Atomic PoE Base Arduino Tutorial

1. Preparation

- Environment setup: Refer to the Arduino IDE Getting Started Guide to complete IDE installation, and install the corresponding board package and required libraries according to your development board.
- Required libraries:
  - M5Unified
  - M5GFX
  - M5-Ethernet
  - PubSubClient
  - ArduinoHttpClient
- Required hardware:
  - AtomS3R
  - Atomic PoE Base

2. Example

- The main controller used in this tutorial is AtomS3R, paired with Atomic PoE Base. Atomic PoE Base communicates with the host via SPI. Modify the pin definitions in the program according to your actual circuit connections. After connection, the corresponding SPI IOs are `G5 (SCK)`、`G7 (MISO)`、`G8 (MOSI)`、`G6 (CS)`.

2.1 Web Server

cpp

```cpp
#include "M5Unified.h"
#include "SPI.h"
#include "M5_Ethernet.h"

#define SCK  5
#define MISO 7
#define MOSI 8
#define CS   6

byte mac[] = {0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0x99};// Custom MAC address
// IPAddress ip(192, 168, 1, 177);                    // Static IP (Custom)

EthernetServer server(80);// Initialize the Web Server on port 80 (standard HTTP port)

void setup() {
    M5.begin();
    Serial.begin(115200);

    M5.Display.setTextDatum(middle_center);
    M5.Display.setFont(&fonts::Font2);

    SPI.begin(SCK, MISO, MOSI, -1);
    Ethernet.init(CS);

    M5.Display.drawString("Init...", M5.Display.width() / 2, M5.Display.height() / 2);
    Serial.println("Initializing...");
    delay(500);

    // To use a static IP, use Ethernet.begin(mac, ip)
    // Attempt to obtain an IP address via DHCP
    while (Ethernet.begin(mac) != 1) {
        Serial.println("Error getting IP address via DHCP, trying again...");
        delay(1000);
    }

    // Check for Ethernet hardware presence
    if (Ethernet.hardwareStatus() == EthernetNoHardware) {
        Serial.println(
            "Ethernet shield was not found. Sorry, can't run without "
            "hardware. :(");
        while (true) {
            delay(1);  // Do nothing if hardware is missing
        }
    }
    if (Ethernet.linkStatus() == LinkOFF) {
        Serial.println("Ethernet cable is not connected.");
    }

    // Start web server
    server.begin();
```

```
    Serial.print("Server is at ");
    Serial.println(Ethernet.localIP());
    M5.Display.clear();
    M5.Display.drawString(Ethernet.localIP().toString().c_str(),
                          M5.Display.width() / 2, M5.Display.height() / 2);
    delay(1000);
}

long lastTime;

void loop() {
    // Listen for incoming client connections
    EthernetClient client = server.available();
    if (client) {
        Serial.println("new client");

        boolean currentLineIsBlank = true; // HTTP requests terminate with a blank line

        while (client.connected()) {
            if (client.available()) {
                char c = client.read();
                Serial.write(c); // Echo request to Serial Monitor for debugging
                // If you've gotten to the end of the line (received a newline
                // character) and the line is blank, the http request has ended,
                // so you can send a reply
                if (c == '\n' && currentLineIsBlank) {
                    // Send a standard http response header
                    client.println("HTTP/1.1 200 OK");
                    client.println("Content-Type: text/html");
                    client.println(
                        "Connection: close");  // Connection will be closed
                                              // after completion of the
                                              // response
                    client.println("Refresh: 5");  // Refresh the page
                                                   // automatically every 5 sec
                    client.println();
                    client.println("<!DOCTYPE HTML>");
                    client.println("<html>");
                    client.print("<h2>Hello M5Stack User!</h2>");
                    client.println("</html>");
                    break;
                }
                if (c == '\n') {
                    // Starting a new line
                    currentLineIsBlank = true;
                } else if (c != '\r') {
                    // You've gotten a character on the current line
                    currentLineIsBlank = false;
                }
            }
        }
        // Give the web browser time to receive the data
        delay(1);
```

```
104         // Close the connection:
105         client.stop();
106         Serial.println("client disconnected");
107     }
108 }
```

2.2 MQTT

cpp

```cpp
#include "M5Unified.h"
#include "SPI.h"
#include "M5_Ethernet.h"
#include "PubSubClient.h"

#define SCK  5
#define MISO 7
#define MOSI 8
#define CS   6

#define PUB_INTERVAL 3000 // Publishing interval  unit: ms
#define PUB_TOPIC "Atomic_PoE_Send"
#define SUB_TOPIC "Atomic_PoE_Receive"

byte mac[] = {0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0x99};// Custom MAC address
// IPAddress ip(192, 168, 1, 177);                    // Static IP (Custom)

const char* mqtt_server = "mqtt.m5stack.com";// MQTT broker address
EthernetClient ethClient;
PubSubClient client(ethClient);

// Handle incoming MQTT messages
void callback(char* topic, byte* payload, unsigned int length) {
    Serial.print("Message arrived [");
    Serial.print(topic);
    Serial.print("] ");

    String payloadStr;
    for (int i = 0; i < length; i++) {
        payloadStr += (char)payload[i];
    }
    Serial.print(payloadStr);
    M5.Display.fillRect(0, 0, 240, 68, TFT_BLACK);
    M5.Display.drawString("Rece: " + payloadStr, M5.Display.width() / 2, 30);

}

// Connect or reconnect to the MQTT broker
void reconnect() {
    // Loop until we're reconnected
    while (!client.connected()) {
        Serial.print("Attempting MQTT connection...\n");
        // Attempt to connect
        if (client.connect("arduinoClient")) {
            Serial.println("Connected");
            M5.Display.clear();
            M5.Display.drawString("Connected!", M5.Display.width() / 2, M5.Display.height() / 2);

            // Once connected, publish an announcement...
            client.publish(PUB_TOPIC, "Client connected");
```

```
            // ... and resubscribe
            client.subscribe(SUB_TOPIC);
        } else {
            M5.Display.clear();
            M5.Display.drawString("Failed!", M5.Display.width() / 2, 60);
            Serial.print("Failed, rc=");
            Serial.print(client.state());
            Serial.println(" try again in 5s");
            // Wait 5 seconds before retrying
            delay(5000);
        }
    }
}

void setup() {
    M5.begin();
    Serial.begin(115200);

    M5.Display.setTextColor(GREEN);
    M5.Display.setTextDatum(middle_center);
    M5.Display.setFont(&fonts::Font2);

    SPI.begin(SCK, MISO, MOSI, -1);
    Ethernet.init(CS);

    M5.Display.drawString("Init...", M5.Display.width() / 2, M5.Display.height() / 2);
    Serial.println("Initializing...");

    // To use a static IP, use Ethernet.begin(mac, ip)
    // Attempt to obtain an IP address via DHCP
    while (Ethernet.begin(mac) != 1) {
        Serial.println("Error getting IP address via DHCP, trying again...");
        delay(1000);
    }

    // Check for Ethernet hardware presence
    if (Ethernet.hardwareStatus() == EthernetNoHardware) {
        Serial.println(
            "Ethernet shield was not found. Sorry, can't run without :(");
        while (true) {
            delay(1);  // Do nothing if hardware is missing
        }
    }
    if (Ethernet.linkStatus() == LinkOFF) {
        Serial.println("Ethernet cable is not connected.");
    }

    Serial.print("IP Address: ");
    Serial.println(Ethernet.localIP());

    M5.Display.clear();
    M5.Display.drawString(Ethernet.localIP().toString().c_str(),
                          M5.Display.width() / 2, M5.Display.height() / 2);
```

```
    // --- MQTT Setup ---
    client.setServer(mqtt_server, 1883);
    client.setCallback(callback);// Register incoming message handler
    delay(1000);
}

long lastTime;

void loop() {
    if (!client.connected()) {
        reconnect();
        delay(500);
        M5.Display.clear();
        M5.Display.drawString("Rece: NULL", M5.Display.width() / 2, 30);
    } else {
        client.loop();// Essential to process incoming messages and maintain the heartbeat
        if (millis() - lastTime > PUB_INTERVAL) {
            lastTime = millis();
            M5.Display.fillRect(0, 68, 240, 67, TFT_BLACK);
            M5.Display.drawString("Send: " + String(lastTime) + " ms", M5.Display.width() / 2, 100)
            String data = "Hello world: " + String(lastTime);
            client.publish(PUB_TOPIC, data.c_str());
            Serial.println("Send Message [" PUB_TOPIC "] " + data);
        }
    }
}
```

2.3 HTTP

cpp

```cpp
#include "M5Unified.h"
#include "SPI.h"
#include "M5_Ethernet.h"
#include "ArduinoHttpClient.h"

#define SCK  5
#define MISO 7
#define MOSI 8
#define CS   6

byte mac[] = {0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0x99};// Custom MAC address
// IPAddress ip(192, 168, 1, 177);                   // Static IP (Custom)

const char* http_server = "httpbin.org";// Target HTTP server
EthernetClient ethClient;
HttpClient client = HttpClient(ethClient, http_server);

void setup() {
    M5.begin();
    Serial.begin(115200);

    M5.Display.setTextColor(GREEN);
    M5.Display.setTextDatum(middle_center);
    M5.Display.setFont(&fonts::Font2);

    SPI.begin(SCK, MISO, MOSI, -1);
    Ethernet.init(CS);

    M5.Display.drawString("Init...", M5.Display.width() / 2, 60);
    Serial.println("Initializing...");

    // To use a static IP, use Ethernet.begin(mac, ip)
    // Attempt to obtain an IP address via DHCP
    while (Ethernet.begin(mac) != 1) {
        Serial.println("Error getting IP address via DHCP, trying again...");
        delay(1000);
    }

    // Check for Ethernet hardware presence
    if (Ethernet.hardwareStatus() == EthernetNoHardware) {
        Serial.println(
            "Ethernet shield was not found. Sorry, can't run without hardware. :(");
        while (true) {
            delay(1);  // Do nothing if hardware is missing
        }
    }
    if (Ethernet.linkStatus() == LinkOFF) {
        Serial.println("Ethernet cable is not connected.");
    }

```

```
    Serial.print("IP Address: ");
    Serial.println(Ethernet.localIP());

    M5.Display.clear();
    M5.Display.drawString(Ethernet.localIP().toString().c_str(),
                          M5.Display.width() / 2, M5.Display.height() / 2);
    delay(1000);
}

void loop() {
    // --- GET request ---
    M5.Display.clear();
    M5.Display.drawString("GET", M5.Display.width() / 2, 20);
    Serial.println("making GET request");

    client.get("/get");
    // read the status code and body of the response
    int statusCode  = client.responseStatusCode();
    String response = client.responseBody();

    Serial.print("Status code: ");
    Serial.println(statusCode);
    Serial.print("Response: ");
    Serial.println(response);
    Serial.println("Wait five seconds");

    M5.Display.drawString("STATUS:", M5.Display.width() / 2, 60);
    M5.Display.drawString(String(statusCode), M5.Display.width() / 2, 100);

    delay(5000);

    // --- POST request ---
    M5.Display.clear();
    M5.Display.drawString("POST", M5.Display.width() / 2, 20);
    Serial.println("making POST request");

    String contentType = "application/x-www-form-urlencoded";
    String postData    = "name=Alice&age=12";

    client.post("/post", contentType, postData);

    // read the status code and body of the response
    statusCode = client.responseStatusCode();
    response   = client.responseBody();

    Serial.print("Status code: ");
    Serial.println(statusCode);
    Serial.print("Response: ");
    Serial.println(response);
    Serial.println("Wait five seconds");

    M5.Display.drawString("STATUS:", M5.Display.width() / 2, 60);
    M5.Display.drawString(String(statusCode), M5.Display.width() / 2, 100);
```

```
104
105     delay(5000);
106 }
```

2.4 NTP

cpp

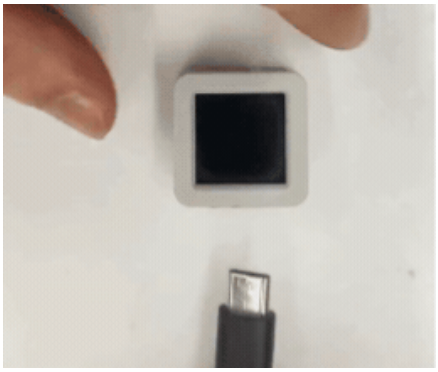
```cpp
#include "M5Unified.h"
#include "SPI.h"
#include "M5_Ethernet.h"

#define SCK  5
#define MISO 7
#define MOSI 8
#define CS   6

byte mac[] = {0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0x99};// Custom MAC address
// IPAddress ip(192, 168, 1, 177);                    // Static IP (Custom)

const char* ntpServerName = "cn.pool.ntp.org";     // NTP Server address
const uint16_t localPort = 8888;                   // Local port to listen for UDP packets
const int timeZone = 8;                            // Time zone offset (Beijing is UTC+8)
const int NTP_PACKET_SIZE = 48;                    // NTP packet size

byte packetBuffer[NTP_PACKET_SIZE];                // Buffer for incoming and outgoing packets
EthernetUDP Udp;

void sendNTPpacket(const char* address);
void printFormattedTime(uint32_t rawTime);

void setup() {
    M5.begin();
    Serial.begin(115200);

    M5.Display.setTextColor(GREEN);
    M5.Display.setTextDatum(middle_center);
    M5.Display.setFont(&fonts::Font2);

    SPI.begin(SCK, MISO, MOSI, -1);
    Ethernet.init(CS);

    M5.Display.drawString("Init...", M5.Display.width() / 2, M5.Display.height() / 2);
    Serial.println("Initializing...");

    // To use a static IP, use Ethernet.begin(mac, ip)
    // Attempt to obtain an IP address via DHCP
    while (Ethernet.begin(mac) != 1) {
        Serial.println("Error getting IP address via DHCP, trying again...");
        delay(1000);
    }

    // Check for Ethernet hardware presence
    if (Ethernet.hardwareStatus() == EthernetNoHardware) {
        Serial.println(
            "Ethernet shield was not found. Sorry, can't run without hardware. :(");
        while (true) {
            delay(1);  // Do nothing if hardware is missing
```

```
        }
    }
    if (Ethernet.linkStatus() == LinkOFF) {
        Serial.println("Ethernet cable is not connected.");
    }

    Serial.print("IP Address: ");
    Serial.println(Ethernet.localIP());

    M5.Display.clear();
    M5.Display.drawString(Ethernet.localIP().toString().c_str(),
                          M5.Display.width() / 2, M5.Display.height() / 2);
    M5.Display.setTextDatum(top_left);

    Udp.begin(localPort); // Start listening for UDP packets
    delay(1000);
}

void loop() {
    Serial.println("Sending NTP packet...");
    sendNTPpacket(ntpServerName);

    delay(1000); // Wait for packet to return

    if (Udp.parsePacket()) { // Check if a response is received
        Serial.println("Packet received");
        Udp.read(packetBuffer, NTP_PACKET_SIZE);

        // --- Parse NTP Timestamp ---
        // NTP timestamp is located at bytes 40-43, representing seconds since Jan 1, 1900
        uint32_t highWord = word(packetBuffer[40], packetBuffer[41]);
        uint32_t lowWord = word(packetBuffer[42], packetBuffer[43]);
        uint32_t secsSince1900 = highWord << 16 | lowWord; // Combine into a 32-bit unsigned intege

        // --- Convert to Unix Epoch Time ---
        // Unix epoch starts in 1970; NTP starts in 1900.
        // The 70-year difference (including leap years) is 2,208,988,800 seconds.
        const uint32_t seventyYears = 2208988800UL;
        uint32_t epoch = secsSince1900 - seventyYears;

        uint32_t bjTime = epoch + (timeZone * 3600); // Adjust for Beijing time zone
        printFormattedTime(bjTime);
    } else {
        Serial.println("No packet received yet.");
    }

    delay(4000); // Sync every 5 seconds, 4+1
}

// Send an NTP request to the given address
void sendNTPpacket(const char* address) {
    memset(packetBuffer, 0, NTP_PACKET_SIZE);
    // Set the NTP request header
```

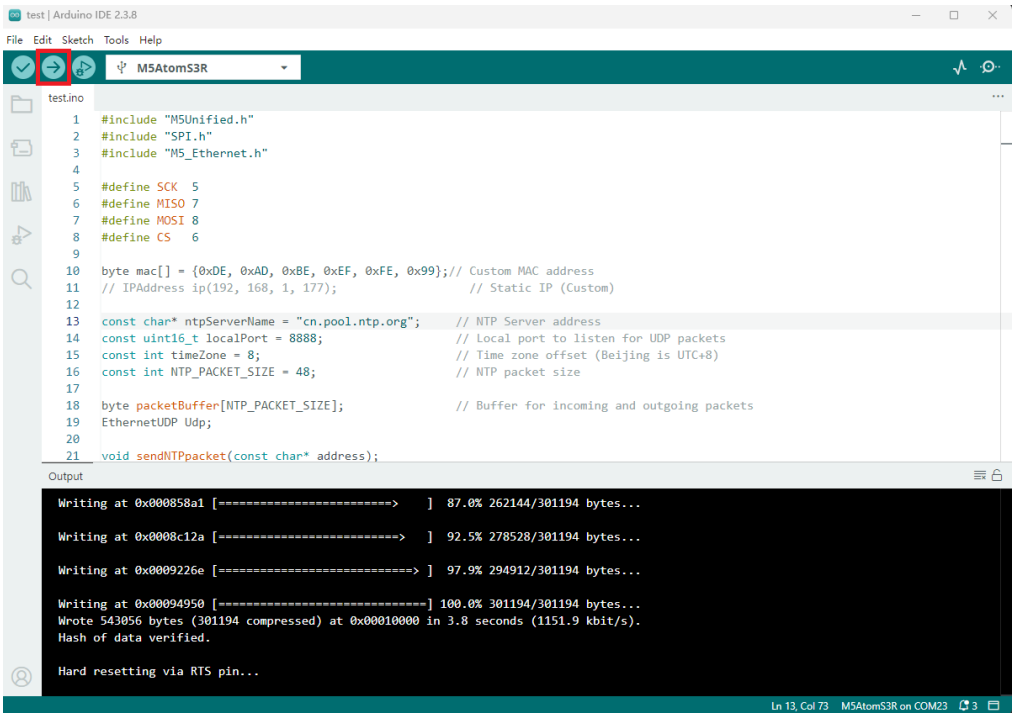
```
    // 0b00011011 represents: LI=00=0 (no warning), VN=011=3 (Version 3), Mode=011=3 (Client mode)
    packetBuffer[0] = 0b00011011;

    Udp.beginPacket(address, 123); // NTP requests are on port 123
    Udp.write(packetBuffer, NTP_PACKET_SIZE);
    Udp.endPacket();
}

// Format and display the time
void printFormattedTime(uint32_t rawTime) {
    int hours = (rawTime % 86400L) / 3600; // 86400 seconds = 1 day
    int minutes = (rawTime % 3600) / 60;
    int seconds = rawTime % 60;

    String timeStr = "Time: " + String(hours) + ":" +
                     (minutes < 10 ? "0" : "") + String(minutes) + ":" +
                     (seconds < 10 ? "0" : "") + String(seconds);

    Serial.println(timeStr);

    M5.Display.clear();
    M5.Display.drawString("Beijing", 10, 30);
    M5.Display.drawString(timeStr, 10, 60);
}
```

3. Compile & Upload

- 1. Press and hold the Boot button on AtomS3R, then release it when the green LED turns on. The device will enter download mode and wait for programming.



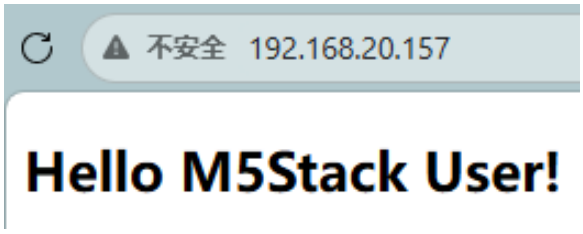
- 2. Select the device port and click the compile and upload button in the upper left corner of Arduino IDE. Wait for the program to complete compilation and upload to the device.



4. Network connection effect

- Web Server

After power-on, Host machine will automatically initialize the Atomic PoE Base module and create a web server. The server IP address will be displayed on the screen. Enter this IP address in your browser to see the message `Hello M5 User!` on the page, and the page will refresh automatically every 5 seconds.



Serial monitor feedback is as follows:

```
Initializing...
Server is at 192.168.20.157
new client
GET / HTTP/1.1
Host: 192.168.20.157
Connection: keep-alive
Upgrade-Insecure-Requests: 1
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64) AppleWebKit/537.36 (KHTML, like Gecko) Chrome/143
Accept: text/html,application/xhtml+xml,application/xml;q=0.9,image/avif,image/webp,image/apng,*/*;q=0.
Accept-Encoding: gzip, deflate
Accept-Language: zh-CN,zh;q=0.9,en;q=0.8,en-GB;q=0.7,en-US;q=0.6,ja;q=0.5,ko;q=0.4

client disconnected
```

- MQTT

After power-on, Host machine will automatically configure the Atomic PoE Base module and connect to the MQTT broker. Once connected, it publishes a message to the broker every 3 seconds. The screen shows send/receive information, and the serial monitor provides more details.

Serial monitor feedback is as follows:

```
Initializing...
IP Address: 192.168.20.157
Attempting MQTT connection...
Connected
Send Message [Atomic_PoE_Send] Hello world: 3001
Send Message [Atomic_PoE_Send] Hello world: 6002
Send Message [Atomic_PoE_Send] Hello world: 9003
Send Message [Atomic_PoE_Send] Hello world: 12004
Send Message [Atomic_PoE_Send] Hello world: 15005
Send Message [Atomic_PoE_Send] Hello world: 18006
Send Message [Atomic_PoE_Send] Hello world: 21007
Send Message [Atomic_PoE_Send] Hello world: 24008
Message arrived [Atomic_PoE_Receive] Hello!
...
```

- HTTP

After power-on, Host machine will automatically configure the Atomic PoE Base module and connect to the HTTP server, then continuously send GET and POST requests in a loop. The main screen displays the request status, and the serial monitor provides more details.

Serial monitor feedback is as follows:

```
Initializing...
IP Address: 192.168.20.157
making GET request
Status code: 200
Response: {
  "args": {},
  "headers": {
    "Host": "httpbin.org",
    "User-Agent": "Arduino/2.2.0",
    "X-Amzn-Trace-Id": "Root=1-69524204-7d767e3110e3bd6d1e28f6a8"
  },
  "origin": "113.88.164.214",
  "url": "http://httpbin.org/get"
}

Wait five seconds
making POST request
Status code: 200
Response: {
  "args": {},
  "data": "",
  "files": {},
  "form": {
    "age": "12",
    "name": "Alice"
  },
  "headers": {
    "Content-Length": "17",
    "Content-Type": "application/x-www-form-urlencoded",
    "Host": "httpbin.org",
    "User-Agent": "Arduino/2.2.0",
    "X-Amzn-Trace-Id": "Root=1-6952420a-588b0f181a6d7b311e694e06"
  },
  "json": null,
  "origin": "113.88.164.214",
  "url": "http://httpbin.org/post"
}
```

- NTP

After power-on, Host machine will automatically configure the Atomic PoE Base module and connect to the NTP server, synchronizing the time once every 5 seconds.

Serial monitor feedback is as follows:

```
Initializing...
IP Address: 192.168.20.157
Sending NTP packet...
No packet received yet.
Sending NTP packet...
Packet received
Time: 17:49:00
Sending NTP packet...
Packet received
Time: 17:49:05
```