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CHALLENGES FOR SEMANTIC LWM2M INTEROPERABILITY IN COMPLEX IoT SYSTEMS

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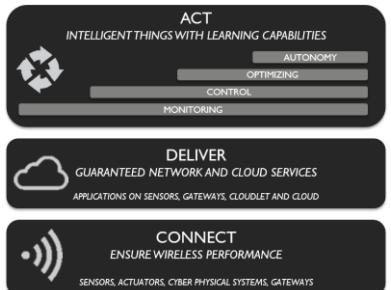
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Fundamental: 3 M€
Strategic: 3,5 M€
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PROJECT HyCoWare

Hybrid Connected Warehouses

WAREHOUSES : Handling of goods by people using transport systems



Increased efficiency and quality → Automated handling



PROJECT HyCoWare

THE PROJECT'S GOALS

NOVEL CONNECTED PRODUCTS

for goods, operators and transport systems,
building upon wireless IoT



Connected operator



Chain-conveyor system:
operator feedback,
localization...



In/outdoor connected
goods via hybrid tags and
advanced readers



2D always-connected
shuttle



Connected operator



ROBUST, FLEXIBLE INTEGRATED SYSTEM

Diagnosable heterogeneous wireless connectivity
Plug-and-produce using open IoT standards

OPEN IoT STANDARDS IN HYCOWARE

OPEN IoT STANDARD-BASED

- Discovery*
- Device management*
- Data access*
- ...

The screenshot shows the Leshan interface with two main sections: "LWM2M Security" and "LWM2M Server".

LWM2M Security: Shows a list of security-related resources with their URIs and status (e.g., Instance 0, LWM2M Server Uri, /0/0).

LWM2M Server: Shows a list of server-related resources with their URIs and status (e.g., Instance 0, Short Server ID, /0/0).

CONNECTED OPERATOR

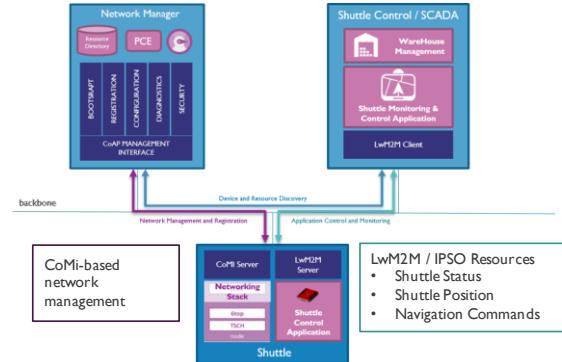


CONVEYOR SYSTEM

SENSRACIUTATOR	LWM2M Objects
APP	/1 LWM2M Server
LWM2M/IPSO	/3 LWM2M Device
CoAP	/4 Connectivity monitoring
UDP	/6 Location
IPv6/v4	/3341 Addressable text display
Wi-Fi	



2D-SHUTTLE



HYBRID TAG



LwM2M / IPSO

CoAP

UDP

IPv6

BLE

LoRa

RFID

WiFi

OUR CONTRIBUTION

CHALLENGES FOR SEMANTIC LWM2M INTEROPERABILITY in COMPLEX IoT SYSTEMS

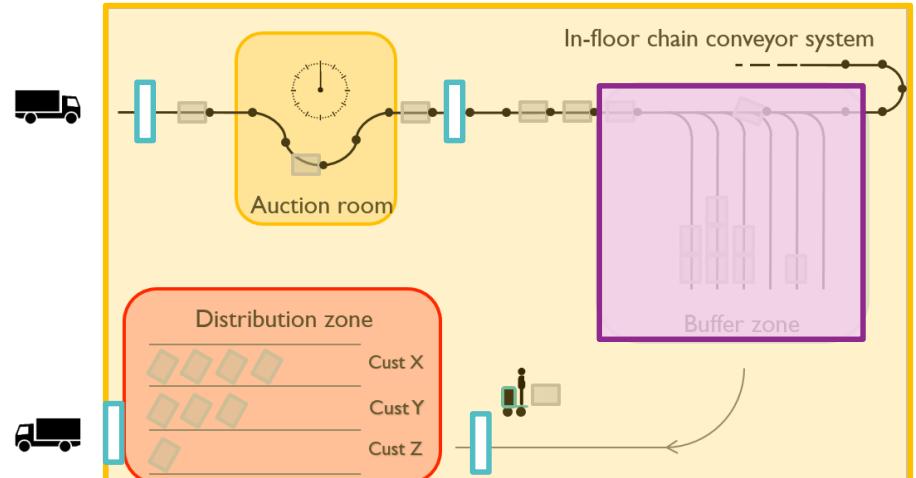
- Hybrid Sensors/Tags
- Support for a reversed LWM2M interaction model
- Management of Constrained Networks
- Bridging RESTful client-server and pub/sub architectures while preserving semantics

HYBRID SENSORS/TAGS

HYBRID SENSORS/TAGS

HYCOWARE - CONNECTED GOODS & OPERATORS

AIM – increase visibility of trolleys carrying buckets with flowers



Blind Spots: Increase visibility of assets by extended localization

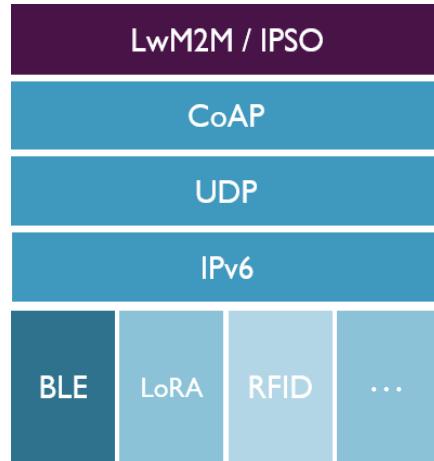


HYBRID TAG DESIGN



1st prototype is available. Serves as development platform.
Pilot production: end of year.

Every tag modelled as single LWM2M device (thousands of tags)



LWM2M Objects	
/1	LWM2M Server
/3	LWM2M Device
/4	Connectivity monitoring (Multiple)
/6	Location / Position
/...	Battery Level
/...	Sensor info (T/Rh)
/...	...

- Individual resources for battery level, temperature, position...
- Custom LwM2M Object for Hybrid Tag??
 - Too Fine Grained...
- Requires many interactions to retrieve all data. e.g. observing on position data!!
- IPSO Composite Object??

HYBRID TAG

LWM2M BATCH MODEL WITH AGGREGATED RESOURCES

Object	Object ID	Object URN	Multiple instances?
LWM2M Batch object	XXXX	urn:oma:lwm2m:ext:XXX	Yes

GET on /XXXX/0/YYYY

```
{"value": ["/1/3/1", "3311/0/5850"]}
```

Resource info

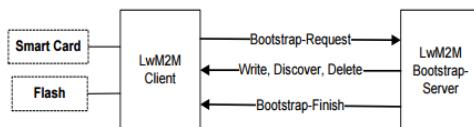
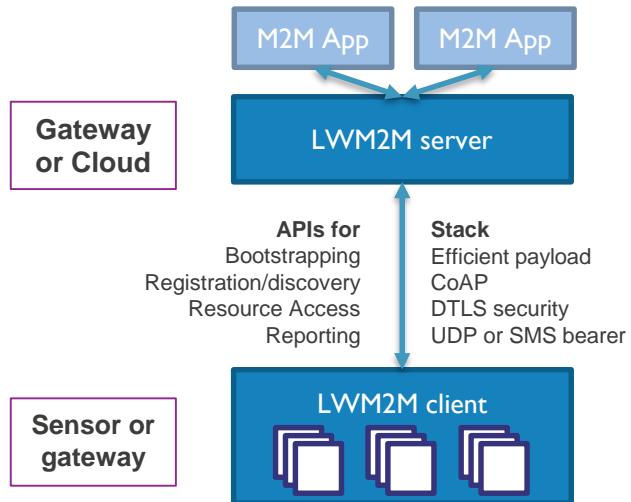
Resource name	Resource ID	Access Type	Multiple instances?	Description
Batch configuration	YYYY	R/W	No	Retrieves or sets batch configuration
Batch value	ZZZZ	R(W)	No	Retrieves or writes

GET on /XXXX/0/ZZZZ

```
{"value": [
    { "uri" : "1/3/1", "value" : "..." },
    { "uri" : "3311/0/5850", "value" : "..." }
]}
```

SUPPORT FOR A REVERSED LWM2M INTERACTION MODEL

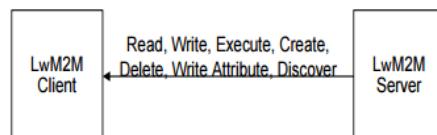
LWM2M INTERACTION MODEL



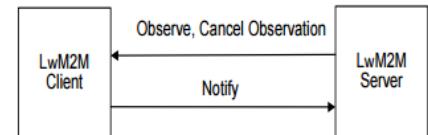
Bootstrap



Client Registration



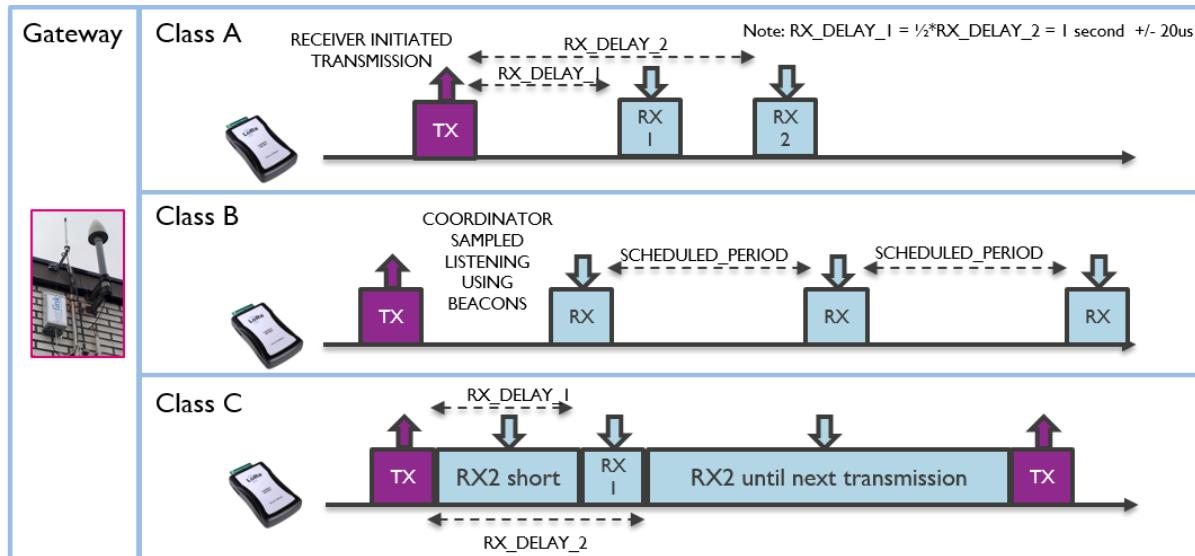
Device Management and Service Enablement



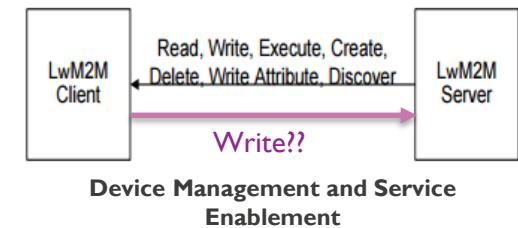
Information Reporting

SUPPORT FOR A REVERSED LWM2M INTERACTION MODEL

LORAWAN DEVICE CLASSES AND MAC



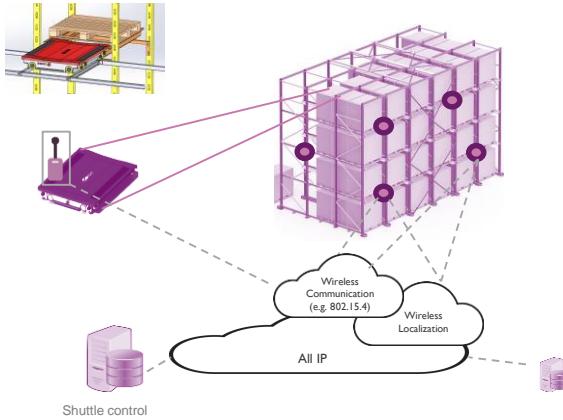
Mostly Class A Devices available on the market today



MANAGEMENT OF CONSTRAINED NETWORKS

MANAGEMENT OF CONSTRAINED NETWORKS

HYCOWARE - 2D-SHUTTLE

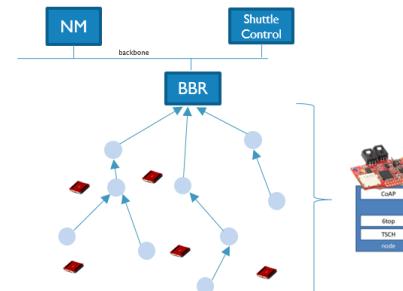
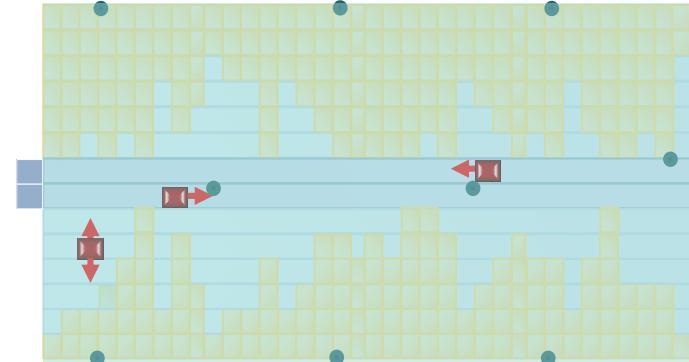


Intelligent Self Contained Transport Vehicles

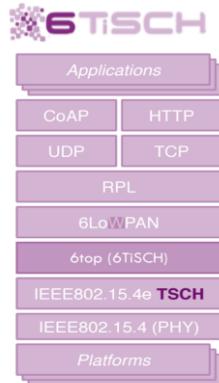
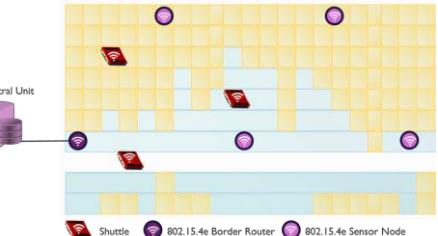


Reliable, Deterministic and Latency Bounded Communication with Shuttle Control System

- To Send Status and Position Updates
- To Receive Navigation Commands

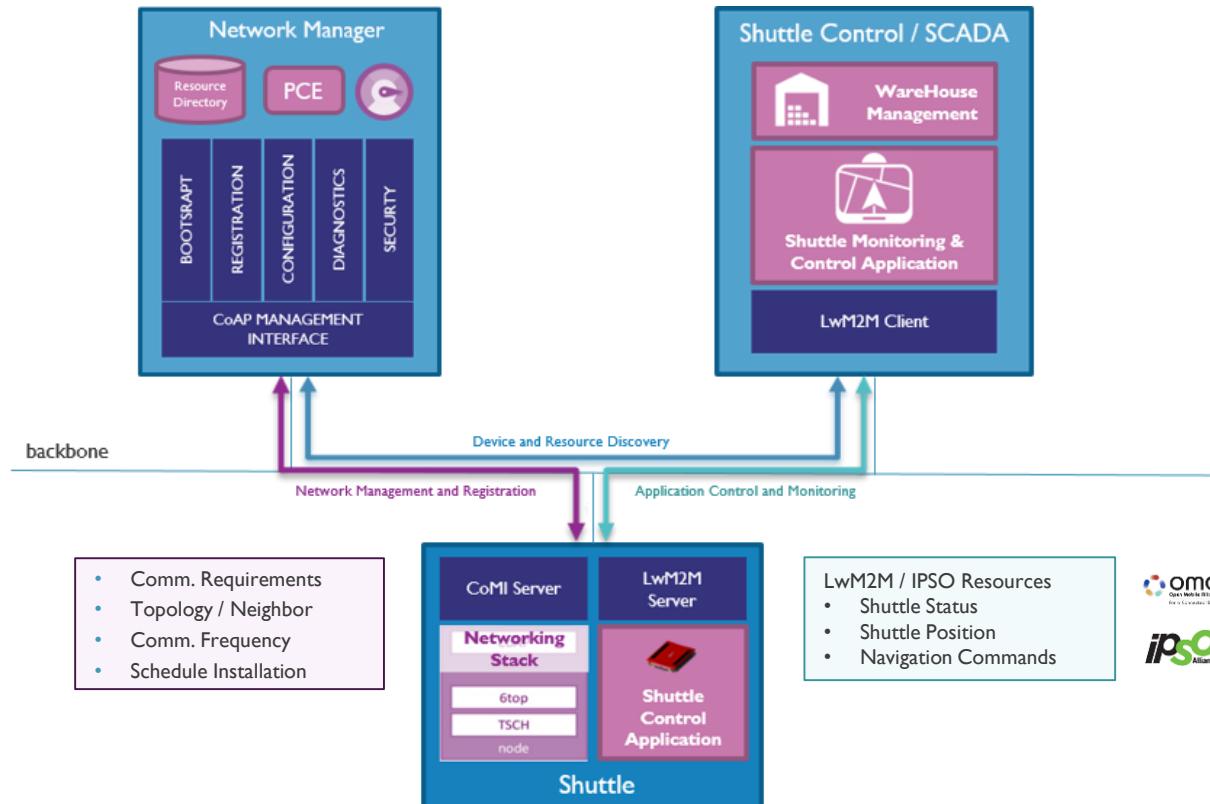


802.15.4e 'Mesh' with wireless backbone



MANAGEMENT IN CONSTRAINED NETWORKS

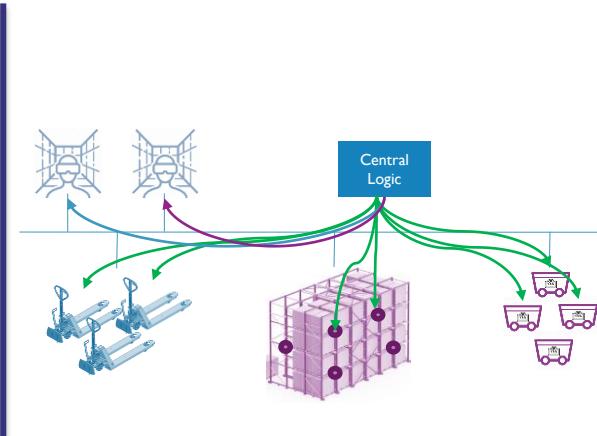
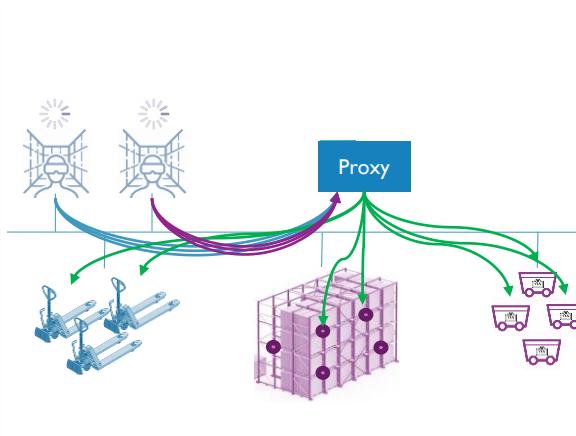
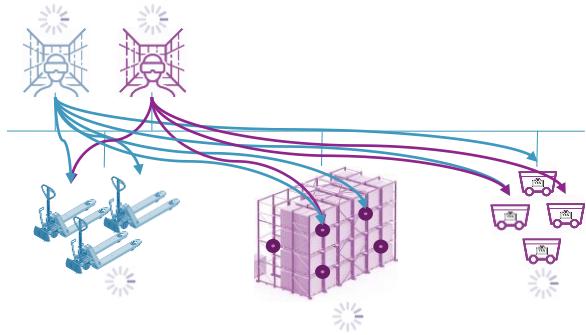
SYSTEM ARCHITECTURE



BRIDGING RESTFUL CLIENT-SERVER AND PUB/SUB ARCHITECTURES WHILE PRESERVING SEMANTICS

PUB/SUB <-> REST BRIDGE

PROBLEM DESCRIPTION



PUB/SUB??

- Each client has to maintain observe on several resources on several devices
 - Each End-device (possibly embedded/constrained) has to handle several notifications for observe requests from various clients for several resources
 - Excessive number of observe and notification messages
- Each client has to maintain observe on several resources on several devices
 - Each End-device (possibly embedded/constrained) has to handle notifications for observe requests for several resources, **but one notification per resource**
 - **Relatively less** number of observe and notification messages

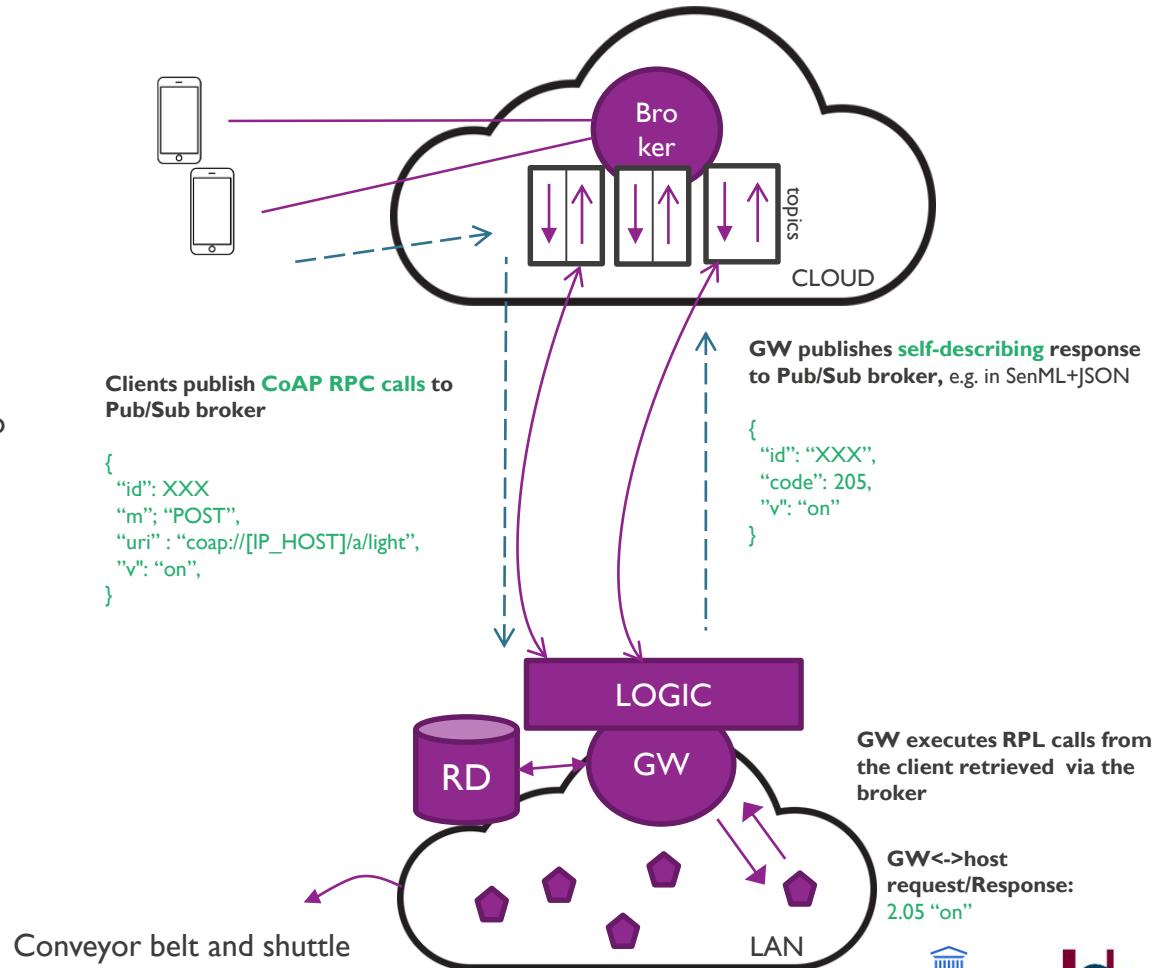
- Main logic is on Central Unit
- Only, central logic has to maintain observe on several resources on several devices and notify client nodes if and only if it is necessary
- Each End-device (possibly embedded/constrained) has to handle notifications for observe requests for several resources, **but one notification per resource**

PUB/SUB <-> REST BRIDGE

Goal? Facilitate data exchange and control between pub/sub and REST hosts.

How? Build a bridge that translates between the two paradigms. Consists of two components:

1. Sharing CoAP responses with subscribers
 2. CoAP request RPC API to issue CoAP requests
- All messages are exchanged in JSON.



CONCLUSION

- Open IoT Standards
 - Flexible, diverse and configurable IoT-based applications
 - Widely scalable and distributed networks of heterogeneous devices, systems and services **at any scale**
 - Several standardization efforts (e.g. LWM2M, IPSO, OCF, oneM2M) defining appropriate semantics to boost the interoperability in the IoT Ecosystem
- Challenges
 - The interoperation and orchestration of devices and systems from different ecosystems
 - Defining complex standard-compliant IoT devices and systems



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