Karlsruhe Institute of Technology

Mashups of Things and APIs

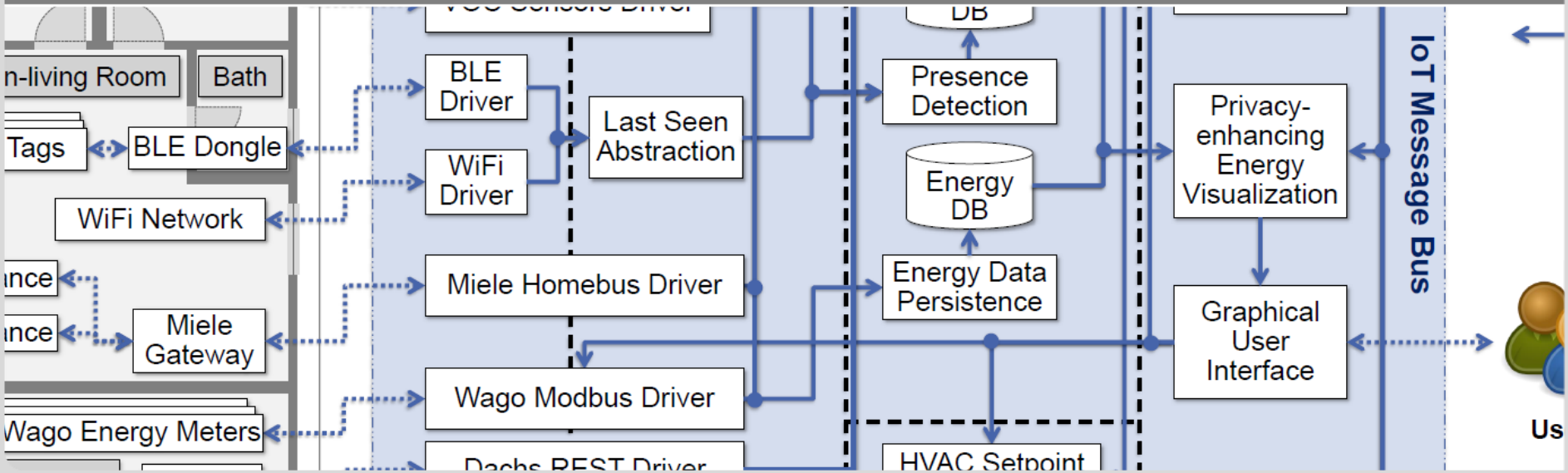
aifb

A Microservice Architecture for the Intranet of Things and Energy in Smart Buildings

The first International Workshop on Mashups of Things and APIs (MOTA 2016)

Kaibin Bao, Ingo Mauser, Sebastian Kochanneck, Huiwen Xu, Hartmut Schmeck

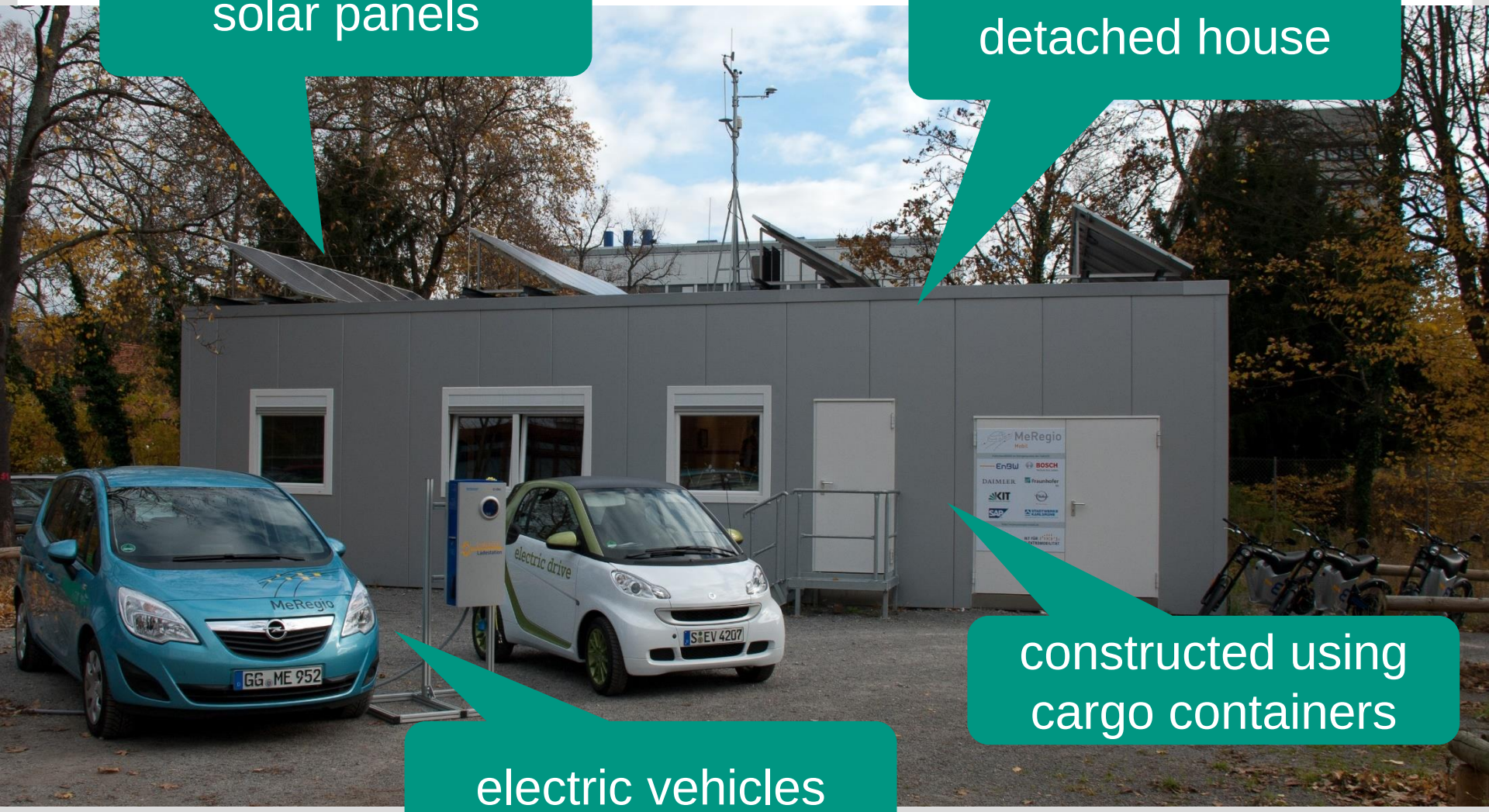
INSTITUTE OF APPLIED INFORMATICS AND FORMAL DESCRIPTION METHODS (AIFB)



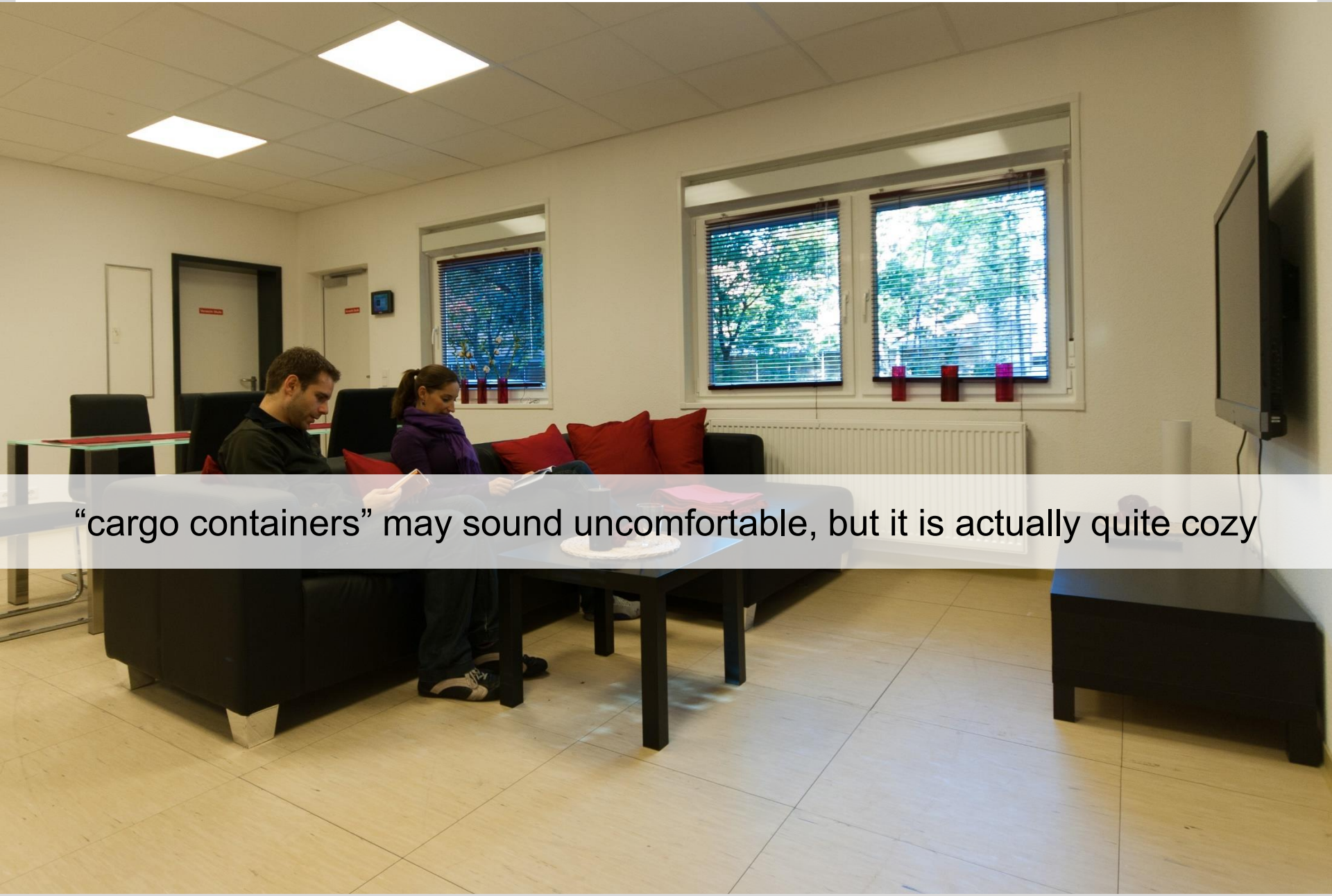
Outline

- USE CASE — Energy Smart Home Lab
- THE PAST — Challenges and Requirements
  Other Architectures for IoT, DSM, HA
- TRANSITION — Selection of a Message Bus Protocol
- THE PRESENT — Our Microservice Architecture
  Conclusion

Energy Smart Home Lab (ESHL)
Research Lab for Demand Side Management

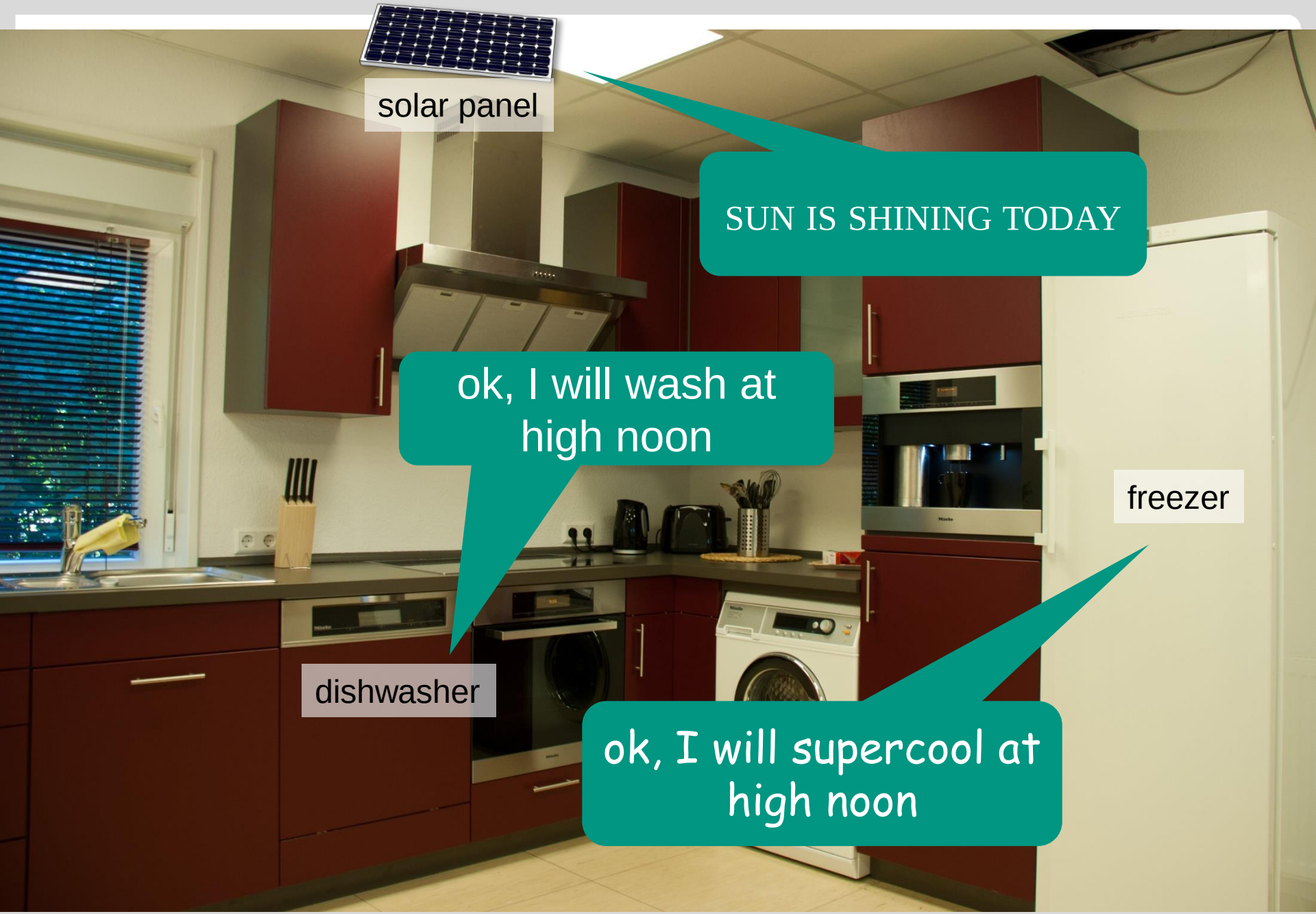


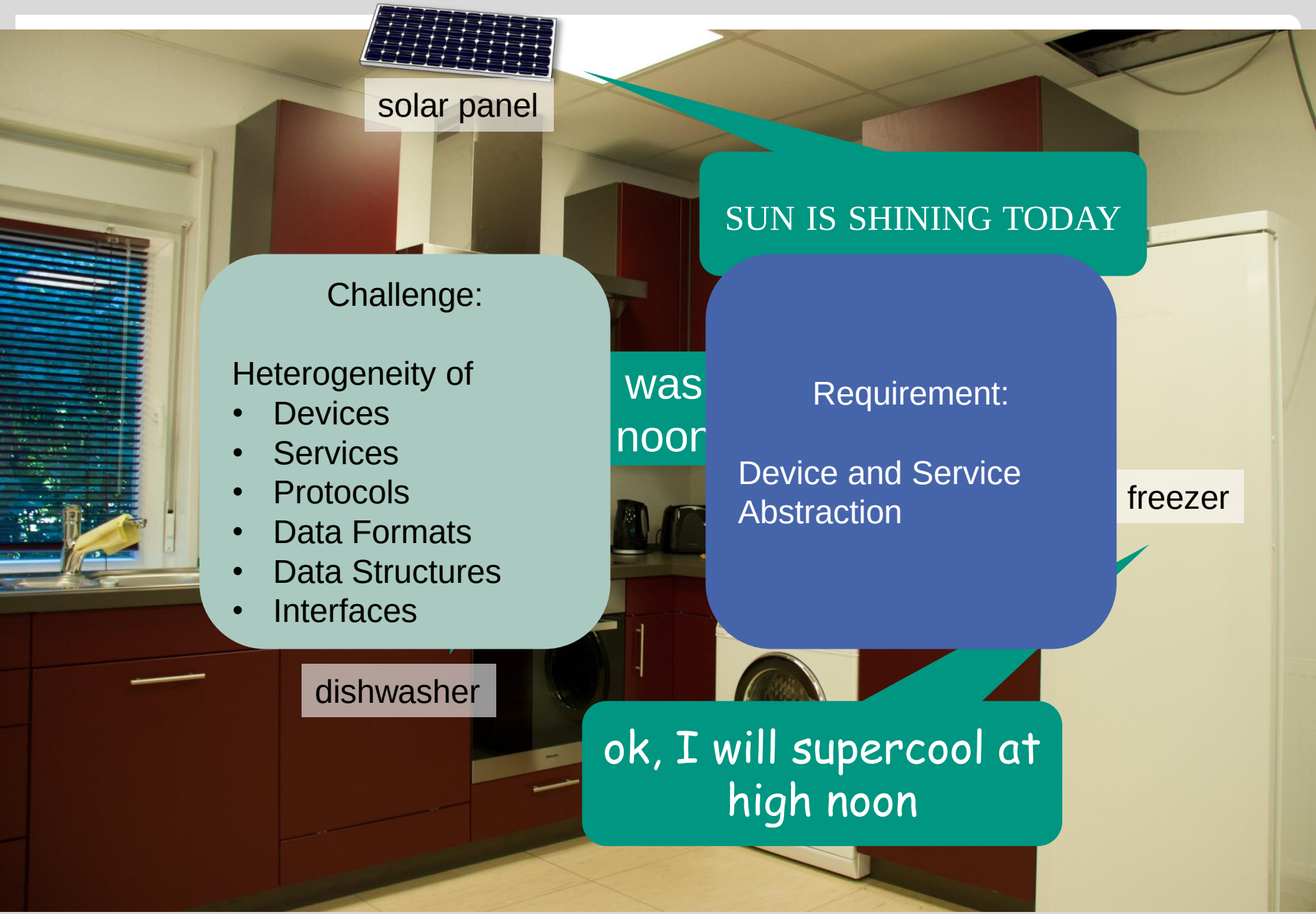
Institute of Applied Informatics and Formal Description Methods aifb


“cargo containers” may sound uncomfortable, but it is actually quite cozy

Research Topics for the ESHL

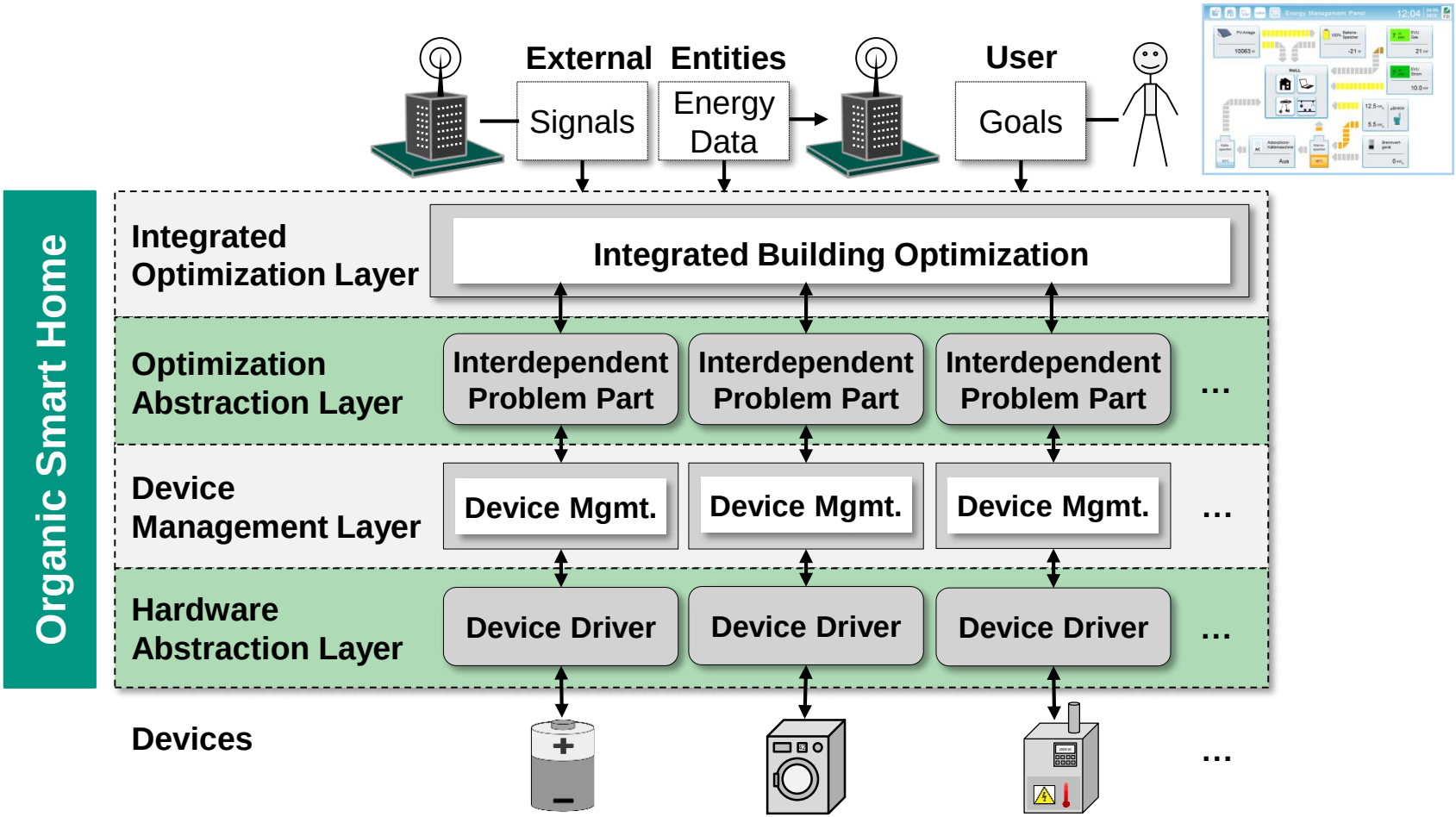
- electric load shaping
  - consume electricity when RES availability is high
  - produce own electricity when energy prices are high
  - reschedule time and intensity of home appliance activation


solar panel
SUN IS SHINING TODAY
ok, I will wash at high noon
freezer
dishwasher
ok, I will supercool at high noon


solar panel
SUN IS SHINING TODAY
Challenge:
Heterogeneity of
• Devices
• Services
• Protocols
• Data Formats
• Data Structures
• Interfaces
was
noon
Requirement:
Device and Service Abstraction
freezer
dishwasher
ok, I will supercool at high noon

Organic Smart Home: Simplified Architecture

www.organicsmarthome.org



More about Organic Smart Home architecture and optimization:
Mauser, I.; Müller, J.; Allerding, F. & Schmeck, H.: "Adaptive Building Energy Management with Multiple Commodities and Flexible Evolutionary Optimization", Renewable Energy, Elsevier, 2015

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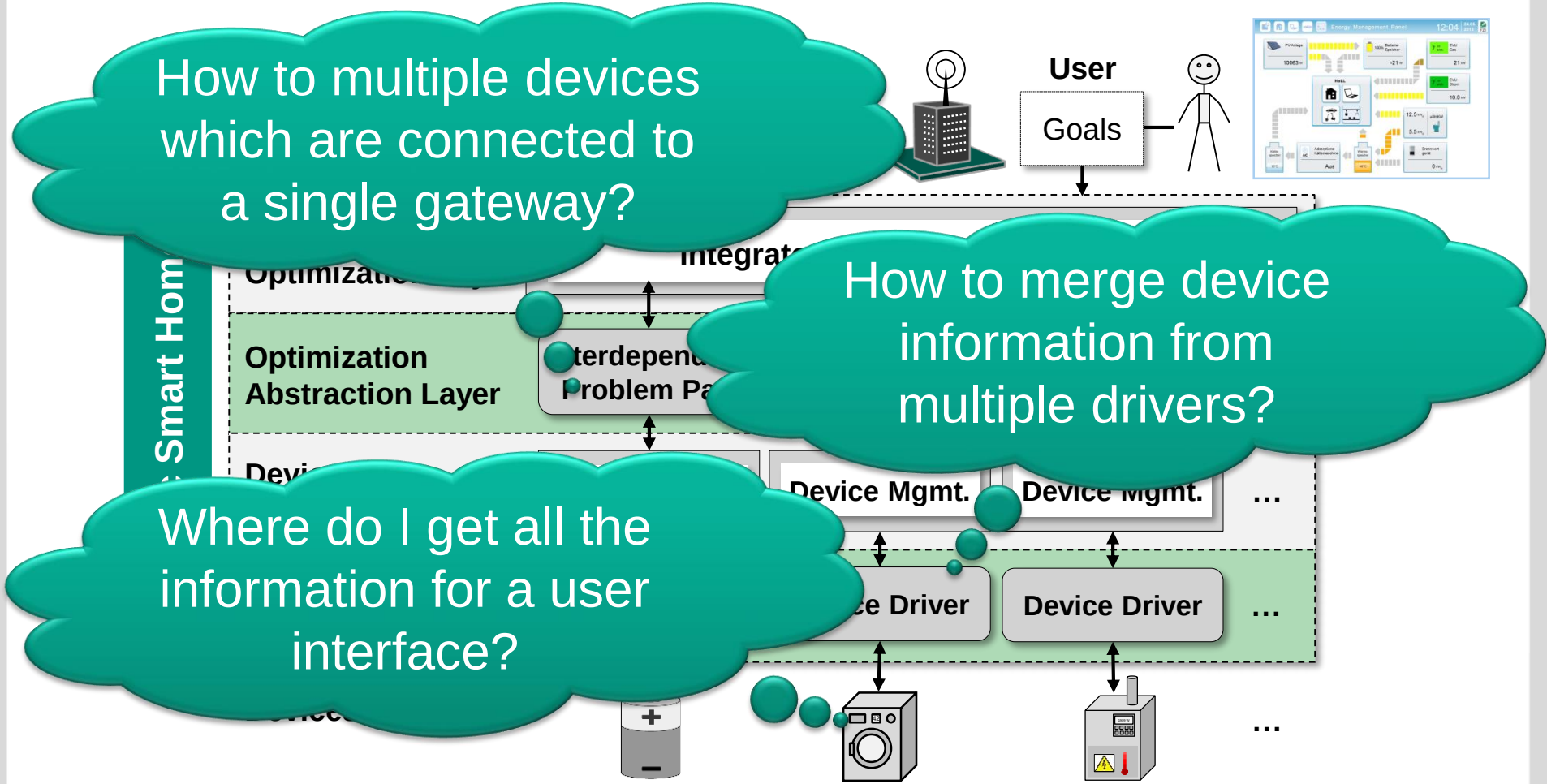

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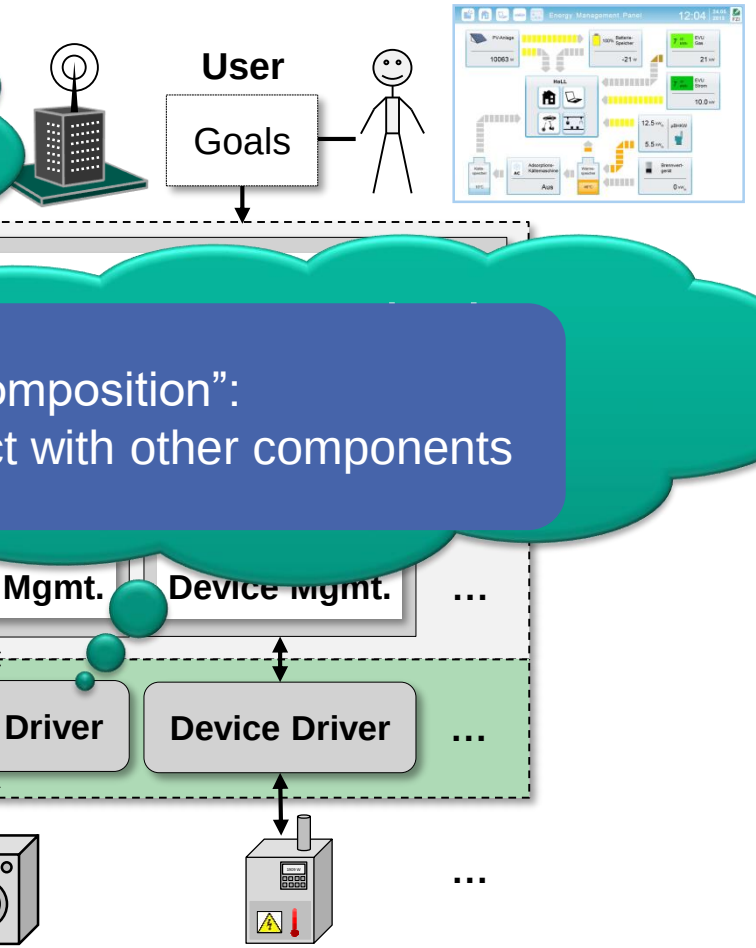
How to multiple devices which are connected to a single gateway?



Requirement “Service Composition”:
Components should be able to interact with other components

Where do I get all the information for a user interface?

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Research Topics for the ESHL

- electric load shaping
  - consume electricity when RES availability is high
  - produce own electricity when energy prices are high
  - reschedule time and intensity of home appliance activation
- home automation
  - comfort, safety and to safe energy
  - remote control / user interface for the smart home
  - presence and activity detection
- energy consumption visualization
  - consumption awareness and saving potential identification

Research Topics for the ESHL

- elec
  - reschedule time and intensity of home appliance activation
- hom
  - remote control / user interface for the smart home
- energy consumption visualization
  - consumption awareness and saving potential identification

Challenge “Evolution of Applications and Abstractions”:
There are always new ideas your framework design might miss

Challenge “Loose Coupling of Components”:
Decompose properly for better maintainability

Challenge “Learning Curve and Language Independence”:
Students needed at least 4 months to get familiar
with the OSH framework

Research Topics for the ESHL

- elec
  - Th
  - p
  - reschedule time and intensity of home appliance activation
- hom
  - con
  - remote control / user interface for the smart home
  - Challenge "Learning Curve and Language Independence":
- energy
  - consumption awareness and saving potential identification

Requirement "Abstract Evolution":
Components should be allowed to add new interfaces without changing the framework

Requirement "Decentralized Components":
Components have to communicate over network sockets

Requirement "Lightweight Runtime Environment":
The smaller the runtime, the easier to understand.
Also avoids runtime lock-in

Comparison of Energy Management / Home Automation Frameworks

System	Means of Modularity	Locality of Abstractions	Weight of Runtime	Composability
Alljoyn	Decentral Processes	Extensible Standard	Light	✓
BOSS / sMAP	Decentral Processes	Core Interfaces	Heavy	✗
EEBus	Processes	Extensible Standard	Light	✓
EF-PI	Java OSGi	Core Interfaces	Heavy	✗
ESH / OpenHAB	Java OSGi	Core Interfaces	Heavy	✓
FHEM	Perl Interfaces	Core Interfaces	Heavy	✓
OGEMA	Java OSGi	Core Interfaces	Heavy	✗
OSH	Java Interfaces	Core Interfaces	Heavy	✓
ESHL	Decentral Processes	Defined by Components	Light	✓

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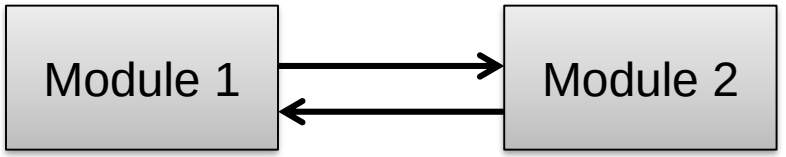
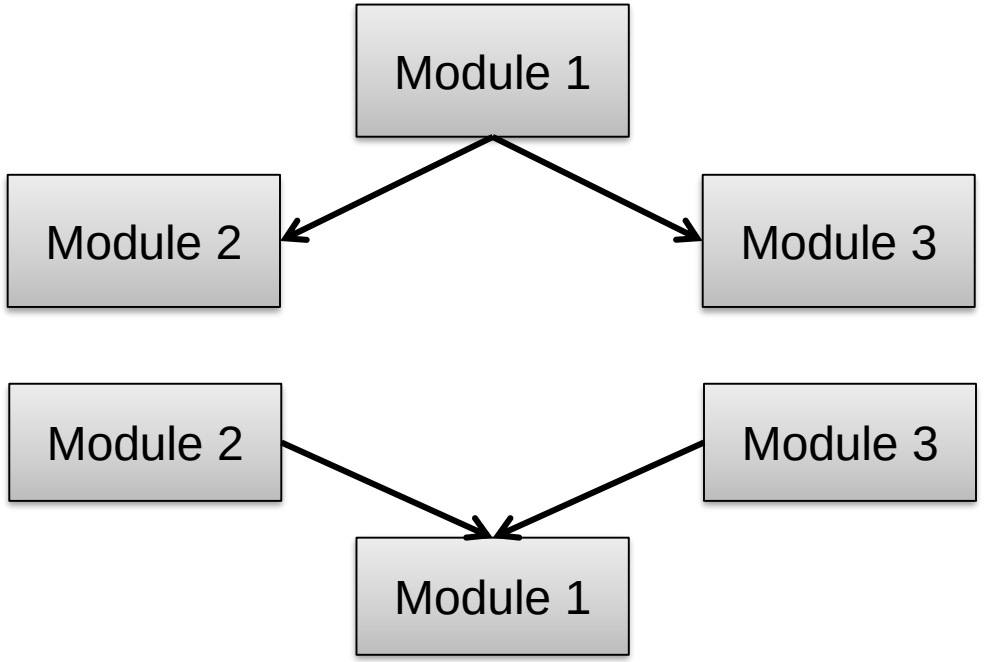
Why not use a message-oriented middleware?

Communication Schemes

- Message Passing
- Remote Procedure Call (RPC)
  - **Routed RPC**
- Publish / Subscribe
  - **Bulletin Board**
  - Message Queuing
  - Notification
- Reduction





Eugster et al. **The many faces of publish/subscribe.** ACM Comp. Surv. 2003.

Comparison of Message Bus Protocols

Feature	AMQP	CoAP	STOMP	MQTT	WAMP	XMPP
Architecture	Central router	Peer-to-peer	Central router	Central router	Central router	Federal routers
RPC	X	✓	X	X	✓	✓
Routed RPC	X	X	X	X	✓	X
Publish / Subscribe	✓	X	✓	✓	✓	✓
Bulletin Board	✓	X	X	✓	✓ (Event History)	✓
Notification	X	✓	X	X	X	X
Message Queuing	✓	X	✓	X	X	✓
Guaranteed Delivery	✓	✓	✓	✓	X	X
Session Persistence	✓	Not necessary	X	X	X	✓
Transport	TCP	UPD, HTTP	TCP, WebSocket	TCP, WebSocket	WebSocket, HTTP	TCP, HTTP, WebSocket
Standardization	OASIS	IETF	-	OASIS	IETF Internet Draft	IETF
No. of Extensions	Low	Low	Low	Low	Low	High
Supported Languages	C, J, Py	C, J, bJS, Py	C, J, bJS, Py	C, J, bJS, Py	C, J, bJS, Py	C, J, bJS, Py

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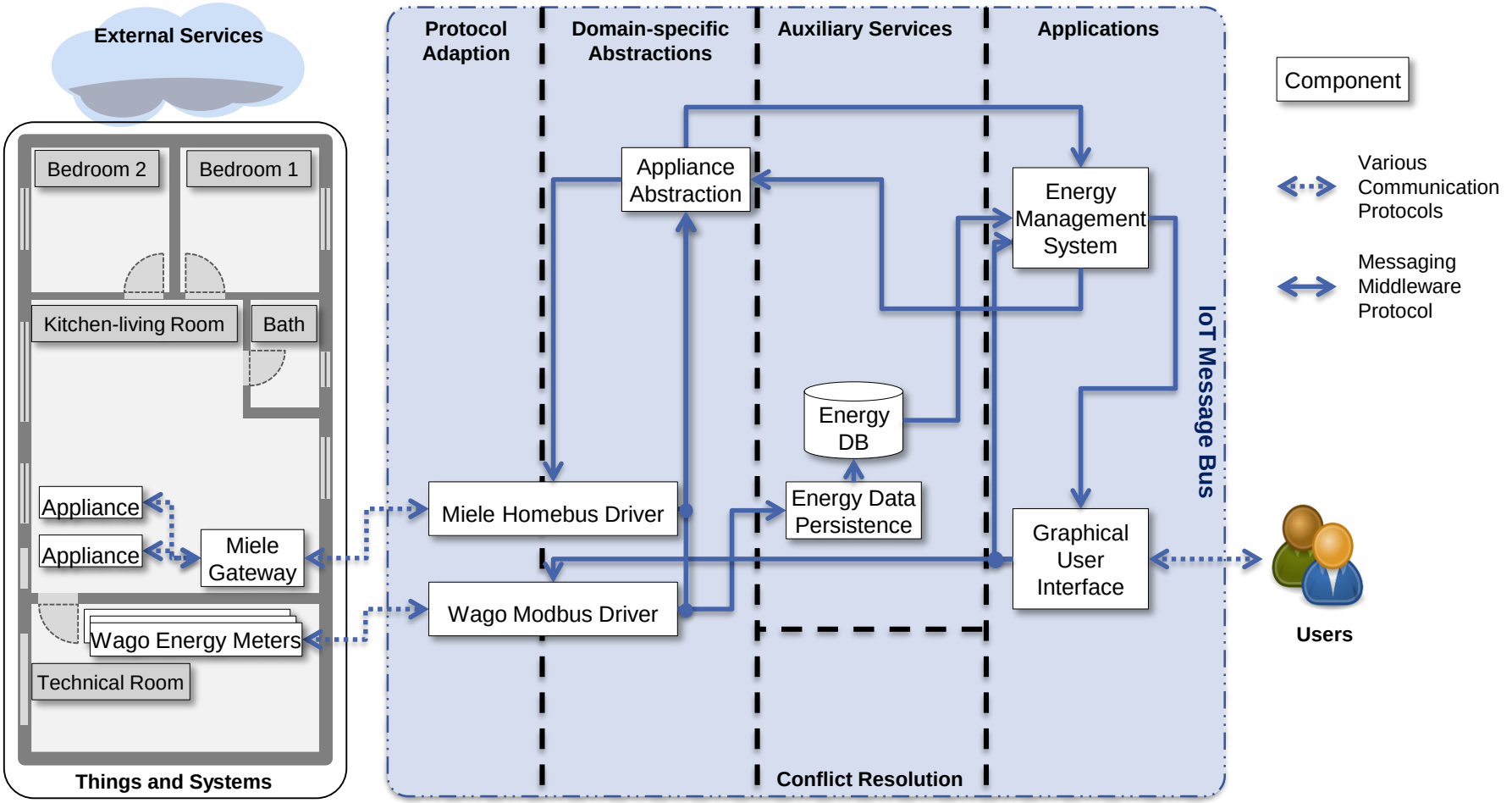
RPC	X	✓	X	X	✓	✓
Routed RPC	X	X	X	X	✓	X
Publish / Subscribe	✓	X	✓	✓	✓	✓
Bulletin Board	✓	X	X	✓	✓ (Event History)	✓
Notification	X	✓	X	X	X	X
Message Queuing	✓	X	✓	X	X	✓
Guaranteed Delivery	✓	✓	✓	✓	X	X
Session Persistence	✓	Not necessary	X	X	X	✓
Transport	TCP				ket,	TCP, HTTP, WebSocket
Standardization						IETF
No. of Extensions					Low	High
Supported Languages	C, J, Py	C, J,		J, bJS, Py	C, J, bJS, Py	C, J, bJS, Py

WAMP Advanced Profile is targeting this missing features

Intranet of Things and Energy

- Modular system of self-contained protocol adaptors and services



Example Messages

- Topic **eshl.wago.v2.readout.wiz.494**


```
{
  "Clamp01": {
    "Q1": 233.89999389648438,
    "Q3": 232.44998168945312,
    "Q2": -12.949999809265137,
    [...]
    "S3": 562.5,
    "S2": 379.1500244140625,
    "S1": 528.8499755859375,
    "U1": 220.00999450683594,
    "U3": 219.989990234375,
    "U2": 219.58999633789062,
    "PF1": -0.85999995470047,
    "PF3": -0.879999995231628,
    "PF2": -0.729999959468842,
    [...]
    "I1": 2.403499841690064,
    "I3": 2.54449987411499,
    "I2": 1.718999862670898,
    "CosPhi1": -0.889999985694885,
    "CosPhi3": -0.909999966621399,
    "CosPhi2": -0.989999949932098,
    "P2": -277.1999816894531,
    "P3": -494.9499816894531,
    "P1": -459.3999938964844,
    "AED1": 1094396083.2,
    "TimestampPFC": "1463737407881",
    "TimestampSYS": "1463737401002",
    [...]
  },
[...]
```


Convention:
Version your topics / interfaces and never drop support for old versions

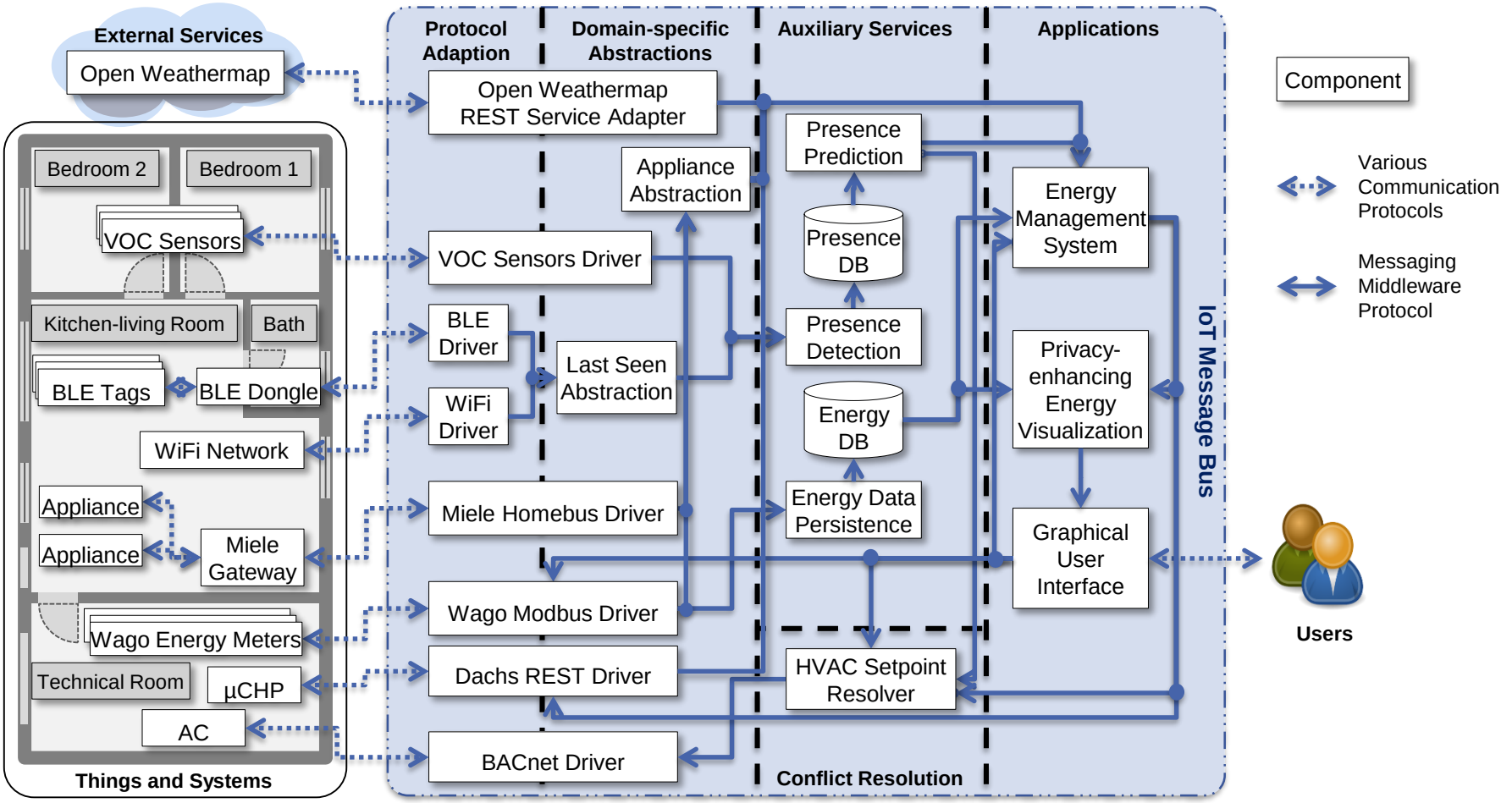
Example Messages

- Topic **eshl.miele.v1.homebus**


```
{
  "-1609555510": {
    "name": "Dishwasher",
    "room": "",
    "stateName": "On",
    "state": 2,
    "additionalName": "",
    "deviceDetails": {
      "stateName": "On",
      "applianceTypeName": "Dishwasher"
    },
    "type": "????????????????",
    "class": 22017,
    "uid": -1609555510
  },
  "-1609555628": {
    "name": "Tumble Dryer",
    "room": "",
    "stateName": "On",
    "state": 2,
    "additionalName": "",
    "deviceDetails": {
      "stateName": "On",
      "applianceTypeName": "Tumble Dryer"
    },
    "type": "T8687C         ",
    "class": 22018,
    "uid": -1609555628
  },
  [...]
}
```

Intranet of Things and Energy

- Modular system of self-contained protocol adaptors and services



Management

- Version your interfaces
  - And never drop support for old versions
- Keep a list of topics, procedures, module names and module locations
- To control your modules, you can use any process supervisor, e.g.
  - supervisord for one machine
  - fleetctl for a distributed system

What we gained

- Stability
  - To add new services, you don’t have to restart the framework
  - It’s much harder to interfere with other modules
- System seems to be much less complex
  - Motivated students / developers
  - Easier to compose new services from existing ones
- You can use your favorite programming language
- Developers need to synchronize much less often
  - Enables parallel development

What is to be improved

- Security
  - Currently purely based on perimeter isolation
- Architecture is not recommended for production systems
  - You know your use cases in production
  - Take advantage of type-safety

Conclusion

- To drive our Smart Home, we applied
  SOA, MOM, Microservice / Unix philosophy

- Avoid to re-implementing the wheel
  - Do your (literature) research
  - Respect the stuff other people do
- Keeping things simple => More people understand => More support
- Use Cases evolve, so consider evolving abstractions

- Source Code: https://github.com/aifb/eshl-iot-bus