Interoperability in IoT

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Embedded Systems Workshop (Monsoon 2021)

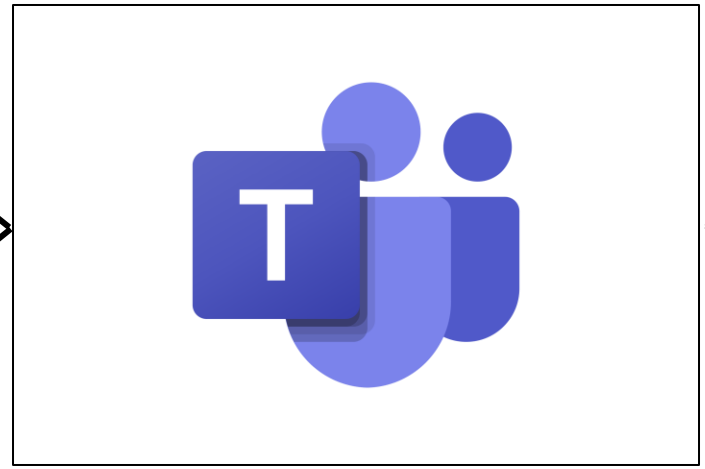
Interoperability in daily life !!

1. Language of the lecture

Syntactic interoperability

2. LAN / WiFi / Cellular Network

Networking interoperability



4. Only block diagrams

Semantic interoperability

3. Linux / Windows / Mac

Platform interoperability

What is interoperability ?

- ISO definition:
  - The capability to communicate, execute programs, or transfer data
  - Requires the user to have little or no knowledge of unique characteristics
- IEEE definition:
  - The ability of two or more systems or components to exchange the information and use the information that has been exchanged
- IoT interoperability:
  - Interoperability in IoT is the compatibility of multiple devices to communicate with each other irrespective of deployed software and hardware.

Why do we need IoT interoperability?

- Diversity in use of Internet of Things
  - Household Appliances
  - Wearables
  - Transportation
  - Hospitality
  - Energy Usage
  - **Smart City**
- Multiple device manufacturers with their own standards

Source: internetofbusiness.com

Why do we need IoT interoperability?

- Devices speak their own language

Ex. Apples HomeKit -Swift language, Google Brillo – Weave, Amazon AWS IoT – SDKs for embedded C and NodeJS

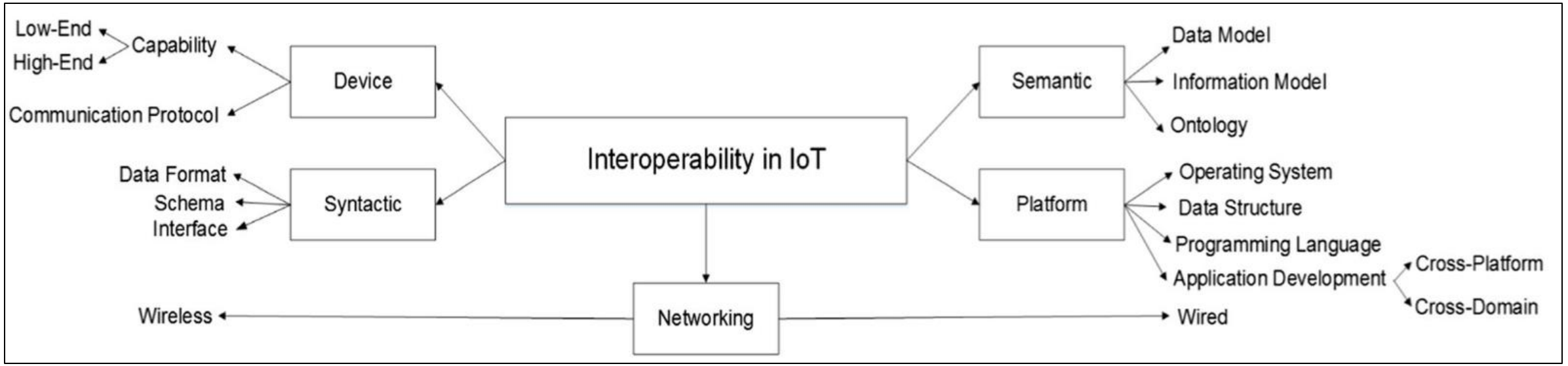
- An obstacle to the growth of IoT

Source: internetofbusiness.com

Source:

- https://en.wikipedia.org/wiki/HomeKit
- https://www.arrkgroup.com/thought-leadership/what-is-google-brillo/
- https://docs.aws.amazon.com/iot/latest/developerguide/iot-sdks.html

Types of Interoperability in IoT



Source: M Noura et. al., Interoperability in Internet of Things: Taxonomies and Open Challenges, 2019

Device Interoperability

- IoT system consists of variety of devices
  - High-end devices – Raspberry Pi, Smartphones, etc.
  - Low-end devices – Low-cost sensors, RFID tags, Actuator, etc.
- Vendor specific device specifications
  - Processor speed, RAM, battery capacity, communication technology, etc.
- Integration of new devices into a IoT platform

Syntactic Interoperability

- Use of serialization (XML / JSON / JSON-LD)
- Compatibility between sender's encoding rules and receiver's decoding rules

```
{
    "m2m:cin":{
        "lbl":["Label-1","Label-2"],
        "con":"[test1,test2]"

    }
}
```

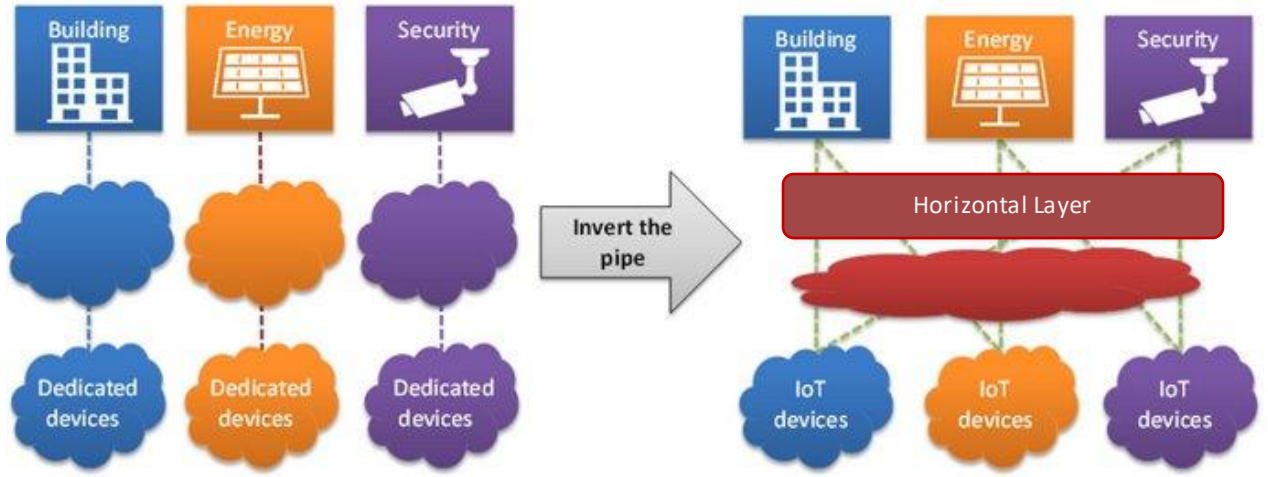
```
<m2m:cin xmlns:m2m="http://www.onem2m.org/xml/protocols">
    <lbl>Label-1 Label-2</lbl>
    <con>[test1,test2]</con>
</m2m:cin>
```

Networking Interoperability

- IoT devices work on heterogeneous, multi-service, multi-vendor networks
  - Wi-Fi, Bluetooth, LoRaWAN, Cellular, etc
- Network level interoperability deals with mechanisms to enable seamless message exchange between systems through different networks
- Handles issues such as addressing, routing, resource optimization, security, QoS and mobility support

Platform Interoperability

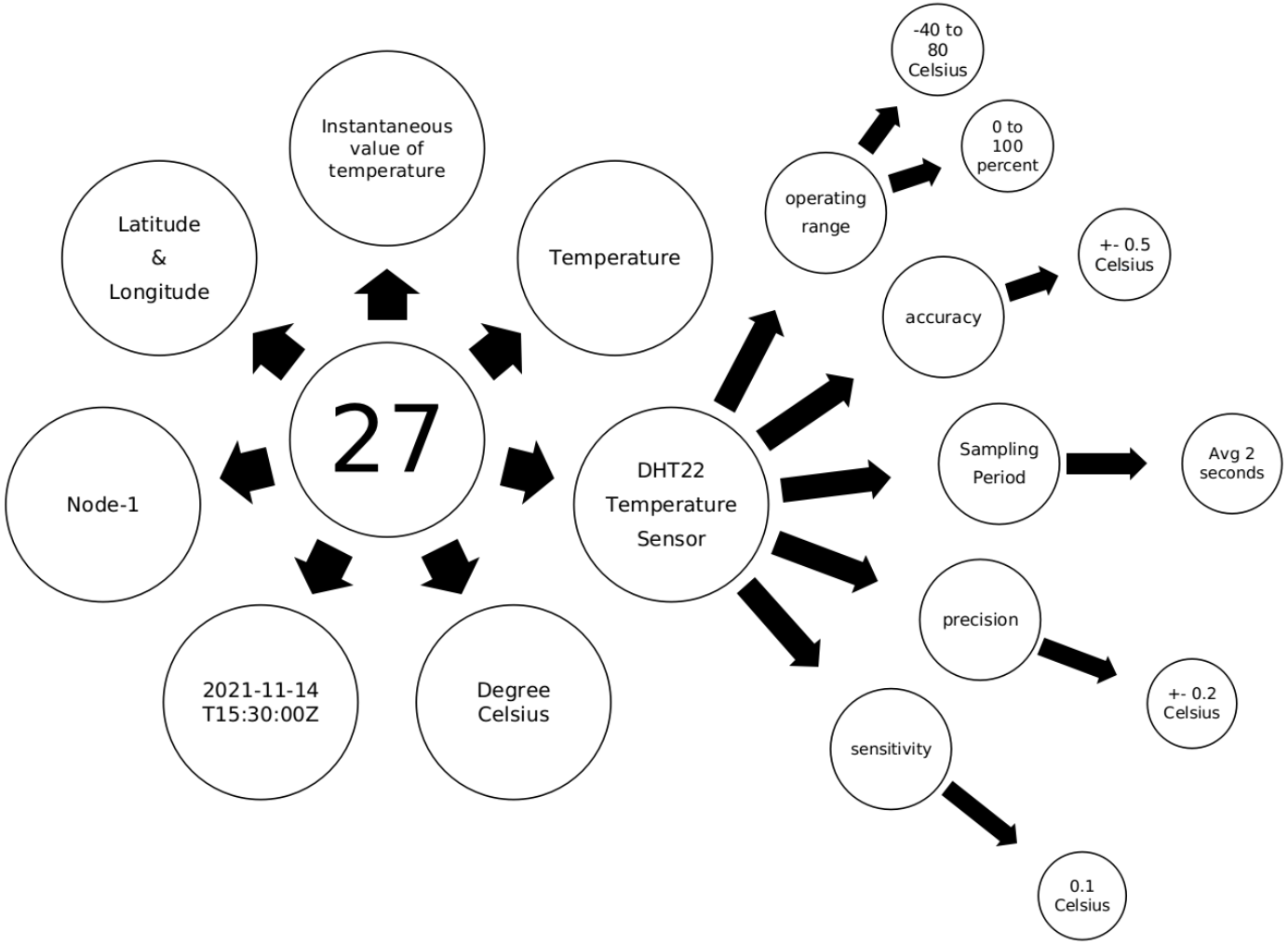
- Issues arise due to;
  - The availability of diverse operating systems (OSs)
  - Programming languages
  - Data structures, architectures and access mechanisms for things
- Need to understand platform specific APIs and data models



Semantic Interoperability

- Exchange knowledge in a meaningful way
- Generate data in a standardized format
- World Wide Web Consortium (W3C) proposed the integration of Semantic Web and IoT : Semantic Web of Things (SWoT)
- Use of ontologies/vocabularies

Ex. ssn, sosa, etc



Source: https://w3c.github.io/sdw/ssn/

Standards jungle of IoT

Home/ Building | Manufacturing/ Industrial Automation | Vehicular/ Transportation | Healthcare | Energy | Cities | Wearables | Farming/ Agrifood

Horizontal/Telecommunication

Source: AIOTI WG3 (IoT Standardisation) – Release 2.8

IoT standards for interoperability

- Device, Network, Syntactical, Semantic, Cross-platform and Cross-domain interoperability
- Interoperability approach
- Openness
- Connectivity
- Application protocols
- Security/ privacy metrics

	Ref	D	N	Sy	Se	CP	CD	Solution	Openness	Data Format	Application Protocols	Connectivity	Priv/ Sec
Standard Frameworks	oneM2M	✓	✓	✓	✓	✓		Open standard. Gateway, API	✓	-	RESTful HTTP, CoAP, MQTT	Cellular, Zigbee, Bluetooth, WiFi	✓
	OMA LWM2M	✓	✓					Open standard	ISC License	XML	CoAP	Cellular, Zigbee, WiFi	✗
	OGC SWE				✓	✓		sensor data model	GPL License	XML, EXI	RESTful HTTP, MQTT	-	✗
	ETSI Smart M2M	✓	✓	✓				Service layer	✓	XML, JSON, EXI	RESTful HTTP, CoAP	Cellular, Zigbee, Bluetooth, WiFi	✓
	HyperCat			✓				open standard, open API	✓	JSON, RDF	RESTful HTTP	-	✗
	AllJoyn	✓						APIs, Open standard protocols	ISC License	JSON, XML, EXI	Proprietary protocol	WiFi, Bluetooth, NFC, ZigBee	✓
	OIC IoTivity	✓						Industry standard technologies, protocol plug-ins, APIs	Apache License 2.0	XML, JSON	RESTful HTTP, CoAP	WiFi, BLE,	✓

Source: M Noura et. al., Interoperability in Internet of Things: Taxonomies and Open Challenges, 2019

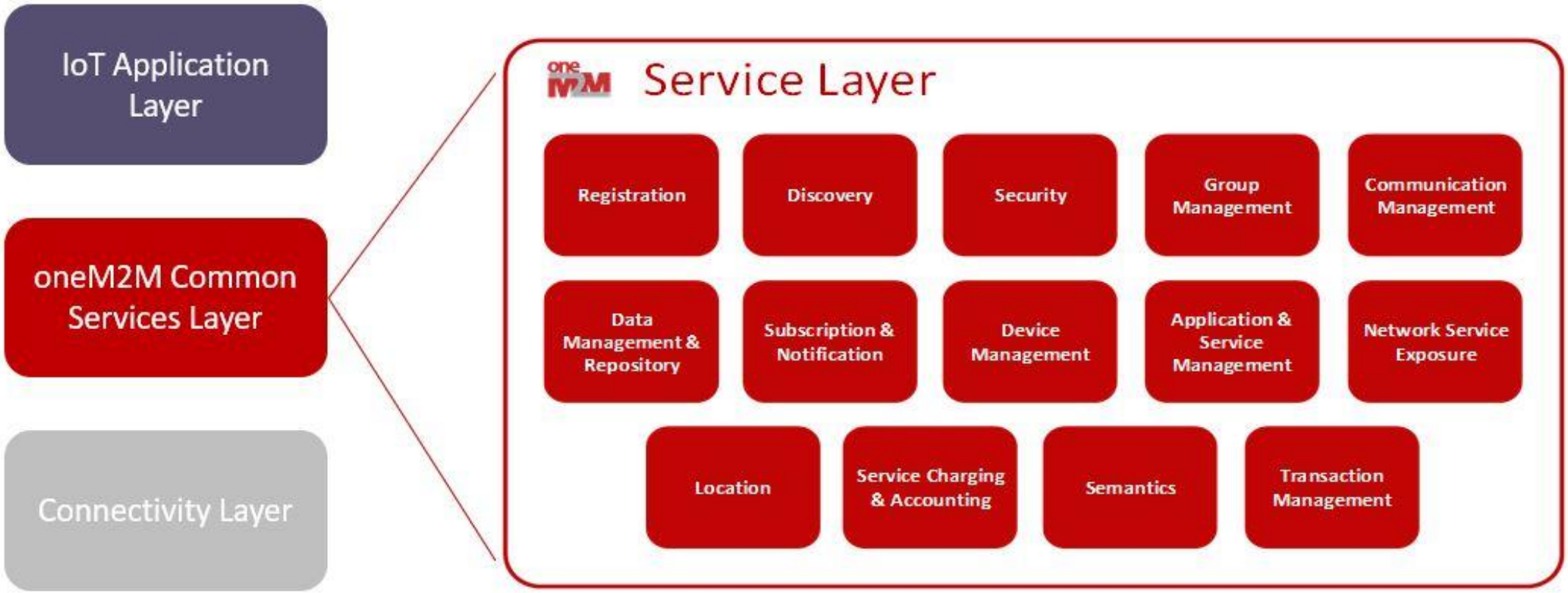
oneM2M standards

- A global initiative to develop IoT standards to enable interoperable, secure, and simple-to-deploy services for the IoT ecosystem.
- Allow any IoT application to discover and interact with any IoT device.
- IoT solutions can interoperate across silo boundaries
- Reduce fragmentation, increase reusability and improve the cost base through economies of scale

Source:

1. https://www.onem2m.org/
2. https://www.onem2m.org/using-onem2m/what-is-onem2m

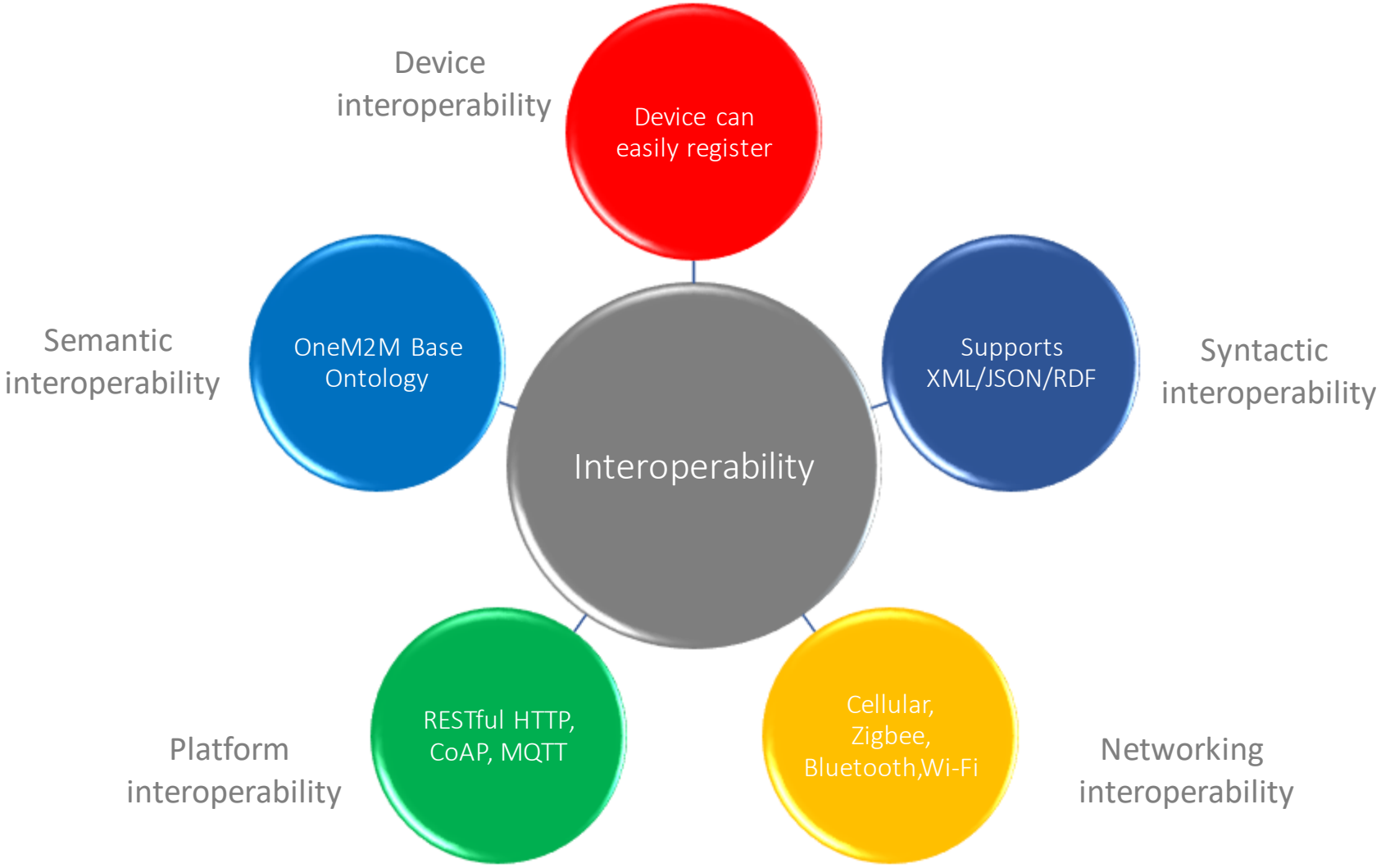
Service Layer



Source:

1. https://www.onem2m.org/using-onem2m/developers/basics#n1a

oneM2M and IoT Interoperability



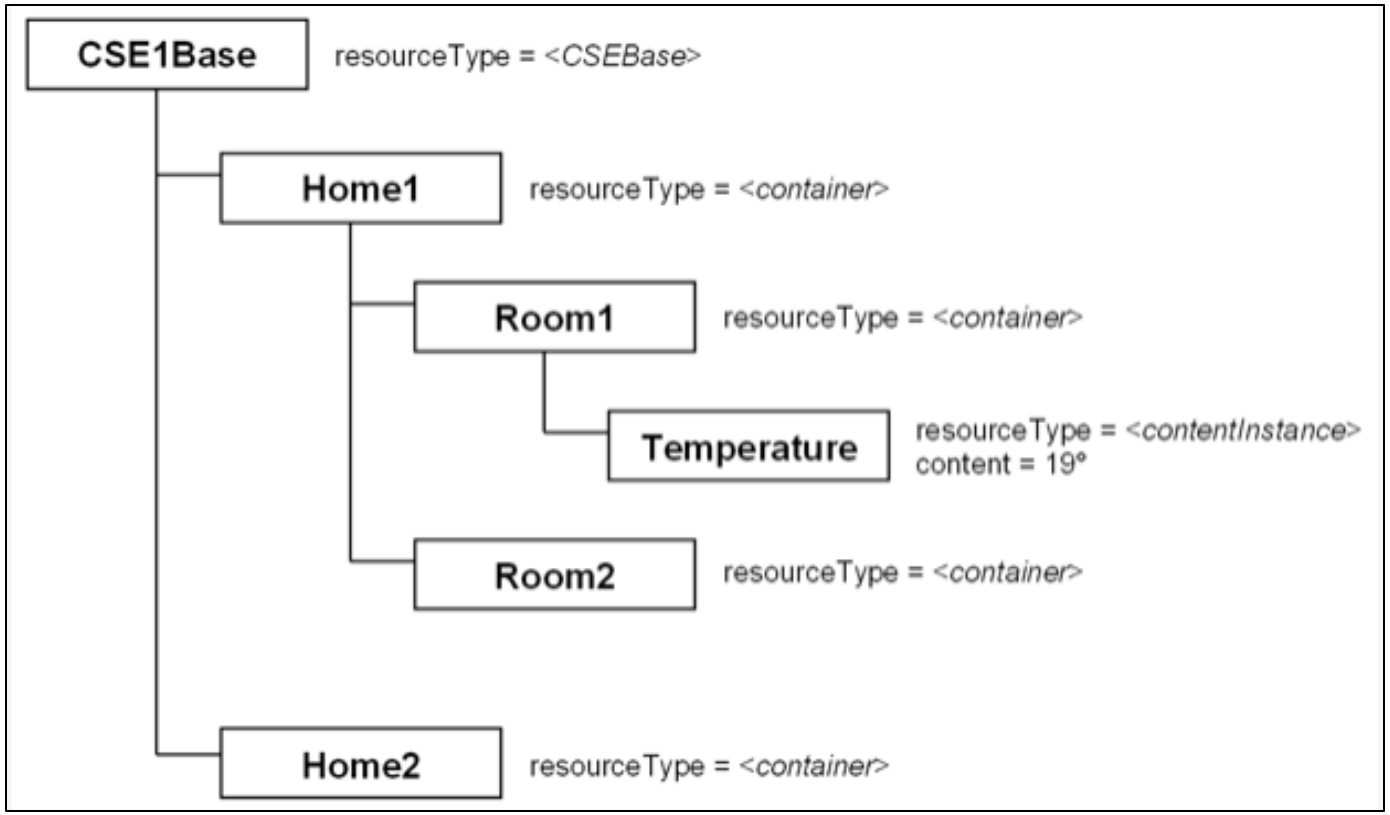
OneM2M Resources

- Common Services Entity (CSE) Base:
  - Parent resource
  - Serves as the root resource for all resources that are residing in the CSE
- Application Entity (AE):
  - Registered to a CSE
  - Serves as the root resource for <*container*>, <*flexContainer*>, <*subscription*> and <*group*> resources
- Container (CNT):
  - Describe attributes of the data and child resources
  - Can be created and organised in a similar manner to folders on a computer
  - Each Container is allocated a unique ID
  - A container can have another container as a child resource
- Content Instance (CIN):
  - Contains a single piece of data sent by the publishing application

Source:

1. https://www.onem2m.org/using-onem2m/developers/rest-resources#n3a

OneM2M Resource Tree



Source:

1. https://www.onem2m.org/using-onem2m/developers/rest-resources#n3a

OM2M platform

- An open-source implementation of oneM2M standards by LAAS-CNRS
- A horizontal M2M service platform
- A horizontal Service Common Entity (CSE) that can be deployed in an M2M server, a gateway, or a device.

Source: https://www.eclipse.org/om2m/

Thank You!