Real-Time Patient Monitoring Using Firebase and ESP32

1. What is Firebase?

- Firebase is a **cloud platform by Google** that stores and manages data online.
- We use **Firebase Realtime Database** because it updates data **instantly whenever it changes**.
- Unlike normal databases, there's **no need to refresh** to see new data.
- This feature is very useful for **patient monitoring**, as doctors need to see live health information.

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2. How Our System Works

- Each patient has an **ESP32 microcontroller** with connected sensors.
- Sensors measure **heart rate, SpO_2 (oxygen level), and body temperature**.
- ESP32 reads these sensor values continuously.
- Using **WiFi**, ESP32 sends the data directly to **Firebase cloud**.
- The **Firebase ESP Client library** helps ESP32 securely connect and send data to Firebase.

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3. How Data is Stored in Firebase

- Data is stored in a **JSON tree structure**, which looks like a tree of information.
- The main folder is called `patients`.
- Each patient has a unique ID, like `P102`.
- Inside each patient ID, the system stores:
  - Heart rate
  - SpO_2
  - Temperature
  - Timestamp (time of measurement)
- This structure makes it easy to **read, update, and manage multiple patients**.

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4. Sending Data from ESP32 to Firebase

1. ESP32 first **connects to WiFi**.
2. ESP32 authenticates with Firebase using the **API key and database URL**.
3. ESP32 reads sensor values continuously.

4. Sensor data is sent to Firebase under the patient's unique ID.
5. This process repeats every few seconds for **continuous updates**.

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5. Real-Time Monitoring

- When ESP32 sends data, Firebase **updates instantly**.
- All connected apps (like doctor's Android app or web dashboard) **receive updates immediately**.
- No manual refresh is needed, so doctors can **monitor patients live**.

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6. Security in Firebase

- Firebase has **security rules** to control who can read or write data.
- This ensures that **only authorized users and devices** can access patient information.
- In our project, we use **time-based rules** for demo purposes, allowing access only for a specific duration.

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7. Why Firebase is Perfect for This Project

- Real-time updates for **live patient monitoring**.
- Cloud storage makes it **accessible from anywhere**.
- Multiple patients can be monitored **simultaneously**.
- Secure system with **controlled access**.
- Doctors can **respond quickly** in emergencies.

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8. Summary

- ESP32 reads sensor data and sends it to Firebase via WiFi.
- Firebase stores data in a structured way and pushes updates automatically.
- Doctors can view **live patient vitals** on apps or dashboards.
- The system is **fast, secure, and easy to manage**, making it ideal for remote patient monitoring.