IoT quel avenir et horizon dans la recherche

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Project ITEA2 Usenet 2007-2010 (silver award ITEA2)

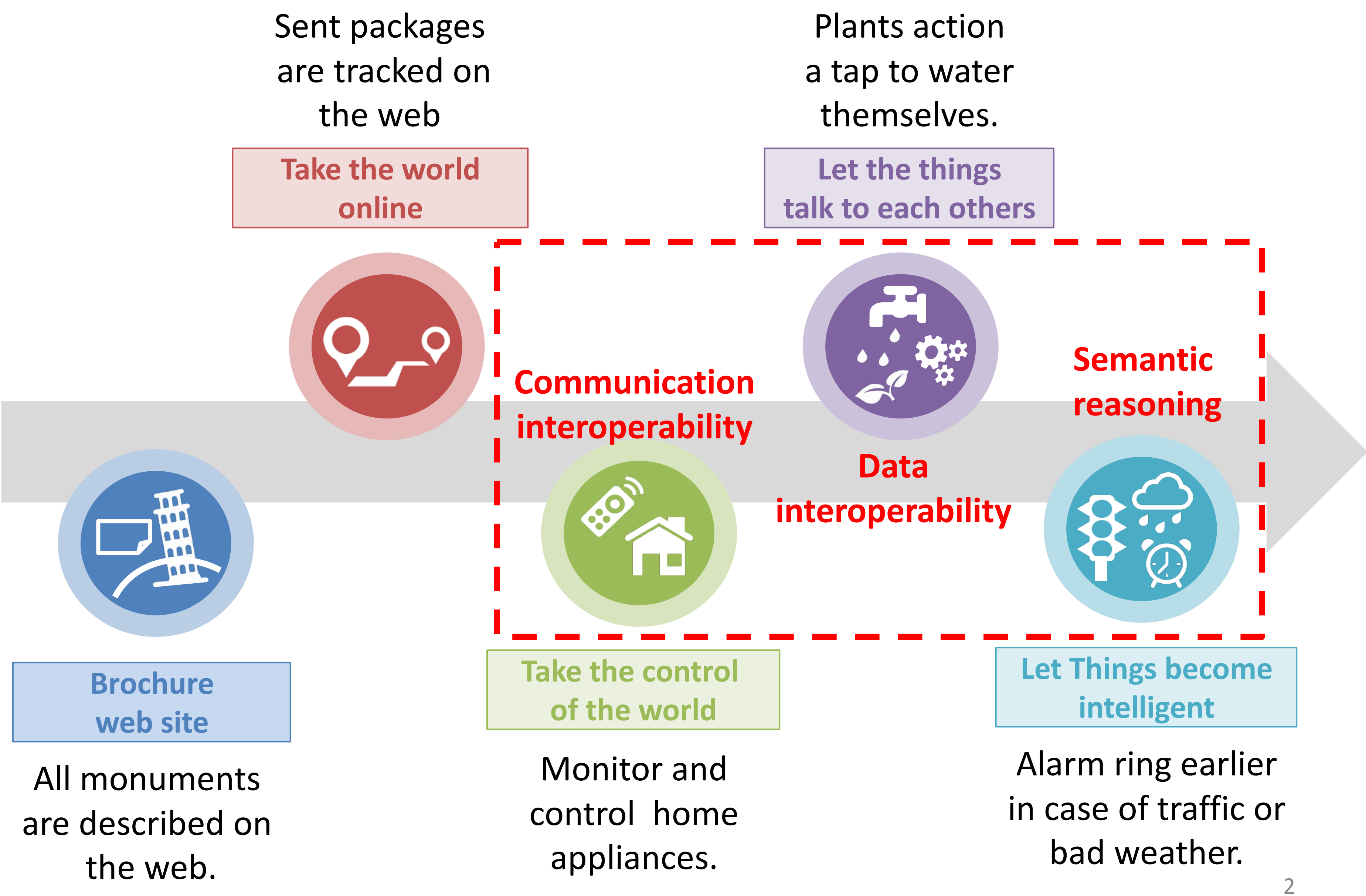
Project ITEA2 A2NETS 2011-2015

Project open source Ecplise : om2m.org

Standardization activities in M2M groups

Startup sensinov.com

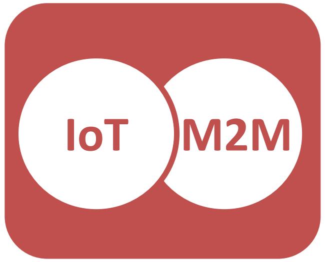
The evolution of IoT



IoT vs M2M

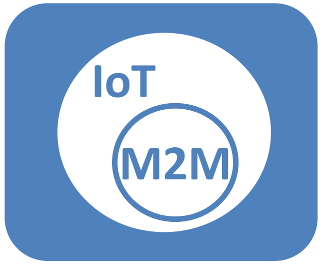
M2M paradigm

The ability of machines to communicate with other devices without human interventions.



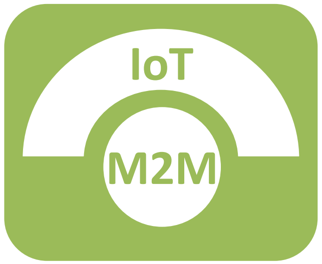
M2M as an industrial environment

- M2M: based on industrial protocols, closed solutions.
- IoT: common usage applications, open solutions for mass.



M2M as a subset of IoT

- M2M: connects devices, electronic sensors, RFID tags.
- IoT: connects general things, animals, peoples.



M2M as the kernel of IoT

Adopted definition

- M2M: plumbing of IoT, required connectivity for things.
- IoT: depends on M2M, not possible without it.

IoT/M2M main challenges*

Vertical Fragmentation

vendor-specific solutions, no interoperability, semantic gap.

Power Management

Inefficient battery life-cycles, lack of clean energy.

Increasing Complexity

Large number of devices, Unmanageable, high costs

Security

Weakness in devices, privacy, fraud, cyber attacks.

Network Misalignment

Devices behavior differs from humans: collapse of internet infra.

*M2M Communications A Systems Approach. David Boswarthick, Omar Elloumi, Olivier Hersen (Wiley April 2012)

IoT/M2M main S&R&D directions

Vertical Fragmentation

- Common services & horizontal architectures
- Semantic Interoperability:
Communication,
Data levels

Power Management

Energy Saving & Harvesting:
Device-level,
Protocols-level,
Application-level

Increasing Complexity

-Autonomic Management
Scalability & virtualization
-Dynamic deployment & discovery
-Model-based design & mgt
- Data Analytics & ML

Security

Authentication, Authorization, Accounting

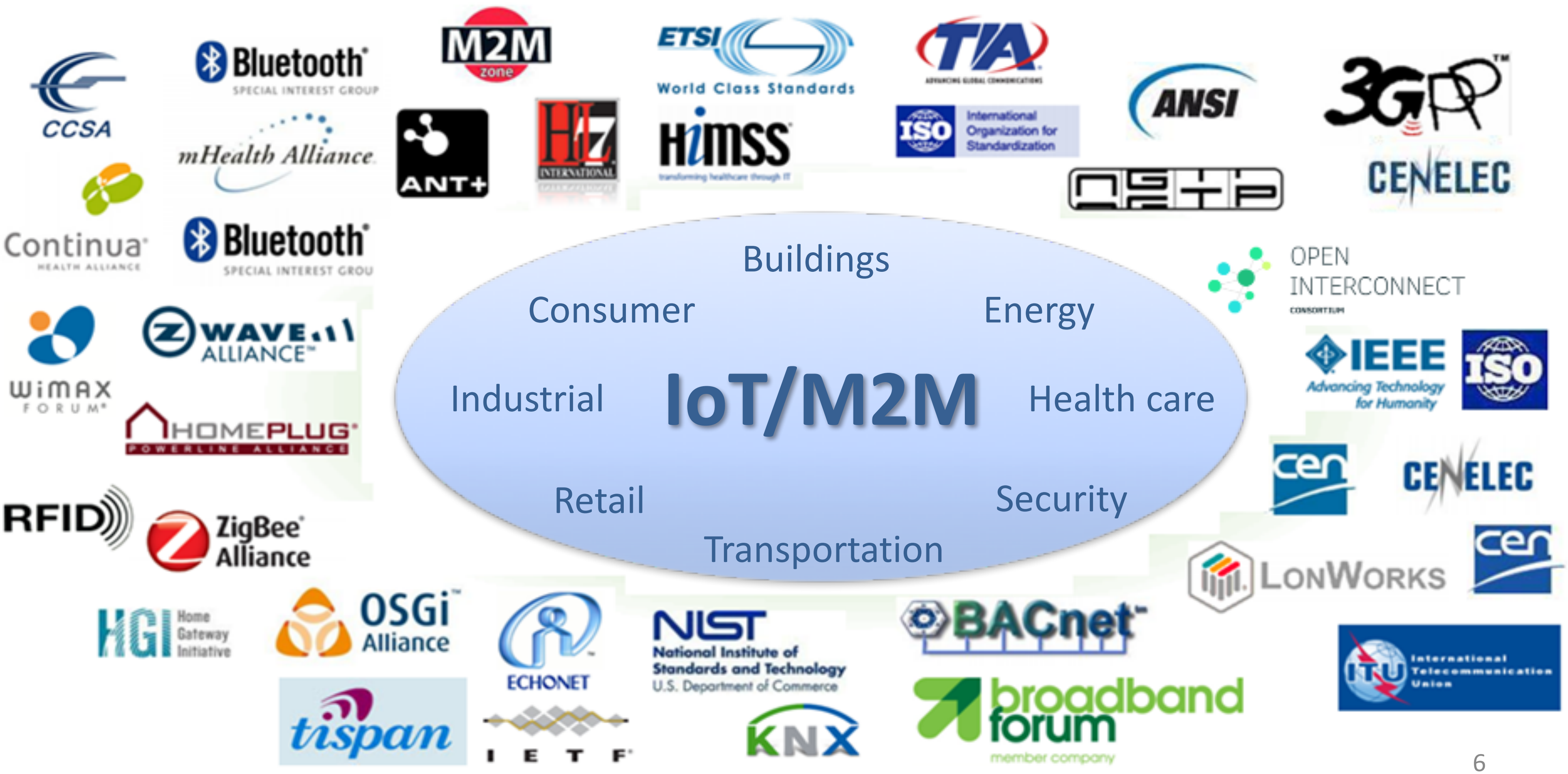
Network Misalignment

-Softwarized & Virtualized Networks: SDN, NFV, LPWAN (LoRa, NB-IoT),
-Sliced Networks (5G)
-Data filtering

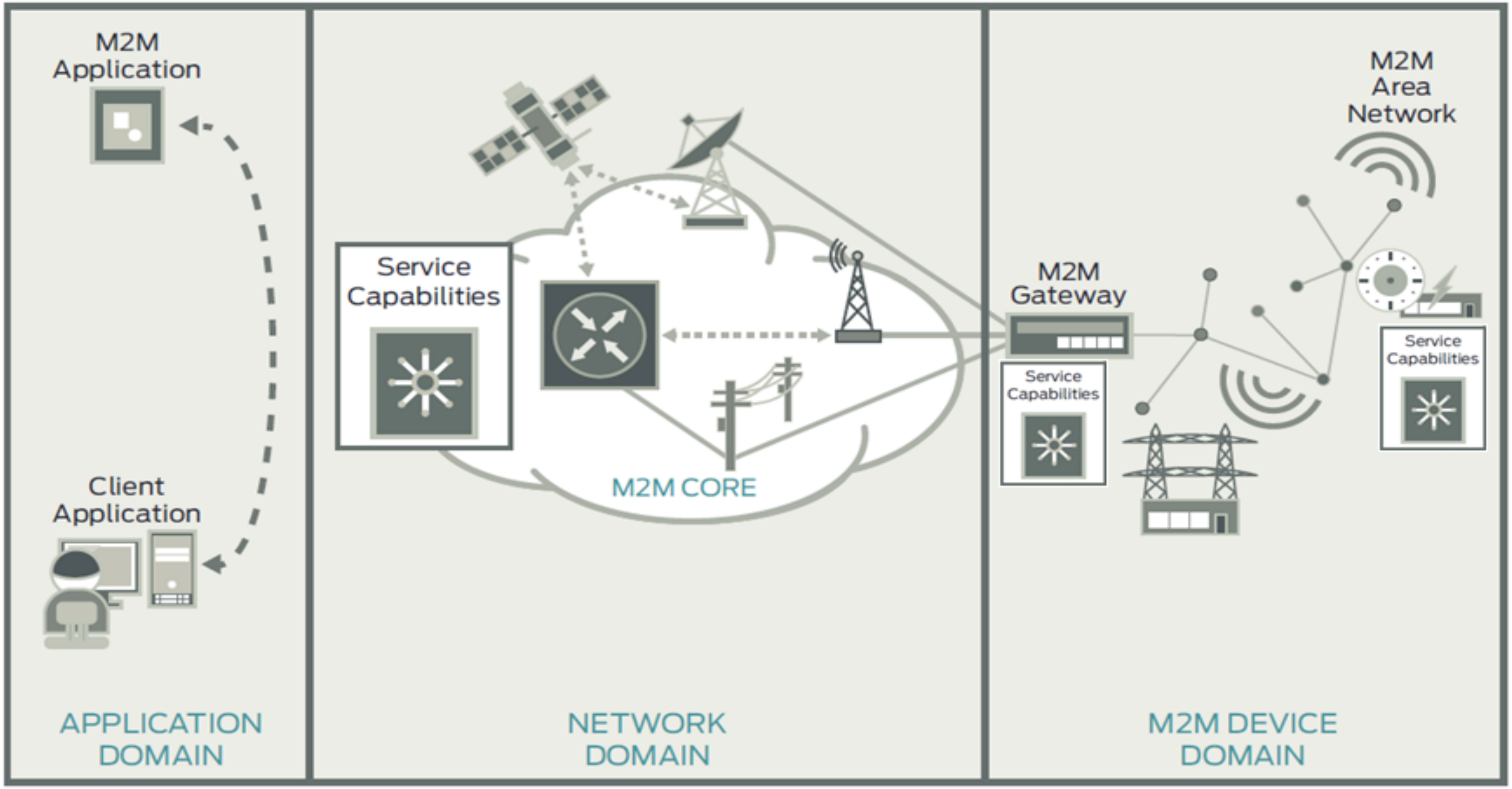
Standards landscape for IoT/M2M

- 143 organizations around the world are involved in IoT/M2M standardization according to the Global Standards Collaboration M2MTask Force.

MSTF M2M Standardization Task Force



IoT/M2M high level reference architecture

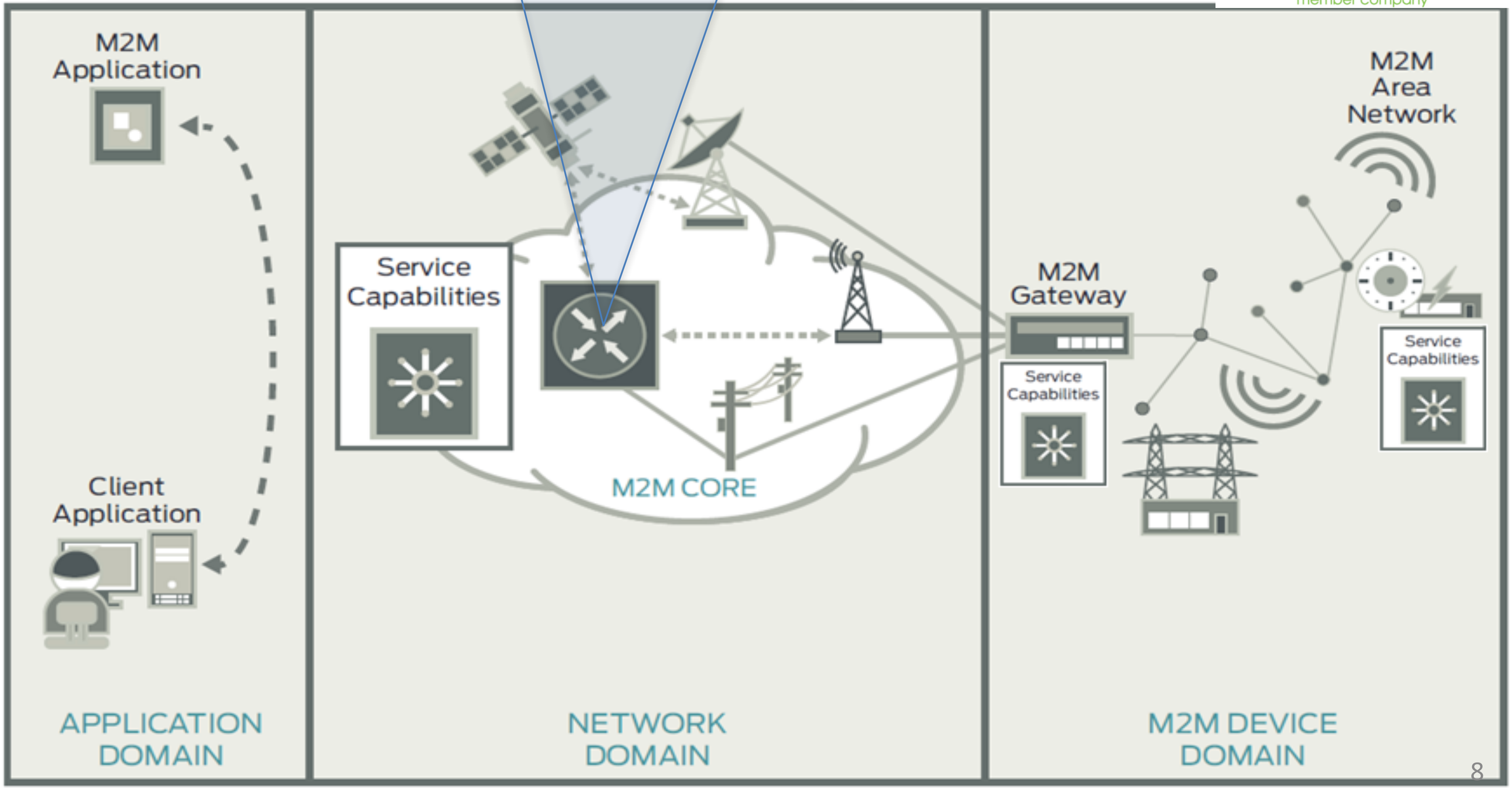


Source: http://www.etsi.org/technologies-clusters/technologies/m2m

Standards for Wide Area Networks

Standards for Wide Area Networks
(3GPP; LPWAN: LoRa, NB-IOT

Target: protect networks against negative effects of M2M traffic (huge number of devices, non-human new traffic …)

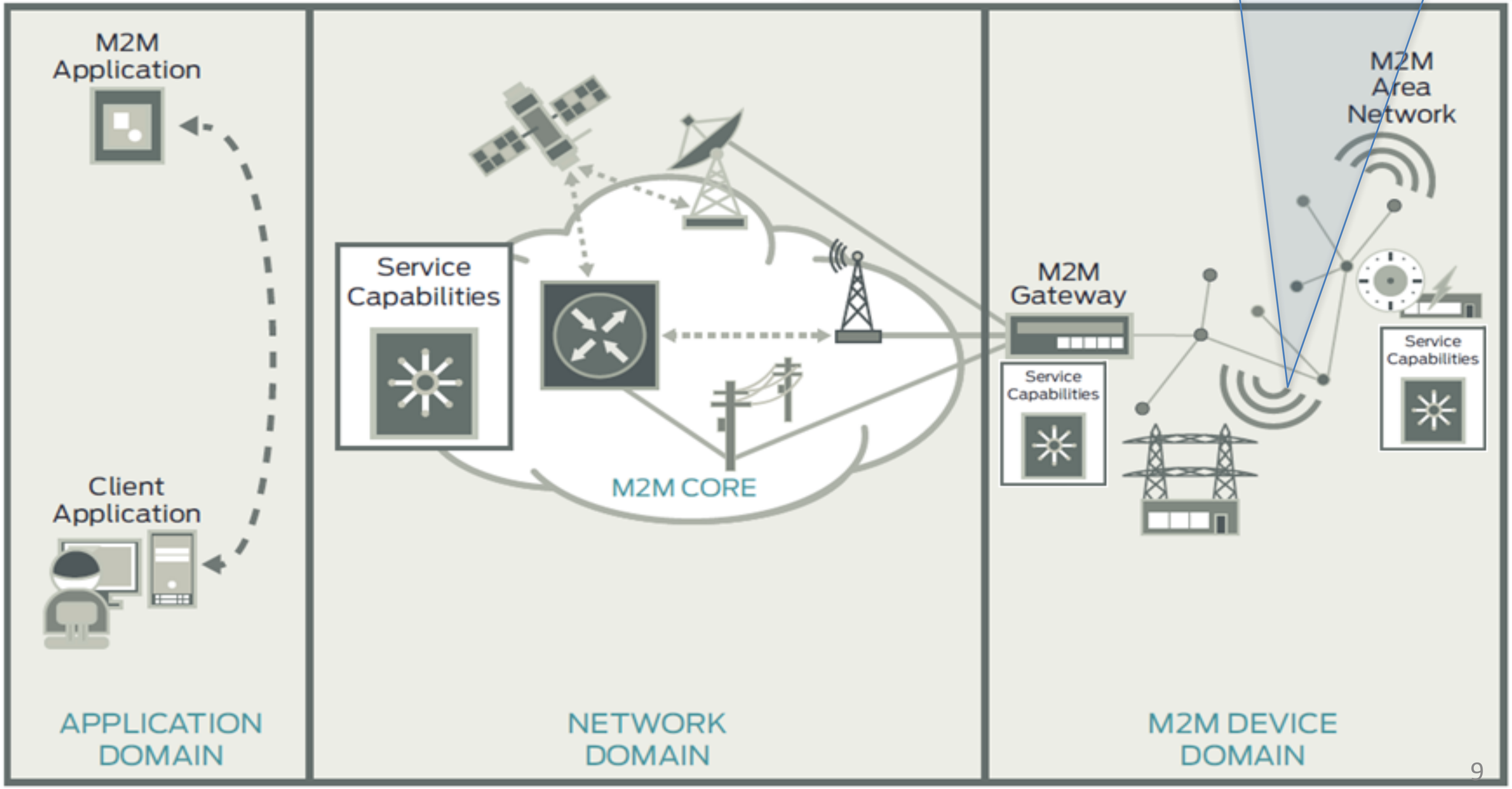


http://www.etsi.org/technologies-clusters/technologies/m2m

Standards for IoT/M2M Area Networks

Standards for Local Area Networks (ZigBee, Bluetooth, PLC, etc.)

Target: foster use of LAN technology by supporting a diverse ecosystem of service providers and device manufacturers.



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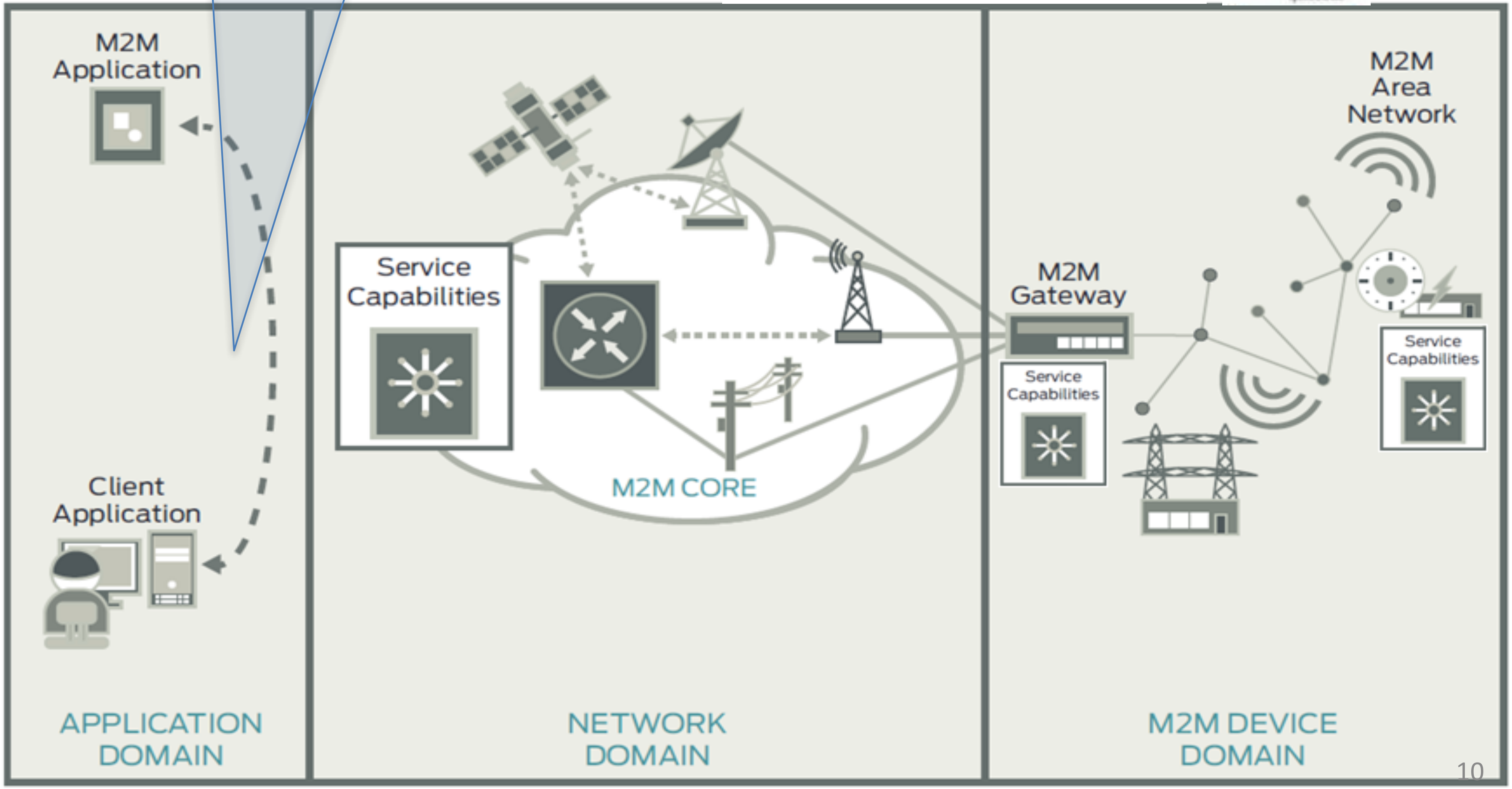
Standards for vertical industries

Standards for vertical Industrial applications

Target: enable interoperable, cost-efficient Solutions.



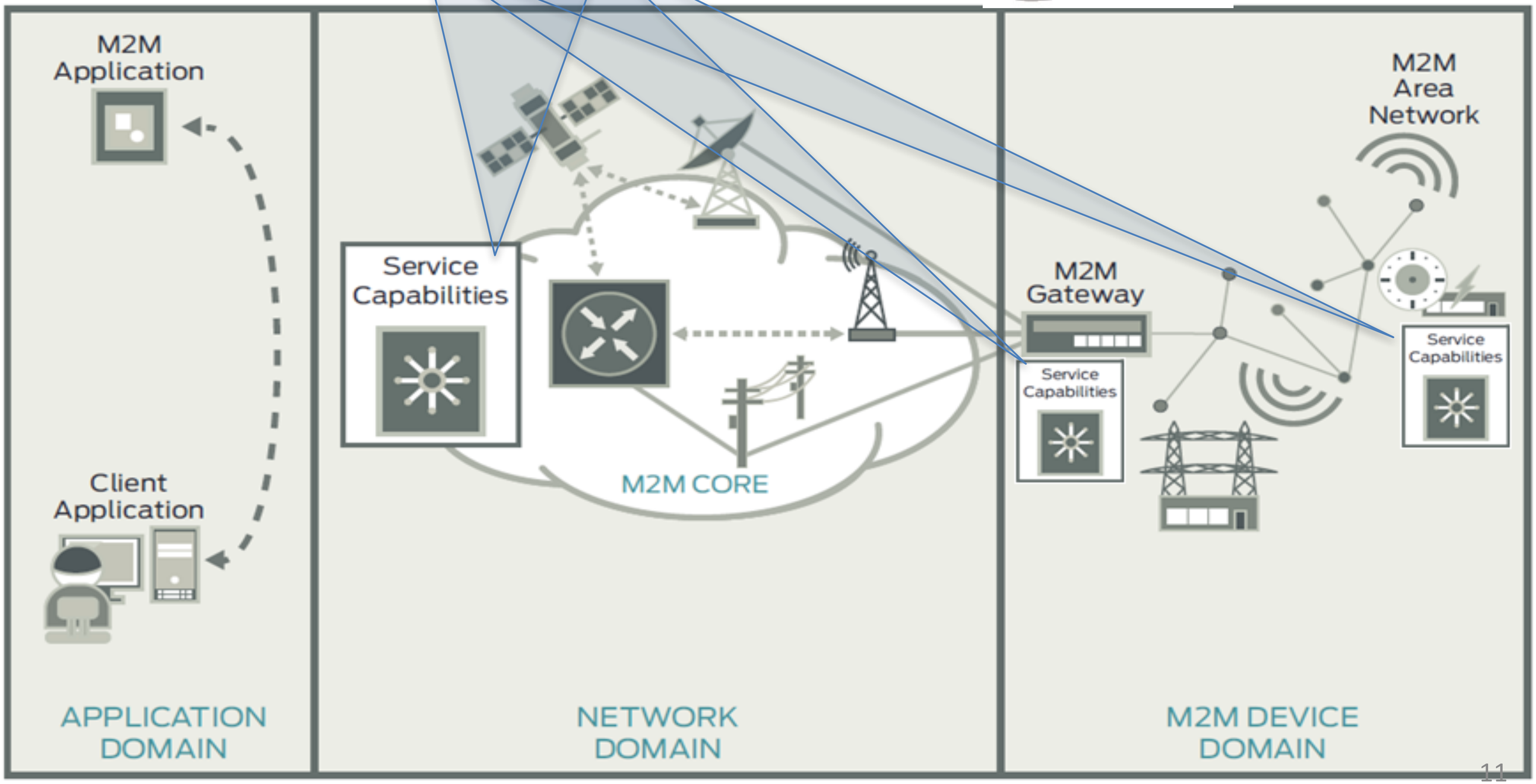
http://www.etsi.org/technologies-clusters/technologies/m2m

Standards for IoT/M2M service capabilities

Standards for IoT/M2M Service capabilities:

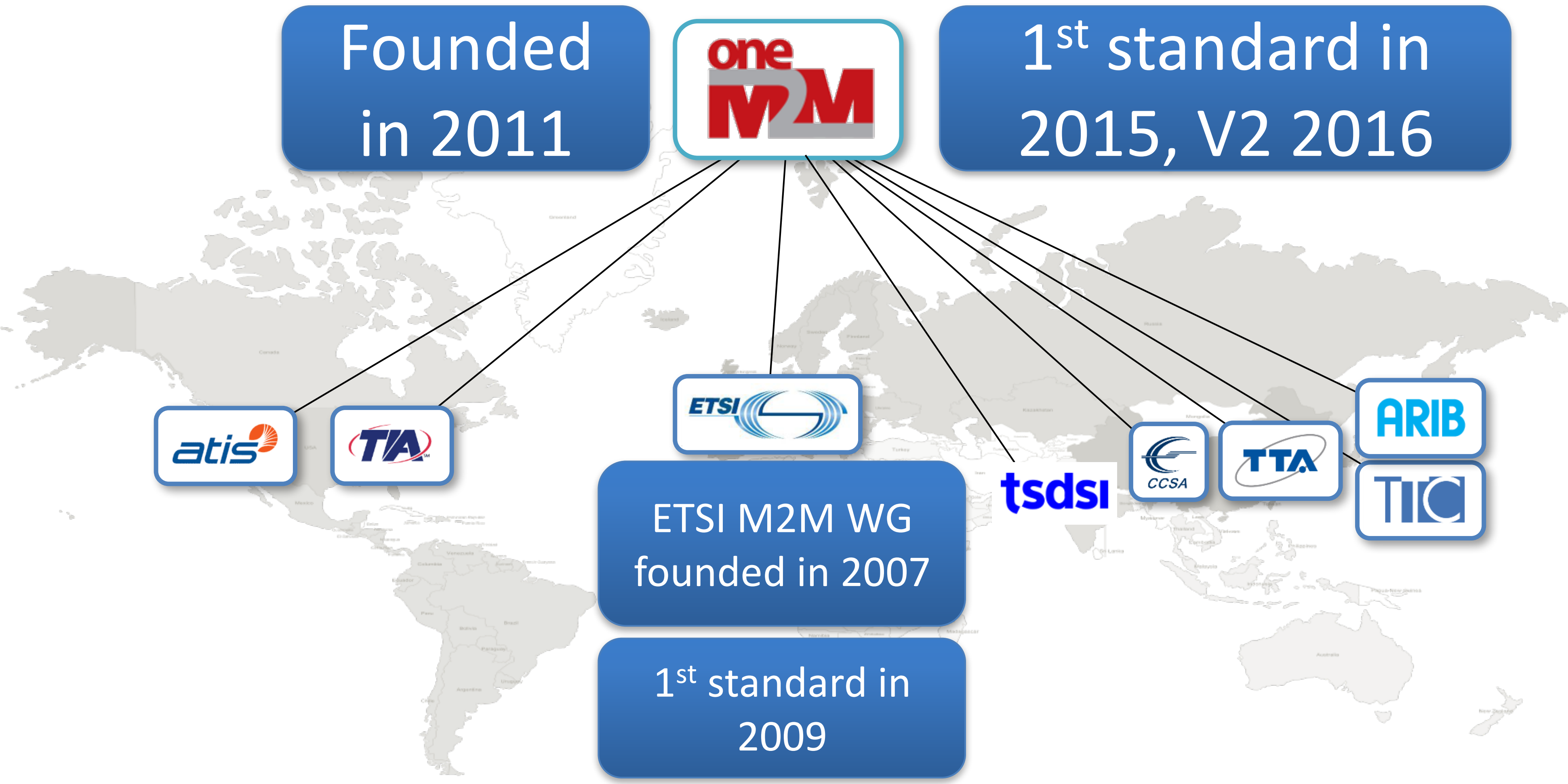
Target: end-to end enablement across servers, gateways, and devices.

Standardized service interfaces.



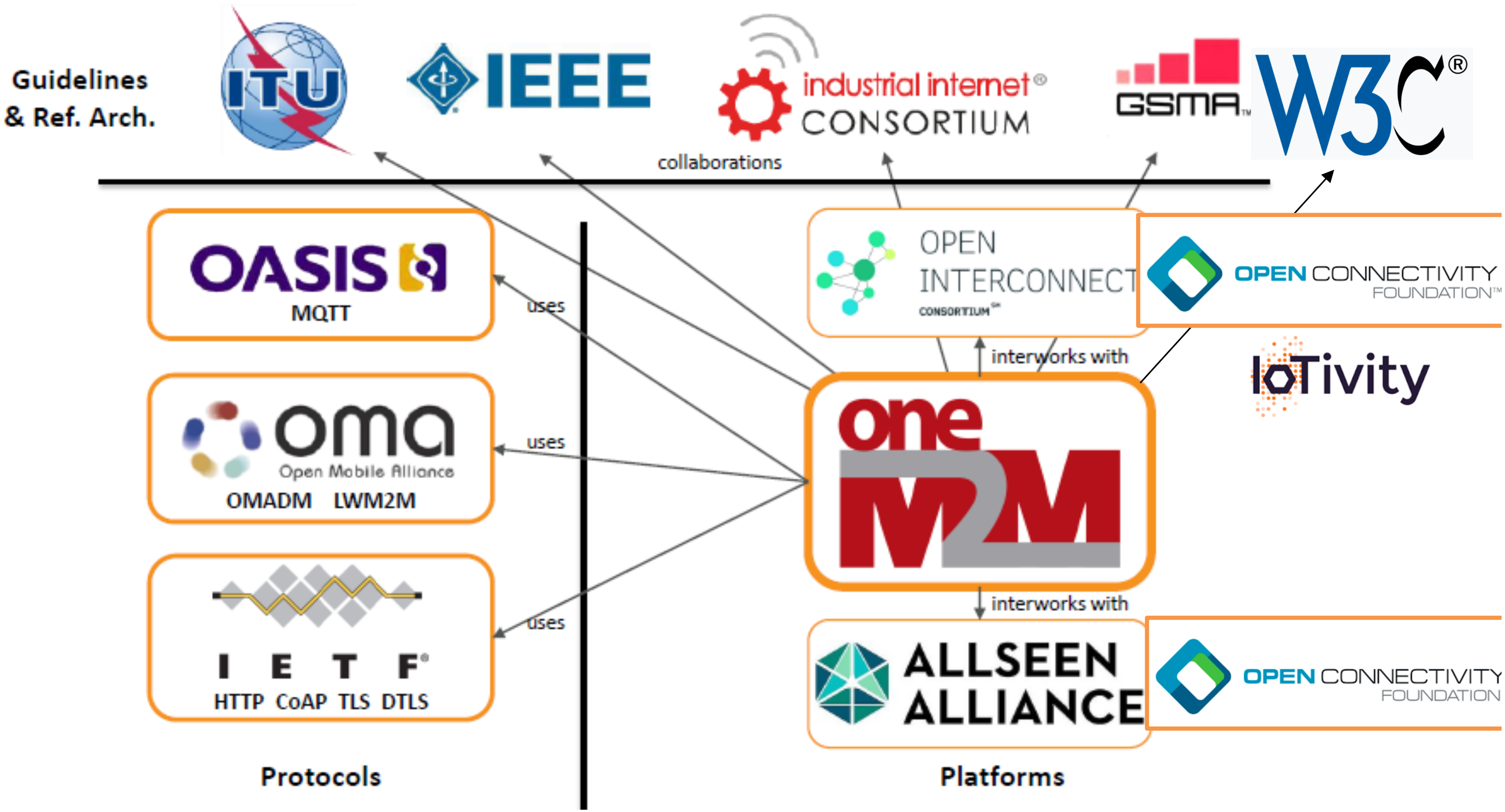
http://www.etsi.org/technologies-clusters/technologies/m2m

The international standardization initiatives



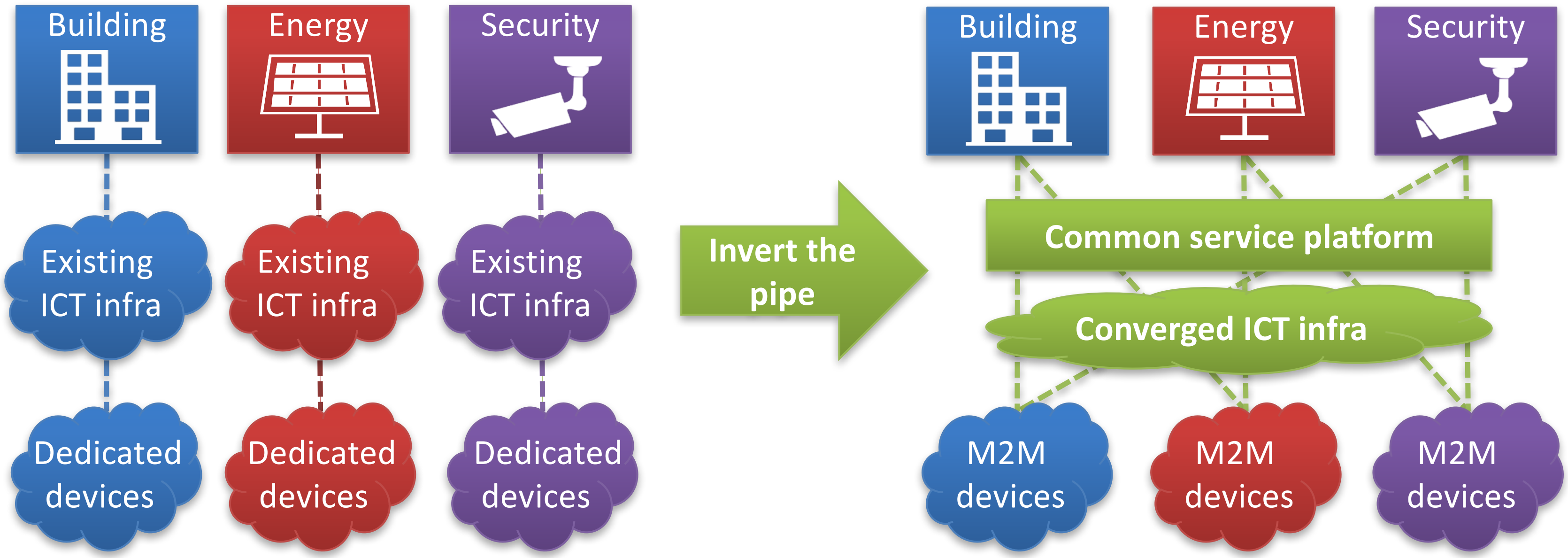
broadband forum · oma Open Mobile Alliance · Continua Health Alliance · HGi · New Generation M2M Consortium

oneM2M liaisons



Enabling IoT/M2M cross-domain interoperability

IoT/M2M interoperability related work



Interoperability solutions

- Standards: ETSI SmartM2M, oneM2M, LWM2M, etc.
- Research projects: IOT-A, openIoT, BETaaS, etc.

Discussion and strategy

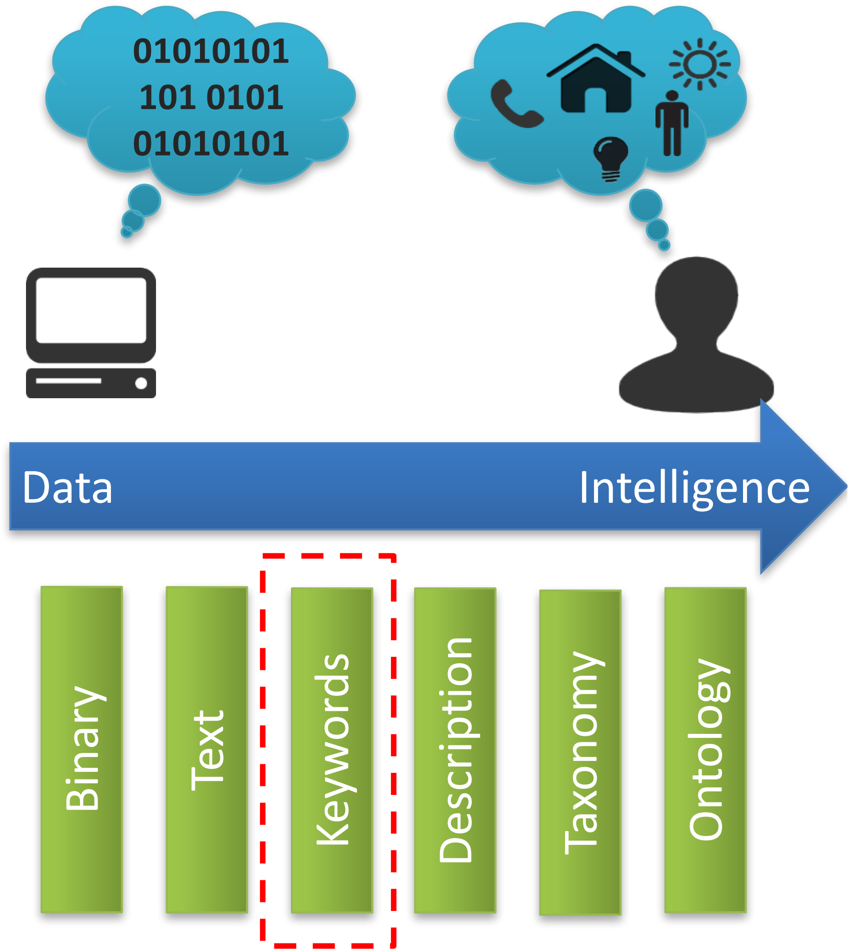
- Horizontality requires standards:
- Int. oneM2M, EU SmartM2M.
- ➢ Extend oneM2M to overcome challenges.

Enabling IoT/M2M cross-domain interoperability

Semantic gap breaks IoT horizontality

Interoperability in IoT standards:

- Resources description and discovery are based on keywords (labels).
- Applications use their own vocabulary (beforehand agreement between designers)
- Limited to some interworking use cases (based on specific format).



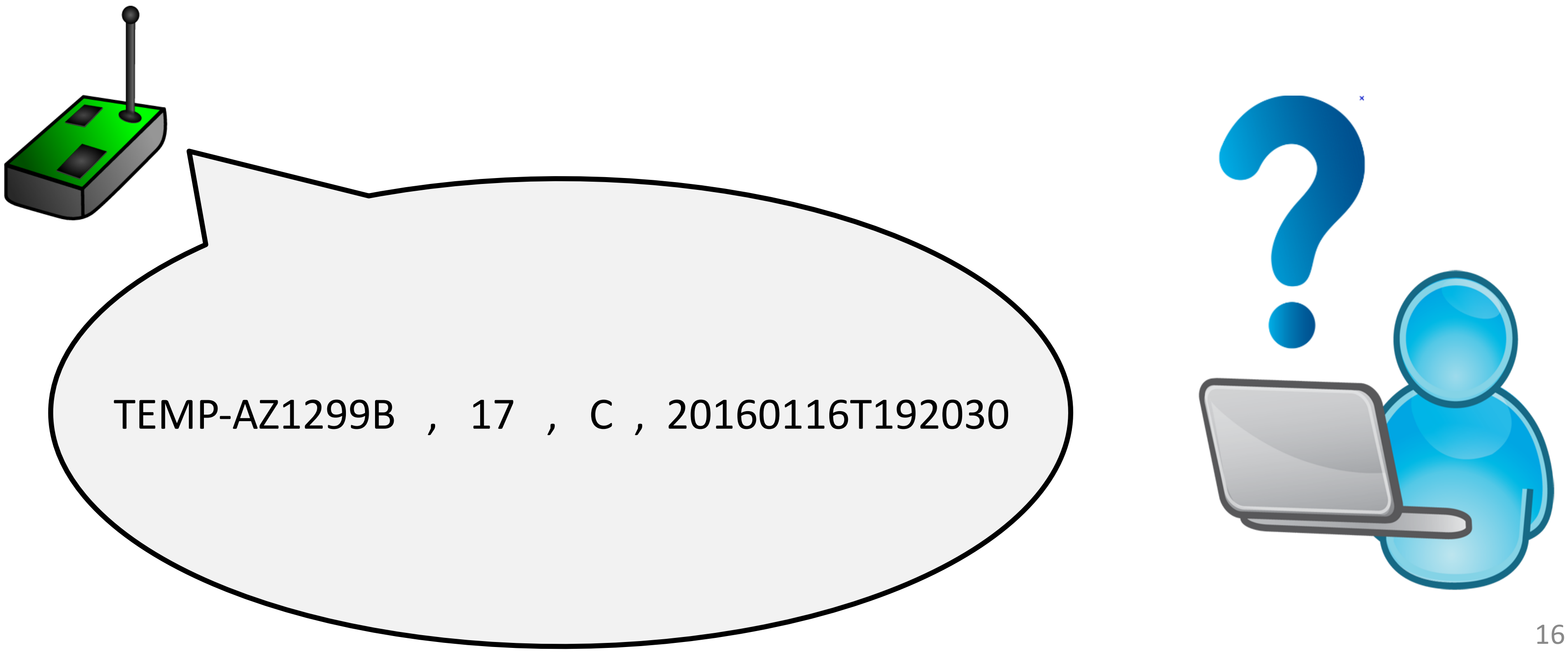
IoT Standards interoperability is based on keywords

Towards a common vocabulary for IoT

- Managing devices with high degree of automation.
- The need for semantic to describe specific domains.
- Easily discover, interpret and share data between vertical applications.

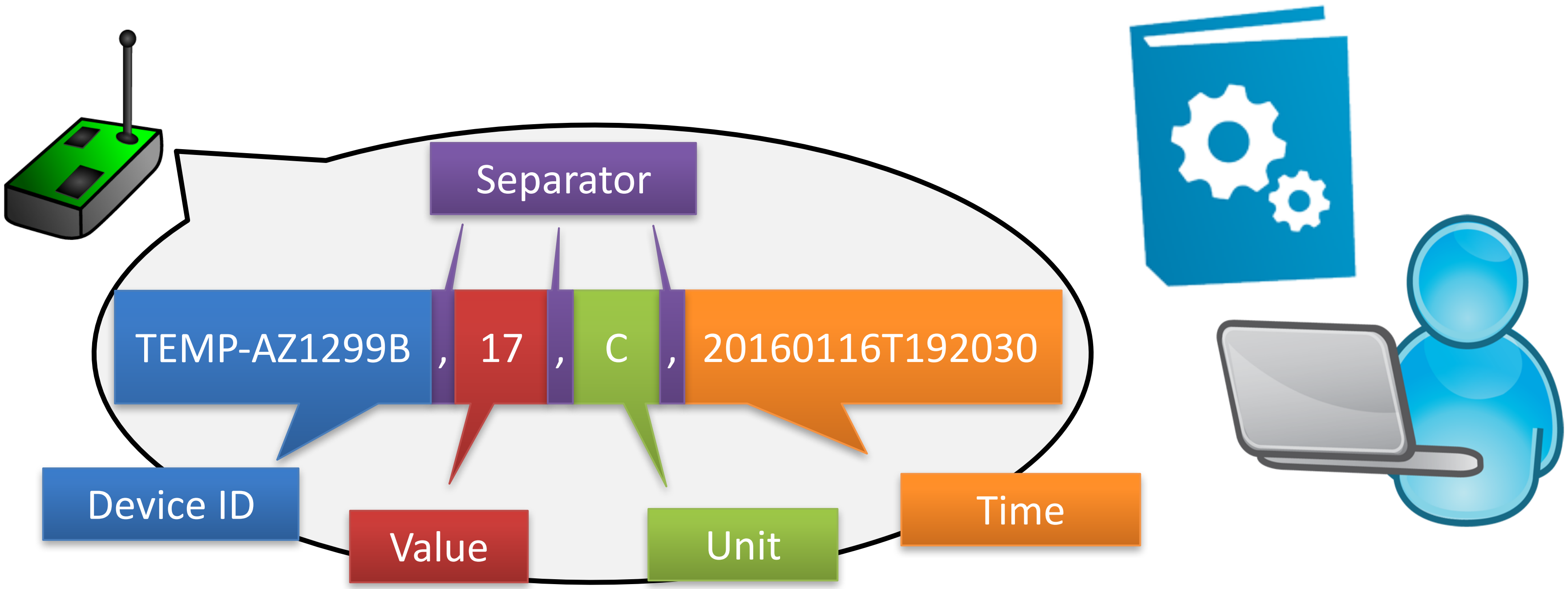
Why do we need semantic ?

- oneM2M Release-1 ensures interoperability at the level of communications.
- Data is treated as black boxes. The content is opaque and applications have to a-priori know how to interpret the data.
- The device is programmed or configured for certain consumers. No data interoperability.



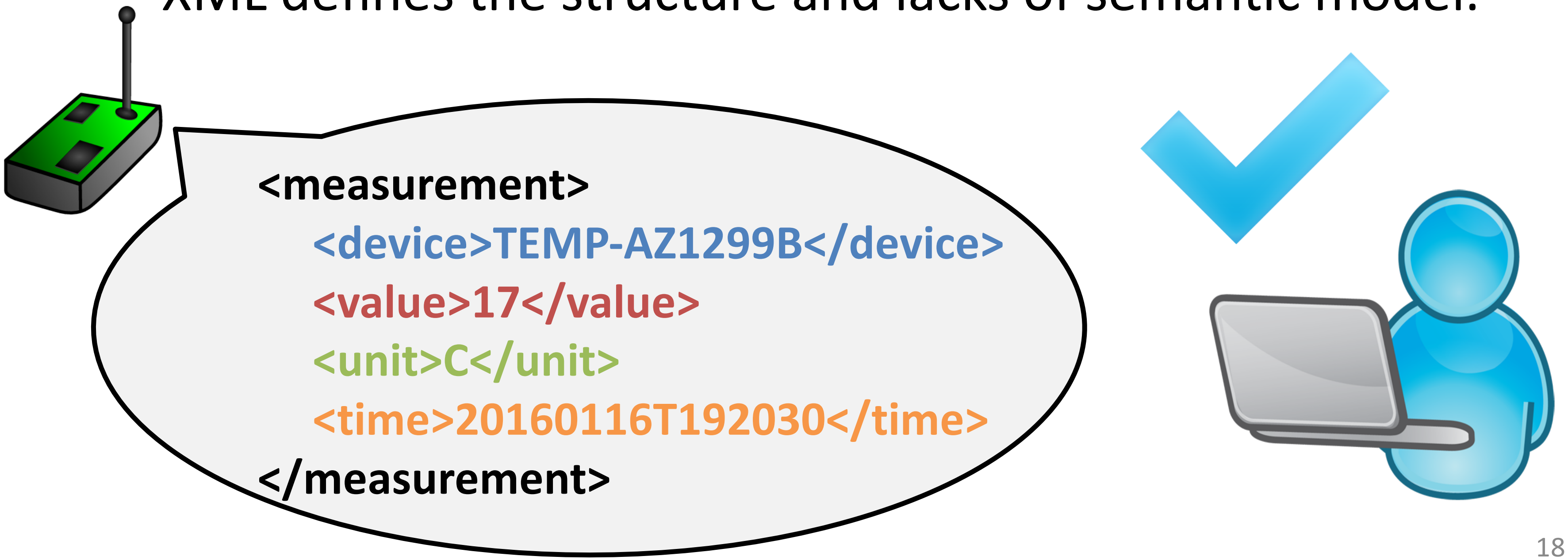
Beforehand agreement required

- It is required by applications to learn information model of each device before using it.
- Hard to integrate and to deal with existing legacy devices.
- Can work in small and closed environnents. But does not scale!



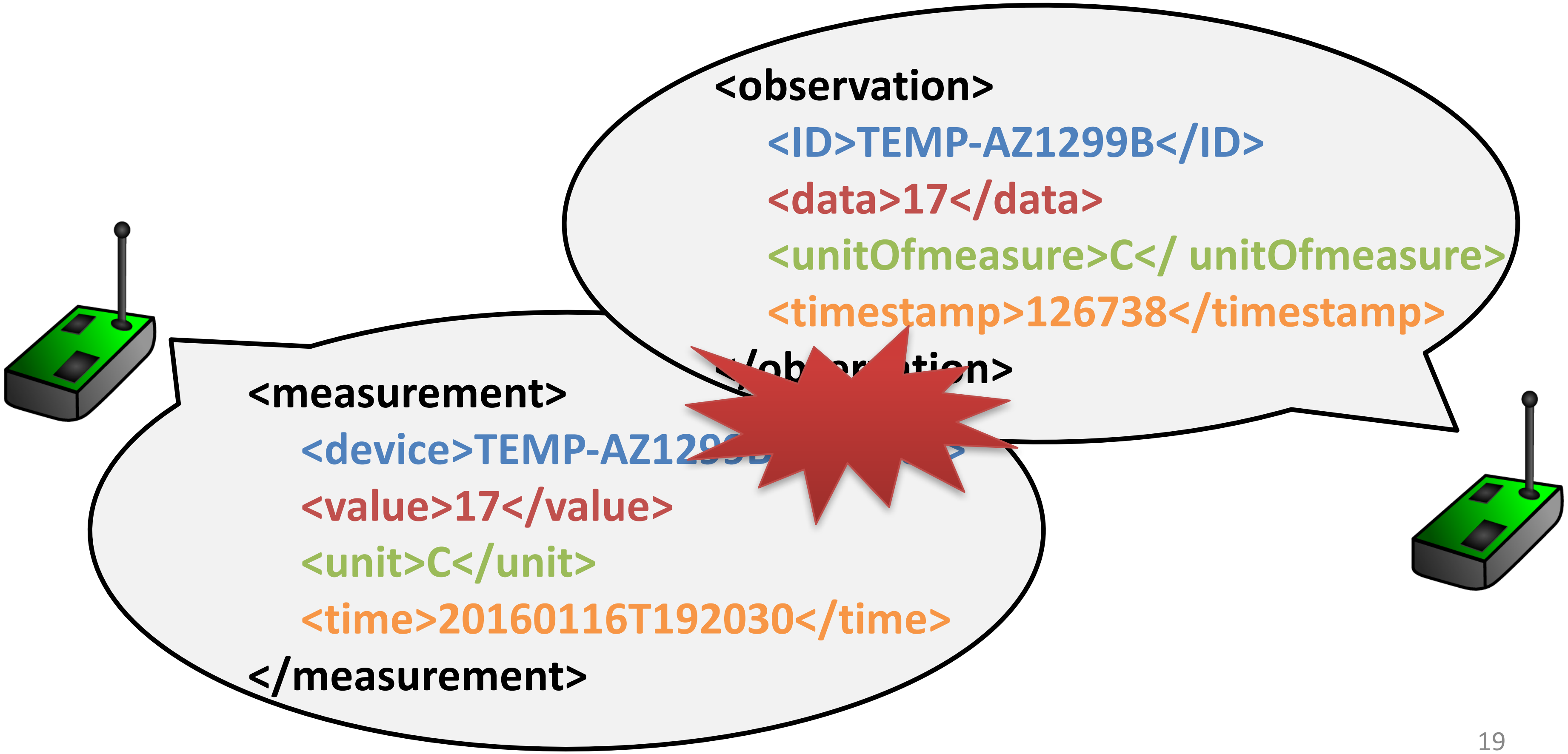
Can XML/JSON do the job ?

- Human can understand XML/JSON Documents.
  - Intuitively clear for human.
  - Tag names provide semantic meaning since they are domain-terms.
- Machines do not have intuition.
  - Tag names do not provide semantics for machines.
  - XML defines the structure and lacks of semantic model.



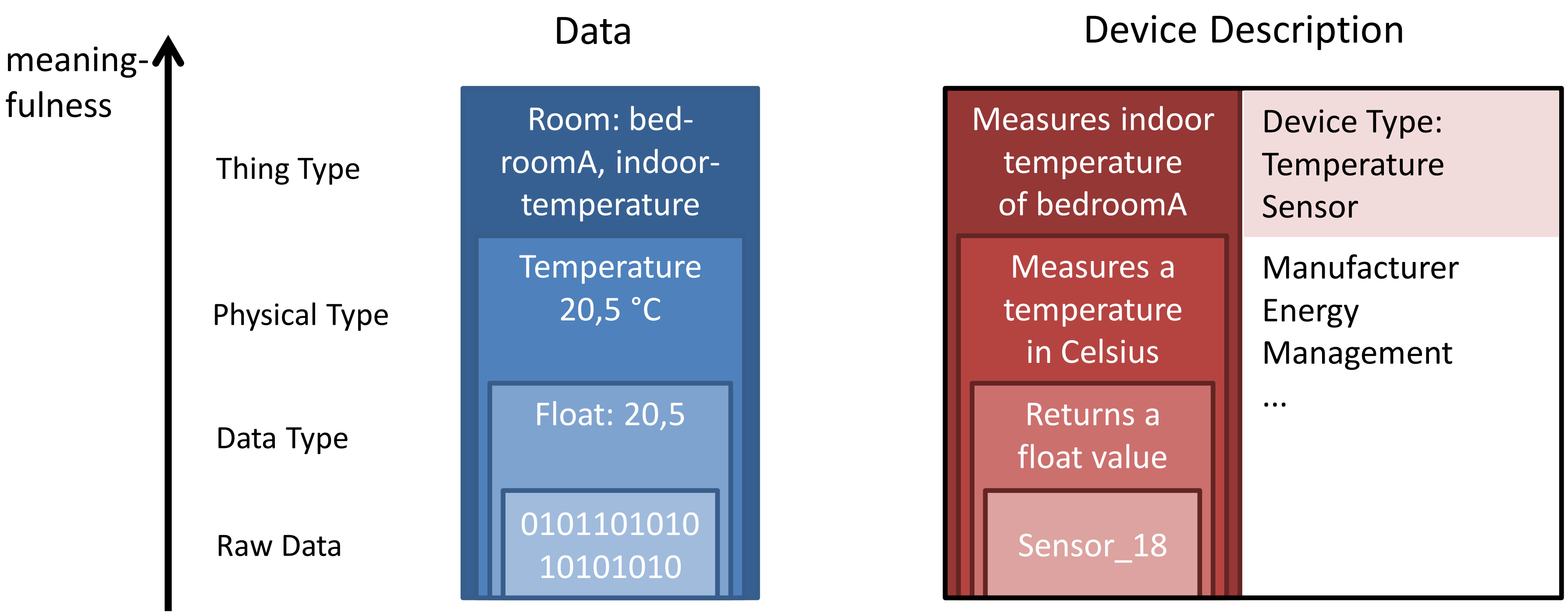
Semantic gap between machines

- Which words shall we use to describe a given set of concepts?
- A common vocabulary is required for IoT to bridge the semantic gap between machines.
- Semantic techniques must be used.



Levels of meaningfullness

- There is not just one single level of semantics that could be attached to a raw data element.
- Different levels of meaningfulness can be identified to describe data and device descriptions.



Reference Ontologies for IoT*

- Existing IoT ontologies:
  - IoT ontology (VTT Fi, Univ. Piraeus Gr), SAREF (ETSI EU), OWL-IoT-S (Univ Galway IR, Univ Surrey UK), IOT-lite (W3C, H2020-FIWARE, H2020-FIESTA), Spitfire (FP7), SSN (W3C), OneM2M base ontology (OneM2M), IoT-O (LAAS, IEEE comm Magazine — Communications Standards Supplement, December 2015)

- Associated IoT Concepts:
  - Actuator, Action, Service, Sensor, Observation, Energy, Lifecycle, Device

*IoT-O, a Core-Domain IoT Ontology to Represent Connected Devices Networks.
Nicolas Seydoux, Khalil Drira, Nathalie Hernandez, Thierry Monteil.
EKAW: Knowledge Engineering and Knowledge Management pp 561-576,
Springer 2016

Enabling IoT cross-domain interoperability

IoT-O ontology for semantic IoT interoperability

Associated approach:

- Reuse existing ontologies (Reduce ambiguity)
- Add new concepts and relationships only when needed.

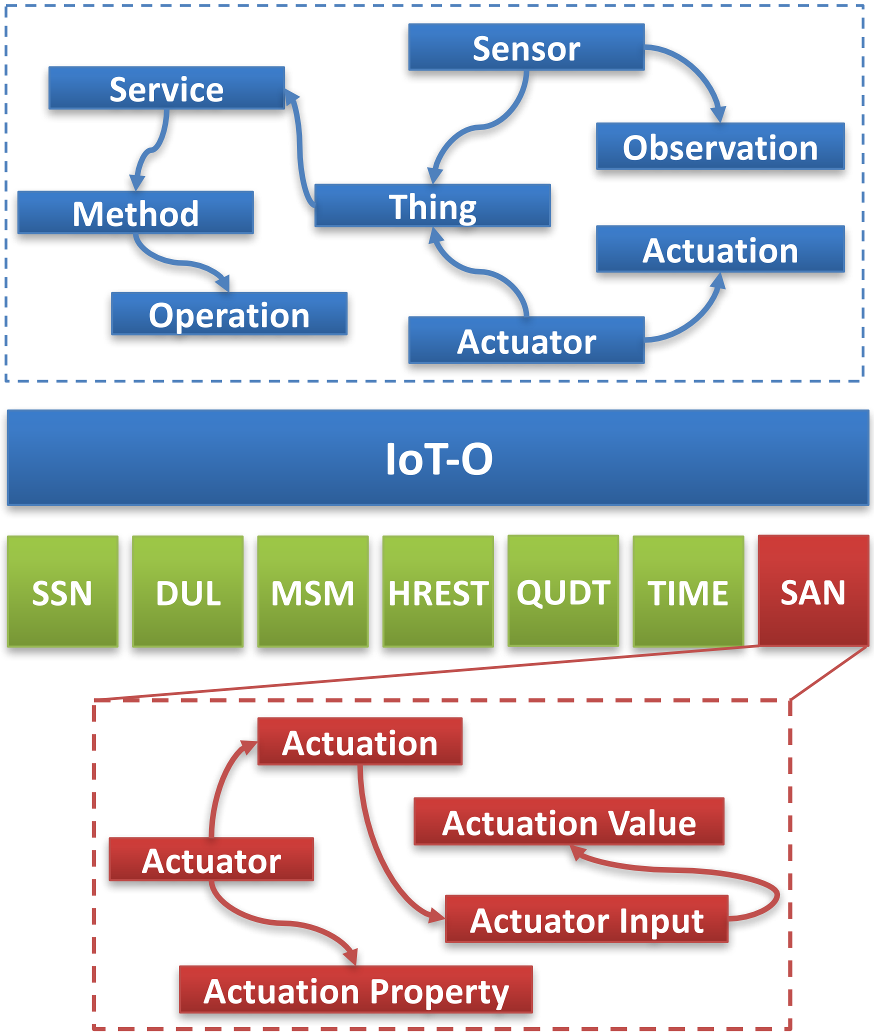
The example of IoT-O*

- Merging and linking popular ontologies (SSN, QUDT, MSM, etc.)
- Defining SAN, the Sensor Actuator Network ontology.

To represent:

- Device information (type, location, etc.),
- Device generated or received data (measurement, timestamp , etc.),
- How to manipulate the device (web service, method, URI, etc.)

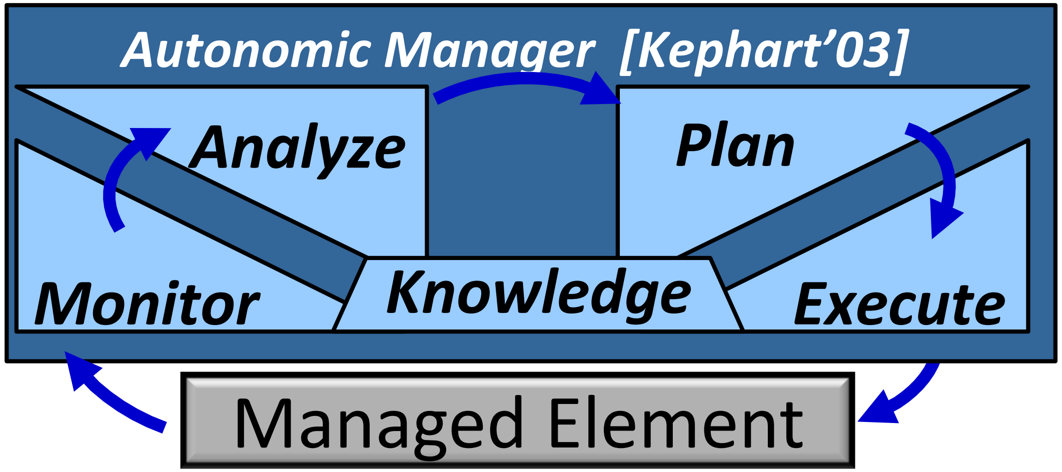
Simplified view of IoT-O ontology



Simplified view of SAN ontology

* BenAlaya et al. IEEE Communication Magazine Alaya Dec. 2015

Autonomic computing paradigm



Existing solutions

- Address specific problems (vertical), focus on one MAPE-K step.
- How different models are shared between MAPE modules ?

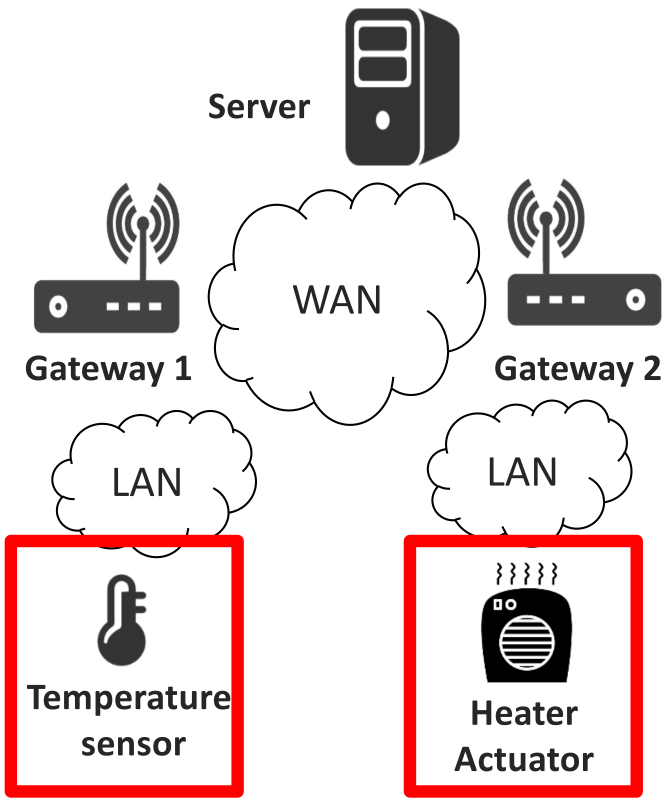
Challenges:

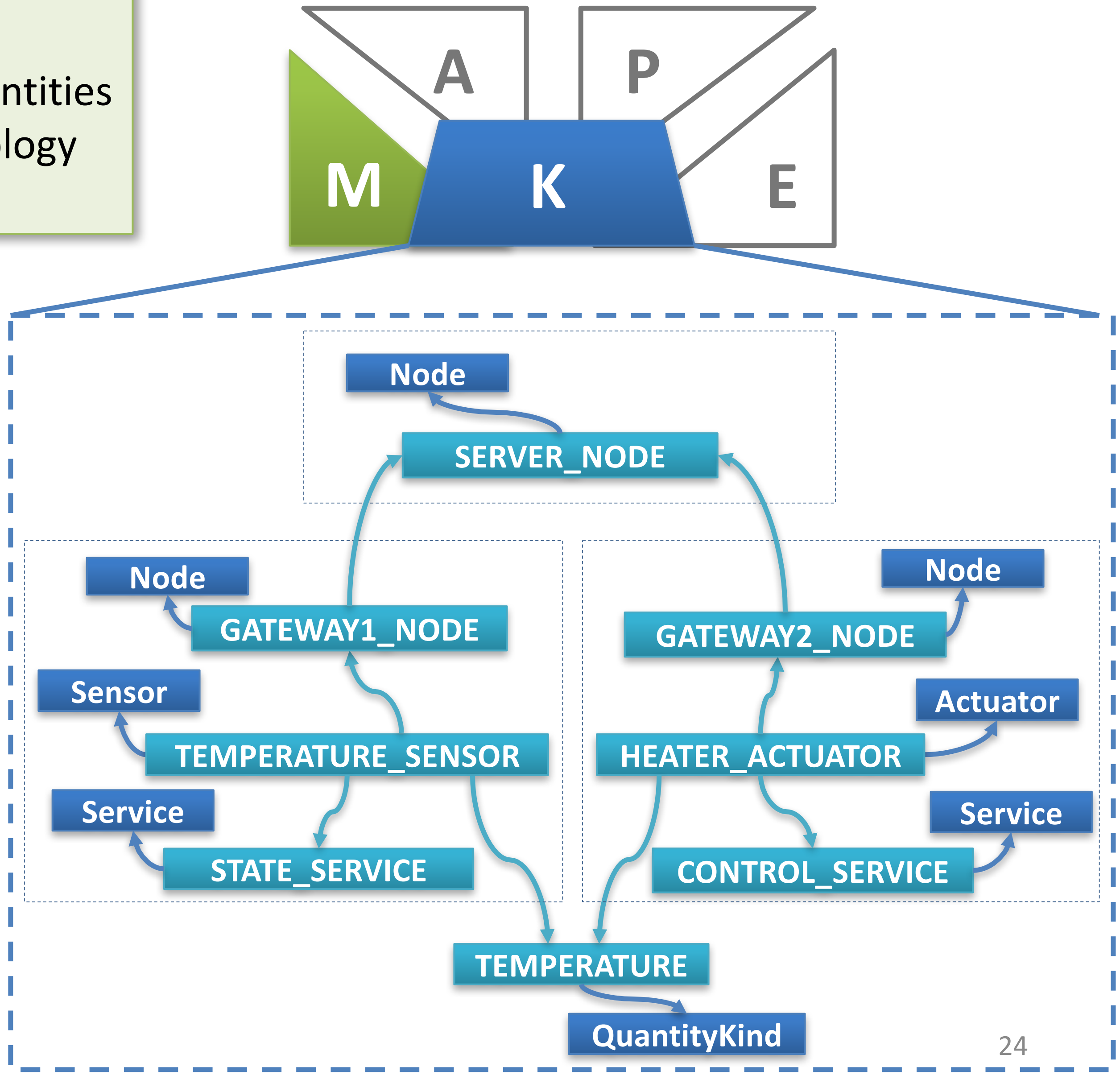
- Generic solutions for autonomic management of IoT systems.
- Ontology for semantic reasoning: self-configuration of devices

Self-configuring IoT devices based on semantic reasoning

1. Monitoring

- Runtime discovery of M2M entities and update of the IoT-O ontology instance.

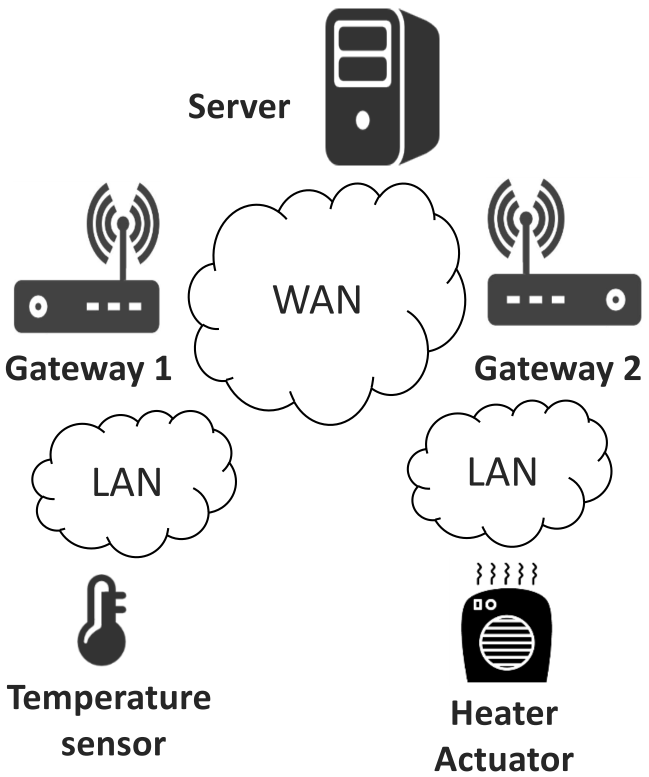


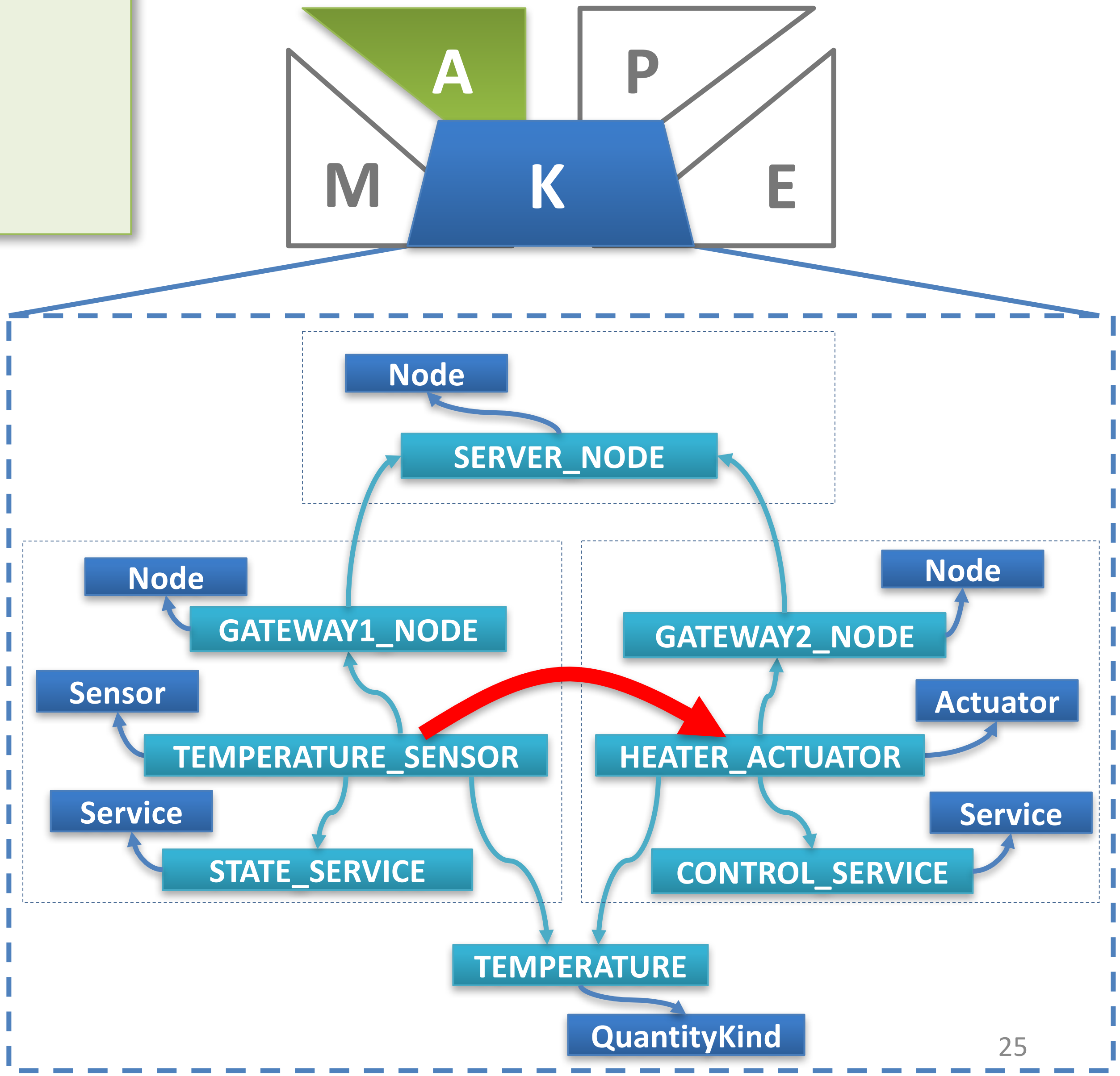


Self-configuring IoT devices based on semantic reasoning

2. Analyzing

- Apply semantic rules to find relevant matching between devices and applications.

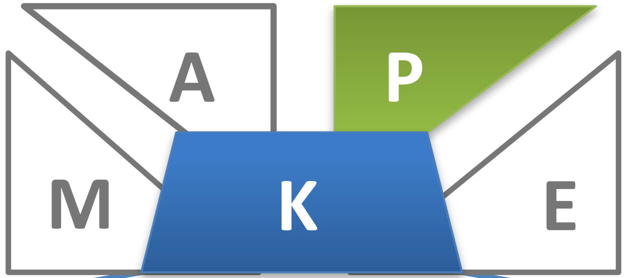


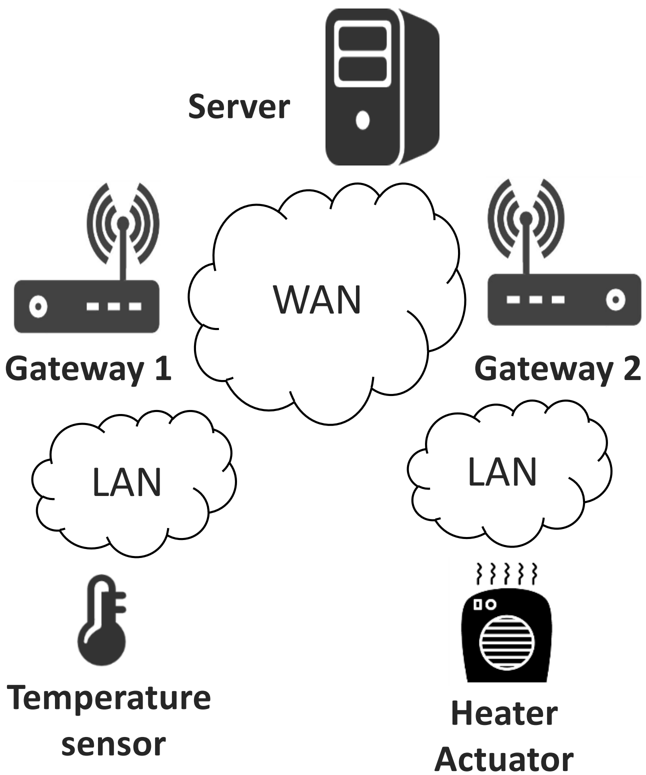


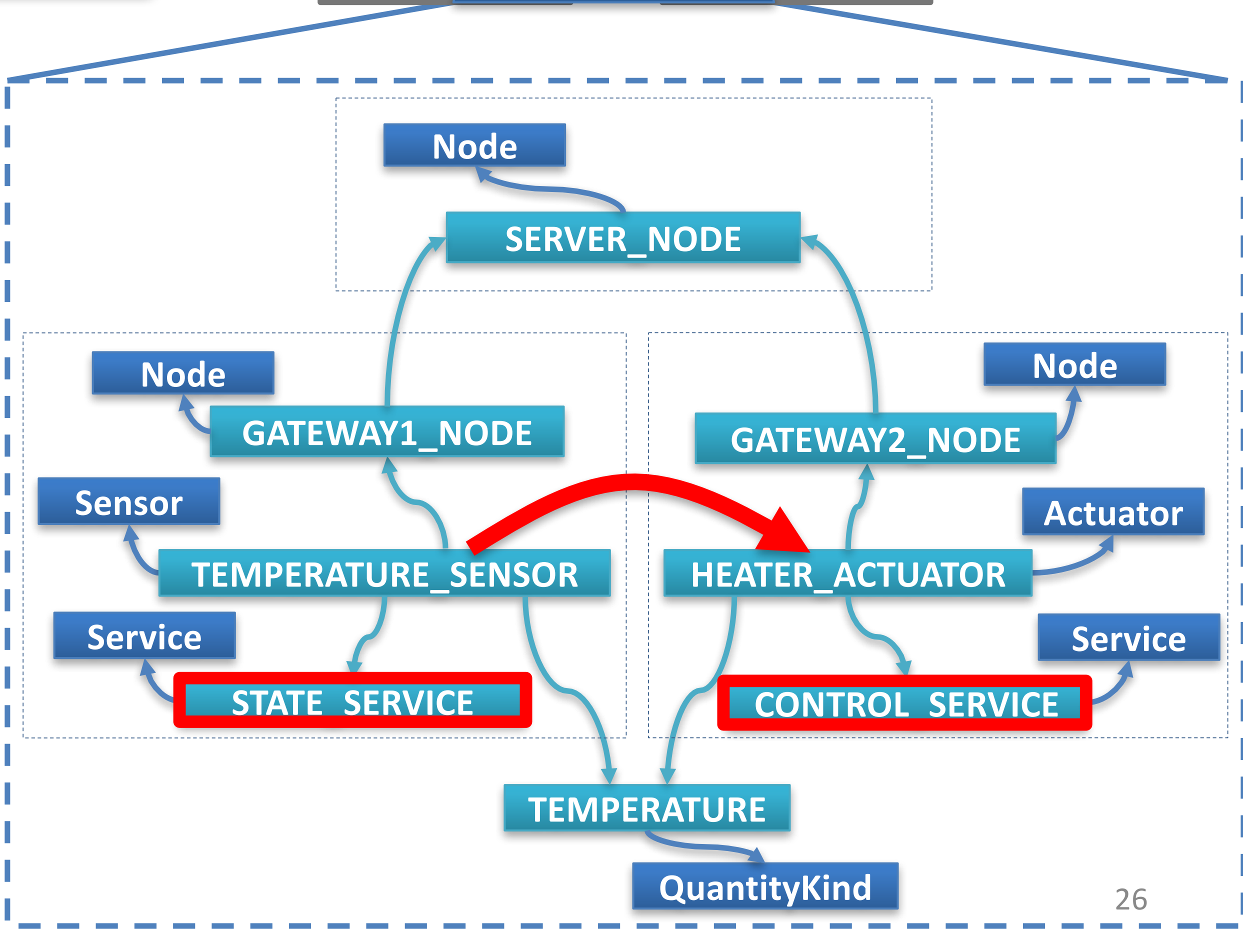
Self-configuring IoT devices based on semantic reasoning

3. Planning

- Query the ontology instance to find service operations of matched devices to create actions.



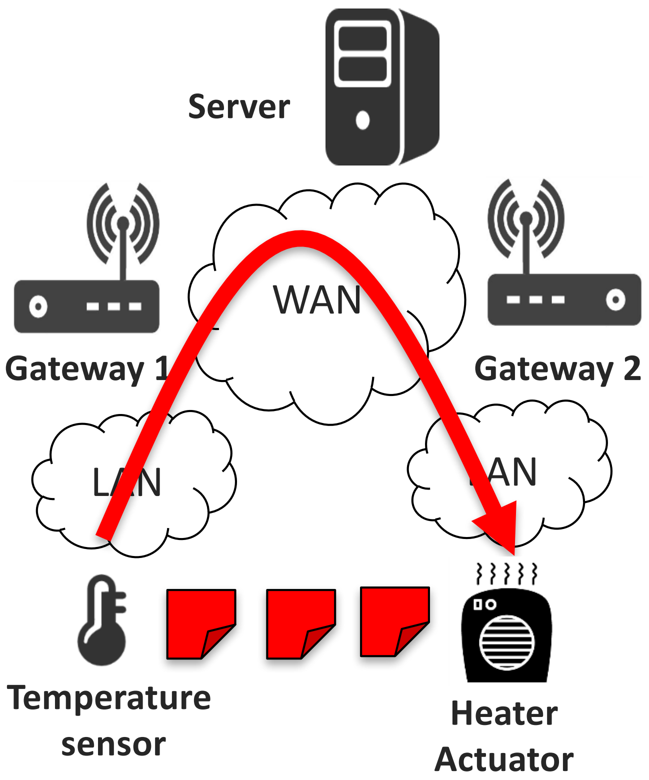


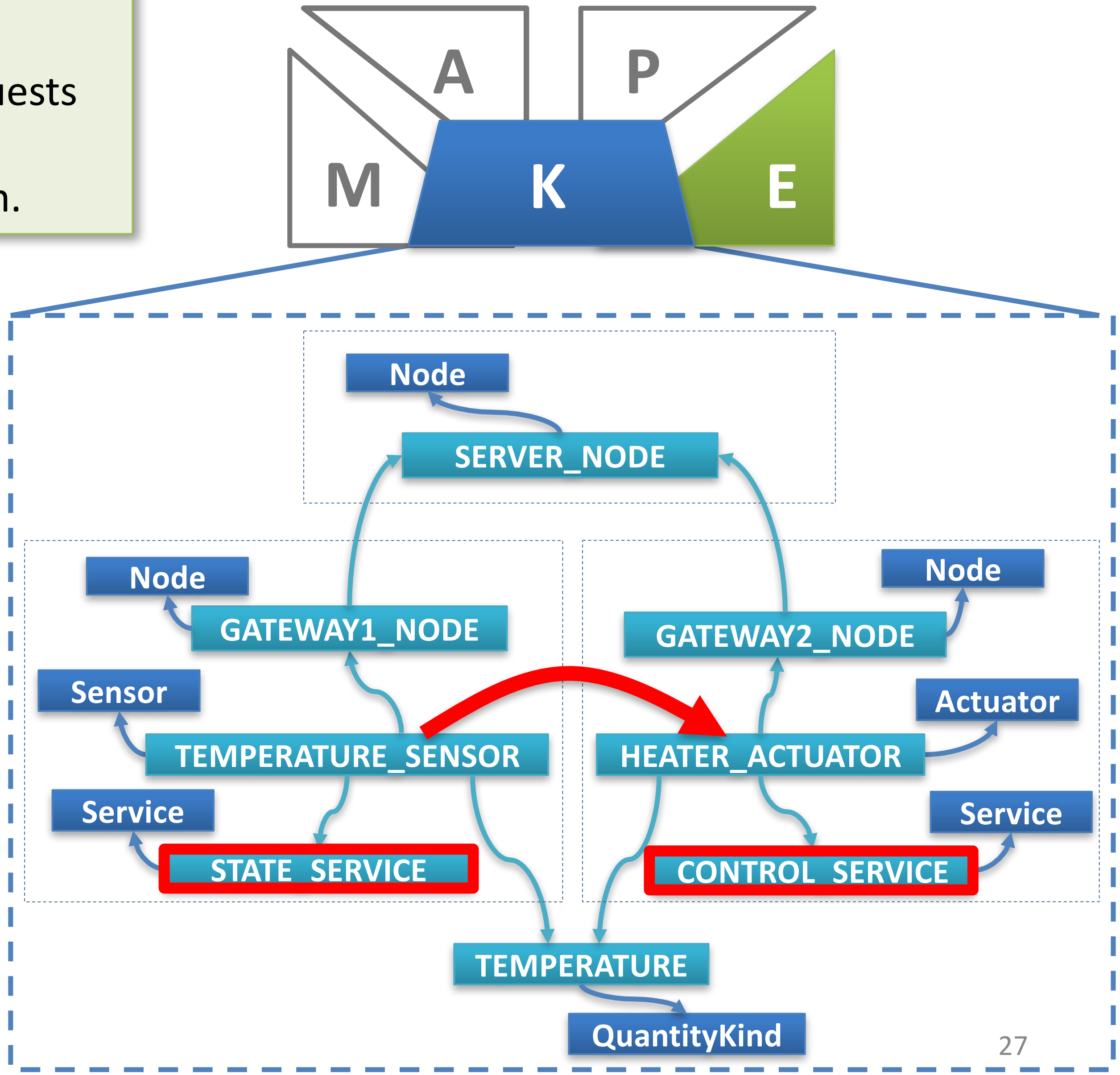


Self-configuring IoT devices based on semantic reasoning

4. Executing

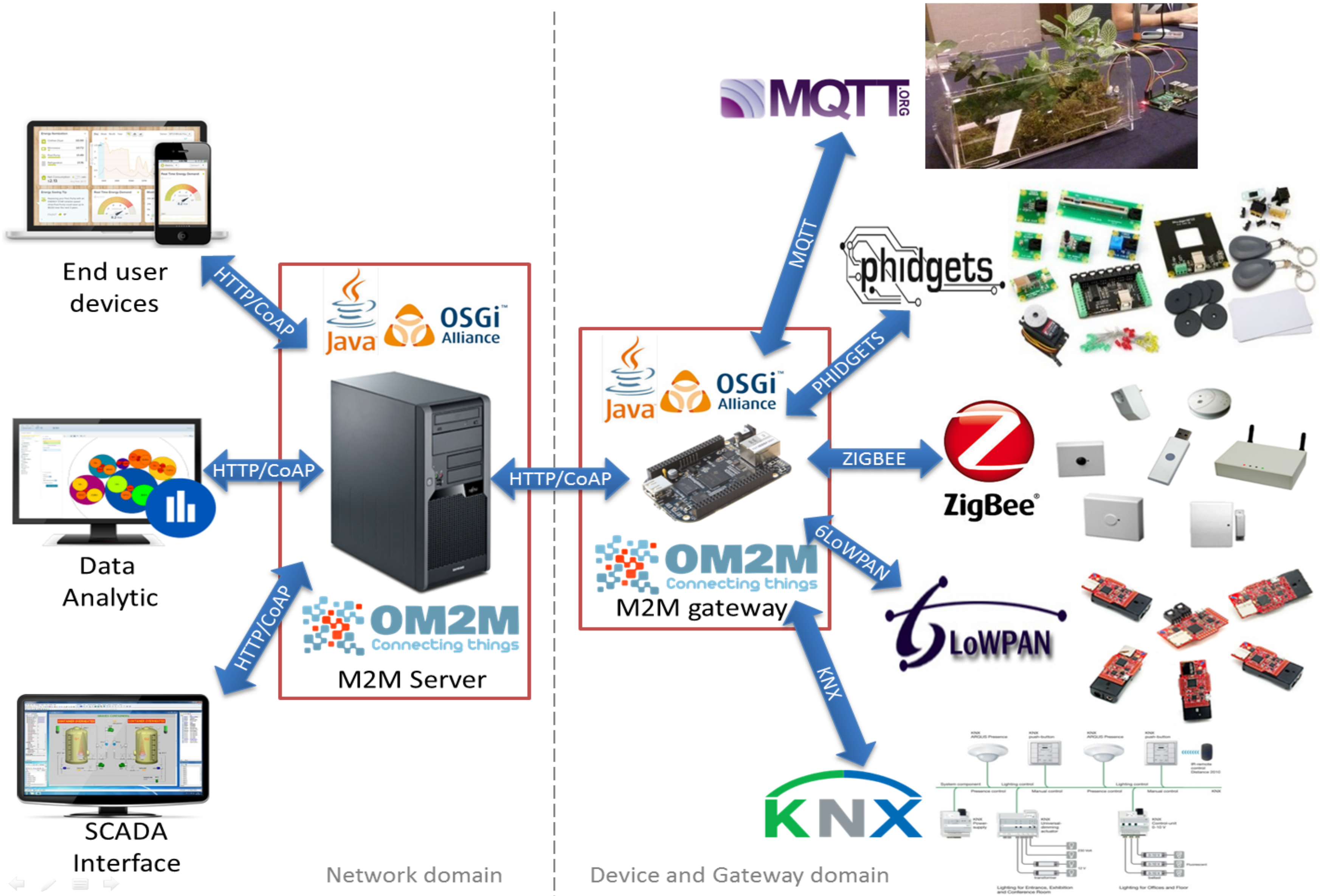
- Convert actions to HTTP requests and create required device subscriptions on the platform.





Enabling IoT cross-domain interoperability

OM2M: horizontal IoT service platform (om2m.org)



Conclusions: The statement

- Semantic interoperability: ripe standards for:
  - Communication level: converging initiatives:
    - Main telecom SDOs (USA/Canada, EU, China, S. Korea, Japan, India) have merged their efforts in a unique international standard: oneM2M
    - Other alliances and foundations: Allseen/Alljoin and OpenConnectivity/Iotivity have also merged
  - Data level: ontology now considered in international standards: oneM2M base ontology, ETSI SAREF ontology
- Design Complexity:
  - Efforts still required in:
    - Autonomic and Cognitive Computing for IoT services and applications: Machine Learning, semantic and automated reasoning, dynamic reconfiguration and adaptability
  - Needs for Solutions in: model-based engineering

Conclusions: The emerging directions

- New Technologies can leverage IoT mass deployment:
  - Towards secure/decentralized/efficient/transparent IoT platforms based on blockchain technology (e.g. platforms: ethereum, distributed block-chain based cloud storage: storj.io)
- We can anticipate the emergence of new extended IoT applications:
  - New Blockchains-IoT smart applications: “from self-driving to self-renting cars” (ride sharing and private transportation platforms: e.g. Slock.it)
- Expected Social/economic impact:
  - Automated management with smart contracts will lead to: Democratization of IoT-based individual economic activities: No need for third party (Banks) -Middlemen (Amazon, AirB&B, Drivy) in distributed transactions.

For more questions, interaction: khalil@laas.fr

Resources available under: om2m.org

Publications available under: www.laas.fr