IoT Full-stack development:

Bicycle Crash Notifier

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Trek Bikes -IoT Trainee

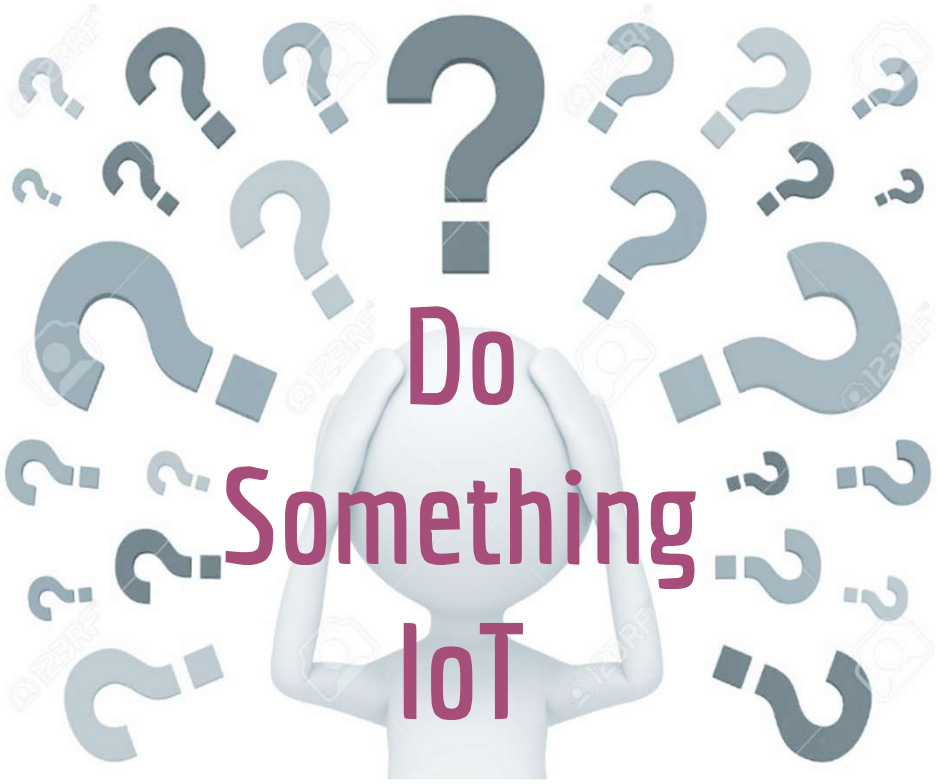
TREK

BONTRAGER

Assignments

e-Bike drive Unit Data
(speed, torque, battery level)

Develop an application



Crash Notifier for Bicycles

- **Reliable**
- **Generic use**
- **Low Cost**
- **Battery powered**
- **Wireless technology**

IoT Technology Stack

Prototyping Challenges

Sensors?

MCU?

Technologies?

Firmware Setup (sleep routines, ISR...)

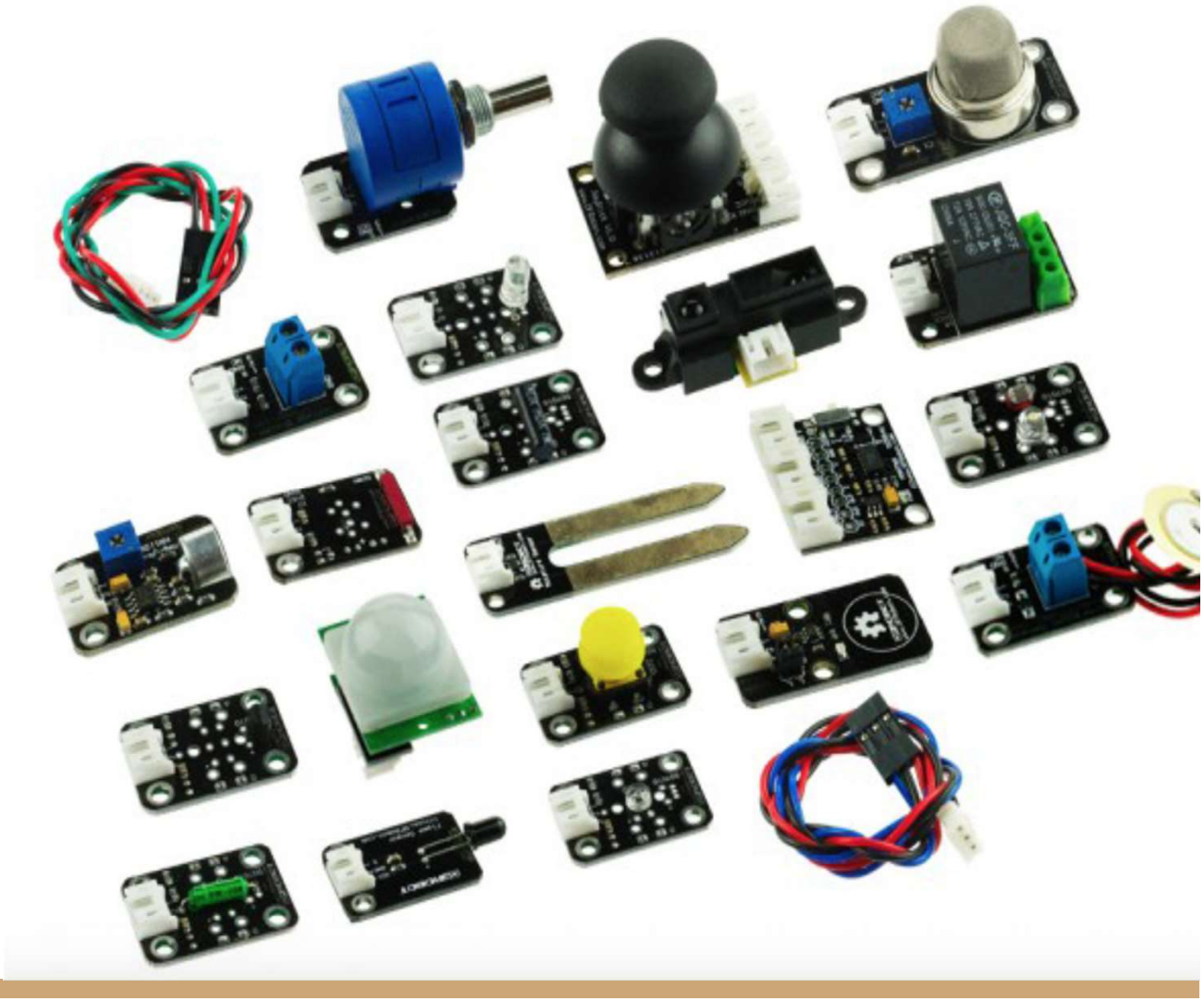
IoT platforms,

Network Servers

Application Servers

Cost

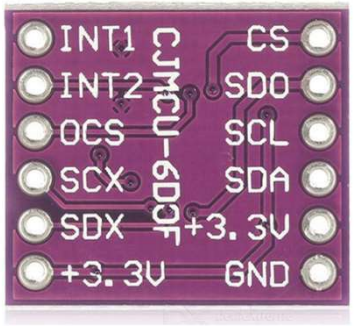
Sensors

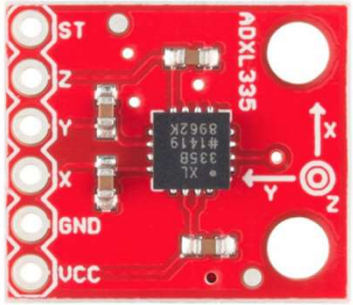


Accelerometer

MEASURES:

- **Acceleration**
- **Angle or Tilt sensing**
- **Motion**
- **Free Fall**





CHARACTERISTICS

Range: ±1g up to ±250g

Interface:

- **Analogic - PWM**
- **Digital- I2C or SPI**

Additional features - selectable measurement ranges, sleep control, 0-g detection, and tap sensing...

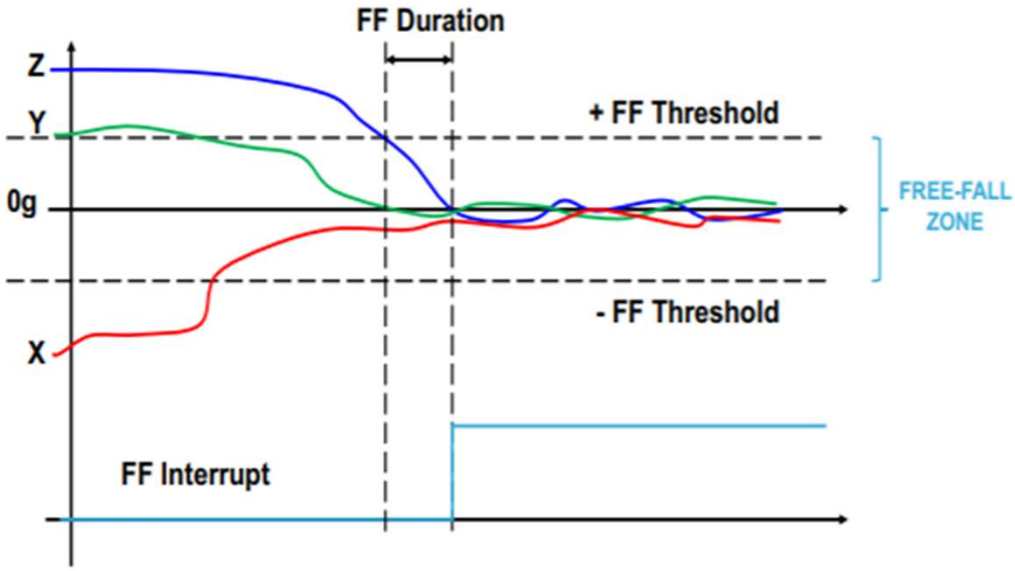
IMU -Accelerometer + Gyroscope (LSM6DS3)

FREE FALL CONFIGURATION

- I2C Interface
- 3 axis
- Full Scale (FS) = ±2 g
- Threshold = ±312 mg ((x,y and z axis)
- FF duration time = 15 msec
- Output Data Rate (ODR) = 416Hz

Read register to count Free Fall

```
if ( readDataByte){
  detectCount ++;}
```



Ultrasonic Range Finder (HC-SR04)

MEASURES:

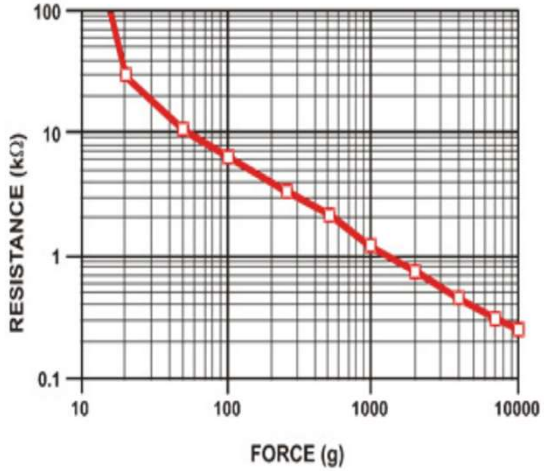
- Distance measurements (up to 4m)
- Object detection, counting
- Level monitoring

Safety distance > 70 cm

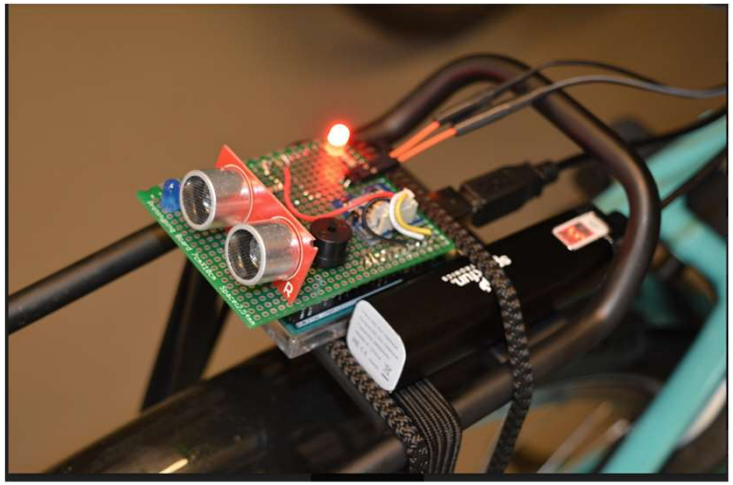
Force Sensing Resistor (FSR-402)

MEASURES:

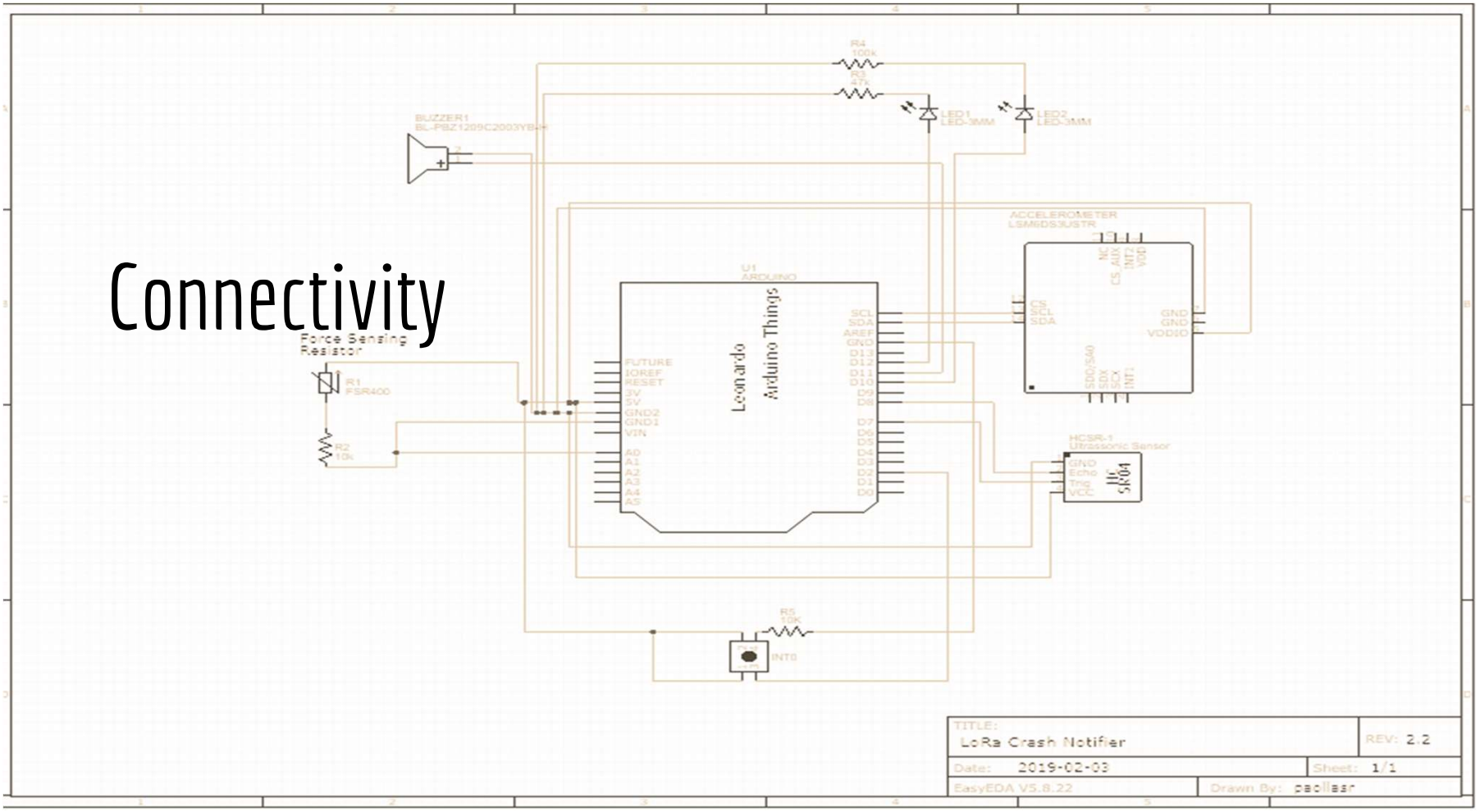
- Detects physical pressure varying the resistance
- Qualitative Sensor (0 up to 255)
- Analog Low Cost Sensor



Prototype #1

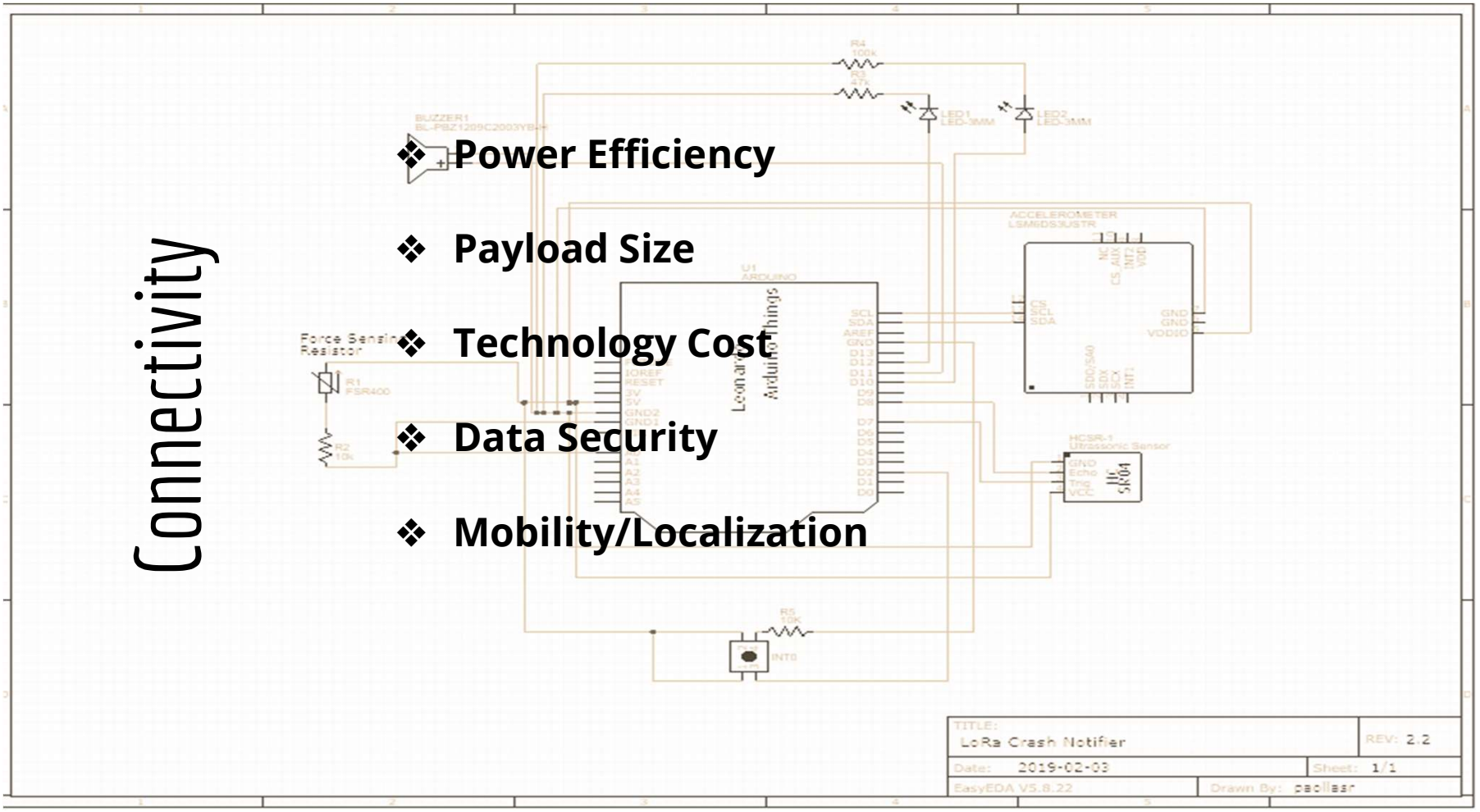


Connectivity



Connectivity

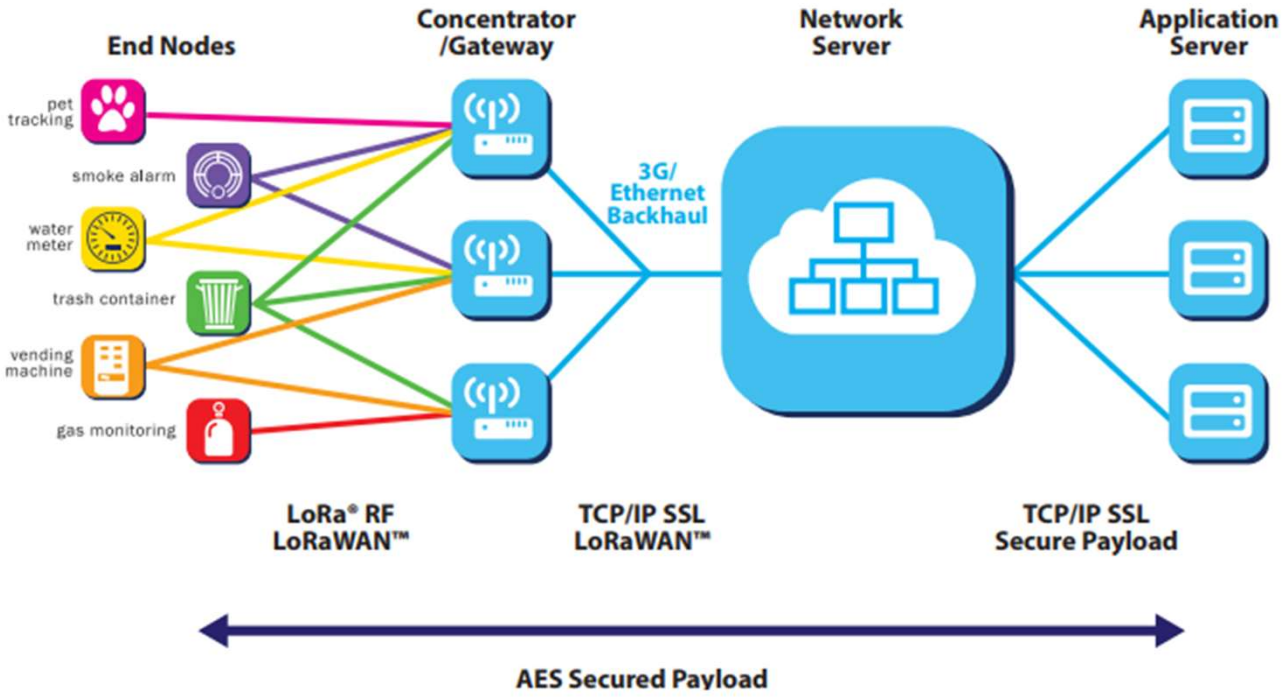
- Power Efficiency
- Payload Size
- Technology Cost
- Data Security
- Mobility/Localization



LPWAN Wireless Technologies

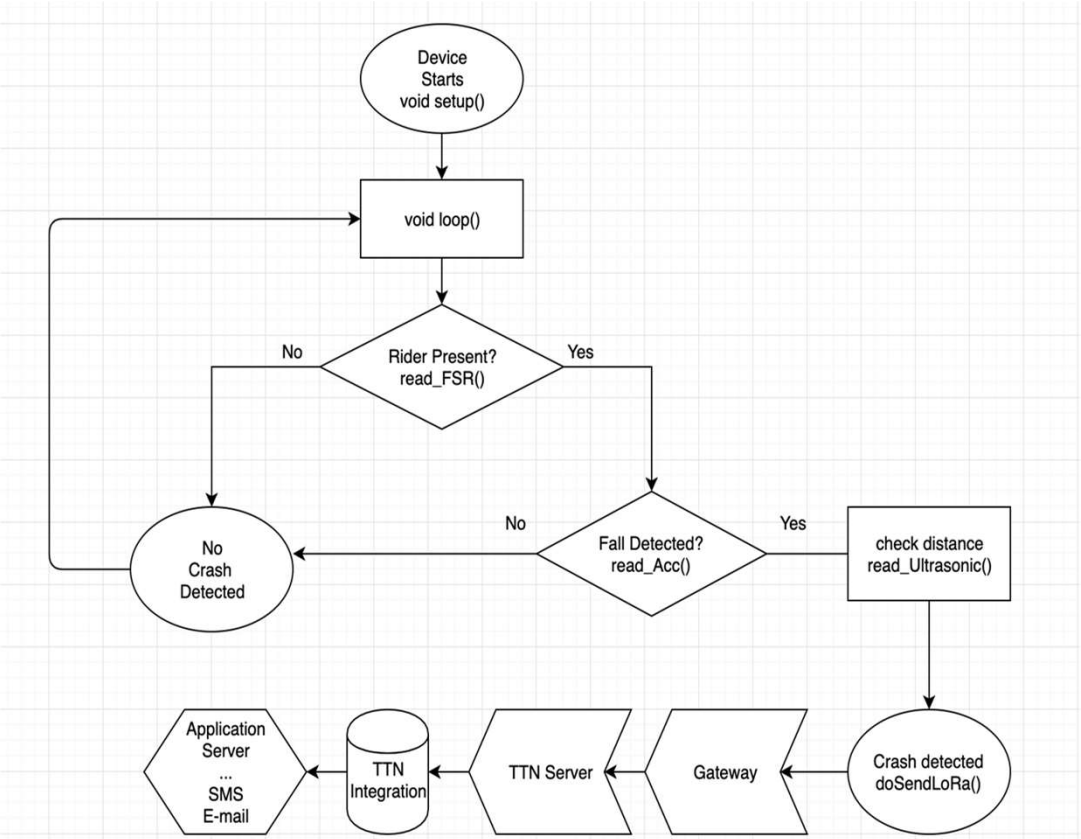
Feature	LoRaWAN	Narrow-Band	LTE Cat-1 2016 (Rel12)	LTE Cat-M 2018 (Rel13)	NB-LTE 2019(Rel13+)
Modulation	SS Chirp	UNB / GFSK/BPSK	OFDMA	OFDMA	OFDMA
Rx bandwidth	500 - 125 KHz	100 Hz	20 MHz	20 - 1.4 MHz	200 KHz
Data Rate	290bps - 50Kbps	100 bit/sec 12 / 8 bytes Max	10 Mbit/sec	200kbps – 1Mbps	~20K bit/sec
Max. # Msgs/day	Unlimited	UL: 140 msgs/day	Unlimited	Unlimited	Unlimited
Max Output Power	20 dBm	20 dBm	23 - 46 dBm	23/30 dBm	20 dBm
Link Budget	154 dB	151 dB	130 dB+	146 dB	150 dB
Batery lifetime - 2000mAh	105 months	90 months		18 months	
Power Efficiency	Very High	Very High	Low	Medium	Med high
Interference immunity	Very high	Low	Medium	Medium	Low
Coexistence	Yes	No	Yes	Yes	No
Security	Yes	No	Yes	Yes	Yes
Mobility / localization	Yes	Limited mobility, No loc	Mobility	Mobility	Limited Mobility No Loc

LoRaWAN Architecture

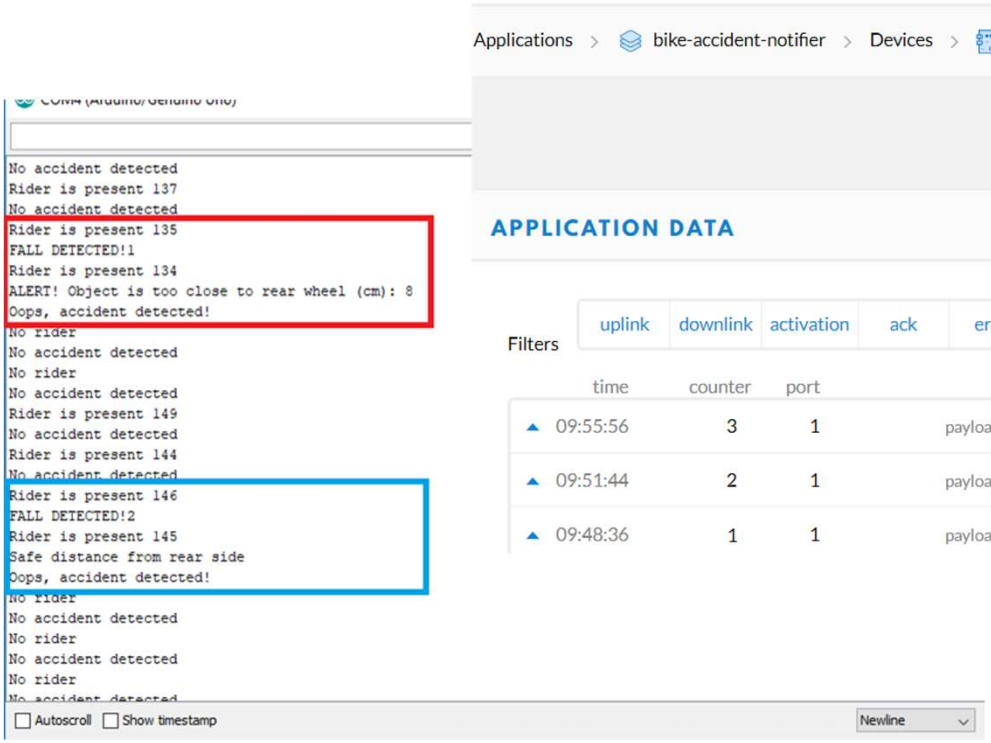


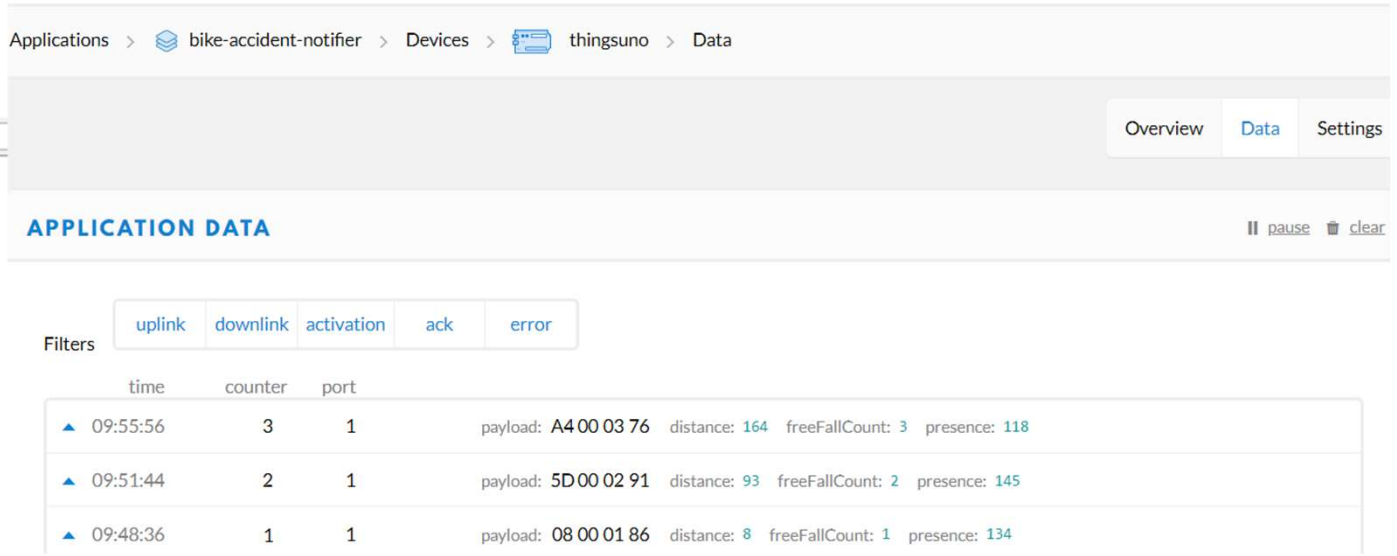
Prototype #1

- **CPU: ARDUINO THINGS UNO**
- **ATmega32u4 (16MHz)**
- **LoRa: RN2483 (class A - 868 MHz)**
- **Arduino IDE compatible**



LoRa Server: The Things Network



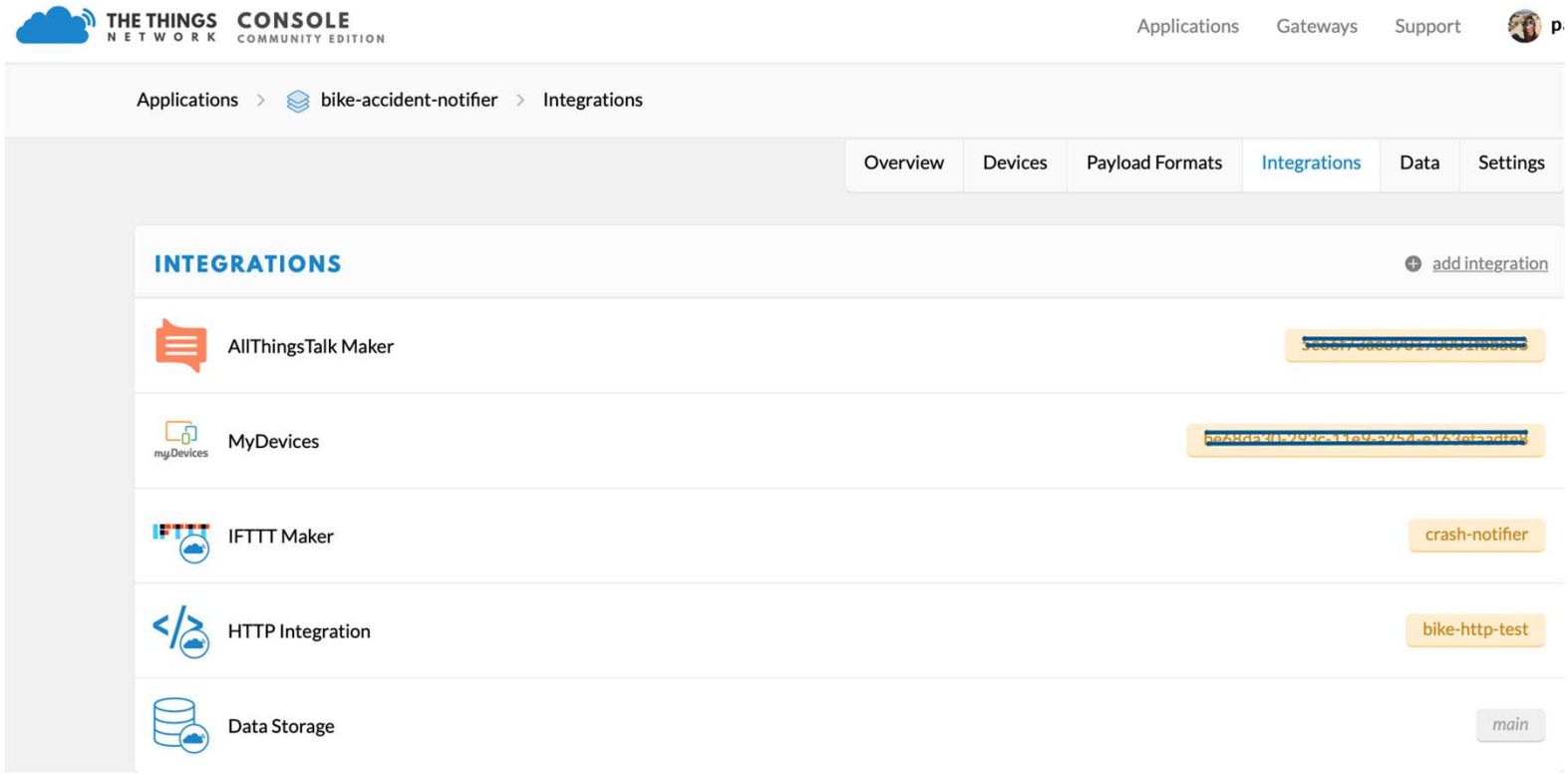


Integrations

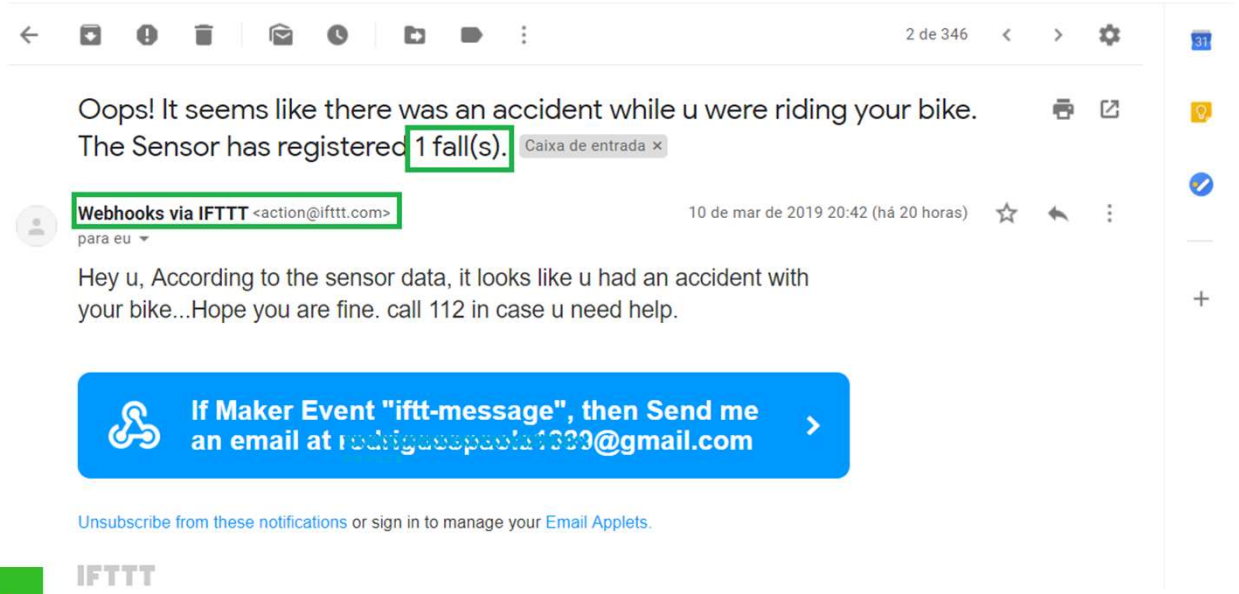
server.js index.html

```
1  console.log("Starting server...")
2
3  const app = require("express")();
4  const http = require("http").Server(app);
5  const bodyParser = require("body-parser");
6
7  const deviceID = "26012339"
8
9  app.use(bodyParser.json())
10 app.use(bodyParser.urlencoded({ extended: false }))
11
12 app.get("/", function(req, res){
13     res.sendFile(__dirname + "/index.html")
14 })
15
16 app.post("/endpoint", function(req, res) {
17   console.log(req.body)
18   res.sendFile(__dirname + "/index.html")
19 })
20
21 http.listen(8000);
```

Integration to Application Server

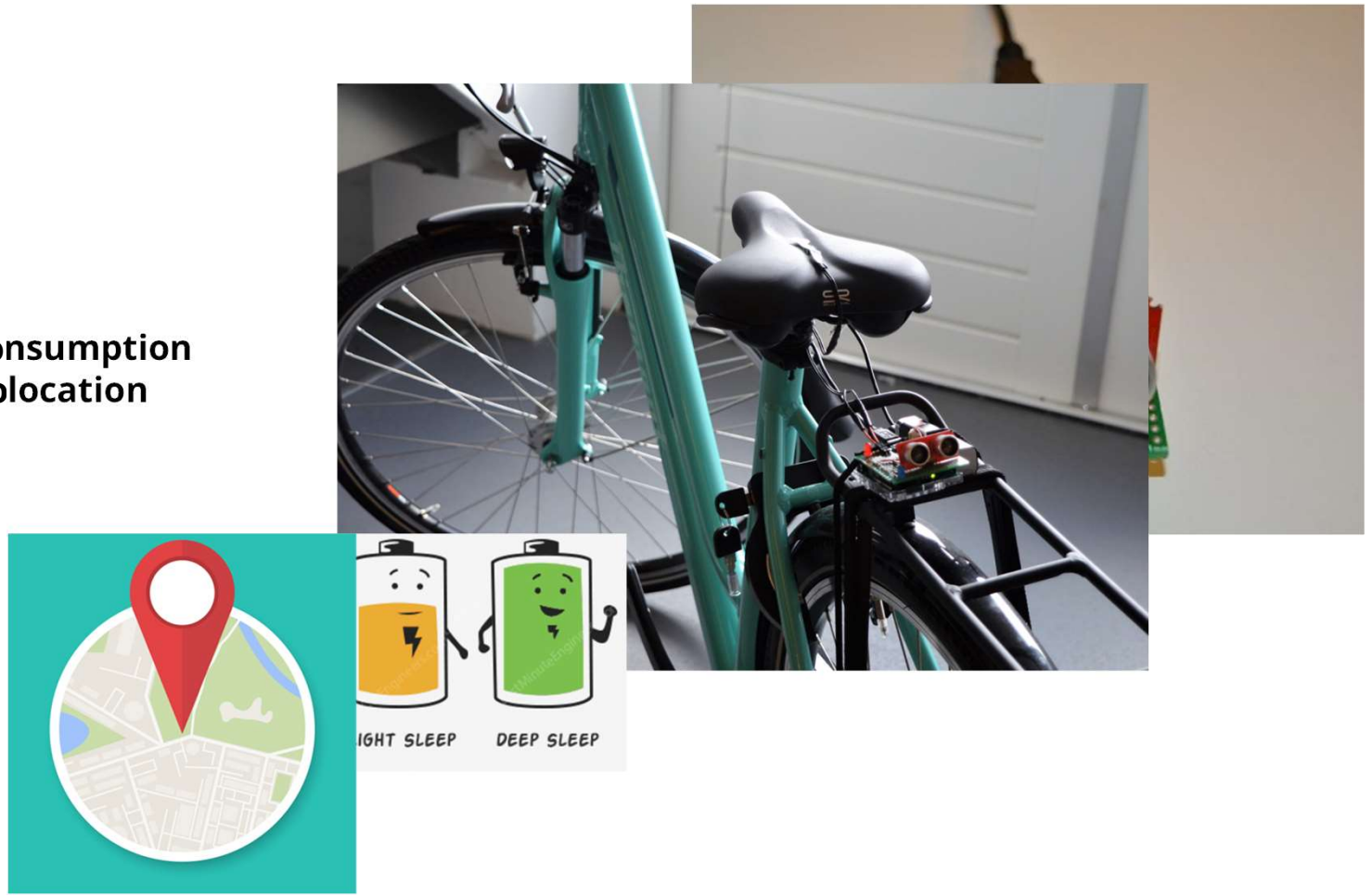


Integration - Application Server



Feedback

- **Design**
- **Power consumption**
- **LoRa Geolocation**



Alternative: Saddle+Device

Smart Saddle

Seat post

Improvements

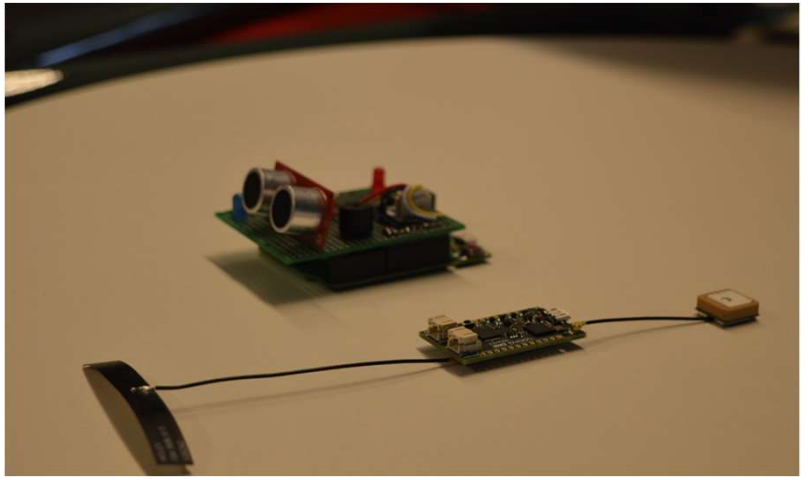
- **Board proper for IoT Development**
- **Identify Rider’s presence using a different sensor**
- **Extra functionalities???**

PROTOTYPE #2

MCU: SodaqOne (32-Bit ARM)
LoRa: RN2483/Class A
Operating Voltage: 3.3V

Sensors

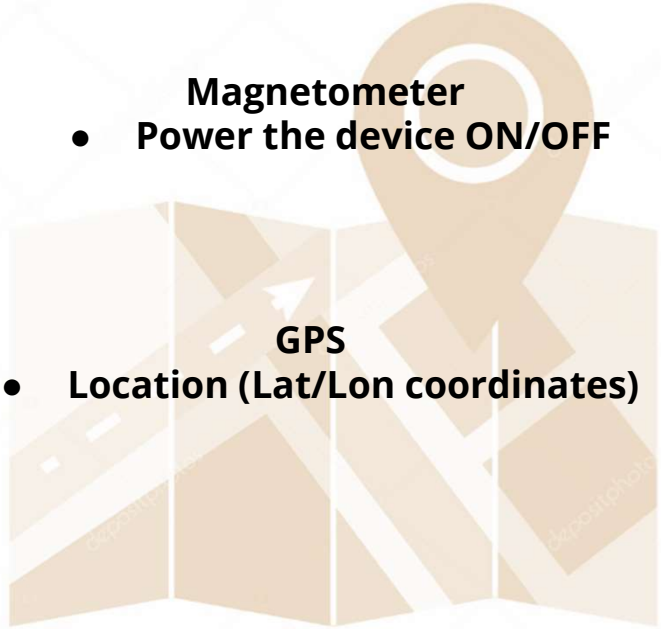
Accelerometer + gyroscope
Magnetometer
GPS Module



Extra Features

Magnetometer

- **Power the device ON/OFF**



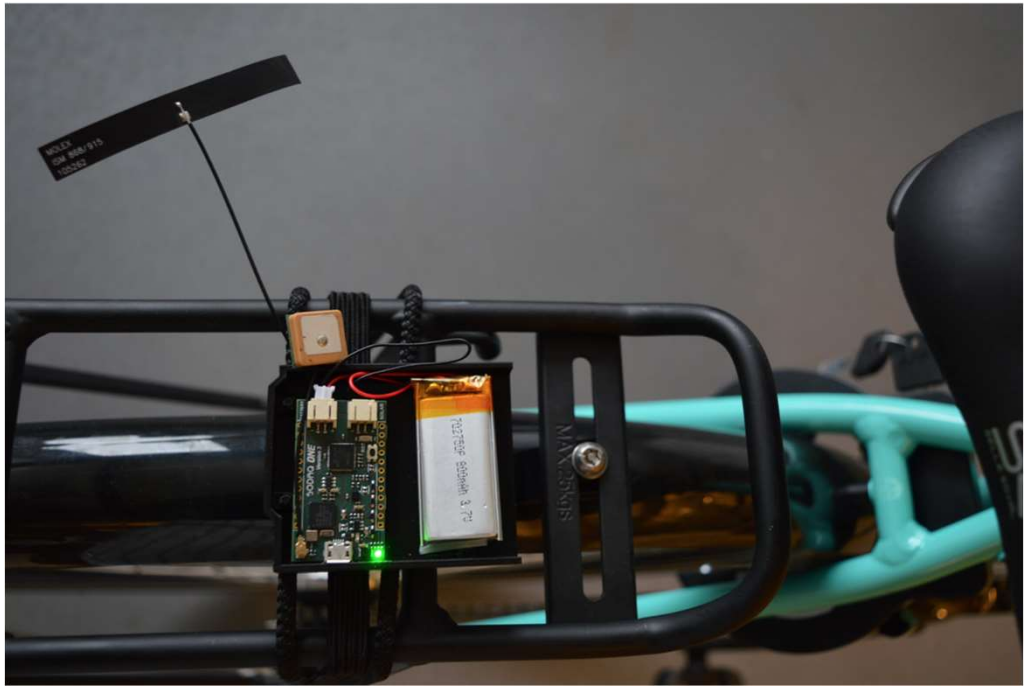
GPS

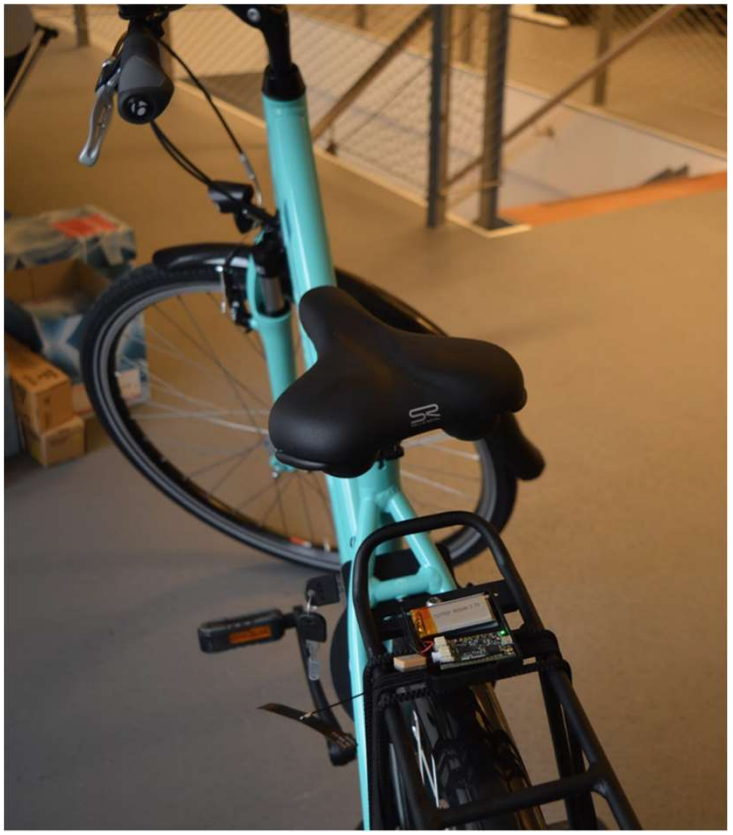
- **Location (Lat/Lon coordinates)**

Power Consumption

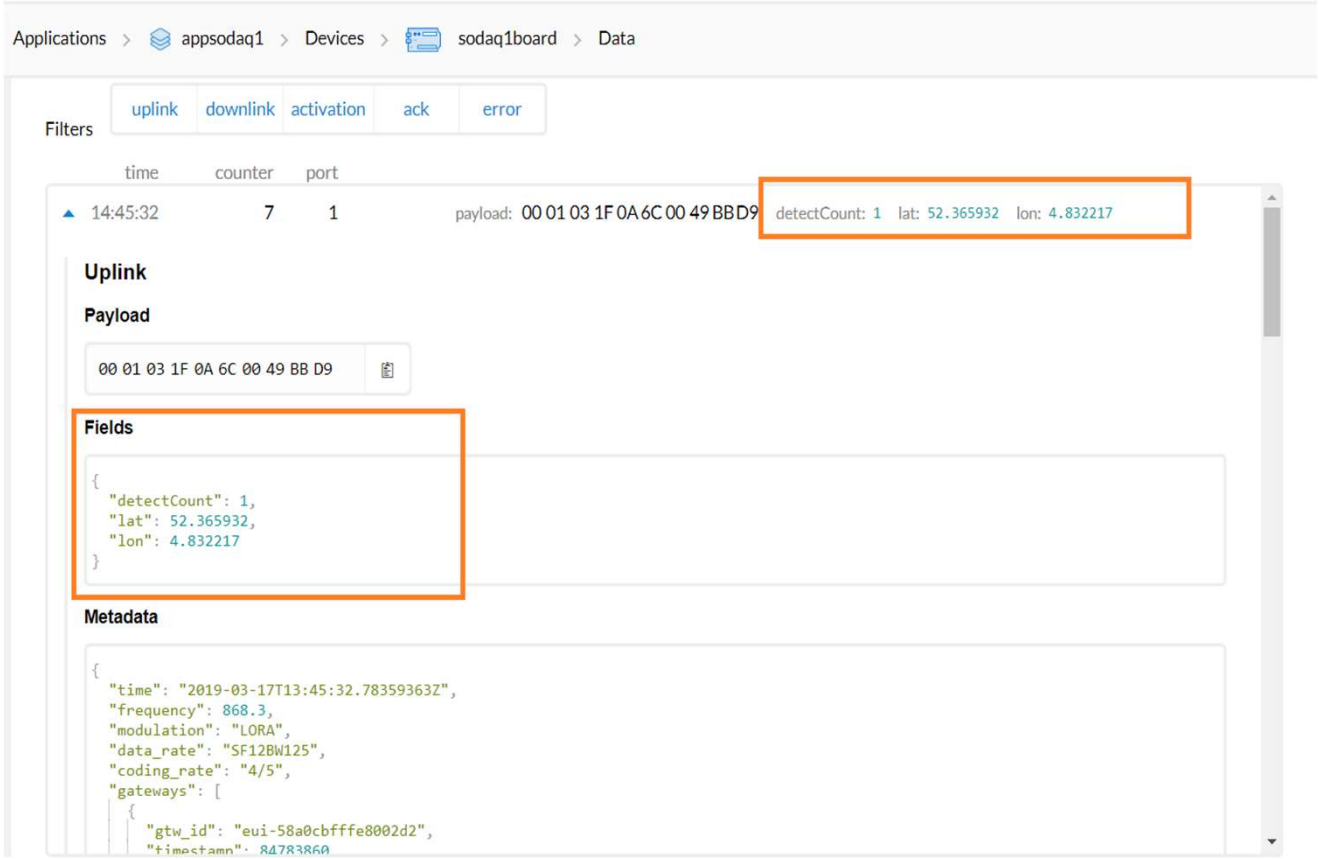
SodaqOne Sleep Mode: 50uA X Arduino 35mA

Prototype #2





TTN Server


Applications > appsodaq1 > Devices > sodaq1board > Data
Filters
uplink
downlink
activation
ack
error
time
counter
port
14:45:32
7
1
payload: 00 01 03 1F 0A 6C 00 49 BB D9
detectCount: 1 lat: 52.365932 lon: 4.832217
Uplink
Payload
00 01 03 1F 0A 6C 00 49 BB D9
Fields
{
"detectCount": 1,
"lat": 52.365932,
"lon": 4.832217
}
Metadata
{
"time": "2019-03-17T13:45:32.78359363Z",
"frequency": 868.3,
"modulation": "LORA",
"data_rate": "SF12BW125",
"coding_rate": "4/5",
"gateways": [
{
"gtw_id": "eui-58a0cbfffe8002d2",

Future Improvements

- **Sleep functions Optimization**
- **Hall Sensor for speed measurement**
- **Fuzzy logic implementation to infer on the accident severity**

```
uint32_t start = millis();
uint32_t timeout = 1L * 1000;
SerialUSB.println(String("waiting for fix ..., timeout=") + timeout + String("ms"));
if (sodaq_gps.scan(true, timeout)) {
    SerialUSB.println(String(" time to find fix: ") + (millis() - start) + String("ms"));
    SerialUSB.println(String(" datetime = ") + sodaq_gps.getDateTimeString());
    SerialUSB.println(String(" lat = ") + String(sodaq_gps.getLat(), 7));
    SerialUSB.println(String(" lon = ") + String(sodaq_gps.getLon(), 7));
    SerialUSB.println(String(" num sats = ") + String(sodaq_gps.getNumberOfSatellites()));

} else {
    SerialUSB.println("No Fix");
}

}
delay(1000);


  SerialUSB.println(lat);
  SerialUSB.println(lon);

    flat = sodaq_gps.getLat();
    flon = sodaq_gps.getLon();
}

void doSend() {

 if(fall == true){


    byte bytesToSend[10];

    bytesToSend[0] = detectCount >> 8;       // High byte Accelerometer
    bytesToSend[1] = detectCount ;           // Low Byte Accelerometer
```

Further use cases...

- Elderly Walkers

- Wheelchairs

- Wearable devices

That’s all folks!

THANKS!