### Project Title

**Smart Metro Gate Access System Using ESP32**

### Motivation

During the July 2024 student revolution in Bangladesh, we saw how fragile the current metro infrastructure is. Many station gates were damaged because the ticketing system failed, creating chaos and unrest. This made us realize the importance of having a **reliable, low-cost, and decentralized smart gate system** that can continue working even when the internet or central servers are down.

Our motivation comes from wanting to build a system that not only ensures smoother passenger flow during normal days but also keeps running during emergencies or unexpected situations. By doing so, we hope to make public transportation safer and more efficient.

### Short Introduction about our project

The existing metro rail ticketing system in Dhaka depends on centralized servers, plastic smart cards, and mechanical gates. Once these fail, everything stops. To solve this issue, we are designing a **dual-access metro gate** powered by ESP32 microcontrollers.

Our system allows passengers to use either a **QR code** or an **RFID card** to pass through the gate. Since everything runs on a local Wi-Fi network, the gates will keep functioning even if the internet or the central server goes offline. This makes the whole system more robust, secure, and reliable.

### Diagram of our project

┌──────────────┐ Wi-Fi (Local AP) ┌──────────────┐

│ Server │◄──────────────────────────────►│ Gate ESP32 │

│ ESP32 (AP) │ │ (Servo + │

│ - Ticket DB │ │ IR + PN532)│

│ - QR Display │ └──────────────┘

│ - RFID Write │

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│ ESP32-CAM │

│ - QR Scan │

│ - Validate │

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### Features of our project

* Passengers can enter using **either a QR code or an RFID card**.
* Ticket validation happens **locally on the ESP32 server** without internet.
* Tickets **automatically expire** after 10 minutes and are deleted shortly after to prevent reuse.
* Two **IR sensors** detect human presence, so the gate only opens when someone is physically there.
* A **servo motor** acts as the gate barrier, ensuring smooth opening and closing.

### Apparatus/Hardware Components

* **ESP32-S3 Dev Module** – controls servo, IR, and RFID.
* **ESP32-CAM** – scans QR codes and verifies them.
* **ESP32 Dev Module (Server)** – runs the Wi-Fi AP, ticket database, GUI, and QR display.
* **2.4 inch TFT Display (ILI9341)** – shows generated QR codes.
* **PN532 RFID Module** – reads and writes RFID cards.
* **Servo Motor** – opens and closes the gate.
* **IR Sensors (x2)** – detect passenger entry.
* Supporting components: jumper wires, breadboard, and external power supply.