WSN is deployed with the intention of acquiring information
- The sensed information are transmitted in the form of packets
- Information theoretic self-management (INTSEM) controls the transmission rate of a node by adjusting a node's sleep time

Benefits

- Reduce consumption of transmission energy of transmitters
- Reduce consumption of receiving energy of relay nodes

Social Sensing in WSNs

✓ Social Sensing-based Duty Cycle Management for Monitoring Rare Events in Wireless Sensor Networks

- WSNs are energy-constrained

Scenario:

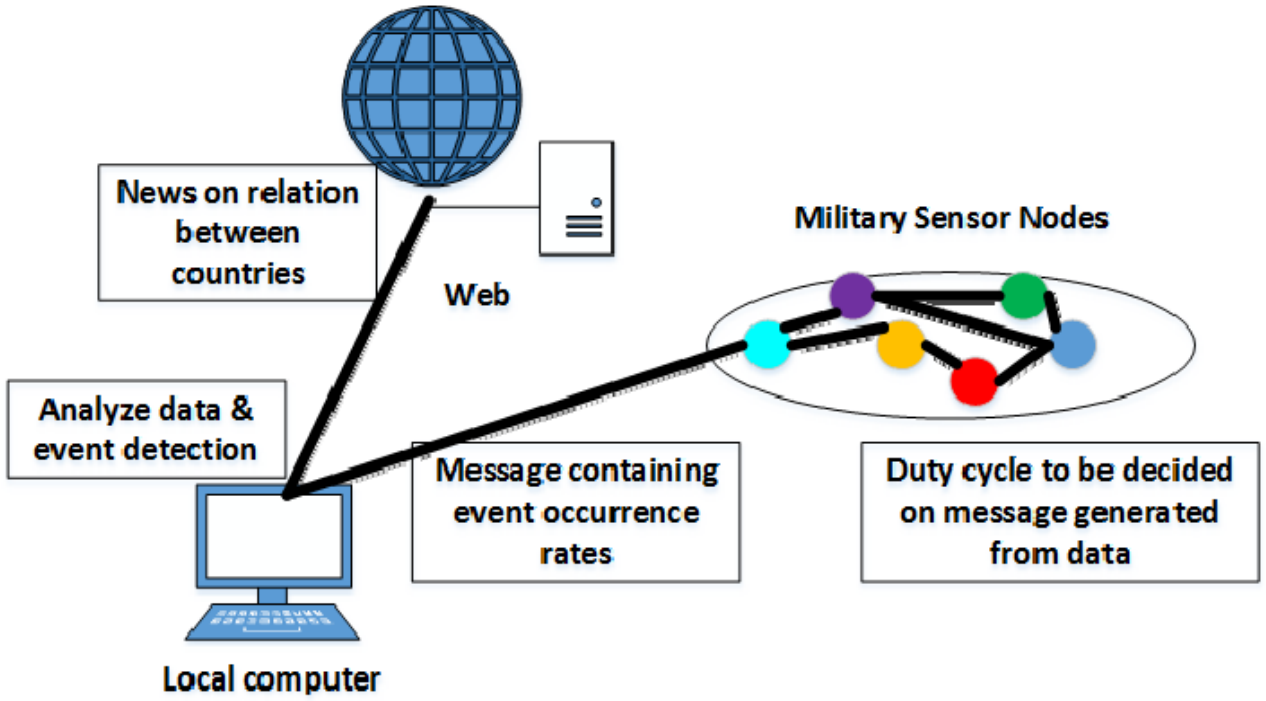
- Event monitoring using WSNs
- Event monitoring or sensing, even if there is no event to monitor or sense
- Example: Submarine monitoring in underwater surveillance

Possible Solution Approach: Duty-cycle management

Limitations:

- Do not distinguish the rare events from regular events
- Ineffective wakeup and sensing under rare event monitoring scenario

Social Sensing



- **Challenges**:
- Distinguish rare events and regular events
- Adapt the duty-cycle with the event occurrence probability.

- Probabilistic duty cycle (PDC) in WSNs
- Accumulates information from the social media to identify the occurrence possibility of rare events
- Adjusts the duty cycles of sensor nodes using weak estimation learning automata

Applications of WSN

Question No: 1

- In general, Z-wave protocol for communication among devices is used for _____.

a. Topology management
b. Home automation
c. Network configuration
d. None of the above

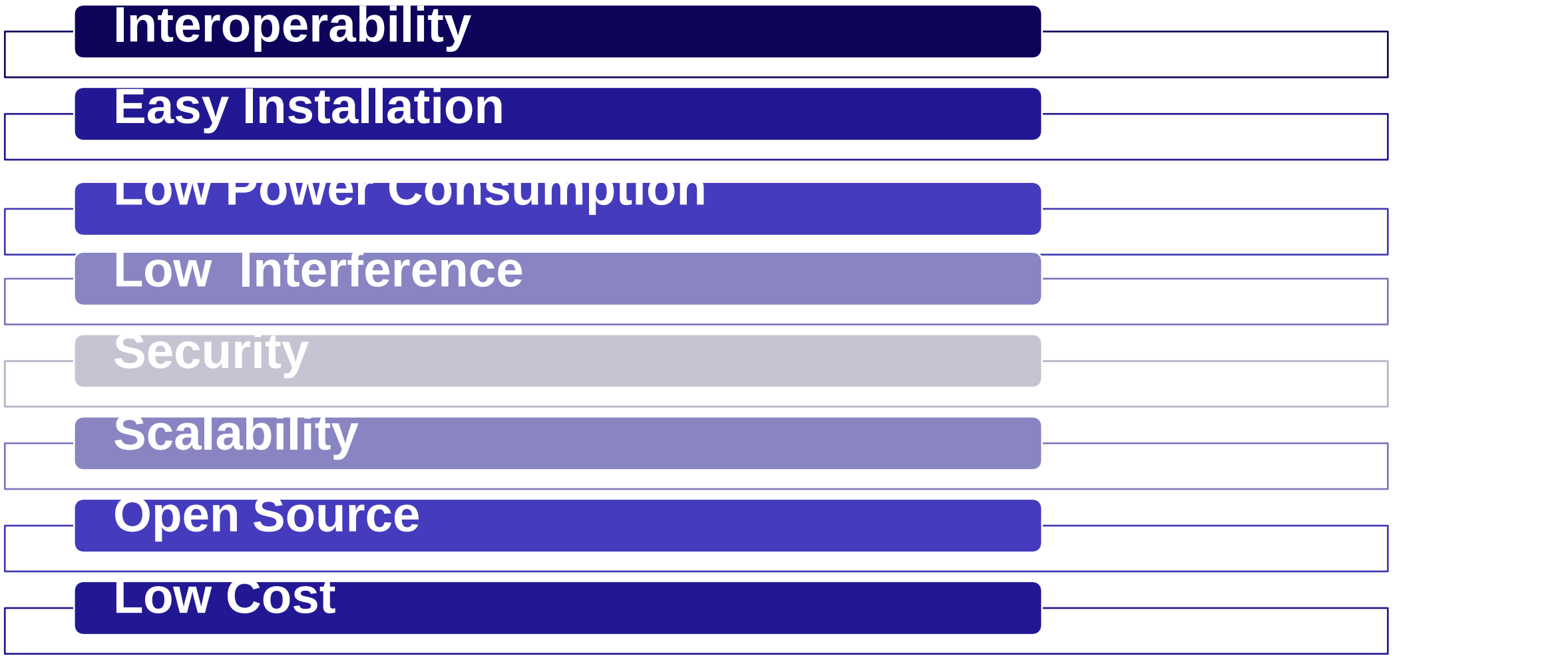
Question No: 1

- Z-wave protocol features.

- Especially developed for home automation.
- It uses RF for signaling and control.
- Operating frequency is 908.42 MHz in the US & 868.42 MHz in Europe.
- Mesh network topology is the main mode of operation, and can support 232 nodes in a network.

Question No: 1

- Reasons for using Z-wave protocol for home automation.



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- In general, Z-wave protocol for communication among devices is used for _____.

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Question No: 2

- Which of the following characteristic of HART Data Link Layer helps it to achieve collision-free and deterministic communication?

a. Super-frames
b. Channel hopping
c. Channel blacklisting
d. All of the above

Question No: 2

- Super Frames

- Super Frames are responsible for collision free and deterministic communication.
- Super-frames consist of grouped 10ms wide timeslots.
- Super-frames control the timing of transmission to ensure collision free and reliable communication

Question No: 2

- Channel Hopping

- ❑ Channel access method.
- ❑ Switching of channels.
- ❑ Used by Low-Power devices to communicate using a wireless link.
- ❑ Improves security.

Question No: 2

- Channel Blacklisting

❑ Channel blacklisting identifies channels consistently affected by interference and removes them from use.

Question No: 2

- Which of the following characteristic of HART Data Link Layer helps it achieve collision-free and deterministic communication?

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Question No: 3

- Which of the following is the basis for Bluetooth technology?

a. Ad-hoc piconets
b. Ad-hoc technology
c. Both (a) and (b)
d. None of the above

Question No: 3

- Bluetooth technology

Bluetooth wireless technology is a short range communications technology.

Intended for replacing cables connecting portable units.

Maintains high levels of security.

Bluetooth technology is based on **Ad-hoc technology** also known as **Ad-hoc Piconets.**

Question No: 3

- Ad-hoc Technology and Ad-hoc piconets

In Ad-hoc technology, the devices spontaneously connect and communicate with each other.

Ad-hoc Piconets

- Ad-hoc network that links devices using Bluetooth.
- Consists of two or more devices.
- allows one master device to interconnect with up to seven active slave devices.

Question No: 3

- Which of the following is the basis for Bluetooth technology?

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Question No: 4

- Which of the following protocol uses healing (message) to bypass radio dead-spots?

a. HART
b. NFC
c. Z-wave
d. None of the above

Question No: 4

- Radio dead-spots

  - Zone where little or no signal can be received.
  - Within the range of a radio transmitter.
  - Process of bypassing radio dead-spots is done using a message called Healing.

Question No: 4

- Which of the following protocol uses healing (message) to bypass radio dead-spots?

a. HART
b. NFC
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d. None of the above

Question No: 5

- Which of the following nodes send false routing messages in the network?

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c. Failed nodes
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Question No: 6

- Which of the following layers provide multiplexing capability in Bluetooth technology?

a. L2CAP
b. RFComm
c. SDP
d. Baseband

Question No: 6

- Protocol stack of Bluetooth technology

Question No: 6

- Baseband

✓ Physical layer of the Bluetooth.
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- Protocol stack of Bluetooth technology

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- Protocol stack of Bluetooth technology: SDP (Service Discover Protocol)

✓ Enables applications to discover available services and their features.

✓Addresses the unique characteristics of the Bluetooth environment such as, dynamic changes in the quality of services in RF proximity of devices in motion.

✓ Can function over a reliable packet transfer protocol.

✓ Uses a request/response model

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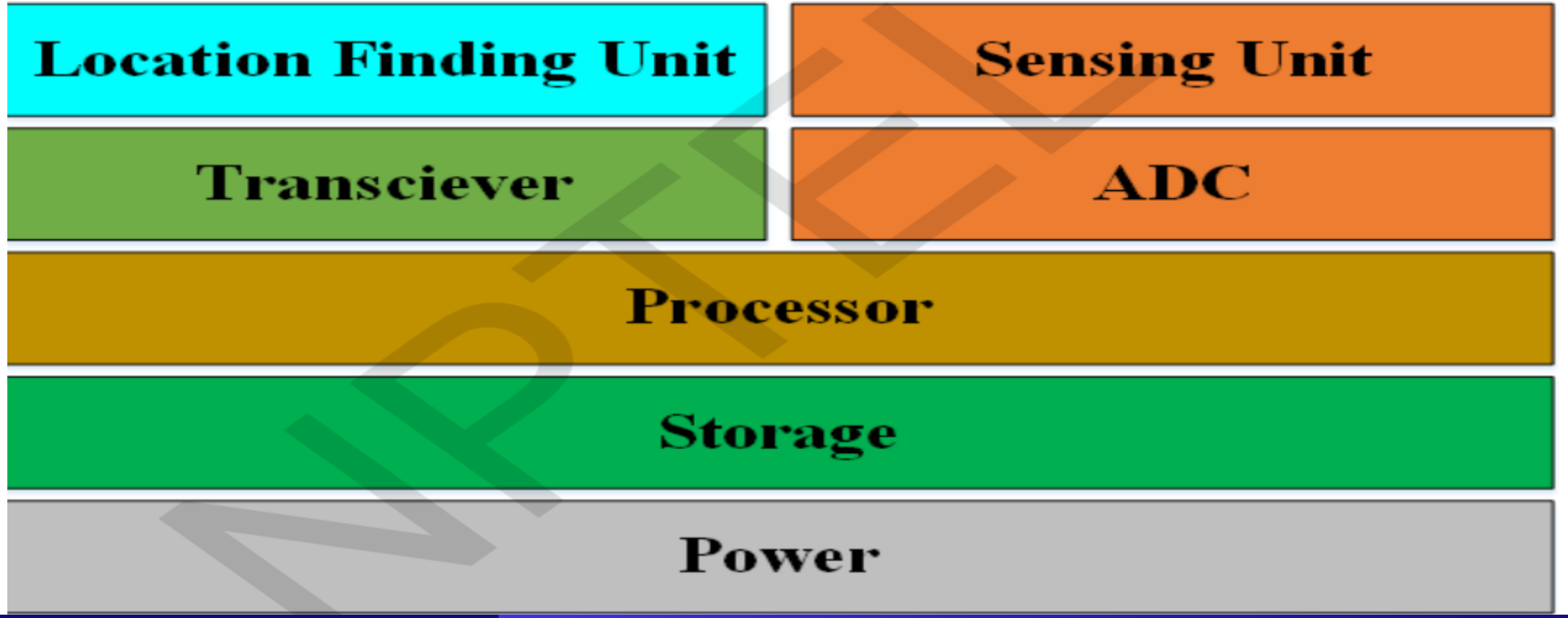
Question No: 7

- Which of the following component can be considered as optional for a sensor node?

a. Sensing unit
b. Transceiver
c. Location finding unit
d. None of the above

Question No: 7

- Component of a sensor node



Question No: 7

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Question No: 8

- Which of the following provide energy to peer-to-peer tags?

a. Reader
b. Own power source
c. Both (a) and (b)
d. Doesn’t require energy

Question No: 8

- Peer-to-Peer tags

  - ❑ Able to collect as well as transmit information.
  - ❑ Smartphones are a good example of active devices
  - ❑ Have their own power source.

Question No: 8

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Question No: 9

- Which of the following schemes re-establish the connectivity between dumb nodes with others?

a. CoRD
b. CaRAD
c. Both (a) and (b)
d. None of the above

Question No: 9

- CoRD and CaRAD

CoRD and CoRAD are the popular schemes that re-establish the connectivity between dumb nodes with others.

Various other schemes:
CoRDWAC
LECRAD

- https://cse.iitkgp.ac.in/~smisra/theme_pages/wsn/WSN.html
- https://cse.iitkgp.ac.in/~smisra/theme_pages/wsn/pdfs/CoRD(okay)_watermark.pdf
- https://cse.iitkgp.ac.in/~smisra/theme_pages/wsn/pdfs/connectivity_with_adjustable_acm(OKAY)_watermark_(1).pdf

Question No: 9

- Which of the following schemes re-establish the connectivity between dumb nodes with others?

a. CoRD
b. CaRAD
c. Both (a) and (b)
d. None of the above

Question No: 10

- Which layer of Bluetooth handles paging?

a. L2CAP
b. RFComm
c. SDP
d. Baseband

Question No: 10

- Paging

Process of **forming a connection** between two Bluetooth devices

Question No: 10

- Baseband

✓ Physical layer of the Bluetooth.
✓ Manages physical channels and links.
✓ Other services include:

  - Error correction
  - Data whitening
  - Hop selection
  - Bluetooth security

✓ Manages asynchronous and synchronous links.
✓ Handles packets, paging and inquiry.

Question No: 10

- Which layer of Bluetooth handles paging?

a. L2CAP
b. RFComm
c. SDP
d. Baseband

Question No: 11

In general, is it advisable to increase the duty cycle of a node in case of rare events for social sensing?

a. Yes
b. No
c. Not Applicable

Question No: 11

- In general, is it advisable to increase the duty cycle of a node in case of rare events for social sensing?

a. Yes
b. No
c. Not Applicable

Duty cycle management: when to wake up the node.

Question No: 12

- Is Zigbee Pro compatible with Zigbee RF4CE?

a. Yes
b. No
c. Not Applicable

Question No: 12

- Is Zigbee Pro compatible with Zigbee RF4CE?

a. Yes
b. No
c. Not Applicable

Zigbee, Zigbee Pro, Zigbee RF4CE, and Zigbee IP are incompatible with each other.

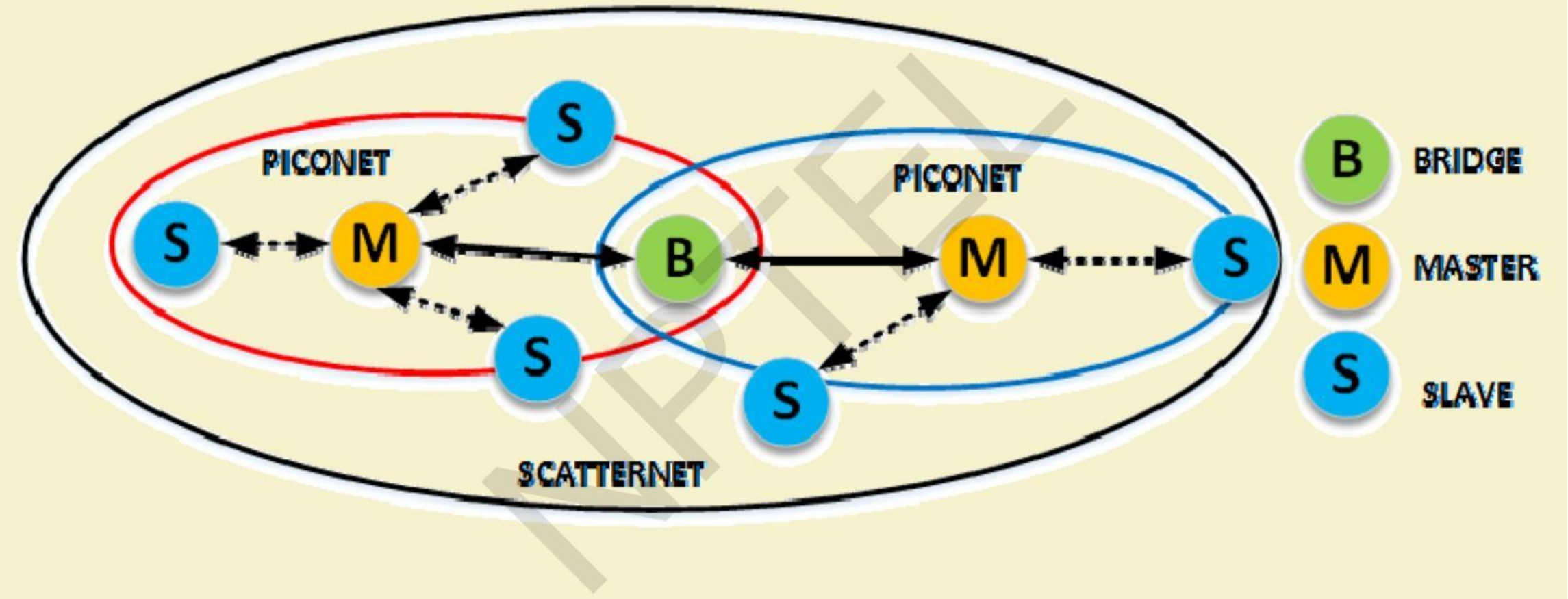
Question No: 13

- Which of the following is True?

a. Scatternet is a subset of Piconet
b. Piconet is a subset of Scatternet
c. A device can be a master in more than one piconet
d. A piconet can have maximum of 10 scatternets

Question No: 13

Piconet And Scatternet



Question No: 13

- Which of the following is True?

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b. Piconet is a subset of Scatternet
c. A device can be a master in more than one piconet
d. A piconet can have maximum of 10 scatternets

Question No: 14

- Which of the following suffers in case of total co-operation in wireless ad hoc and sensor networks?

a. Network delay
b. Network throughput
c. Node’s lifetime
d. All of the above

Question No: 14

- Which of the following suffers in case of total co-operation in wireless ad hoc and sensor networks?

a. Network delay
b. Network throughput
c. Node’s lifetime
d. All of the above

In case of total co-operation in wireless ad hoc and sensor networks, all the requests are accepted. This exhausts the limited energy of the nodes.

In case of total non co-operation in wireless ad hoc and sensor networks, all the requests are not accepted. This lows down the network throughput.

Question No: 15

- Does ISA 100.11A support tunneling mode?

a. Yes
b. No

Question No: 15

- Does ISA 100.11A support tunneling mode?

a. Yes
b. No

A tunneling mode is available to allow legacy data through the ISA 100.11A network.

Question No: 16

Which of the following handles packets, paging and inquiry in Bluetooth?

a. L2CAP
b. Baseband
c. RFComm
d. Physical Radio

Question No: 16

Which of the following handles packets, paging and inquiry in Bluetooth?

a. L2CAP
b. Baseband
c. RFComm
d. Physical Radio

Bluetooth baseband handles packets, paging and inquiry.
See lecture 12

Question No: 17

Which of the following incorporates channel hopping after every packet transmission?

a. Zigbee
b. WirelessHART
c. 6LoWPAN
d. None of these

Question No: 17

Which of the following incorporates channel hopping after every packet transmission?

a. Zigbee
b. WirelessHART
c. 6LoWPAN
d. None of these

The major difference between WirelessHART and Zigbee is the incorporation of channel hopping after every packet transmission in WirelessHART. A Zigbee typically does not have hopping in it, but some variants of Zigbee hops channels only when the entire network hops the channel.

Question No: 18

In “X” protocol, a central network controller device sets-up a network with 1 Network ID and multiple node IDs for the devices in it. The nodes with different Network IDs cannot communicate with each other. What is “X”?

a. Z-wave
b. b. Zigbee
c. c. Bluetooth
d. d. ISA 100.11A

Question No: 18

In “X” protocol, a central network controller device sets-up a network with 1 Network ID and multiple node IDs for the devices in it. The nodes with different Network IDs cannot communicate with each other. What is “X”?

a. Z-wave
b. b. Zigbee
c. c. Bluetooth
d. d. ISA 100.11A

“X” is Z-wave. In Z-wave, nodes with different Network IDs cannot communicate with each other.

Question No: 19

In the context of Sensor Web, SensorML stands for _____.

a. Sensor Modeling language
b. Sensor Machine language
c. Sensor Markup language
d. None of the above

Question No: 19

In the context of Sensor Web, SensorML stands for _____.

a. Sensor Modeling language
b. Sensor Machine language
c. Sensor Markup language
d. None of the above

SensorML stands for Sensor Modeling language.

Question No: 20

Which of the following protocol is best suited to provide interference-free communication while minimizing latency and ensuring quality of service?

a. WirelessHART
b. ISA100.11A
c. Both WirelessHART and ISA100.11A
d. None of these

Question No: 20

Which of the following protocol is best suited to provide interference-free communication while minimizing latency and ensuring quality of service?

a. WirelessHART
b. ISA100.11A
c. Both WirelessHART and ISA100.11A
d. None of these

Both wireless HART and ISA100.11A have mechanisms to tackle channel interference. However, ISA100.11A provides support for legacy technology integration, as well as, minimizes latency and ensures quality of service. These features are not explicitly present in wirelessHART. In light of these additional features, ISA100.11A is the best suited option.

Question No: 21

Which of the following solution approach is used to overcome the limitation of ineffective wakeup and sensing under rare event monitoring scenario in social sensing?

a. Duty-cycle management
b. Sleep-cycle management
c. Packet transmission management
d. Both duty-cycle and sleep-cycle management

Question No: 21

Which of the following solution approach is used to overcome the limitation of ineffective wakeup and sensing under rare event monitoring scenario in social sensing?

a. Duty-cycle management
b. Sleep-cycle management
c. Packet transmission management
d. Both duty-cycle and sleep-cycle management

Social sensing in WSNs often face the limitation of incapability of distinguishing the rare events from regular events and ineffective wakeup and sensing under rare event monitoring scenario. These are usually overcome by duty-cycle management.
See lecture 15

Question No: 22

Which of the following technique Bluetooth master uses to avoid collisions during transmission in a Piconet?

a. Frequency Division Multiplexing
b. Frequency Hopping Spread Spectrum
c. Time Division Multiplexing
d. Direct Sequence Spread Spectrum

Question No: 22

Which of the following technique Bluetooth master uses to avoid collisions during transmission in a Piconet?

a. Frequency Division Multiplexing
b. Frequency Hopping Spread Spectrum
c. Time Division Multiplexing
d. Direct Sequence Spread Spectrum

In a Piconet, the Bluetooth master is responsible for transmission control by dividing the network into a series of time slots amongst the network members, as a part of time division multiplexing scheme.

Question No: 23

Which of the following limitation is faced by total co-operation in Wireless Ad Hoc and Sensor Networks?

a. Decreasing network throughput
b. Decreasing energy
c. Both (a) and (b)
d. No limitation exists

Question No: 23

Which of the following limitation is faced by total co-operation in Wireless Ad Hoc and Sensor Networks?

a. Decreasing network throughput
b. Decreasing energy
c. Both (a) and (b)
d. No limitation exists

In total co-operation, if all relay requests are accepted, nodes will quickly exhaust limited energy.

Question No: 24

Which of the following can function over a reliable packet transfer protocol?

a. L2CAP
b. Service Discovery Protocol
c. RFComm
d. Physical Radio

Question No: 24

Which of the following can function over a reliable packet transfer protocol?

a. L2CAP
b. Service Discovery Protocol
c. RFComm
d. Physical Radio

Service Discovery Protocol (SDP) in Bluetooth can function over a reliable packet transfer protocol.
See lecture 12

Question No: 25

In which of the following mode, NFC devices can act as both readers as well as tags?

a. Reader/writer
b. P2P
c. Emulation
d. NFC devices can’t act as both readers as well as tags

Question No: 25

In which of the following mode, NFC devices can act as both readers as well as tags?

a. Reader/writer
b. P2P
c. Emulation
d. NFC devices can’t act as both readers as well as tags

NFC devices can act as both readers as well as tags (only in emulation mode).
See lecture 11

Question No: 26

In WSN, Information theoretic self-management (INTSEM) controls the transmission rate of a node by adjusting a node's _____.

a. Duty cycle
b. Lifetime
c. Sleep time
d. Can't control the transmission rate

Question No: 26

In WSN, Information theoretic self-management (INTSEM) controls the transmission rate of a node by adjusting a node's _____.

a. Duty cycle
b. Lifetime
c. Sleep time
d. Can't control the transmission rate

Information theoretic self-management (INTSEM) controls the transmission rate of a node by adjusting a node's sleep time.
See lecture 15

Question No: 27

Which of the following layer of ISA 100.11A supports mesh routing?

a. Network layer
b. Data link layer
c. Transport layer
d. MAC layer

Question No: 27

Which of the following layer of ISA 100.11A supports mesh routing?

a. Network layer
b. Data link layer
c. Transport layer
d. MAC layer

Data link layer of ISA 100.11A supports mesh routing and frequency hopping. See lecture 13

Question No: 28

Which of the following is used to avoid interference-prone channels in HART?

a. Channel blacklisting
b. Channel switching
c. Channel hopping
d. Super-frames

Question No: 28

Which of the following is used to avoid interference-prone channels in HART?

a. Channel blacklisting
b. Channel switching
c. Channel hopping
d. Super-frames

In HART, interference-prone channels are avoided by using channel switching post every transmission.

Question No: 29

When the devices are not in range, messages are routed through different nodes to bypass obstructions created by household appliances or layouts. Which of the following exhibit such characteristic of avoiding radio dead-spots?

a. Bluetooth
b. 6LoWPAN
c. Z-wave
d. Zigbee

Question No: 29

When the devices are not in range, messages are routed through different nodes to bypass obstructions created by household appliances or layouts. Which of the following exhibit such characteristic of avoiding radio dead-spots?

a. Bluetooth
b. 6LoWPAN
c. Z-wave
d. Zigbee

The process of bypassing radio dead-spots is done using a message called Healing. Healing messages are a characteristic of Z-wave.

Question No: 30

Which of the following is TRUE in terms of power (in mW) and range (in m) of the classes of Bluetooth devices?

a. Class-1: Power=100mW, Range=100m
b. Class-2: Power=2.5 mW, Range=100m
c. Class-1: Power=2.5 mW, Range=100m
d. Class-2: Power=100 mW, Range=100m

Question No: 30

Which of the following is TRUE in terms of power (in mW) and range (in m) of the classes of Bluetooth devices?

a. Class-1: Power=100mW, Range=100m
b. Class-2: Power=2.5 mW, Range=100m
c. Class-1: Power=2.5 mW, Range=100m
d. Class-2: Power=100 mW, Range=100m

Class-1: Power=100mW, Range=100m; Class-2: Power=2.5 mW, Range=10m

Question No: 31

Choose the correct option based on the following two statements on the HART Physical Layer.
Statement-I: It is derived from the IEEE 802.15.4 protocol.
Statement-II: It operated only in the 2.4 GHz ISM band.

a. Statement-I True and Statement-II False
b. Statement-I False and Statement-II True
c. Both Statements I and II are False
d. Both Statements I and II are True

Question No: 31

Choose the correct option based on the following two statements on the HART Physical Layer.
Statement-I: It is derived from the IEEE 802.15.4 protocol.
Statement-II: It operated only in the 2.4 GHz ISM band.

a. Statement-I True and Statement-II False
b. Statement-I False and Statement-II True
c. Both Statements I and II are False
d. Both Statements I and II are True

Question No: 32

Which of the following characteristic of HART Data Link Layer helps to increase reliability and security?

a. Channel Hopping and Channel Blacklisting
b. Channel Crunching and Jamming
c. Scattering
d. All of these

Question No: 32

Which of the following characteristic of HART Data Link Layer helps to increase reliability and security?

a. Channel Hopping and Channel Blacklisting
b. Channel Crunching and Jamming
c. Scattering
d. All of these

Question No: 33

State True or False
Statement: Channel blacklisting in HART identifies channels consistently affected by interference and removes them from use.

a. True
b. False

Question No: 33

State True or False
Statement: Channel blacklisting in HART identifies channels consistently affected by interference and removes them from use.

a. True
b. False

Question No: 34

At the MAC layer –
Statement-I: WirelessHART utilizes Time Division Multiple Access (TDMA).
Statement-II: ZigBee applies Carrier Sense Multiple Access with Collision Detection (CSMA/CD).

a. Statement-I True and Statement-II False
b. Statement-I False and Statement-II True
c. Both Statements I and II are False
d. Both Statements I and II are True

Question No: 34

At the MAC layer –
Statement-I: WirelessHART utilizes Time Division Multiple Access (TDMA).
Statement-II: ZigBee applies Carrier Sense Multiple Access with Collision Detection (CSMA/CD).

a. Statement-I True and Statement-II False
b. Statement-I False and Statement-II True
c. Both Statements I and II are False
d. Both Statements I and II are True

Question No: 35

NFC works on the principal of

a. Pressure
b. Magnetic Induction
c. Both (a) and (b)
d. None of these

Question No: 35

NFC works on the principal of

a. Pressure
b. Magnetic Induction
c. Both (a) and (b)
d. None of these

Question No: 36

Bluetooth technology is based on Ad-hoc technology also known as?

a. Ad-hoc Piconets
b. Ad-hoc Micronets
c. Ad-hoc Nanonets
d. None of these

Question No: 36

Bluetooth technology is based on Ad-hoc technology also known as?

a. Ad-hoc Piconets
b. Ad-hoc Micronets
c. Ad-hoc Nanonets
d. None of these

Question No: 37

Class 2 Bluetooth radios have a range of about?

a. 1 m
b. 2 m - 5 m
c. 10 m
d. None of these

Question No: 37

Class 2 Bluetooth radios have a range of about?

a. 1 m
b. 2 m - 5 m
c. 10 m
d. None of these

Question No: 38

Which of the following is NOT a phase in Bluetooth connection establishment?

a. Inquiry
b. Booking
c. Paging
d. Connection

Question No: 38

Which of the following is NOT a phase in Bluetooth connection establishment?

a. Inquiry
b. Booking
c. Paging
d. Connection

Question No: 39

Zwave can support _____ number of nodes in a network?

a. 232
b. 233
c. 234
d. 235

Question No: 39

Zwave can support _____ number of nodes in a network?

a. 232
b. 233
c. 234
d. 235

Question No: 40

Topologies allowed in ISA 100.11A are?

a. Ring Only
b. Mesh and Hybrid
c. Mesh and Ring
d. Mesh and Star/Tree

Question No: 40

Topologies allowed in ISA 100.11A are?

a. Ring Only
b. Mesh and Hybrid
c. Mesh and Ring
d. Mesh and Star/Tree

Question No: 41

An example of an Operating System (OS) that a sensor node can have is?

a. MicronOS
b. TinyOS
c. Both (a) and (b)
d. None of these

Question No: 41

An example of an Operating System (OS) that a sensor node can have is?

a. MicronOS
b. TinyOS
c. Both (a) and (b)
d. None of these

Question No: 42

Which of the following is NOT a constraint on sensor nodes?

a. Must consume extremely low power
b. Be non-autonomous
c. Be adaptive to environment
d. None of these

Question No: 42

Which of the following is NOT a constraint on sensor nodes?

a. Must consume extremely low power
b. Be non-autonomous
c. Be adaptive to environment
d. None of these

Question No: 43

Nodes in WSNs that exhibit features of failed nodes but they can also send false routing messages which are a threat to the integrity of the network are called?

a. Normal Nodes
b. Badly Failed Nodes
c. Failed Nodes
d. Selfish Nodes

Question No: 43

Nodes in WSNs that exhibit features of failed nodes but they can also send false routing messages which are a threat to the integrity of the network are called?

a. Normal Nodes
b. Badly Failed Nodes
c. Failed Nodes
d. Selfish Nodes

Question No: 44

Which of the following are the two popular schemes to re-establish the connectivity between dumb nodes with others?

a. CoARD and CoRD
b. CoRAD and CoARD
c. CoRD and CoRAD
d. None of these

Question No: 44

Which of the following are the two popular schemes to re-establish the connectivity between dumb nodes with others?

a. CoARD and CoRD
b. CoRAD and CoARD
c. CoRD and CoRAD
d. None of these

Question No: 45

Full form of WBAN is?

a. Wireless Body Area Network
b. Wirelessed Body Area Network
c. Wireless Bodily Area Network
d. None of these

Question No: 45

Full form of WBAN is?

a. Wireless Body Area Network
b. Wirelessed Body Area Network
c. Wireless Bodily Area Network
d. None of these

Thank You