Numeramini

Cetero censeo homines numerandi sunt!

Das Problem

Wie viele Menschen sind in einem Raum?

Unsere Vision

Modular, verbunden, eingebettet

Optical Distance Sensor

Laser Distance Sensor

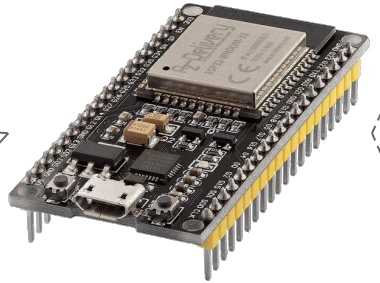
ESP12
Sensor Hub

Camera

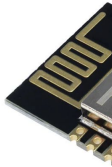
Infrared Camera

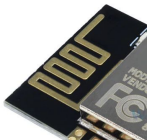
WiFi

Display



ESP32
Webserver
User Interface





Unsere Vision

Implementiert

Modular, verbunden, eingebettet

Optical Distance Sensor

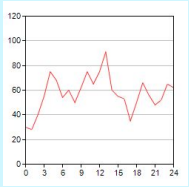
Laser Distance Sensor

ESP12
Sensor Hub

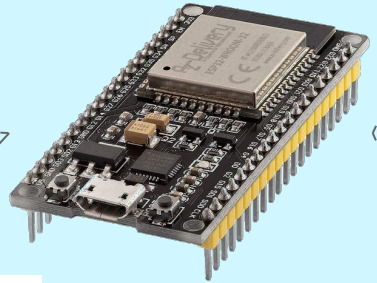
Camera

Infrared Camera

WiFi



Web-Interface



ESP32
Webserver
User Interface

Aktuelle Version

Numeramini

Count

Node Stats

Node	Last Heart Beat	Alive	Role
192.168.4.3	7.2.2023, 11:14:05	1	front
192.168.4.2	7.2.2023, 11:13:56	1	back

Distanz-Sensor

Laser

Photo-sensor

Aktuelle Version

Numeramini

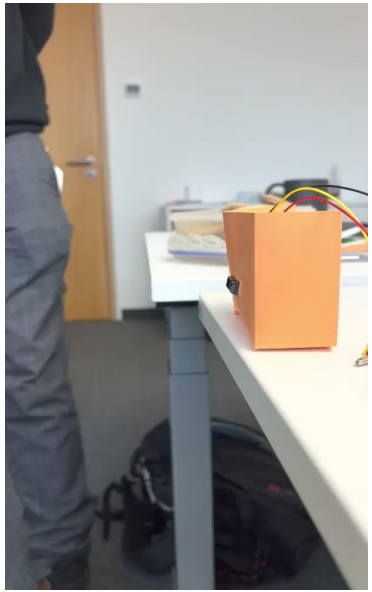
Count

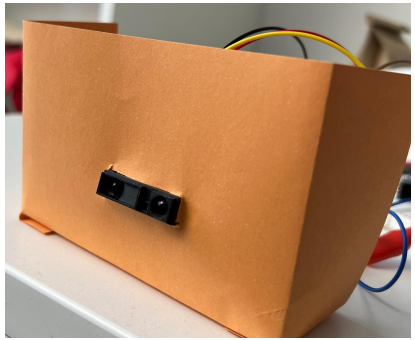
Node Stats

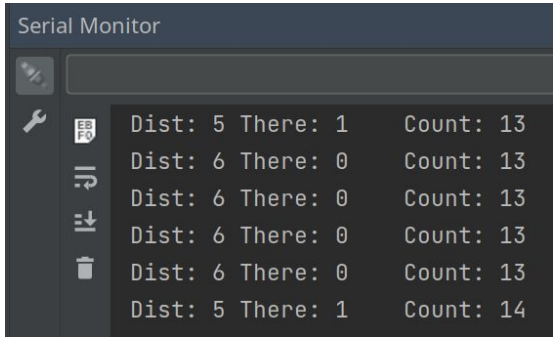
Node	Last Heart Beat	Alive	Role
192.168.4.3	7.2.2023, 11:14:05	1	front
192.168.4.2	7.2.2023, 11:13:56	1	back

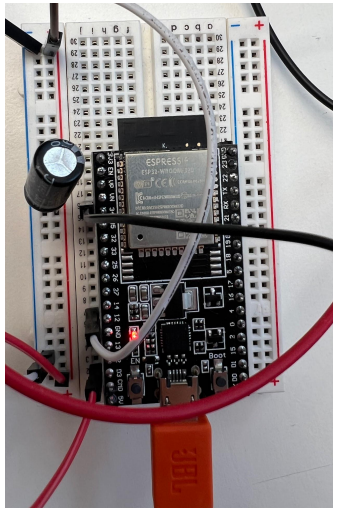
https://cloud.veladus.dev/s/YbSN5zErbs2m72i

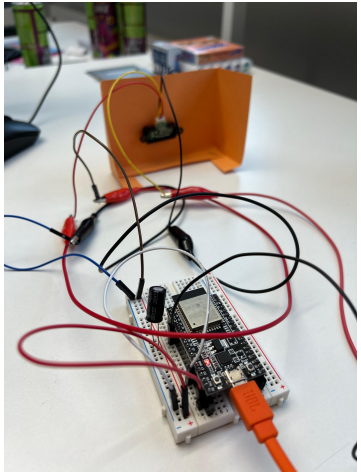
Aktuelle Version



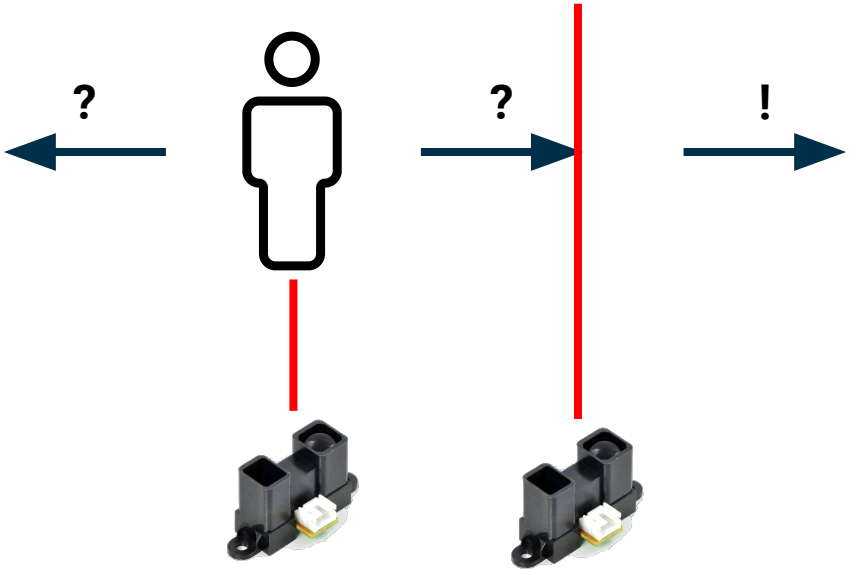








Raus oder Rein?



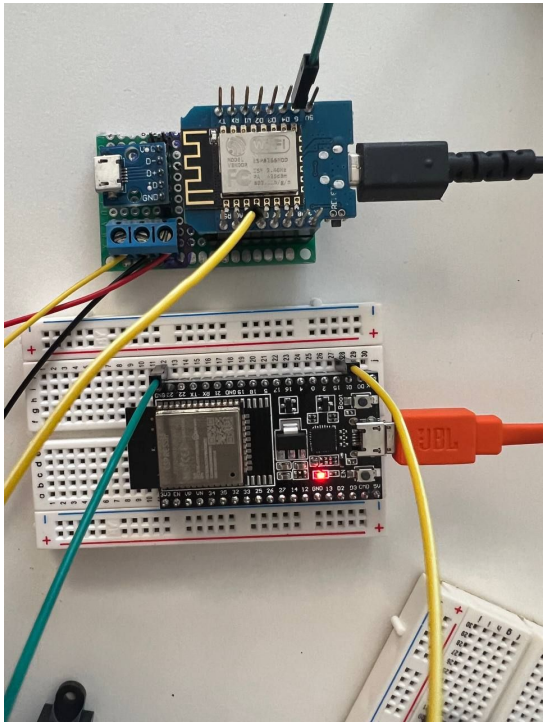
Erstaunlich schwer: Zeitsynchronisation

NTP?

Wie gut muss es sein?

$$\Delta t = \frac{0.1\,\mathrm{m}}{4\,\frac{\mathrm{m}}{\mathrm{s}}} = 0.025\mathrm{s}$$

Wie finden wir heraus, wie gut es ist?



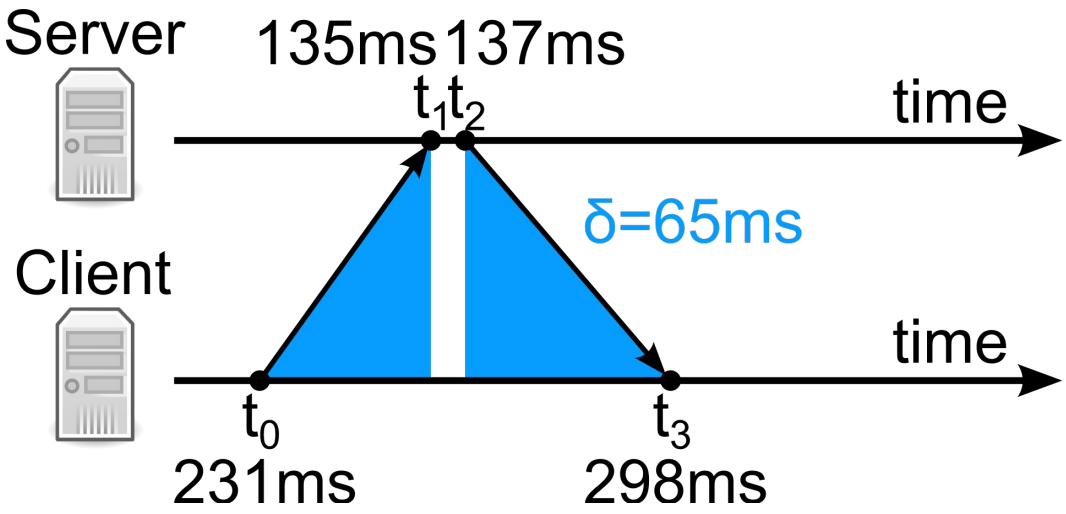
Node

```
void loop() {
    bool current_there = digitalRead(D0);
    if (current_there && current_there != there) {
        Serial.println(get_server_time());
    }
    there = current_there;
}
```

Server

```
if (millis() - last_flank >= 10000) {
    auto time = millis();
    digitalWrite(TIME_SYNC_PIN, HIGH);
    last_flank = time;
    wPrint("\tMillis: "); wPrintln(String(time));
    delay(100);
    digitalWrite(TIME_SYNC_PIN, LOW);
}
```

Reminder: NTP

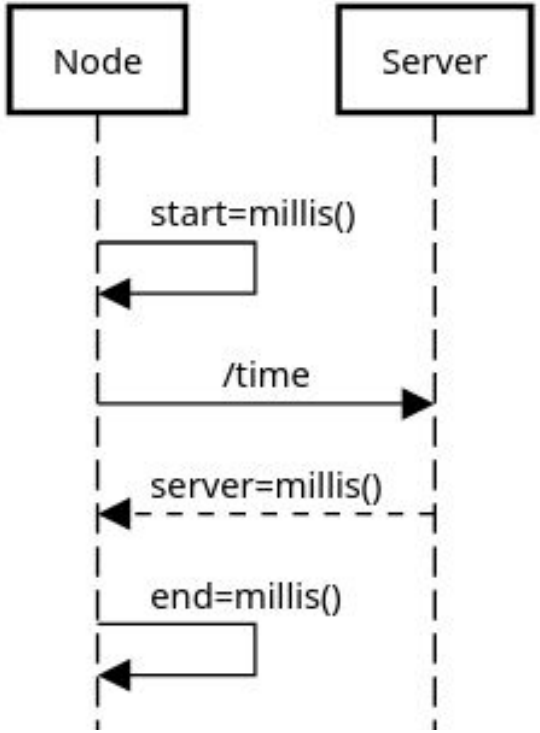


$$\Delta t = \frac{(t_1 - t_0) + (t_2 - t_3)}{2}$$

Annahme: $t_1 = t_2$

$$\Delta t = t_1 - \frac{t_0 + t_3}{2}$$

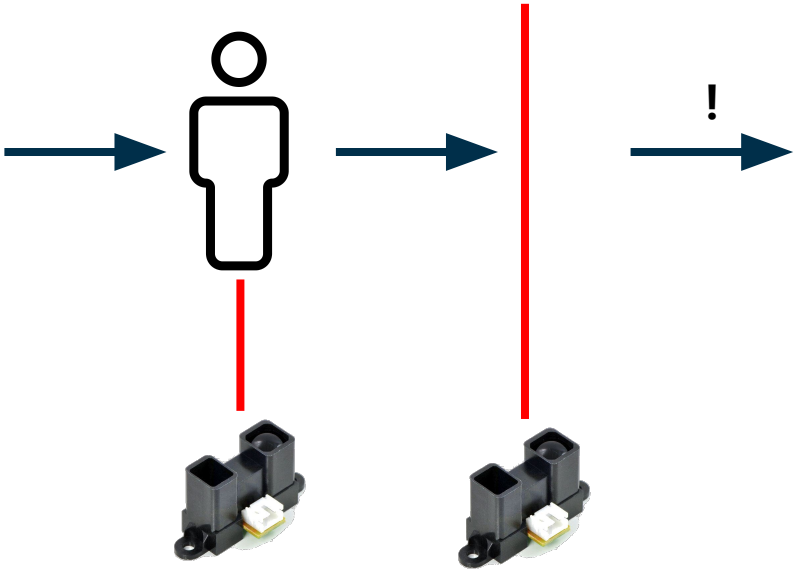
Unser Algorithmus zur Zeitsynchronisation



$$\Delta t = \text{server} - \frac{\text{start} + \text{end}}{2}$$

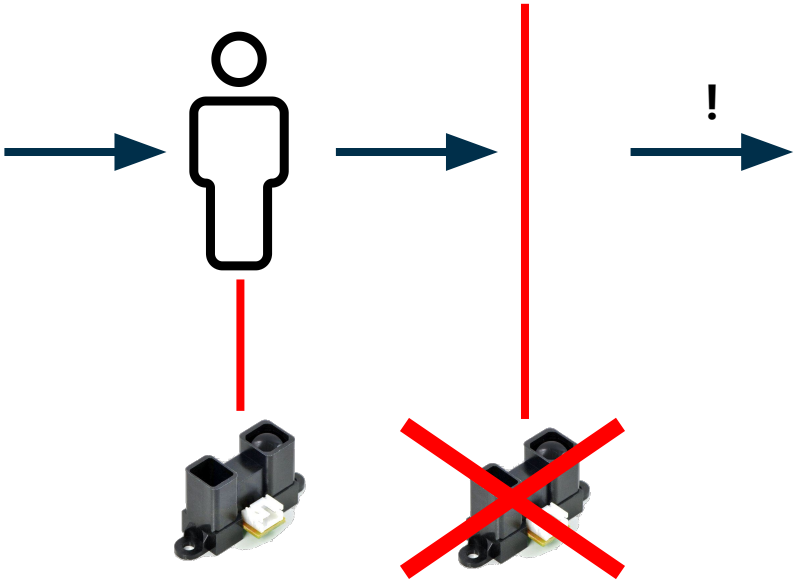
Die letzten 24h
Oder: Warum Ersatzteile gut sind

Ursprüngliche Idee:



Die letzten 24h
Oder: Warum Ersatzteile gut sind

Gestern,
11:00 Uhr



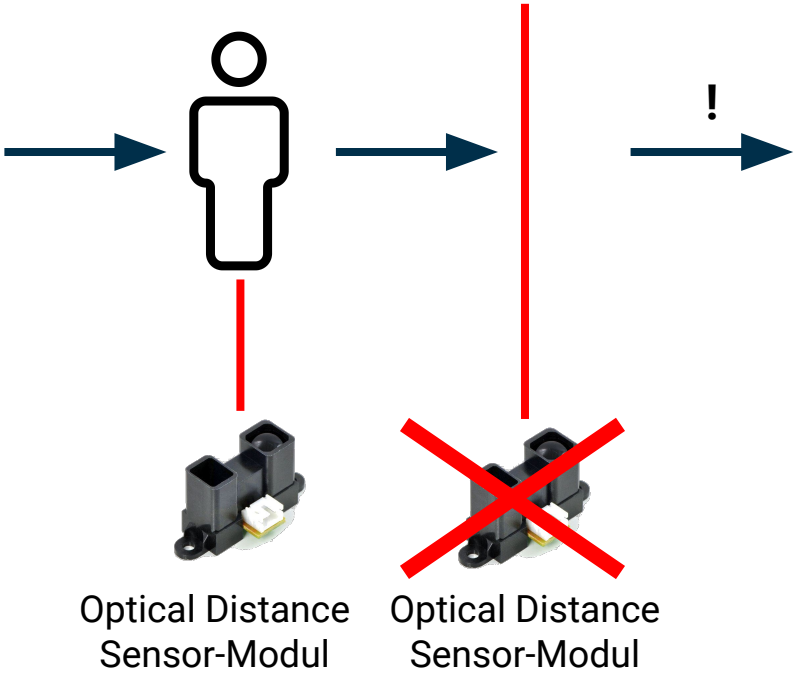
Optical Distance Sensor-Modul

Optical Distance Sensor-Modul

Die letzten 24h
Oder: Warum Ersatzteile gut sind

Ersatzteil?

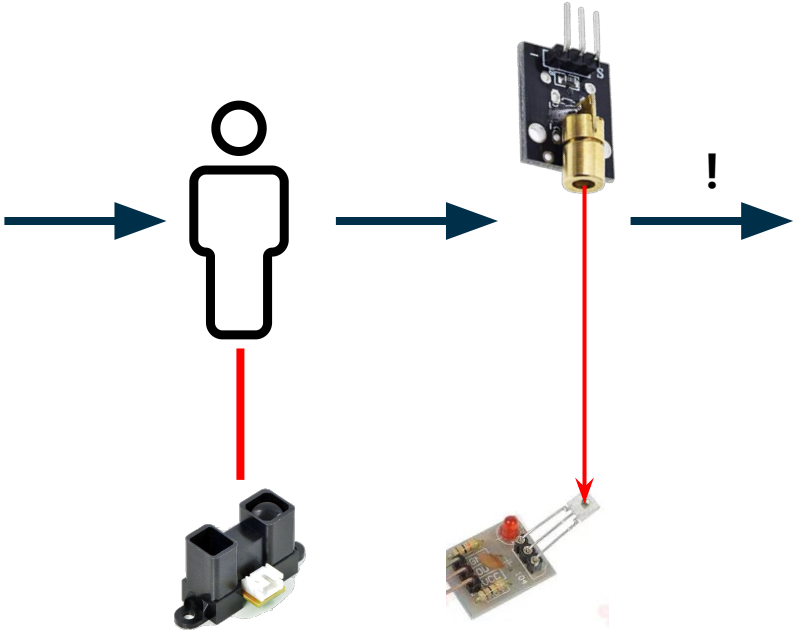
Keins bestellt, käme erst Mittwoch an



Die letzten 24h
Oder: Warum Ersatzteile gut sind

Lösung:

Andere Sensorquelle nutzen

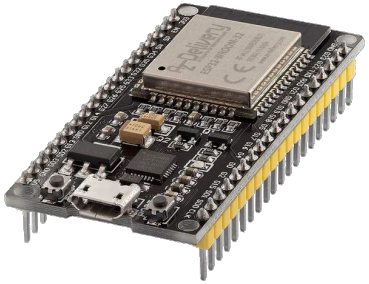


Optical Distance Sensor-Modul

Laser Receiver Sensor-Modul

Demo

Numeramini – Komponenten



Server

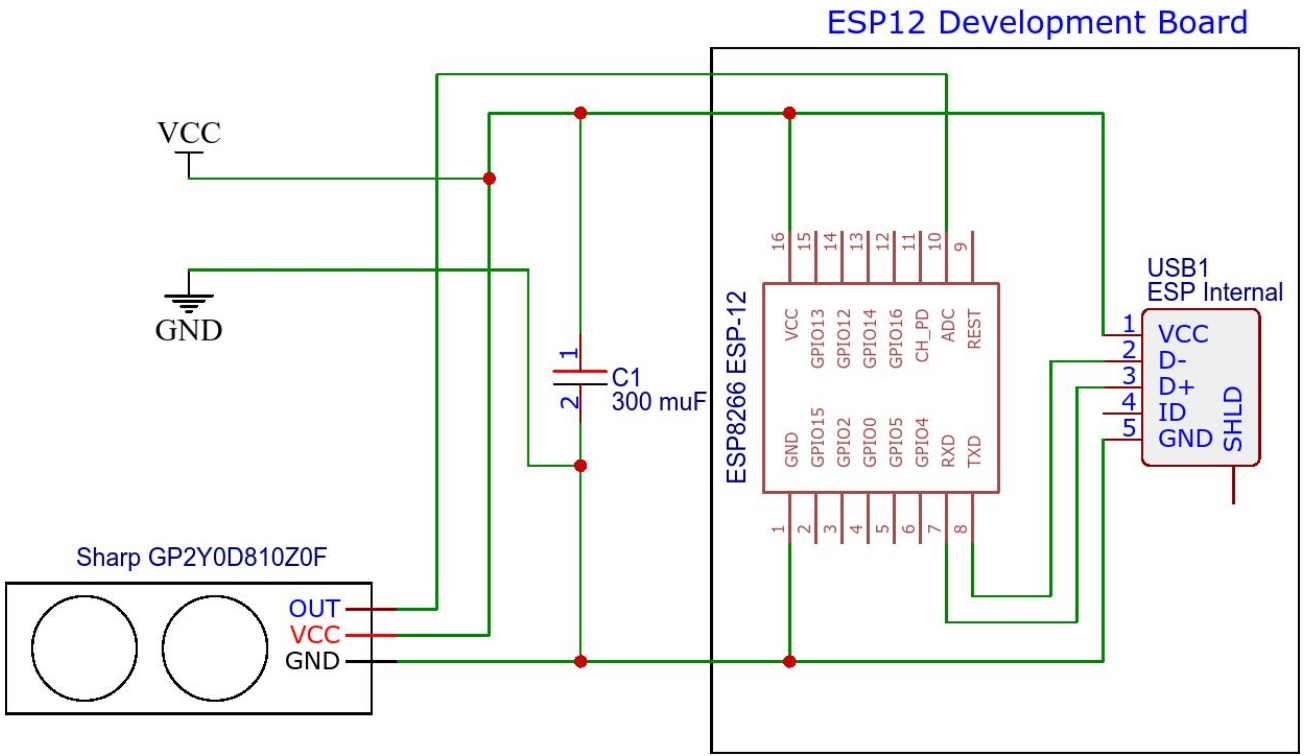
- startet **WiFi**
- registriert und verwaltet Nodes
- berechnet Personenanzahl aufgrund von Node Events verschiedener Sensorklassen
- hostet **HTTP Server** für Kommunikation
- hostet **Overview Page** mit Systemstatistiken
- hostet **Debug Page** mit allem debug output

Numeramini – Komponenten

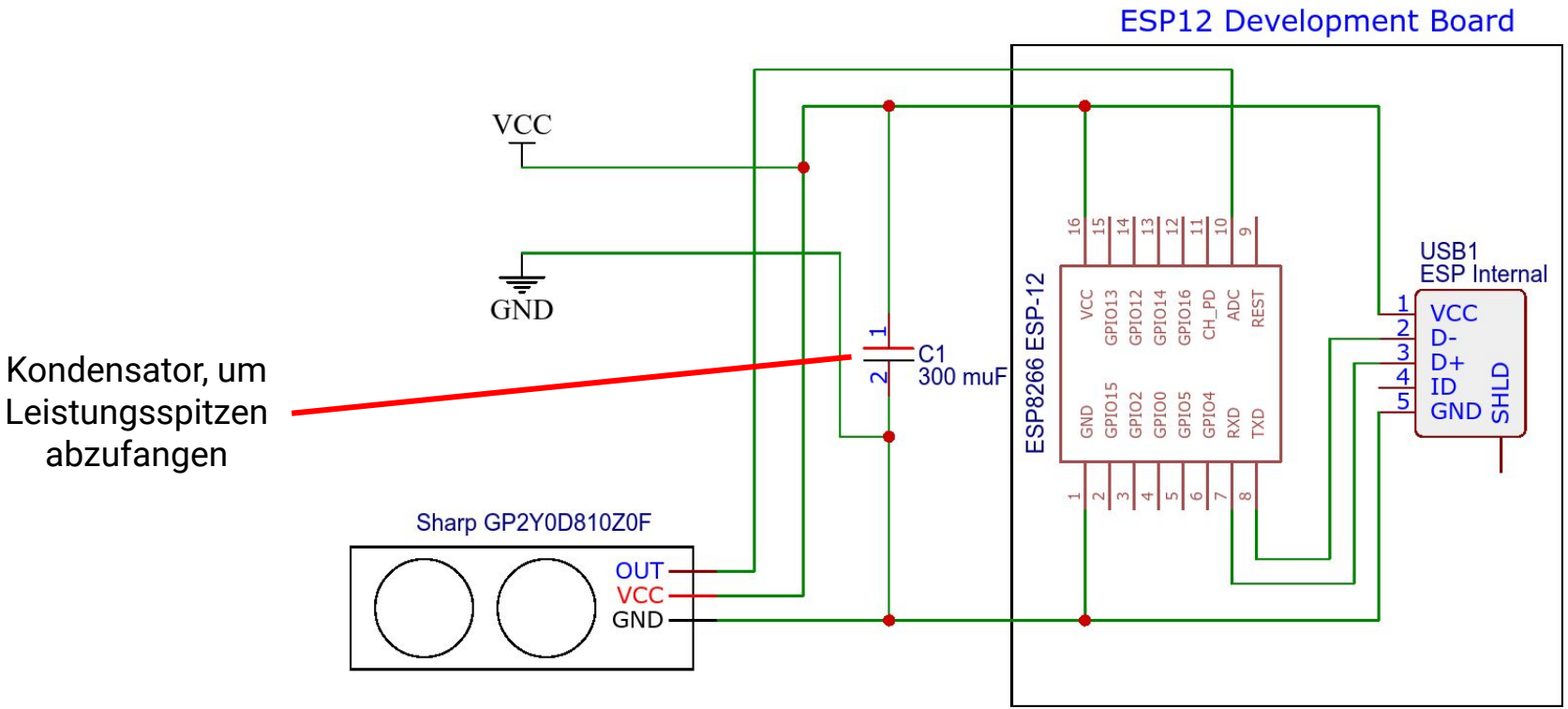
Node

- **verbindet** sich mit Server WiFi
- **registriert** sich mit unique ID
- **spezifiziert** seinen **Sensortypen** und seine **Rolle**
- **synchronisiert** seine **Zeit** mit dem Server
- **sendet** gemessene **Events**

Sensorplatinen

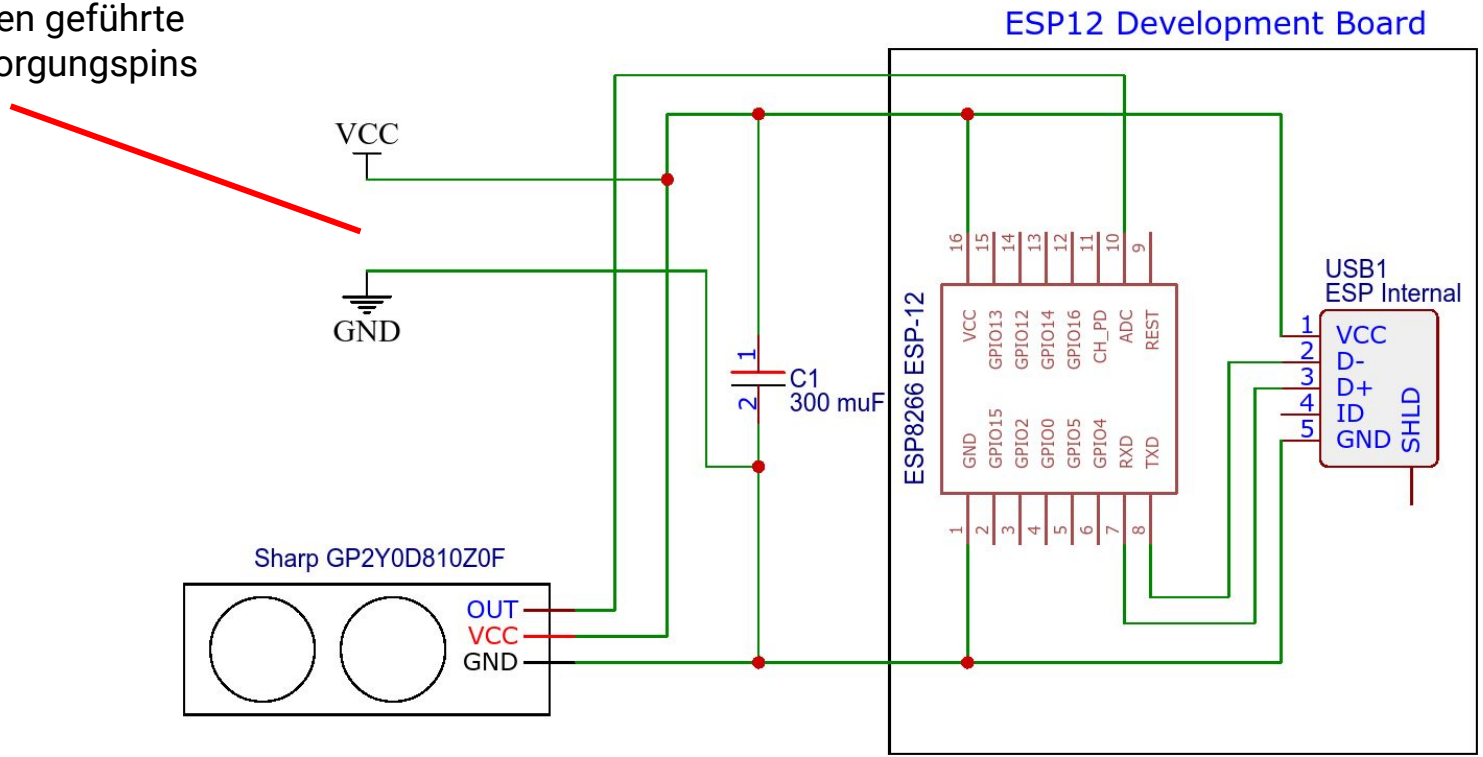


Sensorplatinen



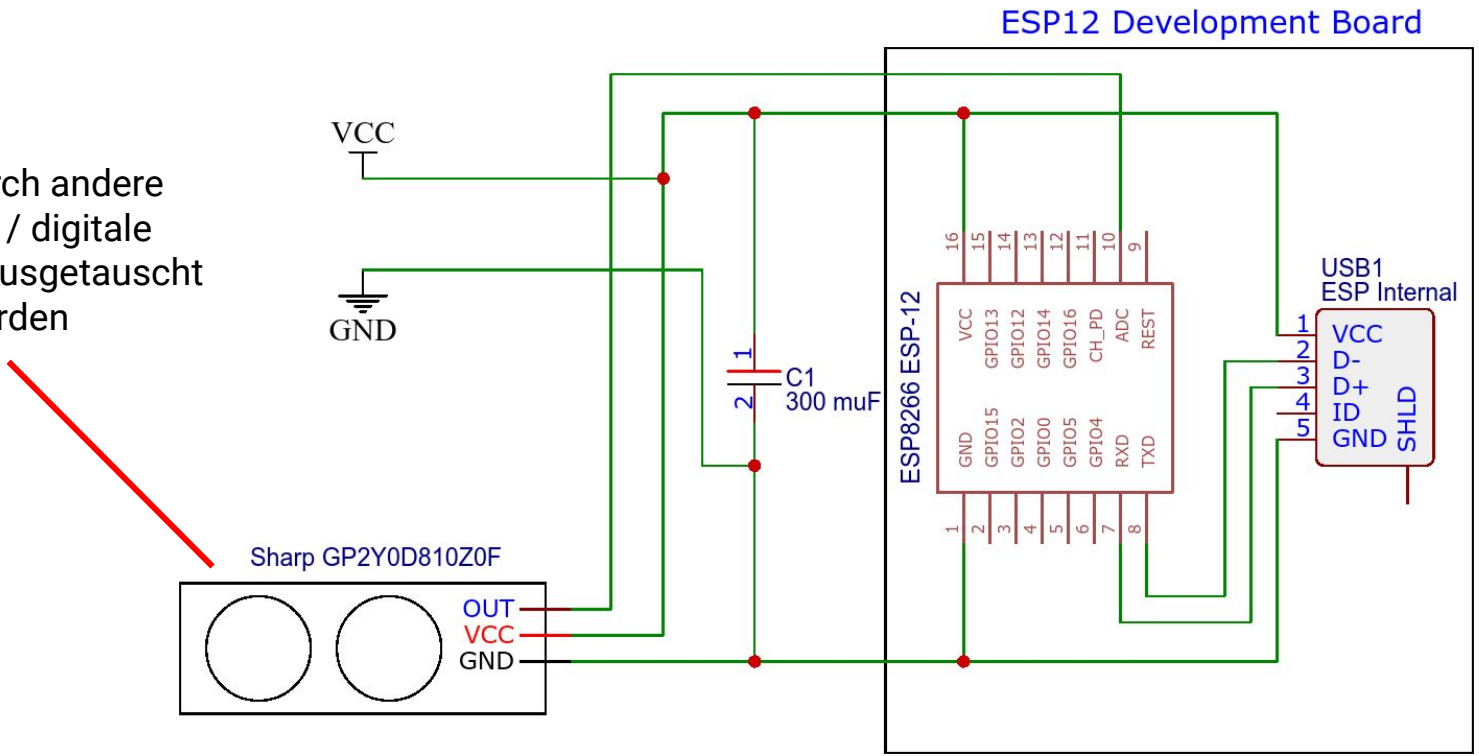
Sensorplatinen

Nach außen geführte Stromversorgungspins

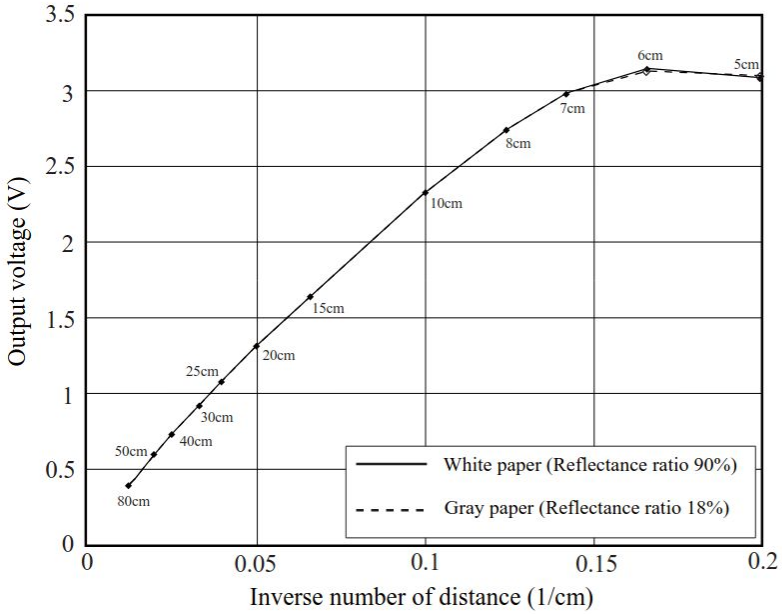


Sensorplatinen

Kann durch andere analoge / digitale Sensoren ausgetauscht werden



Wenn Specs lügen
Oder: Warum wir den Distanzsensor kalibrieren



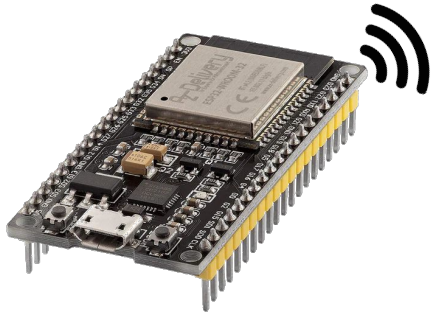
Entfernungsberechnung (Library)

```
distanceCM =
  60.374 *
    pow(
      map(voltage, 0, 1023, 0, 5000)/1000.0,
      -1.16);
```

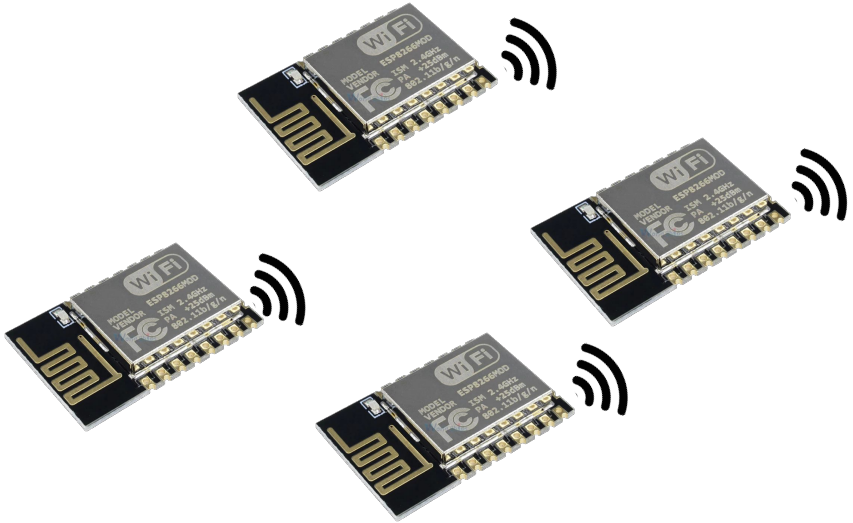
“Ist jemand da?” (Numeramini)

```
bool is_there_distance() {
  int reflectivity = voltage();
  return abs(reflectivity - base_reflectivity)
    > THERE_THRESHOLD;
}
```

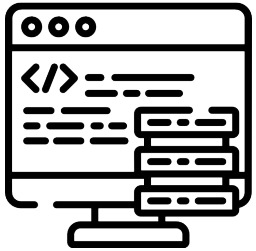
Over-The-Air (OTA) Updates



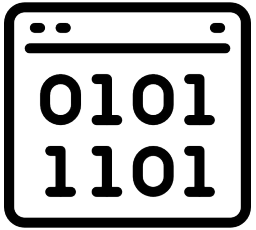
Wie updates?



Over-The-Air (OTA) Updates

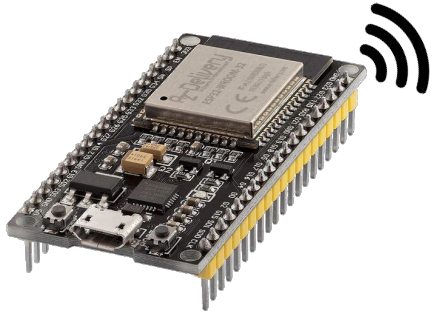


Code



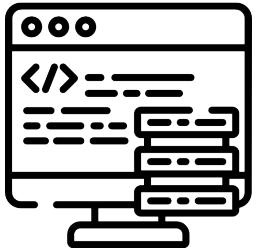
Binary

File Upload

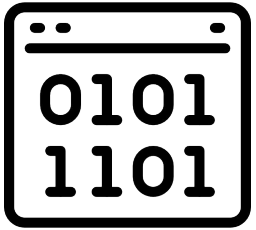


Write Binary to OTA Flash partition, reboot

Over-The-Air (OTA) Updates



Code



Binary

File
Upload

Write Binary to OTA
Flash partition,
reboot

(Same for nodes)

Schmerz mit dem Web-Interface

Tree-shaking

Numeramini

Count

Node Stats

Node	Last Heart Beat	Alive	Role
192.168.4.3	7.2.2023, 11:14:05	1	front
192.168.4.2	7.2.2023, 11:13:56	1	back

Minification
Warum `true`, wenn auch `!0` geht?

Kein Internet

Alles im Flash

Modernes Javascript? Mit weniger als 100kB?

Inlining

Arbeit mit wenig kleinen Libraries
Grafiken? Ohne d3.js?

Was kostet der Spaß?

Bauteil	**Preis**
ESP 32	3,20
ESP 12 (2 St.)	2,20
IR-Distanz-Sensor (2 St.)	6,00
Kondensator	0,03
Micro-USB-Kabel (3 St.)	1,08
Platine (2 St.)	0,12
Summe	**12,63**

Aktueller Stand

- Sensor-gestützte Zählung
- WiFi-Verbindung zwischen den Modulen
- Viele der wichtigen Teile geliefert und eingebunden
  - Micro-Controller (ESP32, ESP12)
  - IR-Sensor
  - Laser-Sensor
- Richtungserkennung
- Protokoll für Modul-Kommunikation
  - Zeit, Heart Beats, Daten
- API zur Abfrage der aufgezeichneten Daten
- HTML-Dashboard
- Genaue Zeitsynchronisation
- Web-basiertes (Debugging-)Interface für den Server

Nächste Schritte

- Mehr Sensoren!
  - Kamera
  - Ultraschall
  - Druck
  - Infrarotkameras
  - Schall?
  - WiFi Signale?
- Dynamische Kalibrierung
- Akku Betrieb der Nodes
- Display für Server

Ausbaustufen

- Ersetze WiFi mit Bluetooth Low Energy
- Setze ML Algorithmen ein, um die Genauigkeit zu verbessern
- Kopple Numeramini mit Smart Home (e.g. Home Assistant) zur Stromverbrauchsreduzierung