ESP32 Communication Protocols

Overview

The ESP32 microcontroller supports a wide range of **communication protocols**, both wireless and wired, making it highly suitable for IoT and embedded systems. These protocols include low-level hardware interfaces as well as high-level networking stacks.

1. Wireless Protocols

- **Wi-Fi (IEEE 802.11 b/g/n):**
  - Operates at 2.4 GHz, up to 150 Mbps.
  - Modes: Station, Access Point (AP), and AP+Station.
  - Supports full TCP/IP stack and higher-level protocols such as HTTP, MQTT, and WebSocket.
- **Bluetooth:**
  - Classic Bluetooth (BR/EDR) for audio and legacy devices.
  - Bluetooth Low Energy (BLE 4.2) for low-power IoT applications.

2. Wired / Peripheral Protocols

- **UART (Universal Asynchronous Receiver/Transmitter):**
  - Multiple UARTs (UART0, UART1, UART2).
  - Commonly used for flashing, debugging, and serial communication.
- **SPI (Serial Peripheral Interface):**
  - 4 SPI controllers (including HSPI and VSPI).
  - Master/Slave operation, speeds up to 80 MHz.
  - Connects to displays, flash memory, and high-speed sensors.

- **I²C (Inter-Integrated Circuit):**
  - Two I²C controllers available.
  - Supports Master/Slave modes.
  - Widely used for sensors, EEPROM, and RTC modules.
- **I²S (Integrated Inter-IC Sound):**
  - Specialized for audio data transfer.
  - Connects to microphones, DACs, and audio codecs.
- **CAN (Controller Area Network):**
  - Used in automotive and industrial communication systems.

3. Analog / Digital Protocols

- **ADC (Analog-to-Digital Converter):** 18 channels, 12-bit resolution.
- **DAC (Digital-to-Analog Converter):** 2 channels, 8-bit resolution.
- **PWM (Pulse Width Modulation):** Available on most GPIOs, used for motor control, LEDs, and signal generation.

4. Networking Protocols (Software Layer)

Over Wi-Fi and Bluetooth, ESP32 supports many higher-level protocols:

- TCP / UDP
- HTTP / HTTPS
- MQTT (Message Queue Telemetry Transport)
- CoAP (Constrained Application Protocol)
- WebSocket
- mDNS / DNS-SD (Service Discovery)
- SNTP (Simple Network Time Protocol)

Summary

ESP32 provides a rich set of communication protocols, including **Wi-Fi, Bluetooth, UART, SPI, I^2C, I^2S, CAN, ADC/DAC, PWM**, and supports higher-level networking protocols such as **HTTP, MQTT, WebSocket, and CoAP**.