BLUETOOTH BASED SMART SENSOR NETWORKS
INTRODUCTION

• Bluetooth is wireless high speed data transfer technology over a short range (10 - 100 meters).

• **Bluetooth Wireless Technology (BWT)** was developed in 1994 at Ericsson in Sweden.

• **Purpose** – Originally it was build to eliminate the need for cable connections between PDAs and notebook PCs. Later the goals were to enable different devices through a commonly accepted standard for wireless connectivity.
INTRODUCTION (contd.)

• Ericsson on advent of BWT conceptualized a Radio Technology through a wireless personal area network (WPAN).

• Group called Bluetooth Special Interest Group (SIG) was formed in 1998 to develop the standard of IEEE 802.15

• This specification standardized the Bluetooth technology worldwide.
BLUETOOTH SPECIFICATIONS

Bluetooth Specifications are:

- Developed by: *Jaap Haarsten* and *Sven Mattisson* in Sweden
- Standard: IEEE 802.15
- ISM Band Frequency: 2.4 GHz
- Range: 10 – 100 meters
- Channel Bandwidth: 1 Mbps
- Maximum Asymmetric Data Transfer Rate: 721 Kbps
TYPES OF BWT

Depending on the *power consumption* and *range* of the device, there are 3 Bluetooth Classes as:

- **Class 1**: Max Power – 100mW ; Range – 100 m
- **Class 2**: Max Power – 2.5mW ; Range – 10 m
- **Class 3**: Max Power – 1mW ; Range – 1 m

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Why the name BLUETOOTH?
The name was adopted as a tribute to the tenth-century Viking king Harald Blåtand who peacefully united Denmark and Norway. Harald liked to eat blueberries, which gave his teeth the coloration that lead to the nickname "Bluetooth."
BLUETOOTH OPERATIONS

• BWT-enabled devices operate in 2.4GHz ISM Band (Industrial, Science, Medical band).

• It uses 79 1-MHz frequencies in the ISM Band.

• Technique used – frequency hopping, to minimize interference from other networks that also use ISM Band.

Figure: BWT-enabled devices hop between frequencies up to 1600 times per second.
Bluetooth Operations (contd.)

HOW TO REDUCE INTERFERENCE?

• BWT devices hop randomly between frequencies up to 1600 times per second.

• So, if another device using a 2.4 GHz frequency (e.g.: cordless phone) , then the interference with the BWT network lasts only for about 1/1600 of a second.

• By then, the devices hop to another frequency.

• High Immunity to interference from other 2.4 GHz devices.
BLUETOOTH TOPOLOGY

Depending on the type of connections established between various Bluetooth devices, 2 main topologies are as:

1. PICONENT TOPOLOGY, and
2. SCATTERNET TOPOLOGY

To any topology, there are 2 prime components:

1. MASTER device
2. SLAVE device
1. PICONET TOPOLOGY

- A *piconet* consists of upto 8 BWT-enabled devices.

- When *piconet* is established, one device sets up *frequency-hopping pattern* and other devices synchronize their signals to the same pattern.

- **Primary Devices**: Those devices which sets the frequency-hopping pattern.

- **Secondary Devices**: Those devices which get synchronized.

- Each *piconet* has a different frequency-hopping pattern.
PICONET TOPOLOGY (contd.)

- In Bluetooth, each *piconet* has 1 Master for establishment of *piconet*, and upto 7 Slave devices.
- Master’s Bluetooth address is used for defining frequency-hopping sequence.
- Slave devices use master clock to synchronize their clocks so as to hop simultaneously.
- For establishing *piconet*, other bluetooth devices in range are discovered by an inquiry procedure.
Piconet Topology (Modes of Bluetooth Communication)

- When more than 7 devices need to communicate, then one or more devices are put in park state.
- 3 Bluetooth Low Power Modes are: SNIFF, HOLD and PARK.
- Park Mode: A device disassociates from piconet when in park mode.
- The master consistently sends warnings to invite a slave to rejoin the piconet.
- The slaves can rejoin only if there are less than 7 slaves.
- If not so, the master has to ‘park’ one of the active slaves.
2. SCATTERNET TOPOLOGY

- *Scatternet* consists of several *piconets* connected by devices participating in multiple *piconet*.

- Here, devices can be slaves in all *piconets* or master in one *piconet* and slave in other *piconets*.

- There is a ‘BRIDGE’ connecting 2 *piconets* which is also a slave in individual *piconets*. 
SCATTERNET TOPOLOGY (contd.)

Advantages of *Scatternet*:

- Higher throughput
- Multi-hop connections between devices in different *piconets*.
FUTURE OF BLUETOOTH

• **BROADCAST CHANNELS:** Adoption of Bluetooth into mobile phones and enable advertising models based on users pulling information from the information points.

• **TOPOLOGY MANAGEMENT:** Automatic configuration of piconet topologies in scatternet situations.

• **QoS IMPROVEMENTS:** Enable audio and video data transmission at higher quality, especially in best effort traffic being transmitted in the same piconet.
BWT SECURITY

BWT security is complex, transparent, and easily implemented. BWT uses 3 security mechanisms: **authentication, authorization** and **encryption**.

3 levels (modes) security are:

- **MODE 1**: No Security;
  anyone can use the device; default setting condition in printers, etc.

- **MODE 2**: Service Level Security;
  permission required to access the device; exchange of business cards; personal authentication.

- **MODE 3**: Link Level Security;
  devices to be paired before connection and transfer.
BLUETOOTH BASED SENSOR NETWORKS

- Challenge: It is to ensure interoperability among various Bluetooth manufactures’ devices and to provide numerous applications.

- One such application is: WIRELESS SENSOR NETWORKS (WSN)

- Important features of WSN: Collaboration of network nodes during execution and Data Centric nature.

- Many smart sensor nodes scattered in the field collect data and send it to users via ‘gateway’ using multi-hop routes.
WIRELESS SENSOR NETWORKS (WSN)

WSN consists of number of small devices equipped with a sensing unit, microprocessors, wireless communication interface and power source.

Two main operations performed by WSN are:

1. **QUERING** – Queries are used when user requires only the current value of the observation.

2. **TASKING** – More Complex operation
   
   Used when a phenomenon has to be observed over a large period of time.
WSN (contd.)

Functions of GATEWAY:

- **Communication with sensor networks**: Shortage Wireless Communication; Discovery of smart sensor nodes

- **Gateway Logic**: Controlling Gateway interface and data flow; Providing uniform access to sensors

- **Communication with users**: Communication over Internet, WAN, Satellite, etc.

Figure: Wireless Sensor Network
SENSOR NETWORK IMPLEMENTATION

• OBJECTIVE: To build a Hardware platform and generic Software Solutions to serve for research in WSN protocols.

• Components of Sensor Network: **Smart Sensor Nodes** and **Gateway**

• Gateway and Smart nodes are members of *piconets* and so, not more than 7 nodes can exist in the network.
Example: Pressure Sensor

For implementation of Pressure Sensor as Bluetooth Node, following components are important:

• Bluetooth Device
• Sensors
• Microcontroller
• TEDS – Transducer Electronic Data Sheet

Figure: SMART SENSOR NODE IMPLEMENTATION
BLUETOOTH HARDWARE ARCHITECTURE

Bluetooth Hardware consists of 3 main functional modules:

- 2.4 GHz Bluetooth RF Transceiver Unit
- Link Management Unit
- Host Controller Interface

HOST CONTROLLER – Consists of a Digital Signal Processing part, having Link Controller(LC) & CPU Core. It interfaces to the Host environment.

LINK CONTROLLER - Consists of Hardware & Software parts to perform Base-Band Processing, and Physical Layer Protocols. Also performs low-level digital signal processing to form connections.
BLUETOOTH HARDWARE ARCHITECTURE (contd.)

- CPU CORE – Helps Bluetooth Module to handle Inquires and filter page request (not involving host device).

- LINK MANAGER - LM software runs on CPU core. LM discovers other remote LMs and communicates to them via LMP (link manager protocols).

- Bluetooth Module also incorporates Higher-Level Software Protocols, governing the functionality and interoperability with other modules.
Figure: BLUETOOTH MODELLED HARDWARE ARCHITECTURE
DISCOVERY OF SMART SENSOR NODES

• After installation, the primary step during execution is to discover the smart sensor nodes in the area.

• The is to prepare a list of sensor’s characteristics and network topology.

• Next in execution process, provision is to have addition of new or removal of existing sensors.
ALGORITHM FOR OPERATION OF NETWORKS

• Initialization of gateway and Bluetooth Inquiry Procedure.
• Discovery of Bluetooth device and Checking of major and minor devices.
• Setting of parameters and assigning type of devices and sensors.
• Description by Service-Class Field.
• Discarding of non-smart nodes.
• Else, service database of the discovered smart node is searched for sensor services.
• If no current sensor profile, then database is searched for serial port connection parameters.
• Lastly, Bluetooth link is established and data exchange with smart node starts.
MERITS and DEMERITS

MERITS of Bluetooth based Smart Sensor Networks:
- Low Cost
- Low Power Consumption
- Short Range
- Wireless Technology
- Reasonable throughput
- Low maintenance cost
- Easy link establishment

DEMERITS of Bluetooth based Smart Sensor Networks:
- Short Range (10 – 100 m)
- Average Speed
- Short Life
THANK YOU