Using IoT to guide tourism

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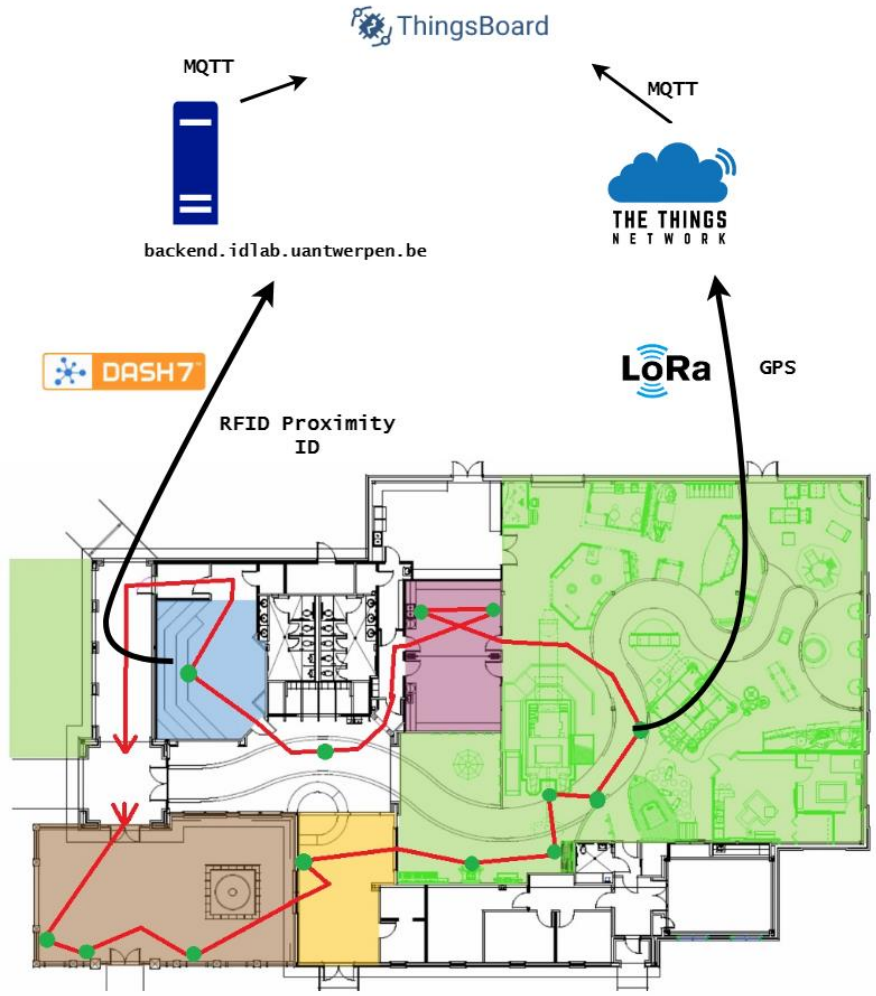
The concept – Recap

- Hassle-free guided tourism experience
- Indoors: museums
  - Tracking with D7 – fingerprinting
- Outdoors: city tours
  - Tracking with LoRa – GPS



Overview

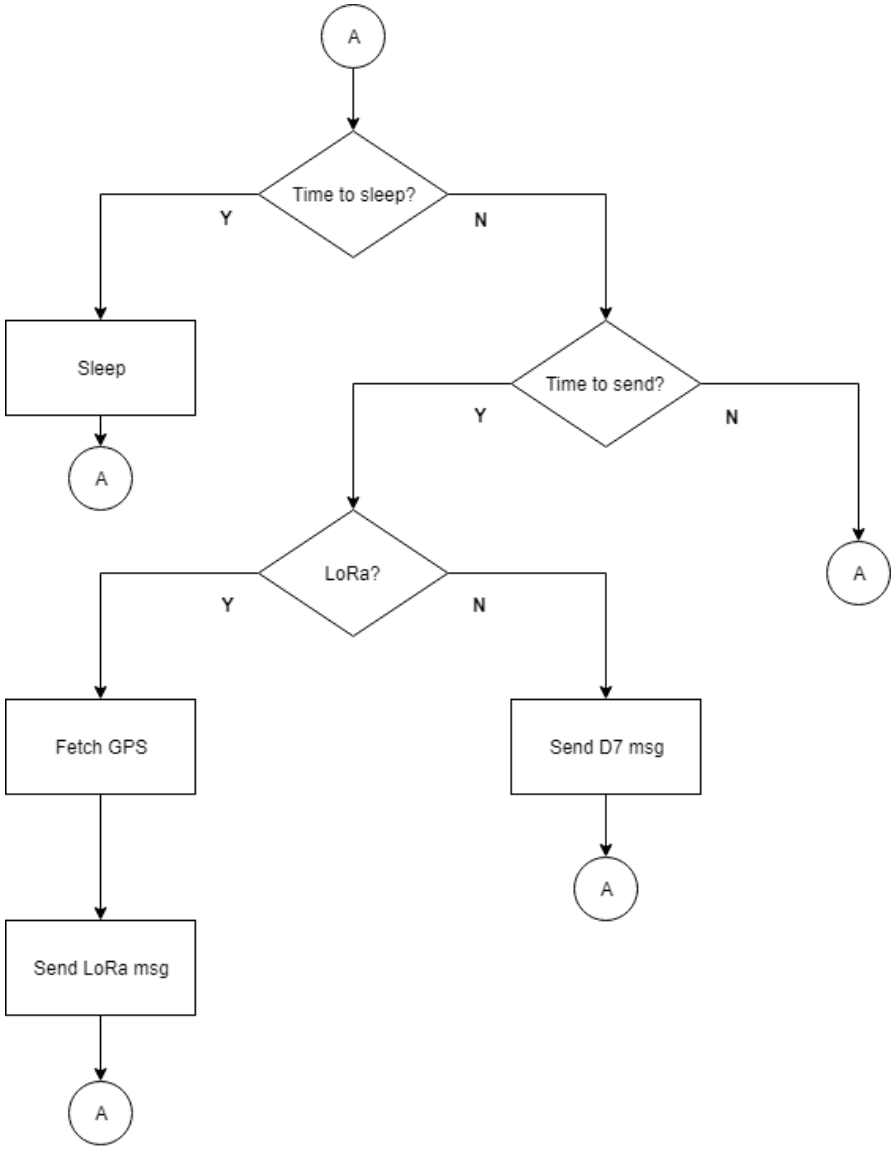
- Handheld device (deep sleep and accelerometer) [Axel]
- Fingerprinting localization using Dash7 [Joris]
- Localization using GPS [Arne]
- Power measurements [Axel]

Handheld Device

Axe
l

Handheld Device

Main program



Handheld Device

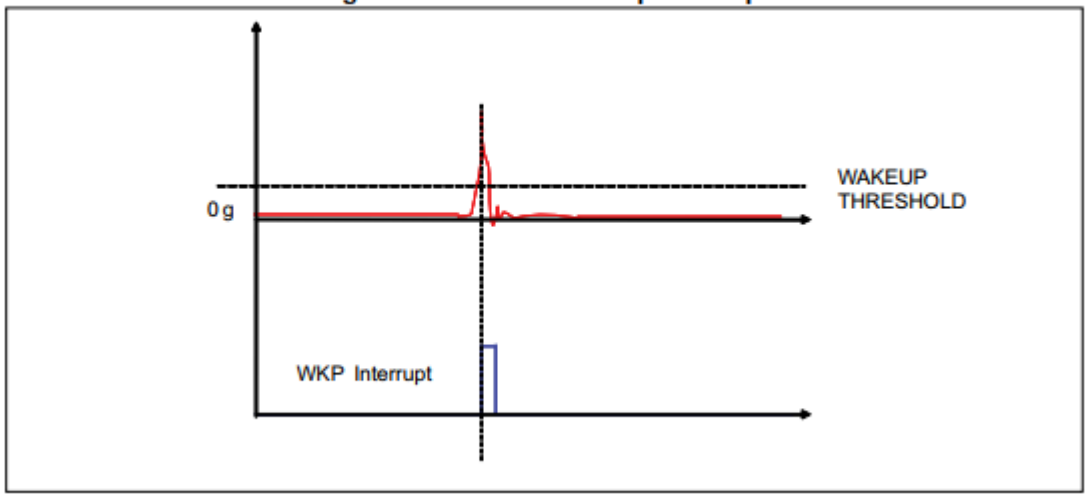
Accelerometer

- 10 Hz
- Low Power mode
- Threshold 250 mg
- X, Y, Z – axises enabled
- INT1
- ISR resets sleeptimer

Table 11. Current consumption of operating modes

ODR [Hz]	Low-power mode (8-bit data output) [µA]	Normal mode (10-bit data output) [µA]	High resolution (12-bit data output) [µA]
1	3.7	3.7	3.7
10	4.4	5.4	5.4
25	5.6	8	8
50	7.7	12.6	12.6
100	11.7	22	22
200	20	40	40
400	36	75	75
1344	--	185	185
1620	102	--	--
5376	186	--	--

Figure 12. Inertial wake-up interrupt



Handheld Device

Sleep mode

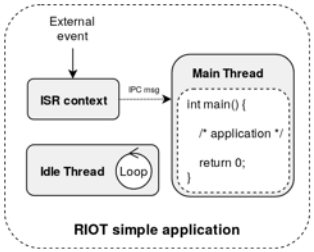
1. Power management API
   -> not yet implemented for our board
1. Extend the API
   -> tried but failed
1. puts(“SLEEPING”);

Power management

Principle:

when all threads are blocked/terminated, the scheduler switches to the idle thread.
The idle thread then goes to lowest possible power mode.

- the desired low-power mode must be unblocked
- the lowest possible power mode is selected ("Cascade")
- API is defined in `pm_layered.h` from system `pm_layered` module



Important:

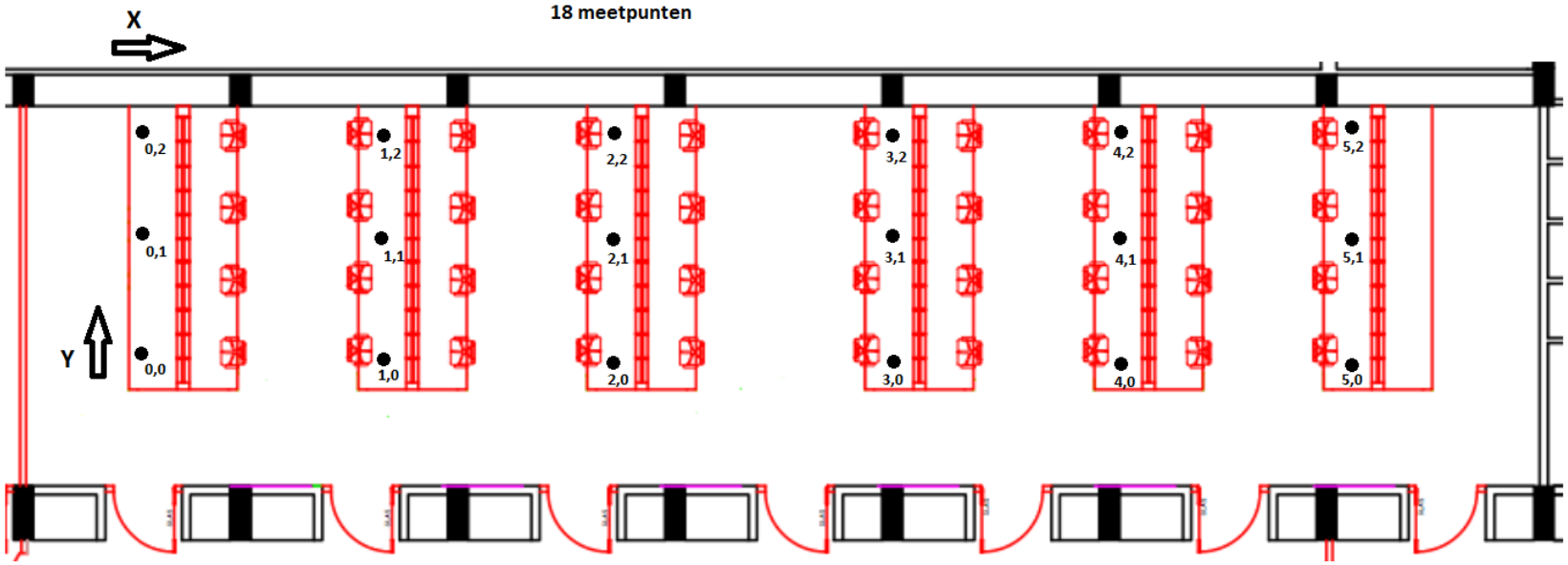
- The board MCU must import the `pm_layered` module
- Still WIP, the design is subject to change in the future

Stop 2	LPR	No	Off	ON	LSE LSI	BOR, PVD, PVM RTC, LCD, IWDG COMPx (x=1..2) I2C3[10] LPUART1[9] LPTIM1 ... All other peripherals are frozen.	Reset pin, all I/Os BOR, PVD, PVM RTC, LCD, IWDG COMPx (x=1..2) I2C3[10] LPUART1[9] LPTIM1	2.57 µA w/o RTC 2.86 µA w/RTC	6.8 µs in SRAM 8.2 µs in Flash

DASH7 – Fingerprinting

Joris

Fingerprinting - training




```
_id: ObjectId("5c18e2c0c7113e1e6a6bc55b")
y: 0
x: 0
gateways: Object
    42373436001c0037: 50
    433731340023003d: 62
    463230390032003e: 43
    4337313400210032: 61
```

```
_id: ObjectId("5c1cf285c7113e8b922e7ff7")
y: 1
x: 4
gateways: Object
    4337313400210032: 48
    433731340023003d: 56
    42373436001c0037: 65
    463230390032003e: 53
```

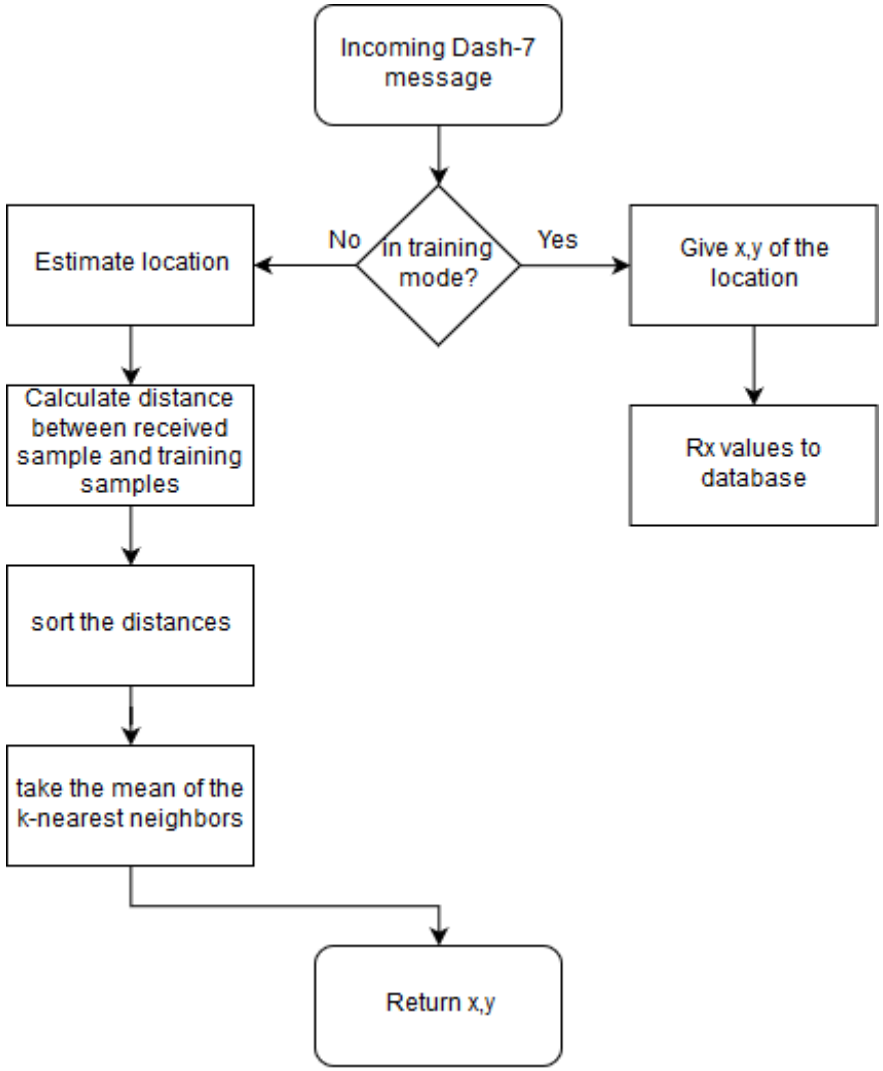
Fingerprinting - operation

- New thread for each message
- K-value: sqrt(total data points)
- Odd value of k

- Euclidean distance:

$$\sqrt{\sum_{i=1}^{k}(x_i - y_i)^2}$$

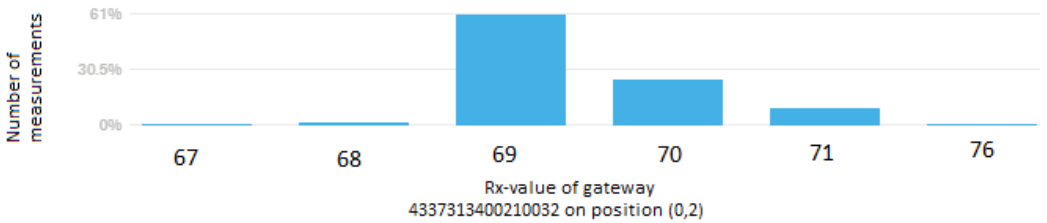
- Gateway missing:
  - Replace rx-value with high number

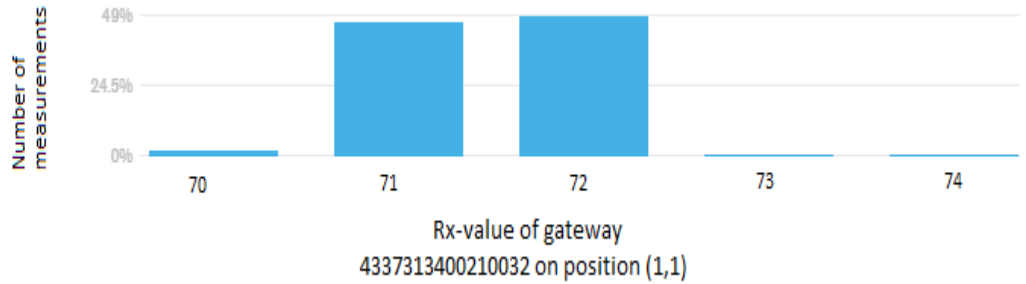


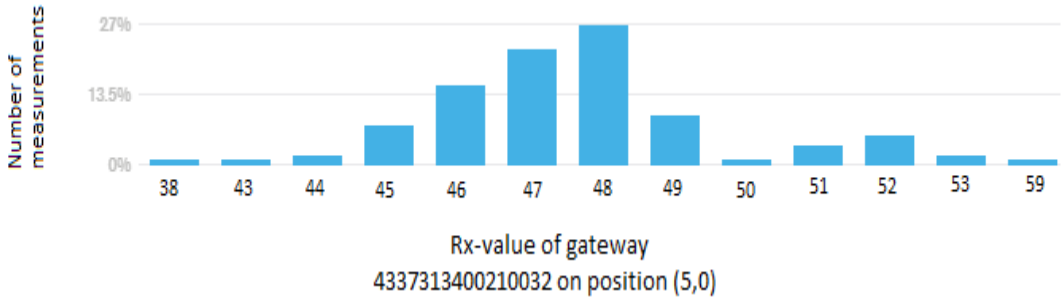
Location estimation error

- Different antenna
  - Monopole
  - Dipole
- Multiple messages
- More gateways
- Different k-value
- Different distance function:

$$\sum_{i=1}^{k} |x_i - y_i|$$







LoRa – GPS

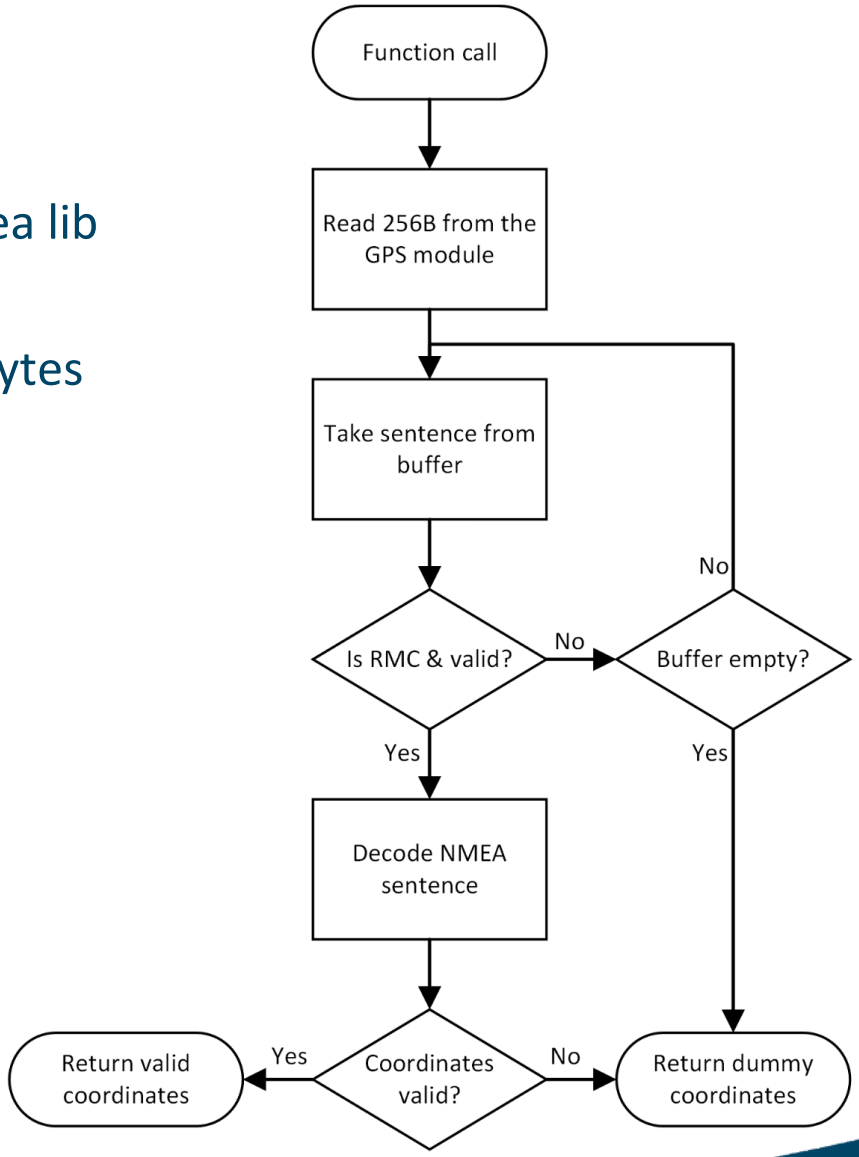
Arne

GPS - obtaining coordinates

- XM1110 I²C on OCTA-mini
- NMEA data is processed using minmea lib

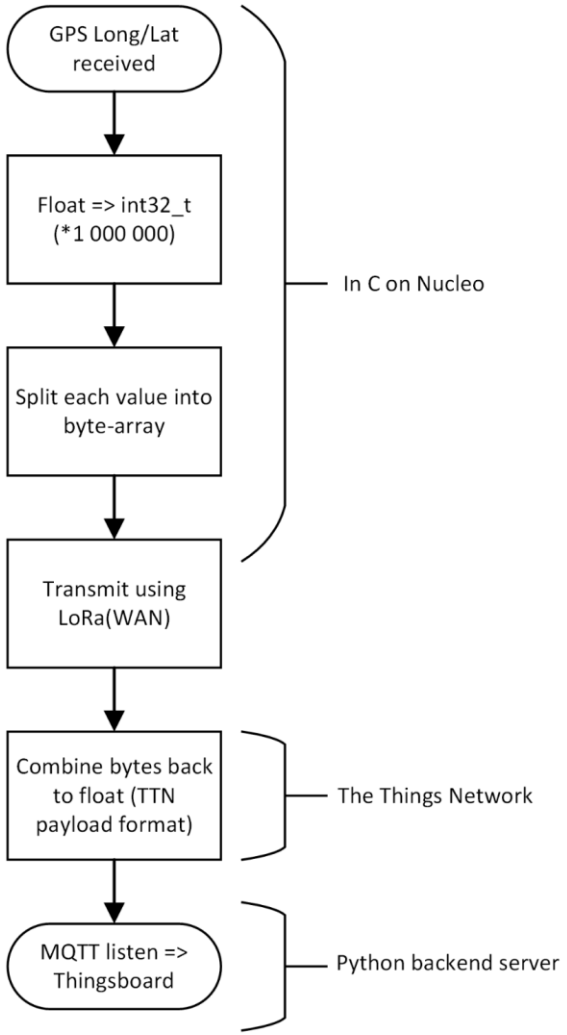
- Sensor periodically queried for 256 Bytes
- Search for RMC-type sentence

  => decode if found



GPS - data transmission

- Only single byte integers with LoRa
  => Split 4B float in four 1B pieces
  => Recombine in TTN with a payload format
- Listen with MQTT on backend server
- Transmit to Thingsboard to visualise



GPS - from dev to release

- Configure GPS module:
  - Sleep when not in use

    =>(161 - PMTK_CMD_STANDBY_MODE)
  - Only output the sentence types that will be used

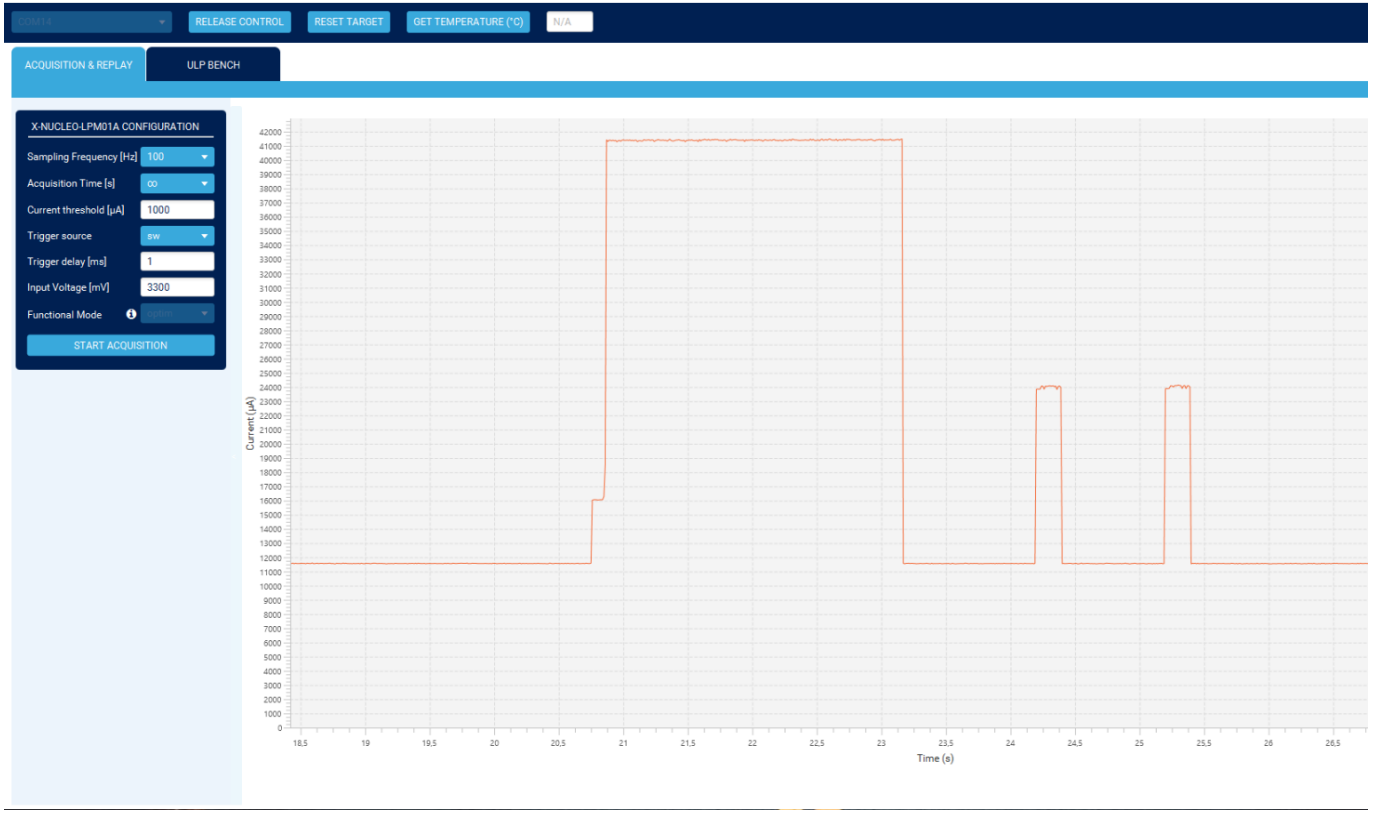
    =>(314 - PMTK_API_SET_NMEA_OUTPUT)
- Include data about fix quality
- Don’t send dummy coordinates
- Send data less frequently

Power Measurements

Axel

Power Measurements

- LoRa



	typical	max		PWR typ/h		PWR max/h	
LoRa-module							
Msg/hour	1	/	[-]				
Msg length	4	/	[byte]				
Sending duration/ message	1472,6	1472,6	[ms]				
Sending current	42,0796	42,0796	[mA]				
Listen duration	370,6	370,6	[ms]				
Listen current	24,1544	24,1544	[mA]				
Idle current	11,078	11,078	[mA]				
Spreading factor	12	/	[-]	0,019699455	[mA]	0,019699	[mA]

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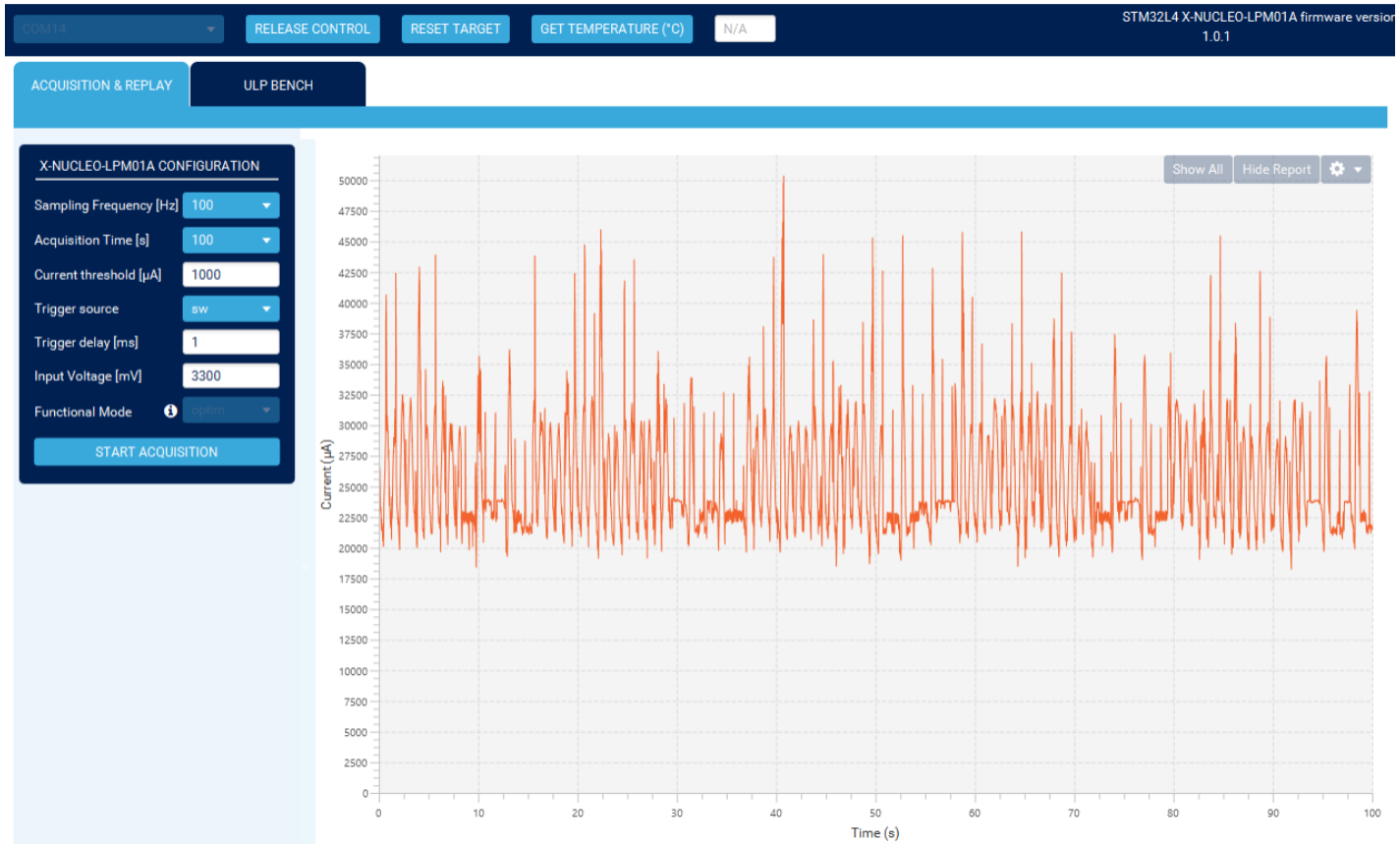
Power Measurements

- GPS module



	typical	max		PWR typ/h		PWR max/h	
GPS							
Measurements/hour	6	/	[-]				
Measurement duration (lorawan academy)	15000	15000	[ms]				
Measuring current	21,707	21,707	[mA]				
Idle current (lorawan academy)	0,08	0,08	[mA]				
Mode: (Acq/FullPWR/GLP)	Acq	/		21,707	[mA]	21,707	[mA]

Power Measurements

- D7

	typical	max		PWR typ/h		PWR max/h	
Dash7-module							
Msg/hour	1	/	[-]				
Msg length	1	/	[byte]				
Resp Mode	NO	/					
Sending duration/ message	124,4	124,4	[ms]				
Sending current	35,402	35,402	[mA]				
Idle current	11,078	11,078	[mA]	0,001223336	[mA]	0,001223	[mA]

Power Measurements

D7 - Mode ANY - No receive

Power Measurements

D7 - Mode ANY - Receive