

MYNO Project

IoT Seminar

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Agenda

- Motivation
- Standards
 - MQTT
 - YANG
 - NETCONF
 - Ontology
- MYNO Architecture
 - Bootstrapping
 - MUP - MYNO Update Protocol
- Conclusion

Motivation

Challenges of the Internet of Things (IoT)

- Heterogeneity of network devices
- Facilitate automatized network management
 - ability to discover device capabilities
 - notifications about changes
 - nodes joining or leaving network

Possible Solution for the Internet of Things (IoT)

- Use standards
- NETCONF protocol (RFC 6241 by IETF)
 - manages device configurations in the network
 - successor of Simple Network Management Protocol (SNMP)
- YANG (RFC 6020 by IETF)
 - data modeling language for NETCONF
- MQTT protocol as a bridge

Base Idea

- By T. Scheffler and O. Bonneß
- Publication “Manage resource-constrained IoT devices through dynamically generated and deployed YANG models”
- in Applied Networking Research Workshop (ANRW), IETF, 2017.

Standards

MQTT

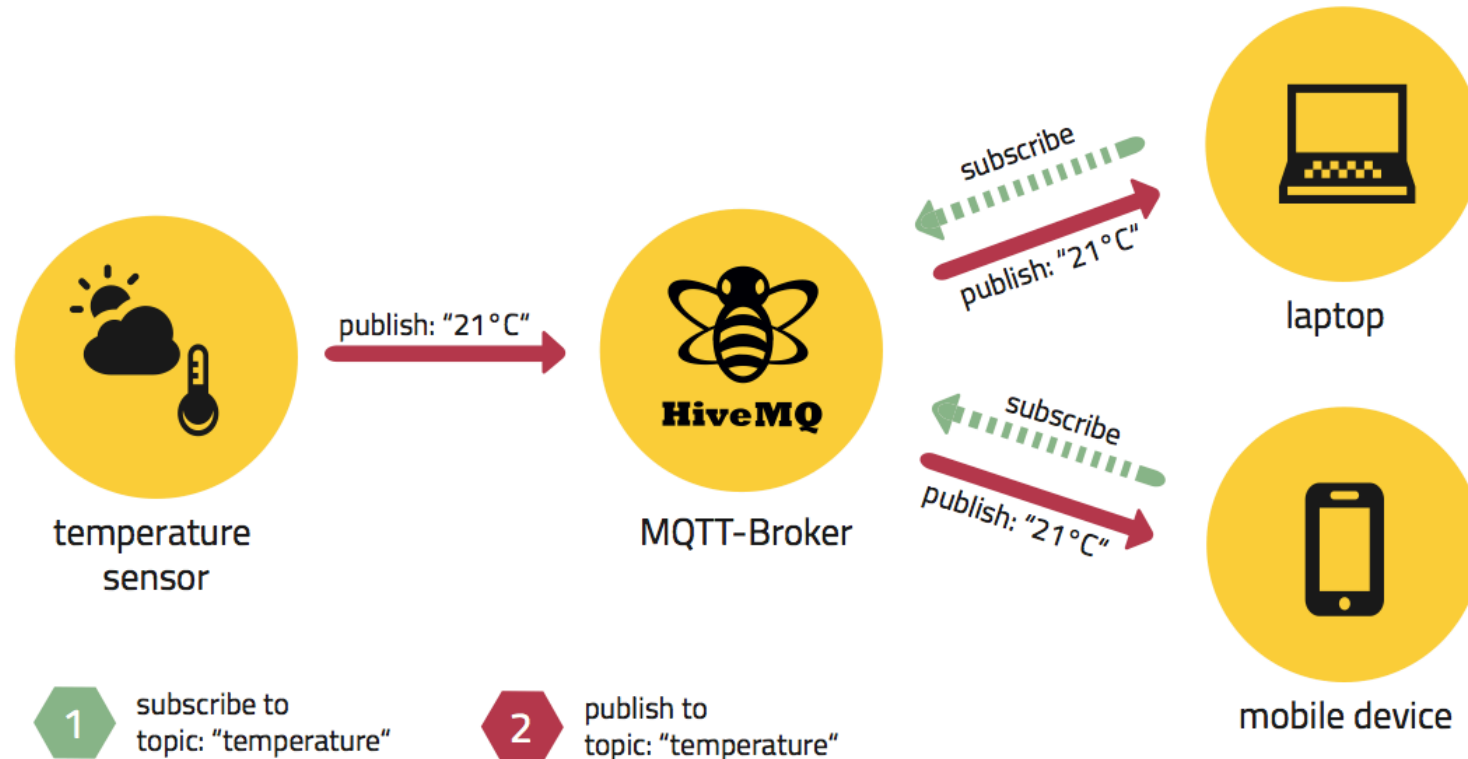
Message Queuing Telemetry Transport

18 years of MQTT



MQTT

Publish/Subscribe Messaging



Source: <http://www.hivemq.com/blog/how-to-get-started-with-mqtt>

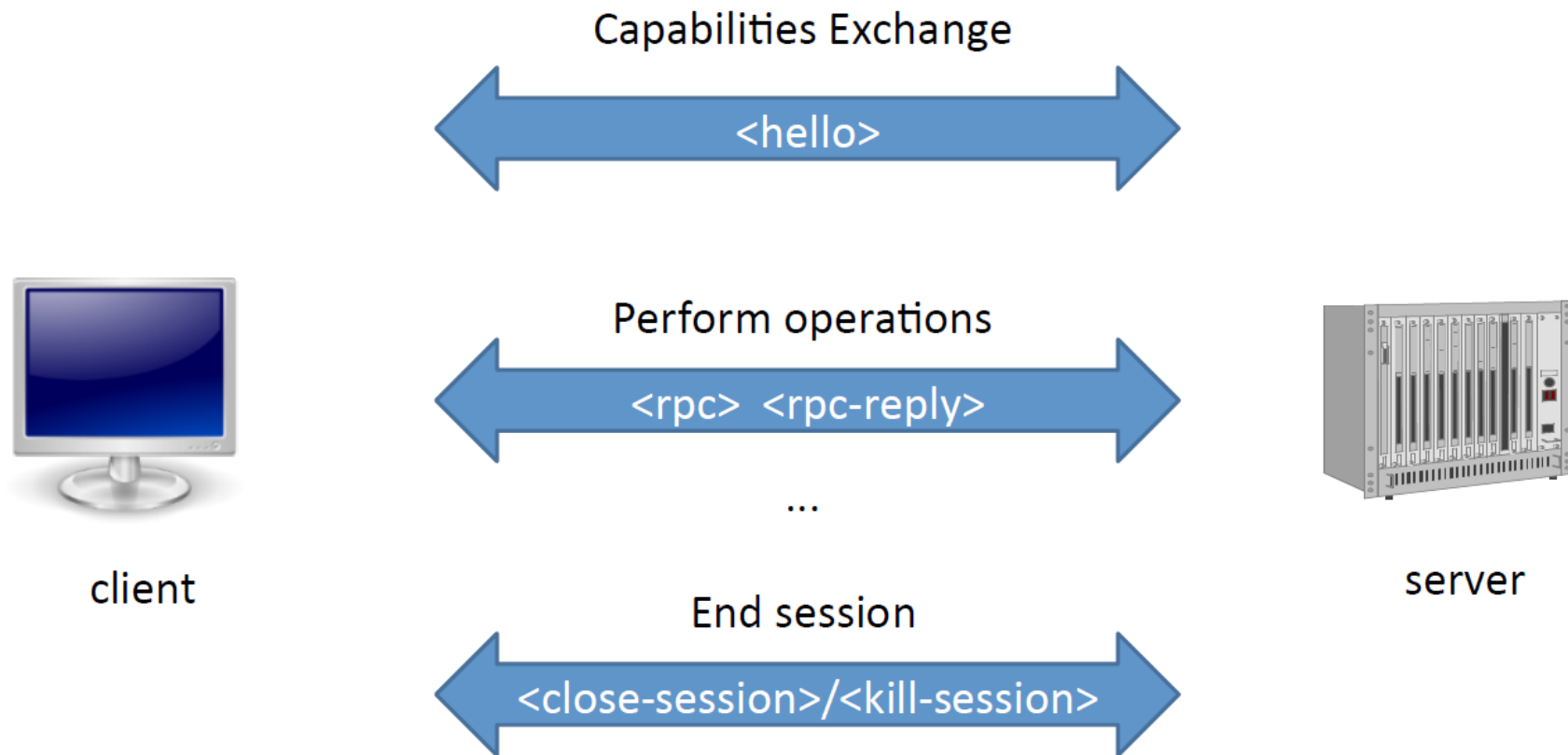
NETCONF and YANG

NETCONF

Network Configuration Protocol

- current version 1.1 published by RFC 6241 in 2011
- mechanisms to install, manipulate, and delete the configuration of network devices
- XML-based data encoding for the configuration data and protocol messages
- operations are realized as remote procedure calls (RPCs)
 - by exchanging `<rpc>` and `<rpc-reply>` messages

Basic NETCONF Session



Source: <https://www.ietf.org/slides/slides-edu-network-configuration-with-netconf-00.pdf>

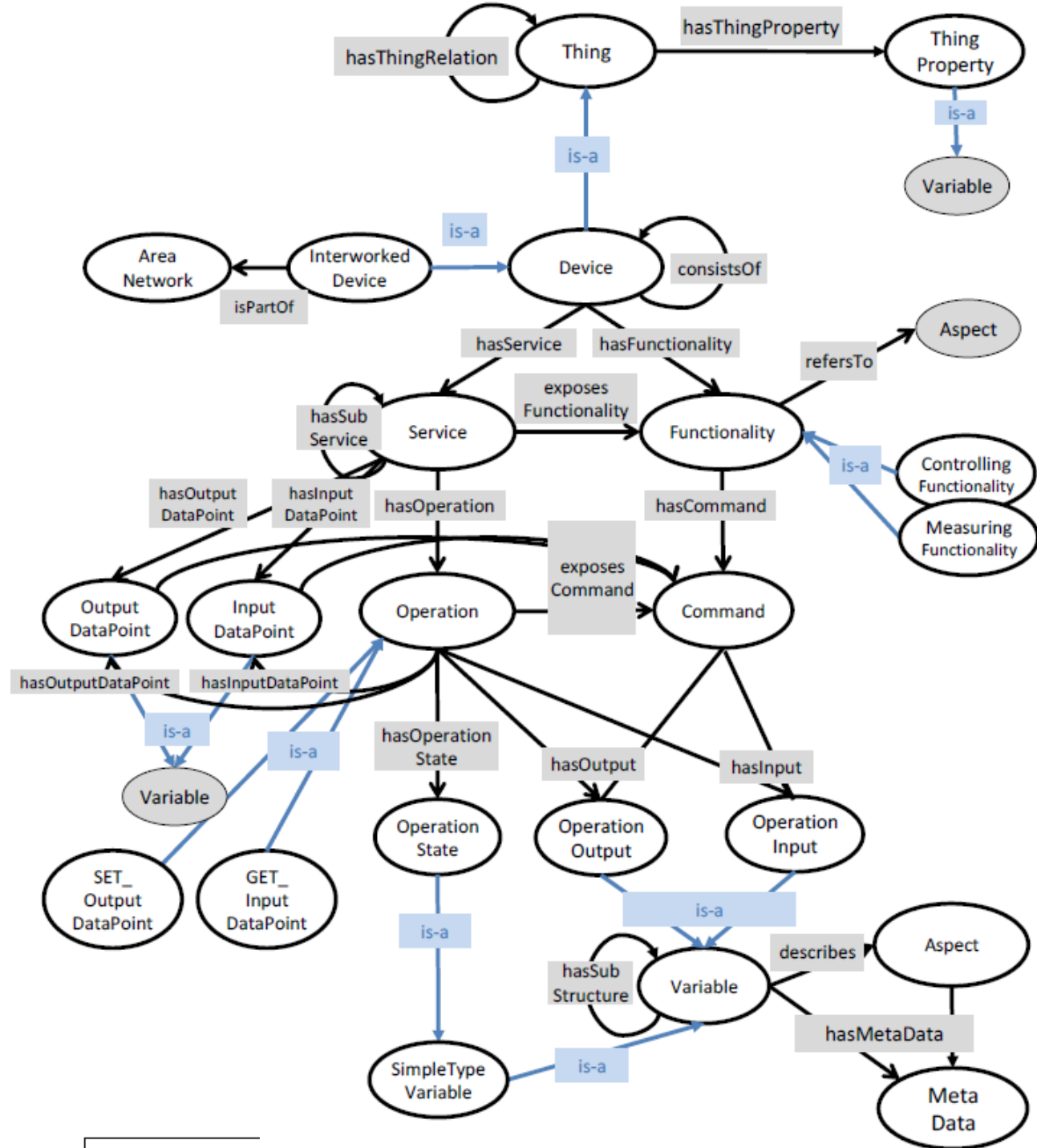
YANG - Data Modeling Language for NETCONF

- RFC 6020 published in 2010, Version 1.1 in RFC 7950
- YANG module defines a hierarchy of data for NETCONF-based operations
 - configurations
 - state data
 - Remote Procedure Calls (RPCs)
 - notifications
- balance between high-level data modeling and low-level encoding



oneM2M
Ontology
for device
capabilities

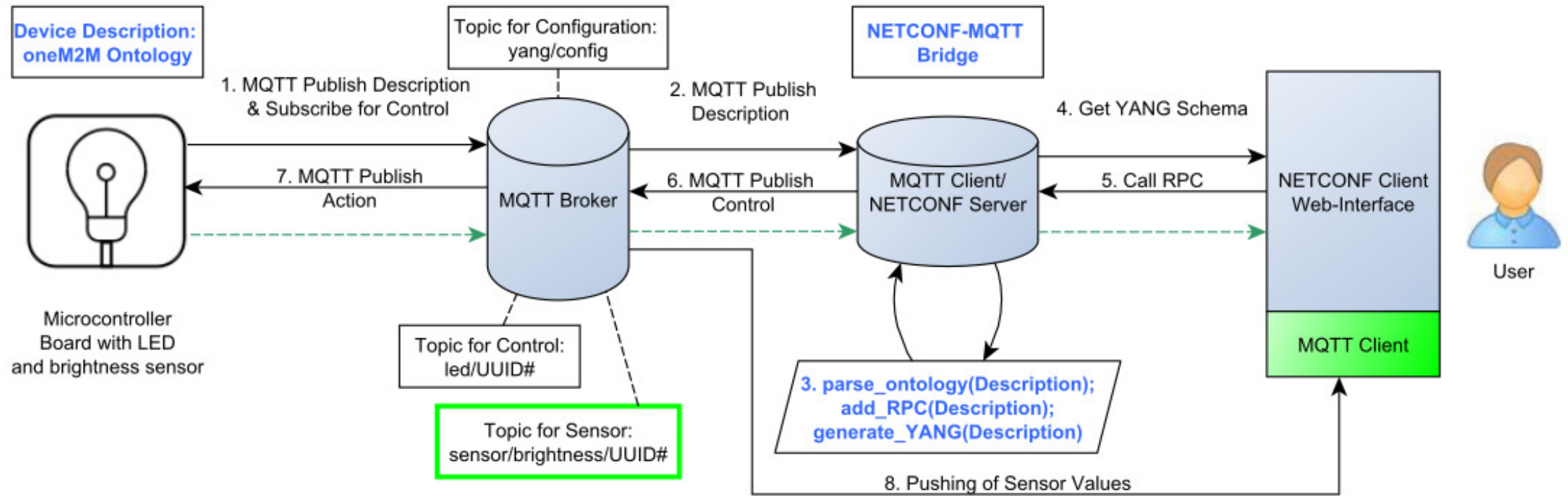
W3C Semantic
Web Standards



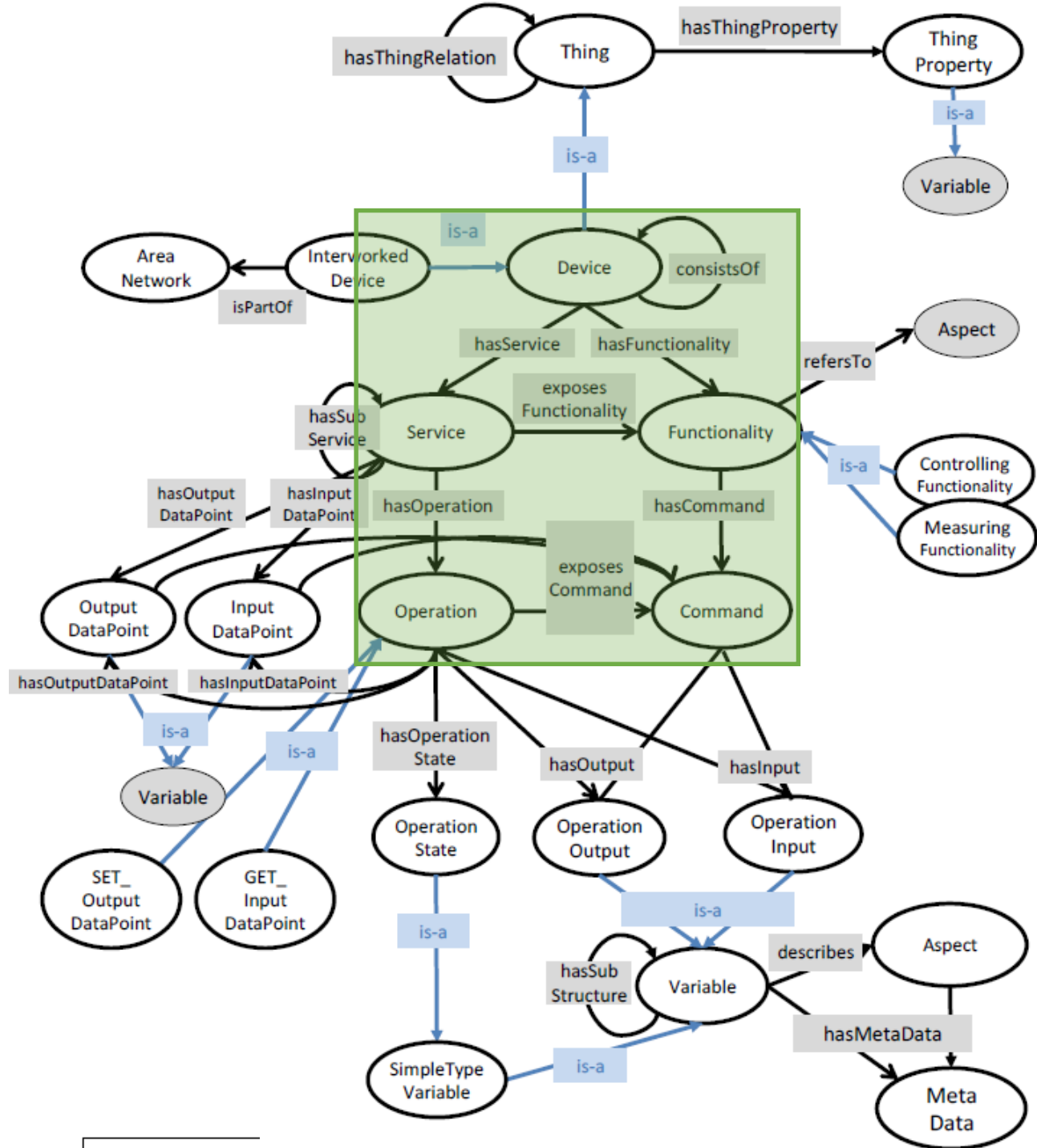
MYNO Project Architecture

Part of the Ph.D. Thesis of Kristina Sahlmann

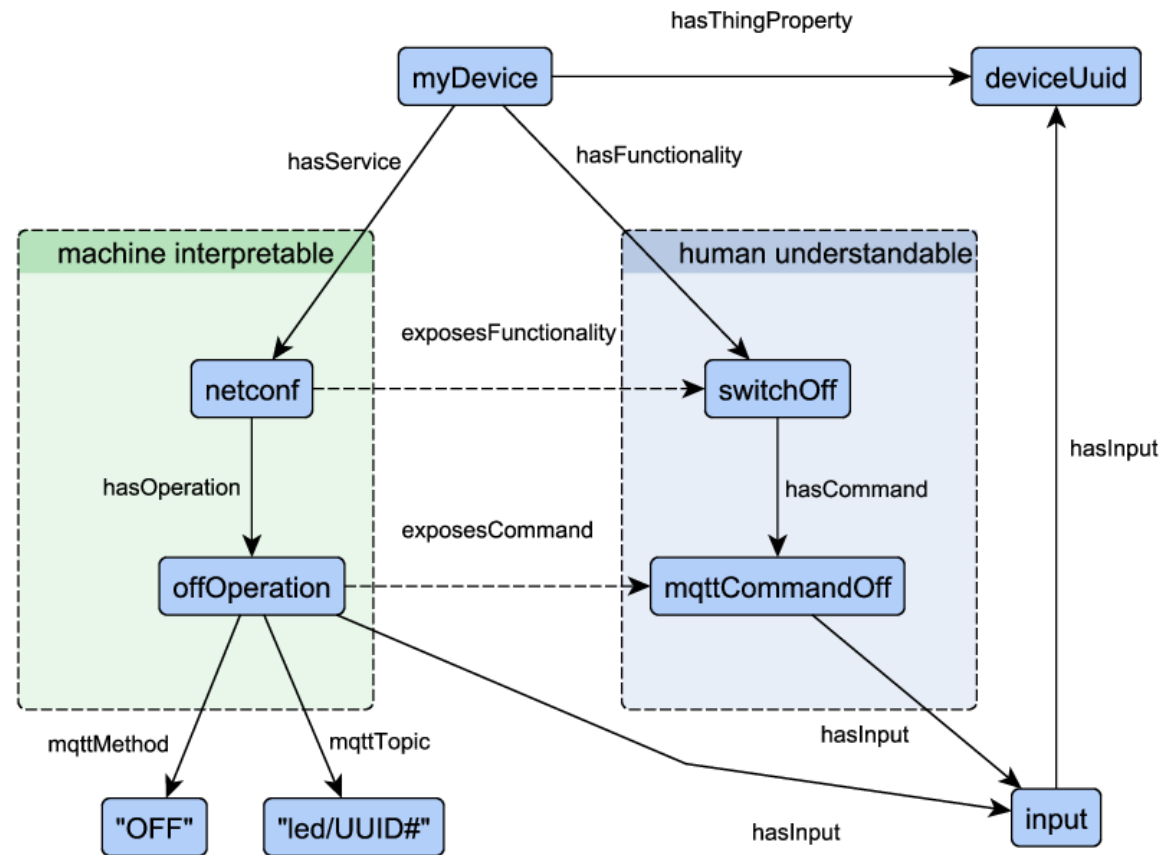
MYNO Architecture and Bootstrapping



Used part
of the
oneM2M
Ontology



Derived instances from the oneM2M Base Ontology



Snippet of the derived ontology

```
...
"@id" : "https://www.cs.uni-potsdam.de/bs/research/myno#myDevice",
"http://www.onem2m.org/ontology/Base_Ontology/base_ontology#Device" ],
"http://www.onem2m.org/ontology/Base_Ontology/base_ontology#hasFunctionality"
: [ { "@id" : "https://www.cs.uni-potsdam.de/bs/research/myno#switchOff" } ],
"http://www.onem2m.org/ontology/Base_Ontology/base_ontology#hasService"
: [ { "@id" : "https://www.cs.uni-potsdam.de/bs/research/myno#netconf" } ],
...
}, { "@id" : "https://www.cs.uni-potsdam.de/bs/research/myno##netconf",
"http://www.onem2m.org/ontology/Base_Ontology/base_ontology#Service" ],
"http://www.onem2m.org/ontology/Base_Ontology/base_ontology#exposesFunctionality"
: [ { "@id" : "https://www.cs.uni-potsdam.de/bs/research/myno#switchOff" } ],
"http://www.onem2m.org/ontology/Base_Ontology/base_ontology#exposesCommand"
: [ { "@id" : "https://www.cs.uni-potsdam.de/bs/research/myno#mqttCommandOff" } ],
...
```

JSON-LD Optimization by replacing namespaces with prefixes

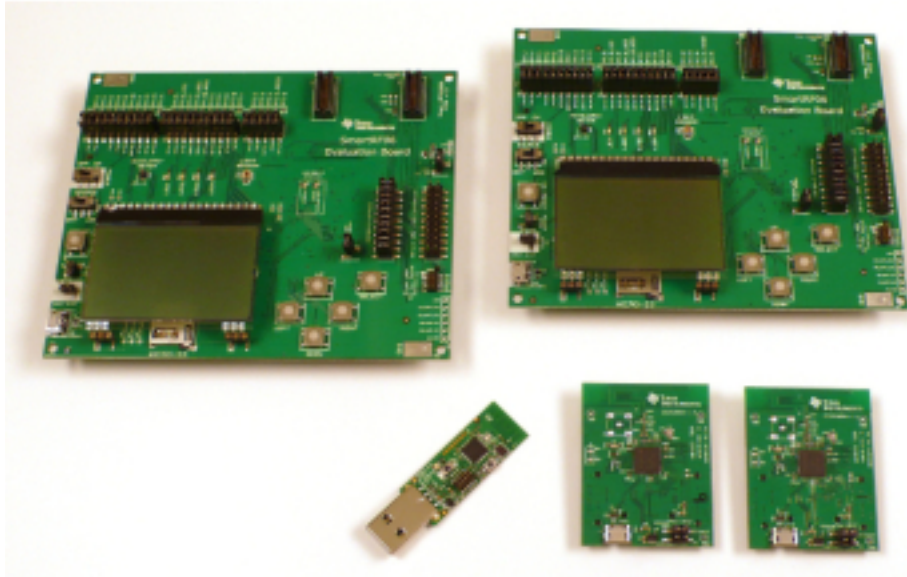
```
1 { "@context": {
2   "myn": "http://yang-netconf-mqtt",
3   "owl": "http://www.w3.org/2002/07/owl",
4   "oneM2M": "http://www.onem2m.org/ontology/Base_Ontology/base_ontology" },
5 { "myn": "myDevice",
6   "@type": [
7     "owl#NamedIndividual",
8     "oneM2M#Device" ],
9   "oneM2M#hasFunctionality": [
10    { "@id": "myn#switchOff" } ],
11   "oneM2M#hasService": {
12     "@id": "myn#netconf" },
13   "oneM2M#hasThingProperty": [
14     { "@id": "myn#deviceUuid" } ] ],
15 { "myn": "netconf",
16   "@type": [
17     "owl#NamedIndividual",
18     "oneM2M#Service" ],
19   "oneM2M#exposesFunctionality": [
20     { "@id": "myn#switchOff" } ],
21   "oneM2M#hasOperation": [
22     { "@id": "myn#offOperation" } ] ],
23 { "myn": "offOperation",
24   "@type": [
25     "owl#NamedIndividual",
26     "oneM2M#Operation" ],
27   "oneM2M#exposesCommand": {
28     "@id": "myn#mqttCommandOff" },
29   "oneM2M#hasInput": {
30     "@id": "myn#input" },
31   "myn#mqttMethod": "OFF",
32   "myn#mqttTopic": "led/UUID#" },
33 { "myn": "switchOff",
34   "@type": [
35     "owl#NamedIndividual",
36     "oneM2M#ControllingFunctionality" ],
37   "oneM2M#hasCommand": {
38     "@id": "myn#mqttCommandOff" },
39 }
```

Snippet of the generated YANG Model

```
1 ( 'module mqtt-led
2 { ...
3   container device {
4     description "MQTT-Device identified by UUID";
5     list device-id {
6       key "uuid";
7       leaf uuid {
8         type string; } }
9   }
10  rpc switchOff {
11    description "Switches the LIFX-Led off";
12    input {
13      leaf uuid {
14        description "Target UUID for request";
15        type string; } }
16  }
17 },
18 { 'switchOff': ('OFF', 'led' ) },
19 { 'F97DF79-8A12-4F4F-8F69-6B8F3C2E78DD' },
20 'LED-LAMP' )
```

Experiments

Hardware: CC2538 Development Kit from Texas Instruments

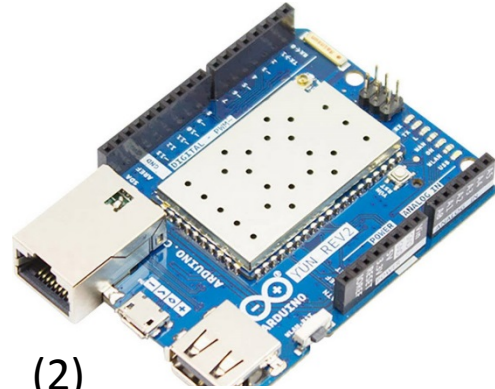


- 32 kiB RAM
- 512 kiB Flash Speicher
- Low Power RF ARM Cortex M3-based System 32-bit processor
- IEEE 802.15.4 compliant (6LoWPAN)

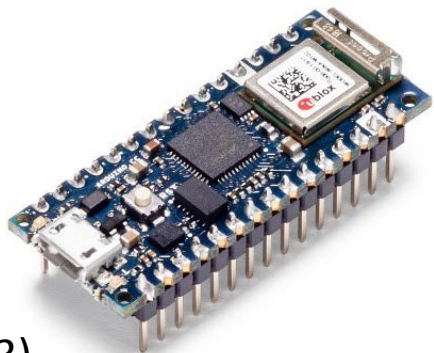
Further heterogeneous Devices with WLAN support



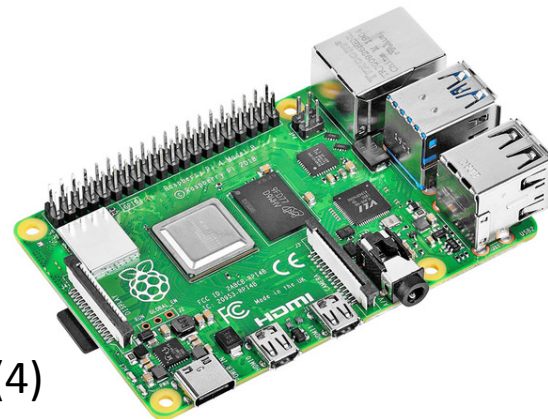
(1)



(2)



(3)



(4)

1. ESP 32 NodeMCU (512 KB RAM, 16 MB ROM)
2. Arduino Yún Rev 2 (16 MB RAM, 64 MB ROM)
3. Arduino Nano 33 IoT (32KB RAM, 256 KB ROM)
4. Raspberry Pi 3 B (1 GB RAM, up to 64 GB ROM through SD card)

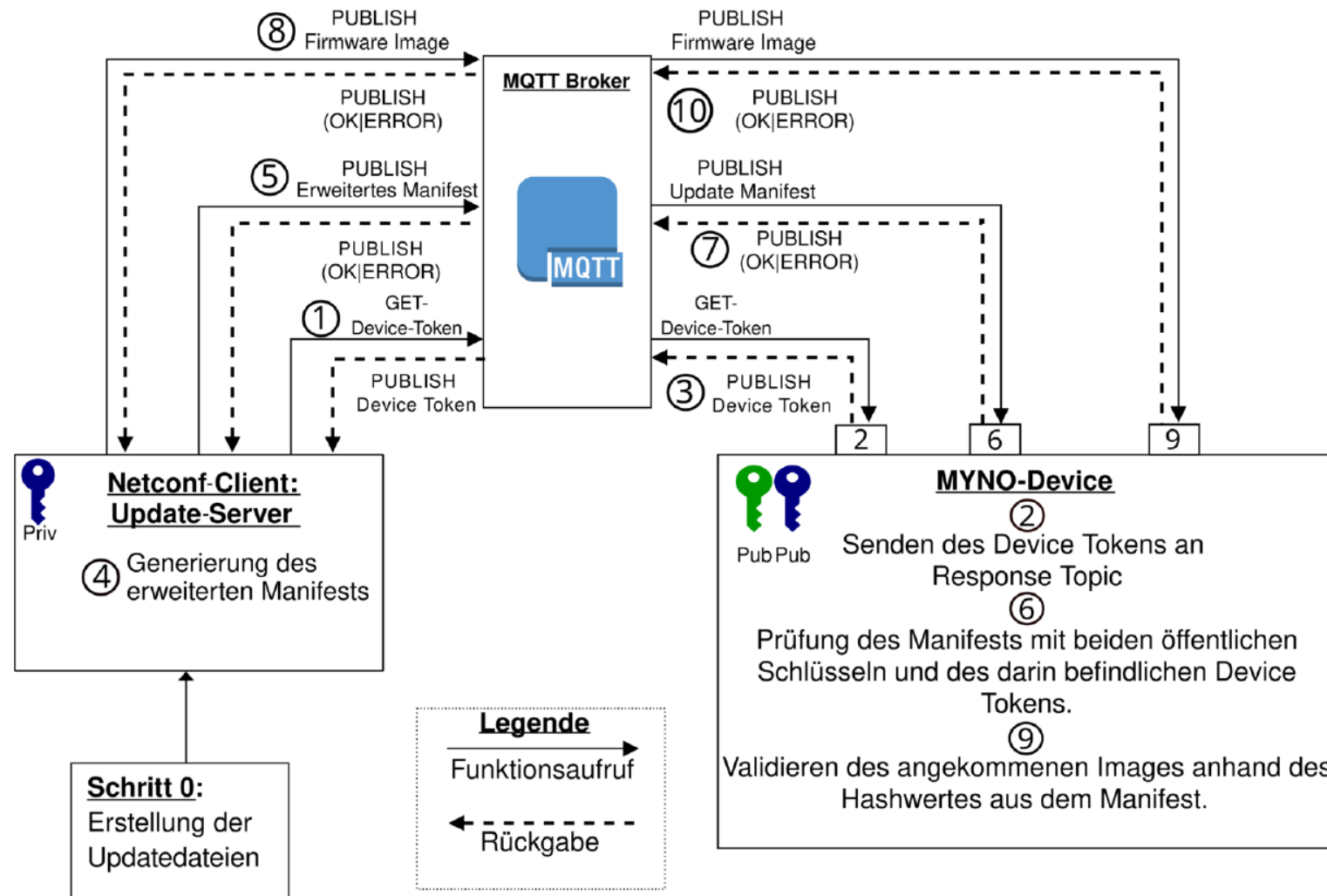
MYNO Update Protocol

Master Thesis of Michael Nowak

Create a Firmware Update



MUP = MYNO Update Protocol



Conclusion

MYNO – comparison aspects

- semantic-based approach: ontology-based device descriptions
- distributed architecture: all components can be distributed
- edge-computing: MQTT Broker and NETCONF-MQTT bridge can run on the edge (Raspberry Pi)
- remote discovery scope: through distributed architecture
- interoperability through standards: MQTT, NETCONF, YANG
- scalability: many devices can connect to MQTT broker
- context-awareness: no (additional configuration required)
- security: secure MYNO Update Protocol, MQTT with TLS and NETCONF over SSH
- bootstrapping: CRUD operations
- network/device management: web-based NETCONF client

References

- *Ontology-driven Device Descriptions for IoT Network Management*
K. Sahlmann, T. Scheffler and B. Schnor, 3rd Workshop on Interoperability and Open-Source Solutions for the Internet of Things (InterOSS-IoT)
Bilbao, Spain, Germany, June 2018
- *Managing IoT device capabilities based on oneM2M ontology descriptions*
K. Sahlmann, T. Scheffler and B. Schnor
16th GI/ITG KuVS Fachgespräch: Drahtlose Sensornetze
Hamburg, Germany, September 2017
- <https://www.cs.uni-potsdam.de/bs/research/projectlot.html>
- <https://www.cs.uni-potsdam.de/bs/teaching/studentThesis.html>