ROHINI COLLEGE OF ENGINEERING AND TECHNOLOGY
AUTONOMOUS INSTITUTION
Approved by AICTE & Affiliated to Anna University
NBA Accredited for BE (ECE, EEE, MECH) | Accredited by NAAC with A+ Grade
Anjugramam - Kanyakumari Main Road, Palkulam, Variyoor P.O. - 629 401, Kanyakumari District.

Department of Biomedical Engineering

VI Semester

CBM 370 - Wearable Devices

Unit- 3 WIRELESS HEALTH SYSTEMS

3.3 BAN and Healthcare

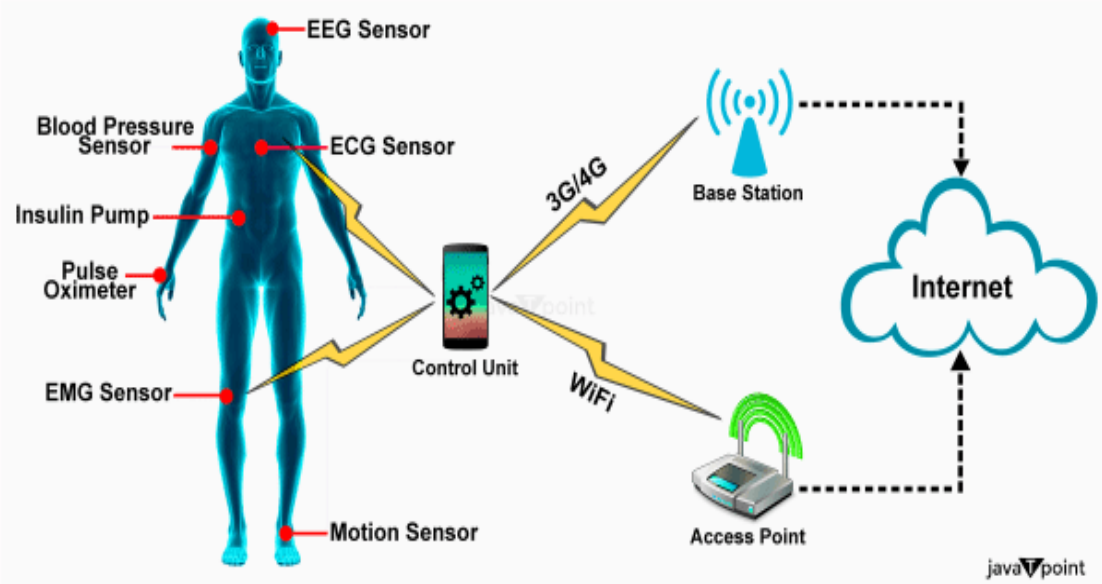
- A Body Area Network (BAN) is a wireless network of small, low-power devices that can be worn on the body, implanted under the skin, or even ingested.
- These devices can collect a variety of physiological data, such as heart rate, blood pressure, temperature, and activity levels. This data is then transmitted wirelessly to a central hub, such as a smartphone or computer, where it can be stored, analyzed, and shared with healthcare providers.

Components of BAN in Healthcare:

1. **Sensors** – Measure physiological parameters such as heart rate, blood pressure, oxygen levels, temperature, ECG, EEG, glucose levels, etc.
2. **Wireless Communication** – Uses protocols like Bluetooth, Zigbee, Wi-Fi, or 5G to transmit data.
3. **Processing Unit** – A microcontroller or smartphone app that collects and processes data.
4. **Cloud/Server** – Stores and analyzes patient data for remote access by healthcare providers.
5. **Actuators** – Devices like insulin pumps or pacemakers that respond to sensor data to deliver treatment.

Applications of BANs in healthcare:

- **Remote patient monitoring:** BANs allow healthcare providers to continuously monitor patients' vital signs and activity levels remotely, without requiring them to be in a hospital or clinic. This is particularly beneficial for patients with chronic conditions, such as heart disease, diabetes, or asthma, as it allows for early detection of potential problems and timely interventions.
- **Personalized medicine:** By collecting continuous data on an individual's health status, BANs can help healthcare providers to personalize treatment plans and make more informed decisions about medication dosages and lifestyle recommendations.
- **Improved patient engagement:** BANs can empower patients to take a more active role in their own healthcare by providing them with real-time feedback on their health status and encouraging them to adopt healthier behaviors.
- **Reduced healthcare costs:** By enabling early detection of health problems and reducing the need for hospitalizations, BANs can help to lower healthcare costs.



Components in the Image:

1. **Sensors on the Human Body:**
   - **EEG Sensor** – Measures brain activity.

- **ECG Sensor** – Monitors heart activity.
- **Blood Pressure Sensor** – Tracks blood pressure levels.
- **Insulin Pump** – Delivers insulin to diabetic patients.
- **Pulse Oximeter** – Measures oxygen saturation in the blood.
- **EMG Sensor** – Records muscle activity.
- **Motion Sensor** – Detects body movement and posture.

2. **Control Unit (Smartphone or Wearable Device):**
   - Collects data from all sensors.
   - Uses **Wi-Fi or 3G/4G** for communication.
3. **Wireless Communication:**
   - **Wi-Fi (Access Point)** – Connects to local networks.
   - **3G/4G (Base Station)** – Connects to mobile networks.
4. **Cloud & Internet:**
   - Data is transmitted to remote healthcare providers for monitoring.
   - Enables **telemedicine, remote diagnosis, and emergency alerts**.

Working:

1. Sensors collect health data.
2. Data is transmitted to a control unit (smartphone, smartwatch, or medical hub).
3. The control unit sends data via Wi-Fi or cellular networks.
4. Data reaches cloud servers, where healthcare professionals can analyze it remotely.

Network requirements:

- ❒ Requirement specification for BAN depends on range, interference, network density, sensors per network, quick time of transmission, in body environment, security or encryption, Quality of services and reliability, enabling priority, support for different data rates, compatibility with other PANs.
- ❒ Range for sensing depends on devices used in BSN. For Bluetooth it is up to 10 meters, for ZigBee device it is 100 meters etc. Network density of BAN is

2-4 networks per meter square. Sensors used per network are 256 devices per network as per BAN standardization group.

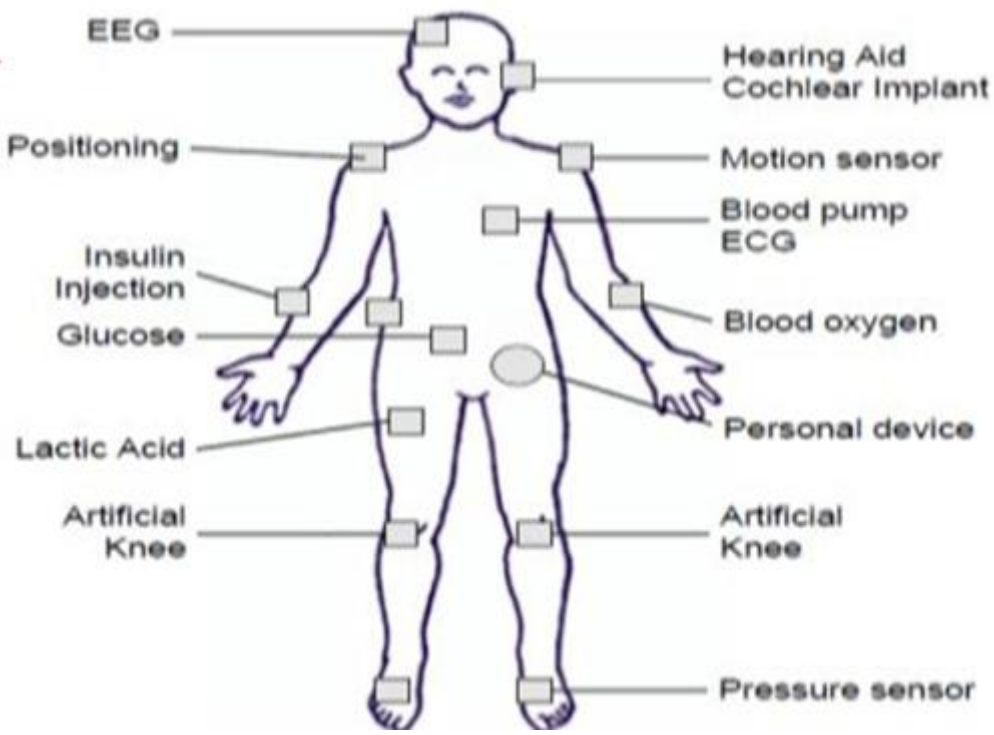


Fig. Example of Patient Monitoring in Wireless Body Area Network

Hardware requirements:

- Hardware requirements specification depends on applications of the sensor network.
- Those are ultra-low power consumption, suitable sensors, lifetime of sensors, low cost, low complexity
- By using ultra low power consumption battery backup is improved so there is no need of changing batteries.
- Suitable sensors should be used for purpose of mobility and monitoring should be possibly transparent.
- Sensors or hardware to be used should be of low cost as the purpose is to provide a technology to the people to get cheaper rate monitoring and also

includes low complexity of hardware for the people who do not like technology because they think it is difficult to use.

- Body areas sensors are composed by
  1.Sensor/actor which is used for measuring the necessary parameters from body.
  2. Battery which is used to provide energy to sensors.
  3. Processor which is used for analysis of data and system management.
  4. Antenna which is used for formatting and sending radio frequency signal.

- Body sensors used in BAN are in-body sensors which are implanted under skin which allows system to measure temperature, glucose etc. and on-body sensors are integrated onto the cloths to measure ECG, heart rate etc.

WIRELESS BODY AREA NETWORK (WBAN):

- Wireless body area network is also part of BAN or Wireless Body Sensor Network (WBSN).
- It is composed of one or more Body Sensor Units (BSU), one Body Central Unit (BCU) and work with long range network such as ZigBee or Bluetooth etc..
- By an a using new technologies in electronics the small sized and intelligent sensors are used in the biomedical system to improve the was am performance of the health care system.
- The sensors are connected to the small sized hardware and the data from the sensors is used to transfer.
- Also the data is sent to the medical server and it is analyzed over there and stored. Wired connection used for this purpose is time consuming and even much complex.
- Also, it includes more deployment cost and maintenance cost. Wireless connection used in the WBAN applications is easier and cost efficient.
- The patient can move anywhere and there is no need to be present in hospital or no need to stay under observation. By using such systems can improve

the medical health care and minimizes the cost. In general, the devices used are of two types such as actuators and sensors.

- Sensors are used to measure the parameters of the patient's body such as body temperature, heart rate etc. To make the connection between the sensors and hardware device the wireless devices are used. The first prototype of Wireless Body Area Network (WBAN) is already started developing by several research groups and commercial vendors.

Challenges in implementing BAN for healthcare:

Implementing **Body Area Networks (BANs) in healthcare** comes with several challenges that must be addressed for effective, secure, and reliable patient monitoring. The key challenges include **data security, power management, and sensor communication.**

1. Data Security & Privacy:

BANs handle **sensitive medical data**, making security and privacy a major concern. Challenges include:

Threats & Risks:

- **Unauthorized Access & Hacking** – Attackers may intercept or manipulate health data.
- **Data Breaches** – Leakage of personal medical records can violate patient privacy laws (HIPAA, GDPR).
- **Man-in-the-Middle Attacks** – Interception of data between sensors and control units.
- **Denial of Service (DoS) Attacks** – Overloading the network can disrupt real-time monitoring.

Solutions:

- **End-to-End Encryption** – Ensures secure data transmission.

- ❒ **Authentication & Access Control** – Multi-factor authentication (MFA) for authorized personnel.
- ❒ **Blockchain for Secure Storage** – Ensures data integrity and transparency.
- ❒ **Anomaly Detection Systems** – Identifies suspicious activity in the BAN.

2. Power Management & Battery Life

Wearable and implantable BAN sensors require low-power operation to function effectively over extended periods.

Challenges:

- ❒ **Limited Battery Life** – Frequent recharging or replacement is impractical for wearables and impossible for implants.
- ❒ **High Energy Consumption** – Wireless data transmission and continuous sensing drain battery life.
- ❒ **Thermal Effects** – Continuous operation may cause heat generation, affecting patient comfort.

Solutions:

- ❒ **Energy-Efficient Wireless Protocols** – Use Bluetooth Low Energy (BLE), Zigbee, or Near-Field Communication (NFC).
- ❒ **Energy Harvesting Techniques** – Utilize body heat, motion, or solar energy to power sensors.
- ❒ **Adaptive Duty Cycling** – Sensors transmit data only when necessary to save power.
- ❒ **Low-Power Hardware & Algorithms** – Optimize software for minimal energy consumption.

3. Sensor Communication & Network Reliability

A BAN consists of multiple interconnected sensors, and seamless communication is essential.

Challenges:

- **Interference & Signal Loss** – Overlapping signals from multiple sensors can cause data corruption.
- **Latency Issues** – Delays in transmitting real-time health data can impact patient care.
- **Standardization Issues** – Different sensors from various manufacturers may not be interoperable.
- **Limited Bandwidth** – Multiple sensors transmitting simultaneously can lead to congestion.

Solutions:

- **Efficient Routing Protocols** – Use AI-driven network management to prioritize critical data.
- **Wireless Standards (IEEE 802.15.6)** – A specialized standard for BAN communication.
- **Error Correction Mechanisms** – Reduces data loss due to interference.
- **Edge Computing** – Processes data locally before transmitting, reducing latency and bandwidth usage.

****