CHALLENGES FOR SEMANTIC LWM2M INTEROPERABILITY IN COMPLEX IoT SYSTEMS

Abdulkadir KARAAGAC*, Floris Van Den ABEELE, Jeroen HOEBEKE

JULY 15, 2017

INTERNET & DATA SCIENCE LAB

IDLAB
GHENT & ANTWERP

300

Internet experts and data scientists

IDLab focuses its research on *internet technologies* and *data science*. We develop technologies outperforming current solutions for communication subsystems, high speed and low power networking, distributed computing and multimedia processing, machine learning, artificial intelligence and web semantics.

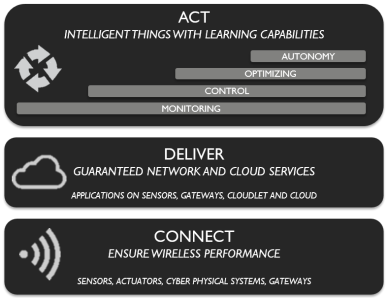
+500

Collaborations with innovative industry

IDLab collaborates with many universities and research centres worldwide and jointly develops advanced technologies with industry (R&D centers from international companies, Flanders' top innovating large companies and SMEs, as well as numerous ambitious startups).

40+ Professors,
40+ Post Docs

Total income (projects): 15 M€/Y
- **Fundamental: 3 M€**
- **Strategic: 3,5 M€**
- **EU projects: 4 M€**
- **Local industry: 4,5 M€**



www.idlab.technology
www.idlab.uantwerpen.be
www.idlab.ugent.be

imec

GHENT UNIVERSITY
Universiteit Antwerpen

PROJECT HyCoWare

Hybrid Connected Warehouses

WAREHOUSES : Handling of goods by people using transport systems



Increased efficiency and quality ➔ Automated handling

eGemin AUTOMATION
CONNECTED CARRIERS
(E'Tow, AGV, cranes. etc.)

AUCXIS RFID SOLUTIONS
CONNECTED GOODS
(RFID tags & readers)

intation
INDUSTRIAL WIRELESS
CONNECTED PEOPLE

waves

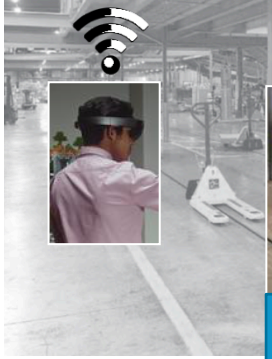
IDLab
INTERNET & DATA LAB

PROJECT HyCoWare

THE PROJECT'S GOALS

NOVEL CONNECTED PRODUCTS
for goods, operators and transport systems,
building upon wireless IoT

intation — Connected operator

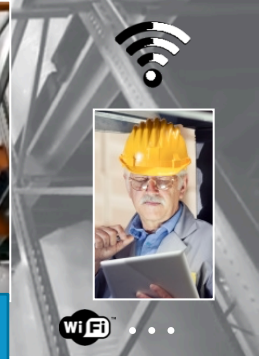


egemin AUTOMATION — Chain-conveyor system: operator feedback, localization…

AUCXIS RFID SOLUTIONS — In/outdoor connected goods via hybrid tags and advanced readers

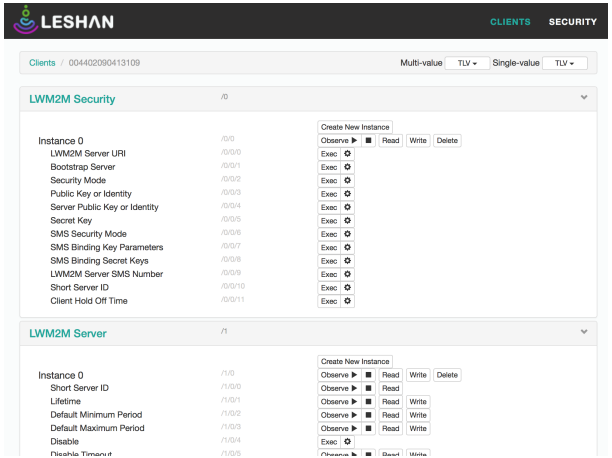
egemin AUTOMATION — 2D always-connected shuttle

intation — Connected operator



ROBUST, FLEXIBLE INTEGRATED SYSTEM
Diagnosable heterogeneous wireless connectivity
Plug-and-produce using open IoT standards

OPEN IoT STANDARDS IN HYCOWARE



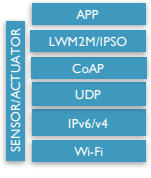
OPEN IoT STANDARD-BASED

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

...

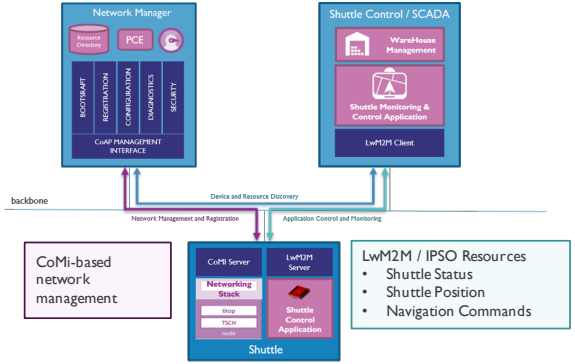
CONNECTED OPERATOR

CONVEYOR SYSTEM

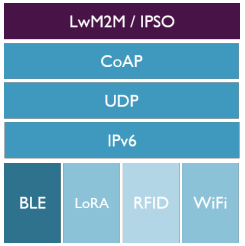


LWM2M Objects	
/1	LWM2M Server
/3	LWM2M Device
/4	Connectivity monitoring
/6	Location
/3341	Addressable text display

2D-SHUTTLE



HYBRID TAG



OUR CONTRIBUTION

CHALLENGES FOR SEMANTIC LWM2M INTEROPERABILITY in COMPLEX IoT SYSTEMS

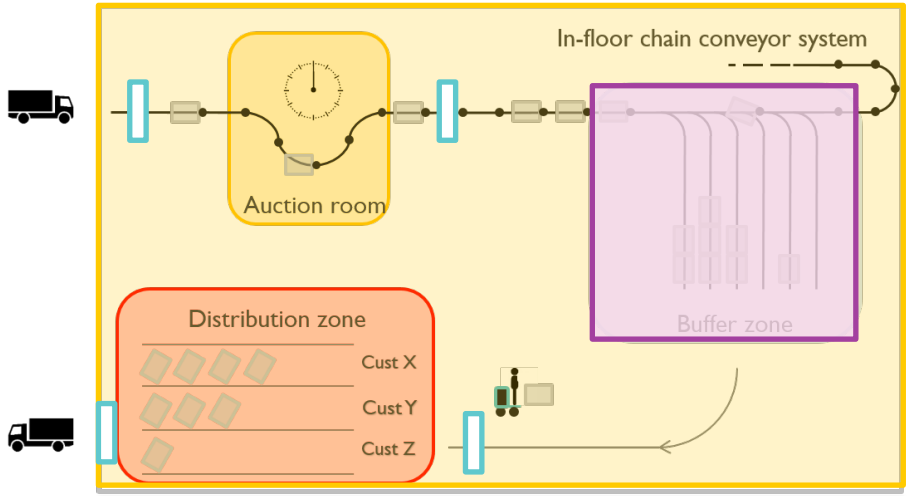
- Hybrid Sensors/Tags
- Support for a reversed LWM2M interaction model
- Management of Constrained Networks
- Bridging RESTful client-server and pub/sub architectures while preserving semantics

HYBRID SENSORS/TAGS

HYBRID SENSORS/TAGS

HYCOWARE - CONNECTED GOODS & OPERATORS

AIM – increase visibility of trolleys carrying buckets with flowers



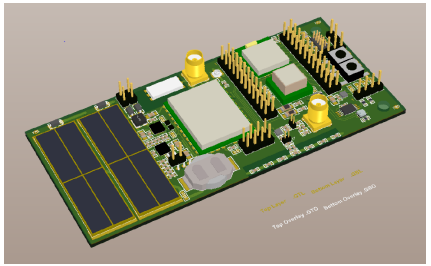
Blind Spots: Increase visibility of assets by extended localization

imec

GHENT UNIVERSITY

Universiteit Antwerpen

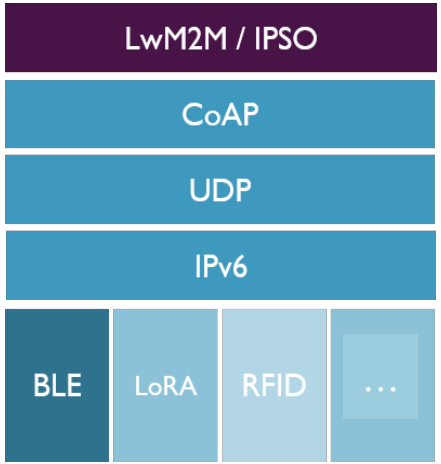
HYBRID TAG
DESIGN



1st prototype is available. Serves as development platform.

Pilot production: end of year.

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



Hybrid Tag

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

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/YYYY

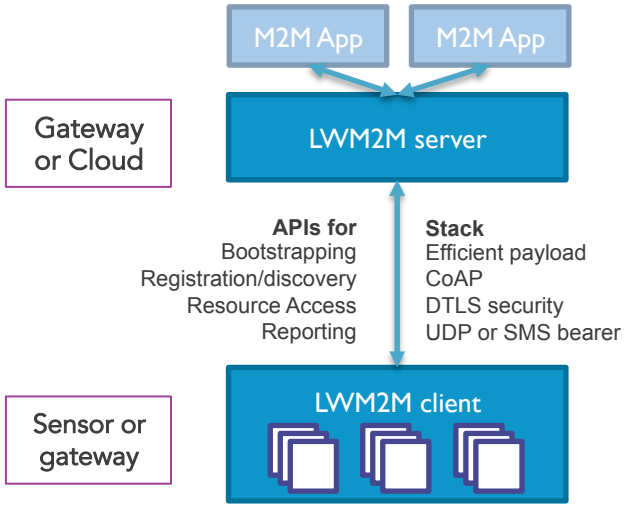
```
{“value”: [”/1/3/1",”/3311/0/5850"]}
```

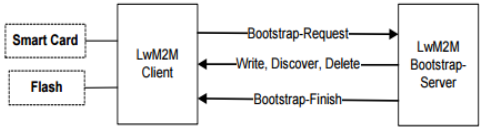
GET on /XXXX/0/ZZZZ

```
{“value”: [
      { “uri” : “/1/3/1”, ”value” : ”…”},
      { “uri” : “/3311/0/5850”, ”value” : ”…”}
]}
```

SUPPORT FOR A REVERSED LWM2M INTERACTION MODEL

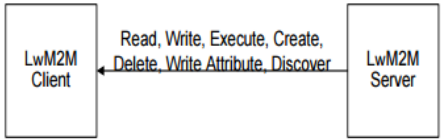
LWM2M INTERACTION MODEL



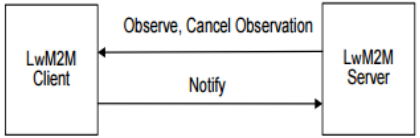


Bootstrap

Client Registration



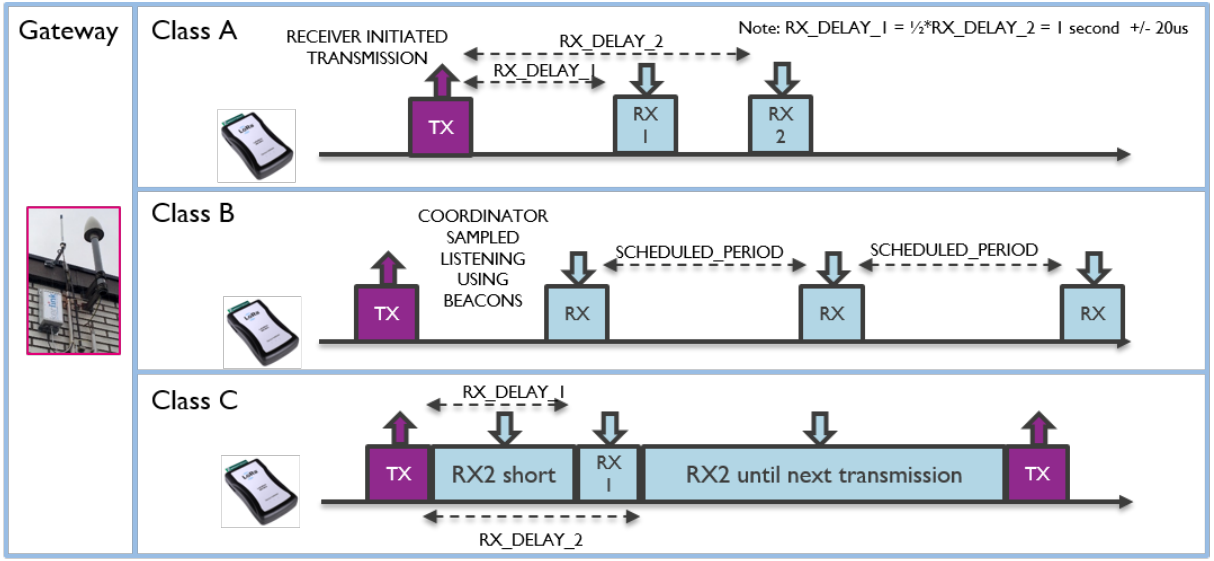
Device Management and Service Enablement



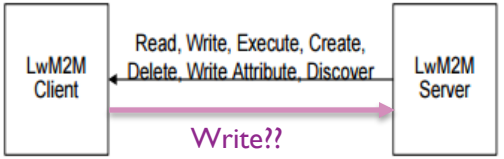
Information Reporting

SUPPORT FOR A REVERSED LWM2M INTERACTION MODEL

LORAWAN DEVICE CLASSES AND MAC



Mostly Class A Devices available on the market today



Device Management and Service Enablement

SUPPORT FOR A REVERSED LWM2M INTERACTION MODEL

LORAWAN DEVICE CLASSES AND MAC

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

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
Short Server ID	…	R(/W)	No	ID of server to which data will be sent (allows to retrieve server URI and security info in corresponding Server and Security Object)
URI Path	…			URI path on server
Periodicity	…	R/W	No	Frequency of uplink transmissions in seconds

* Or extension of previously introduced batch object

Every 'periodicity' seconds

PUT on coaps://server.example.com/URI_path

Credentials | Server URI | URI path

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

Preserve semantcis

imec

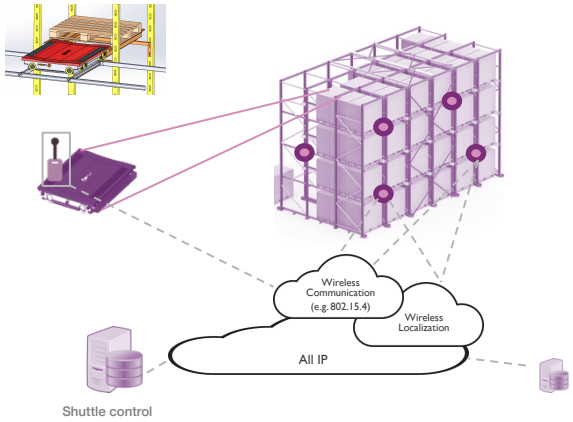
GHENT UNIVERSITY

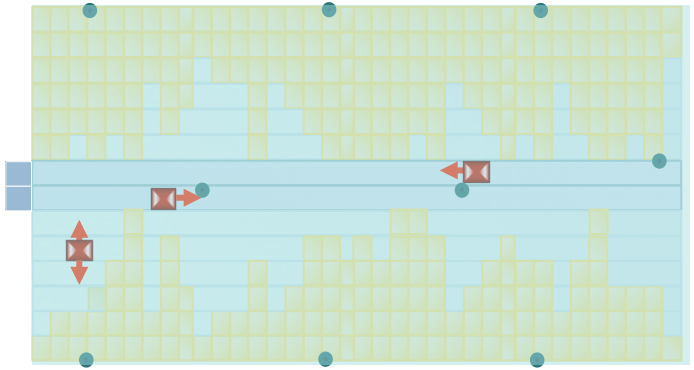
Universiteit Antwerpen

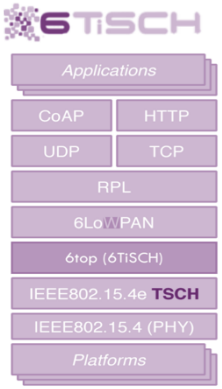
MANAGEMENT OF CONSTRAINED NETWORKS

MANAGEMENT OF CONSTRAINED NETWORKS

HYCOWARE - 2D-SHUTTLE



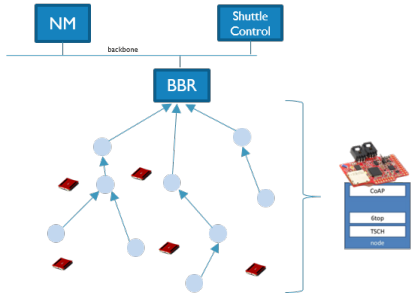




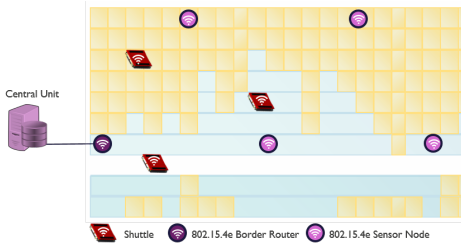
Intelligent Self Contained Transport Vehicles

Reliable, Deterministic and Latency Bounded Communication with Shuttle Control System

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

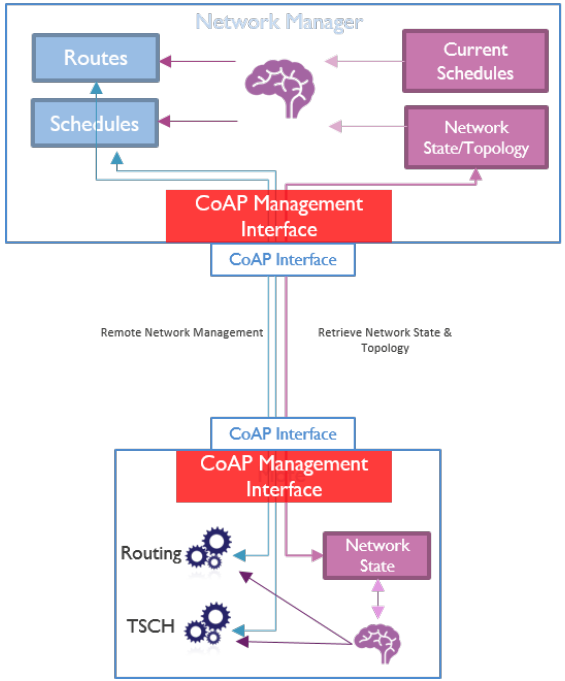


802.15.4e 'Mesh' with wireless backbone



MANAGEMENT OF CONSTRAINED NETWORKS

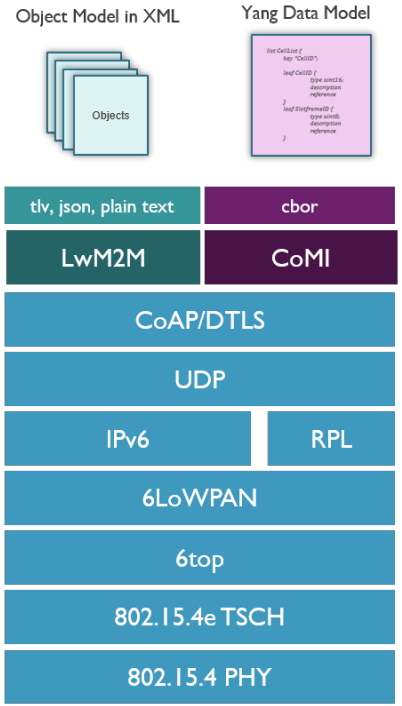
DYNAMIC WIRELESS INDUSTRIAL NETWORKS



II Remote Scheduling and Routing

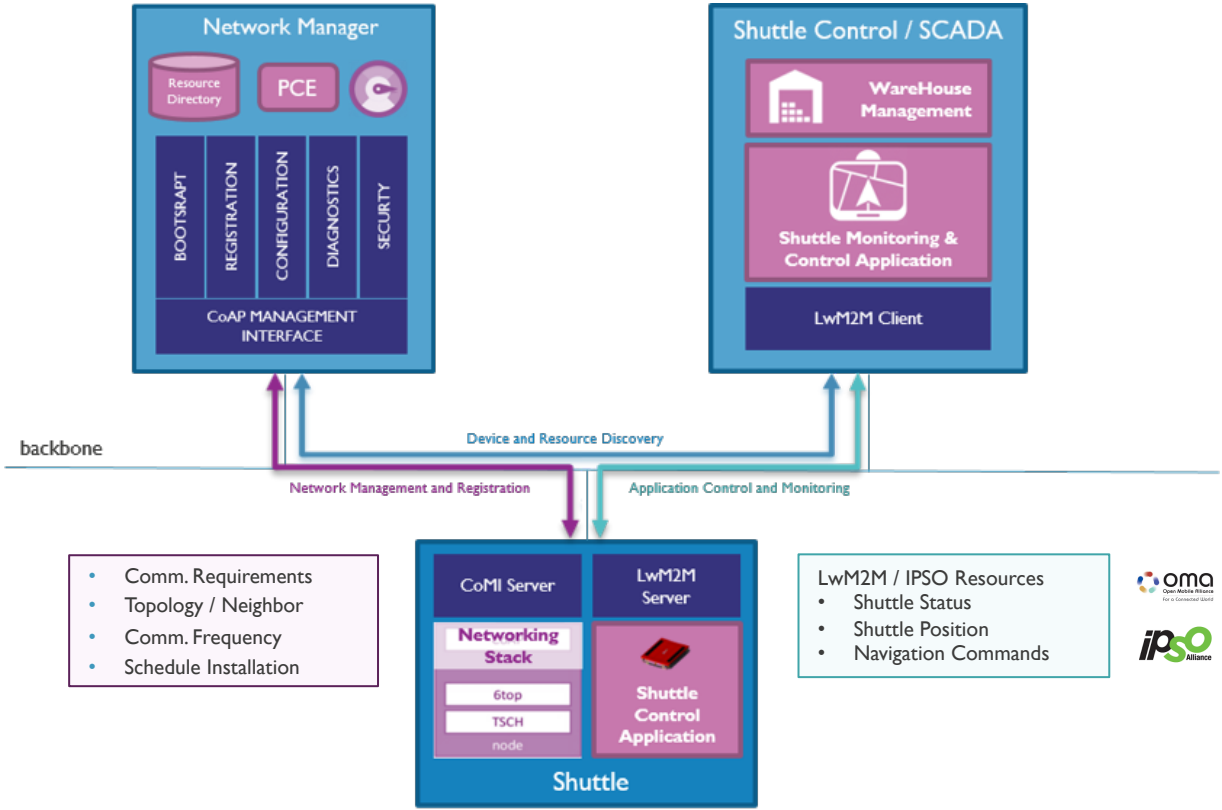
III Management Interface

I Distributed Scheduling and Routing



MANAGEMENT IN CONSTRAINED NETWORKS

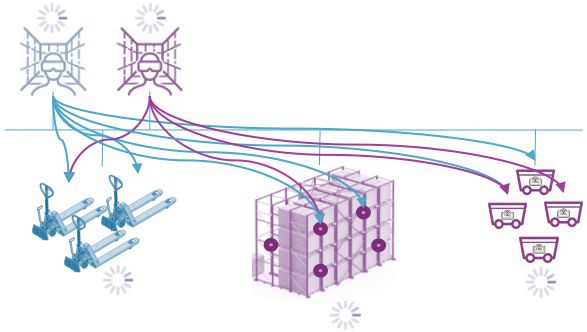
SYSTEM ARCHITECTURE



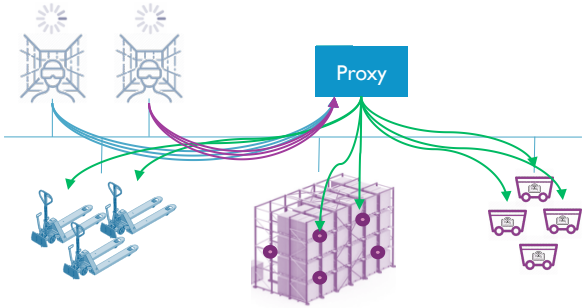
BRIDGING RESTFUL CLIENT-SERVER AND PUB/SUB ARCHITECTURES WHILE PRESERVING SEMANTICS

PUB/SUB <-> REST BRIDGE

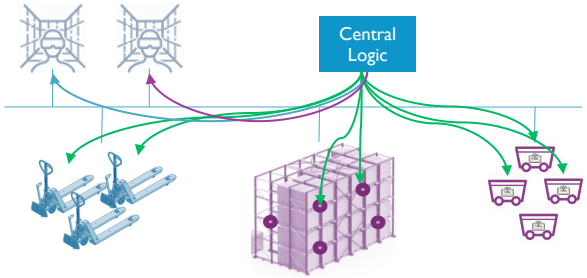
PROBLEM DESCRIPTION



- 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



PUB/SUB??

- 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

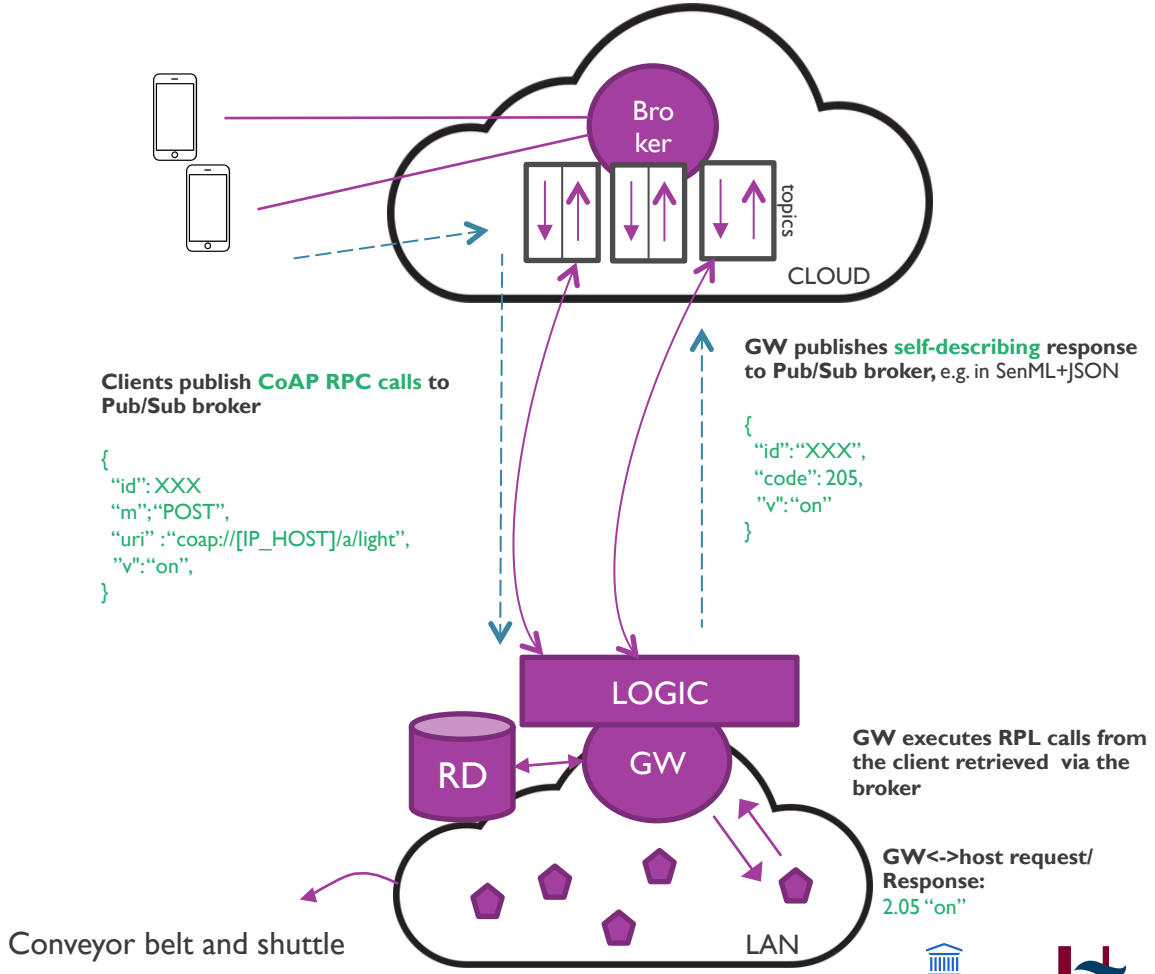
PUB/SUB <-> REST BRIDGE

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
  - What to do when the standard does not exactly offer what you need?

GHENT UNIVERSITY

IDLab
INTERNET & DATA LAB

imec
embracing a better life

Abdulkadir Karaagac

Ghent University – IDLab - imec
iGent Tower - Department of Information Technology
Technologiepark-Zwijnaarde 15, B-9052 Ghent, Belgium
Office 210.010 (11th Floor)
E-mail: abdulkadir.karaagac@ugent.be
Web: IDLab.UGent.be

embracing a better life