IoT Workshop

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What is IoT

Preparations

- Install Arduino IDE
- Install the "ESP8266 core" for Arduino, follow the guide on https://github.com/esp8266/Arduino#installi with-boards-manager.
- Install PubSubClient library with Library manager from within the Arduino IDE.

What is an IoT Device?

- Constrained in (one or more of):
  - Memory
  - CPU
  - Network bandwidth and/or latency
  - Storage
- Has connectivity

Might not have:

- RTC

Extra features:

- IR
- UART
- CAN

Sparkfun and Adafruit etc sell modules with all of these technologies.

IoT Devices - Example chips

Protocol	Chip	Specs
Bluetooth 4/5	nRF52x	32-64 MHz, Cortex-M0/M4F,

Protocol	Chip	Specs
		24-256k RAM, 192-1024 k Flash, $1.88-$3.85
WiFi	ESP8266/ESP32	80MHz-160MHz, 1-2 cores, ~80k RAM, < $1 - $4.53
LoRa	Semtech	$3.23 - $4.74

BT and Wi-Fi has many, many more chips. Technologies based on open/accessible standards. LoRa is much more closed and driven by a single company.

4.53 is quantity=10

LoRa chips are just trancievers, an MCU with LoRa stack is required.

ESP8266 Specifications

CPU	Tensilica Xtensa L106
Frequency	80MHz (160MHz possible
RAM	32 kB instruction RAM 80 kB user RAM 16 kB system RAM
Flash	None, integrated SPI driver
Peripherals	16 x GPIO I²C, SPI, I²S, UART 10 bit ADC Wi-Fi

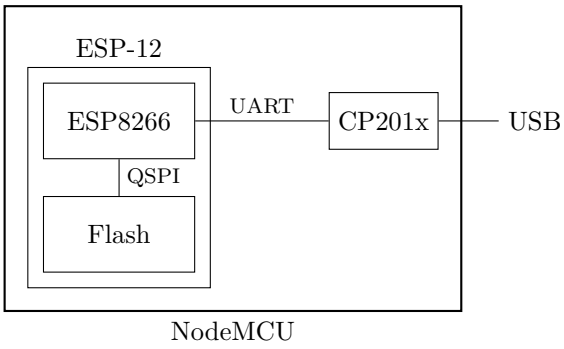
ESP8266 Power usage

State	Current usage
Off	0.5 µA
Deep sleep with RTC	20 µA
Light sleep (with Wi-Fi)	1 mA
Sleep with peripherials	15 mA
TX	170 mA

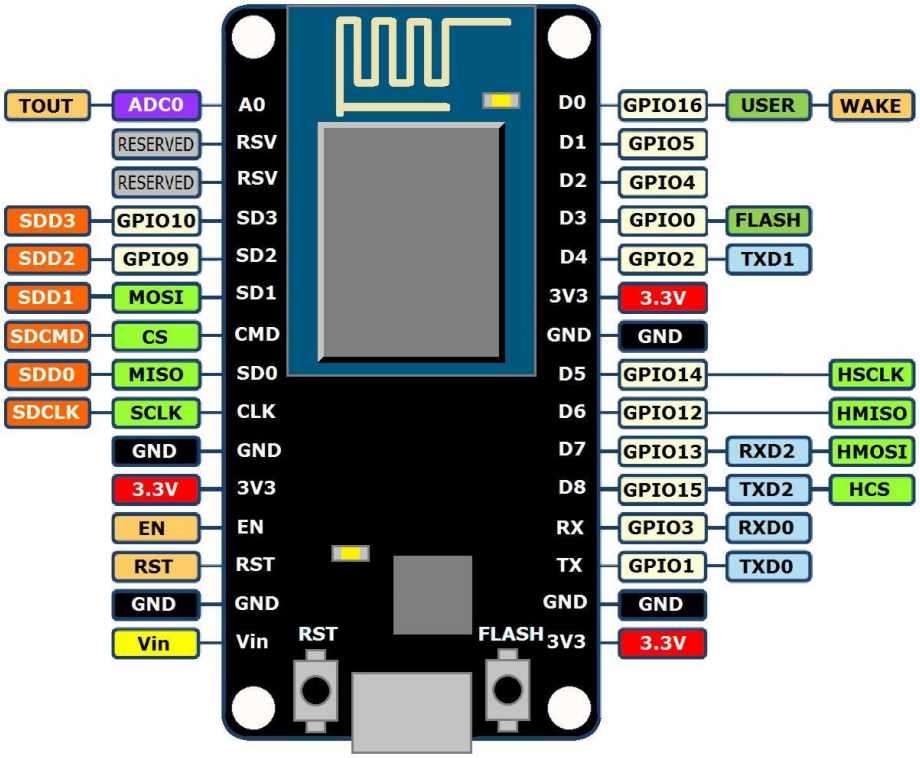
Datasheet page 18

NodeMCU

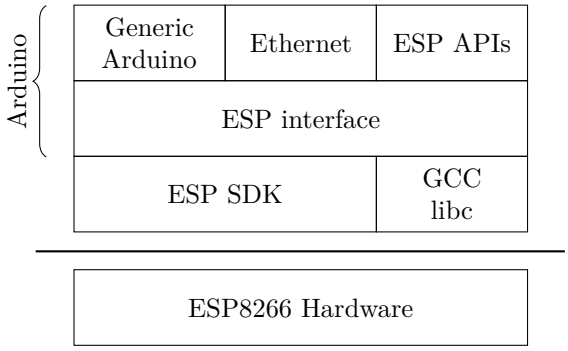
NodeMCU hardware



NodeMCU hardware



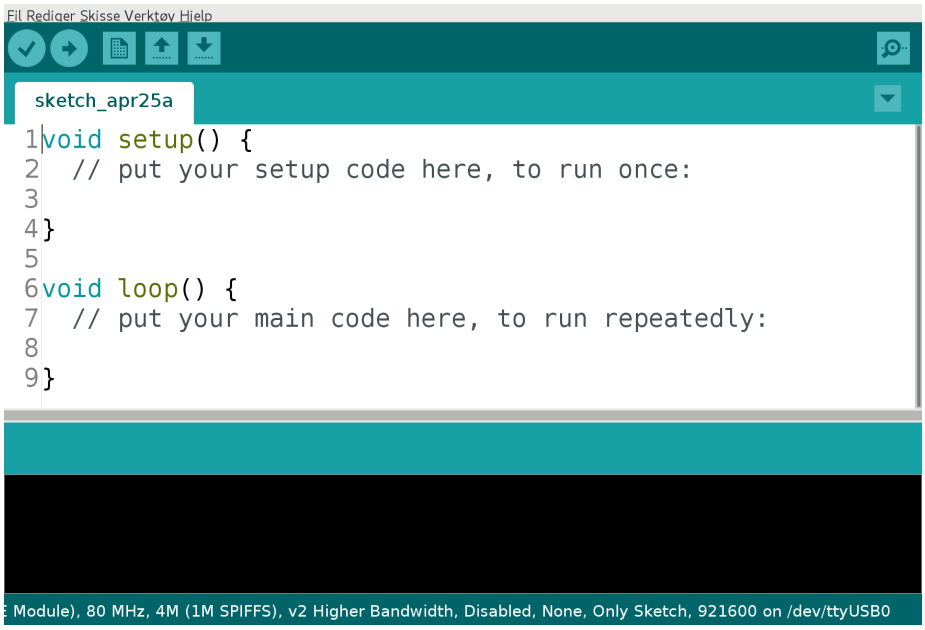
ESP8266 software layers



ESP8266 + Arduino

- Standard Arduino IDE
- ESP8266 Arduino core
  - https://github.com/esp8266/Arduino

Arduino IDE



Generic Arduino APIs

```
// Pin: D0, D1, etc.
// Mode: OUTPUT, INPUT, INPUT_PULLUP
// State: HIGH, LOW, 1/0

void pinMode(pin, mode);
void digitalWrite(pin, state);
int digitalRead(pin);

unsigned long now = millis();
unsigned long now = micros();
```

Assignment: `blink-a-led`

Lecture: MQTT

MQTT

- *Message Queuing Telemetry Transport*
- Wikipedia: MQTT

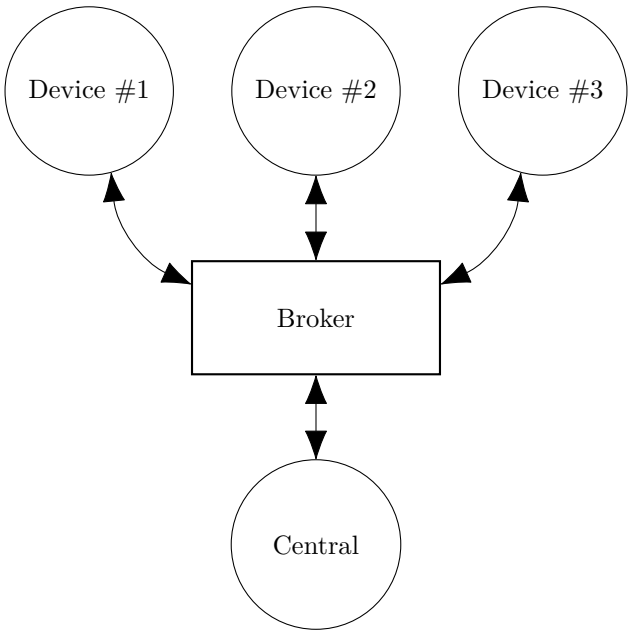
MQTT is *the* standard for IoT applications (and lots of other useful stuff to). Using HTTP is just silly.

Supports SSL, and requires TCP.

Has UDP-like semantics with "fire and forget" but on a higher level (the message always have to be delivered and ACKed by the broker, not it's final recipient.

Version 3.1.1 er den som gjelder, V 3.1 er rar, de andre finnes ikke (før standardisering).

Device and application architecture with MQTT



MQTT Example

The temperature sensor:

- Publishes on:
  - `myapp/$device-id/temperature`
  - `myapp/$device-id/humidity`
  - `myapp/$device-id/altert`
- Subscribes to:
  - `myapp/$device-id/command`

The central application:

- Subscribes to:
  - `myapp/#/temperature`
  - `myapp/#/humidity`
- Publishes on:
  - `myapp/$device-id/command`

Typical first round of implementation.

Commands can be: * load new firmware (maybe an URL and firmware signature). * Set new calibration values * Change reading interval, altert levels (autonomous operation)

MQTT - The protocol

Agents have one of two roles:

- *Client*
  - Publishes *messages*
  - Subscribes / unsubscribes to *topics*
  - Keep alive
- *Broker* (aka Server)
  - Handles network connections
  - Keeps subscriptions
  - Manages client
    - Timeouts and disconnects
    - *last will*
  - Persistence of *retained* messages

network connections: this includes removing closed sockets, client's that doesn't respons to timeouts and duplicate clients.

http://docs.oasis-open.org/mqtt/mqtt/v3.1.1/mqtt-v3.1.1.html

Subscriptions are not permanent. The connection is (unlike HTTP) stateful.

Some messages may be persistent, but only one per topic. You will often end up with a "proper" mq on the backend if queuing is needed.

Push vs pull, central applications can push to clients

MQTT - The protocol - MQTT Topic

- Topic name: `foo/bar/baz`
- Topic filter
  - `foo/bar/?`
  - `foo/#`

ESP Arduino APIs

```
class {
    void restart();
    uint32_t getFreeHeap();
    uint32_t getChipId();

    ...
} ESP;

// Usage
ESP.restart();
```

Connecting to a Wi-Fi

```
#include <ESP8266WiFi.h>

void setup() {
    WiFi.mode(WIFI_STA);
    WiFi.begin("NDC 2018", NULL);

    while (WiFi.status() != WL_CONNECTED) {
        delay(500);
        Serial.print(".");
    }

    Serial.println("");
    Serial.println("WiFi connected");
    Serial.println("IP address: ");
    Serial.println(WiFi.localIP());
}
```

MQTT on Arduino

PubSubClient is our MQTT client implementation.

Preparing to publish messages:

```
#include <ESP8266WiFi.h>
#include <PubSubClient.h>

WiFiClient wifiClient;
PubSubClient mqtt(wifiClient);

String deviceId = "esp-" + String(ESP.getChipId(), HEX);

void setup() {
    // ...
    mqtt.setServer("broker.hivemq.com", 1883);
}
```

MQTT on Arduino

```
void loop()
{
    if (!mqtt.connected()) {
        reconnect();
    }
    else {
        mqtt.loop();
    }

    // Do work
}
```

MQTT on Arduino

```
void reconnect()
{
    do {
        Serial.println("Connecting to MQTT");
        delay(1000);
    } while (!mqtt.connect(clientId.c_str()));

    Serial.println("Connected to MQTT server");
}
```

MQTT on Arduino

```
void sendMessage()
{
    String topic = "ndc/" + deviceId + "/led";
    mqtt.publish(topic.c_str(), "1");
}
```

MQTT on Arduino

Preparing for subscriptions:

```
void setup() {
    ...
    mqtt.setCallback(callback);
}

void callback(char* topic,
              byte* payload,
              unsigned int length) {
}

void reconnect() {
    ...
    // Subscribe to any topics you need
    mqtt.subscribe(topic_pattern);
}
```

Assignment: `mqtt-with-button`

Content

https://github.com/trygvis/iot-workshop-ndc-2018