THE ROLE OF INTEROPERABILITY IN ACHIEVING PROFITABLE GROWTH IN IOT

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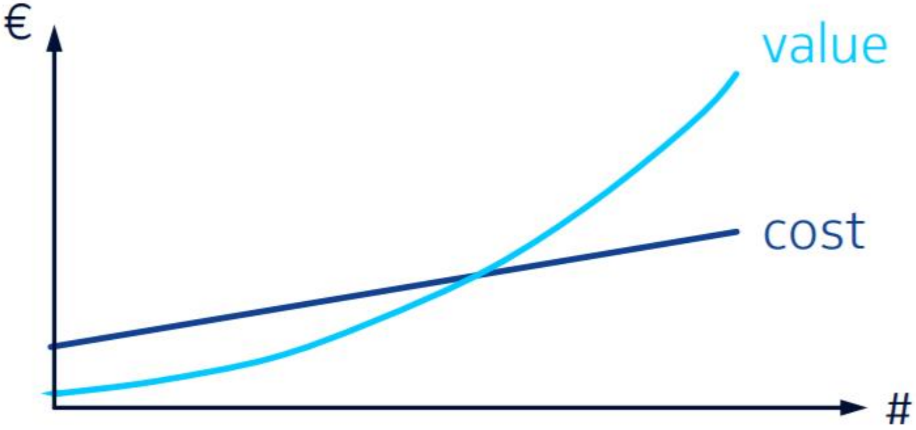
oneM2M www.oneM2M.org

Outline

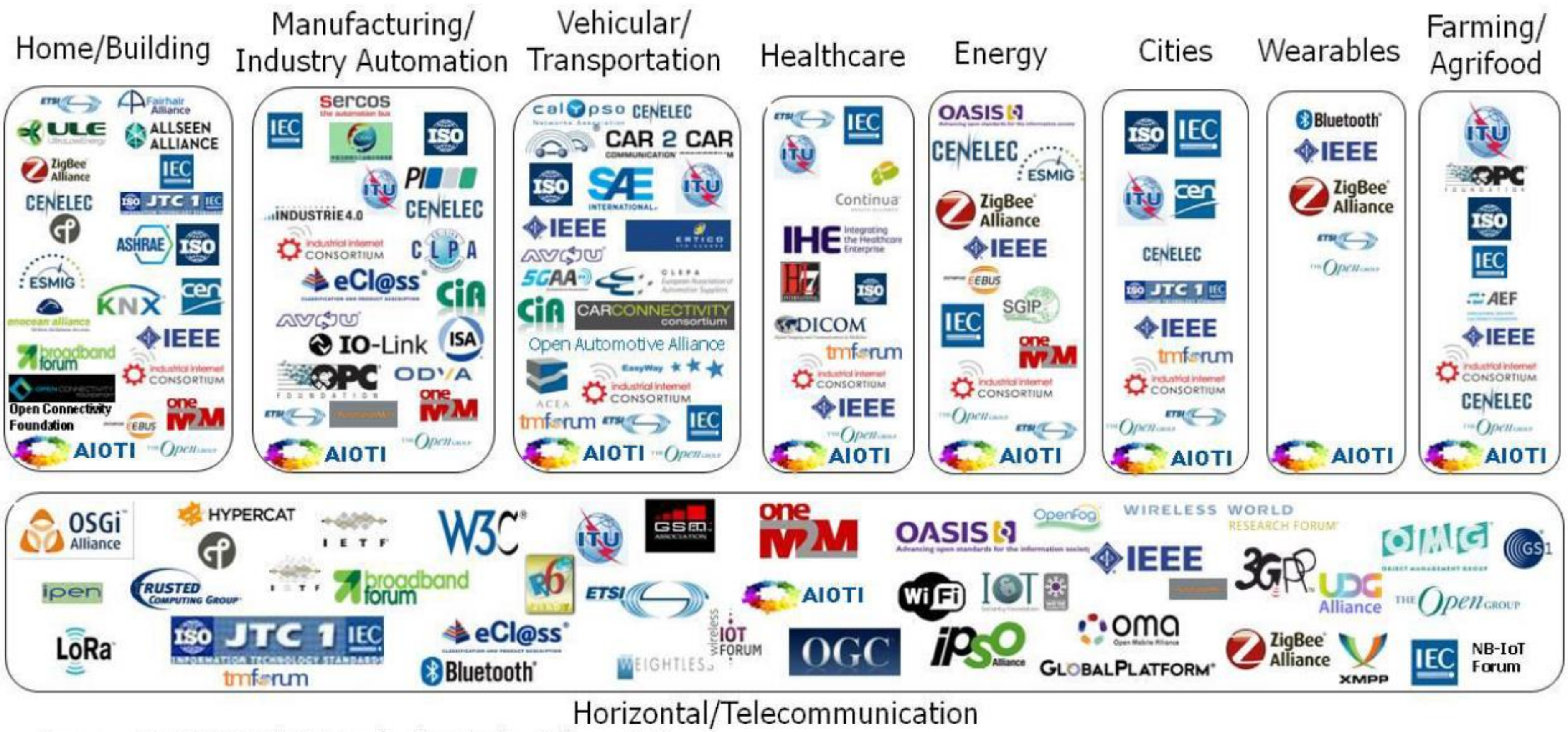
- Why IoT needs interoperability?
- Technology trends for IoT
- Introduction to oneM2M
- Semantic interoperability
- Takeaway

Metcalfe's law

The value of a network is proportional to the square of the number of its nodes – while the cost follows a more or less linear function



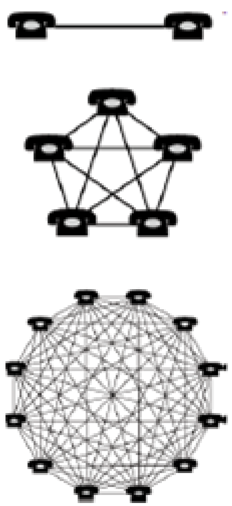
The issue with IoT interoperability is diversity



Source: AIOTI WG3 (IoT Standardisation) – Release 2.7

IoT value will come through Metcalfe's law, **if** we solve interoperability issues **within and across IoT domains**

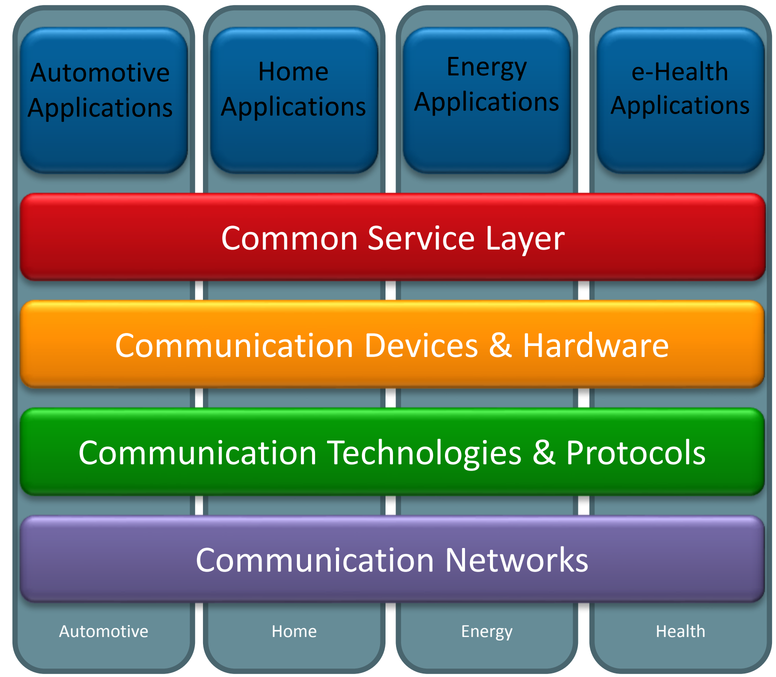
Point-to-point Integrations don't scale



Creating new integrations is unpredictable

Monocultures lock you in

Past choices restrict present action and future vision



Platform based integration
open standards and open source are key

Source: CRYSTAL project/Philips

What market research says

Nearly 40 percent of economic impact requires interoperability between IoT systems

Potential economic impact of IoT[1]

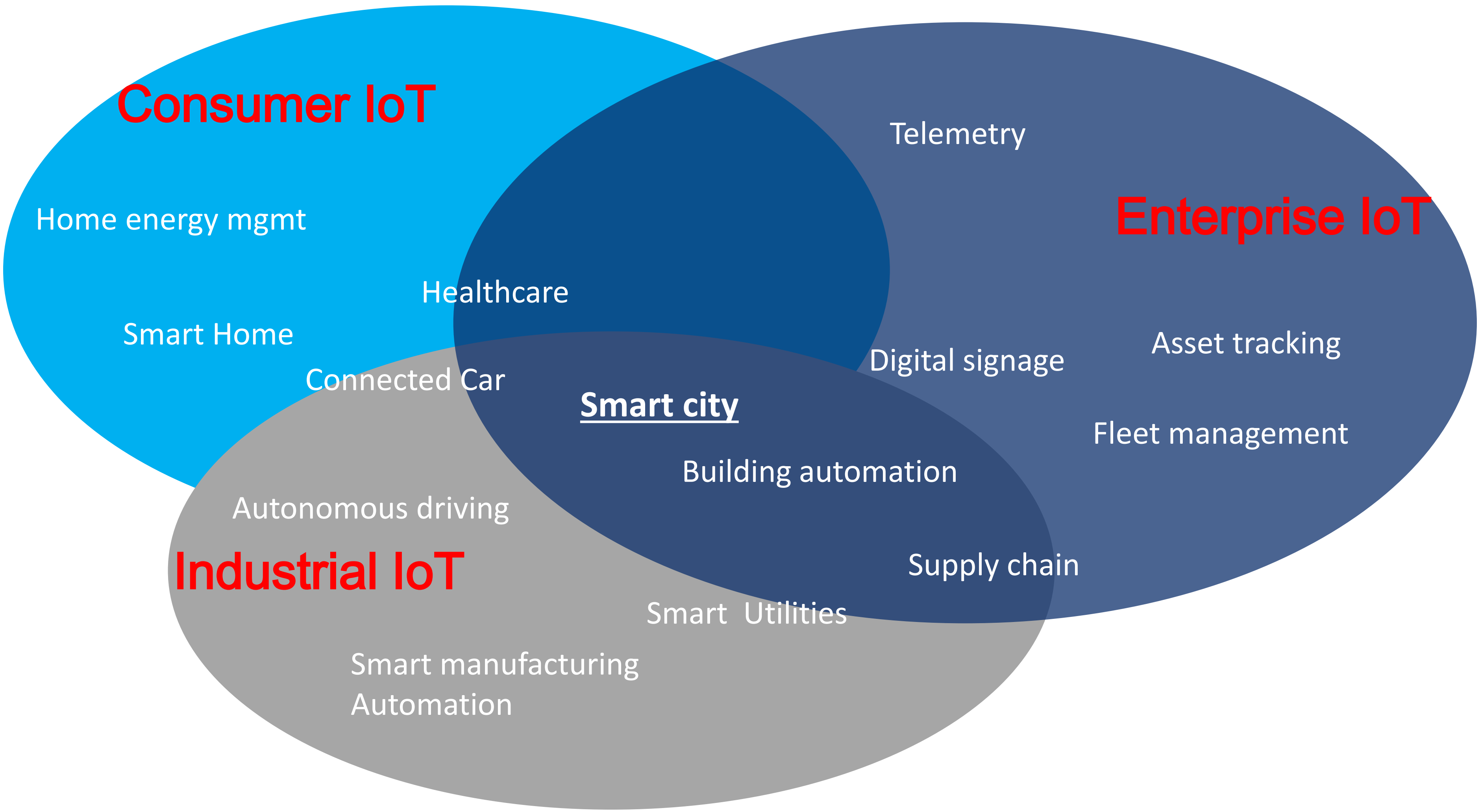
$11.1 trillion

Value potential requiring interoperability ($ trillion)		% of total value	Examples of how interoperability enhances value
Factories	1.3	36	Data from different types of equipment used to improve line efficiency
Cities	0.7	43	Video, cellphone data, and vehicle sensors to monitor traffic and optimize flow
Retail environments	0.7	57	Payment and item detection system linked for automatic checkout
Work sites	0.5	56	Linking worker and machinery location data to avoid accidents, exposure to chemicals
Vehicles	0.4	44	Equipment usage data for insurance underwriting, maintenance, pre-sales analytics
Agriculture	0.3	20	Multiple sensor systems used to improve farm management
Outside	0.3	29	Connected navigation between vehicles and between vehicles and GPS/traffic control
Home	0.1	17	Linking chore automation to security and energy system to time usage
Offices	0[2]	30	Data from different building systems and other buildings used to improve security

1 Includes sized applications only; includes consumer surplus.
2 Less than $100 billion.
NOTE: Numbers may not sum due to rounding.

SOURCE: Expert interviews; McKinsey Global Institute analysis

… in particular true for Smart Cities



What market research says

- ABI Research report: “The Increasing Importance of System Integrators in the IoT Value Chain”, august 2017

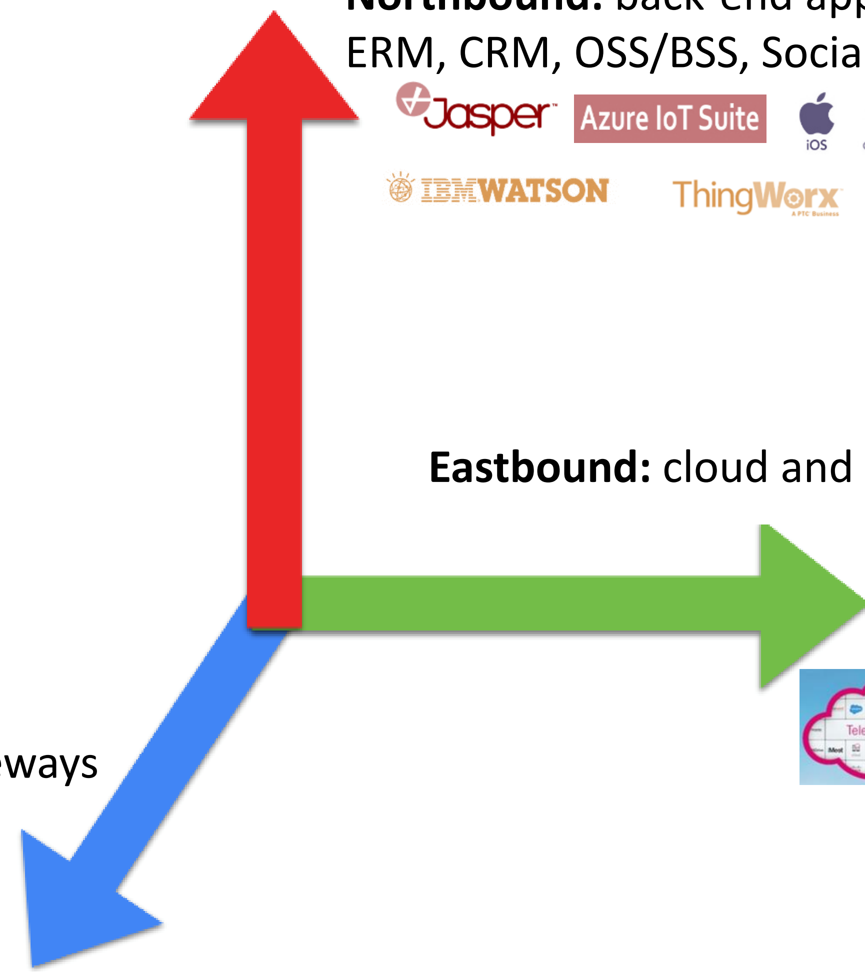
- ABI Research report, “The Role of System Integrators in M2M and IoT”, august 2017

Table 2: IoT System Integration and Consulting Revenues by Region
World Market, Forecast: 2017 to 2022
(Source: ABI Research)

Region	Revenue	2017	2018	2019	2020	2021	2022	CAGR 17-22
North America	(US$ Millions)	$3,194	$3,633	$4,202	$4,902	$5,652	$6,619	15.7%
Western Europe	(US$ Millions)	$2,382	$2,958	$3,652	$4,455	$5,387	$6,740	23.1%
Eastern Europe	(US$ Millions)	$850	$978	$1,125	$1,287	$1,462	$1,744	15.5%
Asia Pacific	(US$ Millions)	$4,680	$5,433	$6,313	$7,260	$8,326	$9,997	16.4%
Latin America	(US$ Millions)	$783	$857	$958	$1,096	$1,252	$1,527	14.3%
Middle East & Africa	(US$ Millions)	$449	$511	$571	$632	$698	$817	12.7%
Total	(US$ Millions)	$12,338	$14,369	$16,823	$19,632	$22,778	$27,445	17.3%

Dimensions for IoT interoperablity

Northbound: back-end apps, Analytics, ERM, CRM, OSS/BSS, Social



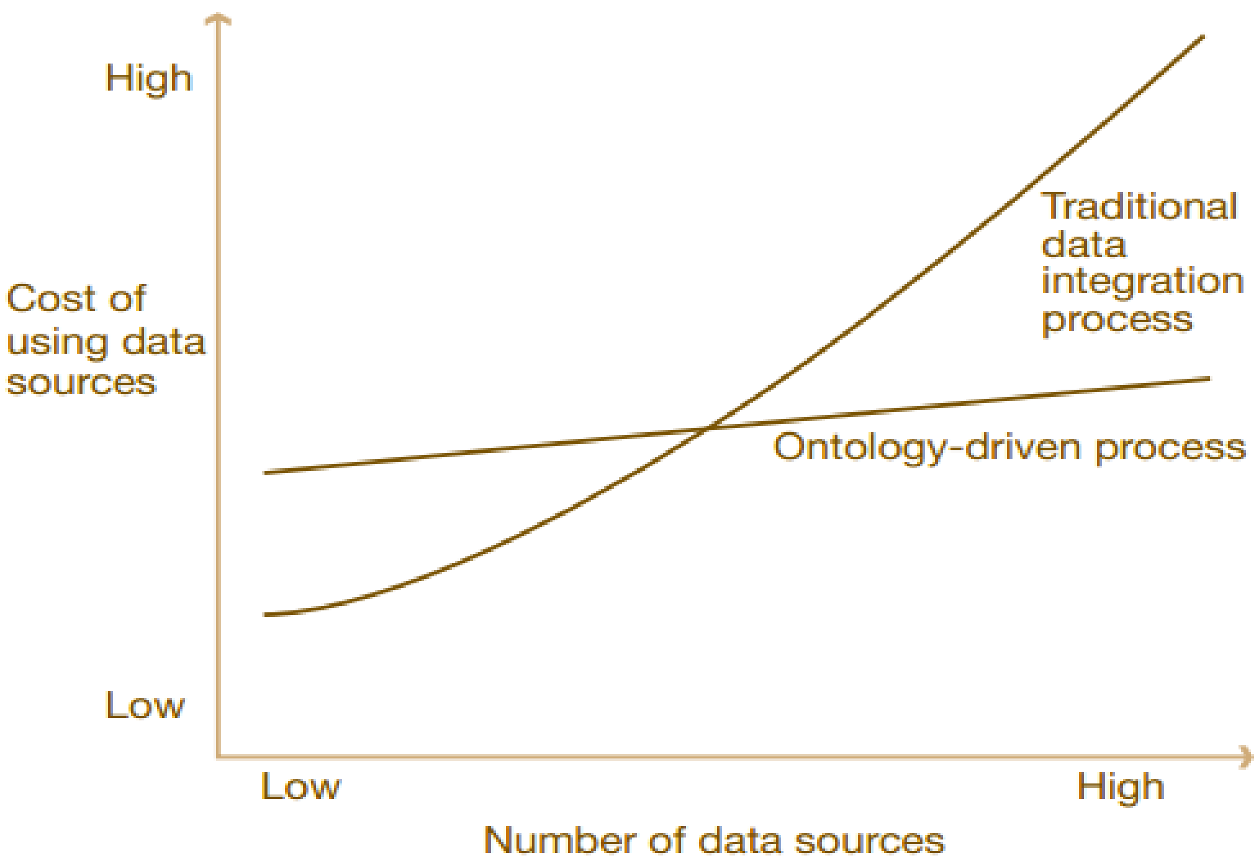
Eastbound: cloud and hosting

Southbound: Devices, gateways and access technologies

LWM2M

The cost of data integration

- Ontology-driven approaches: lower costs when dealing with high number of data sources
- It ensures interoperability for open and big environments.

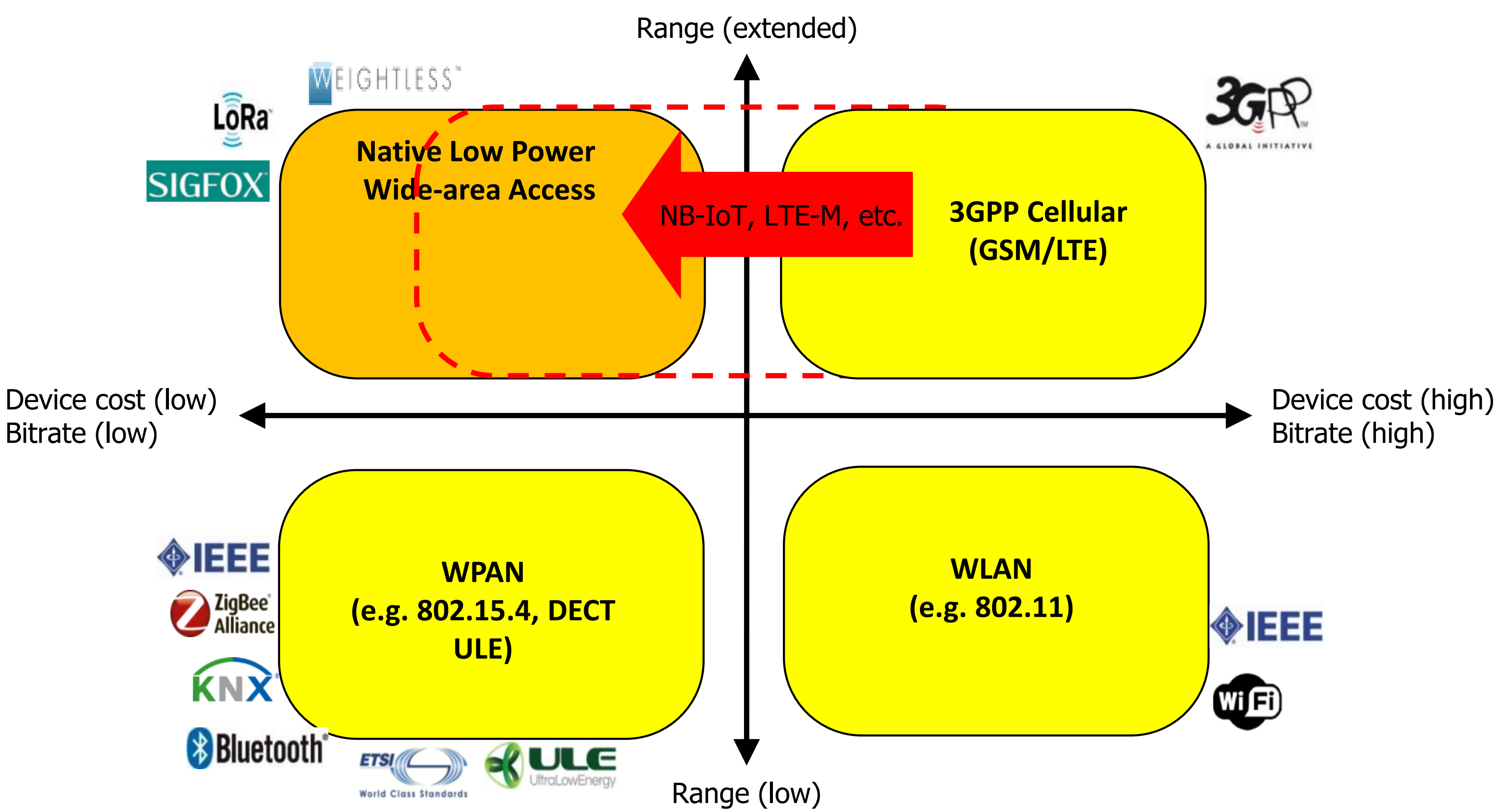


Source: Price Waterhouse Cooper

Why oneM2M? Why now?

- M2M (and IoT) communications existed for so many years, e.g.:
  - SCADA systems
  - Satellite based truck tracking
- So why oneM2M?
  - *Specific standards exist* for home automation, smart factory, energy management, etc. but much larger growth will come from a fully integrated Internet of Things
  - The IoT vision will not materialize if we do not solve interoperability issues, therefore drive down integration costs and ensure time to market
- Why now?
  - Technology is ready for an *outcome based economy* for a large number of use cases, more than what one can think of

Technology 1: connectivity, plenty to chose from

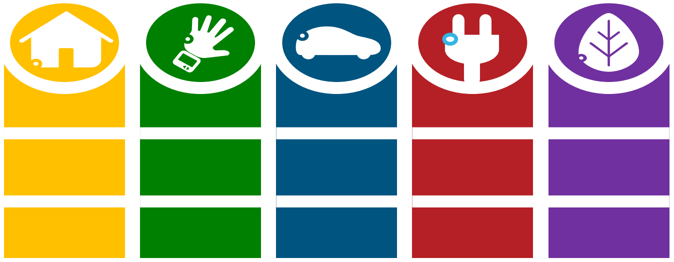


Source AIOTI, modified from an ALU contribution

Technology 2: horizontalization «building IoT in Silos belongs to the past »

NICHE VERTICALS
Low volumes, high ARPC, high TCO

- Devices and Applications are designed as "stove-pipes"
- Devices dedicated for single application use
- Solutions are closed and not scalable: duplication of dedicated infrastructure
- High development & delivery cost

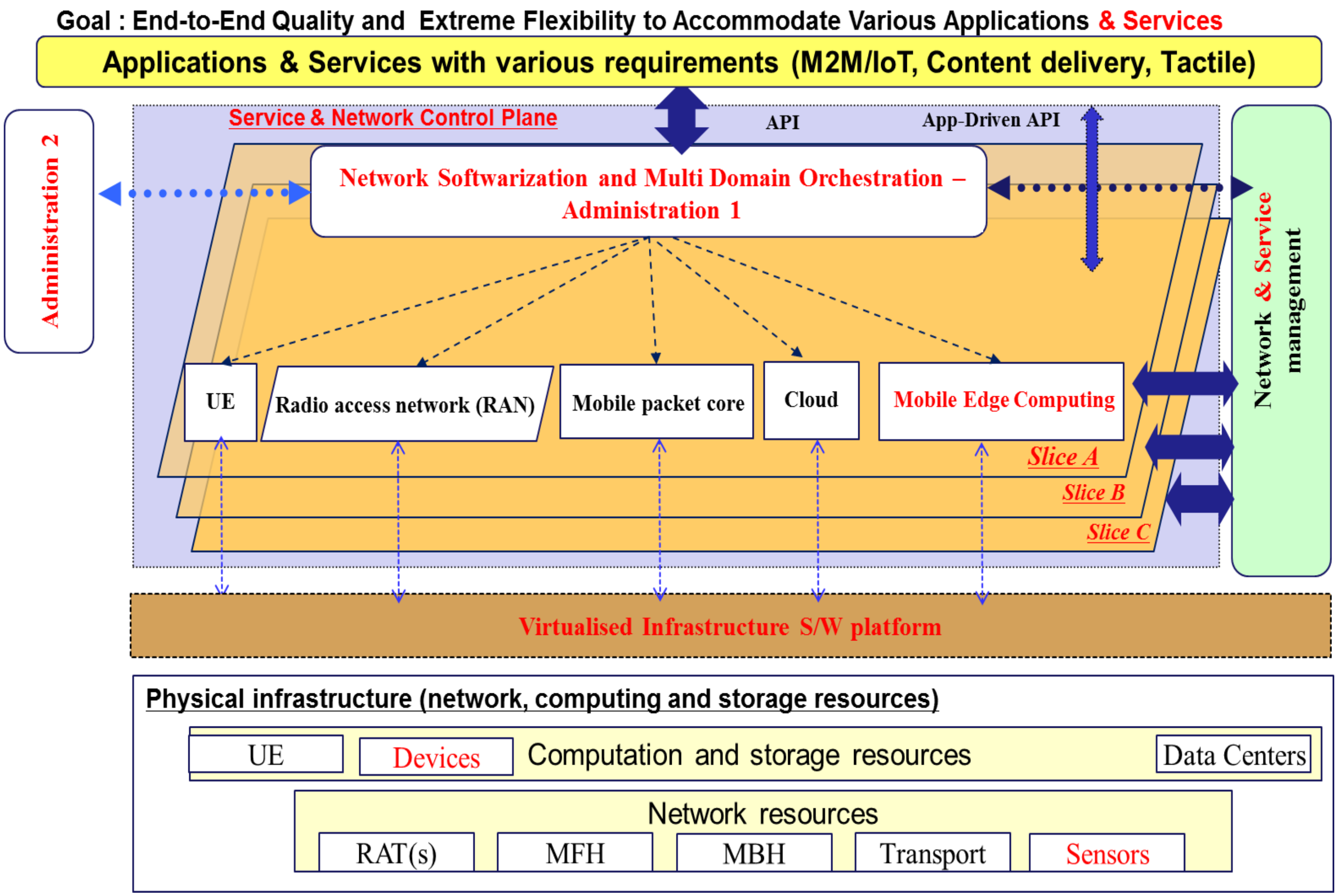


BROAD ADOPTION
High volume, low ARPC, low TCO

- Devices and Applications are designed to collaborate across "clouds"
- Devices are used for multiple application purposes
- Devices and Applications offering continuously evolve
- Easy app development and device integra-tion through APIs and standard interfaces

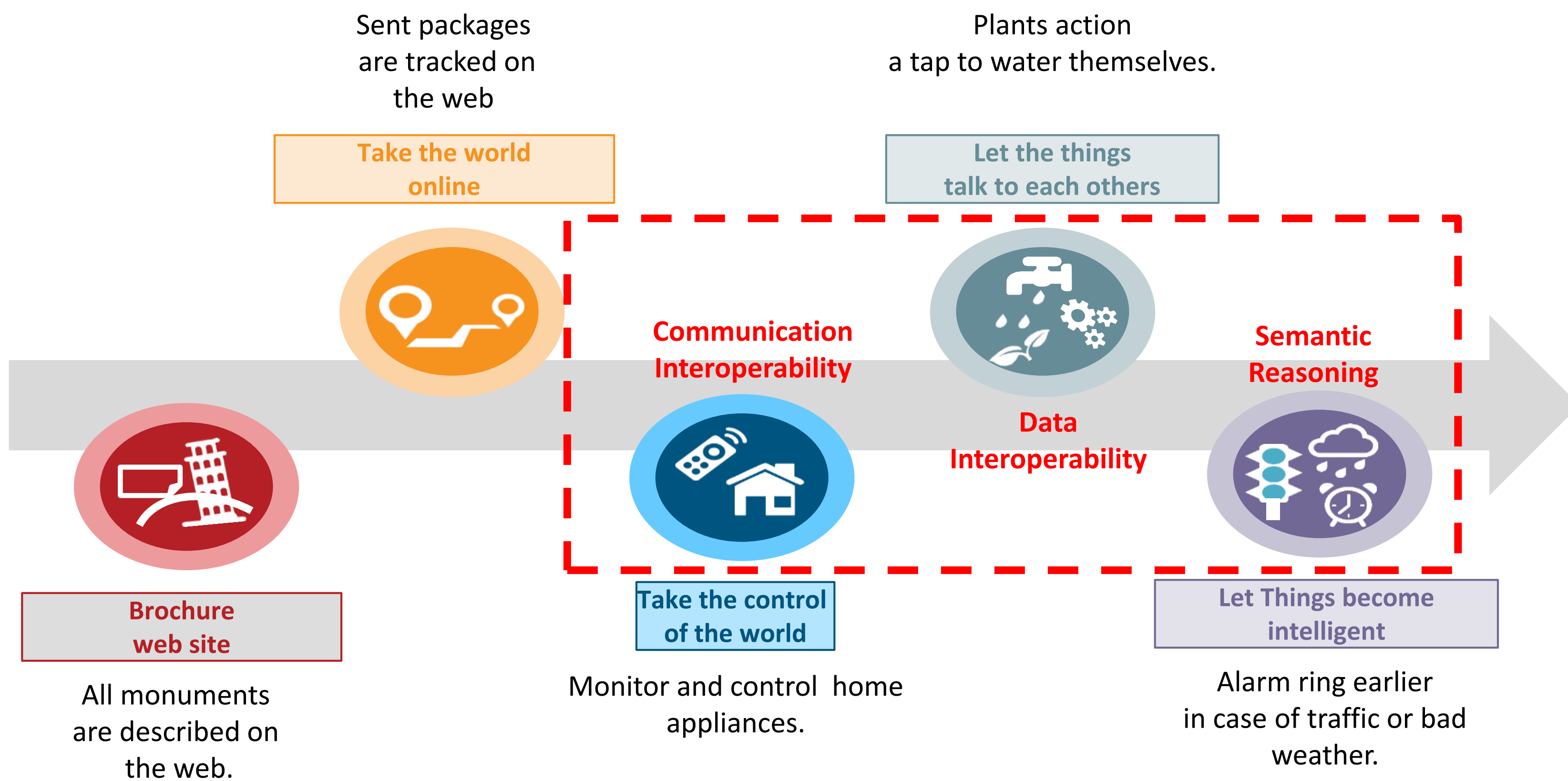
Source: Alcatel-Lucent

Technology 3: "softwarization" and IoT virtualization



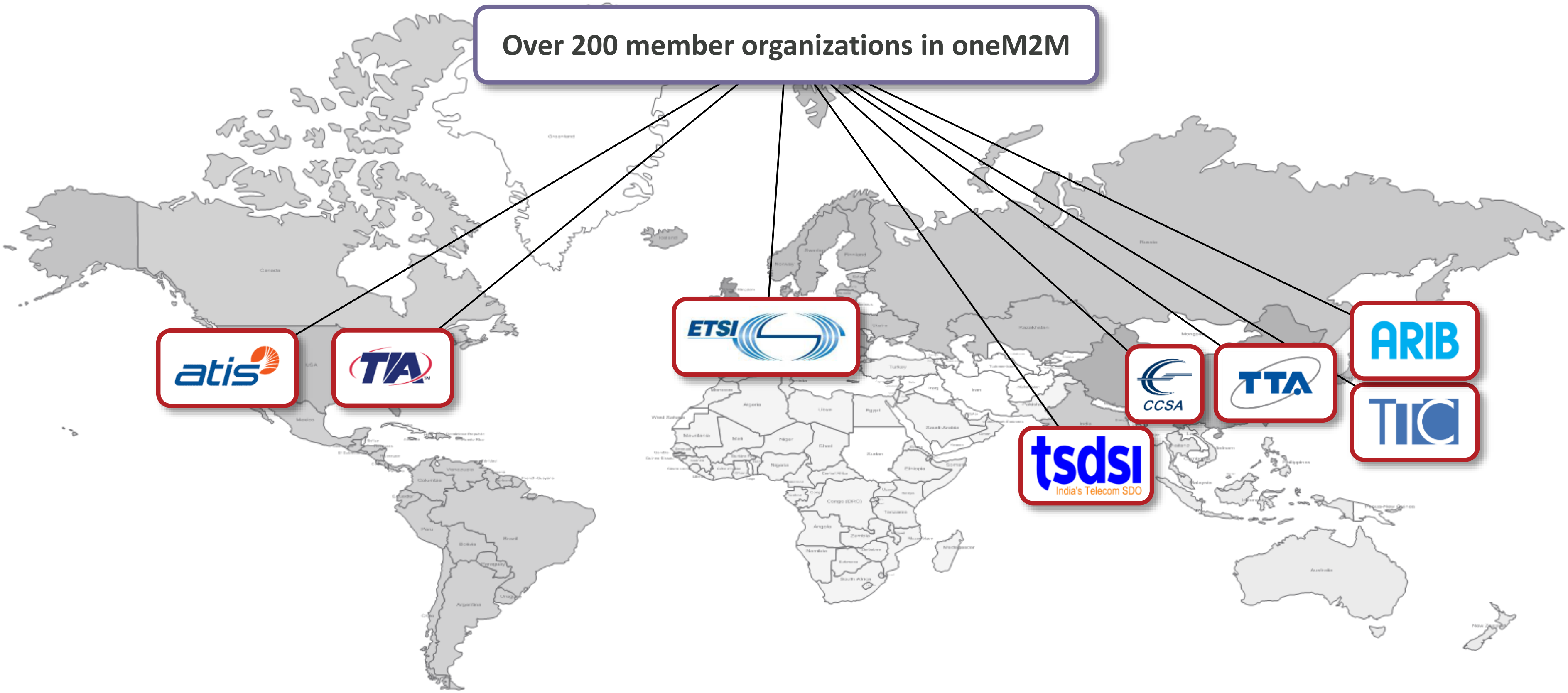
Source: ITU-T Focus Group IMT2020

Technology 4: Semantic interoperability, no longer a research syndrome?



Source: sensinov

oneM2M Partnership Project



CEN CENELEC broadband forum oma Open Mobile Alliance New Generation M2M Consortium GlobalPlatform

www.oneM2M.org

All document are publically available

M2M Common Service Layer in a nutshell

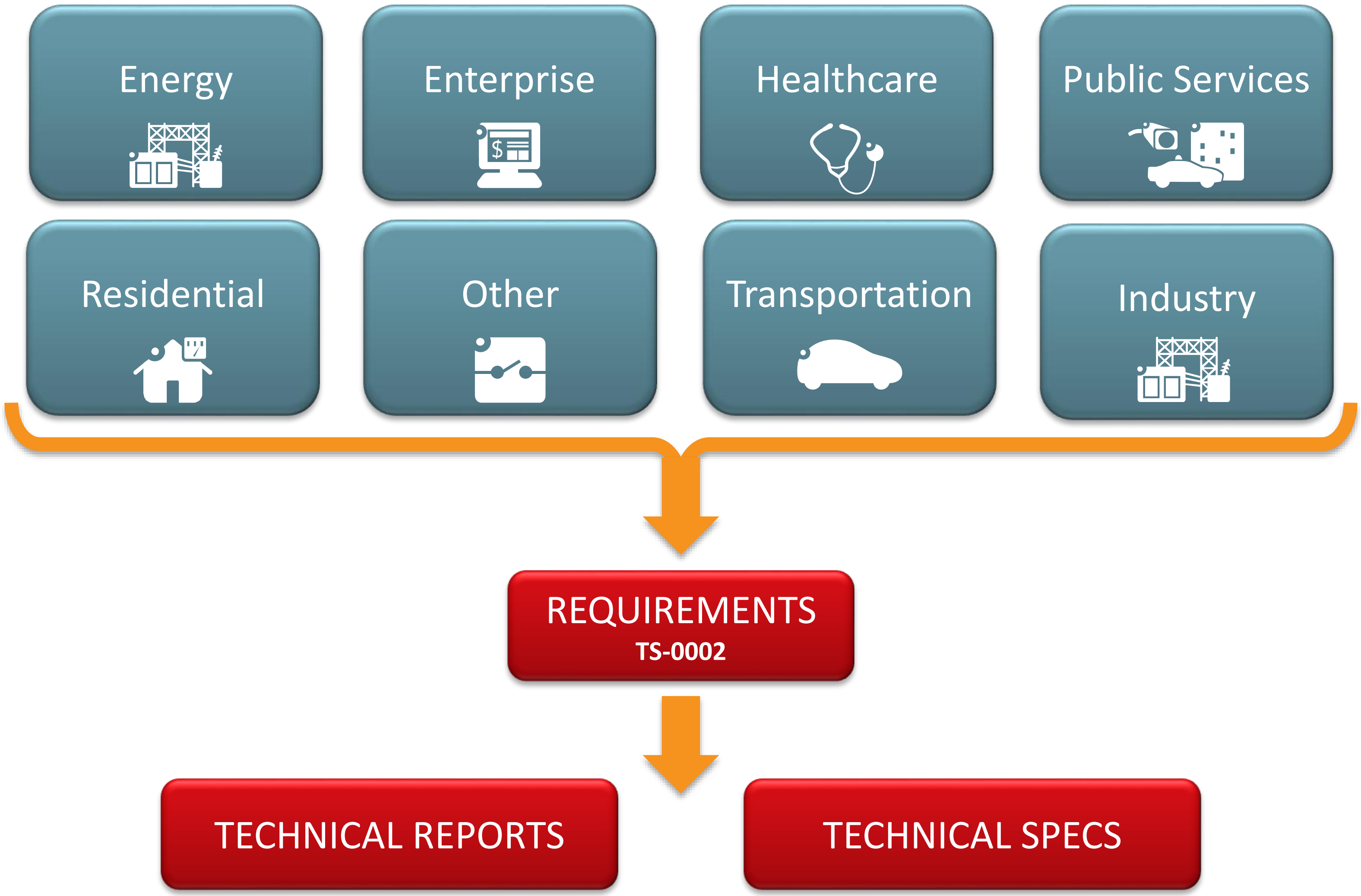
A software “framework”

Located between the M2M applications and communication HW/SW that provide connectivity

Provides functions that M2M applications across different industry segments commonly need (eg. data transport, security/encryption, remote software update...)

Like an “Android” for the Internet of Things
But it sits both on the field devices/sensors and in servers
And it is a standard – not controlled by a single private company

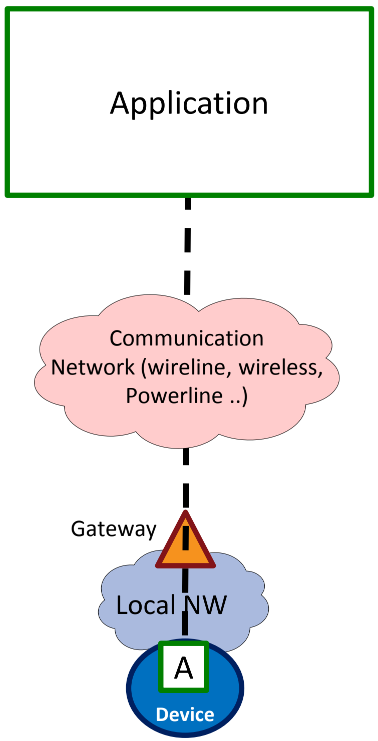
Work Process



oneM2M Architecture approach

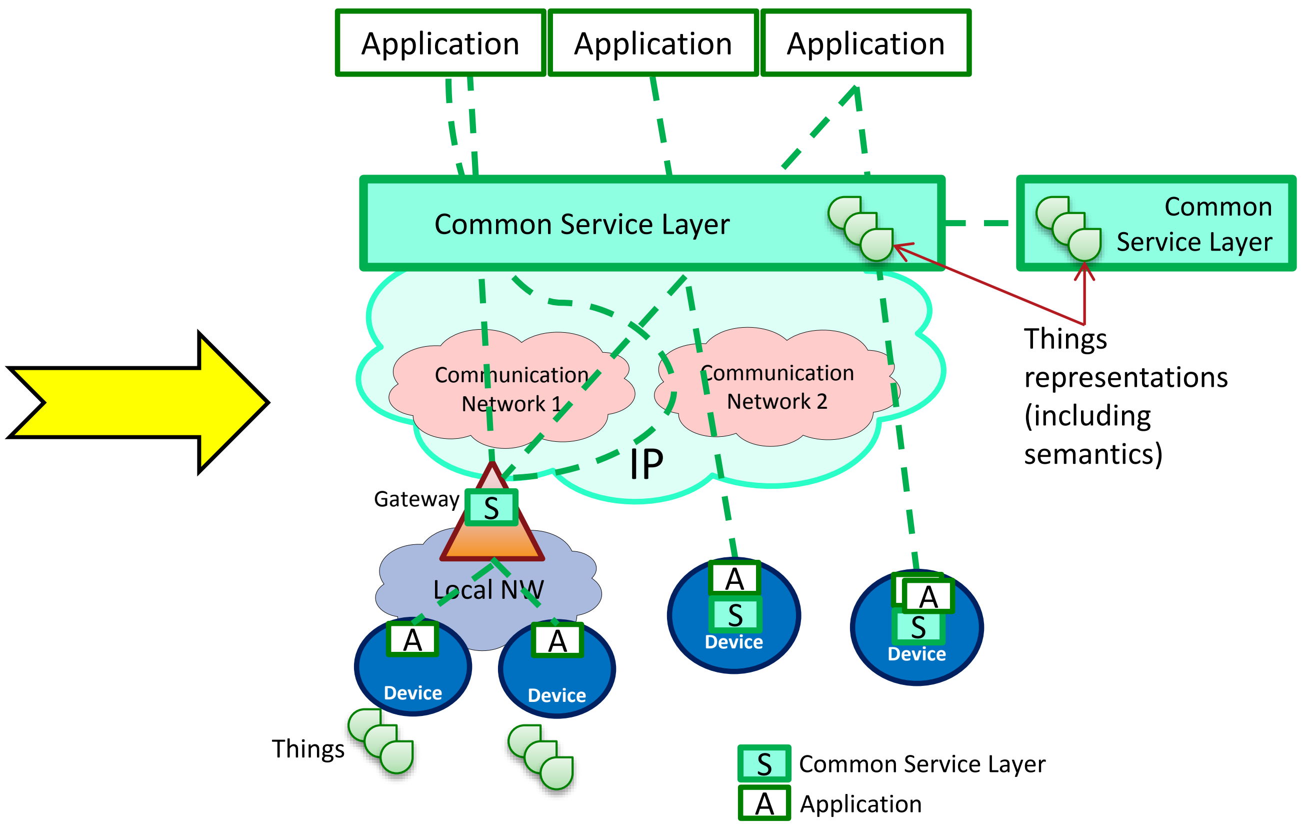
Pipe (vertical):

1 Application, 1 NW,
1 (or few) type of Device
Point to point communications



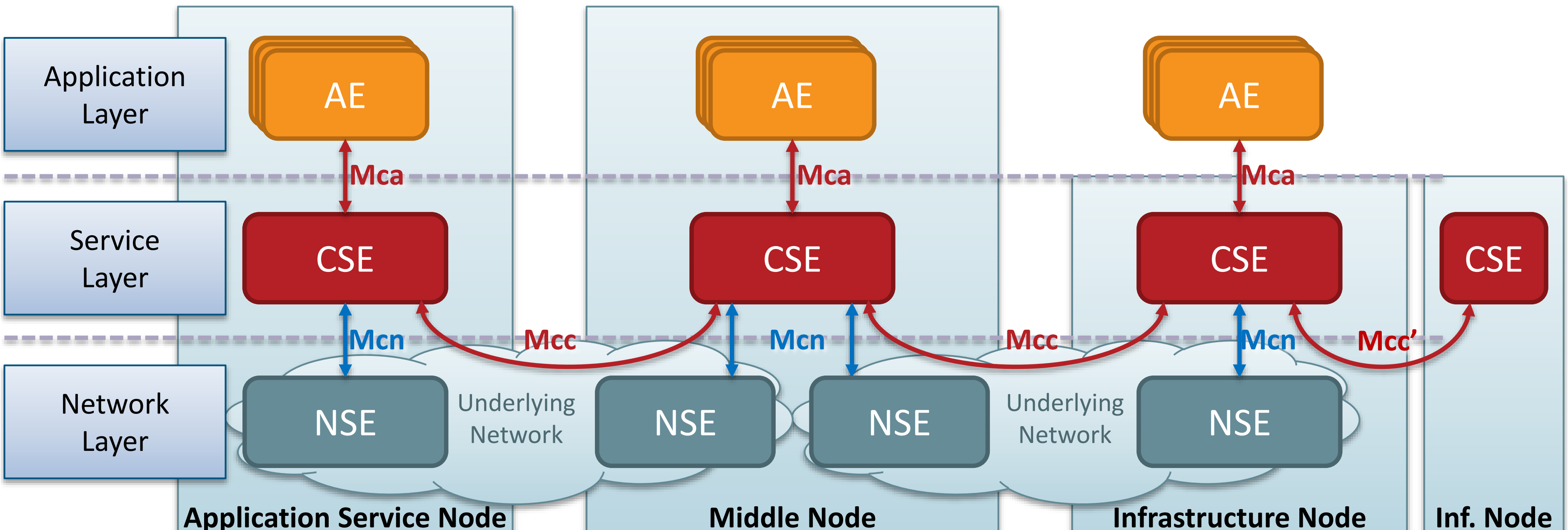
Horizontal (based on common Layer)

Applications share common service and network infrastructure
Multipoint communications



RESTful Architecture

Reference Point	One or more interfaces - Mca, Mcn, Mcc and Mcc’ (between 2 service providers)
Common Services Entity	Provides the set of "service functions" that are common to the M2M environments
Application Entity	Provides application logic for the end-to-end M2M solutions
Network Services Entity	Provides services to the CSEs besides the pure data transport
Node	Logical equivalent of a physical (or possibly virtualized, especially on the server side) device



Multiple protocol bindings (HTTP, CoAP, MQTT, or WebSocket) over Mca, Mcc, Mcc’

Communication Protocols

Reuse IP-based existing protocols

NB: Interworking with field area protocols and data models (OCF, AllSeen, OMA LWM2M, Zwave, etc)

Service Layer
Core Protocols
TS-0004

CoAP | HTTP | MQTT Binding | WebSockets

XML or JSON Content serialization - HTTP Example

REQUEST

GET /~/CSE-178/CSEBase/home/temperature HTTP/1.1
Host: provider.net
X-M2M-Origin: /CSE-123/WeatherApp42
X-M2M-RI: 56398096
Accept: application/json

RESPONSE

HTTP/1.1 200 OK
X-M2M-RI: 56398096
X-M2M-RSC: 2000
Content-Type: application/vnd.onem2m-res+json
Content-Length: 101
{“m2m:cin”:[
"cnf":"application/json:0",
"con":"{'timestamp':1413405177000,'value':25.32}"]
}

Common Service Functions

- Registration
- Discovery & Announcement
- Security
- Group Management
- Data Management & Repository
- Subscription & Notification
- Device Management
- Application & Service Management
- Communication Management
- Network Service Exposure
- Location
- Service Charging & Accounting
- Semantics
- Interworking

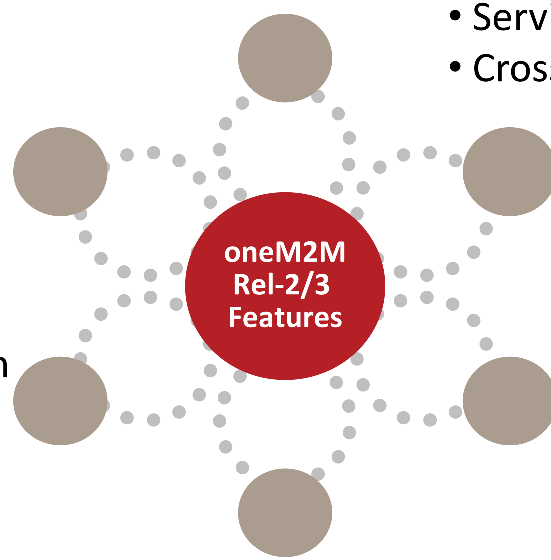
Summary of Release 2/3 Features

Industrial Domain Enablement
- Time series data management
- Atomic Transactions
- Action Triggering
- Optimized Group Operations

Management
- M2M Application & Field Domain Component Configuration

Semantics
- Semantic Description/Annotation
- Semantic Querying
- Semantic Mashups
- oneM2M Base Ontology

Security
- Dynamic Authorization
- End to End Security
- Enrollment & Authentication APIs
- Distributed Authorization
- Decentralized Authentication
- Interoperable Privacy Profiles
- Secure Environment Abstraction



Home Domain Enablement
- Home Appliance Information Models & SDT
- Mapping to existing standards (OCF, ECHONET, GoTAPI...)

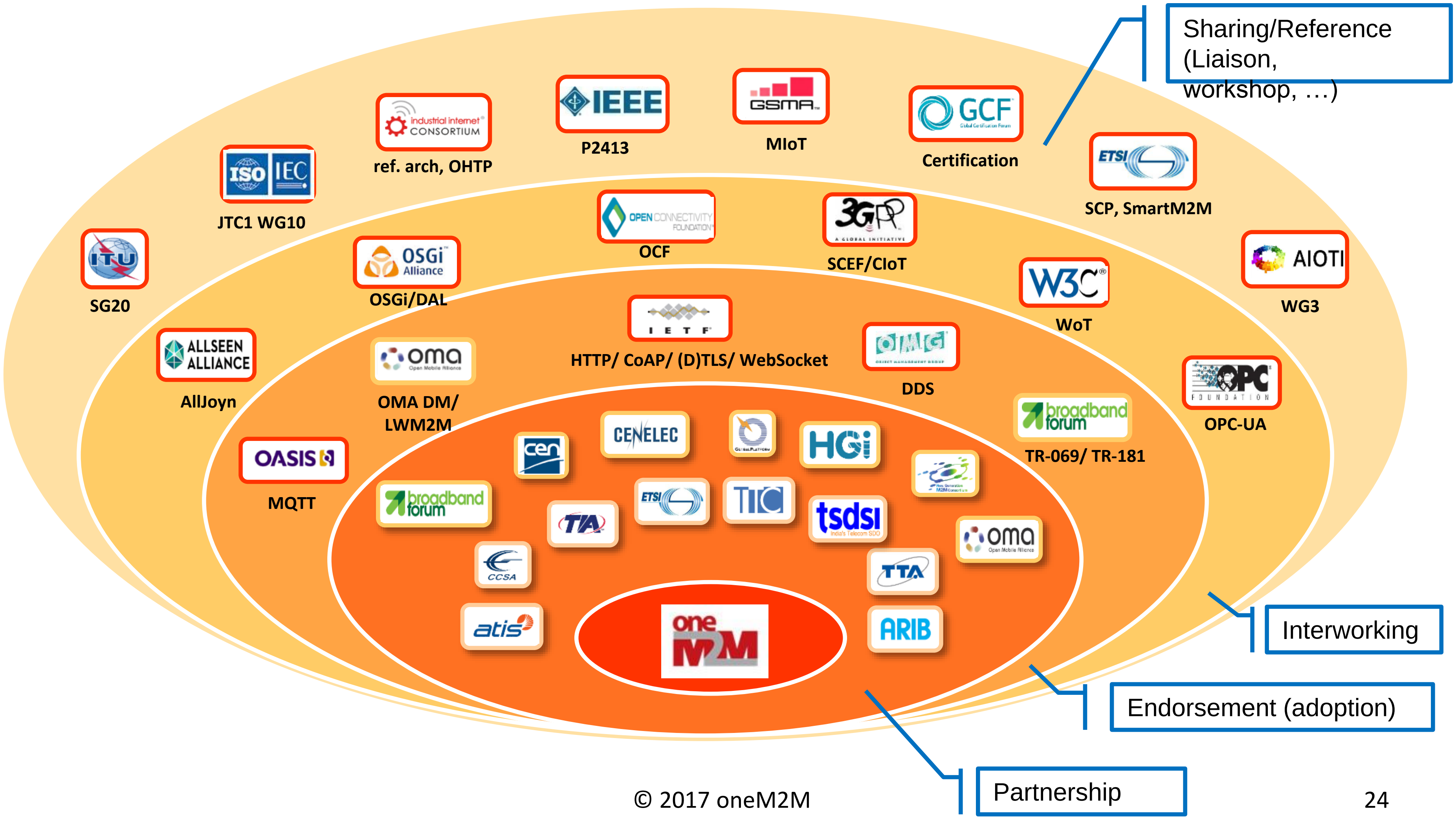
Smart City & Automotive Enablement
- Service Continuity
- Cross resource subscriptions

Market Adoption
- Developer Guides
- oneM2M Conformance Test
- Feature Catalogues
- Product Profiles

oneM2M as generic interworking framework
- 3GPP SCEF
- OMA LWM2M
- DDS
- OPC-UA
- Modbus
- AllJoyn/OCF
- OSGi
- W3C WoT

Nobody can do it alone

- Collaboration is important to reach common understanding, avoid overlap and build **interoperable** IoT ecosystems globally.



Strong Implementation Base

Industry-driven Open source implementations

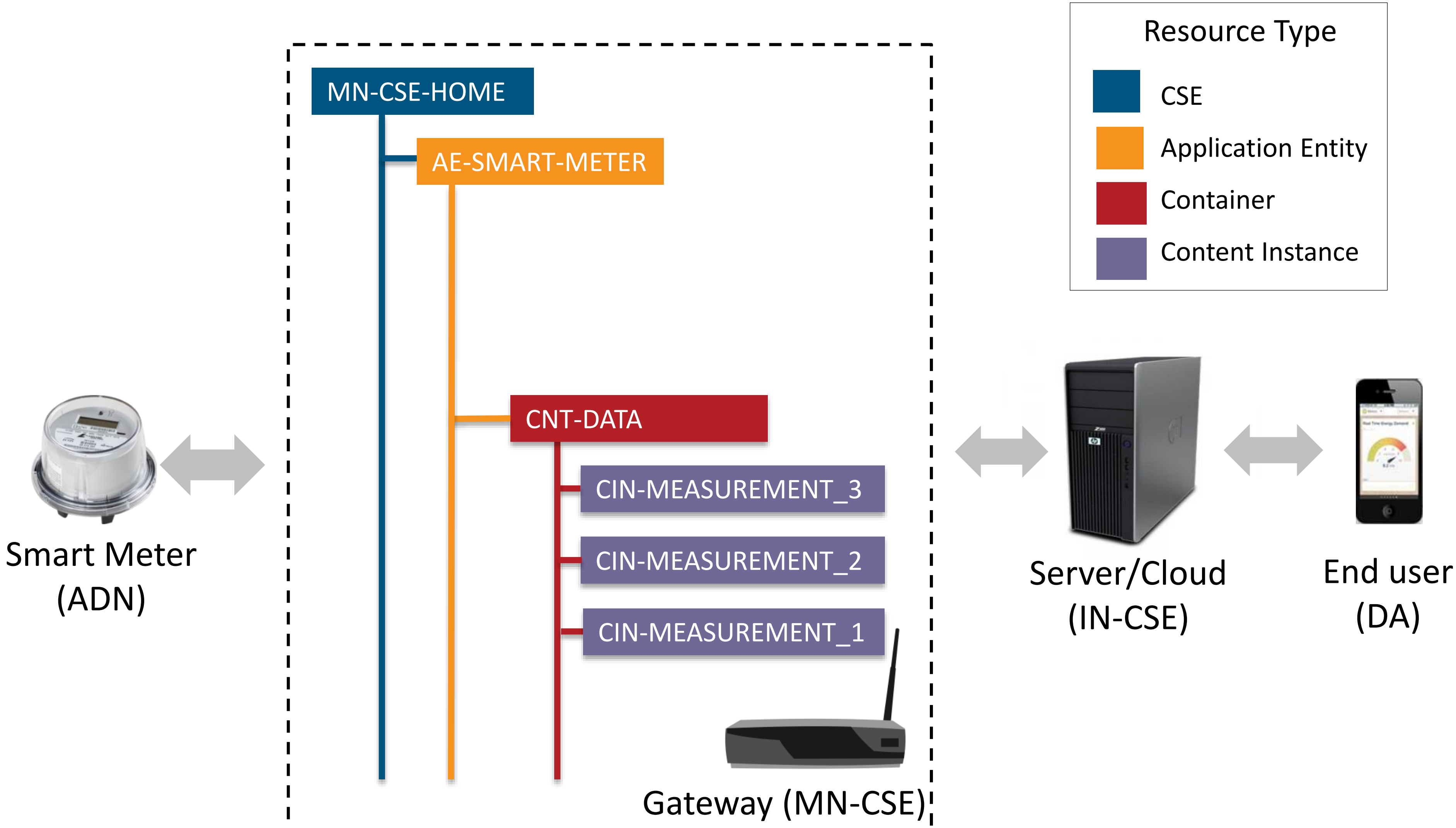
IotDM

OS-IoT

Examples of Commercial implementations /demos

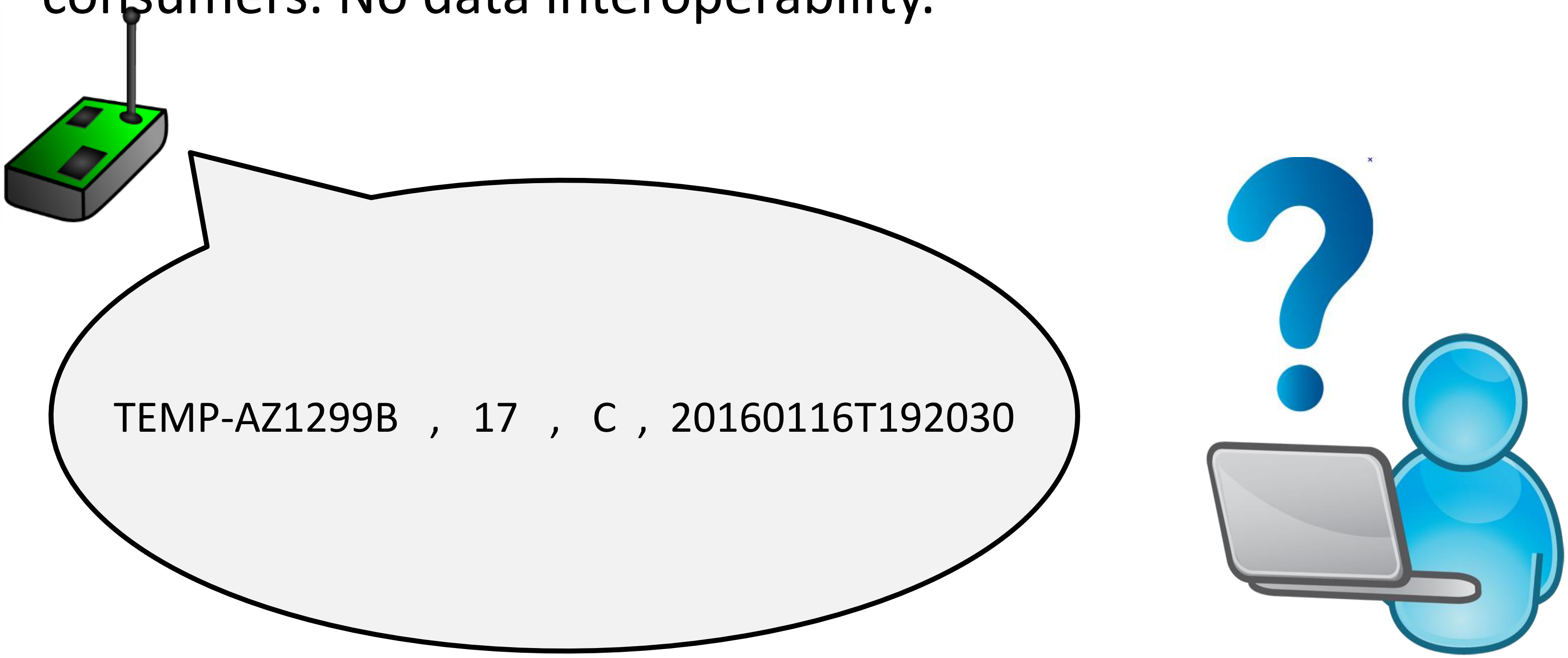
4 interop. events so far

oneM2M resources tree



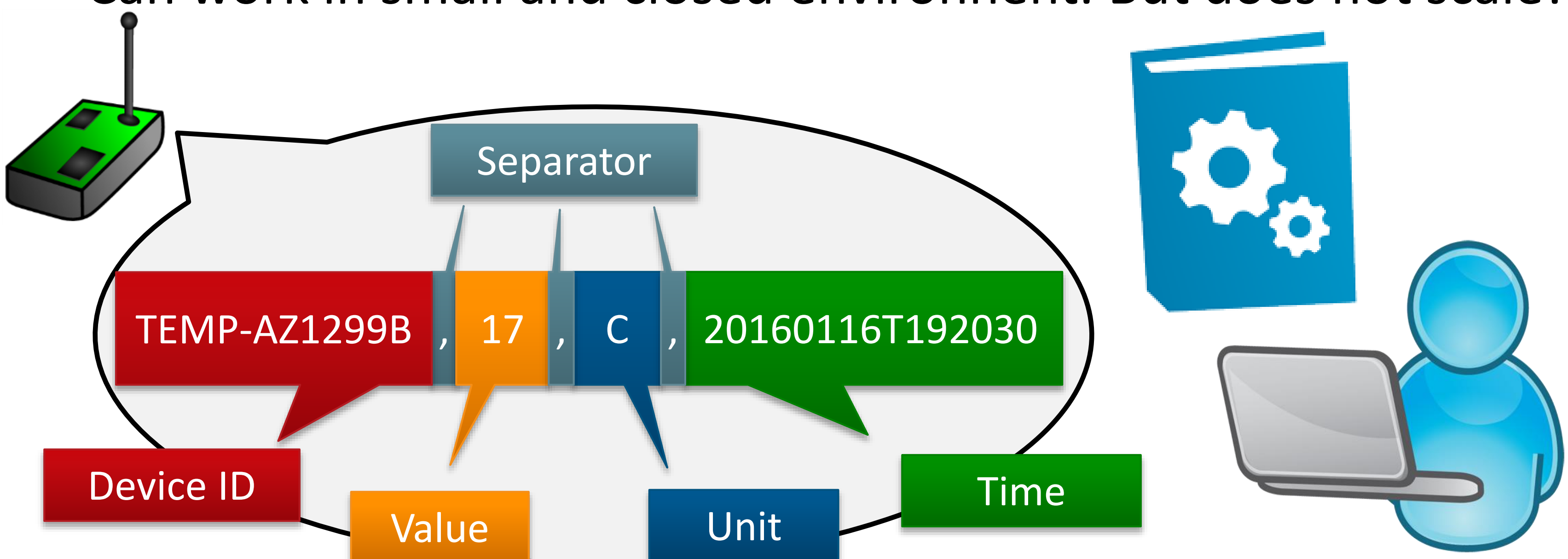
Do we really need semantic ?

- oneM2M Release-1 ensure 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 consumer is programmed or configured for certain consumers. No data interoperability.

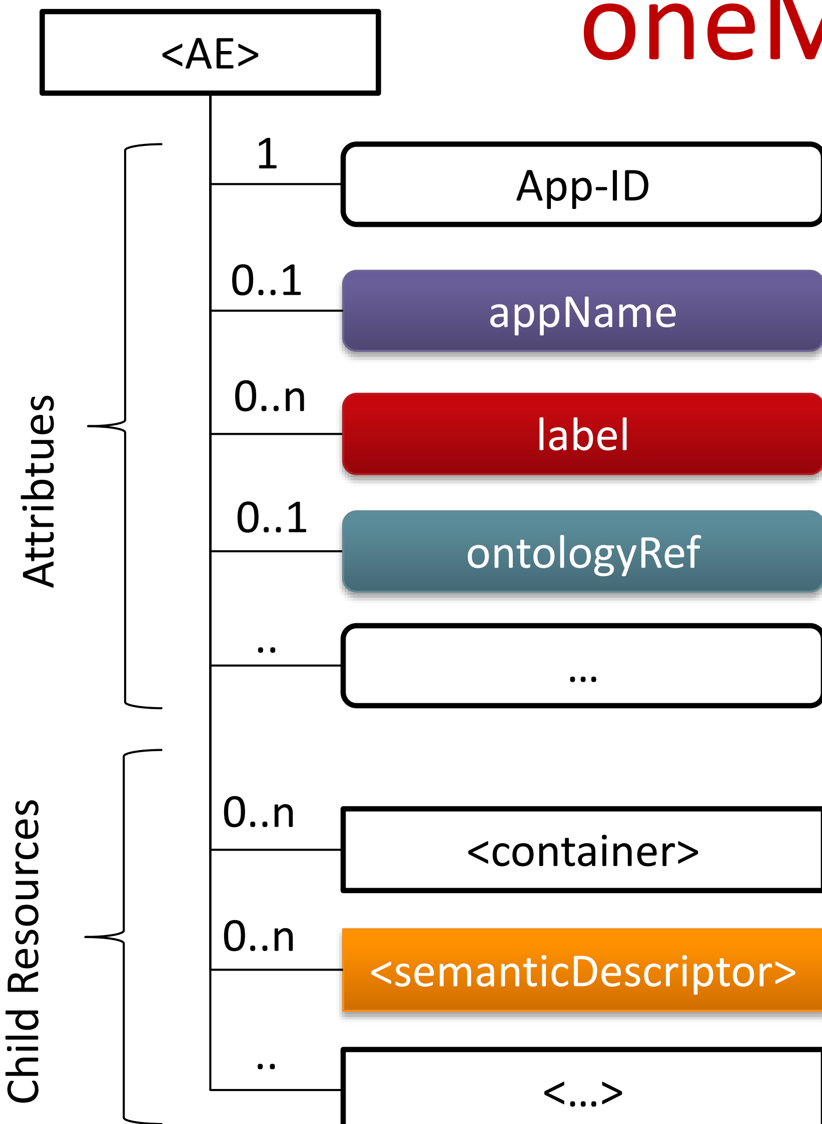


Beforehand agreement required

- It is required to learn information model of each device before using it.
- Beforehand agreement on the data representation is needed between applications and devices.
- Hard to integrate and deal with existing legacy devices.
- Can work in small and closed environnent. But does not scale!



Evolution of semantic in oneM2M



Release-1: Resource Names (Text) can be defined by the client and so have some meaning. E.g. « Temperature-AE »

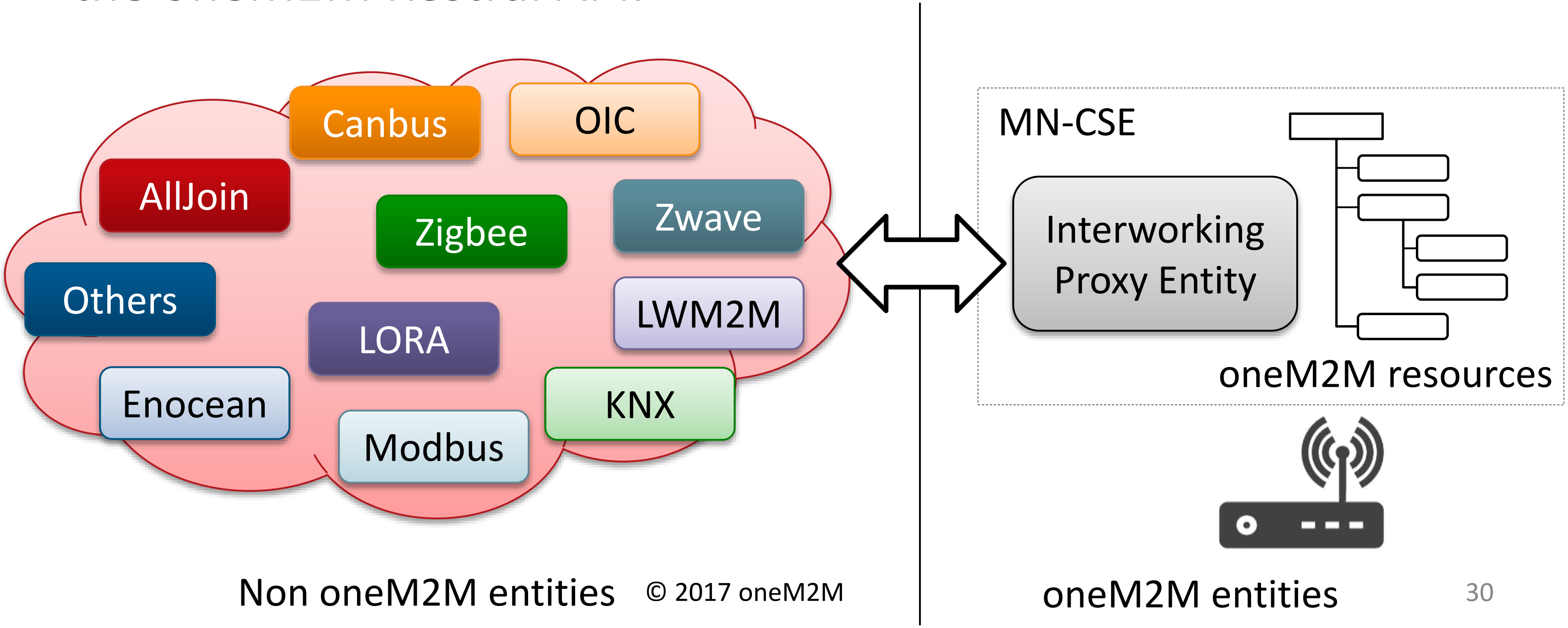
Release-1: A set of labels (keywords) can be defined for each resoruce. E.g. « temperature », « luminosity »

Release-1: Each resource can be linked to an ontology reference (description). E.g. « http://ontology.tno.nl/saref#Device »

Release-2: A complete semantic description can be added to a resource (Ontology). E.g.<RDF>…</RDF>

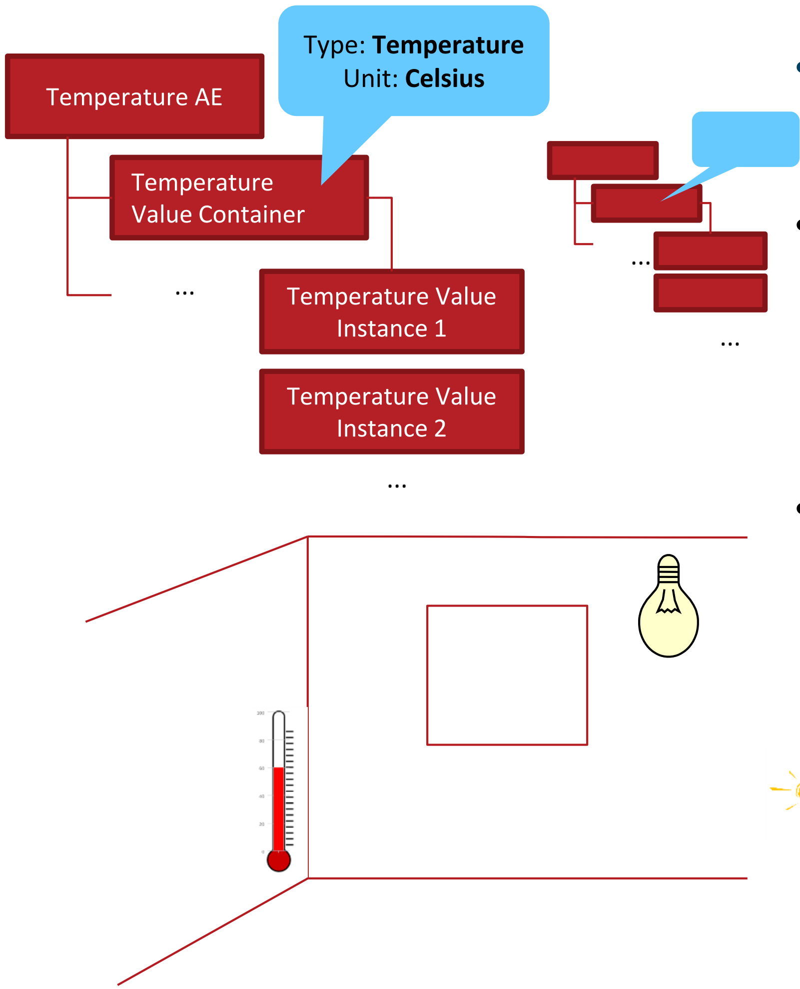
Interworking with non oneM2M devices

- The Interworking Proxy Entity (IPE) abstracts and maps the non-oneM2M data model to the oneM2M resources.
- Bidirectional communication between the oneM2M system and a specific technology (Monitor and Control).
- Seamless interaction between applications and devices using the oneM2M Restful API.



Example: oneM2M Release 2(+) with Semantics

Building Management Application



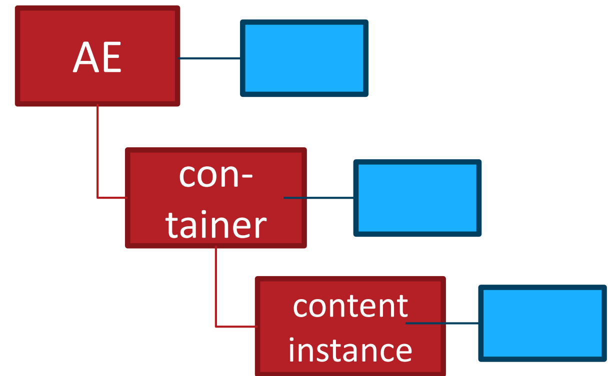
- oneM2M provides resource structure for sensor applications to provide their information
- oneM2M provides semantic information about resource contents and functionalities making use of it
- Functionalities that can be provided or enhanced using semantics
  - Queries/Discovery based on semantic descriptions
  - *Support for analytics (e.g. efficient access to information, deployment of analytics within the platform)*
  - *Support for creation of mash-ups (e.g. enabling IoT scenarios)*
- Applications using the information can
  - Specify what information they are interested in → be notified in case of relevant changes
  - Syntax and semantics of information is made explicit, so applications can decide whether they can handle it, what module is needed for processing etc.

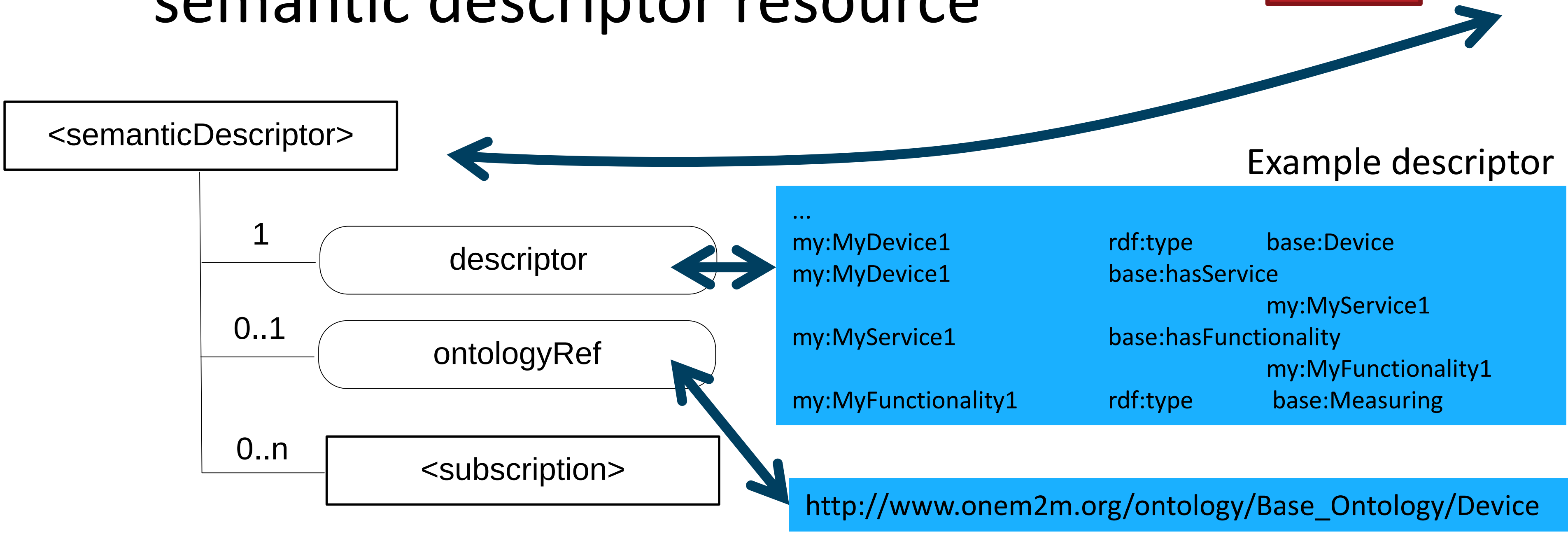
Automatic configuration for every change in available sensors

Source: NEC

Semantic Descriptor Resource Type

- Key oneM2M resource types can be semantically annotated with a description stored in a semantic descriptor resource





Source: NEC

Takeaway

- IoT, here to stay
- Interoperability will make IoT accessible for use cases where cost was prohibitive so far
- Interoperability, within and cross domain, will increase value for IoT
- Interoperability and Certification are key for IoT
- Traditional approaches for integration may not scale
- Semantic interoperability emerging as very promising technology for IoT interoperability