

BODY AREA NETWORKS

BODY AREA NETWORK (BAN):

A Body Area Network (BAN) is a communication system used by devices that work on or inside the human body or animals. It is used in medical, electronic, and entertainment applications. BAN developed from Wireless Sensor Networks (WSN), which are part of a larger network group called Personal Area Networks (PAN). A BAN consists of small devices called nodes (nodes are the small electronic devices placed on, in, or around the human body that collect, process, or transmit data.). These nodes can sense, control, process data, and communicate with each other wirelessly. BAN works around the human body. It collects and monitors body signals, physical activities, and environmental data. It can also process and store this information. BAN is not only used outside the body. It can also be implanted inside the body to perform special medical tasks.

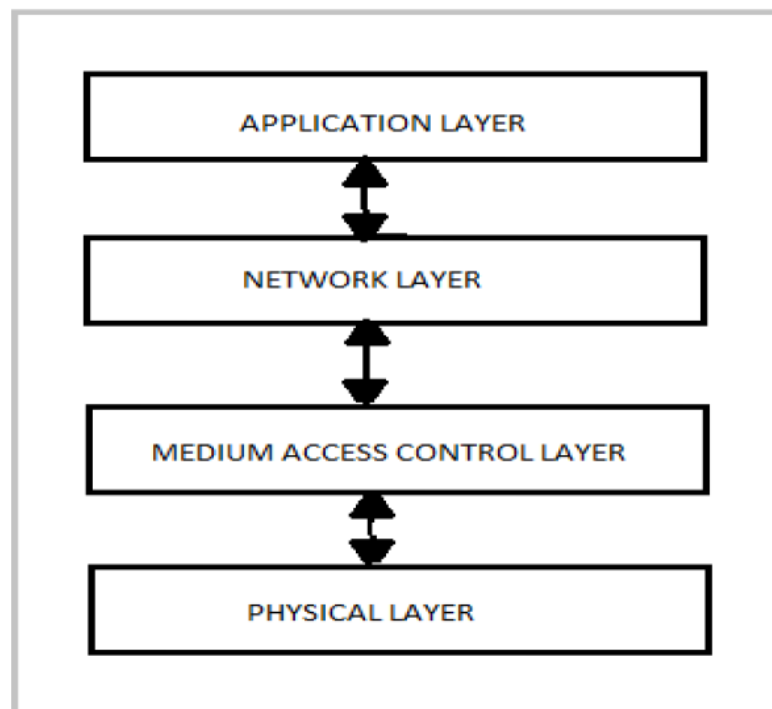
Example of a Body Area Network:

A patient with heart problems wears and uses:

- A **smartwatch** that measures heart rate and activity
- A **chest patch sensor** that monitors ECG signals
- A **blood pressure monitor** worn on the arm
- A **glucose monitor** attached to the skin

All these devices are connected via short-range wireless technology (like Bluetooth) and send data to the patient's smartphone. The smartphone then forwards the information to the hospital's monitoring system.

BAN ARCHITECTURE:



PHYSICAL LAYER:

The PHY (Physical) layer is the lowest and most basic layer in a Body Area Network (BAN). It is responsible for sending and receiving raw data between devices. Different frequency bands are used for communication around the human body. The 403 MHz band is mainly used for implanted medical sensors. Other frequencies like 13.5 MHz, 400 MHz, 900 MHz, 2.4 GHz, and 3.1–10.6 GHz are used for sensors placed on the body. Usually, radio signals travel around the body instead of passing through it. This can cause problems if two implanted sensors are placed on opposite sides of the body, because the signal may not reach properly and some data can be lost.

MEDIUM ACCESS CONTROL LAYER:

In a **Body Area Network (BAN)**, all sensor nodes use the same wireless channel to send data. The **MAC layer** controls how these nodes use the shared channel. There are two main types of MAC protocols:

- **Schedule-based MAC:**

Each node is given a fixed time slot to send data So, nodes take turns. This avoids packet collision (data crashing with each other).

Contention-based MAC:

Nodes decide by themselves when to send data. Many nodes may try at the same time. This method is more practical and flexible for BAN. Contention-based MAC is commonly used because it can handle more devices easily (good scalability).

NETWORK LAYER:

The **network layer** in a BAN is responsible for sending data packets correctly and finding the best path from one node to another node.

In **ZigBee networks**, two main routing protocols are used:

- **AODV (Ad hoc On-demand Distance Vector)** – It finds a route only when needed. It does routing work only when data has to be sent.
- **HERA (Hierarchical Routing Algorithm)** – It uses a layered or hierarchical structure to build and manage the network.

Other routing protocols are:

- **SPIN (Sensor Protocol for Information via Negotiation)** – It shares data in a smart way to avoid sending duplicate information.
- **TEEN (Threshold sensitive Energy Efficient sensor Network)** – It sends data only when certain limits (threshold values) are reached, which helps save energy

APPLICATION LAYER:

In the application layer, the main component is the Operating System (OS). The OS controls and manages parts like radio, sensors, timers, and memory. It also provides simple APIs so that applications can easily use the system. The application interface is different for different BAN applications (like medical or fitness use). The Operating System in a BAN is **simple and lightweight** because sensor nodes have **limited power, memory, and processing ability**.

NETWORK TOPOLOGIES OF BAN:

A Body Area Network (BAN) is a group of small devices worn on the body that use sensors and actuators to collect and share information about the environment, physical activity, or health. BAN nodes are commonly classified into two broad categories:

- Peripheral nodes

- Central nodes

Peripheral nodes:

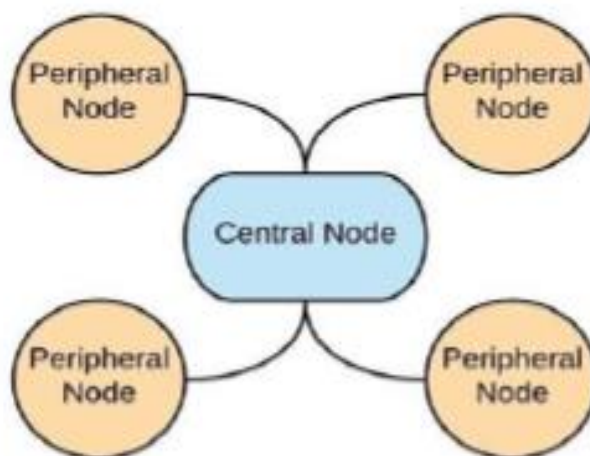
These are simple devices with low power and small processors. Peripheral nodes have sensors to monitor their environment and communication interfaces to transfer and receive information.

Central nodes:

These are more powerful devices with better processing and communication abilities. The central node collects data from the sensor devices and sends the information to the cloud or other systems.

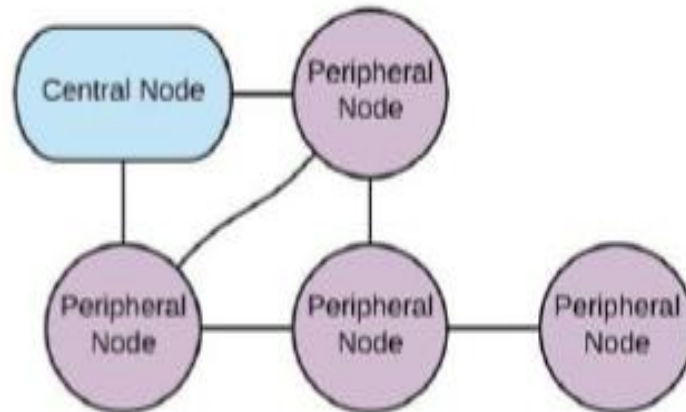
A good design is very important for wearable devices, especially in emergency and medical systems where a person's life may depend on correct information. For the hardware of BAN devices, there are different setups. The IEEE 802.15 group suggests different types of nodes. A low-power microcontroller attached with multiple sensors that monitor the environment, Nodes for medical purposes, Devices that collect or aggregate information, Nodes that control the administration of medication like an infusion-pump controller, Devices acting like a gateway or access point. The selection of hardware for a BAN application depends on the requirements of the system to be developed. The network topology means the arrangement of nodes in a BAN, describing the communication between nodes. There are several options to connect nodes in a BAN. The IEEE TG6 suggests three types of network topologies

STAR TOPOLOGY:



This representing a star topology, each peripheral node has a direct connection to the central node

MESH TOPOLOGY:



In a mesh topology, not all peripheral nodes have a direct connection to the central node.

HYBRID TOPOLOGY:

It is a combination of star and mesh topologies, which is a hybrid topology.

