智慧整合感控系統概論
Introduction to Cyber-Physical Systems

物聯網需求與系統架構
(Requirements and System Architecture of the IoT)

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Taipei Tech Electronic Engineering

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學習目標

1. IoT System Structure
2. Introduction to oneM2M
3. Use-Case-Driven Requirements
4. High Level Architecture

IoT Industry Alliances

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IoT Industry Alliances

- AllSeen Alliance
- Open Connectivity Foundation (OCF)
- Google Weave
- Apple Homekit
- Industrial Internet Consortium

AllSeen Alliance

- AllSeen Alliance provides the AllJoyn™ framework that is open source software that allows for proximity peer to peer over various transports.
- It is written in C++ at its core, and provides multiple language bindings and complete implementations across various operating systems and chipsets.
- The AllJoyn framework provides an object-oriented approach to making peer to peer easy, avoiding the need to ever deal with lower-level network protocols and hardware.

AllSeen Alliance

- The AllJoyn SDK provides a set of APIs that allow a novice developer to create applications that take advantage of AllJoyn's capabilities.
  - Java API
  - C++ API
  - C# Unity API
  - C API

Open Connectivity Foundation (OCF)

- The Open Connectivity Foundation (OCF) is creating a specification and sponsoring an open source project to make this possible.
- OCF will unlock the massive opportunity in the IoT market, accelerate industry innovation and help developers and companies create solutions that map to a single open specification. OCF will help ensure secure interoperability for consumers, business, and industry.

Open Connectivity Foundation (OCF)

- The OCF unifies the entirety of the former Open Interconnect Consortium (OIC) with leading companies at all levels – silicon, software, platform, and finished-goods – dedicated to providing this key interoperability element of an IoT solution.
- The OCF sponsors the IoTivity open source project which includes a reference implementation of our specification available under the Apache 2.0 license.
- The OCF also includes all the activities formerly sponsored by UPnP Forum.

Google Weave

- Weave is an application-layer protocol for interacting with devices.
- It has three main components:
  - Weave cloud service
  - Device-side library(libweave, libuweave) and wrappers
  - Client library(android, iOS, web)

Google Weave

- It provides turnkey supports:
  - Device discovery
  - Authentication
  - Provisioning
  - Real time communication

Apple Homekit

- An iOS(8) framework for home automation
- Discover HomeKit accessories (devices)
- Configure
- Create actions and control devices
- Actions can be grouped and triggered using Siri.
- A common database stored on iOS, contains all home information configured. Available to all apps.

Apple Homekit

- App interaction to DB is done through HomeKit
- Access to home devices remotely through iOS connectivity
- HomeKit API can only be used if App is in foreground.

Industrial Internet Consortium

- It is a nonprofit partnership of Industry, Government and Academia.
- Founded by AT&T, Cisco, General Electric, Intel and IBM.
- Started in March, 2014, not a standards-setting consortium.
- Utilize existing and create new industry use cases and testbeds for real-world applications.

Industrial Internet Consortium

- Deliver best practices, reference architectures, case studies, and standards requirements to ease deployment of connected technologies.
- Influence the global development standards process for internet and industrial systems.
- Facilitate open forums to share and exchange real-world ideas, practices, lessons, and insights.
- Build confidence around new and innovative approaches to security.

oneM2M

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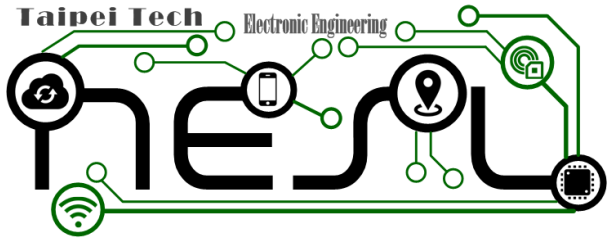

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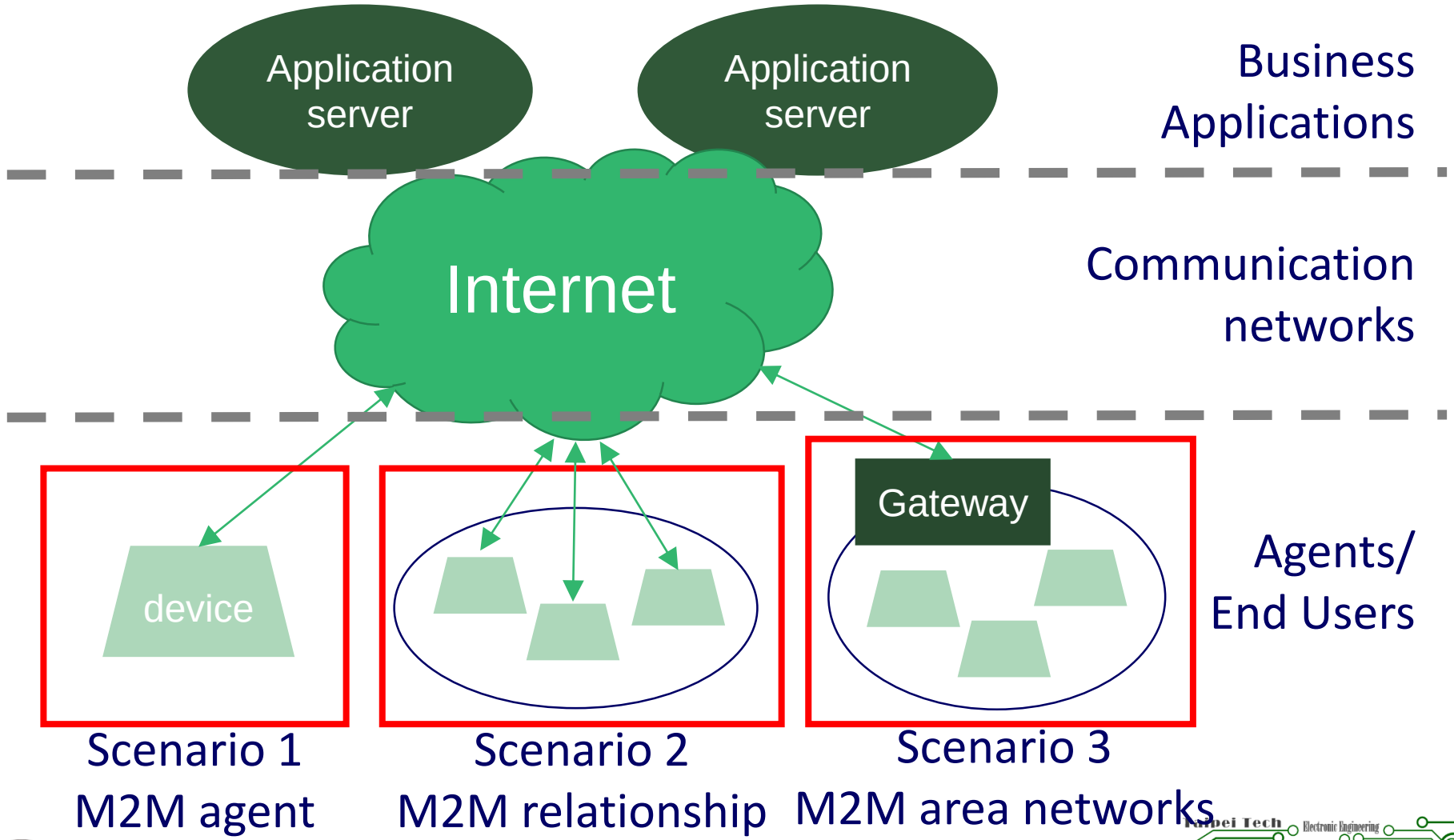
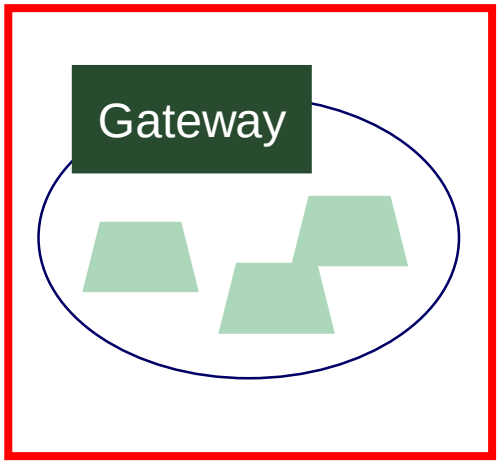
IoT/M2M System Structure



M2M Area Networks

- “M2M area network” is introduced by ETSI.
- Provide PHY and MAC layer connectivity between M2M devices connected to the same M2M area network
- Allow M2M devices to gain access to a public network via a gateway



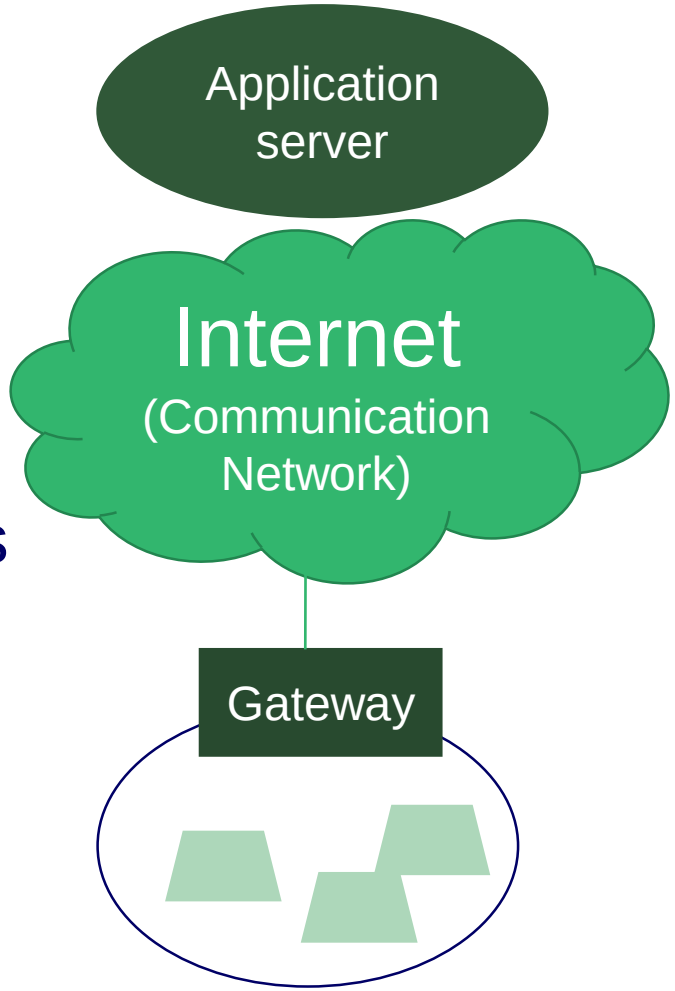
M2M area network

⇳

devices + gateway

Characteristics of M2M

- Information exchange over communication networks
  - Via mobile networks or public Internets
- A group of similar devices
  - Devices with limited capacities
  - Hierarchical architecture
  - Autonomous



Characteristics of M2M Applications

- A large amount of devices
  - Scalability issues
  - Non-classical usage patterns in mobile networks
    - E.g., not always active - only be triggered for specific reason and only do things in some fixed time.
- A large variety of devices
  - Diverse requirements, e.g., data exchange rate, latency, reliability
  - Various wireless communication protocols

Characteristics of M2M Applications

- Transparency
  - No need for human interference
  - High autonomy
- Intrusiveness: privacy issues
- Criticality: life-savers, life-critical

M2M Devices

- Battery powered
  - E.g., water meters are located outdoors and cannot be easily connected to a power supply.
- Embedded
  - Many devices are deployed in systems with specific operating condition and with limited computation power.
  - E.g., the OBD in car
- Here to stay
  - Many devices are static or with very low mobility.

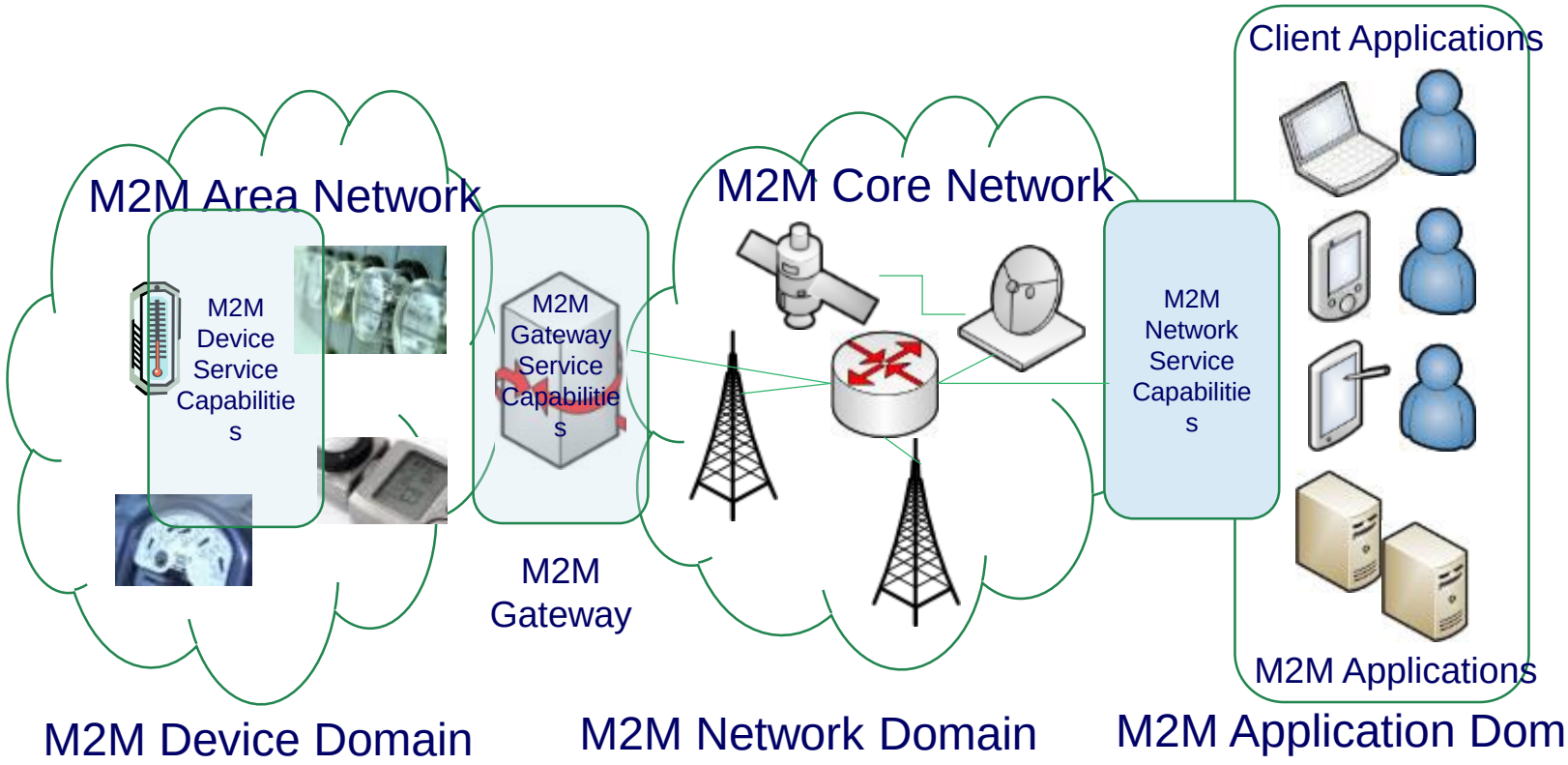
Challenges

- Fragmentation of solutions
  - It is important to have service platforms that can be reused for multiple applications.
- Network misalignment
  - large numbers of devices generating very small amounts of data transport and potentially a very significant overload of the control and connectivity planes.
- Security and Privacy issues
  - E.g., eHealth, Smart Grid, etc.
  - Data sharing vs. data protection

Predecessor of oneM2M

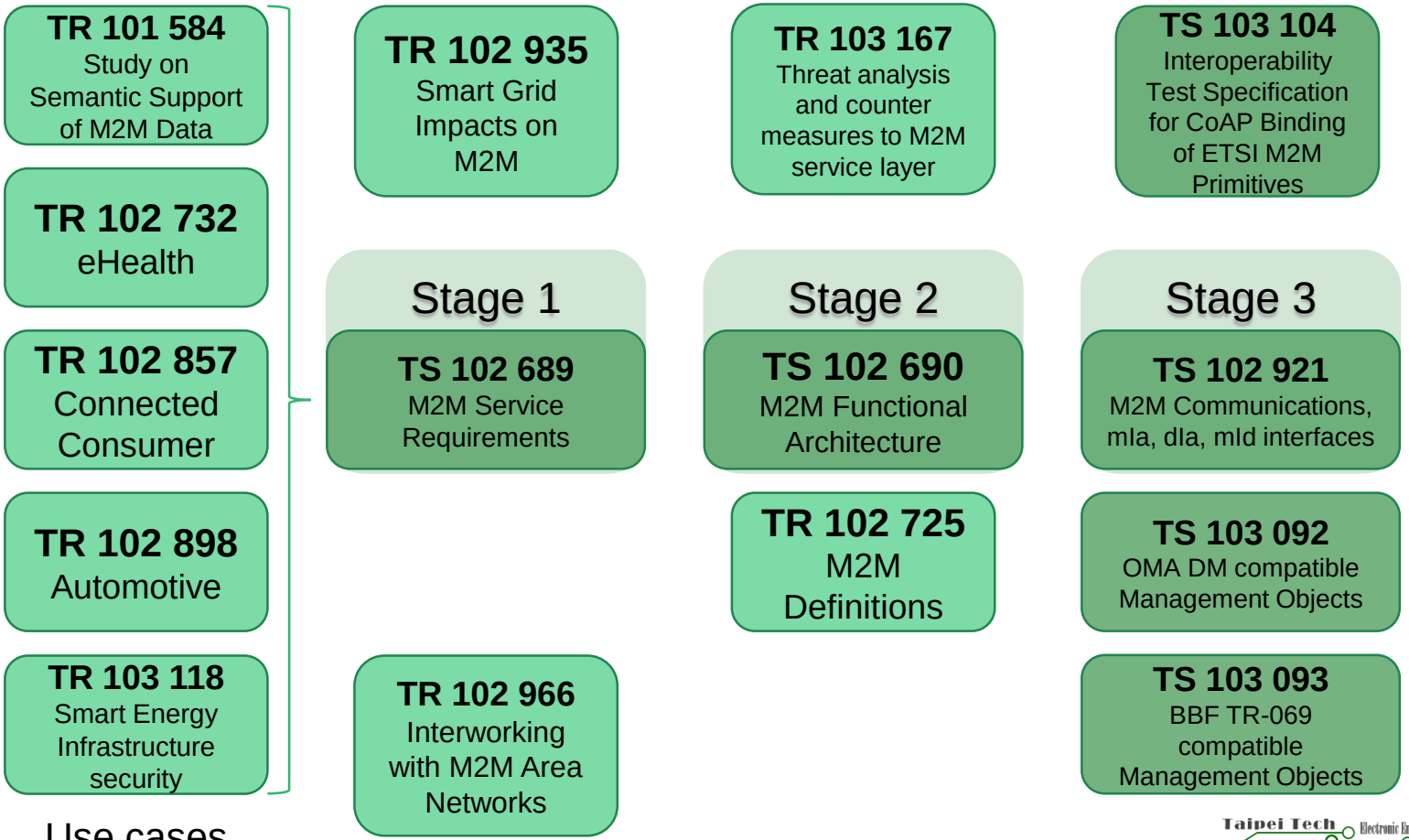
- ETSI TC M2M
  - ETSI (European Telecommunications Standards Institute) TC (Technical Committee) M2M established in Jan. 2009
  - To develop and maintain an end-to-end overall telecommunication high level architecture for M2M
  - To identify gaps with existing standards and provide specifications to fill these gaps

ETSI M2M Network



ETSI M2M Specification

- Release 1 (End of 2011), Release 2 (Early 2013)



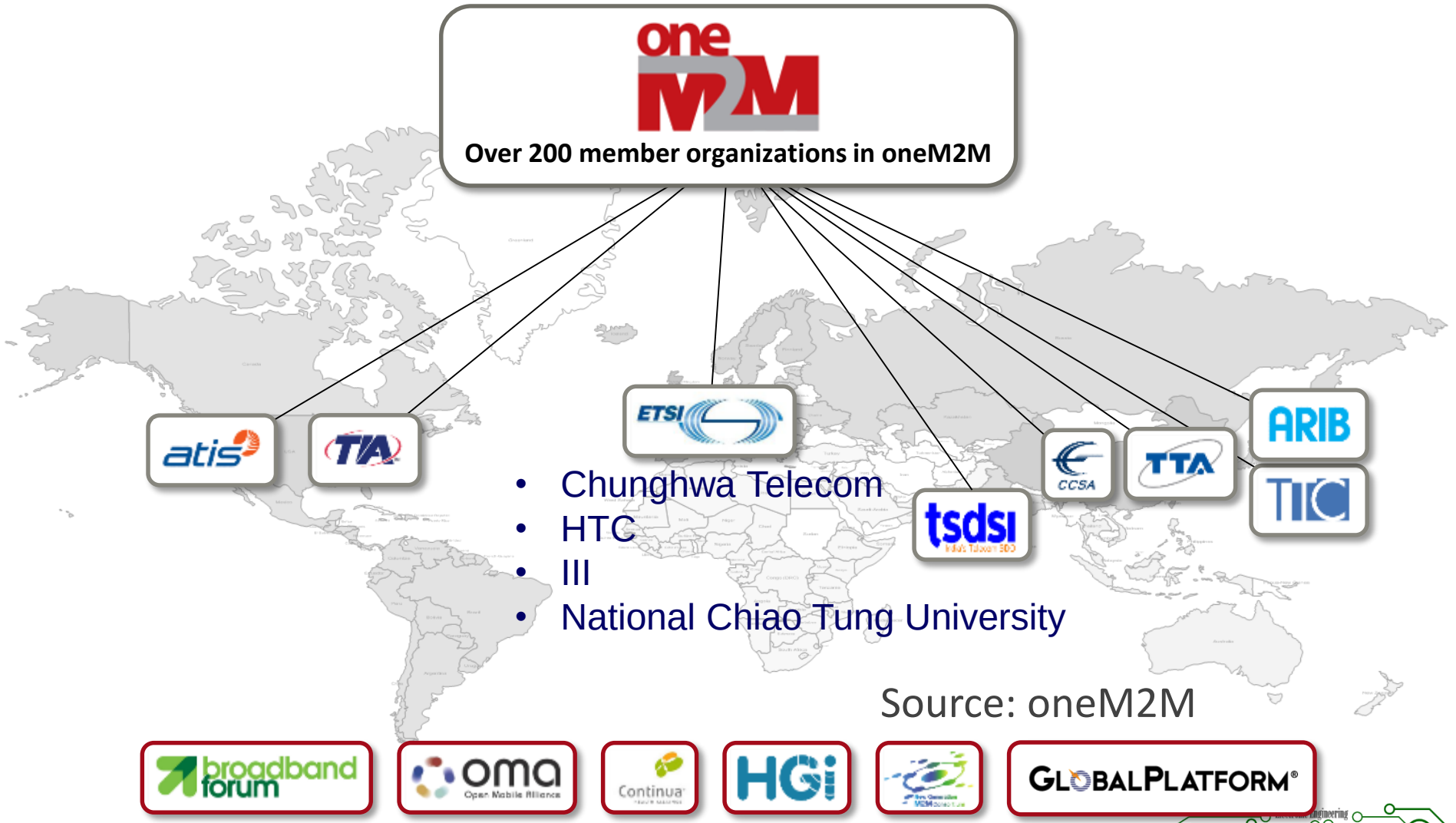
Transition from ETSI M2M to oneM2M

- ETSI worked with other standard development organizations in the world to launch oneM2M Partnership Project In July 2012
  - A global Initiative focused on consolidation and standardization of a common M2M Service Layer which can be embedded in hardware or software
  - Objectives are to enhance interoperability, simplify development of applications, boost economies of scale, and reduce standards overlap.

Transition from ETSI M2M to oneM2M

- ETSI M2M technical specifications have been transferred to oneM2M.
- ETSI TC M2M has been changed to ETSI TC SmartM2M since November 2013 to focus on EU regulations and verticals.

oneM2M Partnership Project



- Chunghwa Telecom
- HTC
- III
- National Chiao Tung University

Source: oneM2M

The Purpose and Goal of oneM2M

- oneM2M technical specifications are to address the need for a common M2M Service Layer that can be readily embedded within various hardware and software, and relied upon to connect the myriad of devices in the field with M2M application servers worldwide.
- Initially, oneM2M shall prepare, approve and maintain the necessary set of Technical Specifications and Technical Reports for:
  - Use cases and requirements for a common set of Service Layer capabilities;

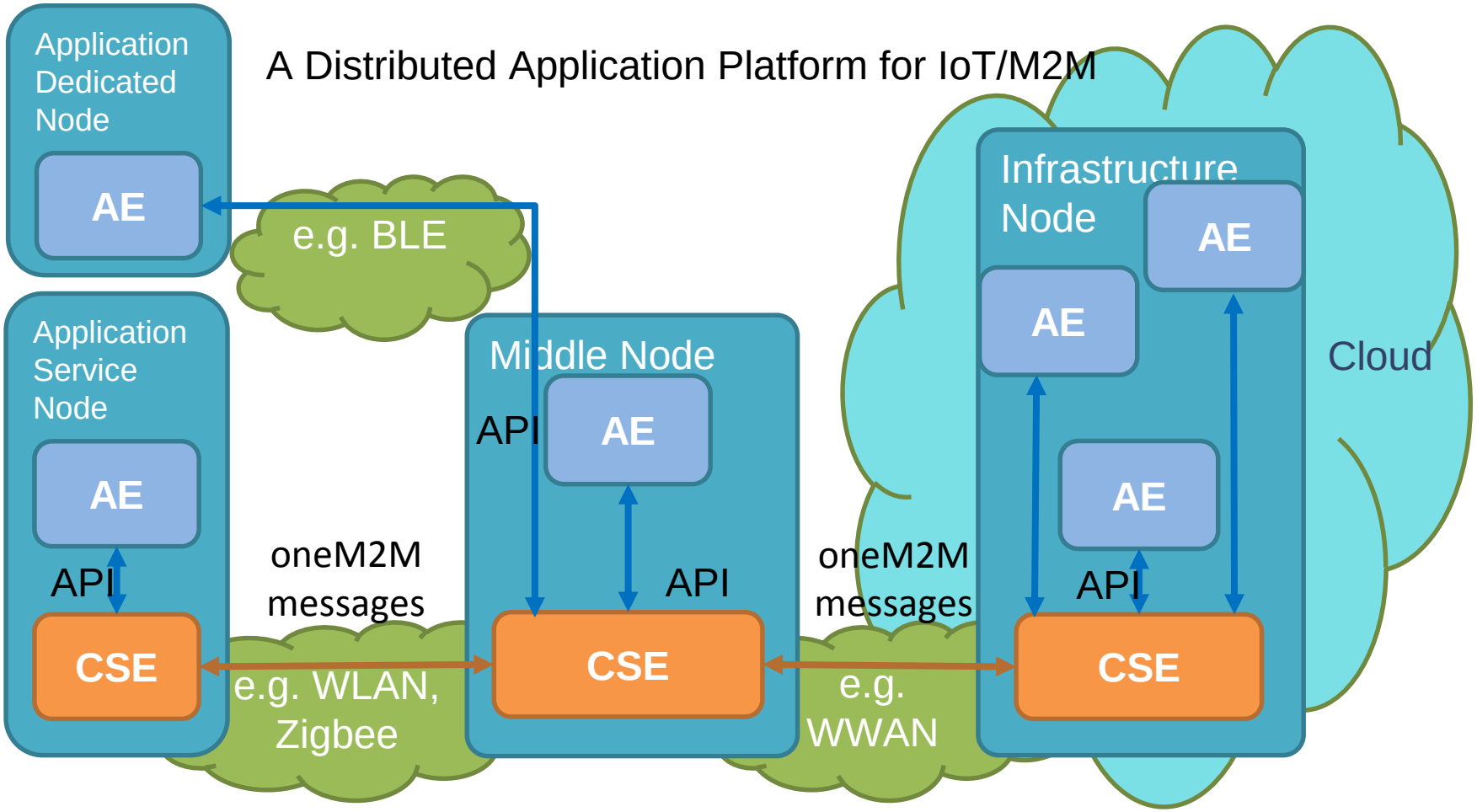
The Purpose and Goal of oneM2M

- Service Layer aspects with high level and detailed service architecture, in light of an access independent view of end-to-end services;
- Protocols/APIs/standard objects based on this architecture (open interfaces & protocols);
- Security and privacy aspects (authentication, encryption, integrity verification);
- Reachability and discovery of applications;
- Interoperability, including test and conformance specifications;

The Purpose and Goal of oneM2M

- Collection of data for charging records (to be used for billing and statistical purposes);
- Identification and naming of devices and applications;
- Information models and data management (including store and subscribe/notify functionality);
- Management aspects (including remote management of entities); and
- Common use cases, terminal/module aspects, including Service Layer interfaces/APIs between Application and Service Layers;
- Service Layer and communication functions

oneM2M Network



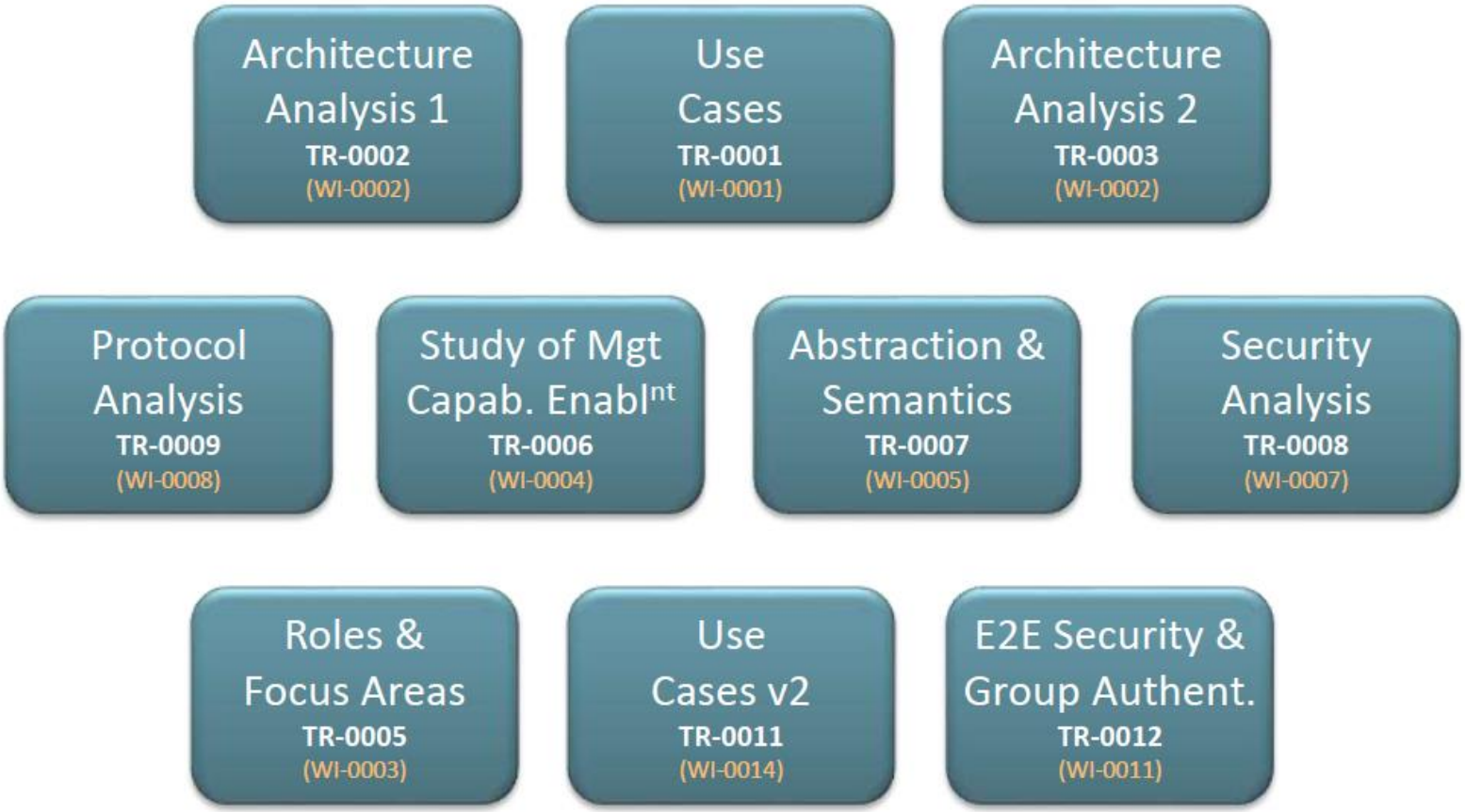
Technical Report (TR)

- Study before standards specifications
- These reports are not standards
- The ideas, however, lead to standards specifications.

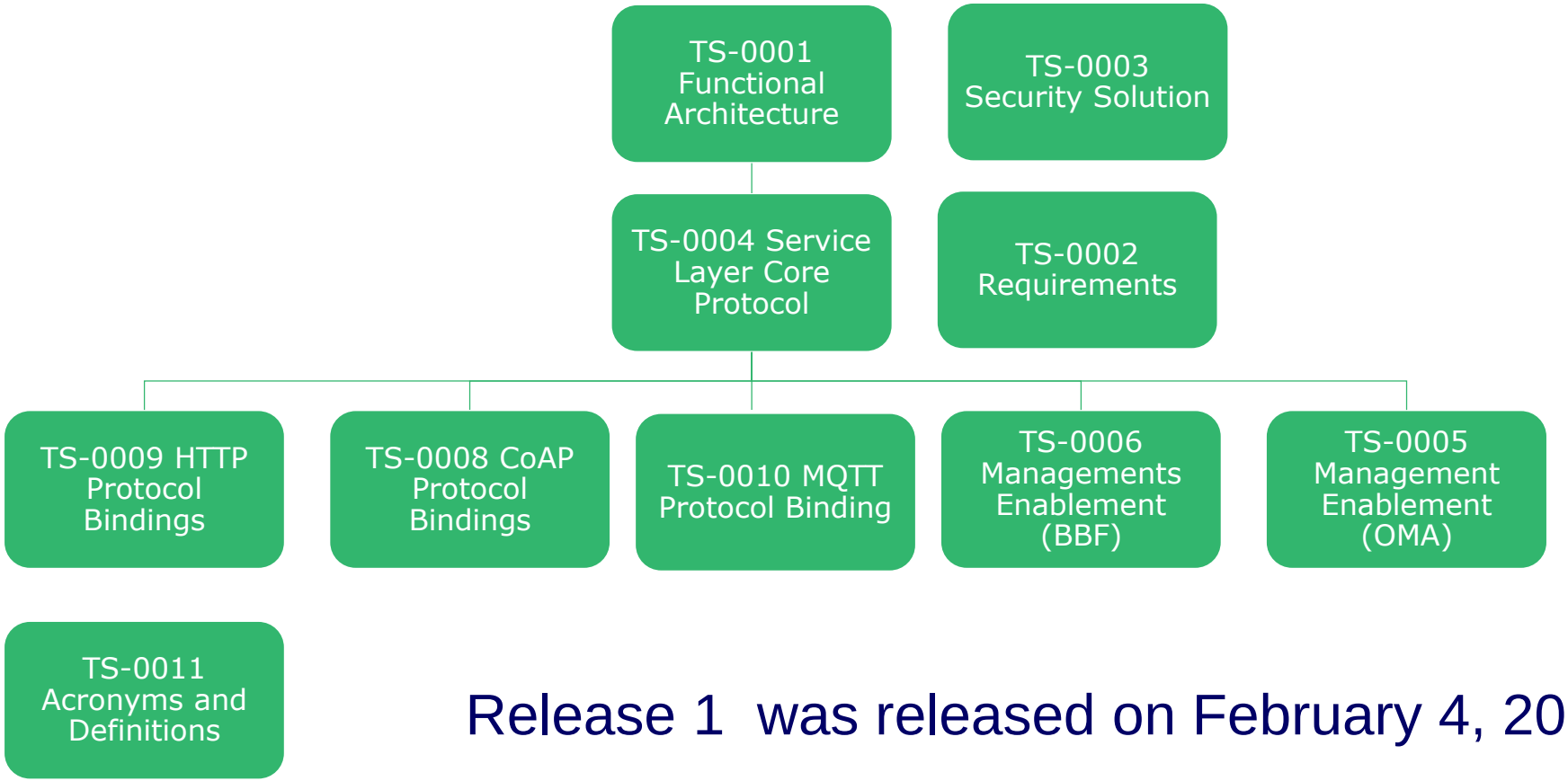
Technical Specification (TS)

- There are official standards specifications.
- It follows three stages of specification from high level to low level
  - Stage 1: Requirements
  - Stage 2: Architecture
  - Stage 3: Interfaces, APIs

Release 1 Technical Reports



Release 1 Technical Specifications



Release 1 was released on February 4, 2015.

oneM2M Infrastructure Domain

- The infrastructure domain is the M2M core network and normally resides in a cloud environment.
- The infrastructure domain can leverage the existing telecom networks including fixed and mobile networks (4G now or 5G in the future). But, mobile networks will be the primary M2M core.

oneM2M Infrastructure Domain

- The infrastructure node is the M2M server in the core network.
- Common Service Entities (CSE) are network functions defined to support M2M applications.

oneM2M Field Domain

- The field domain is the M2M area network and normally resides at the edge of the network.
- The field domain employs a large variety of wireless and wireline protocols and technologies.
- The field domain consists of both M2M devices and gateways.
- The former have two types: Application Dedicated Node and Application Service Node.
- The latter are also called Middle Nodes.

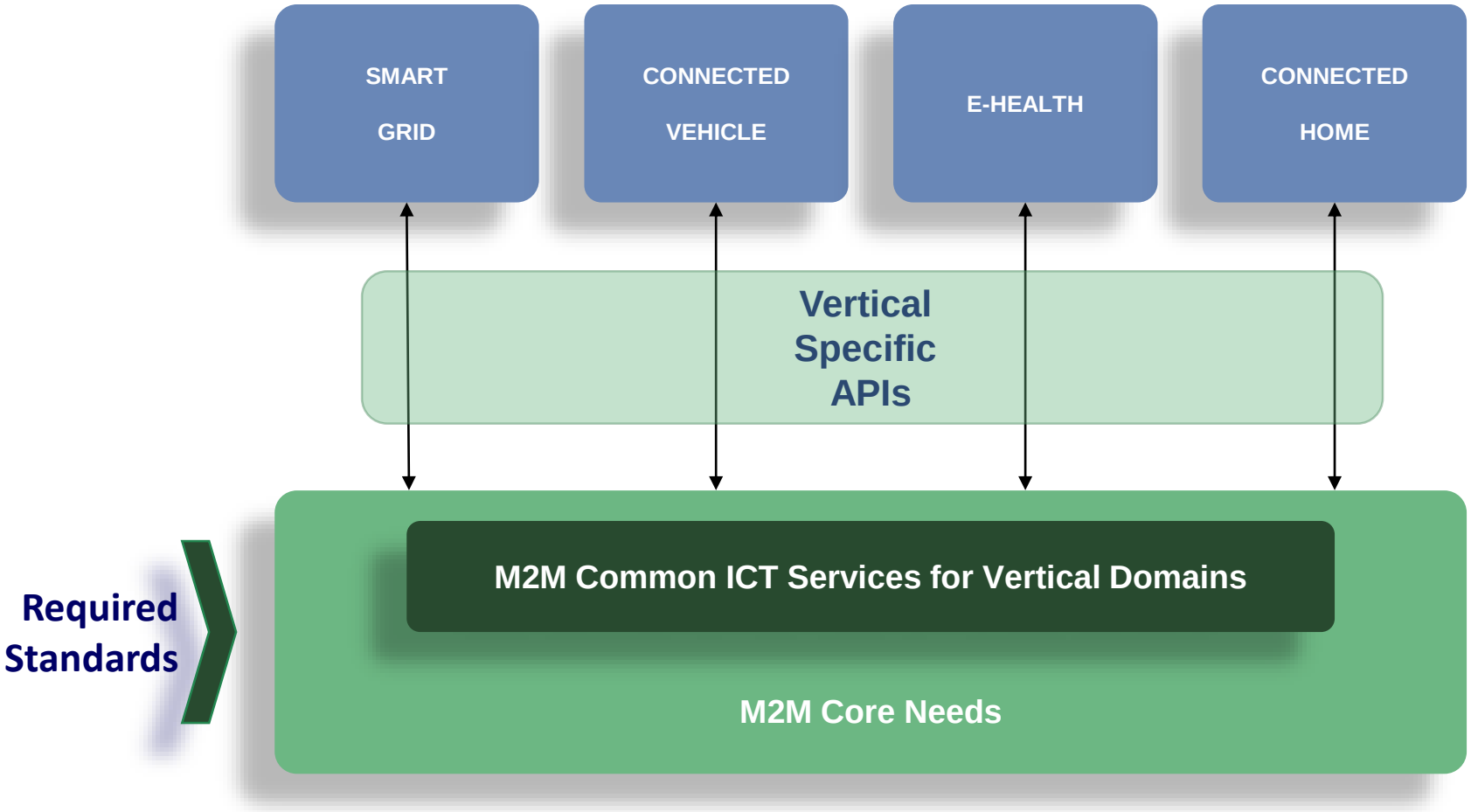
Importance of oneM2M Work

- Create a common service layer for mass-scale M2M applications, covering all domains of M2M, not just one domain in particular.
- It hides the complexity of network usage from applications, thus simplifying the implementation burden for application developers.
- The service layer also controls then communications occur, depending on factors such as the time-sensitivity of communications and the economics of data transfer.

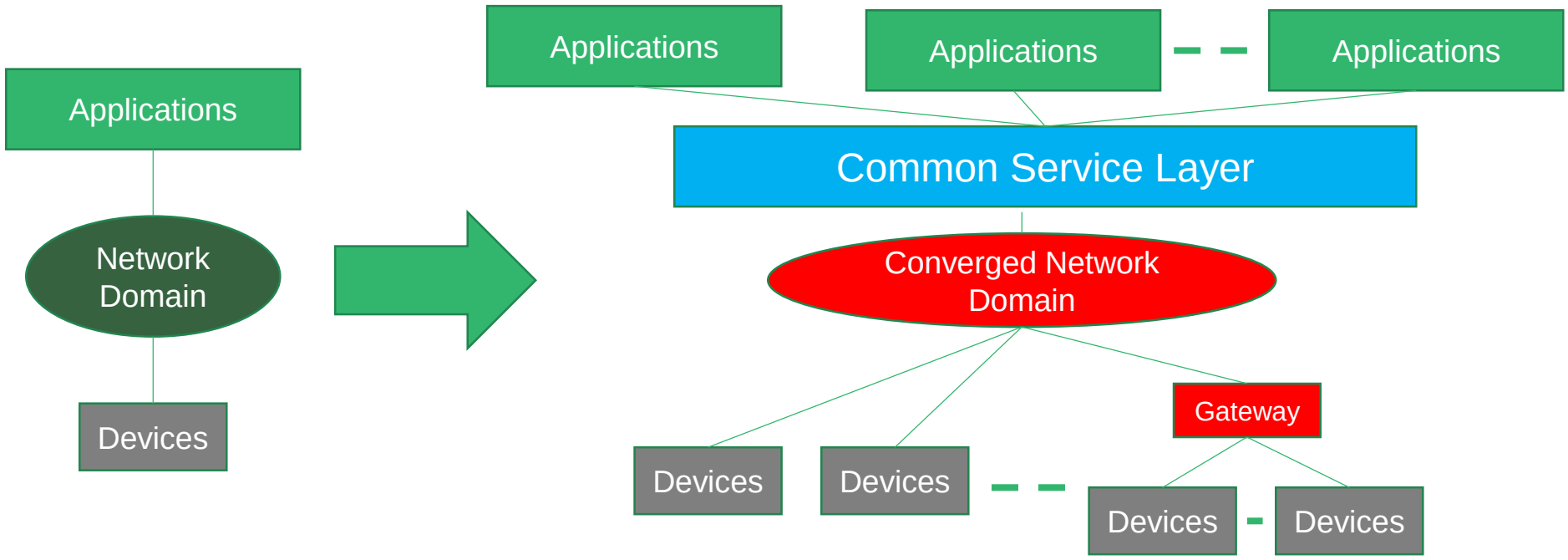
Why M2M Common Service Layer

- Enable the development of M2M applications by focusing on high level functionality than lower level tasks like network access control, authentication or routing.
- Enable data retrieval and control of sensors by any application via a common horizontal service layer.
- Provide network-based services such as charging, security, data publication and subscription.

Common Horizontal Service Layer



Future Vision



What is a Use Case?

- A use case describes the interactions between one or more actors and the system under consideration for achieving certain functions.
- Actors can be a device or a person outside the system.
- The system is treated as a black box where the physical architecture of the system is not important.

Use Case

Derive oneM2M Requirements in TR-0001

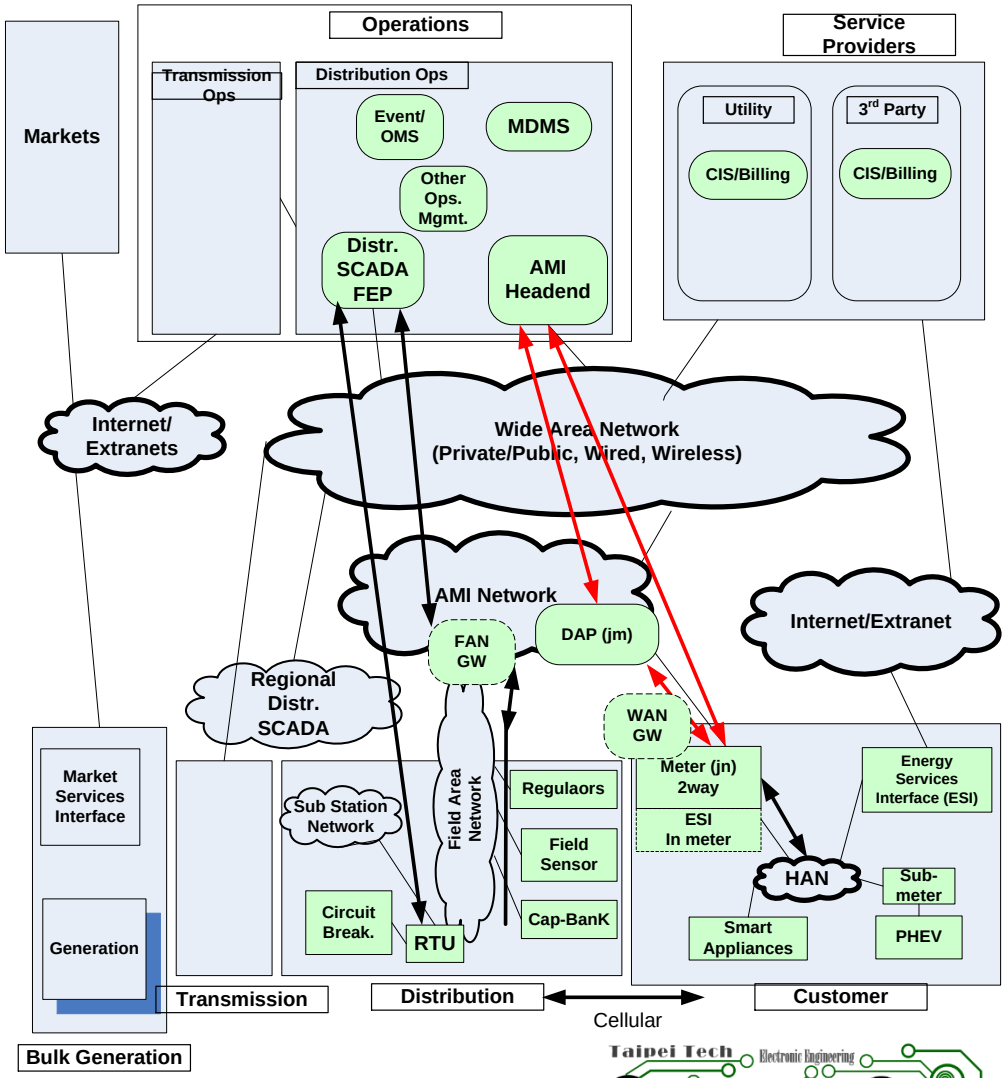
Energy	Wide area energy related measurement & control system for transmission and distribution	Analytics for oneM2M	Smart Meter Reading	Environmental Monitoring for Hydro-Power Generation using Satellite M2M	Oil and Gas Pipeline Cellular/Satellite Gateway		
Enterprise	Smart building						
Healthcare	M2M Healthcare Gateway	Wellness services					
Public Services	Street Light Automation	Devices, Virtual devices and Things	Car/Bicycle Sharing Services	Smart parking			
Residential	Home Energy Management	Home Energy Management System	Plug-In Electrical Charging Vehicles and power feed in home scenario	Real-time Audio/Video Communication	Event Triggered Task Execution		
Transportation	Vehicle Diagnostic & Maintenance Report	Remote Maintenance services	Neighborhood Alerting on Traffic Accident	Fleet management service using Digital Tachograph			
Other	Extending the M2M Access Network using Satellites	Peer communication between M2M devices	M2M data traffic management by underlying network operator	Collection of M2M system data	Optimizing connectivity management parameters with mobile networks	Optimizing mobility management parameters with mobile networks	Sleepy nodes

Methodology Used by oneM2M

- Use of a Template to Describe Use Case
  - Description
  - Source
  - Actors
  - Pre-conditions
  - Triggers
  - Normal Flow
  - Alternative flow
  - Post-conditions
  - High Level Illustration
  - Potential Requirements

Smart Metering Reading - Use Case (1)

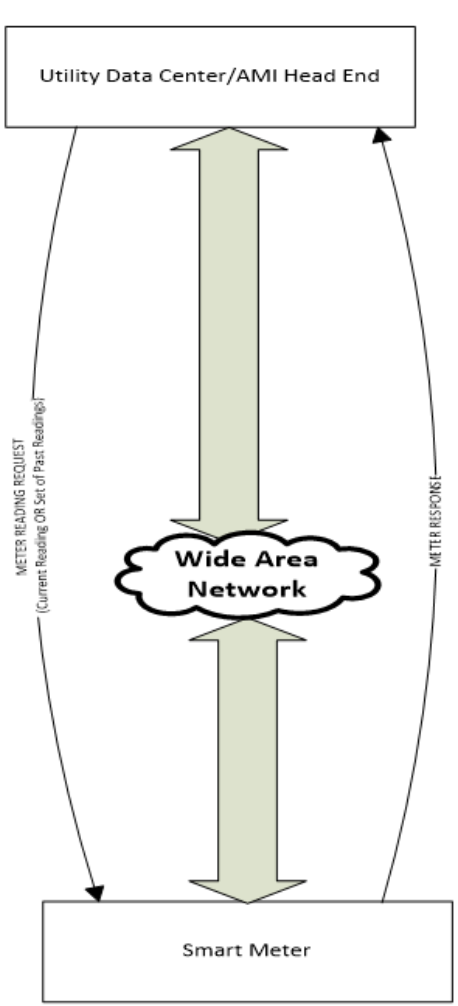
- Conceptual Actors/Data Flow Diagram

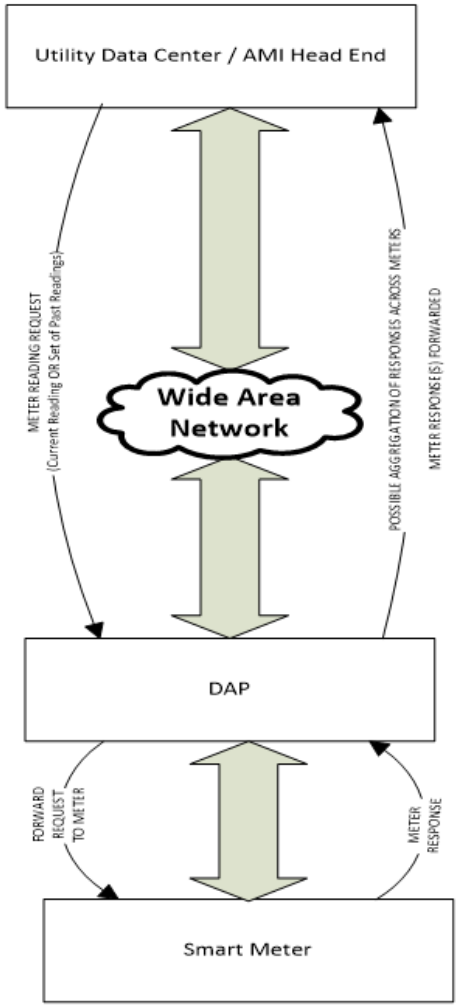


Source: oneM2M TR-0001

Smart Metering Reading - Use Case (2)

- Typical Smart Meter Reading Flows A (on left) and B (on right)





Source: oneM2M TR-0001

Wellness Service Use Case (1)

- Description
  - This use case introduces several services based on wellness data collected by wellness sensor devices via mobile device such as smartphones and tablets which is regarded as M2M gateway.
  - Some wellness sensor devices are equipped with M2M area network module and measure individual wellness data. The mobile device connects to the wellness sensor devices by using the M2M area network technology, collecting and sending the wellness data to application server.

Wellness Service Use Case (1)

- It is important to consider that mobile device as M2M gateway has mobility. For instance, there are possibilities for a mobile device to simultaneously connect to many wearable wellness sensor devices, and to connect newly to wellness sensor devices which have never connected previously at the location of outside.
- This use case illustrates potential requirements from the use case of wellness services utilizing mobile device.

❖ Source

- KDDI (TTC)

Wellness Service Use Case (1)

- Actors
  - M2M Device: wellness sensor device is blood pressure sensor, heart rate sensor and weight scale, for example. It can measure wellness data of users, may be multi-vendor, and equipped with several kind of communication protocol.
  - M2M Area Network: network which connects between M2M device and M2M gateway.
  - M2M Gateway: mobile device (e.g. a smart phone) which can receive wellness data from wellness sensor devices and communicate with application servers.

Wellness Service Use Case (1)

- Mobile Network: network which has functions to communicate wellness data and control message between M2M gateway and M2M service platform.
- M2M Service Platform: platform where management server is located and which is used by the Application Server to communicate with the M2M Gateway.
- Management Server: server which manages the gateway such as mobile device, and controls its configuration such as installing/uninstalling applications.

Wellness Service Use Case (1)

- Application Server: server which serves the wellness services such as indicating the graph of wellness data trend.

❖ Note: Definition of some words is in discussion. Therefore, the description of these actors may change.

Wellness Service Use Case (2)

- Pre-conditions
  - Wellness sensor devices are able to establish a connection to the mobile device in order to send wellness data to M2M Service Platform or Application Server. It is first time to associate the mobile device with the wellness sensor devices.
- Triggers
  - New wellness sensor devices such as weight scale are detected by mobile device. User tries to associate the detected devices.

Wellness Service Use Case (2)

- Examples are below:
  - User buys several kind of wearable wellness sensor devices such as blood pressure sensor, heart rate sensor. In order to start monitoring vital data using these sensors, User tries setting of these devices simultaneously.
    - Note that please refer to [i.4] ETSI TR 102 732 “Use cases of M2M applications for eHealth”. (Normal Flow)
  - User buys wellness sensor devices such as weight scale, and newly deploys them at User’s house to check the wellness status daily. (Normal Flow)

Wellness Service Use Case (2)

- User goes to a fitness center to do exercise and checks the effect by utilizing equipment which is owned by fitness center and has never connected to User's mobile device. (Alternative Flow 1)

Wellness Service Use Case (2)

- Normal Flow
  1. Usually wellness sensor devices are bought by Users. These devices are deployed in User's house, or are worn with User.
  2. The mobile device detects new wellness sensor devices and tries to connect to it under User's permission to connect (pairing between sensor device and mobile device).

Wellness Service Use Case (2)

3. The mobile device has established a connection to the wellness sensor device, and then the mobile device receives additional information of the wellness sensor device (e.g. type of device, service certificates of the device, required application software …).
4. The mobile device is provided with the appropriate application software from the Management Server and is appropriately configured by the Management Server.
5. When the User measures the data by using wellness sensor device, the mobile device collects the data and sends it to the Application Server.

Wellness Service Use Case (3)

- Alternative flow
  1. As indicated in the Normal Flow, usually the wellness service collects the data from wellness sensor devices which the User owns.
  2. When the mobile device is brought outside, there is an opportunity to connect new wellness sensor devices (e.g. blood pressure which is set in fitness center).
  3. The mobile device detects new wellness sensor devices and tries to connect to them under User's permission to connect.

Wellness Service Use Case (3)

4. The mobile device has established a connection to the wellness sensor device and then the mobile device receives additional information of the wellness sensor device (e.g. type of device, service certificates of the device, required application software …).
5. The mobile device is provided with the appropriate application software and is appropriately configured by the Management Server.
6. When the User measures the data by using wellness sensor device, the mobile device collects the data and sends it to the Application Server.

Source: oneM2M TR-0001

Home Energy Management Use Case (1)

- Description
  - This use case is to manage energy consumption at home so that consumers can be aware of their daily home energy consumptions and able to control this consumption by remote actions on home appliances. Innovative services can be developed from the data (energy) collection and sent to either the consumers/ equipment or to Business-to-Business market.

Source: oneM2M TR-0001

Home Energy Management Use Case (1)

- The use case focuses on a home Energy Gateway (EGW) that collects energy information from the electrical home network and communicates it to an M2M system for aggregating and processing of the data. Services can then be developed from the collected data.
- The EGW performs an initial treatment of the data received from various sources (sensors, context) as follows:
  1. aggregating and processing the obtained information:
  2. sending some information to the remote M2M system e.g. sending alerts through the M2M system

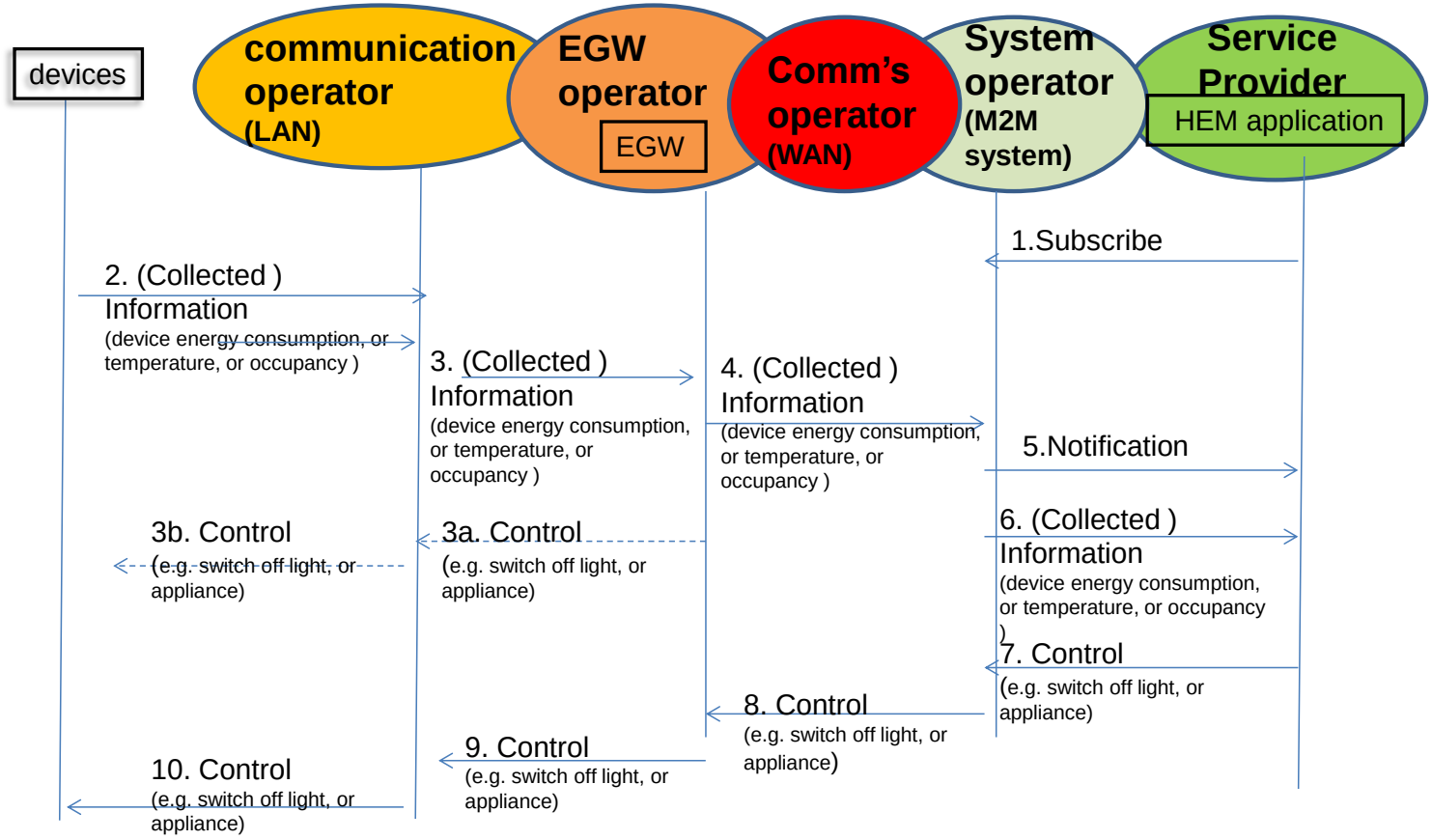
Home Energy Management Use Case (1)

3. using some information locally for immediate activation of some actuators/appliances
4. Is connected (wirelessly or via wireline) to home devices, including the home electrical meter, for information on global or individual consumption of the appliances
5. Providing displayable consumed energy-related information to the end-user/consumer terminals (PC, mobile phone, tablet, TV screen, etc)

- Ref:[i.6] {HGI-GD017-R3 (Use Cases and Architecture for a Home Energy Management Service}

Home Energy Management Use Case (2)

Home Energy Management Normal Flow



Source: oneM2M TR-0001

TS-0002 M2M Requirements

- Major categories of requirements

OSR	72 agreed requirements	Overall System Requirements
MGR	17 agreed requirements	Management Requirements
ABR	03 agreed requirements	Abstraction Requirements
SMR	07 agreed requirements	Semantics Requirements
SER	26 agreed requirements	Security Requirements
CHG	06 agreed requirements	Charging Requirements
OPR	06 agreed requirements	Operational Requirements
CRPR	05 agreed requirements	Comm. Request Processing Requirements
NFR	02 agreed requirements	Non Functional Requirements

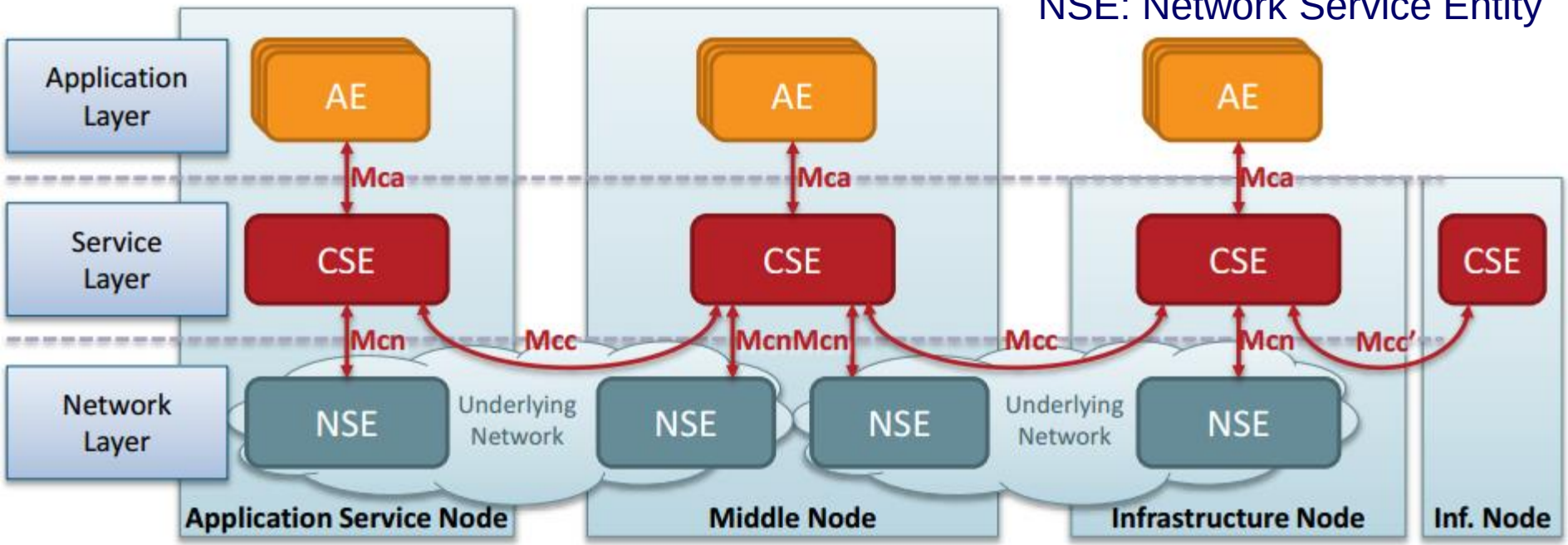
Examples of requirements

- [OSR-001] The M2M System shall be able to allow communication between M2M Applications in the Network Domain & M2M Applications in the Device Domain by using multiple communication means based on IP access.
- [MGR-007] The M2M System shall provide the capability for monitoring and diagnostics of M2M Gateways/Devices in M2M Area Networks.
- [SER-008] The M2M system shall support countermeasures against unauthorized access to M2M services and M2M application services.

oneM2M Functional Architecture

- A Distributed Application Platform for IoT/M2M

AE: Application Entity
CSE: Common Service Entity
NSE: Network Service Entity



Source: oneM2M

oneM2M Functional Architecture (Cont.)

- Specified in oneM2M TS-0001.
  - Three layers of architecture
    - Application Layer
    - Service Layer
    - Network Layer
  - Three types of entities:
    - AE: Application Entity
    - CSE: Common Service Entity
    - NSE: Network Service Entity

oneM2M Functional Architecture (Cont.)

- Four types of nodes
  - Application Dedicated Node
  - Application Service Node
  - Middle Node
  - Infrastructure Node.
- Four Reference Points
  - Mcc (CSE-CSE)
  - Mca (CSE-AE)
  - Mcn (CSE-NSE)
  - Mcc' (between 2 service providers).
- Mch, for charging, is also defined (but not shown here) between the IN-CSE and a charging server.

What Are M2M Common Service Entity?

- M2M common service entity can reside in Application Service Node, Middle Node and Infrastructure Node.
- There are 12 common functions defined in oneM2M CSE.

oneM2M Common Service Functions

- A Distributed Application Platform for IoT/M2M

Source: oneM2M

Samples of oneM2M Common Service Functions

- Registration
  - CSE-CSE Registration, AE-CSE Registration, …
- Discovery
  - Discovery of entities and information/resources
- Security
  - confidentiality, integrity, availability, credential/key management, encryption, privacy, authentication, authorization
- Group Management
  - Management of groups, support of bulk operations and access

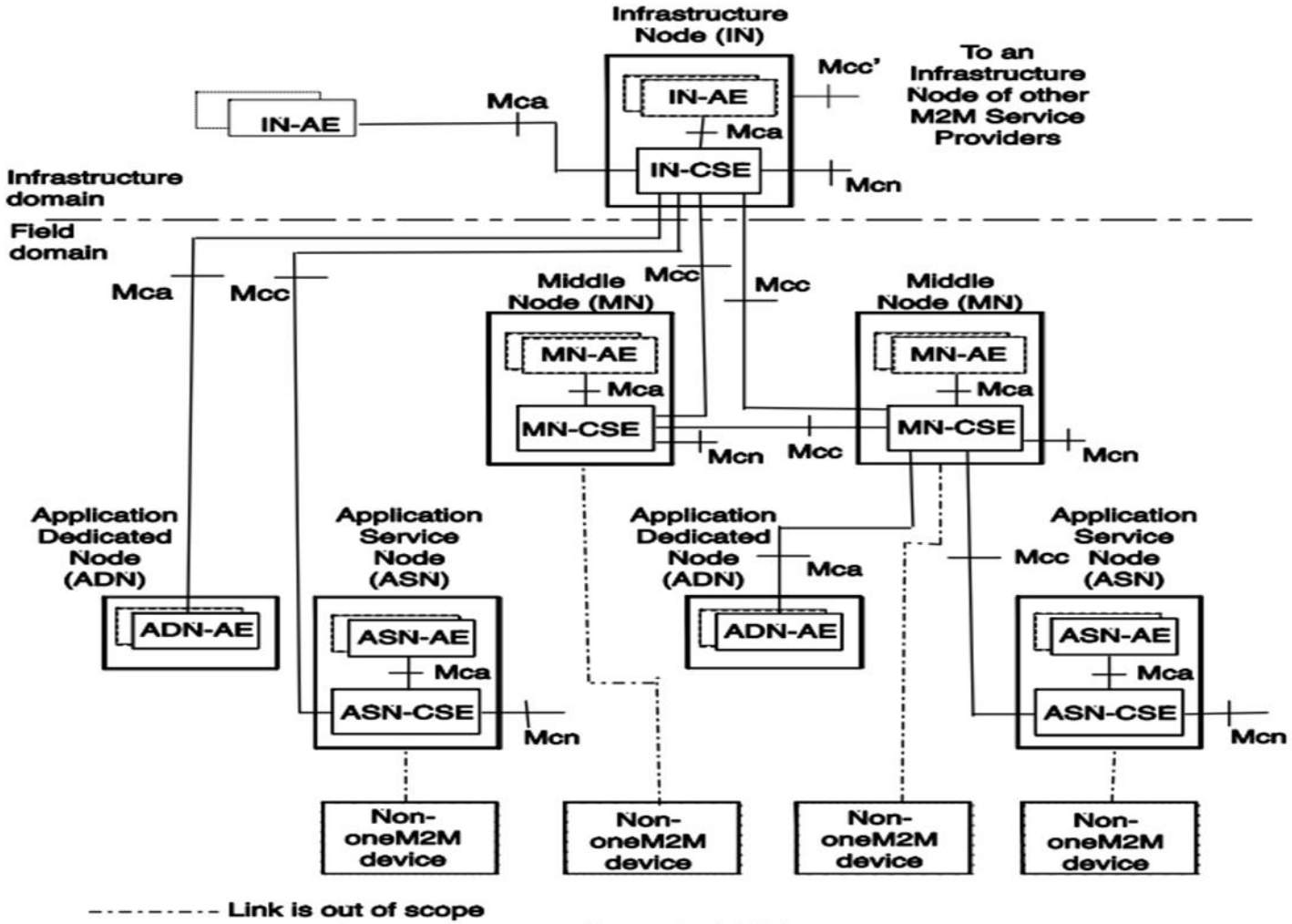
Samples of oneM2M Common Service Functions

- Device Management
  - Firmware updates, configuration settings, topology management, Software installation, logging, monitoring, diagnostics, Reuse of existing DM technologies
- Subscription & Notification
  - Support of event-related notifications (change of values)
- Network Exposure
  - Abstraction of the underlying network interface, (eg. usage of remote device triggering, location services, …)

Samples of oneM2M Common Service Functions

- Communication Management
  - Selection of communications channels, scheduling, Store-and-forward, reachability status awareness
- Location
  - Manages and provides location information services

Overall oneM2M Functional Architecture



Source: oneM2M TS-0001

總結

- oneM2M follows a rigorous process to define a high level architecture for IoT/M2M
  - It starts from use case studies across many use cases to capture sufficient requirements.
  - Based on these requirements, a high-level IoT/M2M architecture is developed.
- The architecture consists of two domains
  - field domain and infrastructure domain.
- Four types of nodes are defined
  - Application Dedicated Node, Application Service Node, Middle Node and Infrastructure Node.

總結

- Four Reference Points are defined
  - Mcc (CSE-CSE), Mca (CSE-AE), Mcn (CSE-NSE) and Mcc' (between 2 service providers).
- Twelve common service functions are also identified.
- These service functions are distributed in the M2M networks and can reside in Application Service Node, Middle Node and Infrastructure Node to support M2M services.

附錄 - oneM2M Specification

- oneM2M Published Documents
  - http://www.onem2m.org/technical/published-documents
- oneM2M – Webinars
  - http://www.onem2m.org/insights/webinars