Smart Energy Monitor (SEM)

> An implementation of different modes of SEM IOT project.

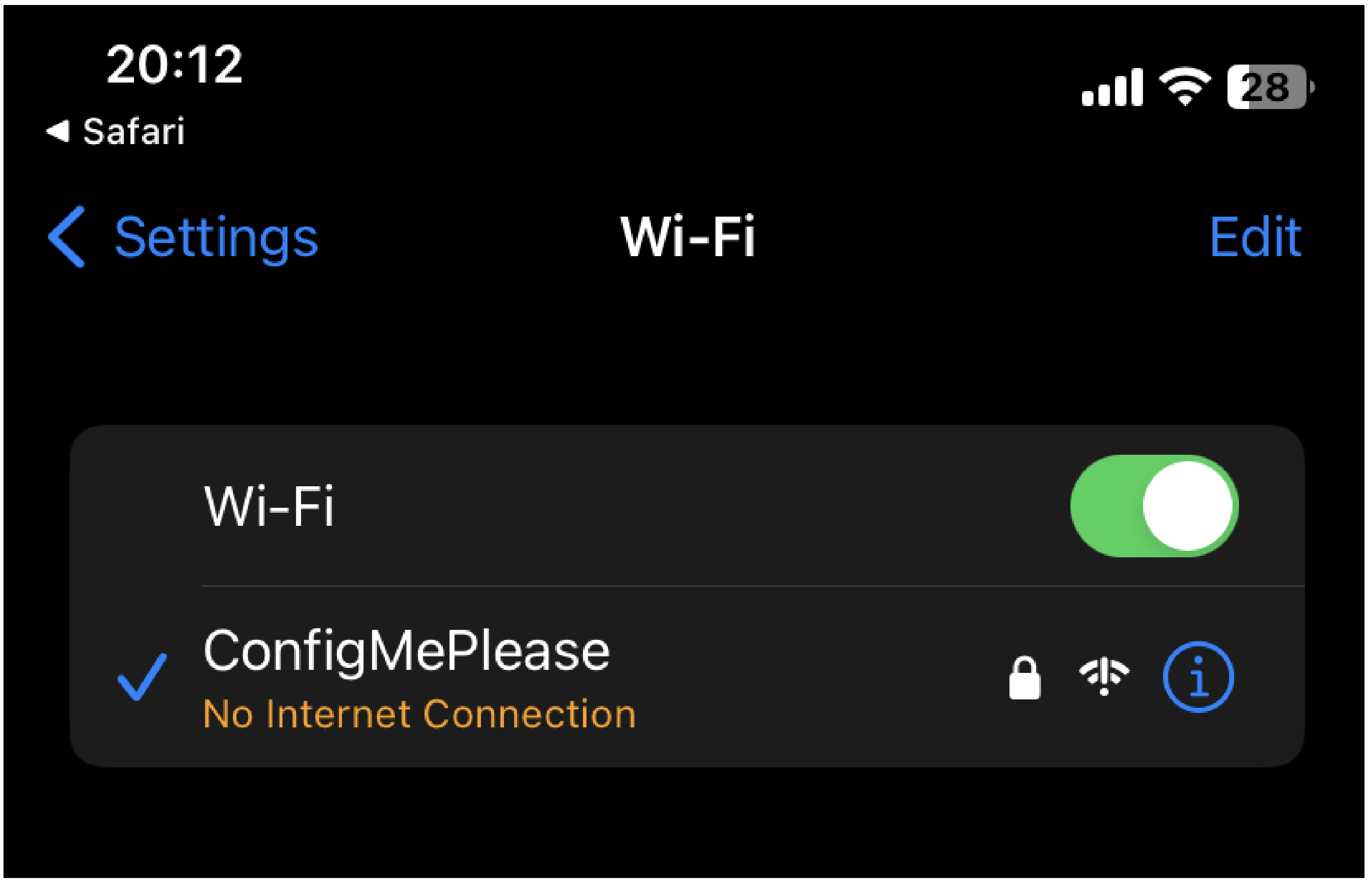
Introduction

The whole project is for measuring and monitoring energy of home devices. It can show some statistics information about electric devices energu usage. The part that is implemented in this repository is 4 different modes of this project. the SEM device can be operated in 4 different modes.

Getting-Started

First of you have to connect device into urban electrisity.

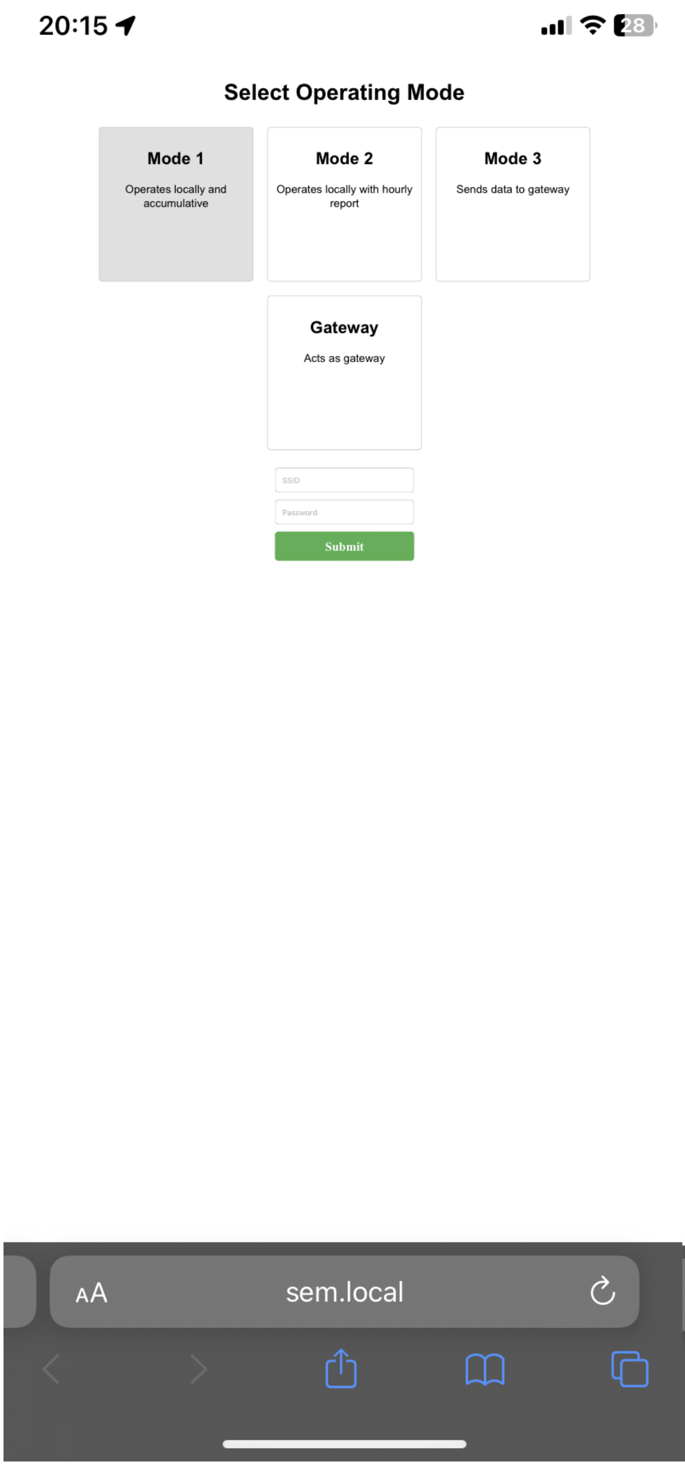
Then go to Wifi setting of your phone or computer. Connect to

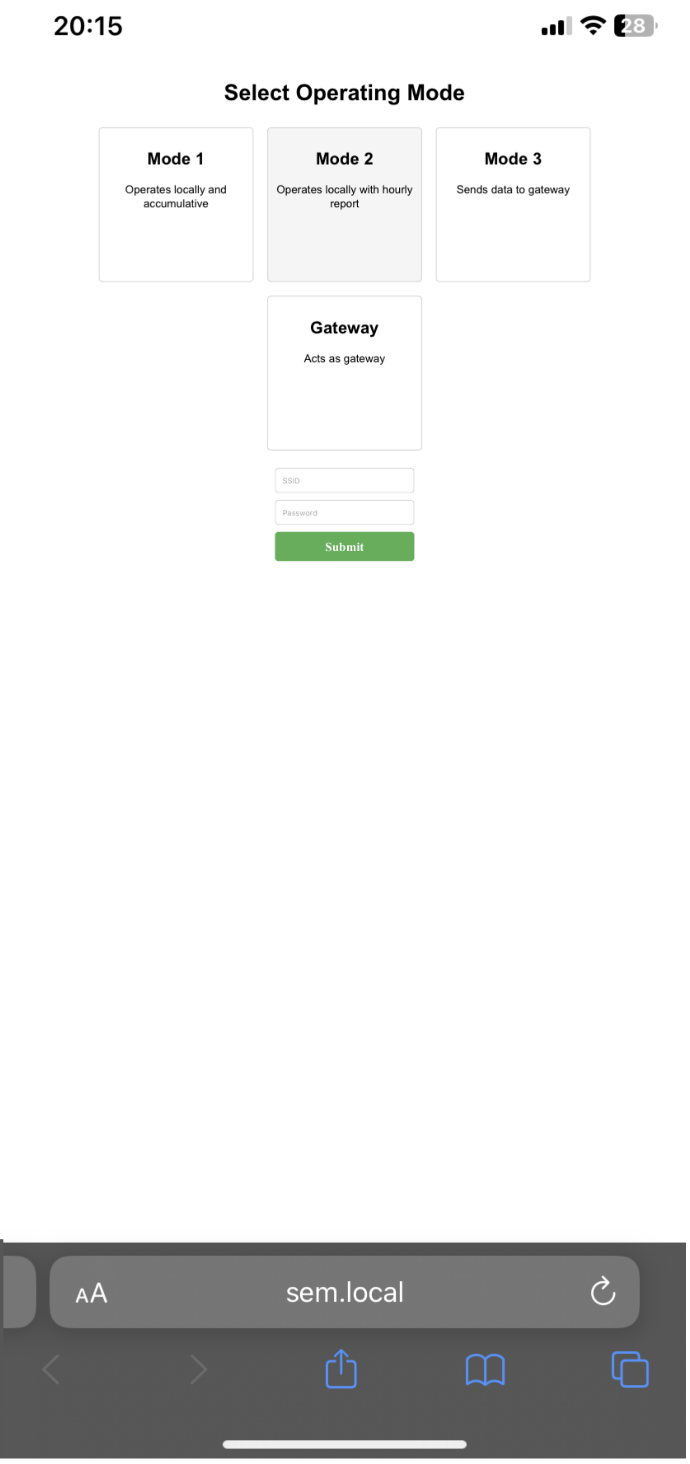


Go to your browser and enter <sem.local> The page containes 3 modes plus 1 gateway mode.

Mode 1,2

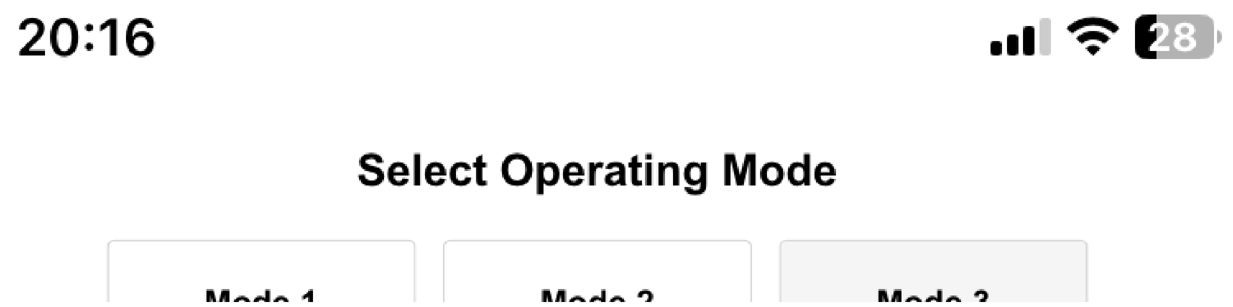
Mode 1,2 is for local mode of device using mobile App. The differene of this 2 modes is in the data which is calculated. In mode 1 its aggregate energy, but in mode 2 the data is per hour. In order to work in these modes you have to enter SSID and Password which you want to use for your device. In mode 1,2 you device works as an Access Point.

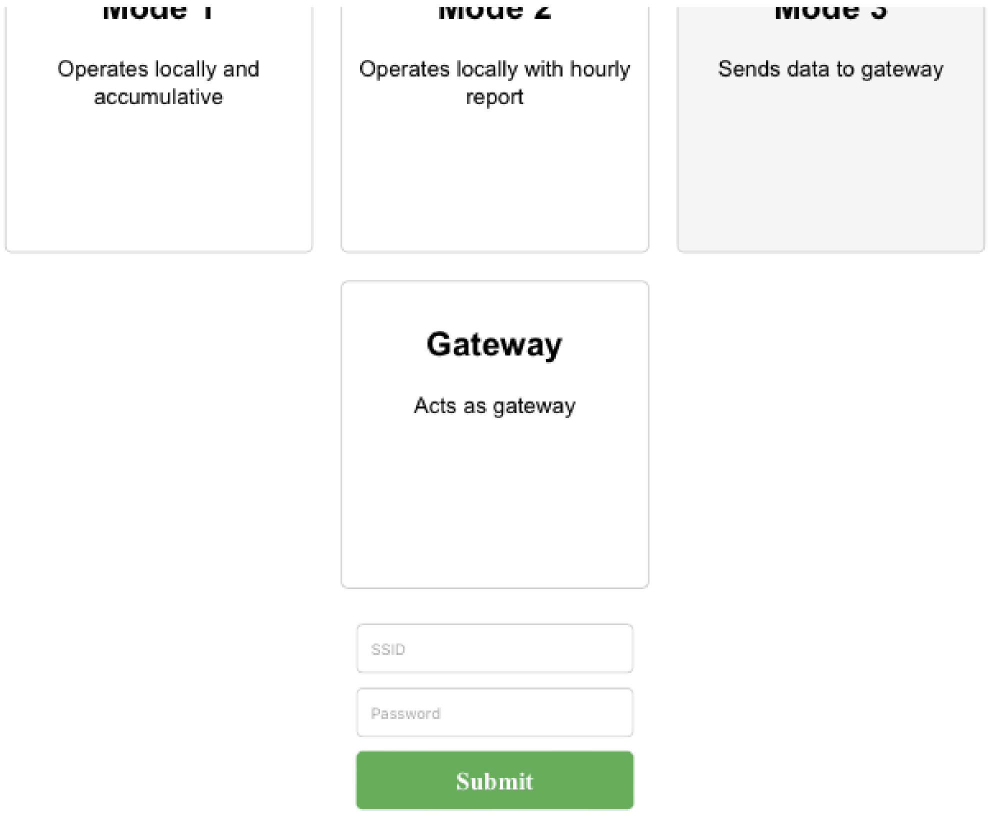




Mode 3

In the third mode your device works as a node. It should be connected into a SSID and use it as a gateway. So you should enter SSID and Password of a router or external network.





Mode 1

Operates locally and accumulative

Mode 2

Operates locally with hourly report

Mode 3

Sends data to gateway

Gateway

Acts as gateway

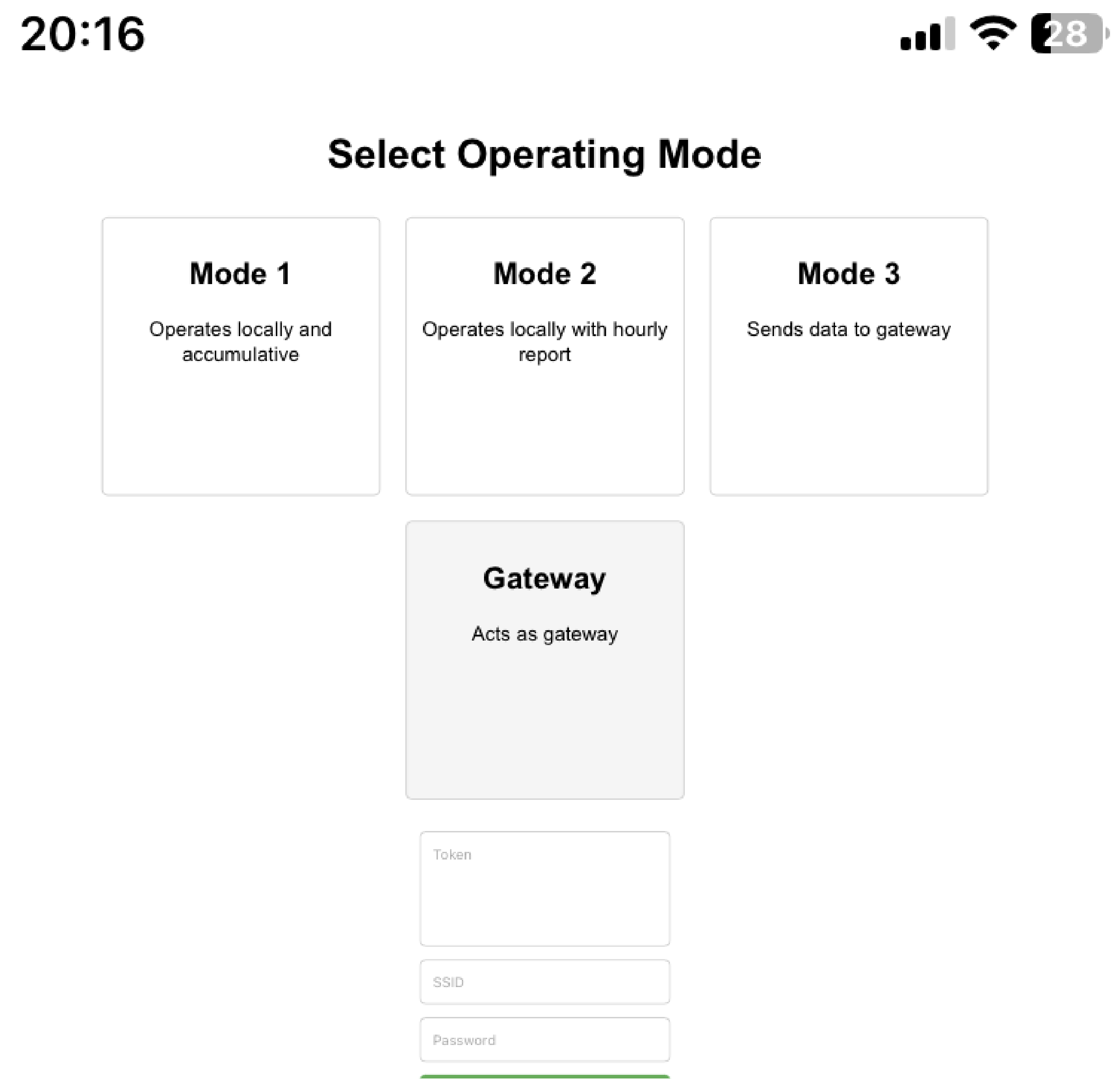
SSID

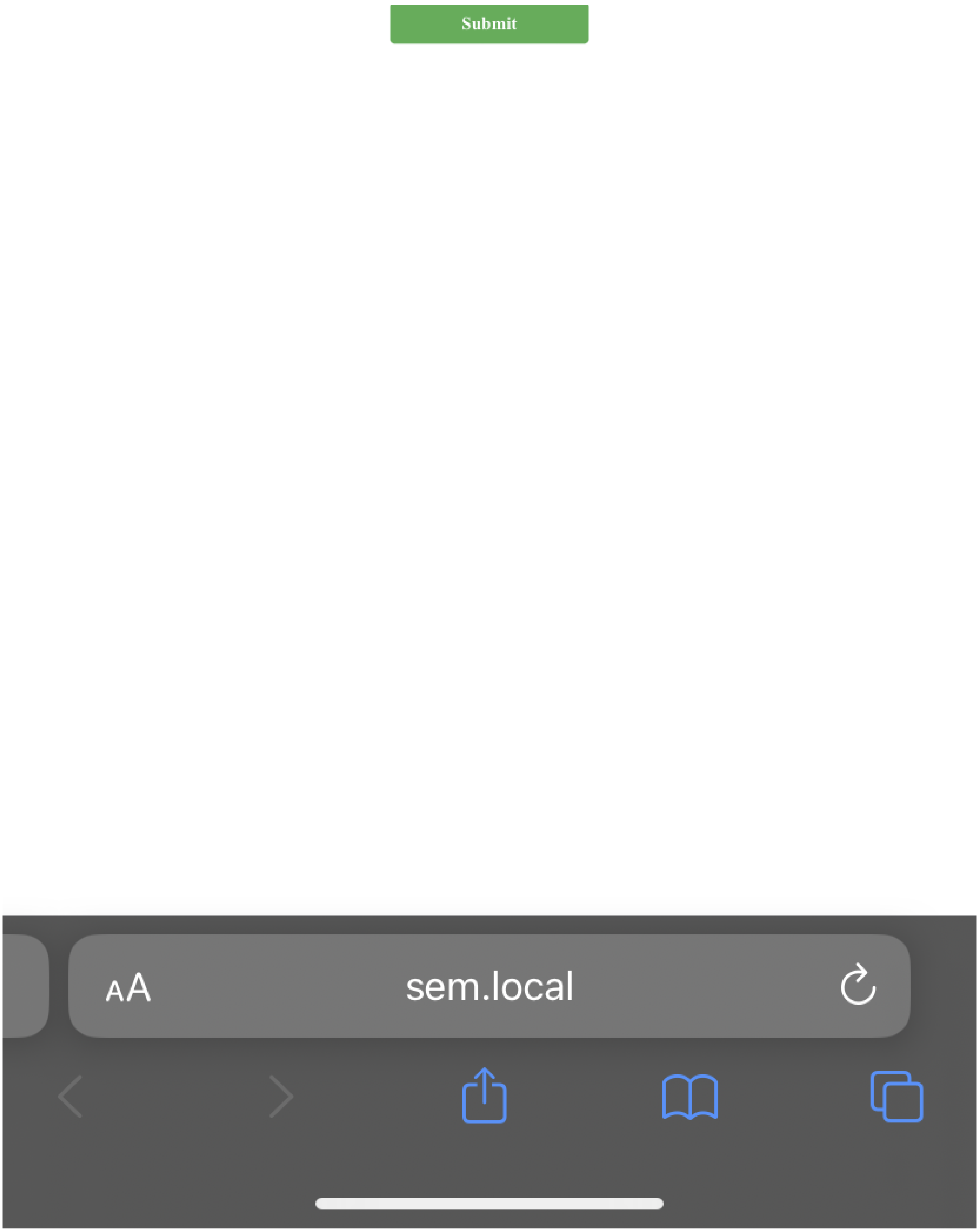
Password

Submit

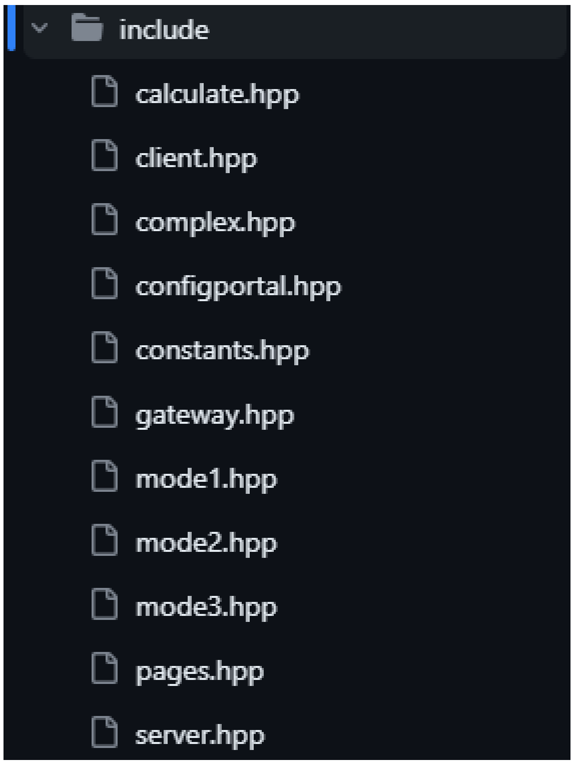
Mode 4(Gateway)

The last mode is gateway mode. SEM device is a gateway here. So you should enter SSID and Password of a router or external network. Here you should enter the token which MobileApp or website gives to you. The network which you connect to, should be the one in mode 3





Includes



```
include
    calculate.hpp
    client.hpp
    complex.hpp
    configportal.hpp
    constants.hpp
    gateway.hpp
    mode1.hpp
    mode2.hpp
    mode3.hpp
    pages.hpp
    server.hpp
```

calculate.hpp

As it can be understood by its name, this library helps us for our calculations. The functions are based on the official library of Arduino.

client.hpp

This library is for requesting https by clients.

complex.hpp

This library is for calculate and work with complex numbers.

configportal.hpp

This library is for the main portal of application(sem.local). Based on our current mode, the device is an access point or not. The token attribute is only used in gateway mode. In "configPortal.cpp" this attributes are filled and response to each endpoint of this webpage is set.

constants.hpp

Our constants are in this library. We divide the constants into 4 groups. The first group is for pins of the board. The second one has addresses of NVS. The third group has the constants of config portal (sem.local). The last group, which is named others, is for MDNS configuration. This information can be set in "constants.cpp" file. For example the SSID and Password of SEM (configMePlease).

gateway.hpp

mode1.hpp

mode2.hpp

mode3.hpp

Same as arduino, esp has 2 main functions: Init and loop. Based on the mode which we are in, the function which is related to that mode is called. The signature of those functions are in .hpp files.

page.hpp

This library is for html pages. We have two pages. The first page is for the configuration page (configPage) and the second one will be shown when the configuration is done.

server.hpp

The last library is for creating esp asynchronous web server.

Mode1

Mode 1,2 is for local mode of device using mobile App. The differene of this 2 modes is in the data which is calculated. In mode 1 its aggregate energy, but in mode 2 the data is per hour. First of all we should implement some libraries which are defined in Includes

```
void onData(AsyncWebServerRequest *request)
{
  DynamicJsonDocument doc(1024);
  JsonArray data = doc.createNestedArray("data");
  StaticJsonDocument<192> doc2;
  doc2["consumption"] = getEnergy();
  doc2["voltage"] = getVoltage();
  doc2["current"] = getCurrent();
  doc2["THDv"] = getThdVoltage;
  doc2["THDi"] = getThdCurrent();
  data.add(doc2);

  doc["mode"] = "mode1";
  doc["mac"] = WiFi.macAddress();

  AsyncResponseStream *response = request-
>beginResponseStream("application/json");
  serializeJson(doc, *response);
  request->send(response);
}
```

This function recieves a request as a parameter. Based on that request , creates a response.response is a json file which contains mode, energy and mac. The getEnergy function that fills energy field is in calculate.hpp. Wifi.macAddress is in wifi.h that is a library in constants.hpp Then , the created json file will be serialized and will be sent as response.

```
void Mode1_Init(void)
{
  server->on("/", HTTP_GET, [](AsyncWebServerRequest *request)
             { request->send(200, "text/plain", "hello"); });
  server->on("/data", HTTP_GET, onData);
  server->onNotFound([](AsyncWebServerRequest *request)
                     { request->send(404, "text/plain", "Not found"); });
  server->begin();
  debugln("started mode 1 server");
}
```

In this function we first set our endpoints. We only have 2 endpoints, so for every other endpoints except “/” and “/data” the result will be 404 not found. onData function is called when we are in “/data” endpoint.

After creating endpoints, we begin the server.

```
void Mode1_Loop(void)
{
  delay(SAMPLE_PERIOD);
  debugln("[A]: Start Calculating.");
  calculateANDwritenergy();
}
```

We have 5s delay per loop and in each loop by calling calculateANDwritenergy, the calculation of the energy begins. This function is overwritten in calculate.hpp

Mode2

Mode 1,2 is for local mode of device using mobile App. The differene of this 2 modes is in the data which is calculated. In mode 1 its aggregate energy, but in mode 2 the data is per hour. First of all we should implement some libraries which are defined in Includes

```
static int callback(void *data, int argc, char **argv, char **azColName)
{
  int i;
  for (i = 0; i < argc; i++)
  {
    Serial.printf("%s = %s\n", azColName[i], argv[i] ? argv[i] : "NULL");
  }

  if ((argc == 7) && (tmpIdx < 100))
  {
    tmpRowid[tmpIdx] = atoll(argv[0]);
    tmpEnergy[tmpIdx] = atof(argv[1]);
    tmpVoltage[tmpIdx] = atof(argv[2]);
    tmpCurrent[tmpIdx] = atof(argv[3]);
    tmpThdVoltage[tmpIdx] = atof(argv[4]);
    tmpThdCurrent[tmpIdx] = atof(argv[5]);
```

```
      tmpPf[tmpIdx] = atof(argv[6]);
      tmpIdx++;
      clbCount++;
    }

  return 0;
}
```

This function is called in db_exec(). After we pass records of a query, this function runs some calculations on each record of that query

```
int db_exec(sqlite3 *db, const char *sql)
{
  debugln(sql);
  int rc = sqlite3_exec(db, sql, callback, (void *)data, &zErrMsg);
  if (rc != SQLITE_OK)
  {
    Serial.printf("SQL error: %s\n", zErrMsg);
    sqlite3_free(zErrMsg);
  }
  else
  {
    Serial.printf("Operation done successfully\n");
  }
  return rc;
}
```

This function receives a database and a query for that database. Then runs the query on database and

```
void mode2OnData(AsyncWebServerRequest *request)
{
  char tmpstr[200];
  tmpIdx = 0;
  sqlite3_close(db1);
  if (db_open("/spiffs/test1.db", &db1))
    return;
  clbCount = 0;
  sprintf(tmpstr, "SELECT rowid, energy, voltage, current, tvoltage, tcurrent, pf
FROM test1 ORDER BY rowid ASC LIMIT 100 OFFSET %ld;", readOffset); // WHERE
rowid=%ld;", sqlite3_last_insert_rowid(db1));
  rc = db_exec(db1, tmpstr);
  if (rc != SQLITE_OK)
  {
    sqlite3_close(db1);
    return;
  }
  readOffset += clbCount;
  if (clbCount < 100)
  {
    rc = db_exec(db1, "DELETE FROM test1;");
    if (rc != SQLITE_OK)
    {
      sqlite3_close(db1);
      return;
    }
    readOffset = 0;
  }
  DynamicJsonDocument doc(12288);
  JsonArray data = doc.createNestedArray("data");

  for (size_t i = 0; i < tmpIdx; i++)
  {
    StaticJsonDocument<192> doc2;
    doc2["consumption"] = tmpEnergy[i];
    doc2["voltage"] = tmpVoltage[i];
    doc2["current"] = tmpCurrent[i];
    // doc2["pf"] = tmpPf[i];
    doc2["THDv"] = tmpThdVoltage[i];
    doc2["THDi"] = tmpThdCurrent[i];
    data.add(doc2);
  }

  doc["mode"] = "mode2";
  doc["mac"] = WiFi.macAddress();

  AsyncResponseStream *response = request-
>beginResponseStream("application/json");
  serializeJson(doc, *response);
  request->send(response);
}
```

This method has a query which is going to be run on the database. After that, creates a json file based on records of a query. This response will be shown on the "/data" endpoint. The json parameters are: {consumption, voltage, current, THDv, THDi} which are field by records of the query. The {mac} parameter is field by a method that is in wifi.h (in constants.hpp)

```
void Mode2_Init(void)
{
  server->on("/", HTTP_GET, [](AsyncWebServerRequest *request)
             { request->send(200, "text/plain", "hello"); });
  server->on("/data", HTTP_GET, mode2OnData);
  server->onNotFound([](AsyncWebServerRequest *request)
                     { request->send(404, "text/plain", "Not found"); });
  server->begin();
  debugln("started mode 2 server");
  dbInit();
}
```

In this function we first set our endpoints. We only have 2 endpoints, so for every other endpoint except “/” and “/data” the result will be 404 not found. onData function is called when we are in “/data” endpoint. After creating endpoints, we begin the server.

```
void Mode2_Loop(void)
{

  static unsigned long lastMillis = 0, lastMillis2 = 0, lastMillis3 = 0,
lastMillis4 = 0;


  if (millis() - lastMillis > SAMPLE_PERIOD)
  {
    debugln("[A]: Start Calculating.");
    calculateANDwritenergy();
    lastMillis = millis();
  }

  if (millis() - lastMillis2 > 3600000)
   {
     saveToFlash();
     lastMillis2 = millis();
   }
}
```

Each hour, saves data on the database by calling saveToFlash() function.

Mode3

In the third mode your device works as a node and sends data the the gateway. First of all we should implement some libraries which are defined in Includes

```
void sendDataToGW()
{
  DynamicJsonDocument doc(1024);
  doc["consumption"] = getEnergy();
  doc["voltage"] = getVoltage();
  doc["current"] = getCurrent();
  doc["THDv"] = getThdVoltage();
  doc["THDi"] = getThdCurrent();
  doc["mode"] = "mode3";
  doc["macAddress"] = WiFi.macAddress();

  String output;
  serializeJson(doc, output);
  sendHttpPOSTrequest("http://gateway.local/publish", output, false);
}

void Mode3_Init(void)
{
    createClient();
}

void Mode3_Loop(void)
{
  delay(SAMPLE_PERIOD);
  debugln("[A]: Start Calculating.");
  calculateANDwritenergy();
  sendDataToGW();
}
```

Functionality of "sendDataToGW()" is like the onData() method in mode 1,2. But here we don’t need any endpoint or any request for sending that json. However in this method the json file is created every time we call the function (every 5s in "Mode3_Loop()") and then it serializes the Json file and sends it to the gateway by a POST method. The Json file contains some information about the energy which is filled by the functions of headers.

Gateway

The last mode is gateway mode. SEM device is a gateway here. First of all we should implement some libraries which are defined in Includes.

```
void action(AsyncWebServerRequest * request, uint8_t *data, size_t len, size_t
index, size_t total) {
  debugln("post received");
  request->send(200);
  String temp = String((char*) data);
  deserializeJson(docs[pckt_cnt], temp);
  pckt_cnt++;
}
```

This function receives data which are sent from nodes(mode3). After receiving successfully and sending the 200 ok response, it collects and locates them in a buffer (“docs”).

```
void Gateway_Init(void)
{
    server->on(
              "/publish",
              HTTP_POST,
              [](AsyncWebServerRequest * request){},
              NULL,
              action);
  server->begin();

  setupHttpsClient();
}
```

Like init methods in all other modes, it creates an endpoint for its own functionality. Here the endpoint for gateway is “/publish”

```
void Gateway_Loop(void)
{
  if((pckt_cnt>=50||(millis()-lastSend>=sendInterval)) && pckt_cnt > 0)
  {
    debugln("sending to server");
    DynamicJsonDocument doc(30 * 1024);
    JsonArray data = doc.createNestedArray("data");
    for(int i=0;i<pckt_cnt;i++)
    {
      data.add(docs[i]);
    }
    String sendData;
    serializeJson(doc, sendData);
    sendHttpPOSTrequest("http://5.160.40.125:8080/consumption/mode-4", sendData,
true);
    pckt_cnt = 0;
    lastSend = millis();
  }
  delay(1000);
}
```

In this function all data in the buffer(“docs”) is going to be read. There is a condition at the beginning of the loop. It's for checking the buffer and reading them either every time its timeout ends or every time the buffer reaches 50 packets. Then the packets (data) in the buffer will be serialized and sent to the server.