**Smart Traffic Signal System with Emergency Vehicle Priority using ESP32, WS2812B LEDs, and RFID**

**1. Introduction**

Urban traffic congestion often causes delays for emergency vehicles such as ambulances and fire trucks. To solve this problem, a **Smart Traffic Signal System** is proposed using an **ESP32 microcontroller**, **WS2812B NeoPixel LEDs**, and an **RFID (RC522) module**. The system simulates a four-way traffic intersection with real-time signal control and gives **priority access to emergency vehicles** when detected via RFID card authentication.

**2. Objectives**

* To design a **four-way traffic light controller** using ESP32.
* To simulate **traffic lights** with WS2812B LED strips.
* To integrate an **RFID-based detection system** for emergency vehicles.
* To implement **priority control logic** so emergency vehicles can pass without delay.
* To develop a **low-cost and scalable prototype** suitable for smart city applications.

**3. Methodology**

1. **Hardware Components**
   * ESP32 Development Board
   * WS2812B NeoPixel LED Strip (15 LEDs)
   * RC522 RFID Reader Module
   * Authorized RFID cards/tags
   * Power supply and jumper wires
2. **Working Principle**
   * Normally, the system cycles through traffic signals for each road (Green → Yellow → Red).
   * WS2812B LEDs are programmed to represent the traffic lights for each direction.
   * When an authorized RFID card (representing an ambulance) is detected by the RC522 module, the ESP32 immediately overrides the normal sequence.
   * The road corresponding to the emergency vehicle is turned **Green**, while all other signals remain **Red** for a fixed duration.
   * After the emergency vehicle passes, the system returns to normal traffic sequencing.
3. **Software Implementation**
   * Developed using **Arduino IDE**.
   * **Adafruit NeoPixel library** controls LED color patterns.
   * **MFRC522 library** is used for RFID card detection.
   * Interrupt-based logic ensures fast response to emergency detection.

**4. Applications**

* Smart traffic management in **urban intersections**.
* **Emergency vehicle priority** (ambulance, fire brigade, police).
* Can be scaled into **IoT-based traffic monitoring** systems with sensors and cloud integration.
* Educational projects for **IoT, Embedded Systems, and Smart Cities**.

**5. Advantages**

* **Low cost** and simple implementation.
* **Fast response** to emergency vehicles.
* **Energy efficient** due to LED-based simulation.
* Can be **upgraded** with IoT, sensors, and machine learning.

**6. Conclusion**

The proposed system demonstrates how a **traffic intersection** can be controlled using ESP32 and WS2812B LEDs while integrating an **RFID-based emergency override**. This ensures that ambulances and other priority vehicles pass quickly and safely, reducing delays and potentially saving lives. The project serves as a foundation for more advanced **Smart Traffic Control Systems** in smart cities.