Better dress warm

-

IoT meets Zabbix

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IoT meets Zabbix

What is the IoT?

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What is the IoT?

The „Internet of Things“ provides a network for a more direct integration of the physical world into computer driven systems and automatic data processing.

This usually requires (physical) devices that act as:

- Sensors
- Actuators

… and provide connectivity to exchange their data with either backend services or other devices.

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What is the IoT?

IoT application types:

Consumer Applications
- Smart home

Industrial Applications
- Manufacturing, Agriculture

Commercial Applications
- Healthcare, Transportation, Building automation

Infrastructure Applications
- Energy management, Environmental monitoring

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What is the IoT?

Gartner estimates that 6.4 billion connected things will be in use in 2016, and will reach 20.8 billion in 2020.

Category	2014	2015	2016	2020
Consumer	2,277	3,023	4,024	13,509
Business: Cross-Industry	632	815	1,092	4,408
Business: Vertical-Specific	898	1,065	1,276	2,880
Grand Total	**3,807**	**4,902**	**6,392**	**20,797**

Source: Gartner (November 2015) - https://www.gartner.com/newsroom/id/3165317

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What makes up an IoT device?

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What makes up an IoT device

Characteristics of an IoT device:

- Works self contained.
- Acts as sensor and/or actuator.
- Provides connectivity to a network or another (gateway) device.
- Exchanges (small) amounts of data – usually with a backend service.
- Can be remotely monitored, controlled or even updated.
- Operates mobile or stationary.
- Optimized for battery operation, when running mobile.

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What makes up an IoT device

Network communication

Power consumption

Data rate

Range

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What makes up an IoT device

Data rate, range and power consumption

Technology Comparison	2G GSM	3G UMTS	4G LTE	Wi-Fi 802.11n	Lora/Sigfox
Range	Long	Long	Long	Limited (<100m)	Long 1 - 100 Km
Topology	P2P	P2P	P2P	P2P/Mesh	P2P
TX Current Consumption 3.3V	30 – 400 mA	500 – 1000 mA	600 – 1100 mA	50 – 400 mA	<20 mA
Idle Current Consumption 3.3V	2 - 3 mA	4 – 5 mA	6 – 8 mA	35 - 45 mA	<0.009 mA
Energy Harvesting	No	No	No	No	Possible
Operating life on battery (2000mAh) A=active, I=idle	(A) 4-8 h (I) 36 d	(A) 2-4 h (I) 20 d	(A) 2-3 h (I) 12 d	(A) 4-8 h (I) 2 d	10+ years
Usable data rate	9.6 kbps	384 kbps	150 mbps	450 mbps	0.250 - 11 kbps

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What makes up an IoT device

Our choice:
Use 2.4 GHz Wi-Fi as default.

- Available in most environments.
- Better range than 5 GHz.
- Cheap to implement.
- Perfect, if battery power does not matter.
- Direct communication with IP based networks.
- Native support of Zabbix protocol possible.

Special care when running on batteries. Only enable radio and connect to Wi-Fi if needed to reduce power consumption.

If a very high battery up time is needed, use LoRa with separate LoRa IP-Gateway.

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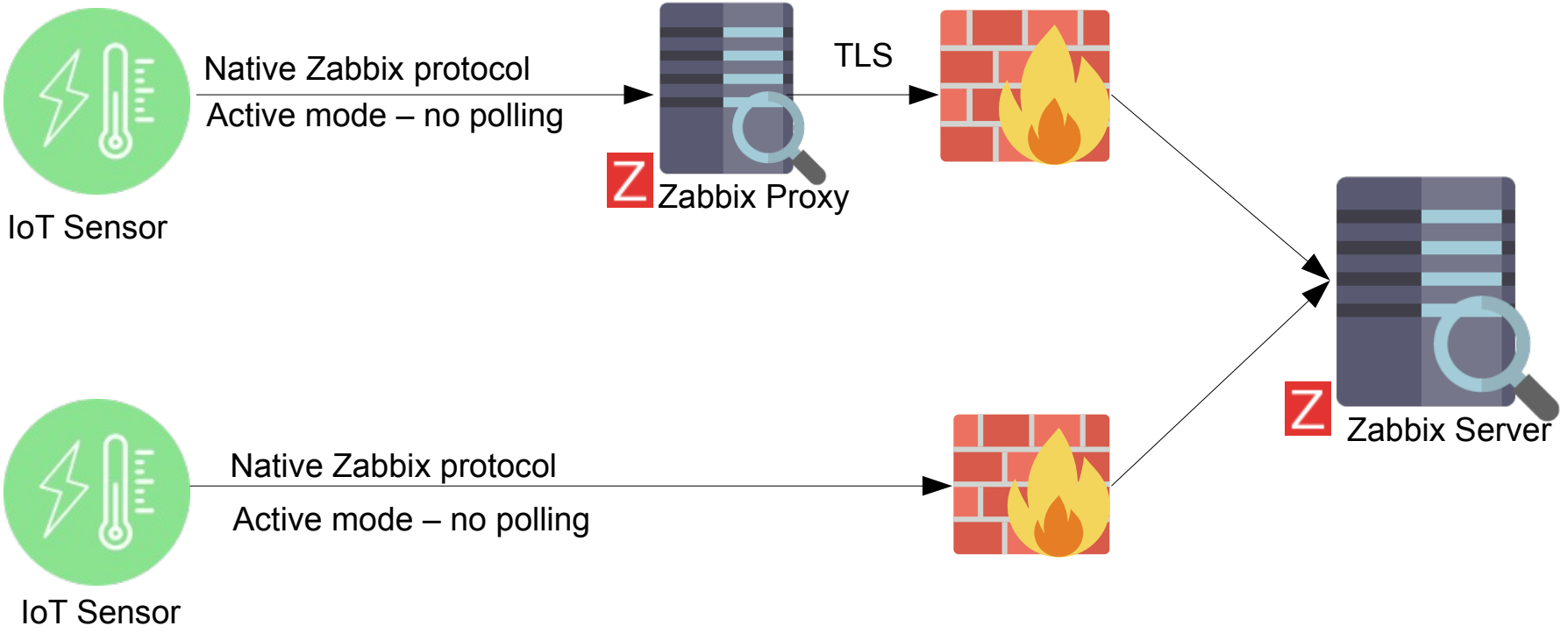
What makes up an IoT device

Network communication between IoT sensor and Zabbix



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What makes up an IoT device

The result – our first IoT sensor with optional external connector

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Use case

Special thanks to

FHB original GmbH & Co.KG

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Use case

About FHB original GmbH & Co.KG

- Located in Germany.
- Started in 1947 as a manufacturer of “Guild Clothing”.
- In this segment, as of today, market leader in Europe.
- Extended product line to various kinds of “Work Clothing”.
- Manufacturing in Germany and eastern Europe.
- Office in Shanghai, Asia.
- German brand award - winner in 2018.

FHB

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Use case

Product pictures across portfolio as of today.

FHB

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Use case

Storage Hall

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Use case

Sensor Data

Name	Last check	Last value	Change	
Fails (4 Items)				
Fails [Wlan]	09/09/2018 05:53:54 PM	0		Graph
Fails [Transmission]	09/09/2018 05:53:54 PM	0		Graph
Fails [Sensor]	09/09/2018 05:53:54 PM	0		Graph
Fails [Connection]	09/09/2018 05:53:54 PM	0		Graph
Metrics (6 Items)				
Temperature [C]	09/09/2018 05:53:54 PM	22.88 C	+0.12 C	Graph
Temperature External [C]	09/09/2018 05:53:54 PM	23.75 C	-0.12 C	Graph
Indoor Air Quality [Index]	09/09/2018 05:53:54 PM	95 idx	-2 idx	Graph
Humidity [%]	09/09/2018 05:53:54 PM	52.33 %	+0.4 %	Graph
Dewpoint [C]	09/09/2018 05:53:54 PM	12.6 C	+0.22 C	Graph
Air Pressure [Pa]	09/09/2018 05:53:54 PM	101.4 KP	-10.5 P	Graph
Stats (4 Items)				
WLan RSSI [dBm]	09/09/2018 05:53:54 PM	-61 dBm	+1 dBm	Graph
WLan AP Connect Time [sec]	09/09/2018 05:53:54 PM	2.2 sec		Graph
VCC [V]	09/09/2018 05:53:54 PM	3.11	+0.01	Graph
Restart Reason	09/09/2018 05:53:54 PM	5		Graph

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Implementation

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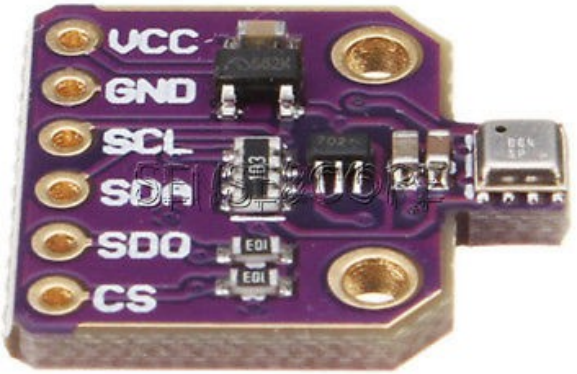
Implementation

What's needed to build a sensor?

Microcontroller with Wi-Fi and I2C Bus.
(Espressif ESP32)



Sensor with I2C Bus
(Bosch BME280 / BME680)

Firmware/Software that implements the Zabbix communication protocol

"I2C" (Inter-Integrated-Circuit) aka "TWI" (Two-Wire-Interface) is an industrial standard for sensor communication. Depending on the application, various I2C sensors can be used. Examples:

Pressure, Weight, Motion, Distance, Magnet Fields, Water detection, Electric Power, Gas detection etc.

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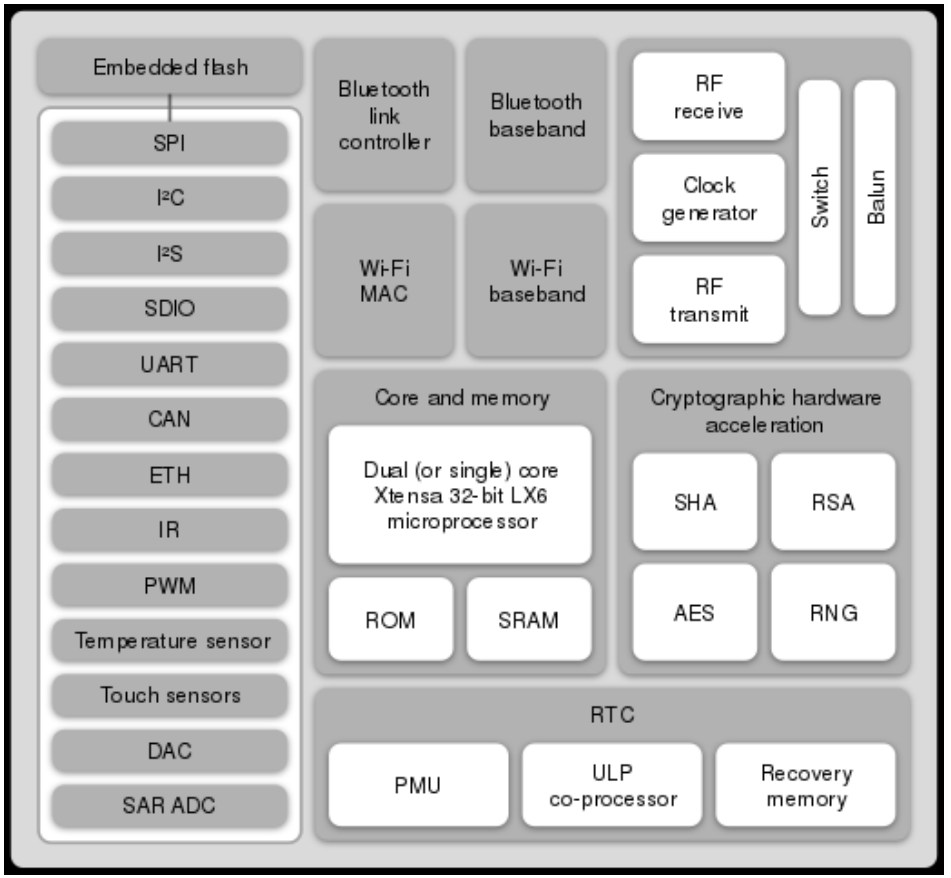
Implementation

Espressif ESP32 function block diagram



Software Environment

- Programming Language: C
- Programming Language: C++
- Programming Language: Python*

- Espressif native IDF (Iot Development Framework)
- FreeRTOS Realtime Operating System (with support from Amazon)
- Arduino compatible libraries

Espressif Systems' ESP32 Now Qualified for Amazon FreeRTOS

Posted On: May 15, 2018
"Today, Espressif Systems' ESP32-DevKitC & ESP-WROVER-KIT are qualified for Amazon FreeRTOS..."

Source: https://aws.amazon.com/about-aws/whats-new/2018/05/esp32-qualified-for-amazon-freertos

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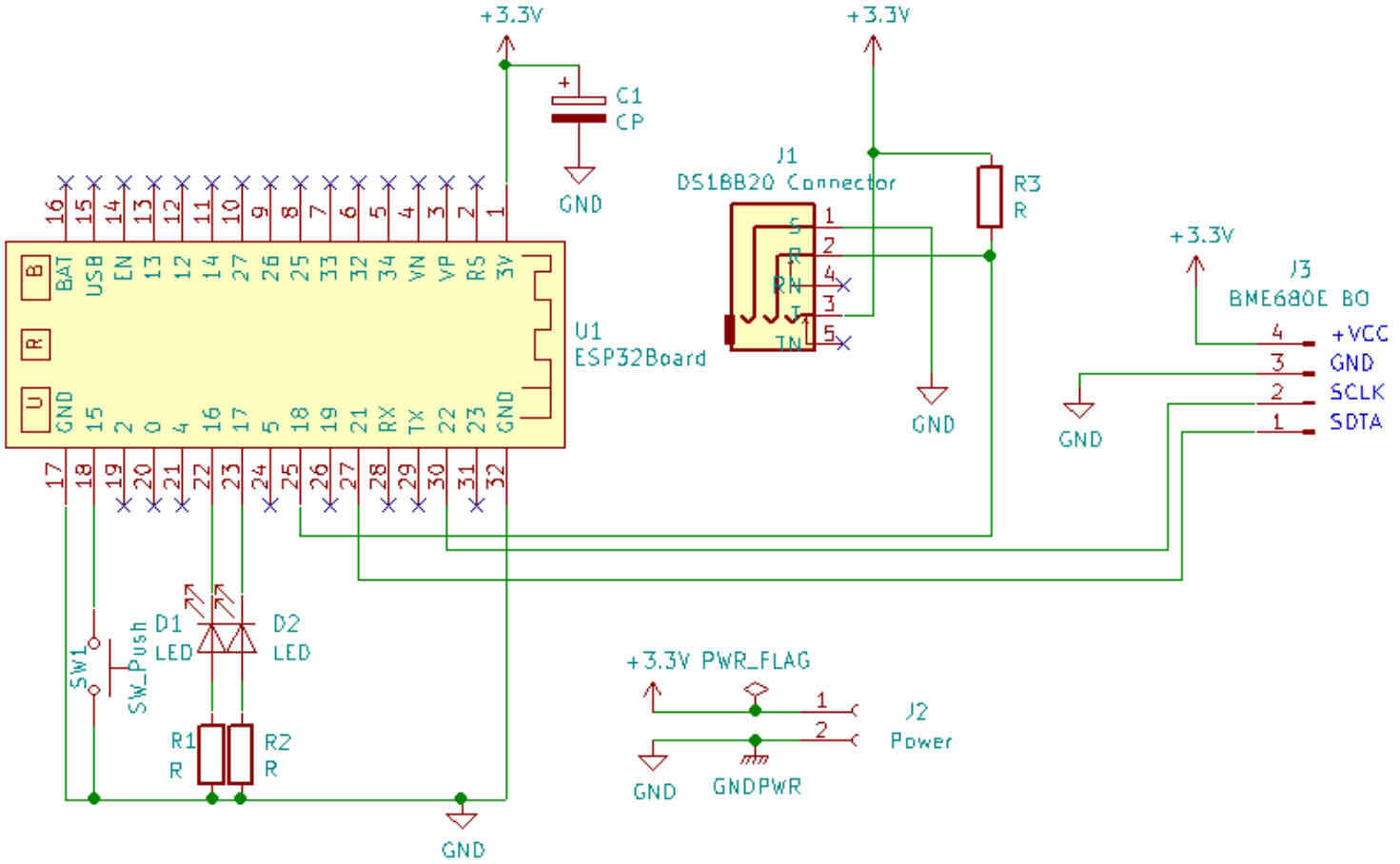
Implementation

Circuit diagram with connector for optional external sensor



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Implementation

Zabbix sender protocol

- <HEADER> - "ZBXD\x01" (4 + 1 = 5 bytes).
- <DATALEN> - data length (8 bytes). 64 bit number in little-endian format.
- <PAYLOAD> - data (length bytes). JSON formatted data.

Maximum payload size: 128MB in one connection.

Example payload:

```
{
    "request":"sender data",
    "data":[
        {
            "host":"imssensor",
            "key":"temp",
            "value":"23.4"
        },
        {
            "host":"imssensor",
            "key":"hum",
            "value":"41.5"
        }
    ]
}
```

Source: https://www.zabbix.com/documentation/3.4/manual/appendix/protocols/header_datalen

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Implementation

Software design – Operation modes

- "**Setup**" mode: Sensor starts as Wi-Fi access point with DHCP and web server to allow initial configuration through a web interface.
- "**Power save**" mode: Sensor connects to the configured Wi-Fi network, measure metrics and sends them to Zabbix. After this it sleeps for a given time to save energy.
- "**Online**" mode: Sensor works like in "power save" mode, but stays online. It also starts a web server to allow real-time monitoring of metrics through web interface and REST API.

Push button and LEDs to select and visualize mode of operation.

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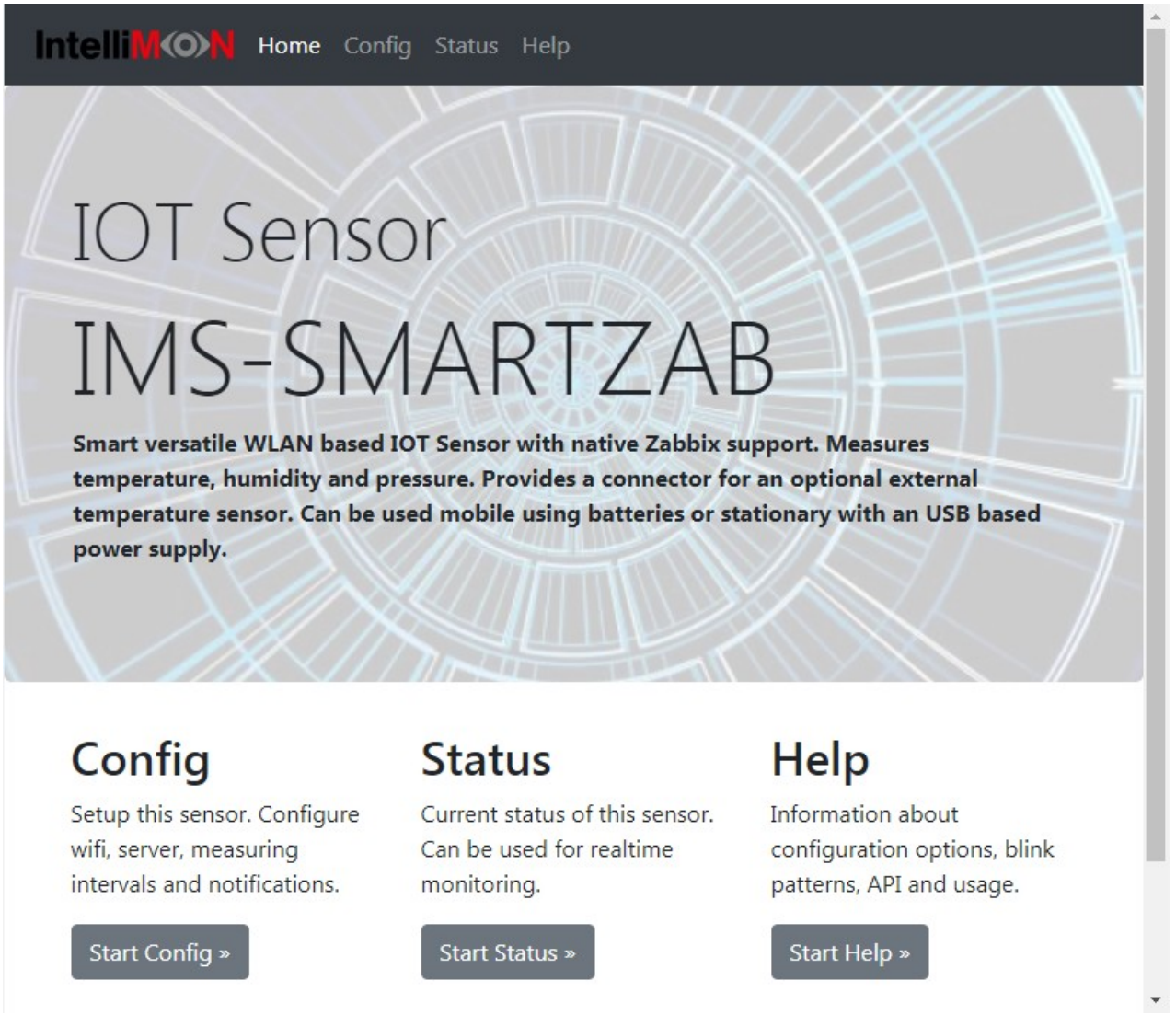
Implementation

Webinterface



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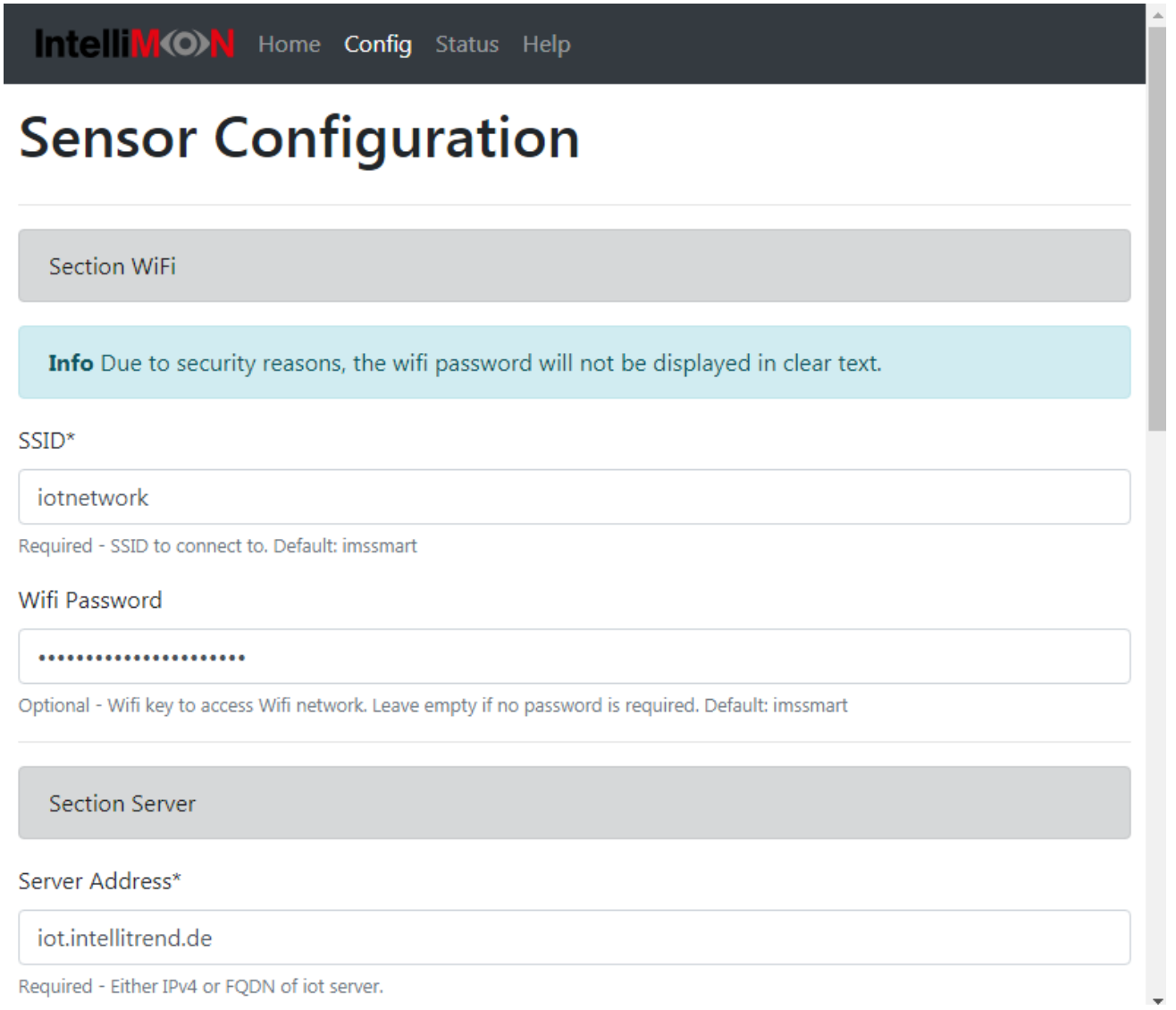
Implementation

Webinterface



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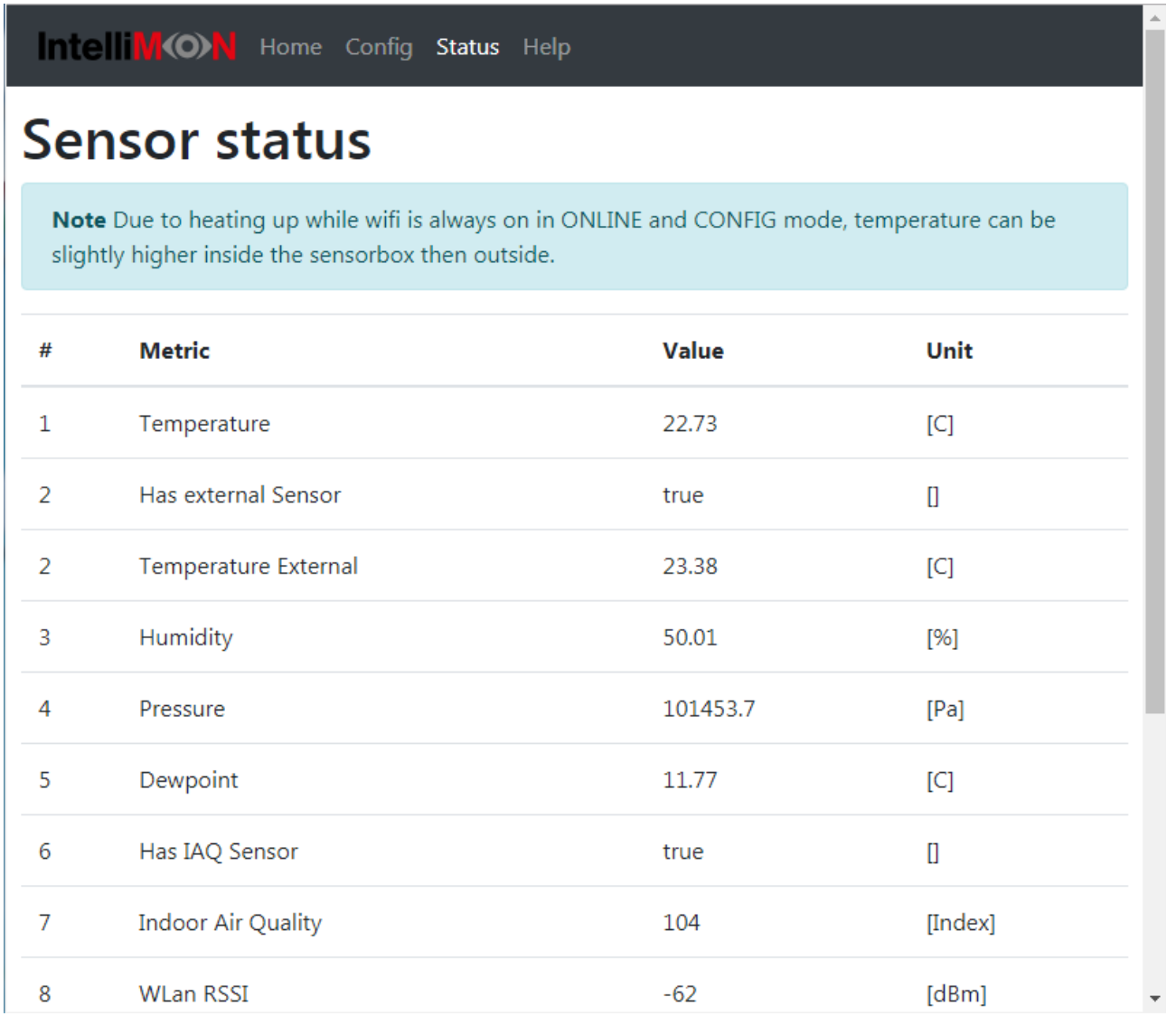
Implementation

Webinterface



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Build an IoT device

More Sensors…

How IoT “friendly” is Zabbix?

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More sensors

Reaching

500.000 sensor hosts

7.000.000 Items / 3.000.000 Triggers

Status of Zabbix

Parameter	Value	Details
Zabbix server is running	Yes	localhost:10051
Number of hosts (enabled/disabled/templates)	500134	500006 / 0 / 128
Number of items (enabled/disabled/not supported)	7000141	7000134 / 0 / 7
Number of triggers (enabled/disabled [problem/ok])	3000060	2500060 / 500000 [2 / 2500058]

		last	min	avg	max
Values processed by Zabbix server per second	[all]	53.68 K	53.68 K	56.64 K	59.59 K

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More sensors

Reaching 500k hosts.

- Typical installations have a higher “NVPS to hosts” ratio.
- IoT applications have a lower “NVPS to hosts” ratio, due to the usually lower measuring interval, but their high number of hosts. (Each sensor represents a host).

How does Zabbix deal with it?

(Note: In this context host represents also the associated items and trigger).

Example:
10k hosts * 18 items (1min) = 18.000 values / min = 3.000 NVPS.
600k hosts * 18 items (60min) = 10.800.000 values / hour = 3.000 NVPS

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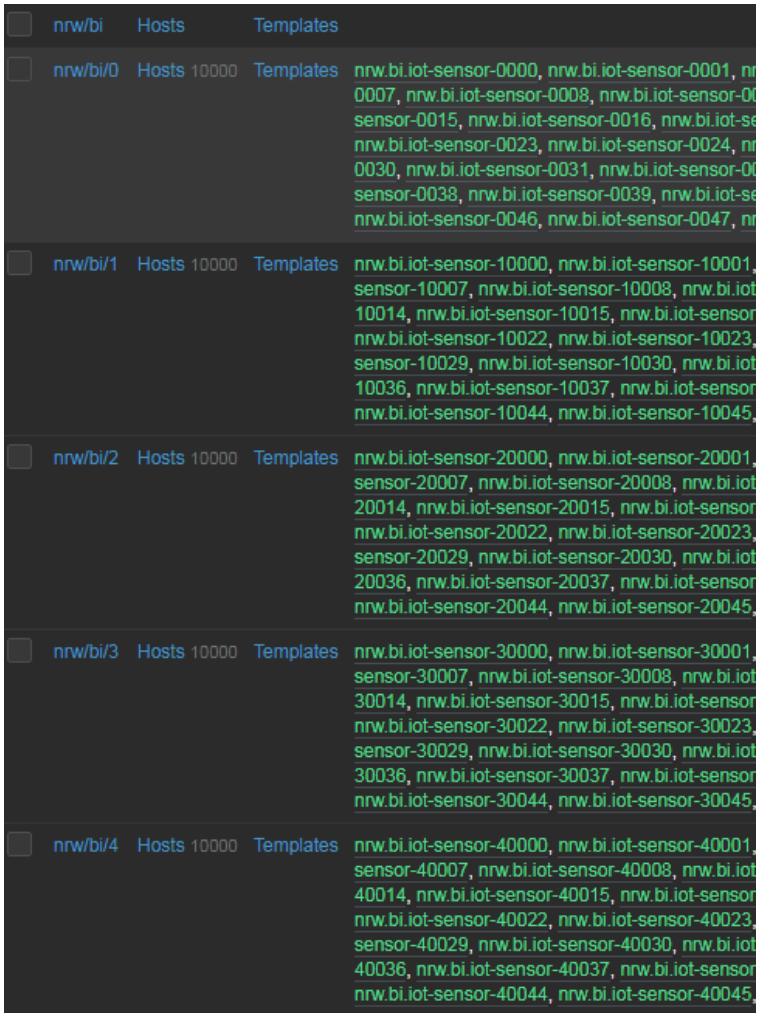
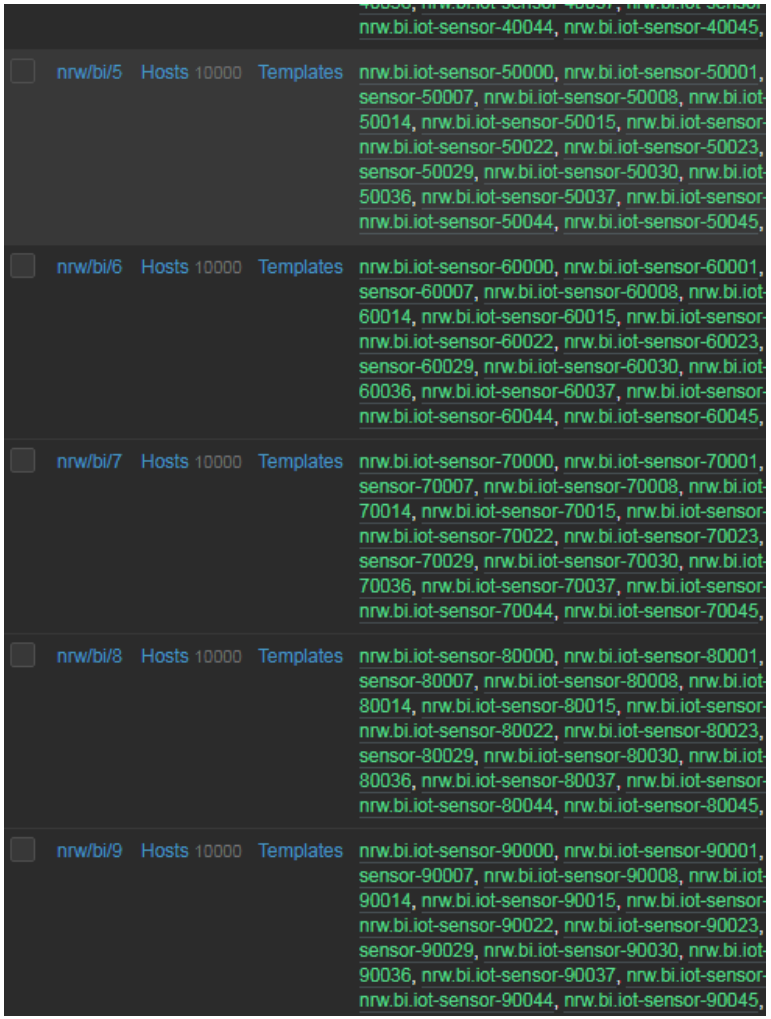
More sensors



nrw/bi	Hosts	Templates	
nrw/bi/0	Hosts 10000	Templates	nrw.bi.iot-sensor-0000, nrw.bi.iot-sensor-0001, nr 0007, nrw.bi.iot-sensor-0008, nrw.bi.iot-sensor-0 sensor-0015, nrw.bi.iot-sensor-0016, nrw.bi.iot-se nrw.bi.iot-sensor-0023, nrw.bi.iot-sensor-0024, nr 0030, nrw.bi.iot-sensor-0031, nrw.bi.iot-sensor-0 sensor-0038, nrw.bi.iot-sensor-0039, nrw.bi.iot-se nrw.bi.iot-sensor-0046, nrw.bi.iot-sensor-0047, nr
nrw/bi/1	Hosts 10000	Templates	nrw.bi.iot-sensor-10000, nrw.bi.iot-sensor-10001, sensor-10007, nrw.bi.iot-sensor-10008, nrw.bi.iot 10014, nrw.bi.iot-sensor-10015, nrw.bi.iot-sensor nrw.bi.iot-sensor-10022, nrw.bi.iot-sensor-10023, sensor-10029, nrw.bi.iot-sensor-10030, nrw.bi.iot 10036, nrw.bi.iot-sensor-10037, nrw.bi.iot-sensor nrw.bi.iot-sensor-10044, nrw.bi.iot-sensor-10045,
nrw/bi/2	Hosts 10000	Templates	nrw.bi.iot-sensor-20000, nrw.bi.iot-sensor-20001, sensor-20007, nrw.bi.iot-sensor-20008, nrw.bi.iot 20014, nrw.bi.iot-sensor-20015, nrw.bi.iot-sensor nrw.bi.iot-sensor-20022, nrw.bi.iot-sensor-20023, sensor-20029, nrw.bi.iot-sensor-20030, nrw.bi.iot 20036, nrw.bi.iot-sensor-20037, nrw.bi.iot-sensor nrw.bi.iot-sensor-20044, nrw.bi.iot-sensor-20045,
nrw/bi/3	Hosts 10000	Templates	nrw.bi.iot-sensor-30000, nrw.bi.iot-sensor-30001, sensor-30007, nrw.bi.iot-sensor-30008, nrw.bi.iot 30014, nrw.bi.iot-sensor-30015, nrw.bi.iot-sensor nrw.bi.iot-sensor-30022, nrw.bi.iot-sensor-30023, sensor-30029, nrw.bi.iot-sensor-30030, nrw.bi.iot 30036, nrw.bi.iot-sensor-30037, nrw.bi.iot-sensor nrw.bi.iot-sensor-30044, nrw.bi.iot-sensor-30045,
nrw/bi/4	Hosts 10000	Templates	nrw.bi.iot-sensor-40000, nrw.bi.iot-sensor-40001, sensor-40007, nrw.bi.iot-sensor-40008, nrw.bi.iot 40014, nrw.bi.iot-sensor-40015, nrw.bi.iot-sensor nrw.bi.iot-sensor-40022, nrw.bi.iot-sensor-40023, sensor-40029, nrw.bi.iot-sensor-40030, nrw.bi.iot 40036, nrw.bi.iot-sensor-40037, nrw.bi.iot-sensor nrw.bi.iot-sensor-40044, nrw.bi.iot-sensor-40045,



			nrw.bi.iot-sensor-40044, nrw.bi.iot-sensor-40045,
nrw/bi/5	Hosts 10000	Templates	nrw.bi.iot-sensor-50000, nrw.bi.iot-sensor-50001, sensor-50007, nrw.bi.iot-sensor-50008, nrw.bi.iot- 50014, nrw.bi.iot-sensor-50015, nrw.bi.iot-sensor- nrw.bi.iot-sensor-50022, nrw.bi.iot-sensor-50023, sensor-50029, nrw.bi.iot-sensor-50030, nrw.bi.iot- 50036, nrw.bi.iot-sensor-50037, nrw.bi.iot-sensor- nrw.bi.iot-sensor-50044, nrw.bi.iot-sensor-50045,
nrw/bi/6	Hosts 10000	Templates	nrw.bi.iot-sensor-60000, nrw.bi.iot-sensor-60001, sensor-60007, nrw.bi.iot-sensor-60008, nrw.bi.iot- 60014, nrw.bi.iot-sensor-60015, nrw.bi.iot-sensor- nrw.bi.iot-sensor-60022, nrw.bi.iot-sensor-60023, sensor-60029, nrw.bi.iot-sensor-60030, nrw.bi.iot- 60036, nrw.bi.iot-sensor-60037, nrw.bi.iot-sensor- nrw.bi.iot-sensor-60044, nrw.bi.iot-sensor-60045,
nrw/bi/7	Hosts 10000	Templates	nrw.bi.iot-sensor-70000, nrw.bi.iot-sensor-70001, sensor-70007, nrw.bi.iot-sensor-70008, nrw.bi.iot- 70014, nrw.bi.iot-sensor-70015, nrw.bi.iot-sensor- nrw.bi.iot-sensor-70022, nrw.bi.iot-sensor-70023, sensor-70029, nrw.bi.iot-sensor-70030, nrw.bi.iot- 70036, nrw.bi.iot-sensor-70037, nrw.bi.iot-sensor- nrw.bi.iot-sensor-70044, nrw.bi.iot-sensor-70045,
nrw/bi/8	Hosts 10000	Templates	nrw.bi.iot-sensor-80000, nrw.bi.iot-sensor-80001, sensor-80007, nrw.bi.iot-sensor-80008, nrw.bi.iot- 80014, nrw.bi.iot-sensor-80015, nrw.bi.iot-sensor- nrw.bi.iot-sensor-80022, nrw.bi.iot-sensor-80023, sensor-80029, nrw.bi.iot-sensor-80030, nrw.bi.iot- 80036, nrw.bi.iot-sensor-80037, nrw.bi.iot-sensor- nrw.bi.iot-sensor-80044, nrw.bi.iot-sensor-80045,
nrw/bi/9	Hosts 10000	Templates	nrw.bi.iot-sensor-90000, nrw.bi.iot-sensor-90001, sensor-90007, nrw.bi.iot-sensor-90008, nrw.bi.iot- 90014, nrw.bi.iot-sensor-90015, nrw.bi.iot-sensor- nrw.bi.iot-sensor-90022, nrw.bi.iot-sensor-90023, sensor-90029, nrw.bi.iot-sensor-90030, nrw.bi.iot- 90036, nrw.bi.iot-sensor-90037, nrw.bi.iot-sensor- nrw.bi.iot-sensor-90044, nrw.bi.iot-sensor-90045,

PoC setup: 500k hosts. Organized in a total of 50 hostgroups of 10k hosts per group using hierarchical hostgroups.

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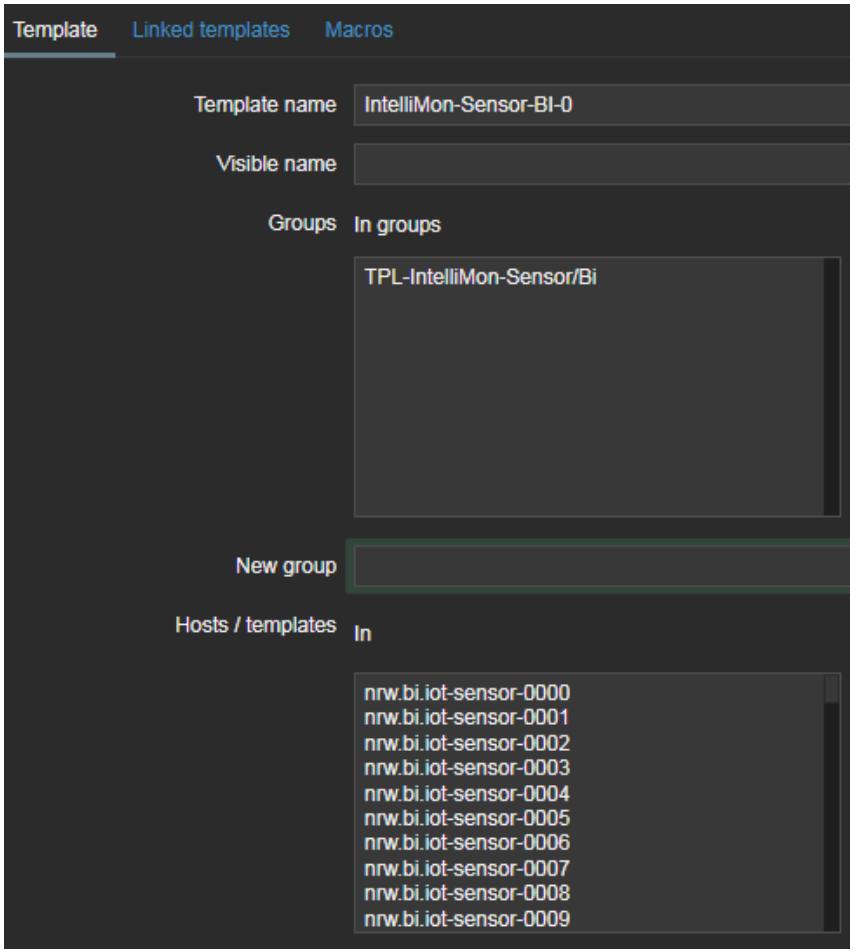
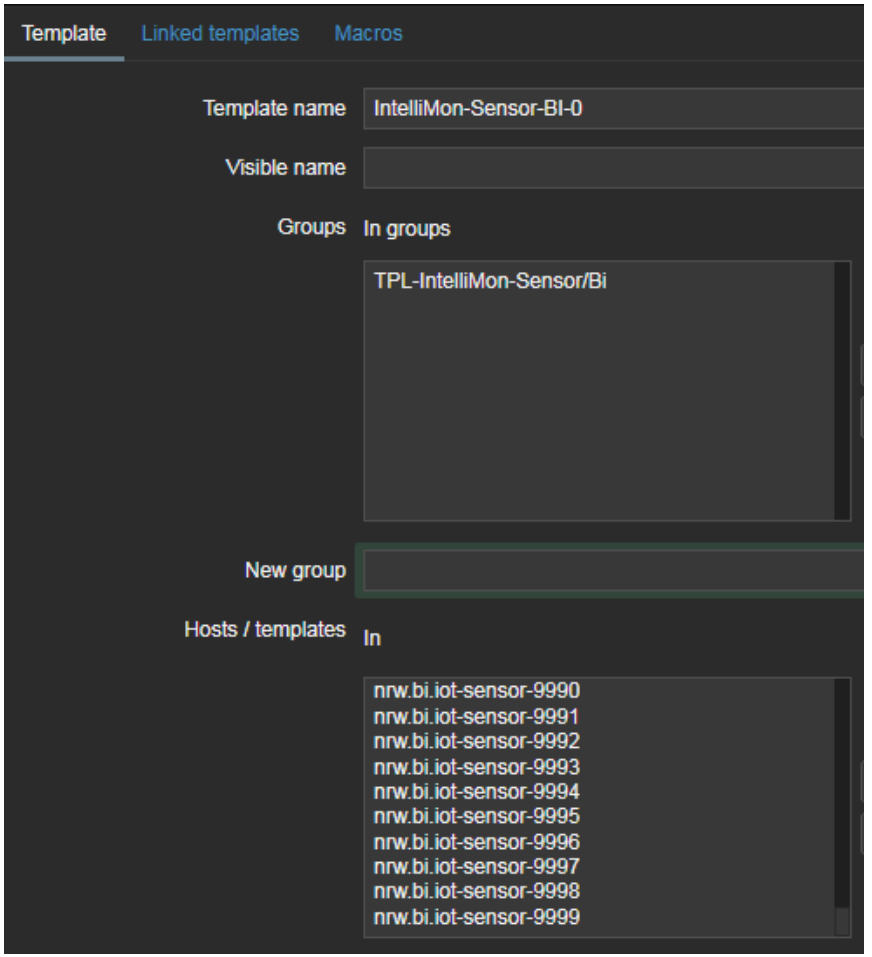
More sensors





PoC setup: One template (14 Items/6 Triggers) assigned to a group of 10k hosts. Templates assigned: 50. Total number of items/trigger used: 7Mio/3Mio.

IoT meets Zabbix

More sensors

Reaching 500.000 hosts.

- Zabbix Server can manage huge numbers of “NVPS” in an IoT like setup. (PoC reached ~60K with standard server hardware).
- Zabbix Trapper items are very efficient, no need for polling.
- Zabbix Server limits the number of host/items/triggers due to its maximum “CacheSize” of 8GB, but we did not even came close. (Only used 42% with 500k Hosts, 7Mio Items and 3Mio Triggers).
- Depending on how hosts are organized, managing huge number of hosts (>200k hosts) becomes slow.
- Managing templates becomes slow, if a template is assigned to a large number of hosts (>100k hosts).

IoT meets Zabbix

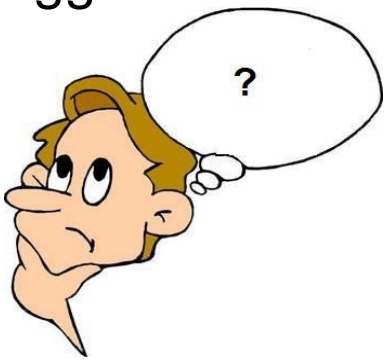
Build an IoT device

Lessons learned

IoT meets Zabbix

Lessons learned – Part 1

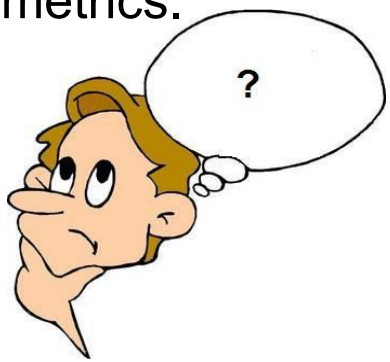
- Wi-Fi AP connection time is important for energy consumption.
- A stable and good (low RSSI) Wi-Fi connection saves a lot of energy. Zabbix is great at monitoring these metrics on top.
- Optional TLS encryption of payload takes additional time, thus more energy. Better let Zabbix Proxy do the work.
- AA batteries and rechargeable NiMH cells are a bad choice. Better use LiPo or LiFePo4 cells.
- For battery powered sensors, setup a trigger to warn when VCC gets low.
- When expecting data in a regular interval, add a “nodata()” trigger.
- Adding a REST API to the sensor extends its usability a lot.



IoT meets Zabbix

Lessons learned – Part 2

- Zabbix Server is really great for collecting huge number of values.
- Use Zabbix Proxies if data collection itself becomes an issue.
- Put not more than 10.000 hosts in one hostgroups, or better <=1000 if paging in the frontend is needed.
- Limit the number of hosts assigned to one template to 10.000.
- Adjust the Database, Zabbix Server, Zabbix Proxies and PHP settings.
- Depending on NVPS, history/trend settings and trigger usage, database partitioning is needed.
- “Zabbix Sender protocol” is efficient and also has a very low overhead.
- The addition of “Item preprocessing” gives more options to pass metrics.
- The support of Elasticsearch and the recent addition in 4.0 of “Real-Time export of events, values and trends” allows easier processing of sensor data by 3rd party apps.



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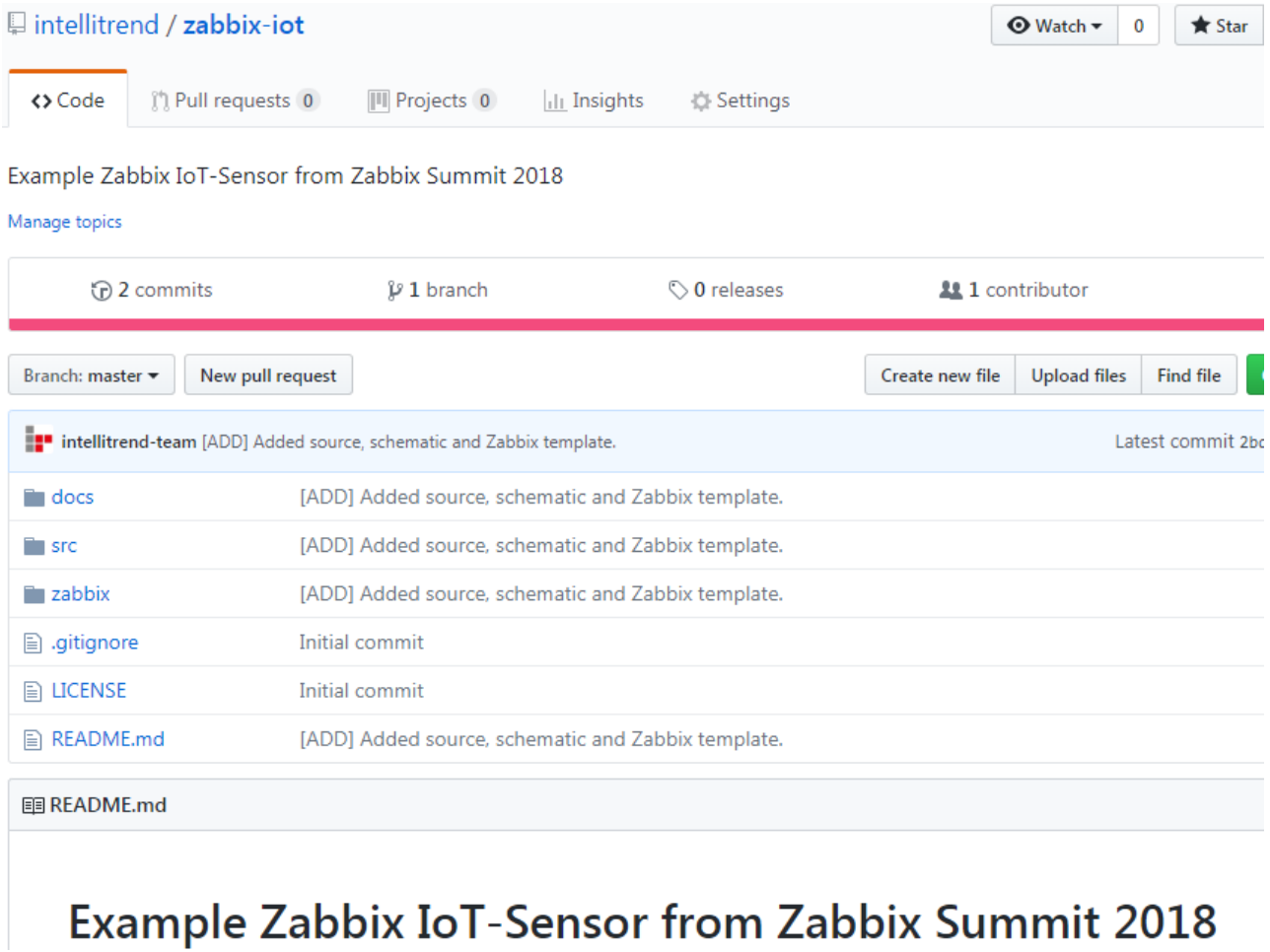
Make your own device

https://github.com/intellitrend/zabbix-iot



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Thank You!

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