5G System and Service Providers (SP)
New Services
Data-centric approach

to

LF Edge Akraino
API TSC Sub-committee

Ike Alisson
2021-02-19 Rev PA9

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Introduction

Two (2) Questions on APIs & Data-centric Platforms/Systems/Solutions

Nr. 1 Functional Process - **HOW?**

Nr. 2 Purpose / Intent - **WHAT?**

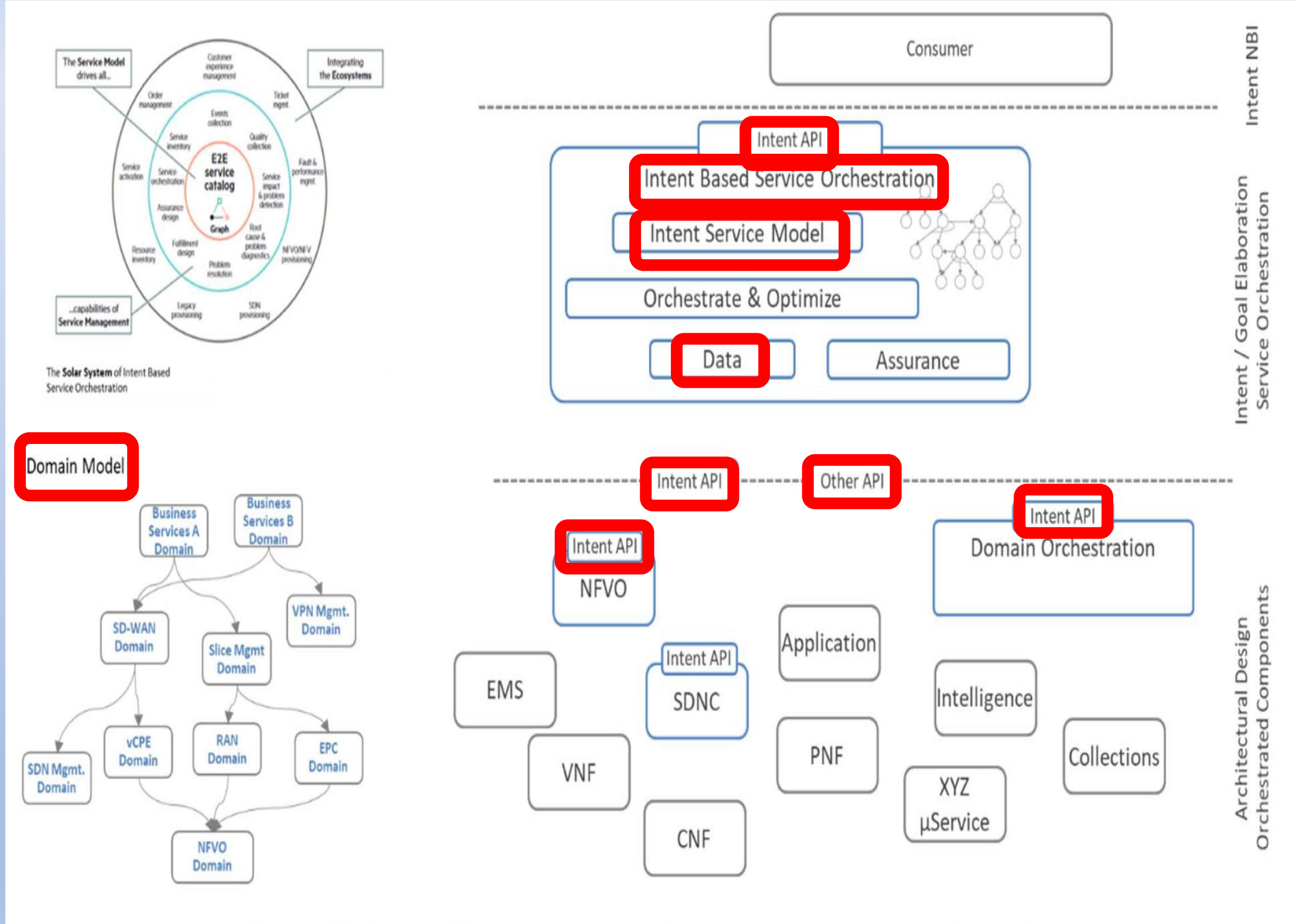


Figure 10: Intent-based Service Orchestration across Domains, driven by Intent-based Service Models

Ref: ETSI GR 005 Means of Automation May 2020: 22, 26

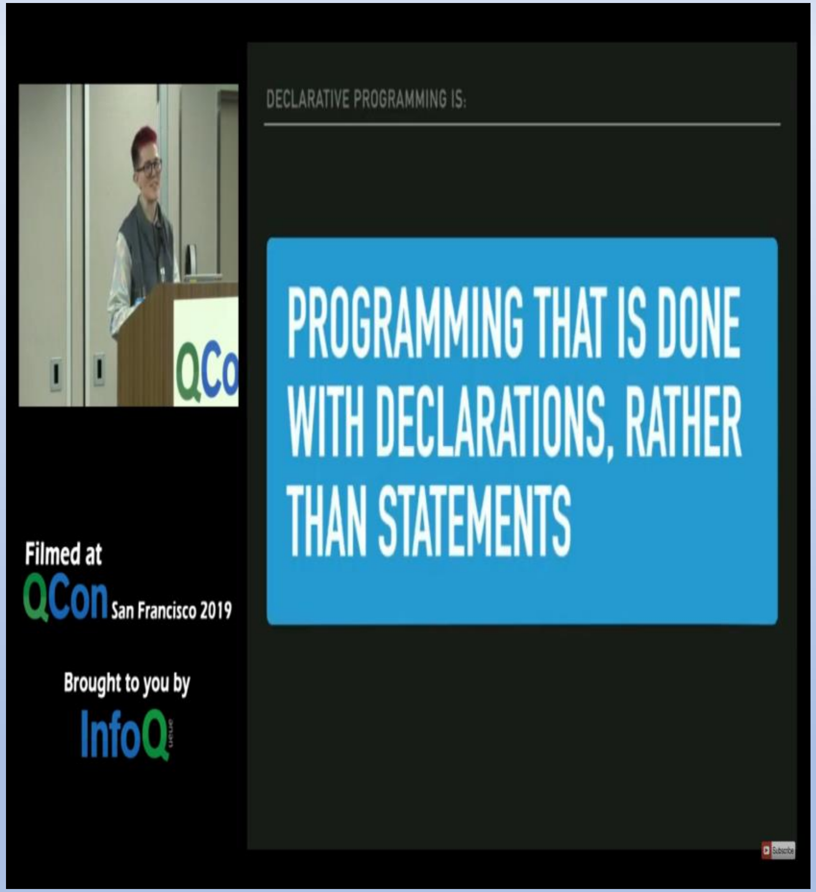
Two (2) Questions on APIs:

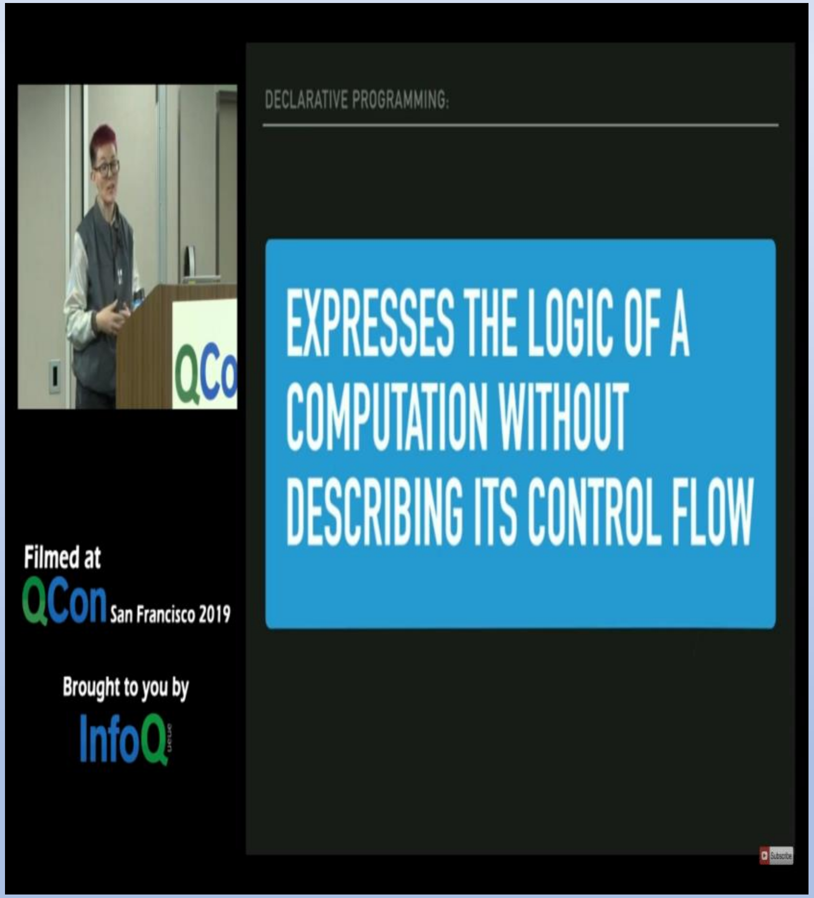
Nr. 1 APIs: Type and Functions - **HOW?**

APIs

Ref 3GPP TS 23.222 & TS 29.222 CAPIF for NAPS Rel 16 & 17, Dec 2020: 24,16

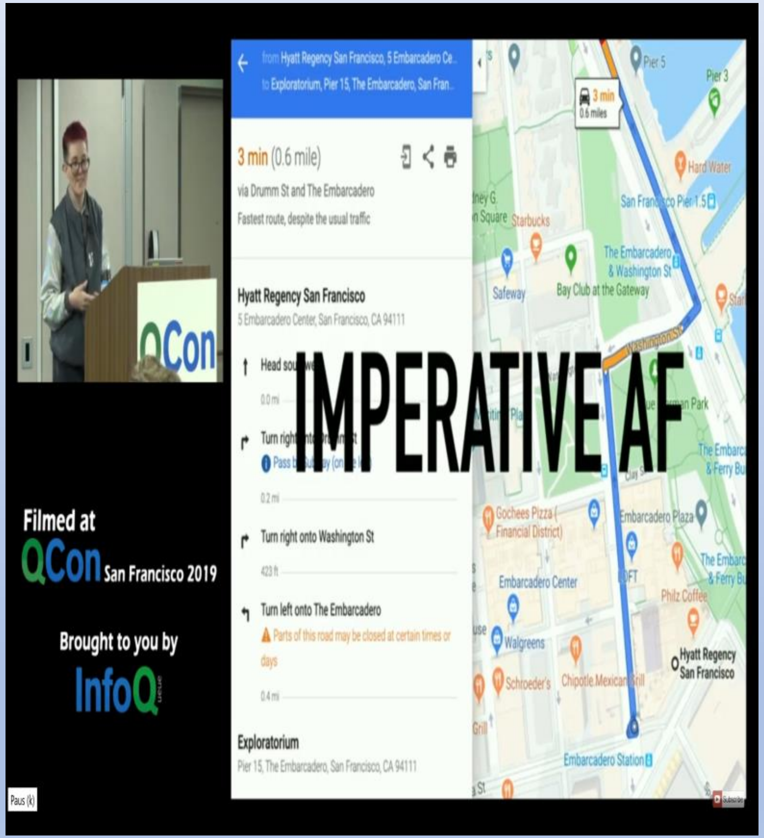
1. Declarative APIs & YAML - 1



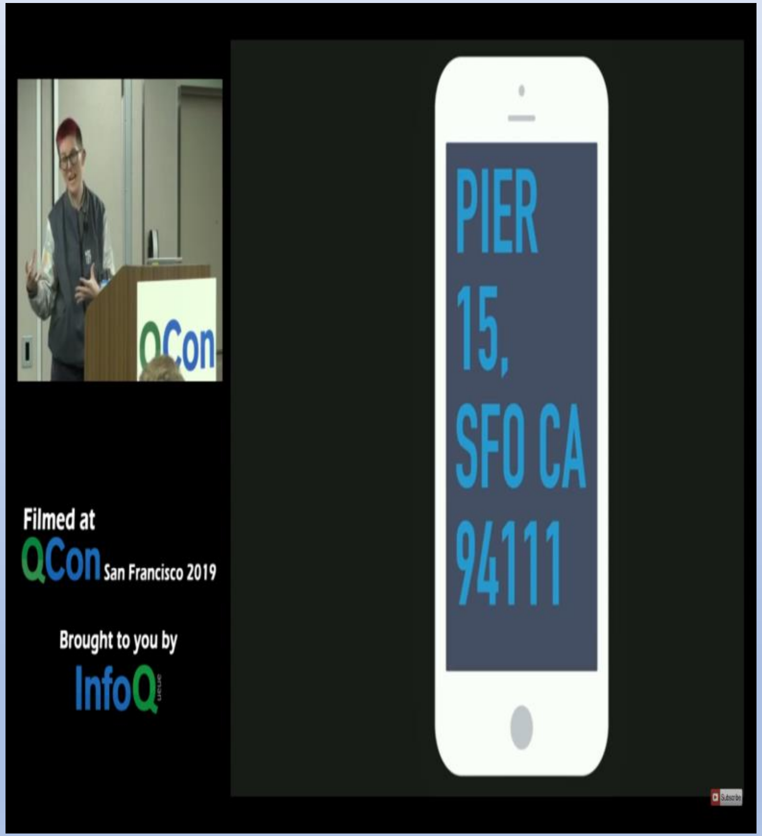


1. Declarative APIs & YAML - 2

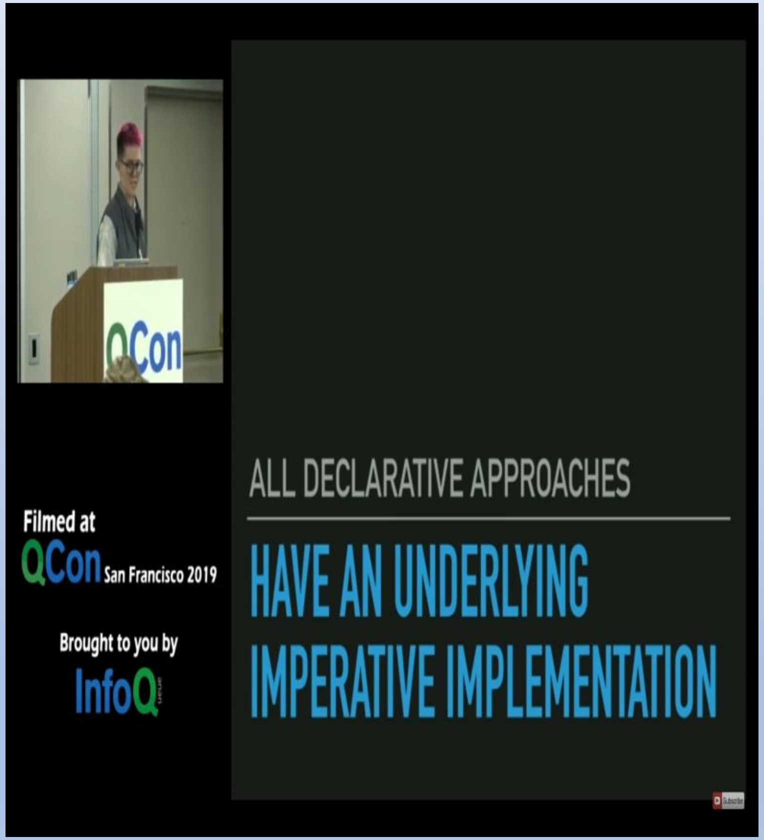
1. Imperative



2. Declarative



3. All Declarative Approaches have Imperative Implementation



Declarative APIs & YAML - 3

1. The Non-RT RIC is deployed in a **Service Management & Orchestration Framework (SMO)** & provides **Declarative Policy Guidance** for Cell-level Optimization by providing the optimal configuration values for cell parameters over the O1 Interface.

2. The Non-RT RIC also **sends Declarative Policies** for UE-level optimization to the Near-RT RIC via the A1 interface.

3. The Near-RT RIC then translates the recommended **Declarative Policy** from the Non-RT RIC over A1 interface into per-UE Control and **imperative policy over the E2 interface**.

4. The Non-RT RIC develops **ML/AI-driven Models** for Policy Guidance and non-RT Optimization as rApp Microservices.

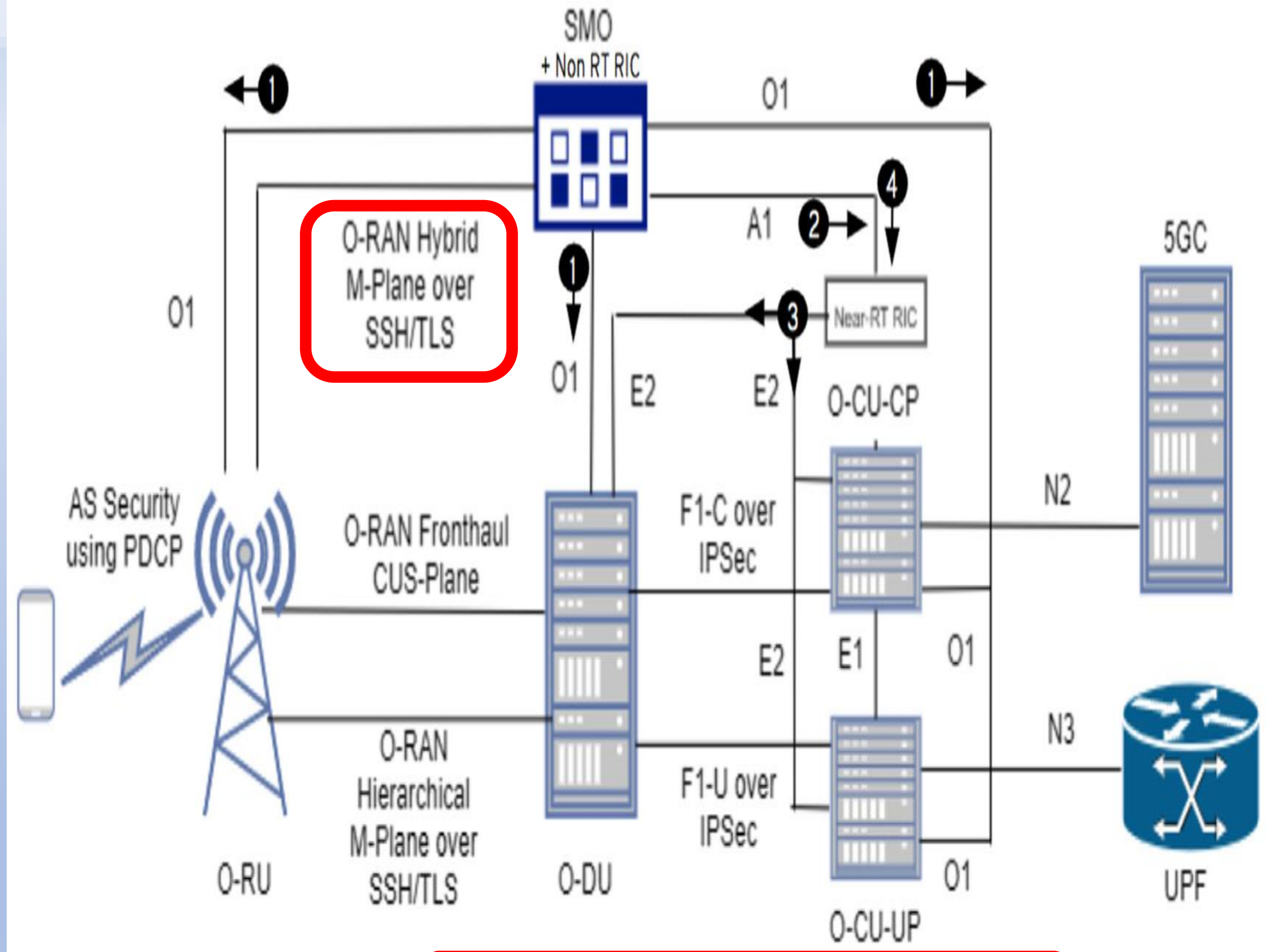


Fig. 6: Non-Real-Time RIC Declarative Policies and Objective Intents

Ref Altiostar Redhat WP Security in Open RAN, Feb 2021: 6

1. Declarative APIs & YAML - 4

Declarative Kubernetes Lifecycle Management with Kubernetes Cluster API v1alpha1

Kubernetes Declarative API

Cluster API is a Declarative API Specification.

Cluster API is the API Specification that helps provide **Uniform and Consistent Management for Kubernetes Clusters** regardless of the underlying infrastructure.

For v1alpha1, the API comprises 5 Custom Resource Definitions (CRDs):

1. Cluster,
2. Machine,
3. Machine Set,
4. Machine Deployment, and
5. Machine Class. Kubernetes

Cluster API Lays the Groundwork for Declarative Kubernetes Lifecycle Management with v1alpha1, May 2019

1. Declarative APIs & YAML - 4a

The OS Virtualisation Technology allows partially shared execution Context for different Containers. Such a shared Execution Context is frequently referred to as a Container Pod.

In addition to Hypervisor-based Execution Environments that offer HW Abstraction & Thread Emulation Services, **the OS Container Execution Environment provides Kernel Services that include:**

1. **Process Control.** EXAMPLE 1: OS process creation; scheduling; wait and signal events; termination.
2. **Memory Management.** EXAMPLE 2: Allocation and release of regular and large pages; handling memory- mapped objects and shared memory objects.
3. **File System Management.** EXAMPLE 3: Creation, removal, open, close, read and write file objects.
4. **Device Management.** EXAMPLE 4: Request, release, configuration and access.
5. **Communication Services.** EXAMPLE 5: *Protocol Stack Services*, Channel Establishment and Release, PDU Transmission and Reception.
6. **System Information Maintenance.** EXAMPLE 6: Time and date, system and OS Resource Data, performance and fault indicators.

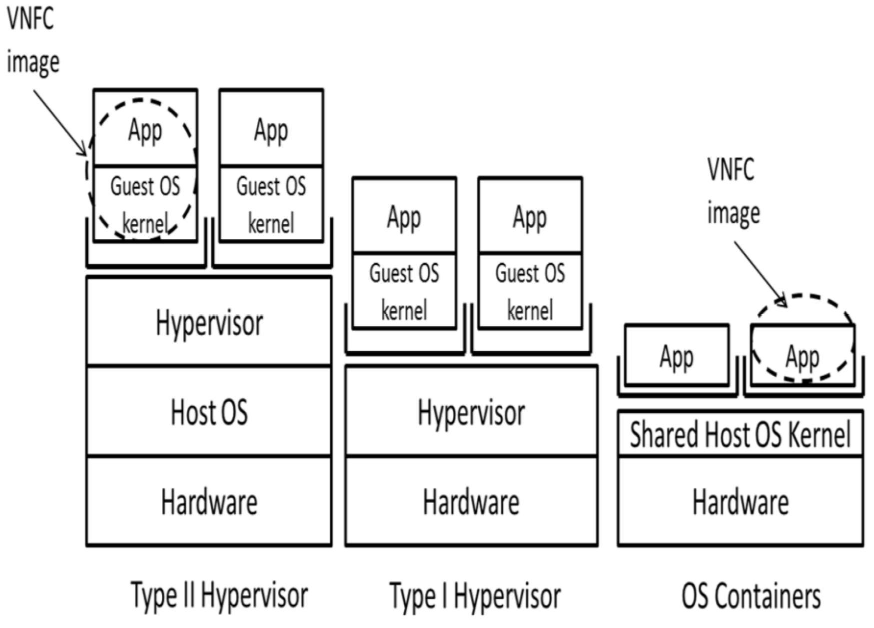


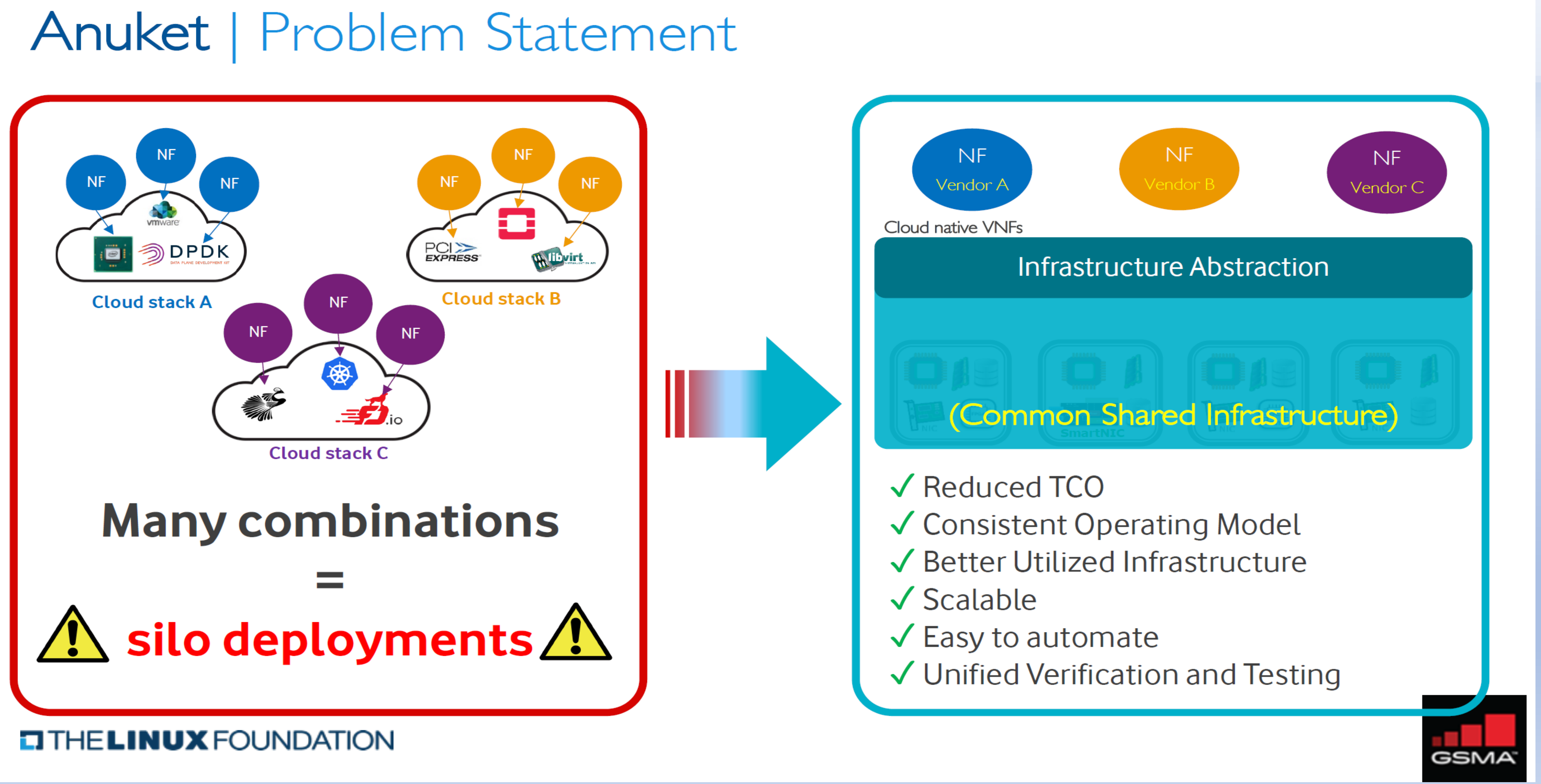
Figure 1: Hypervisor vs. OS Container solutions

OS Virtualisation provides Storage Abstraction on File System Level rather than on Block Device Level.

Each container has its separate file system view, where the guest file system is typically separated from the host file system. Containers within the same pod might share file systems where modifications made in one container are visible in the others.

Ref: ETSI MEC WP GR 027 Support for AVT Nov 2019: 7-8

1. Declarative APIs & YAML - 4b



1. Declarative APIs & YAML - 5

ETSI GS MEC 009 V2.2.1 (2020-10)

GROUP SPECIFICATION

Multi-access Edge Computing (MEC);
General principles, patterns and common aspects of MEC Service APIs

1. Declarative APIs & YAML - 6

ETSI ISG MEC
World Class Standards

5.3 Provision of an OpenAPI definition

An ETSI ISG MEC GS defining a RESTful MEC service API should provide a supplementary description file (or supplementary description files) compliant to the OpenAPI specification [i.14], which inherently include(s) a definition of the data structures of the API in JSON schema or YAML format. A description file is machine readable facilitating content validation and autocreation of stubs for both the service client and server. A link to the specific repository containing the file(s) shall be provided. All API repositories can be accessed from https://forge.etsi.org. The file (or files) shall be informative. In case of a discrepancy between supplementary description file(s) and the underlying specification, the underlying specification shall take precedence.

5.4 Documentation of the API data model

5.4.1 Overview

Clause 5.4 and its clauses specify provisions for API data model documentation for ETSI ISG MEC GSs defining RESTful MEC service APIs. Clause 5 in annex D provides a related data model template.

The data model shall be defined using a tabular format as described in the following clauses. The name of the data type shall be documented appropriately in the heading of the clause and in the caption of the table, preferably as defined in clause 5.2.2 and in annex D.

1. Declarative APIs & YAML - 7

What is APIs YAML: Machine Readable Specification

YAML 1.2 is a superset of JSON (JavaScript Object Notation) with [some built-in advantages], e.g.

YAML can

- Self-reference,
- **Support Complex Datatypes,**
- Embed Block Literals,
- Support comments, and more.

YAML tends to be more readable than JSON.

Ref. http://apisyaml.org/

1. Declarative APIs & YAML - 8

OpenAPI Specification

OPENAPI INITIATIVE

Version 3.0.3

4.2 Format

An OpenAPI document that conforms to the OpenAPI Specification is itself a JSON object, which may be represented either in JSON or YAML format.

In order to preserve the ability to round-trip between YAML and JSON formats, YAML version 1.2 is *RECOMMENDED* along with some additional constraints.

Note: While APIs may be defined by OpenAPI documents in either YAML or JSON format, the API request and response bodies and other content are not required to be JSON or YAML.

Swagger
Supported by SMARTBEAR
Why Swagger? Tools Resources

OpenAPI Specification

Version 3.0.3

Format

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Access Context Manager documentation

Overview

Training and tutorials

Access Context Manager allows enterprises to configure access levels which map to a policy defined on request attributes. Learn more

Guides

Quickstart

Creating a basic access level

Managing access levels

IAM Roles for Administering Access Context Manager

Creating an access policy

Reference

Access level attributes

Example YAML for an access level

Custom access level specification

REST API

RPC API

Resources

Quotas and limits

Release Notes

Pricing

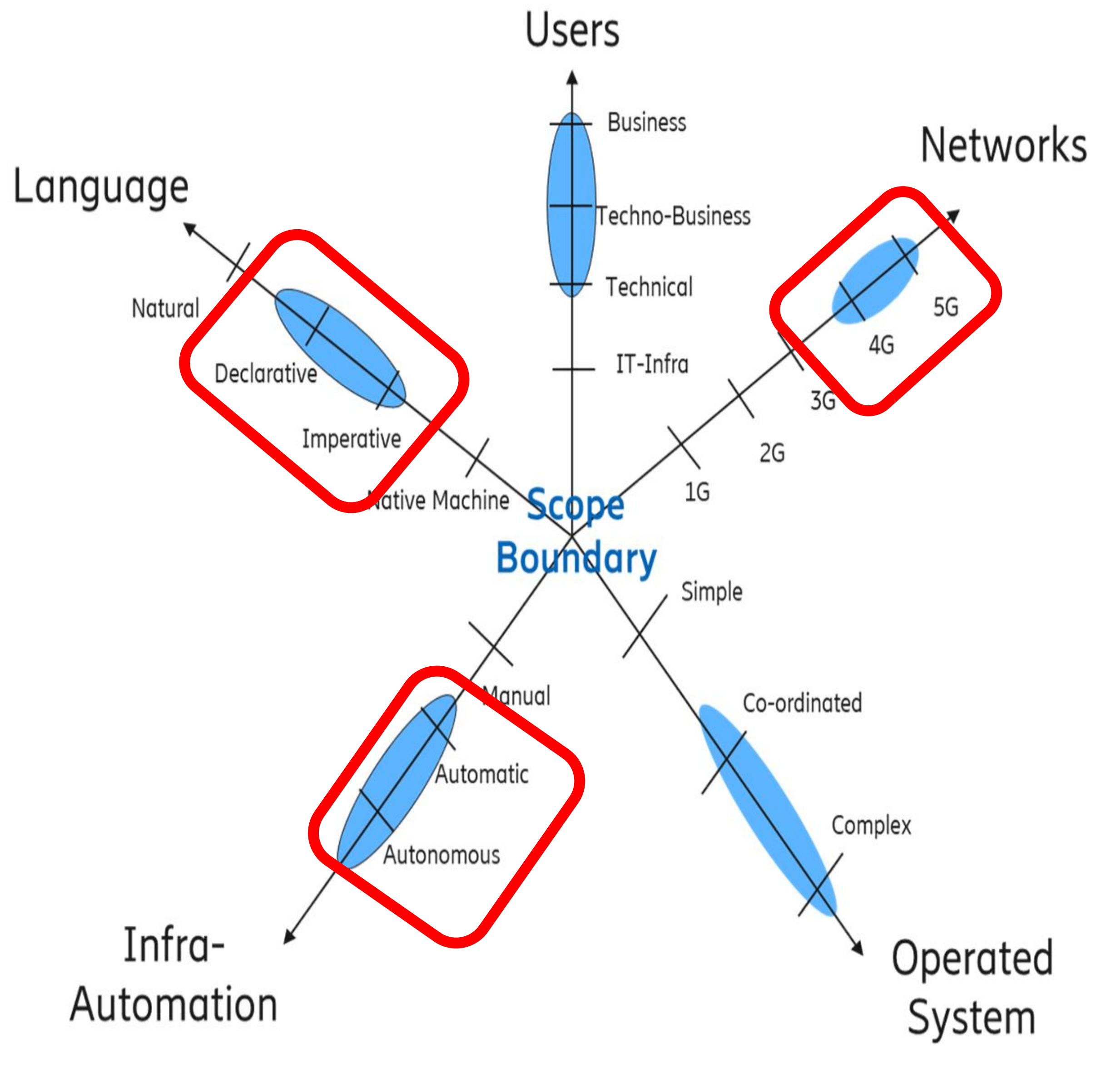


Figure 4.2.1: Dimension of intent

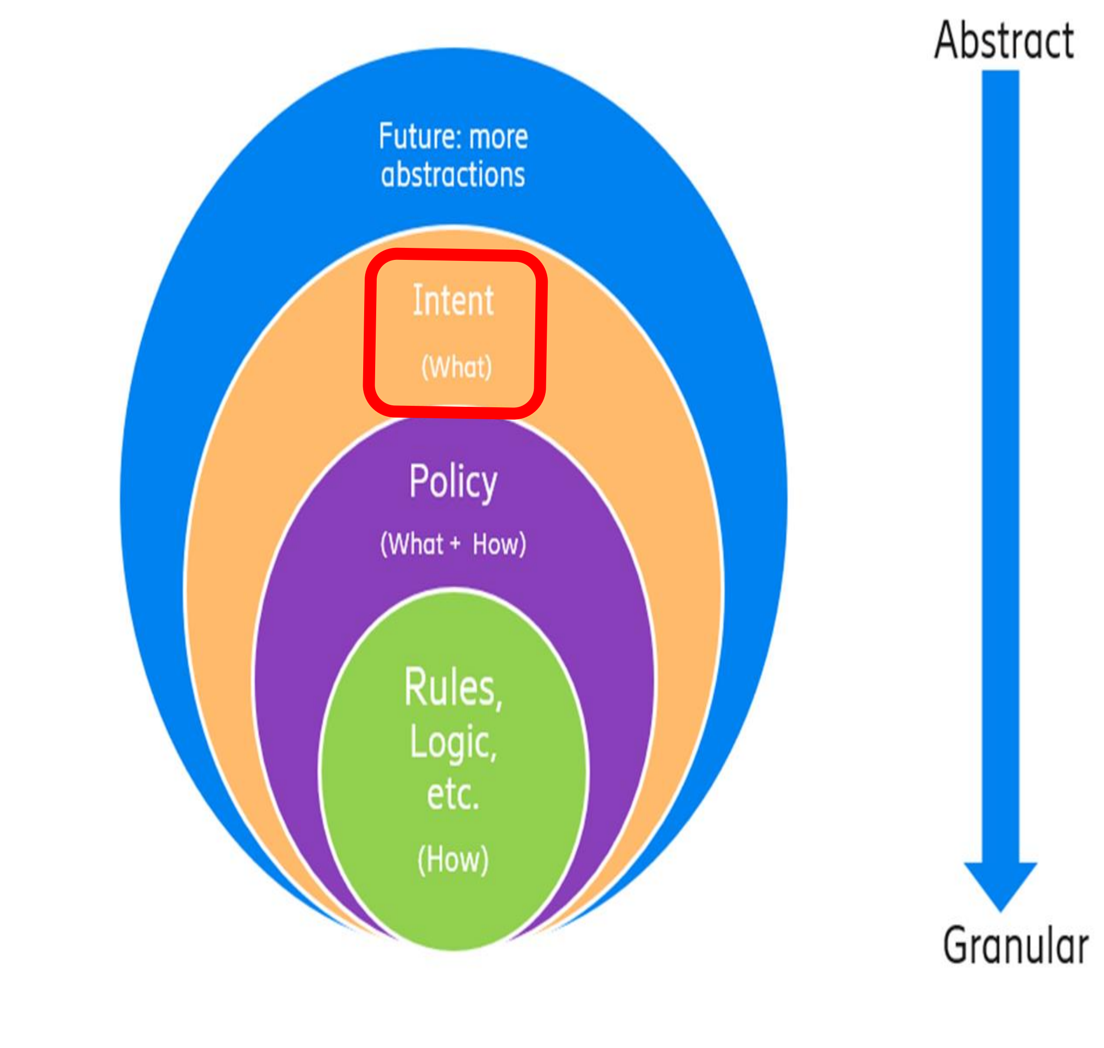


Figure 4.6.1: Intent driven management vs Policy driven management

Ref: 3GPP TR 28.812 Study on scenarios for Intent driven management services for mobile networks Rel.16: 17

Use of the Policy Continuum

Declarative Policies are used in the service, administrator, and device views, since they enable logic programs to express and act on Goals that are applicable to the needs of these actors:

Declarative policies are likely not applicable to the instance view, since that would require a device that could evaluate declarative logic.

Declarative policies could, of course, be used in the Business view. However, declarative policies use formal logic, which is difficult for business actors to use.

Imperative Policies are used in the Service, administrator, device, and instance views, since they enable actors to specify a Policy using a simple syntax:

Imperative policies could, of course, be used in the business view. However, intent policies are judged to be easier to use.

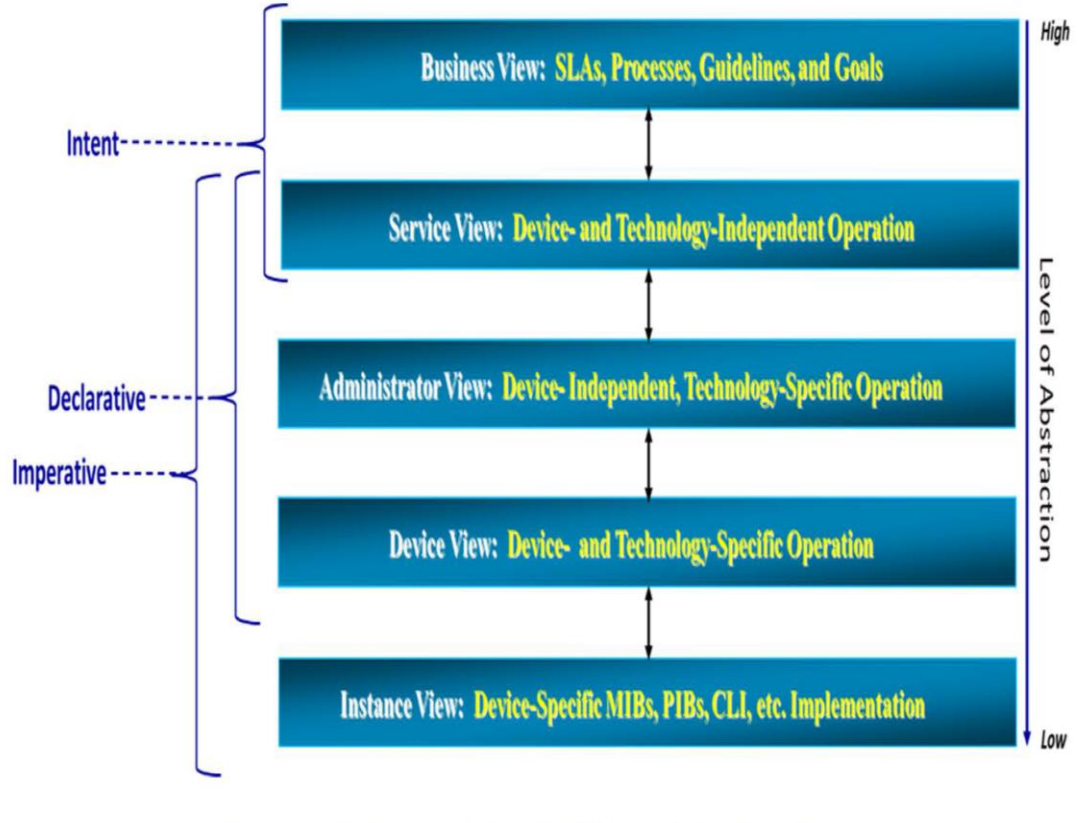
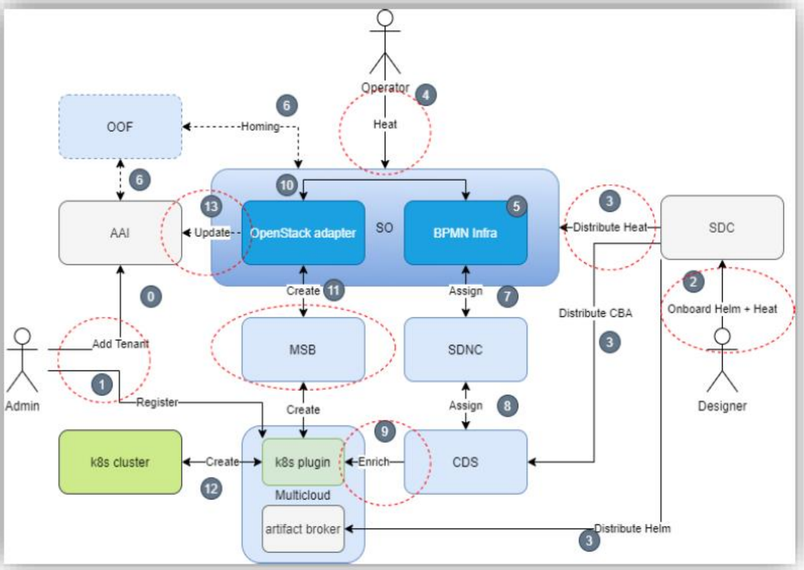


Figure 5.1-1: Mapping Actors to Different Policy Paradigms

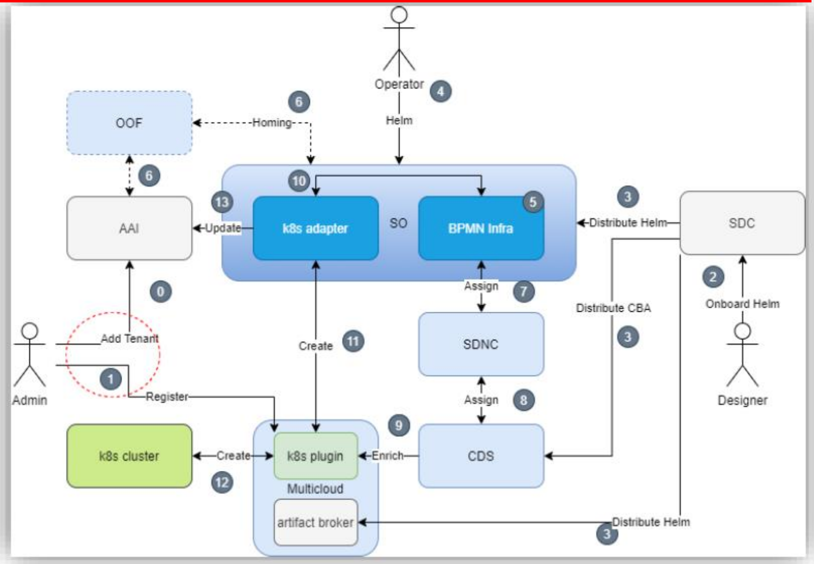
ONAP CNF Journey (REQ-341)

Prepared by Lukasz Rajewski (Orange), Seshu Kumar (Huawei)

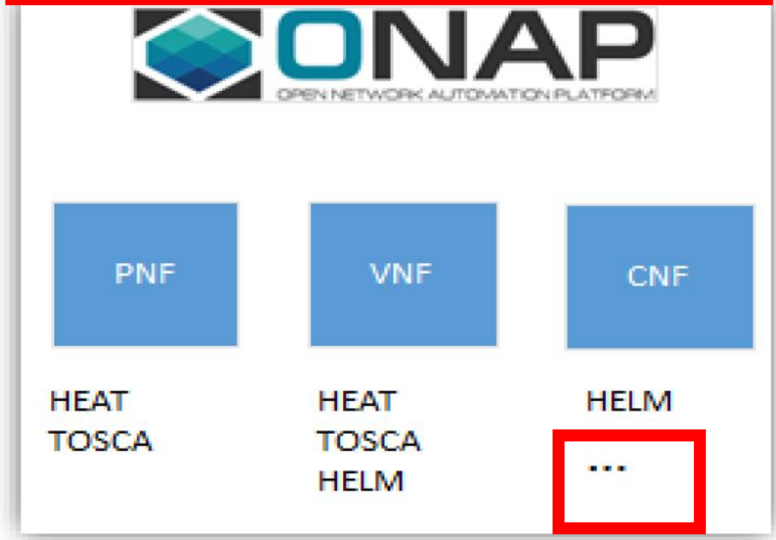
ONAP OPEN NETWORK AUTOMATION PLATFORM **Completed**



ONAP OPEN NETWORK AUTOMATION PLATFORM **On-Going**



ONAP OPEN NETWORK AUTOMATION PLATFORM **Expected**



Till Frankfurt

- ✓ Embedding the Helm into the Heat package distro
- ✓ CLOUD_TECHNOLOGY_SPECIFIC artifact distributes Helm
- ✓ Installation of Helm package(s) into K8s cluster
- ✓ Basic Helm enrichment through CDS - Introduced

Guilin Brings

- ✓ HELM artifact is Introduced to make Helm charts a first class citizen
- ✓ HELM artifacts supported in Day 0 and Day 1
- ✓ Native Helm support in E2E Orchestration
- ✓ Enhanced native Helm enrichment through CDS, K8s Plugin interactions.

Beyond

- ✓ Cross community Integration and SDO Compliance
- ✓ Extension to CNF model with Health Check and Monitoring of CNF resources
- ✓ Auto discovery of K8S cluster in ONAP
- ✓ Intent Driven orchestration and Service Control Loop Inc. CNFs

Ref: ONAP Honolulu CNF Task Force Requirements Oct 2020

Jira Software Dashboards Projects Issues Create Search Log In

Release Requirements / REQ-329

Guilin-R7 - Support for Intent-based Network

Clone++ Export

Details

Type:	Epic	Status:	DONE
Priority:	High	Resolution:	Done
Affects Version/s:	None	Fix Version/s:	Guilin Release
Labels:	None		
Epic Name:	Intent-based Network		
Requirement Type:	Requirement (DEPRECATED)		
PoC:	PoC		
TSC Priority:	4		
Arch Review:	Not yet performed		
Scope Status:	Original Scope		
T-Shirt Size:	XL		
M1 Scorecard:	Green		
M1 Approval:	GO		
M2/3 Scorecard:	Green		
M2/3 Approval:	GO		
M4 Scorecard:	Green		
M4 Approval:	GO		

People

Assignee:	Huang ZongHe
Reporter:	Huang ZongHe
Votes:	0 Vote for this issue
Watchers:	9 Start watching this issue

Dates

Created:	20/May/20 2:29 AM
Updated:	06/Jan/21 8:56 AM
Resolved:	02/Dec/20 8:32 AM

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MEF

SERVICE STANDARDS | MEF APIs | LEARN | ENGAGE | CERTIFY | FOR MEMBERS

MEF and TM Forum Collaborate on Open APIs for Service Automation

MEF and TM Forum align to bring consistency and ease-of-use to standardized APIs for inter-provider services

Los Angeles, 7 October 2020 – MEF and TM Forum have completed initial efforts to ensure that both organizations are aligned to use open standard APIs to automate inter-provider services for digital transformation. This collaboration will help service providers accelerate their transition from operating within limited ecosystems/islands to being integral players in a worldwide federation of networks supporting on-demand digital services across multiple providers.

Share:

Media Contact:

Ashley Schulte
Connect2 Communications for MEF
MEF@connect2comm.com

TM Forum and MEF have specifically aligned on the following:

- TM Forum is developing Domain Context Specialization Guidelines that enable MEF LSO Sonata APIs to conform to TM Forum Open API standards.
- TM Forum API tooling is now being used by MEF to build the set of LSO Sonata APIs.
- LSO Sonata API product payloads work in alignment with TM Forum API standards using a polymorphic approach.
- The organizations have established a framework for ongoing collaboration.

1. "5G Network Mobility at "Cell" & "Cloud" Edge - NGMN WP Feb 2015 - 1

tmforum

Themes | Member Resources | Collaboration | Education & Services | Research

Member Resources

- Open Digital Framework
- Open Digital Architecture
- Frameworx
- Open APIs
- Toolkits

Join the Project

Open APIs

Delivering business agility within companies and across digital ecosystems

TM Forum's suite of 50+ REST-based Open APIs has been collaboratively developed to be used in a range of scenarios, internally enabling service providers to transform their IT and operational agility and customer centricity, while externally delivering a practical approach to seamless end-to-end management of complex digital services.

Learn more about the program.

Explore the Open APIs:

3GPP 5G

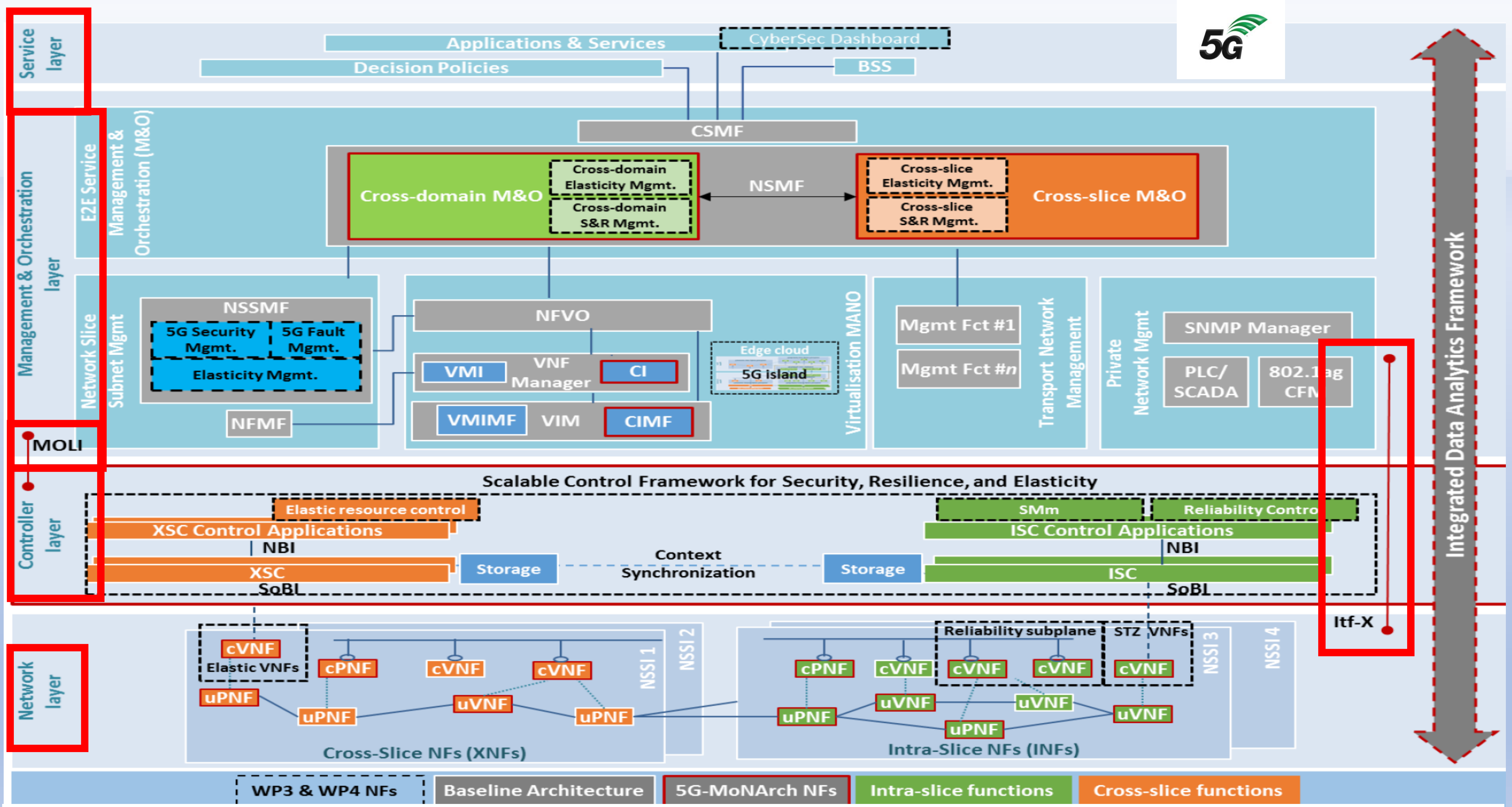


Figure 2-2: 5G Mobile Network overall Architecture

Ref 5G PPP Mobile Network Architecture MoNArch D 2.3 April 2019: 18

1. 5G NF as a Service "Producer" and "Consumer" (+ Intent)

Communication between consumer and producer	Service discovery and request routing	Communication model
Direct communication	No NRF or SCP; direct routing	A
	Discovery using NRF services; no SCP; direct routing	B
Indirect communication	Discovery using NRF services; selection for specific instance from the Set can be delegated to SCP. Routing via SCP	C
	Discovery and associated selection delegated to an SCP using discovery and selection parameters in service request; routing via SCP	D

Table E.1-1: Communication models for NF/NF Services interaction

2. 5G NDL - Network Data Layer - separation of the 5G "Compute" from "Storage" via 5G UDM in NFs implementation into VNFs & PNFs related

(NF) Application Context (Unstructured Data in UDSF)
from
(NF) Application Business Logic (Structured Data in UDR)

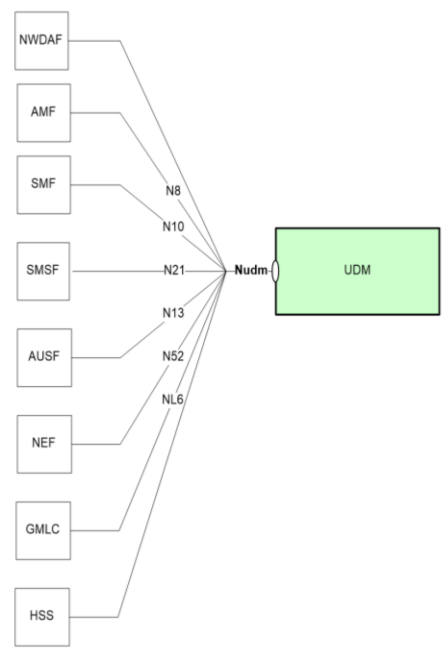


Figure 4.1-1: Reference model – UDM

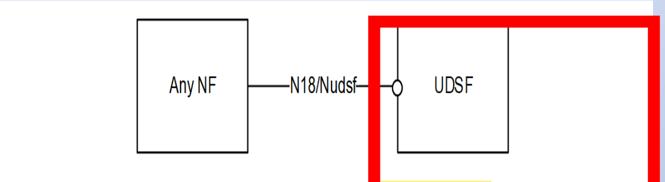


Figure 4.2.5-1: Data storage architecture for unstructured data from any NF

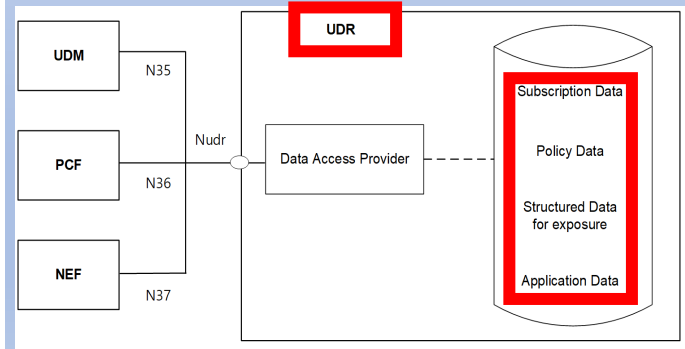


Figure 4.2.5-2: Data storage architecture

Ref 5G PPP Mobile Network Architecture MoNArch D 2.3 April 2019: 18

5G NF/NF Services Interaction as Producer and Consumer

Model A - Direct communication without NRF interaction: Neither NRF nor SCP are used. **Consumers** are configured with **Producers' "NF Profiles"** and directly communicate with a **Producer** of their choice.

Model B - Direct communication with NRF interaction:

Consumers do discovery by querying the NRF. Based on the discovery result, the **Consumer** does the selection. The **Consumer** sends the request to the selected **Producer.**

Model C - Indirect Communication without Delegated Discovery: **Consumers** do discovery by querying the NRF. Based on discovery result, the **Consumer** does the selection of an **NF Set or a specific NF instance of NF instance set.** The Consumer sends the request to the SCP containing the **address of the selected Service Producer pointing to a NF Service Instance or a set of NF Service Instances.** In the latter case, the SCP selects an **NF Service Instance**. If possible, the SCP interacts with NRF to get selection parameters such as location, capacity, etc. The SCP routes the request to the **selected NF Service Producer Instance.**

Model D - Indirect communication with delegated Discovery: **Consumers** do not do any discovery or selection. The **Consumer** adds any **necessary Discovery and Selection Parameters required to find a suitable Producer to the Service** request. The SCP uses the request address and the discovery and selection parameters in the request message to route the request to a suitable producer instance. The SCP can perform discovery with an NRF and obtain a discovery result.

Communication between consumer and producer	Service discovery and request routing	Communication model
Direct communication	No NRF or SCP; direct routing	A
	Discovery using NRF services; no SCP; direct routing	B
Indirect communication	Discovery using NRF services; selection for specific instance from the Set can be delegated to SCP. Routing via SCP	C
	Discovery and associated selection delegated to an SCP using discovery and selection parameters in service request; routing via SCP	D

Table E.1-1: Communication models for NF/NF Services interaction summary

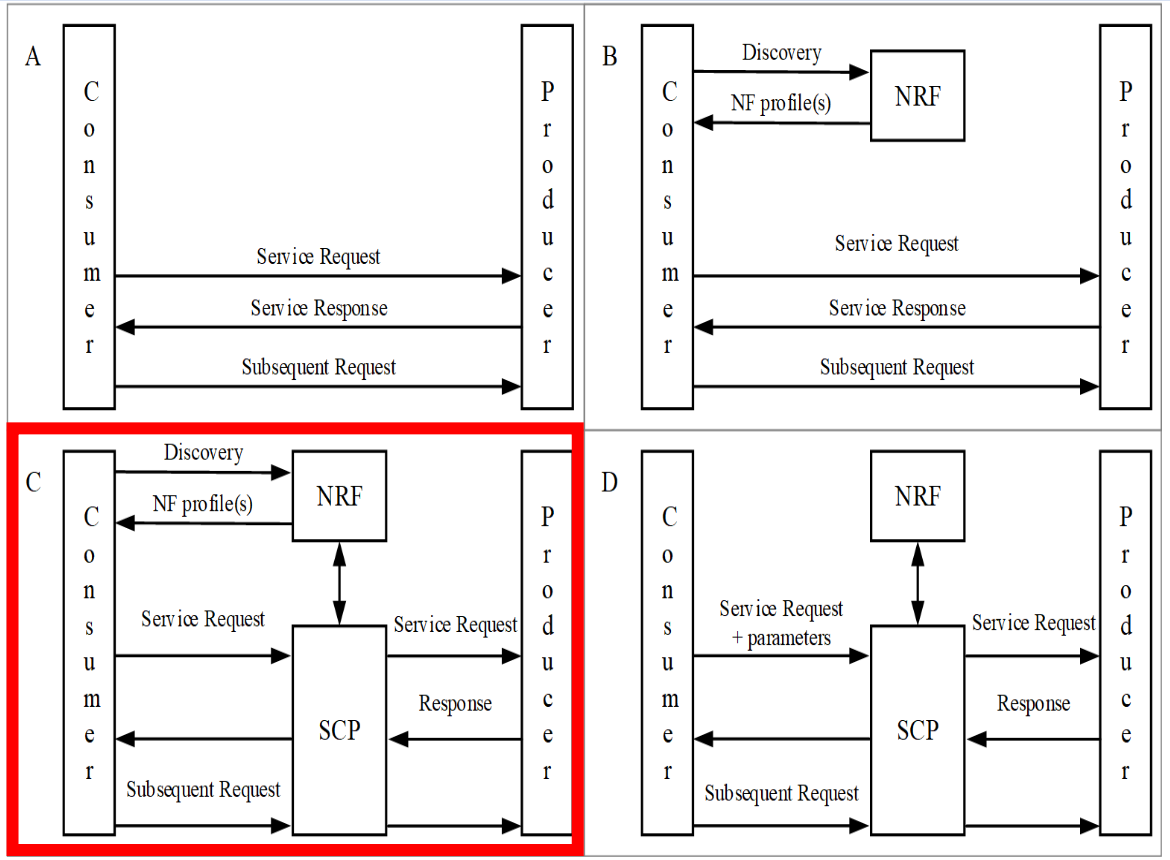


Figure E.1-1: Communication models for NF/NF services interaction

Ref: 3GPP TS 23.501System architecture for the 5G System Annex E Rel.16, Aug 2020: 404 - 405

5G NFs Services as Producer and Consumer

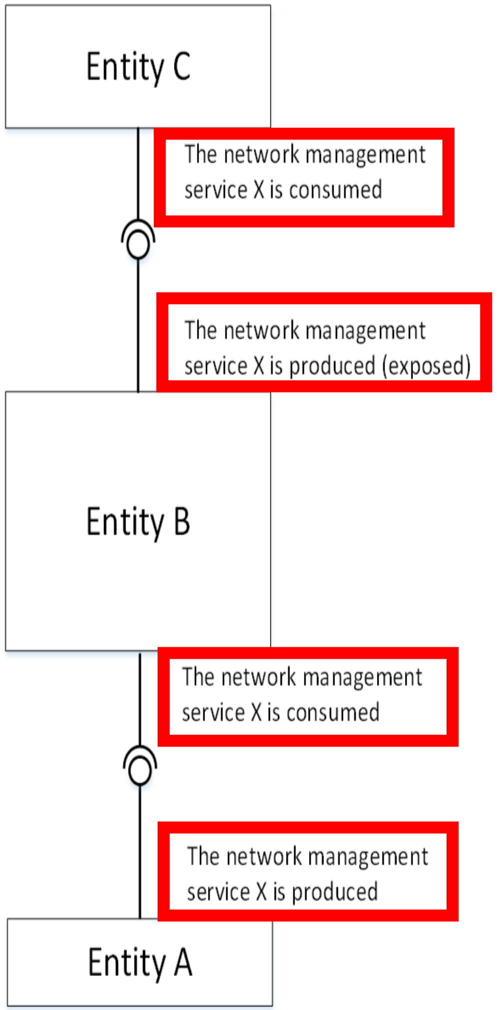


Figure 5.1.1-1. Example of producers and consumers of the management service

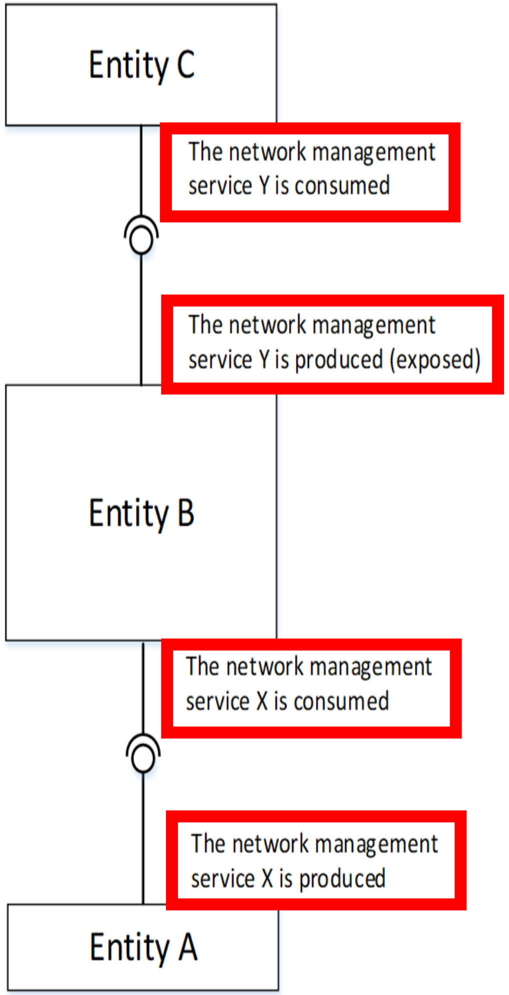


Figure 5.1.1-2. Example of producers and consumers of management services

Ref: 3GPP TR 28.533 Management and orchestration Architecture Framework Rel.16, March 2020: 15

Management Services (MnS)

An Management Service (MnS) offers Capabilities for Management and Orchestration of Network and Service.

The entity producing an MnS is called **MnS Producer.**

The entity consuming an MnS is called **MnS Consumer.**

An MnS provided by an MnS Producer can be consumed by any entity with appropriate Authorisation and Authentication.

An MnS Producer offers its services via a Standardized Service Interface composed of individually specified MnS Components.

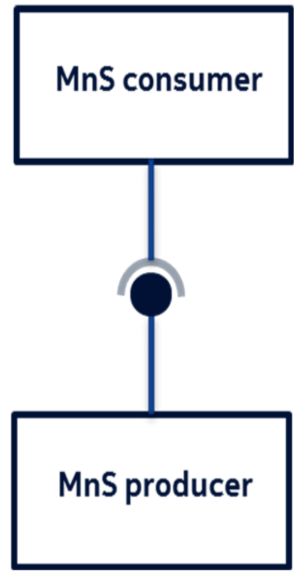


Figure 4.1.1: MnS producer and MnS consumer

Ref: 3GPP TR 28.533 Management and orchestration Architecture Framework Rel.16, March 2020: 8

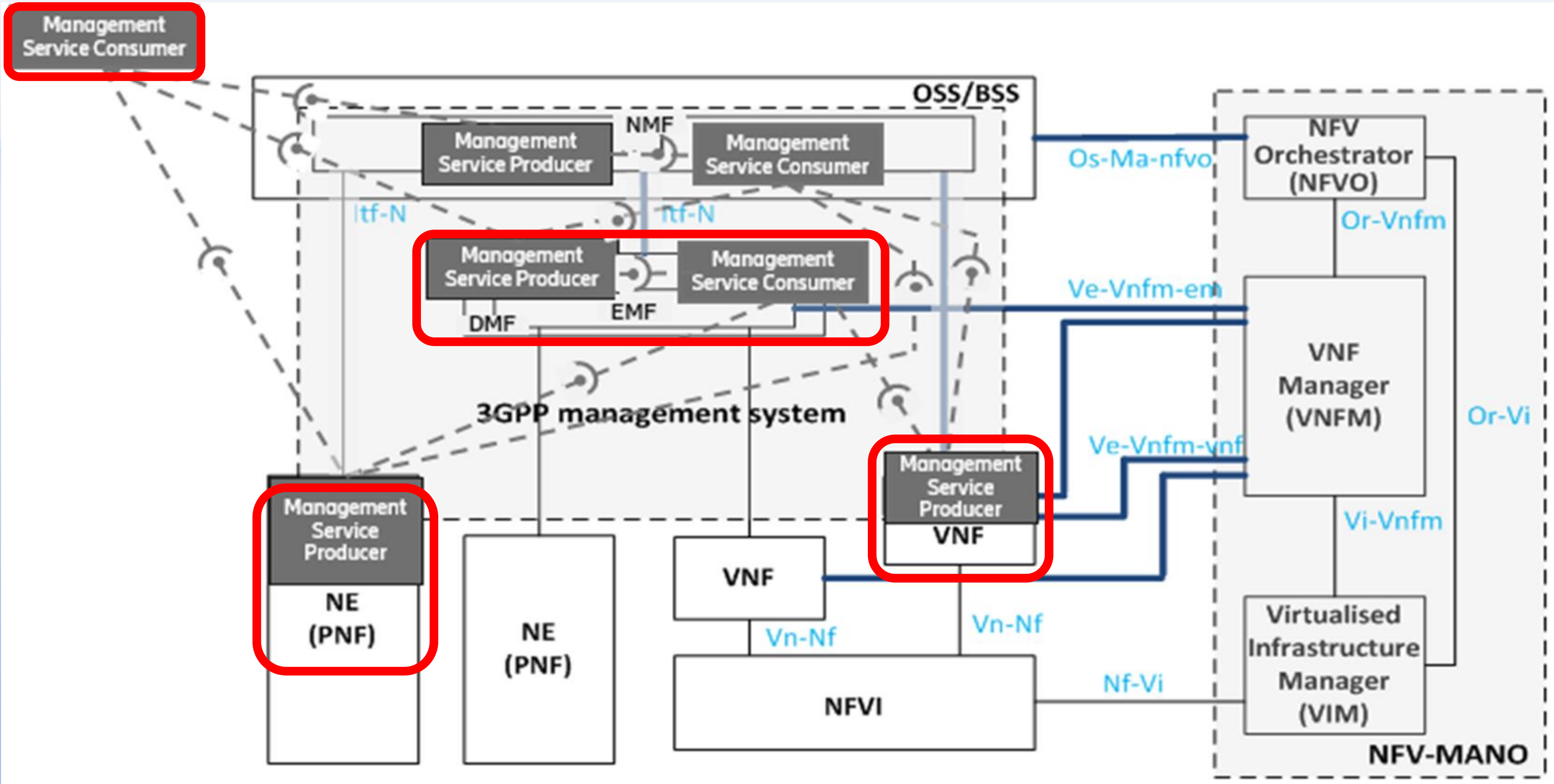


Figure C.1: Example of Management service producer and consumer interaction mapped into the pre-Rel-15 management reference model [10]

Ref: 3GPP TR 28.533 Management and orchestration Architecture Framework Rel.16, March 2020: 29

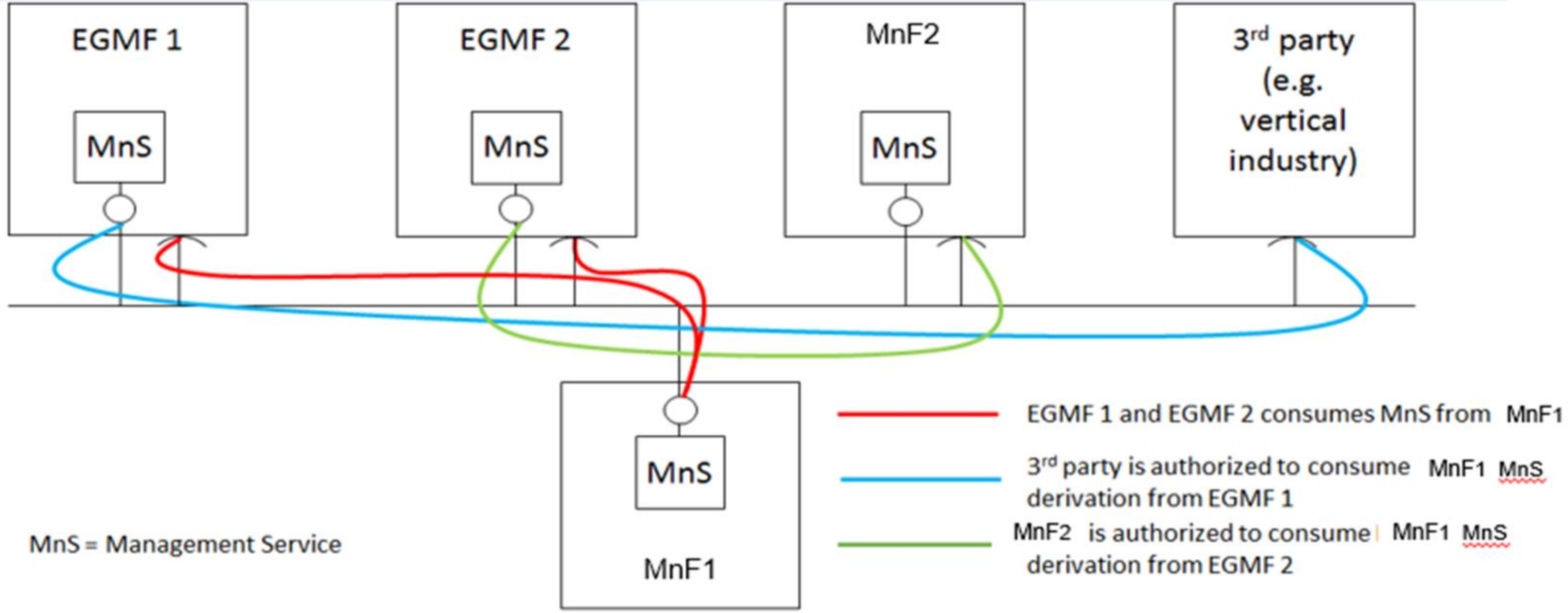


Figure A.3.1: MnF-1 Management Service (MnS) exposed through Exposure Governance Management Function 1 (EGMF 1) and through Exposure Governance Management Function 2 (EGMF 2)

Ref: 3GPP TR 28.533 Management and orchestration Architecture Framework Rel.16, March 2020: 22

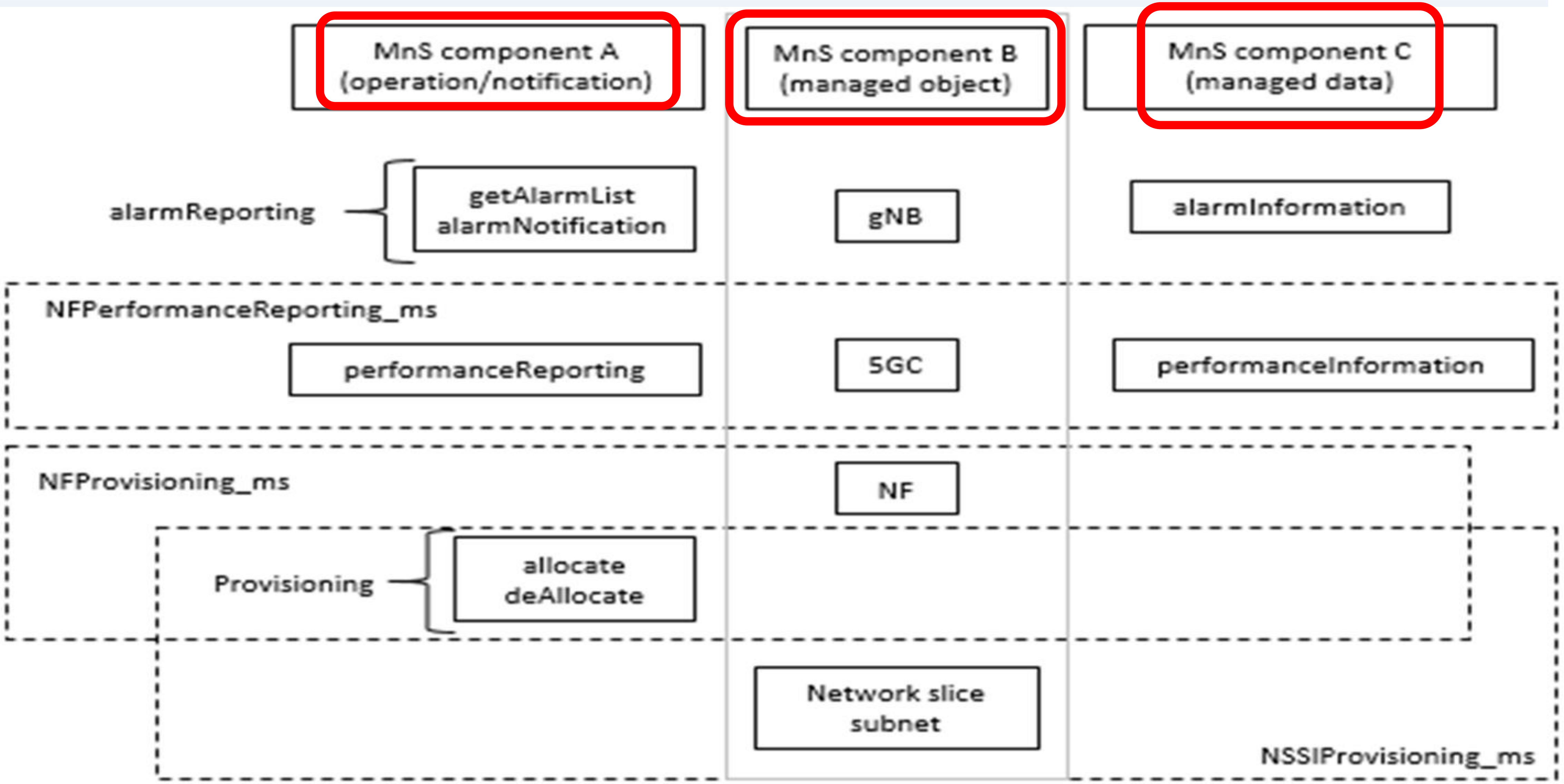


Figure 4.3.1: Example of Management Service and component type A, B and C

Ref: 3GPP TR 28.533 Management and orchestration Architecture Framework Rel.16, March 2020: 10

Intent driven Management Service (Intent driven MnS) concept

Perform Network Management Tasks

Identifying, Formulating and Activating Network Management Policies

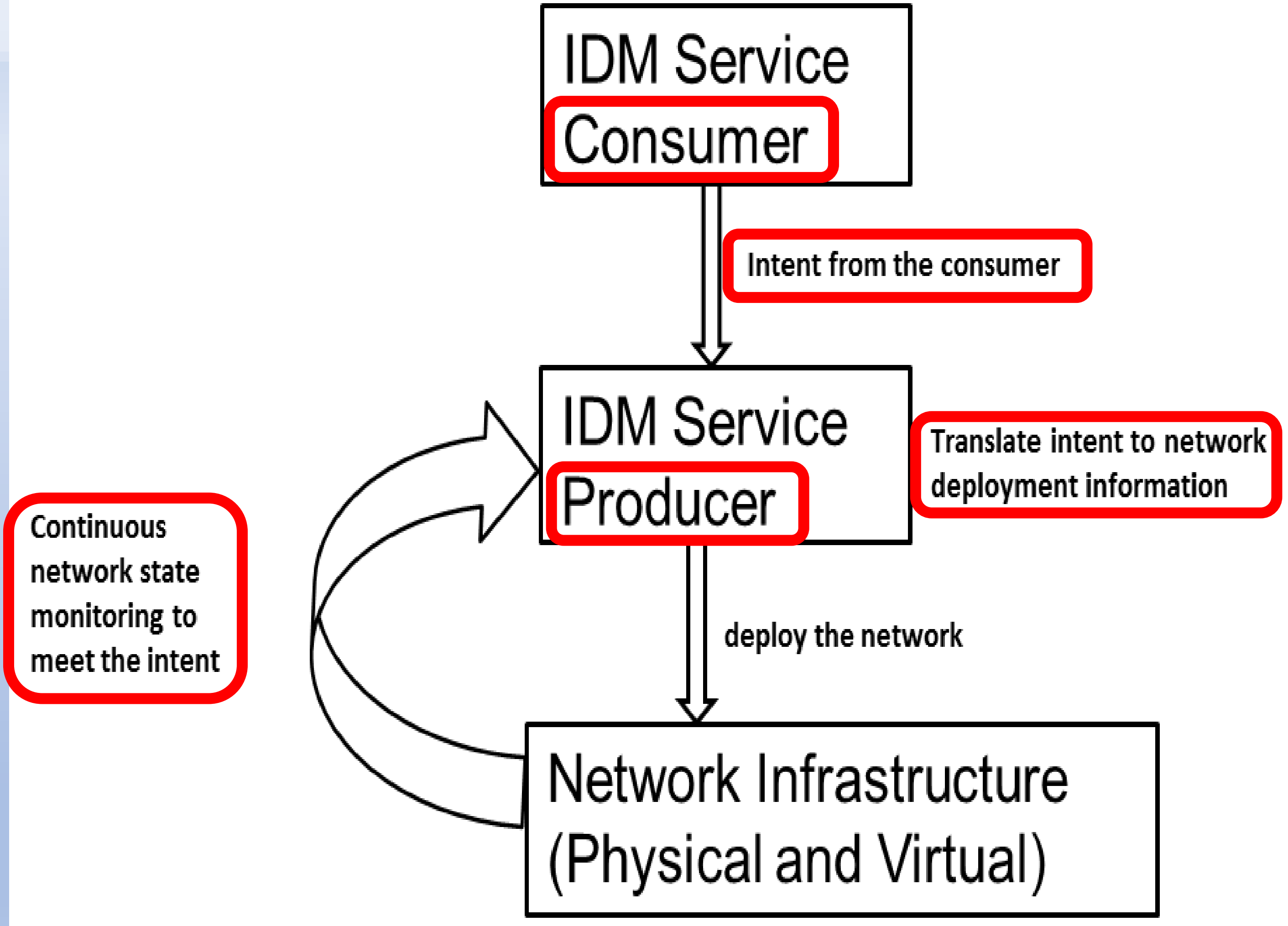


Figure 4.1.2.1-2: An example of using Intent driven management service for network provisioning

Ref: 3GPP TR 28.812 Study on scenarios for Intent driven management services for mobile networks Rel.16: 9-10

- Intent from Communication Service Provider (Intent-CSP)
- Intent from Network Operator (Intent-NOP)

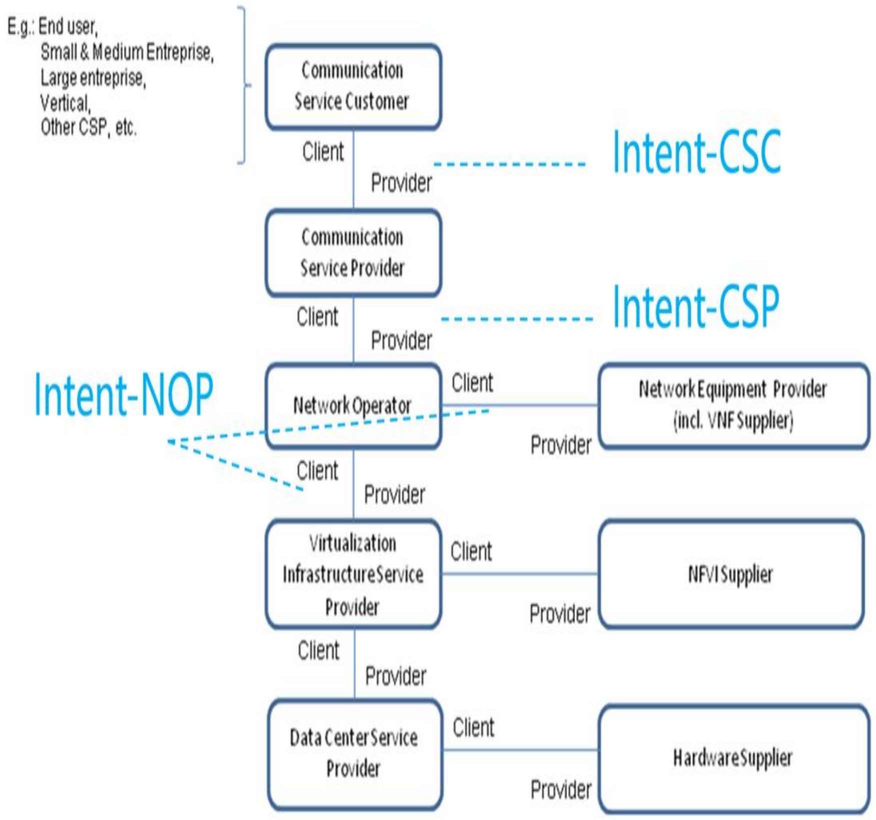


Figure 4.1.2.4-1: Concept for utilization of intent

4.1.2.5 Intent driven Management Service (MnS) interactions with 3GPP management functions

The following figure shows the interaction of intent driven management service (MnS) with management functions.

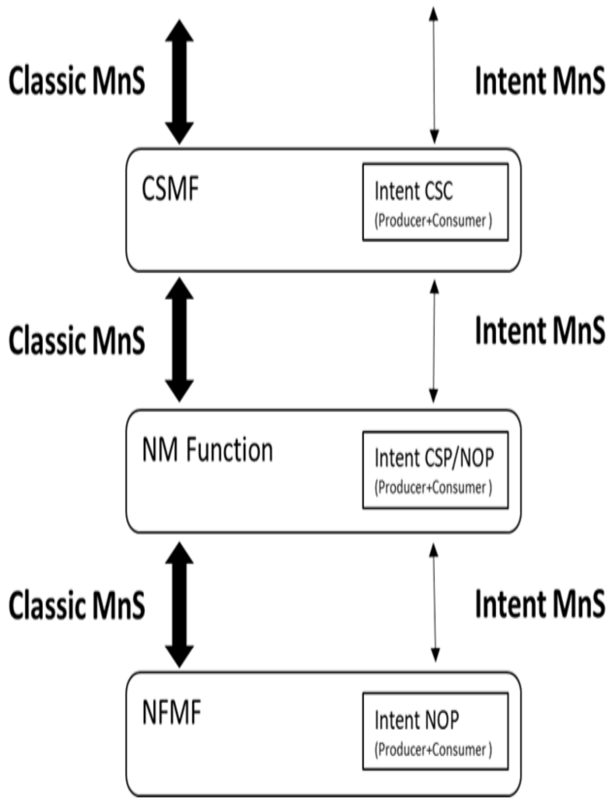


Figure 4.1.2.5.1: The intent driven management service (MnS) vs classic MnS

Ref: 3GPP TR 28.812 Study on scenarios for Intent driven management services for mobile networks Rel.16: 11-12

1. "5G Network Mobility at "Cell" & "Cloud" Edge - NGMN WP Feb 2015 - 8

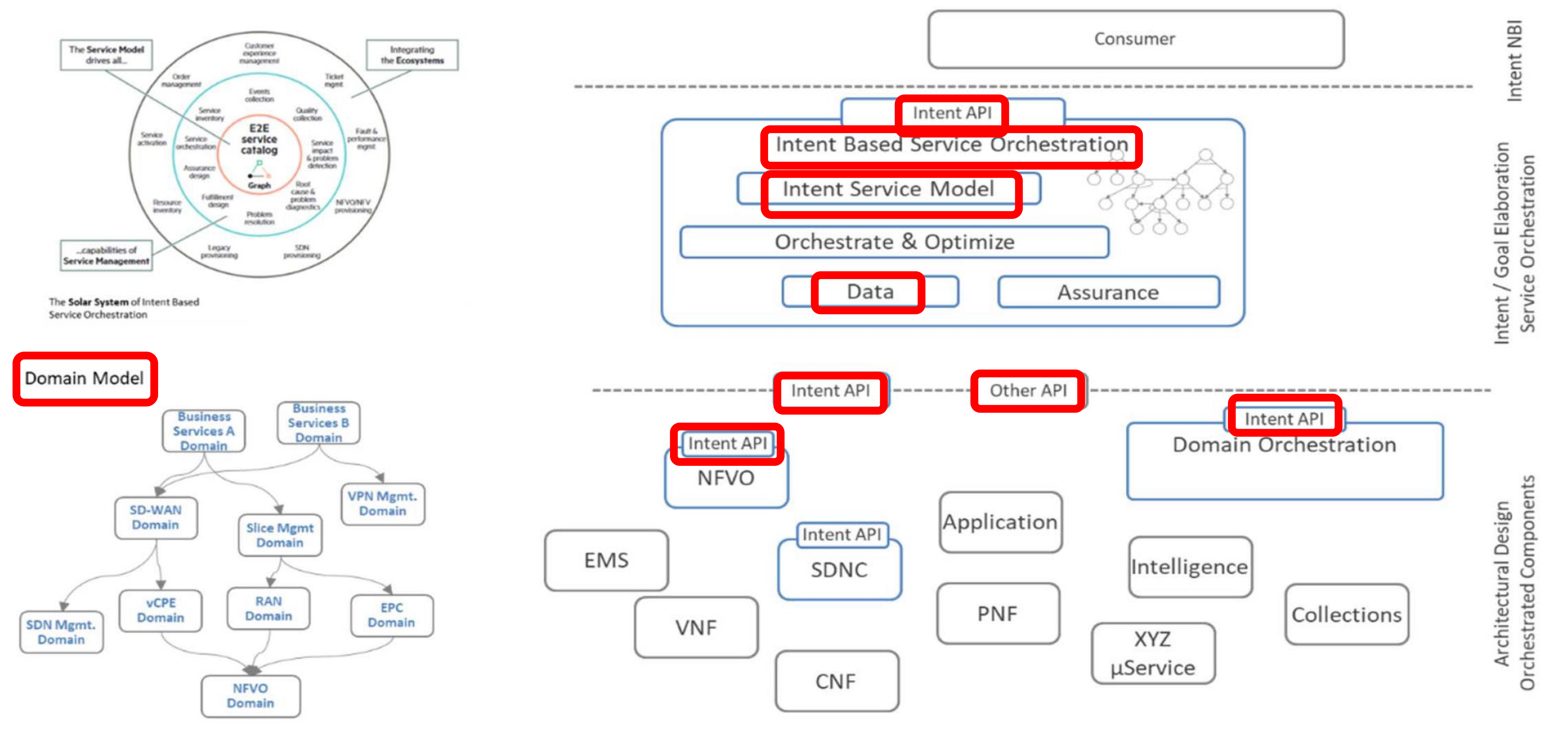


Figure 10: Intent-based Service Orchestration across Domains, driven by Intent-based Service Models

Ref: ETSI ZSM GR 005 Means of Automation May 2020: 26

Interface 1: NWDAF interacts with AF (via NEF) using NW layer SBI.

Interface 2: N1/N2 interface.

Interface 3: O&M layer configures the NF profile in the NRF, and NWDAF collect the NF capacity information from the NRF.

Interface 4: MDAF interacts with Application/Tenant using Northbound Interfaces (NBI).

Interface 5: MDAF interacts with RAN DAF using O&M layer SBI.

Interface 6: NWDAF consumes the services provided by MDAF using cross layer SBI.

Interface 7: MDAF consumes the services provided by MWDAF using cross layer SBI.

Interface 8: MDAF collects data from NW layer via trace file/monitoring services.

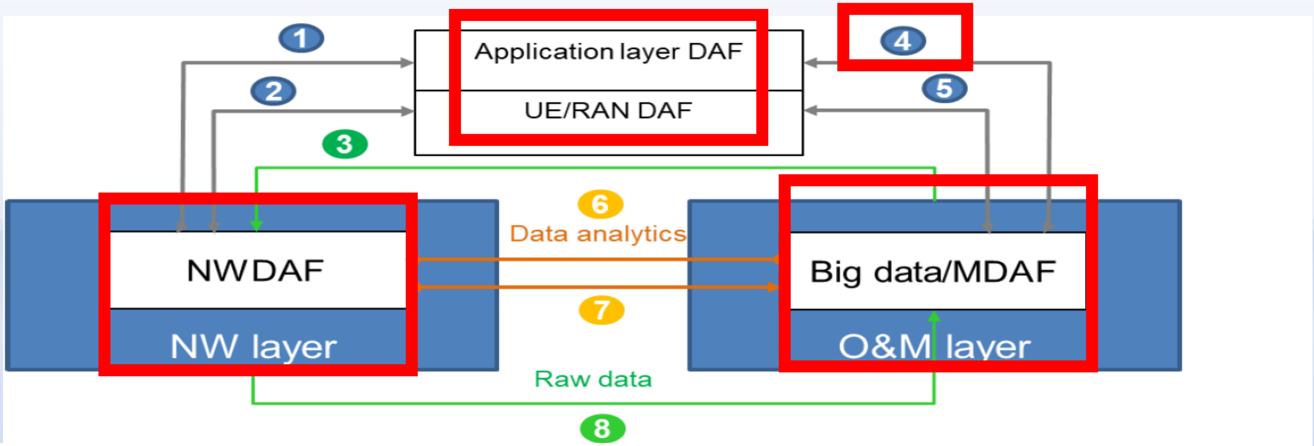


Figure 4-3: Data Analytics framework in 5G Mobile Network Architecture

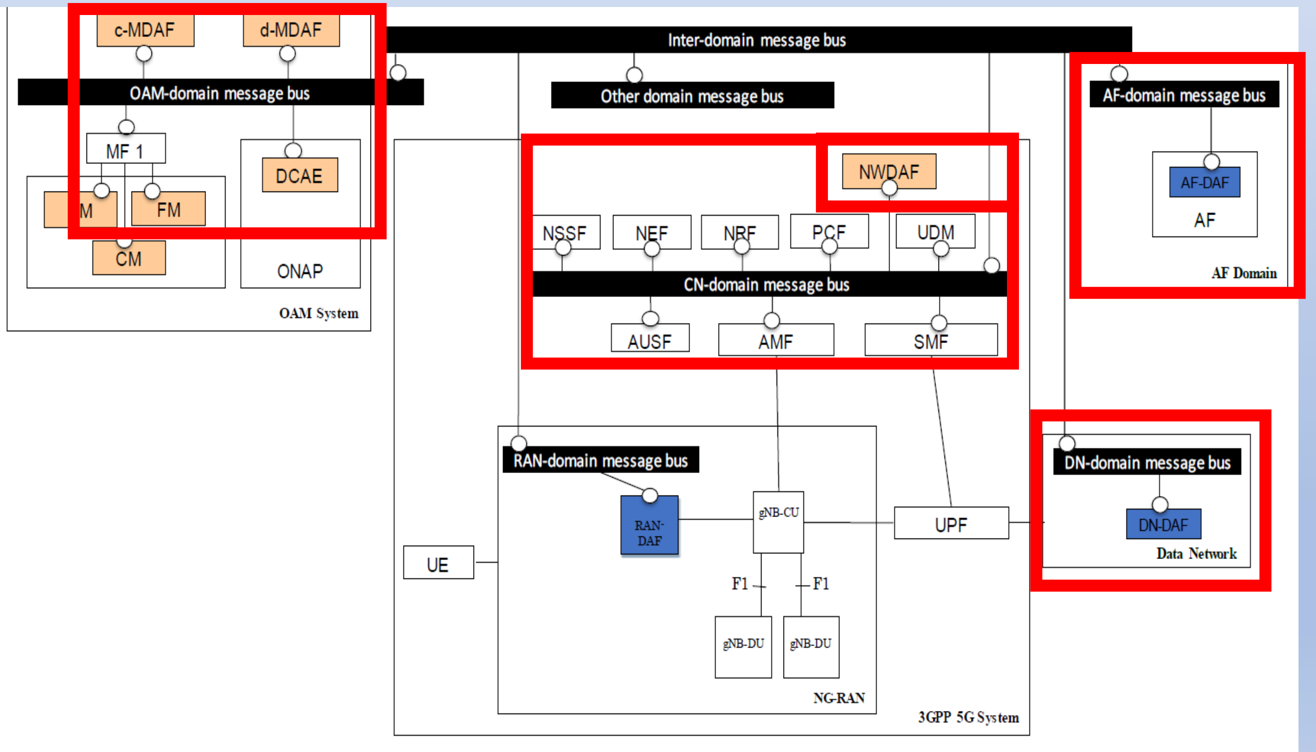


Figure 4-4 5G Mobile Network Architecture Integrated Analytics Architecture

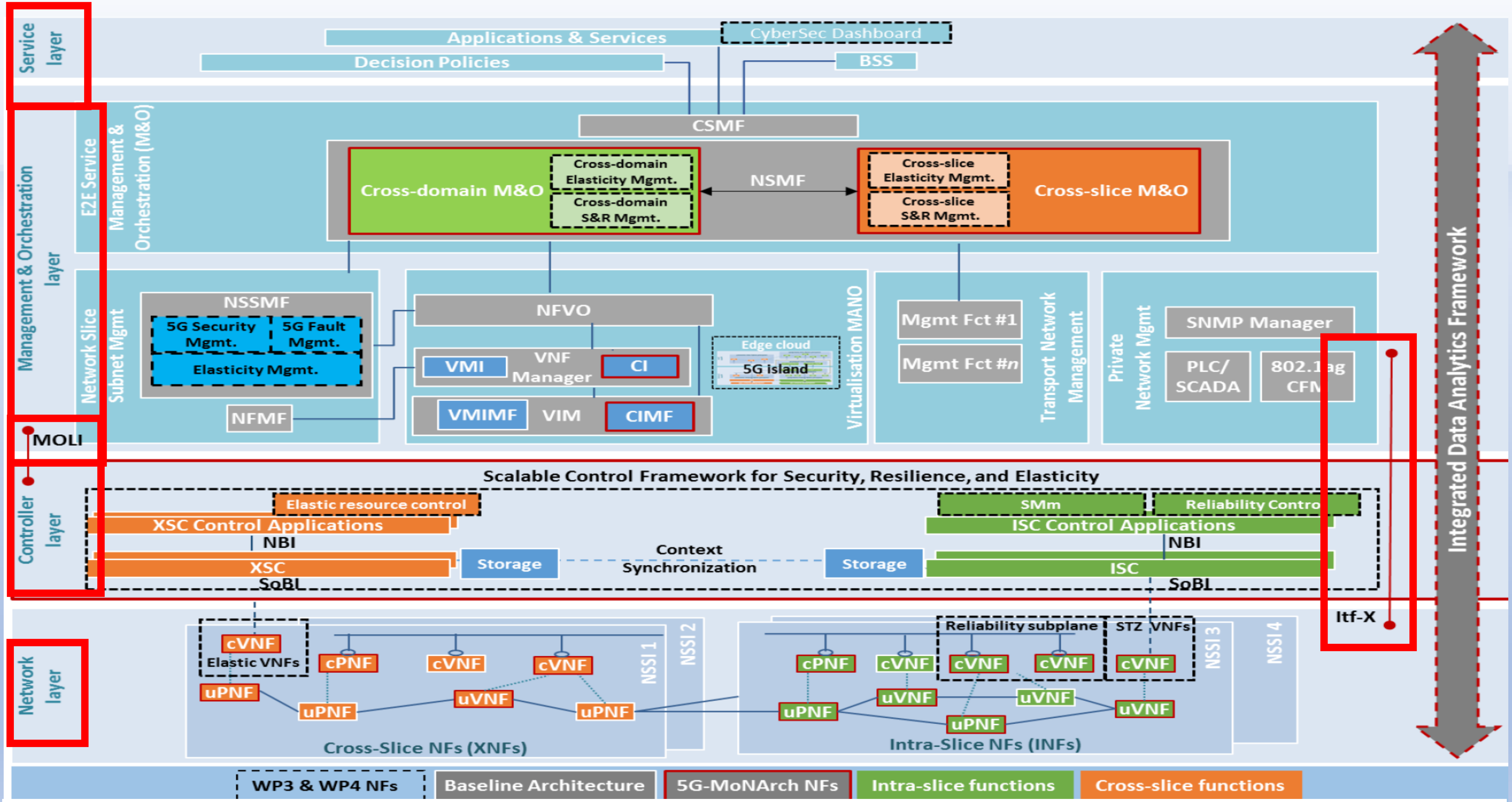


Figure 2-2: 5G Mobile Network overall Architecture

Ref 5G PPP Mobile Network Architecture MoNArch D 2.3 April 2019: 18

2. 5G NDL - Network Data Layer - separation of the 5G "Compute" from "Storage" via 5G UDM in NFs implementation into VNFs & PNFs related

(NF) Application **Context (Unstructured Data in UDSF)**

from

(NF) Application **Business Logic** (**Structured Data in UDR)**

Communication between consumer and producer	Service discovery and request routing	Communication model
Direct communication	No NRF or SCP; direct routing	A
	Discovery using NRF services; no SCP; direct routing	B
Indirect communication	Discovery using NRF services; selection for specific instance from the Set can be delegated to SCP. Routing via SCP	C
	Discovery and associated selection delegated to an SCP using discovery and selection parameters in service request; routing via SCP	D

Table E.1-1: Communication models for NF/NF Services interaction summary

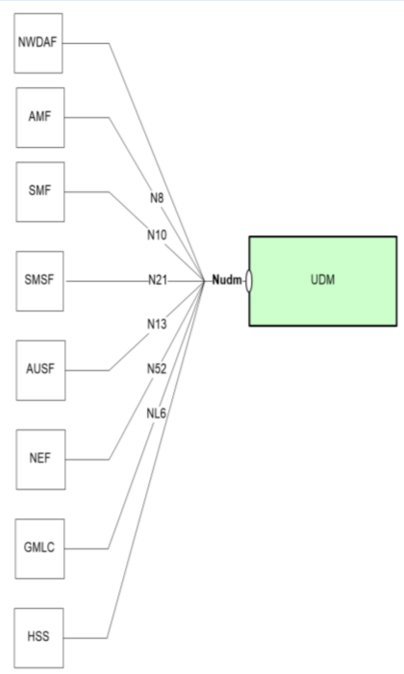


Figure 4.1-1: Reference model – UDM

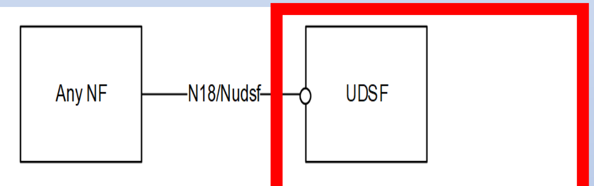


Figure 4.2.5-1: Data storage architecture for unstructured data from any NF

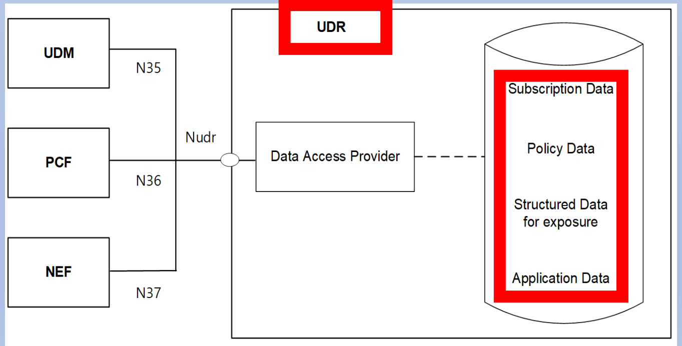


Figure 4.2.5-2: Data storage architecture

Ref 5G PPP Mobile Network Architecture MoNArch D 2.3 April 2019: 18

5G Guidelines & Principles for Compute - Storage Separation

Data Storage Architectures

As depicted in Figure 4.2.5-1, the 5G System Architecture allows any NF to store and retrieve its **Unstructured Data into/from a UDSF (e.g. UE Contexts**).

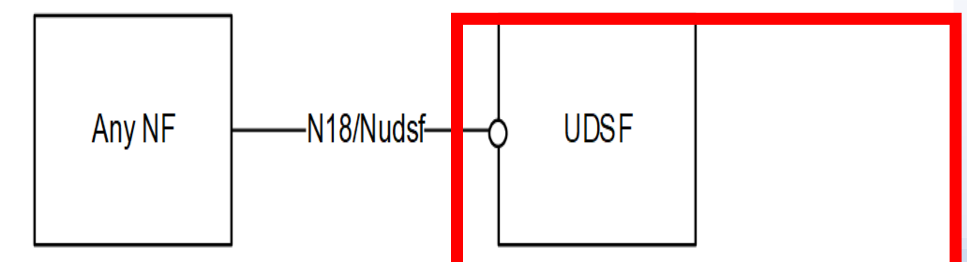


Figure 4.2.5-1: Data storage architecture for unstructured data from any NF

As depicted in Figure 4.2.5-2, the 5G System Architecture allows the **UDM, PCF and NEF** to store data in the **UDR** (Fig. 4.2.5-2), including **Subscription Data and Policy Data** by UDM and PCF, **Structured Data for Exposure and Application Data** (including Packet Flow Descriptions (PFDs) for Application Detection, AF request information for multiple UEs) by the NEF.

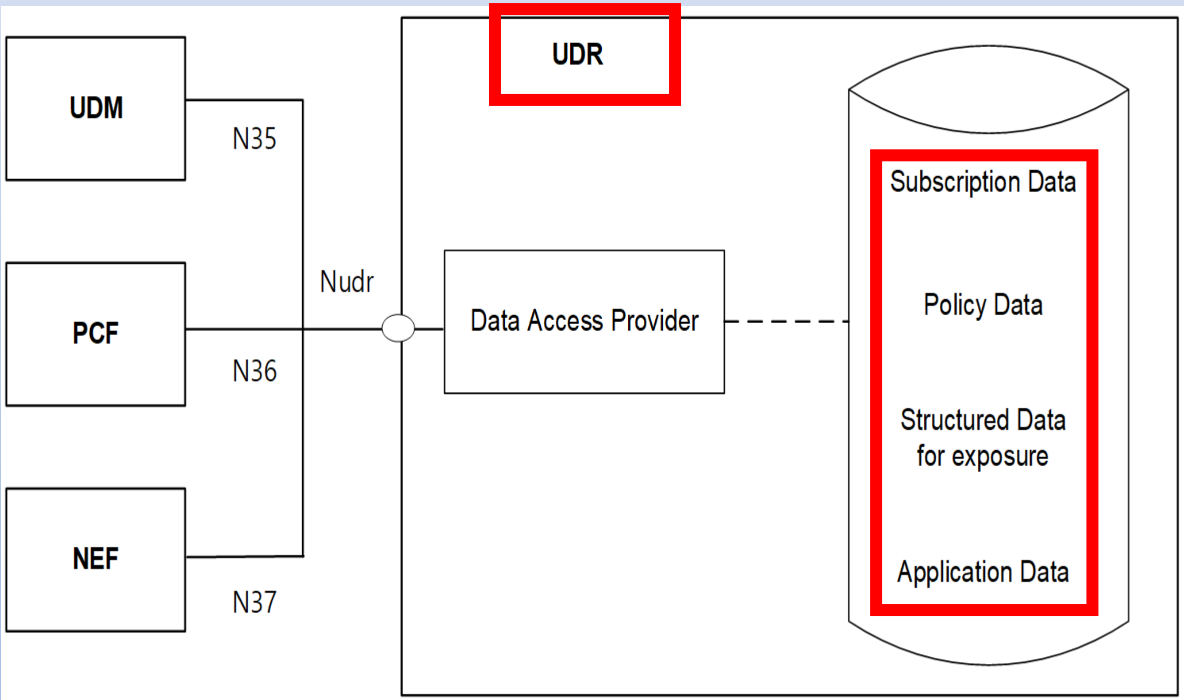


Figure 4.2.5-2: Data storage architecture

3GPP TS 23.501 System Architect for 5G System Rel 16 Aug 2020: 38

Stateless NFs (for any 5GC NF type)

An NF may become Stateless by Storing its Contexts as Unstructured Data in the UDSF.

An UDM, PCF and NEF may also Store own Structured Data in the UDR.

An UDR and UDSF cannot become stateless.

An NF may also be deployed such that several stateless network function instances are present within a set of NF instances. Additionally, within an NF, an NF service may have multiple instances grouped into a NF Service Set if they are interchangeable with each other because they share the same context data. See clause 5.21 of 3GPP TS 23.501 [3].

A UDM / AUSF / UDR / PCF group may consist of one or multiple UDM / AUSF / UDR / PCF sets.

6.5.3 Stateless NFs (for any 5GC NF type)

6.5.3.1 General

An NF may become stateless by storing its contexts as unstructured data in the UDSF.An UDM, PCF and NEF may also store own structured data in the UDR. An UDR and UDSF cannot become stateless.

An NF may also be deployed such that several stateless network function instances are present within a set of NF instances. Additionally, within an NF, an NF service may have multiple instances grouped into a NF Service Set if they are interchangeable with each other because they share the same context data. See clause 5.21 of 3GPP TS 23.501 [3].

A UDM / AUSF / UDR / PCF group may consist of one or multiple UDM / AUSF / UDR / PCF sets.

6.5.3.2 Stateless NF as service consumer

1. When the NF service consumer subscribes (explicitly or implicitly) to notifications from another NF service producer, the NF service consumer may provide a binding indication to the NF service producer as specified in clause 6.3.1.0 of 3GPP TS 23.501 [3] and clause 4.17.12.4 of 3GPP TS 23.502 [4], to enable the related notifications to be sent to an alternative NF service consumer within the NF (service) set, in addition to providing the Callback URI in the subscription resource.
2. A NF service producer or SCP may use the Nnrf_NFDiscovery service to discover NF service consumers within an NF (service) set.
3. An NF service producer may become aware of a NF service consumer change, via receiving an updated binding information (i.e. when the binding entity corresponding to the binding level is changed), or via an Error response to a notification, via link level failures (e.g. no response from the NF), or via a notification from the NRF that the NF service consumer has deregistered. The HTTP error response may be a 3xx redirect response pointing to a new NF service consumer.

NOTE: When the binding entity other than the one corresponding to the binding level is changed, it indicates the

UDSF Services

The following table illustrates the UDSF Services.

Nudsf_UnstructuredDataManagement Service

Description: NF Service Consumer intends to query data from UDSF.

Inputs, Required: Data Identifier.

Data Identifier uniquely identifies the Data to be retrieved from the UDSF

Inputs, Optional: None.

Outputs, Required: Requested data.

Table 5.2.14-1: NF Services provided by UDSF

NF service	Service Operations	Operation Semantics	Example Consumer(s)
Unstructured Data Management	Query	Request/Response	Any NF
	Create	Request/Response	Any NF
	Delete	Request/Response	Any NF
	Update	Request/Response	Any NF

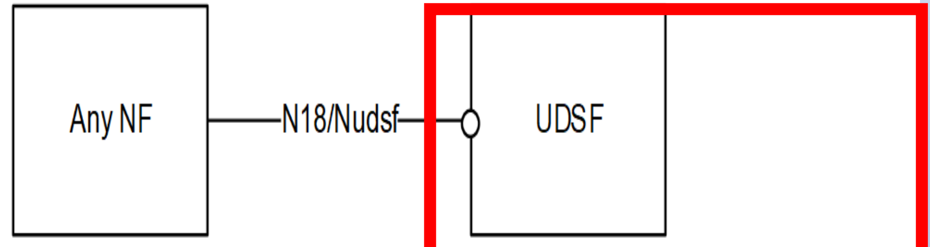


Figure 4.2.5-1: Data storage architecture for unstructured data from any NF

Context Definition

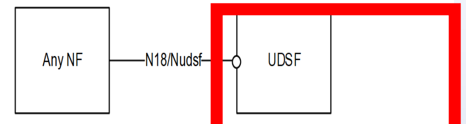


Figure 4.2.5-1: Data storage architecture for unstructured data from any NF

One of the most popular definitions of context is: **"Context** is any information that can be used to **characterize the situation of an entity**.

An "Entity" is a Person, Place, or Object that is considered relevant to the interaction between a user and an application, including the user and application themselves" .

The updated definition of Context is:

*"The Context of an Entity is a **Collection of Measured and Inferred Knowledge that describe the State and Environment in which an Entity exists or has existed".***

This definition emphasizes two (2) Types of Knowledge

1. Facts (which can be measured) and
2. *Inferred* Data, which results from ML & Reasoning Processes applied to Past & Current Context.

It also includes Context History, so that current decisions based on Context may benefit from past decisions, as well as Observation of How the Environment has changed.

3GPP TS 23.502 Procedures for 5GS System Rel 16 Aug 2020: 541 - 542

5G System Architecture - Access Traffic Steering, Switch and Splitting (ATSSS)

The ATSSS feature enables a Multi-Access (MA) PDU Connectivity Service, which can exchange PDUs between the UE and a Data Network (DN) by simultaneously using one (1) 3GPP Access Network and one (1) non-3GPP Access Network and two (2) independent N3/N9 tunnels between the PSA and RAN/AN.

The Multi-Access PDU Connectivity Service is realized by establishing a Multi-Access PDU (MA PDU) Session, i. e. **a PDU Session that may have User-Plane (UP) Resources on two(2) Access Networks (ANs).**

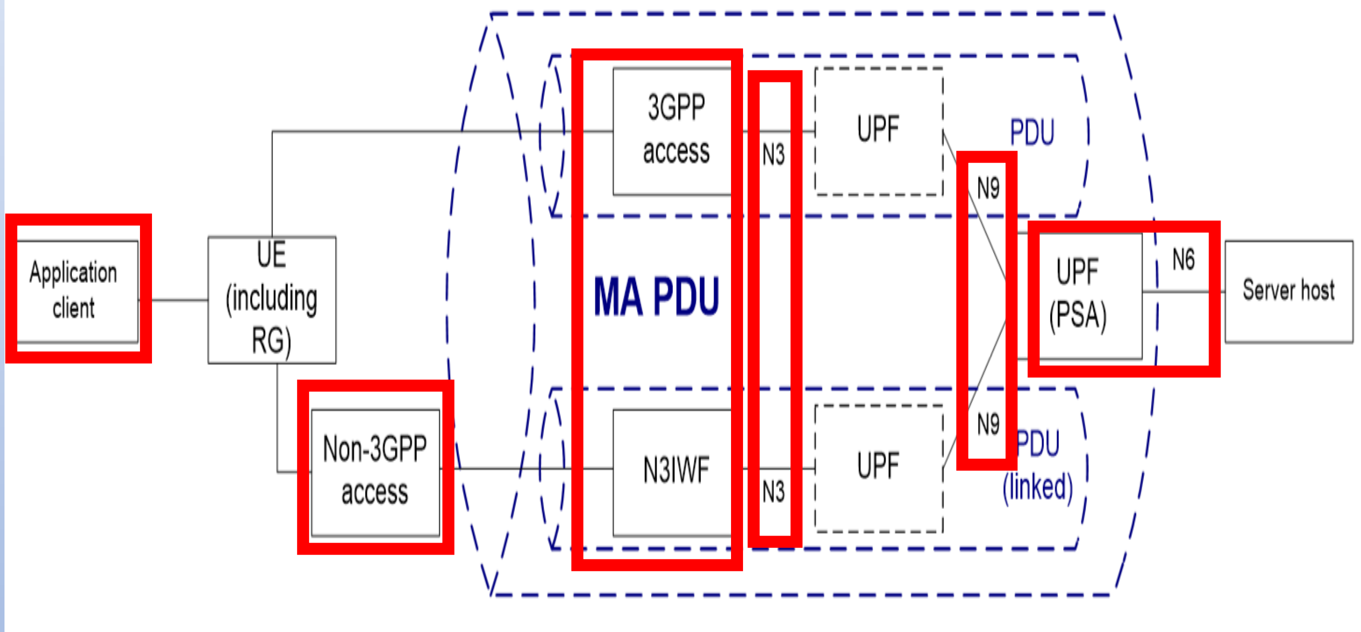


Figure 1: MA PDU session

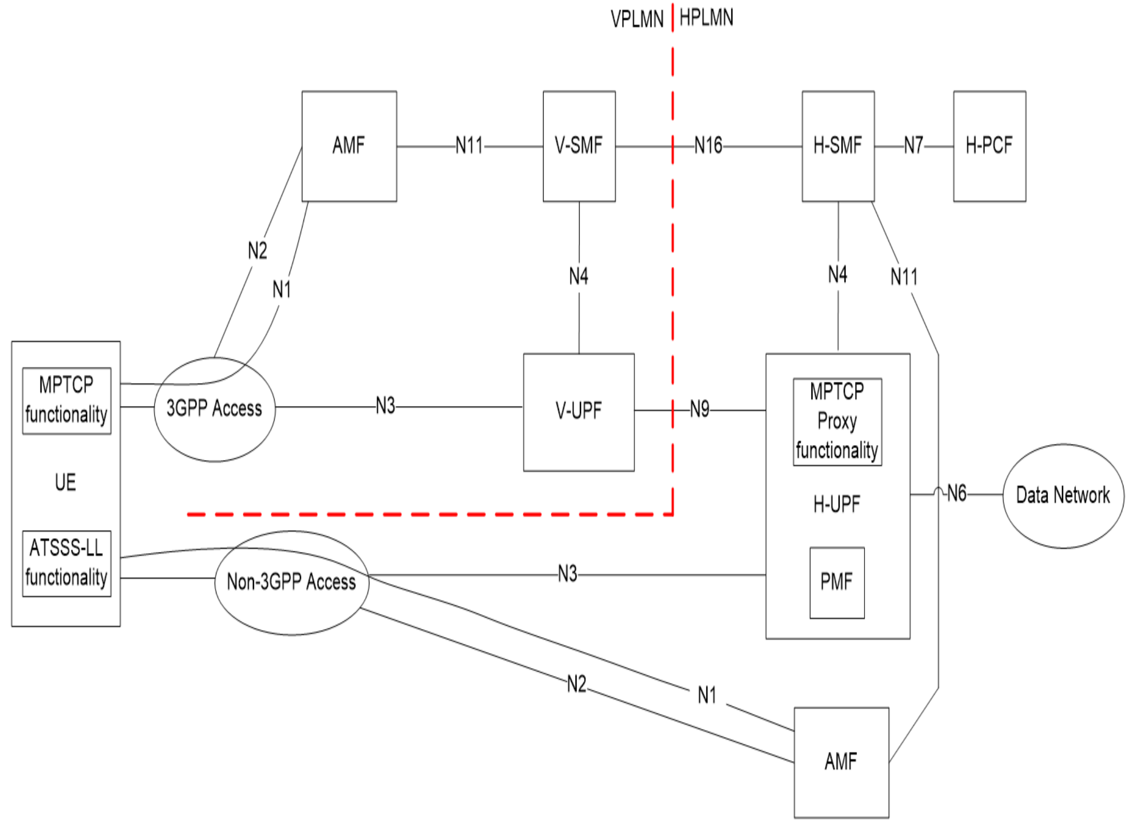


Figure 4.2.10-3: Roaming with Home-routed architecture for ATSSS support (UE registered to different PLMNs)

Ref 3GPP TR 21 916 Rel 16 Description. Summary of Rel 16 Work items Sep 2020:31, 33

3GPP 5G Network and Wi-Fi Network Communication Availability and Reliability

Relation of Communication Service: **Availability and Reliability**

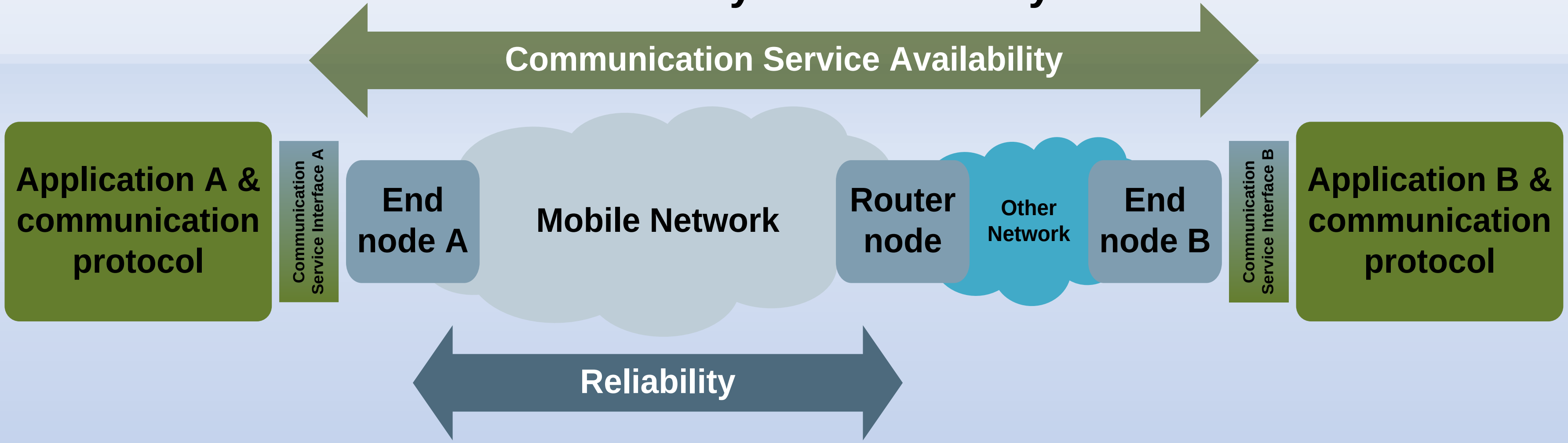


Figure C-4: Example in which communication Service Availability & Reliability have different values.

Packets are delivered over a daisy chain of a Mobile Network and another Network (e.g. IEEE 802.11n based).

Reliability is evaluated for the Mobile Network only,
Availability depends on the performance of both Networks.

Communication Service **Availability** - measured between the two (2) Communication Service Interfaces,
Reliability - measured between End Node A and the Router Node.

This has implications for, e.g. the maximum communication latency allowed for each network. In case the agreed end-to-end latency between the service interfaces is, for instance, 100 ms, and the 802.11n network has a latency of 30 ms, the maximum allowable latency for packages in the mobile network is 70 ms (NOTE). So, if the latency in the mobile network exceeds 70 ms, the communication service availability is 0%, despite the agreed QoS stipulating a larger end-to-end latency, i.e. 100ms.

NOTE: The transit time through the router node is not considered here. It is assumed to be very small and much less than 100 ms.

Service Subscriptions related to Latency in Standardized and Private Slice Types

Network Slice Providers can build their Network Slice Product offering based on S-NESTs (Standardized Network Slice Type) and/or their P-NESTs (**Private NESTs).**

Standardized Network Slice Type (S-NEST) NST-A, for which the attribute Packet Delay Budget Value Range is between **1 ms and 100 ms, is specified by 3GPP.**

Network Slice Provider **(NSP)** may offer 3 products based on **NST-A**:

- **Platinum NST-A** based Network Slice Product, where the attribute ‘ **Packet Delay Budget’ Value Range is between 1 ms and 10 ms**

- **Gold NST-A** based Network Slice Product, where the attribute **Packet Delay Budget’ Value Range is between 11 ms and 50 ms**

- **Silver NST-A** based Network Slice Product, where the attribute **Packet Delay Budget’ Value Range is between 51 ms and 100 ms.**

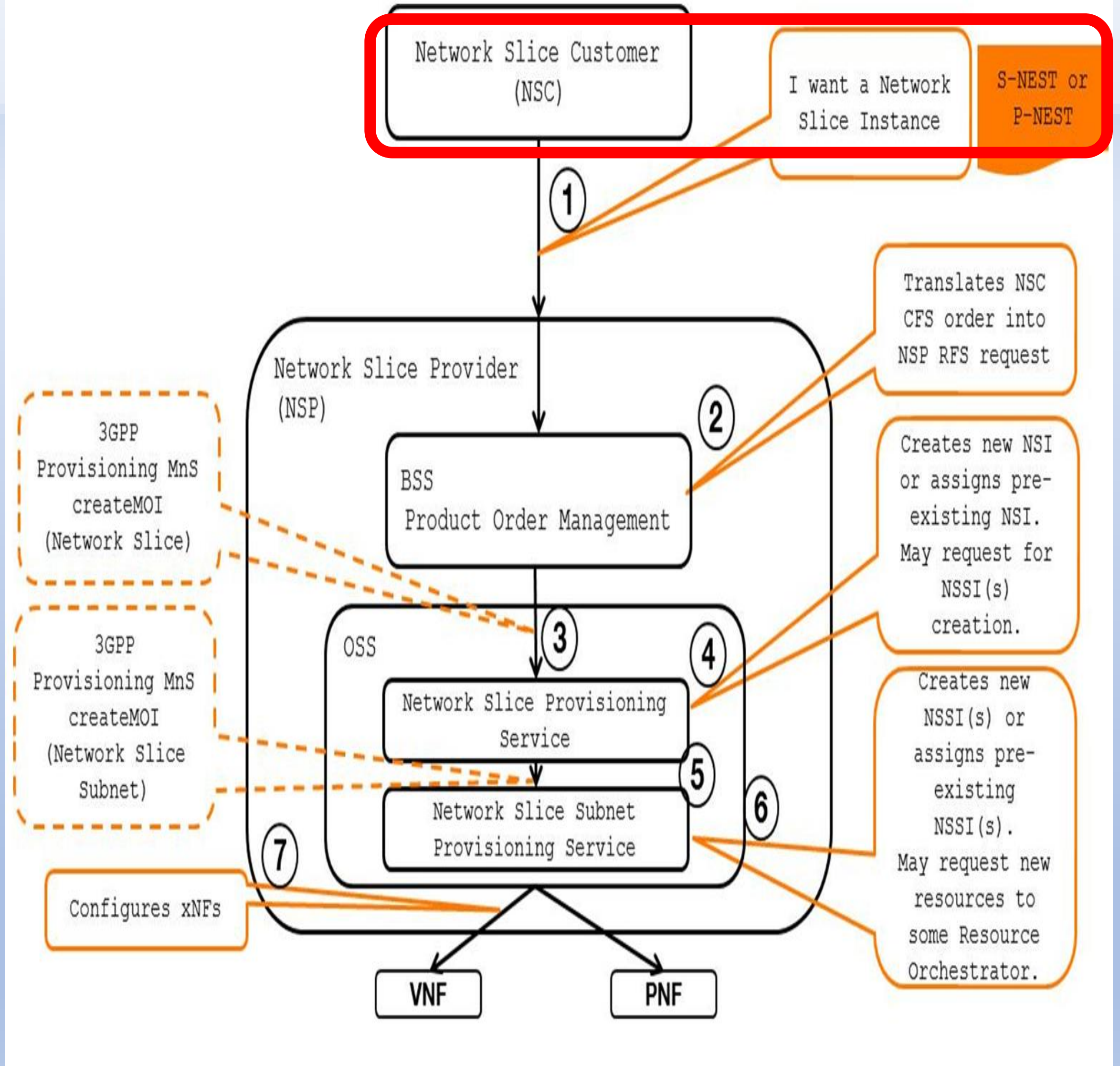


Figure A.2: Network Slice journey (NSaaS model) – high-level call flow

Ref 3GPP TS 28.531 Slicing Mngmnt & Orchestr, Rel 16 Dec 2020: 67 - 68

3GPP 5G NAPS -Northbound Application Program Interfaces (APIs) - 1

5G NAPS Reference model

The NEF Northbound Interface resides between the NEF and the AF.

It specifies RESTful APIs that allow the AF to access the Services and Capabilities provided by 3GPP Network Entities and securely exposed by the NEF.

An AF can get services from multiple NEFs, and an NEF can provide services to multiple AFs.

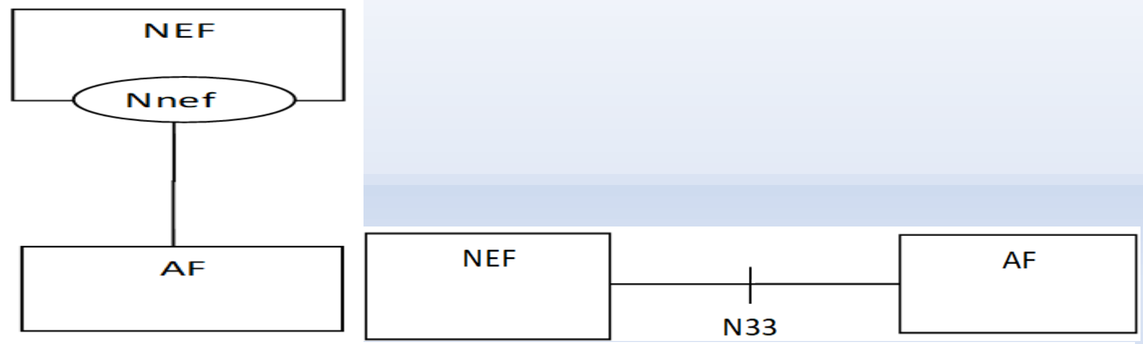


Fig. Reference Architecture for the Nnef Service SBI & Reference Point representation

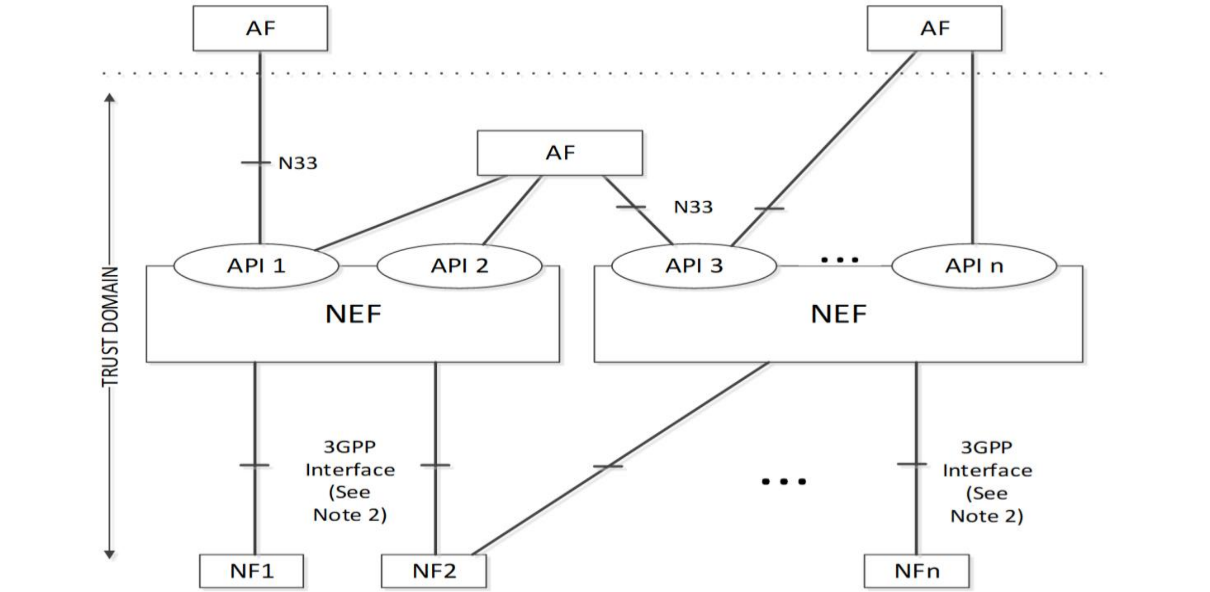


Fig. Network Exposure Function NEF in Reference Point Representation Non-roaming Architecture

3GPP TS 29. 522 The 5G NEF NAPS Dec 2020: 14 - 16 & TS 23.501 Aug 2020: 33

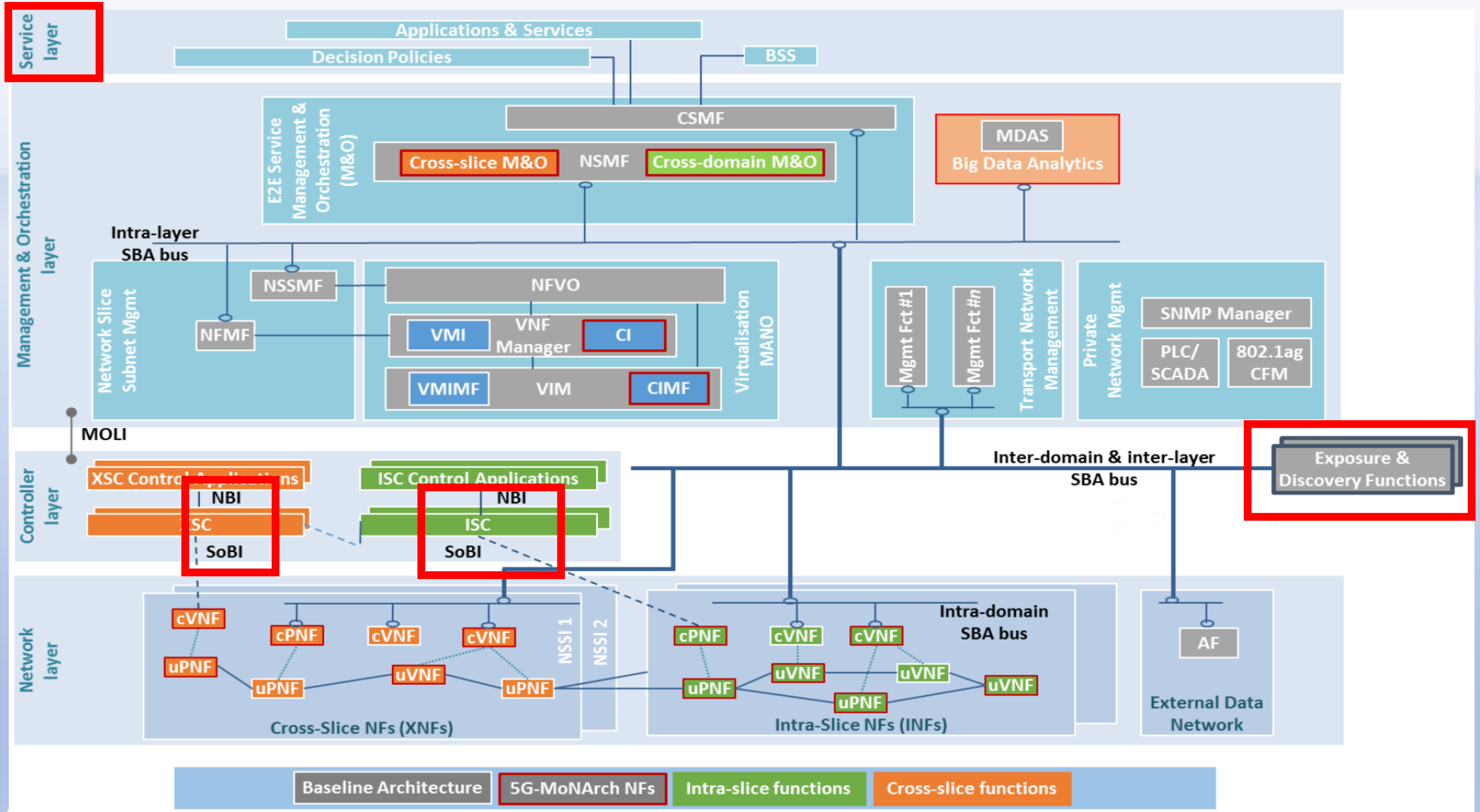
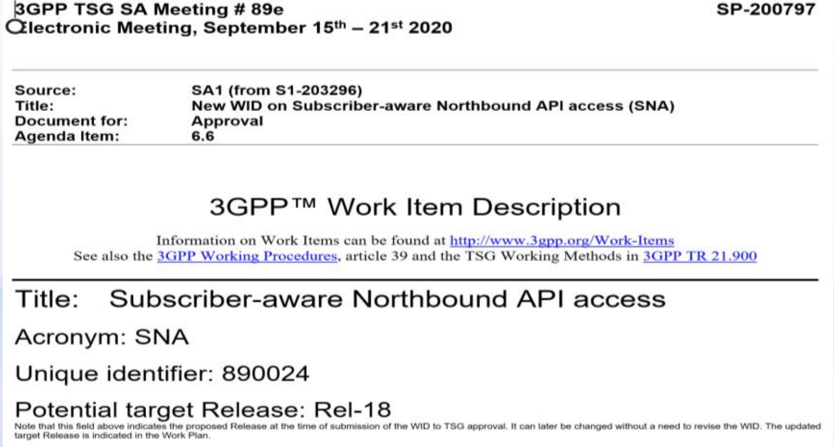


Figure 2-3: Service-based Representation of 5G Mobile Network overall Architecture

Ref 5G PPP Mobile Network Architecture MoNArch D 2.3 April 2019:20

3GPP 5G Rel. 18 SNA - SEES and FMSS NAPS to 5G Subscriber -2

"The Operator shall be able to provide to a 3rd Party Service Provider secure and chargeable access to the Exposed Services/Capabilities i.e. to Authenticate, Authorize and Charge the 3rd Party entities."


3GPP TSG SA Meeting # 89e SP-200797
Electronic Meeting, September 15th – 21st 2020

Source: SA1 (from S1-203296)
Title: New WID on Subscriber-aware Northbound API access (SNA)
Document for: Approval
Agenda Item: 6.6

3GPP™ Work Item Description

Information on Work Items can be found at http://www.3gpp.org/Work-Items
See also the 3GPP Working Procedures, article 39 and the TSG Working Methods in 3GPP TR 21.900

Title: Subscriber-aware Northbound API access
Acronym: SNA
Unique identifier: 890024
Potential target Release: Rel-18

Note that this field above indicates the proposed Release at the time of submission of the WID to TSG approval. It can later be changed without a need to revise the WID. The updated target Release is indicated in the Work Plan.

MNO can allow the API access of an 3rd Party entity by taking into account the 5GS Subscriber-based check.

Possibility of utilizing those APIs can be open directly to the 5GS subscriber. MNOs need to be cautious of securing its 5GS Subscribers' Privacy.

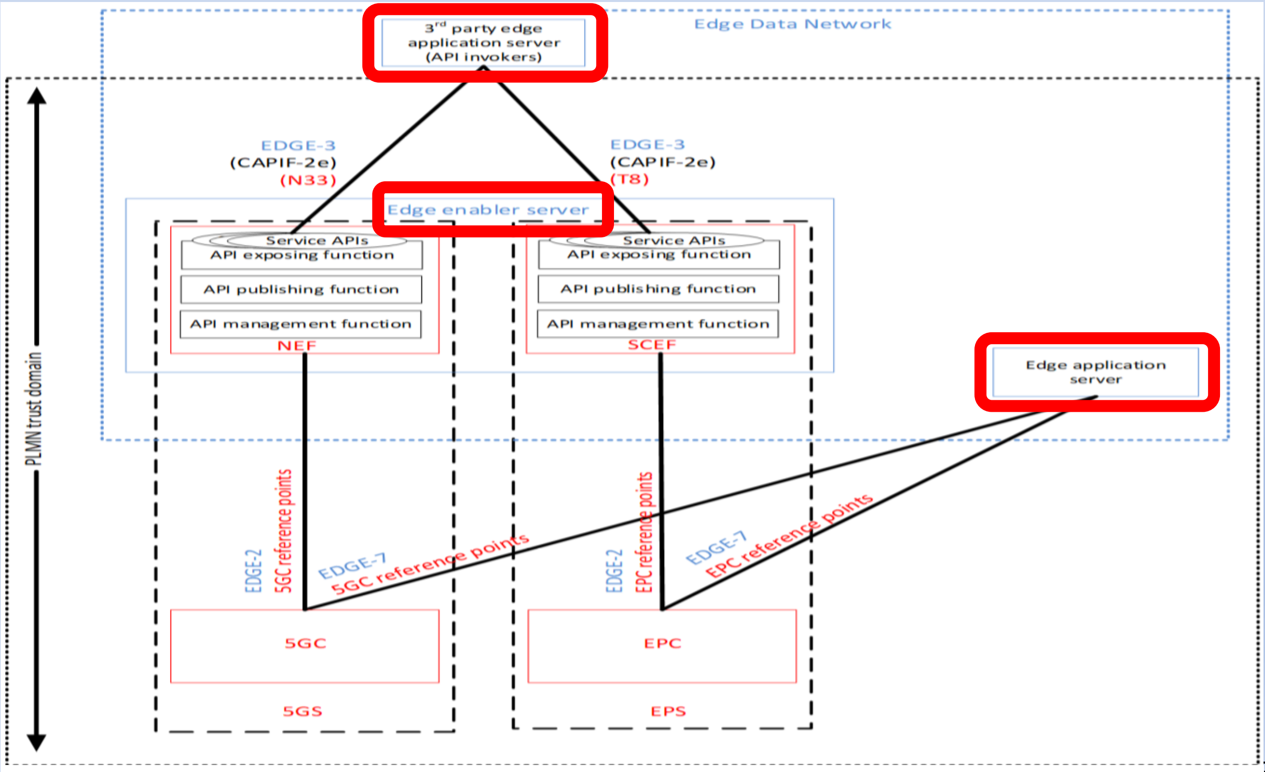


Figure 7.10.1.4.-1: EES and EAS direct interaction with 3GPP Core Network

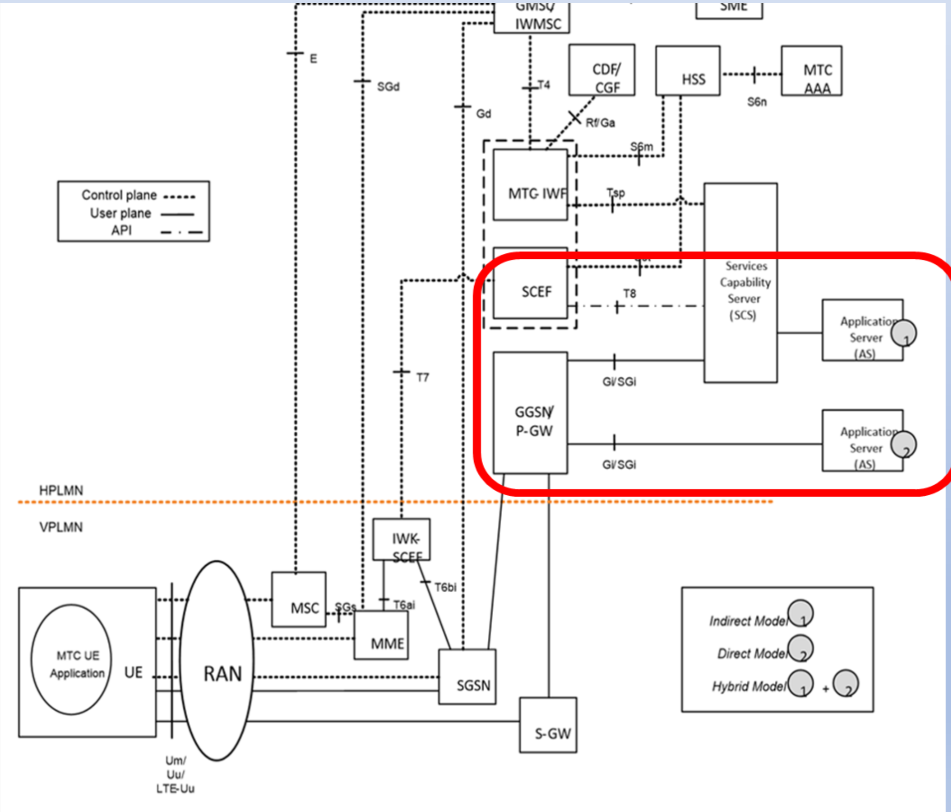


Figure 4.2-1b: 3GPP Architecture for Machine-Type Communication (Roaming)

3GPP TSG SA SP 200 797 SNA Subscriber-aware Northbound API access Rel 18 Sept 2020

GSMA Operator Platform (OP) Telco Edge Proposal

Operator Platform Telco Edge Proposal
Version 1.0
22 October 2020

User to Network Interface - UNI

User-Network Interface (UNI): enables the User Client (UC) hosted in the UE to communicate with the OP.

1. The primary function of the UNI is to enable a User Client to interact with the OP, to enable the matching of an Application Client with an Application Instance on a Cloudlet.

3. User Client should be capable of being implemented on User Equipment SW, e.g. as an SDK or OS add-on.

4. The UNI shall allow the User Client to discover the existence of an Edge Cloud service.

5. The OP's UNI shall allow the User client registration process with the Operator Platform SRM.

Federation Broker Role for Federation and Platform Interconnection

One of the Operator Platform’s primary purposes is offer to Customers an extended Operator footprint and capabilities through interconnecting with other Operators’ resources and Customers. This is achieved by the Federation E/WBI interface; to interconnect entities of OP belonging to different operators, enterprises or others. The capability to exchange Authentication and Authorisation between federated OPs is required.

1.3 Reference Architecture

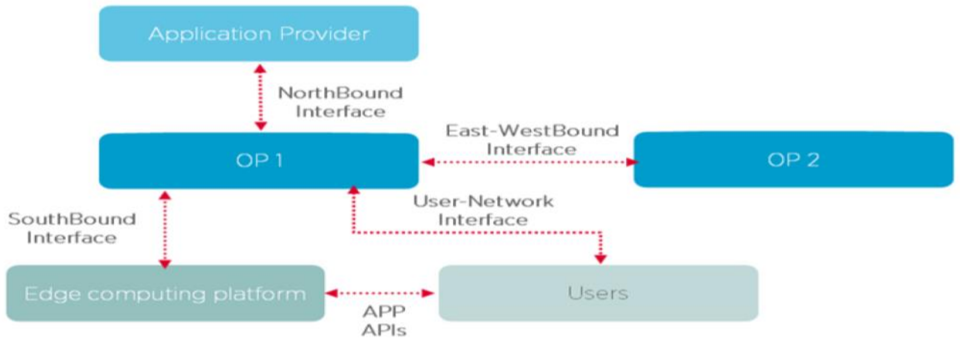


Figure 1: High-Level Reference Architecture

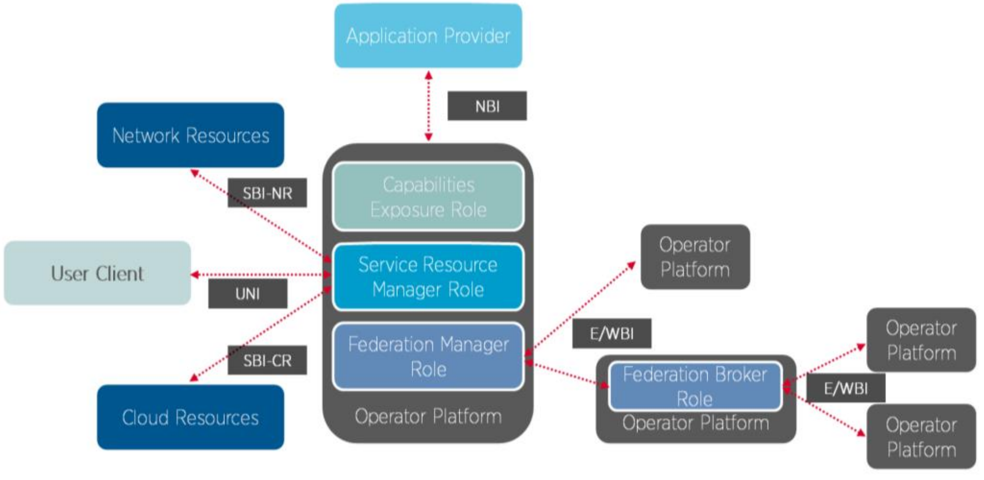
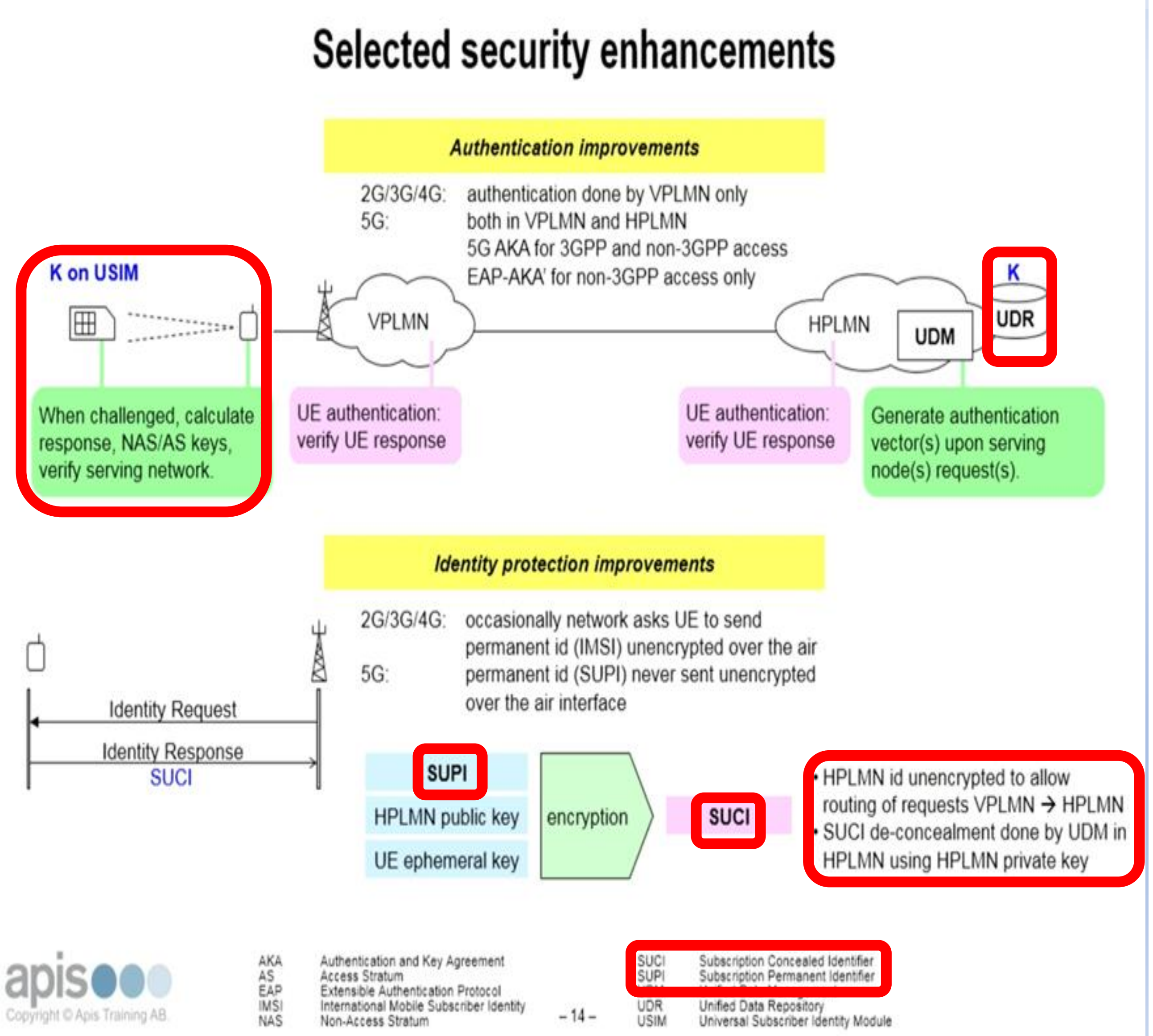


Figure 2: OP Roles and Interfaces Reference Architecture

GSMA OPG.01 - Operator Platform Telco Edge Proposal Oct 2020: 39, 40

2. ETSI MEC renamed in March 2017 & 3GPP 5G NSA Rel. 15 Mobility - 4



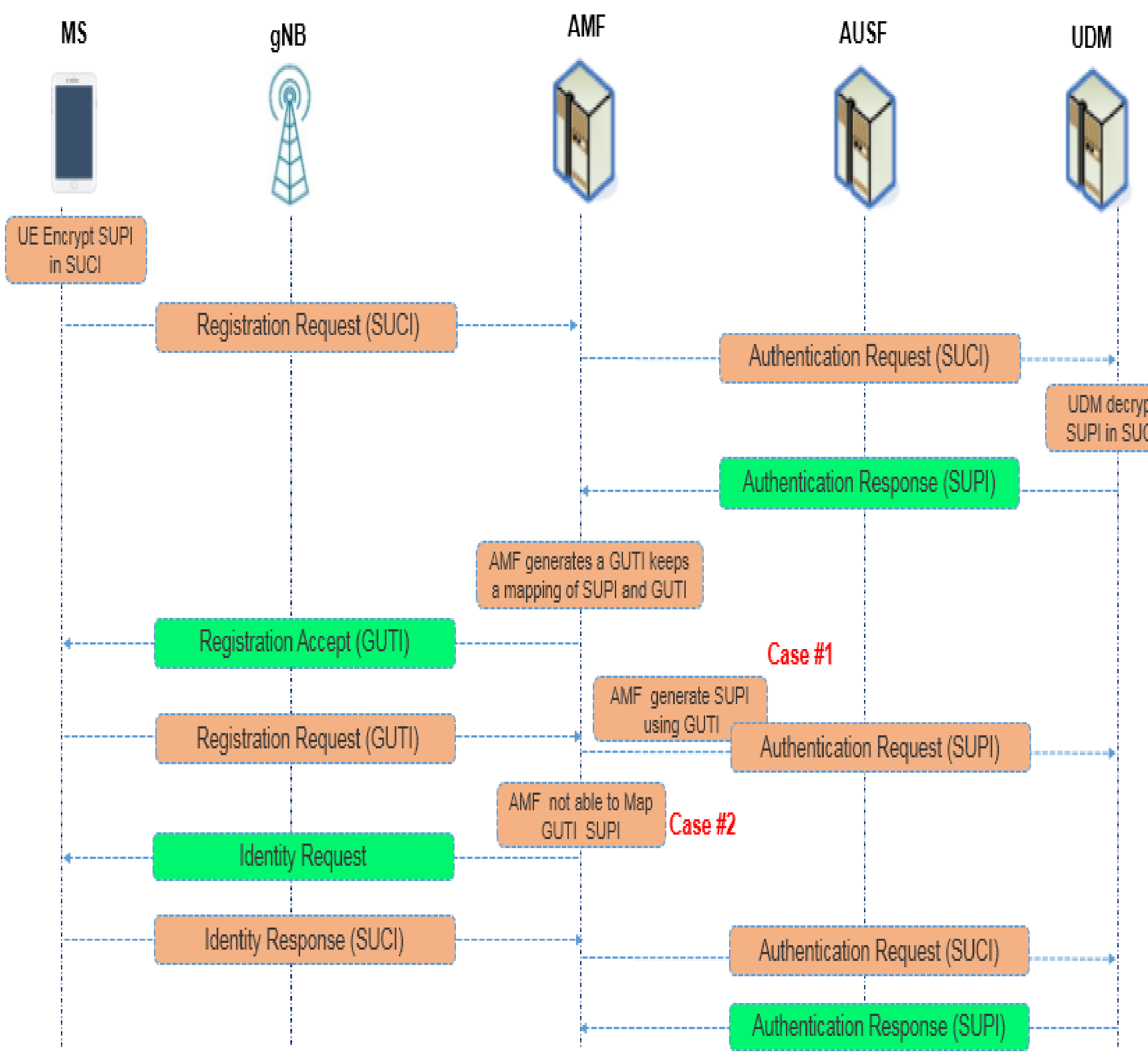


Figure 4-2 illustrates the set of technology domains considered in the present document. In deployments, there may be additional technology domains. Clause 6 documents the northbound interfaces of management domains based on different technologies.

The NBIs of the E2E service management domain are to be defined.

One candidate: TM Forum Interfaces.

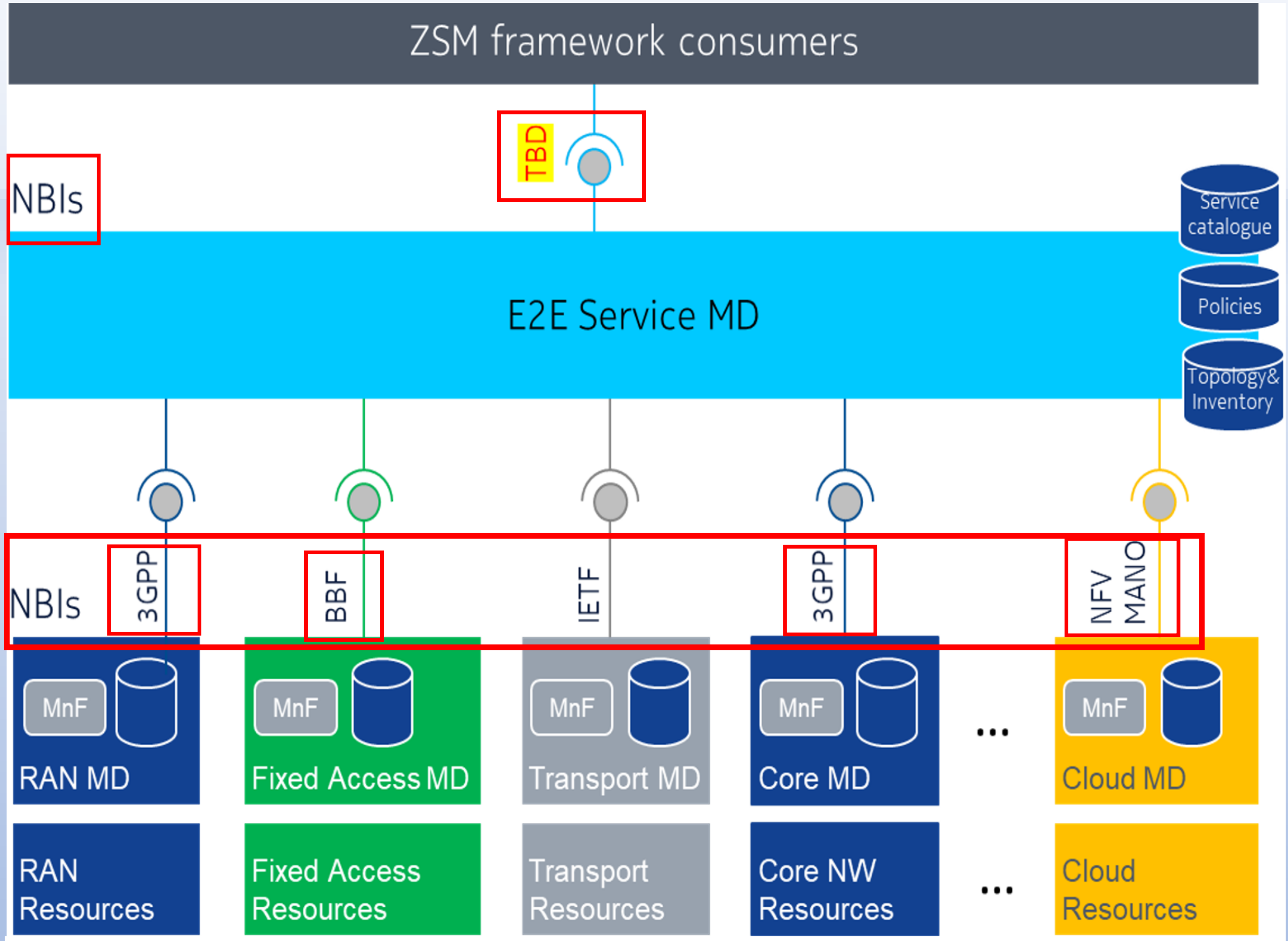


Figure 4-2: Domain NBIs consumed during the Management of the Lifecycle of E2E Services

Two (2) Questions on APIs:

Nr. 1 APIs: Type and Functions - **HOW?**

IoT

Ref 3GPP TS 23.222 & TS 29.222 CAPIF for NAPS Rel 16 & 17, Dec 2020: 24,16

2. ETSI MEC re-named in March 2017 & 3GPP 5G NSA Rel. 15 Mobility - 2

1. **"Mobility" Paterns Re-defined/Diversified - UEs categorized/defined as:**
   1. **Stationary** during their entire usable life (e.g., sensors embedded in infrastructure)
   2. **Nomadic during Active Periods**, but Stationary **between activations** (e.g., Fixed Access)
   3. **Mobile within a Constrained & Well-Defined Space/Area**
      (**Spatially Restricted** e.g., in a Factory or Stadion or Airport),
   4. **Fully Mobile (WAN)**.

0 IP Anchor Node & UE - Relay) - deployed at the "Edge" for
- 5G Network Traffic offloading onto traditional IP Routing Networks

- as UE moves, changing the **IP Anchor Node** needed in order to reduce
  - IP Traffic Load,
  - End-to-End latency
  - Better User Experience

- Seamless access to both 3PGG and non - 3GPP Network Access Technology (e.g WiFi, Bluetooth, Ethernet &..)

- Dynamic Subscriber Management via
  GSMA Standardised eUICC OTA Platform (SM-DP & SM-SR Platform)

3.1 5GS Network Capabilities & MEC Integration - 1

In the **5GS Specifications** there is a **Set of New Functionalities that serves as Enablers for Edge Computing.**

These Enablers are essential for Integrated MEC Deployments in 5G Networks.

1. Local Routing and Traffic Steering:

- 5G CN provides the means to select Traffic to be routed to the Applications in the Local Data Network (DN).
- A PDU Session may have multiple N6 Interfaces towards the DN.
- The UPFs that terminate these interfaces are said to support *PDU Session Anchor functionality*.
- UPF's Traffic steering is supported by Uplink Classifiers that operate on a set of Traffic Filters or
  - alternatively by IPv6 Multi-Homing, where multiple IPv6 prefixes have been associated with the PDU session

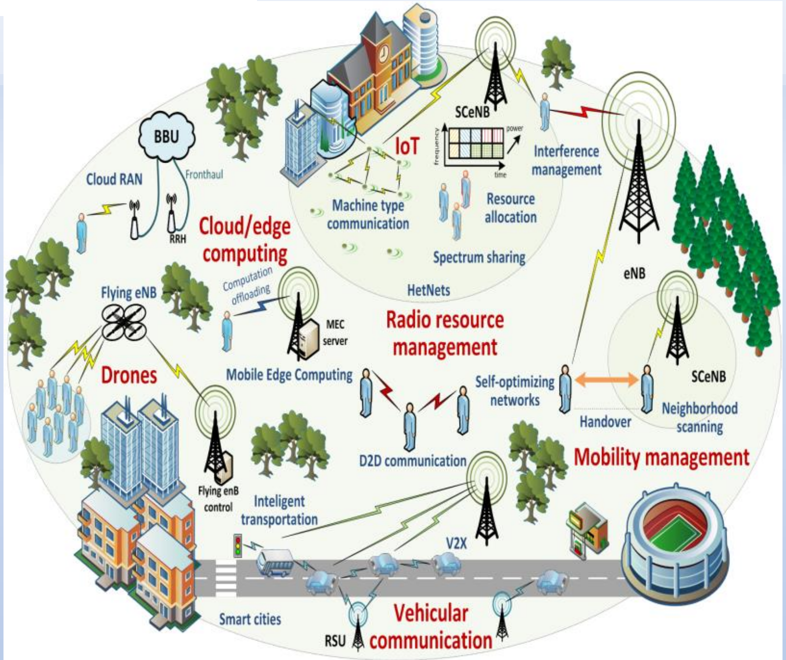
2. The AF ability to influence UPF (re)selection & Traffic Routing:

directly via the Policy Control Function (PCF) or indirectly via the Network Exposure Function (NEF), depending on the operator's Policies.

3. The SSC - Session & Service Continuity modes for different UE & Application Mobility Scenarios.

4. Support of Local Area Data Network (LADN) by the 5G Core Network

by providing support to connect to the LADN in a certain area where the applications are deployed. The access to a LADN is only available in a specific LADN service area, defined as a set of Tracking Areas in the serving PLMN of the UE. LADN is a service provided by the serving PLMN of the UE.



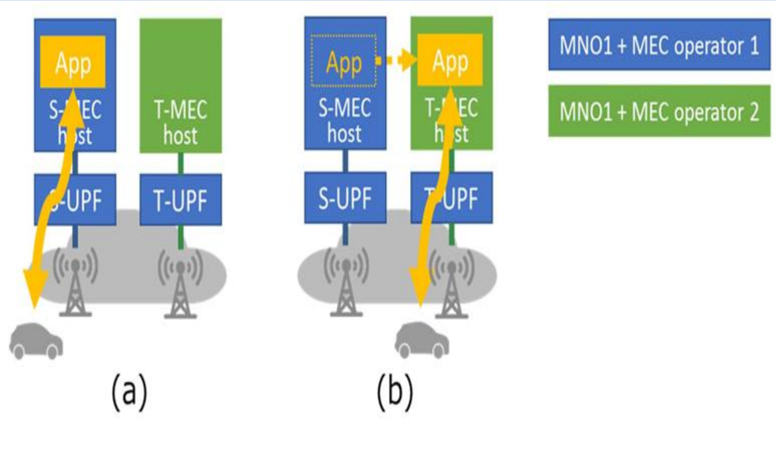


Figure 5.1.1.3-2: Inter-operator mobility support

3.1 5GS Network Capabilities & MEC Integration - 4: 5G CAPIF & MEC Service Registry - 1

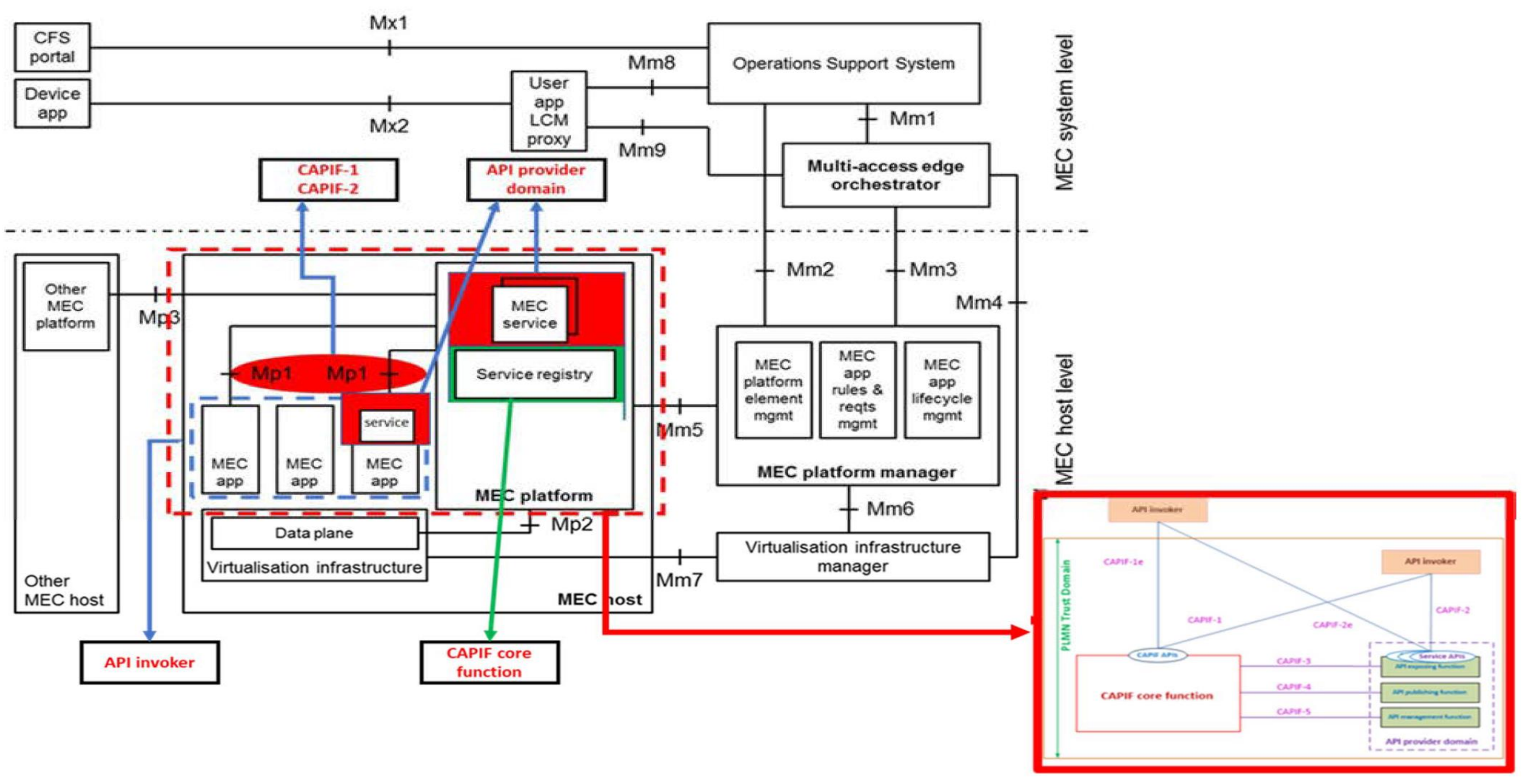


Figure 4.3.1-1: Relationship between MEC and 5G common API framework

3.2 5GS Network Capabilities & MEC Integration - 1: Management Host & System Level

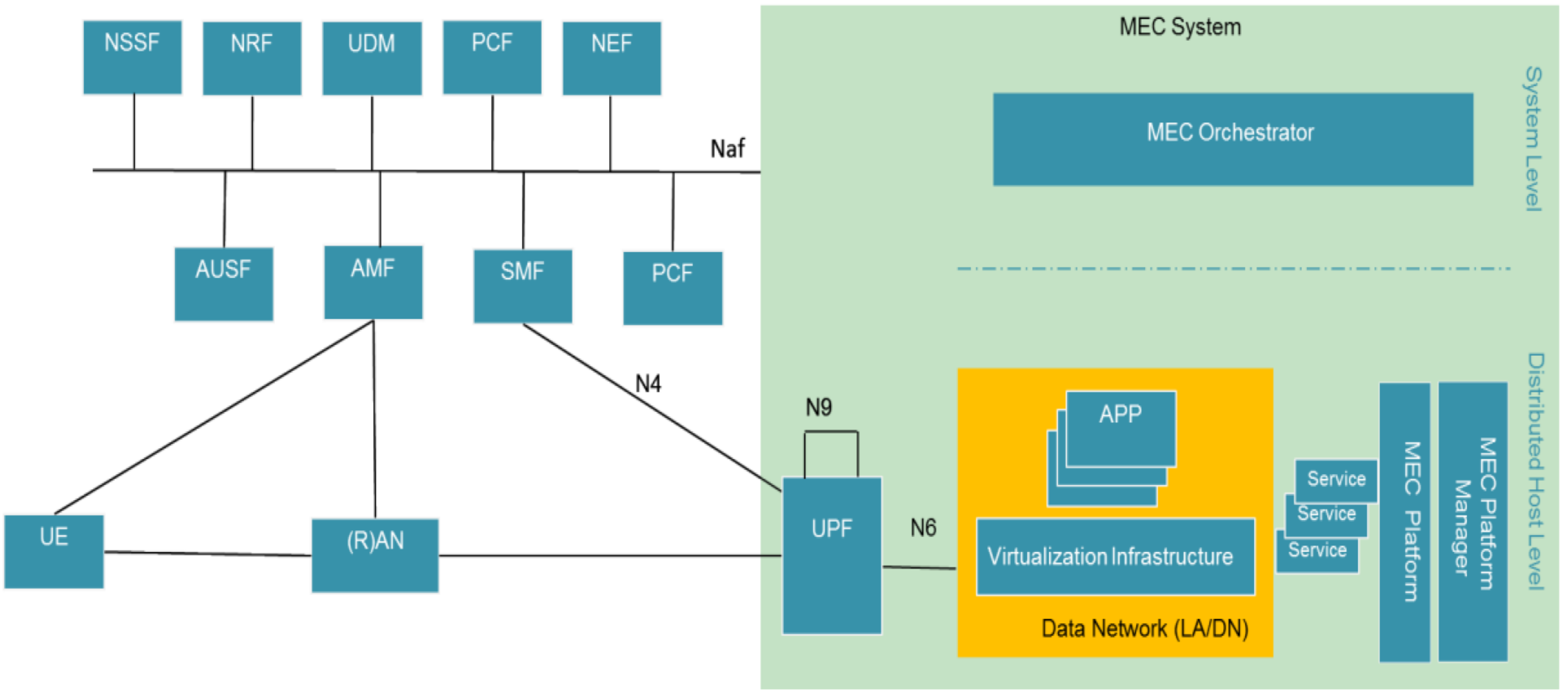


Figure 2. Integrated MEC deployment in 5G network

3.4 3GPP EDGEAPP & ETSI MEC SW for developing MEC Applications - 8 MEC in LADN

A.2.3 Option 3. Use of LADN

Edge computing services can be provided via Edge-dedicated Data Networks deployed as LADNs. The PLMN supports edge computing services in the EDN service areas which can be identified by the service area corresponding to the respective LADN DNNs or LADN DNN and subset of Tracking Areas corresponding to the LADN service area. The LADN service area is the service area that the Edge Computing is supported. Each individual EAS in the LADN may support the same or smaller service area than the LADN.

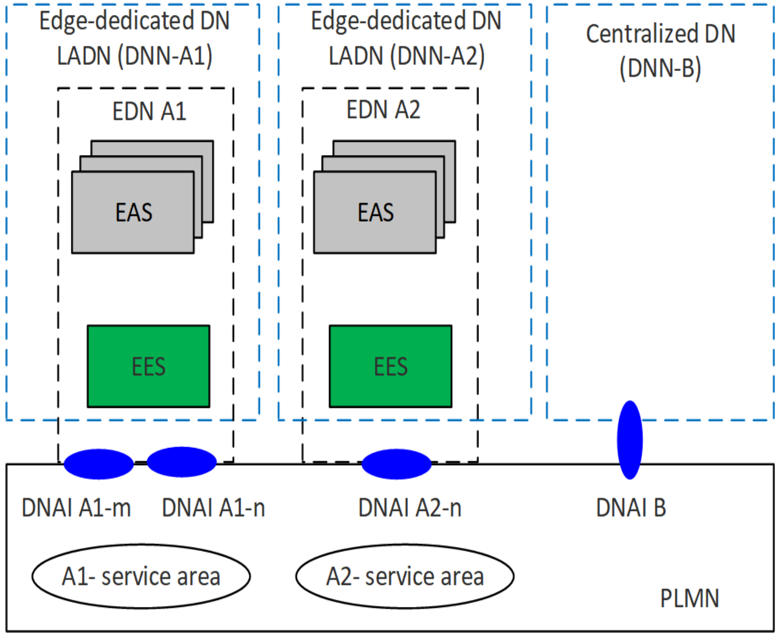


Figure A.2.3-1: Option 3: Use of LADN(s)

1. MEC & the local UPF collocated with the eNB/gNB Base Station
2. MEC collocated with a Transmission Node, possibly with a local UPF
3. MEC & the local UPF collocated with a Network Aggregation Point
4. MEC collocated with the CN Functions (i.e. in the same DC)

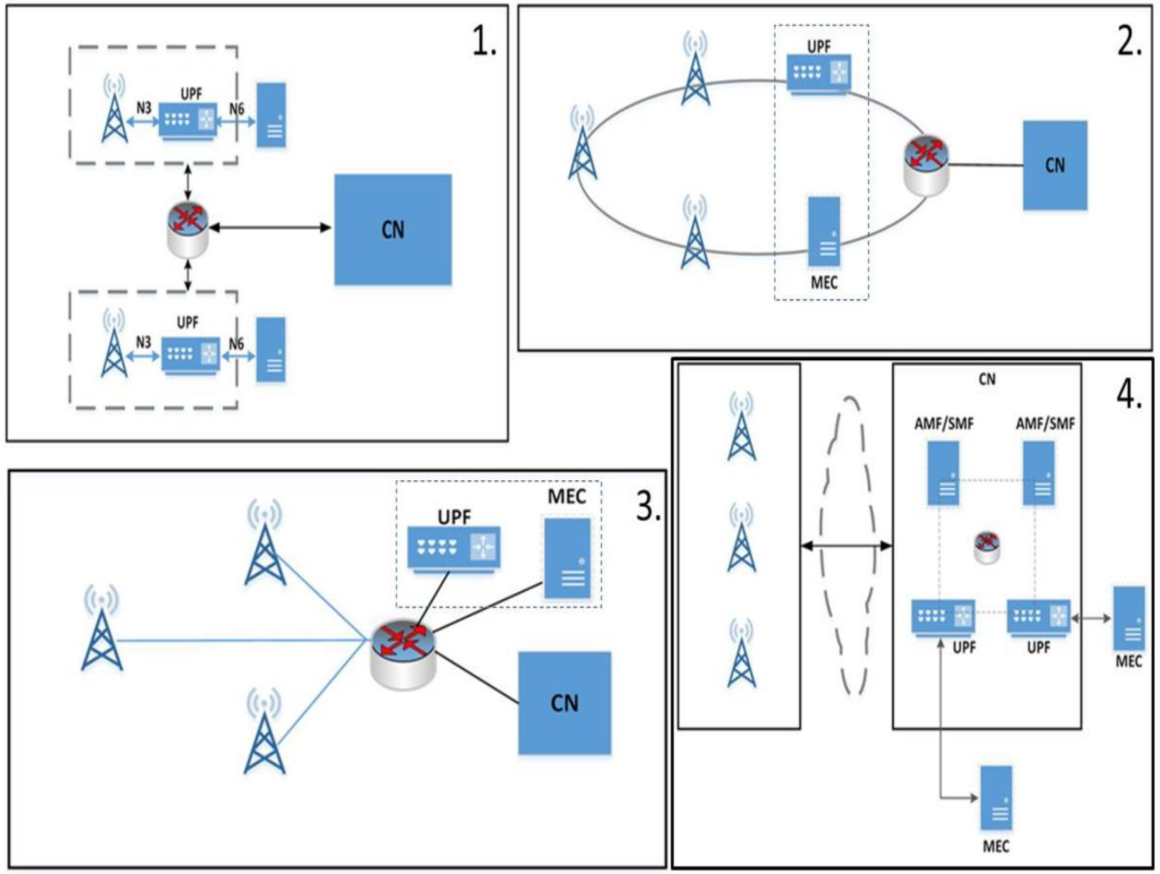


Figure 3. Examples of the physical deployment of MEC.

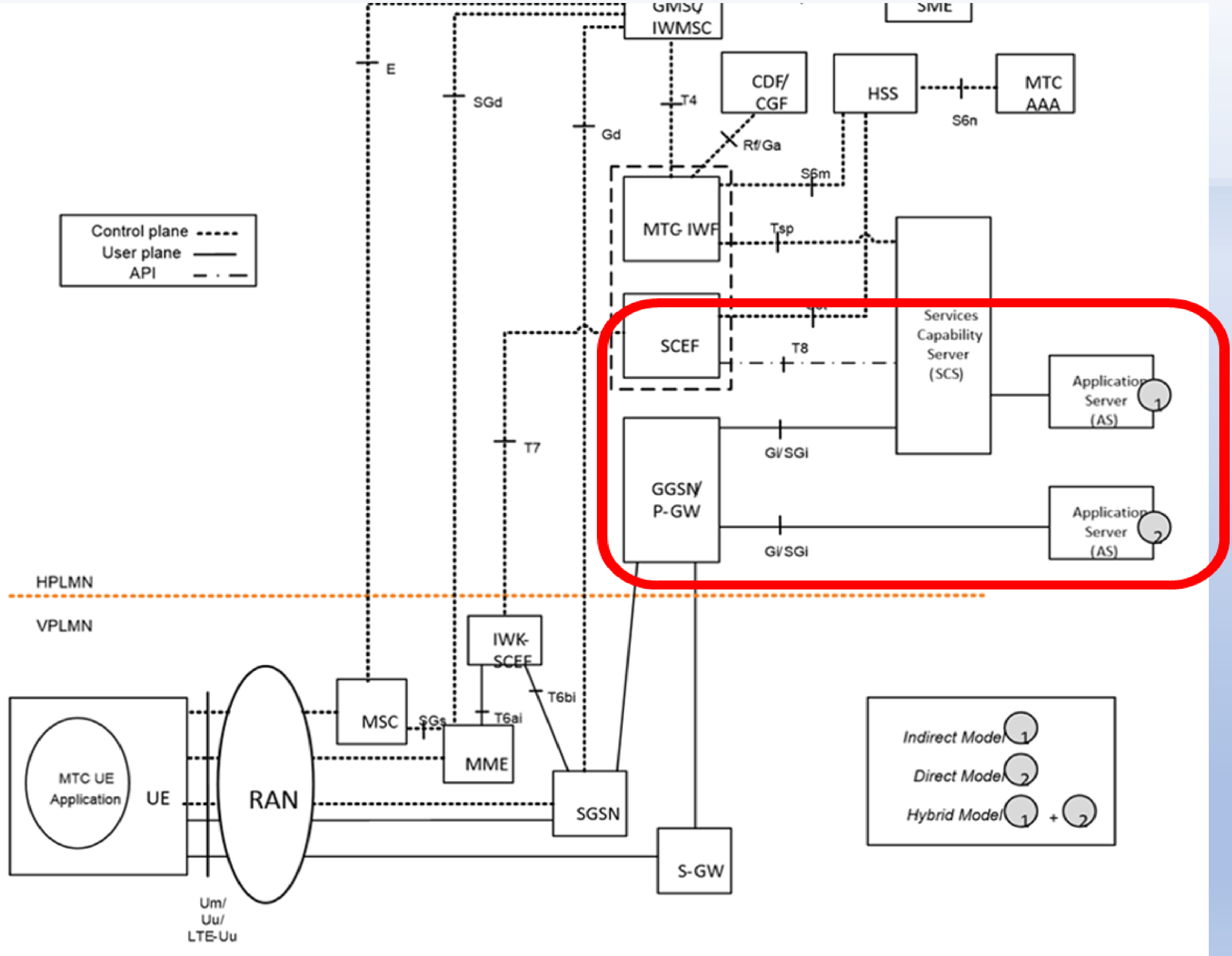


Figure 4.2-1b: 3GPP Architecture for Machine-Type Communication (Roaming)

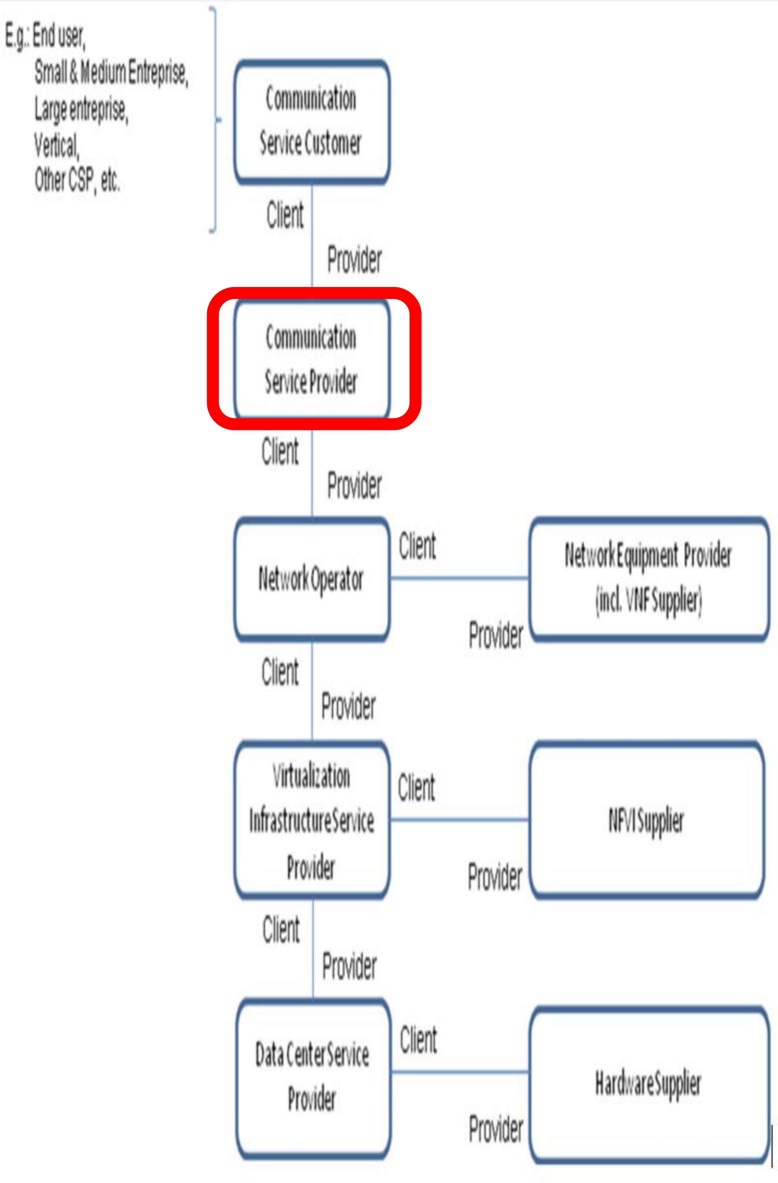


Figure 4.8.1: High-level model of roles

Standardised SST values

Standardized SST values provide a way for establishing global interoperability for slicing so that PLMNs can support the roaming use case more efficiently for the most commonly used Slice/Service Types.

The SSTs which are standardised are in the following Table 5.15.2.2-1.

Table 5.15.2.2-1 - Standardised SST values

Slice/Service type	SST value	Characteristics
eMBB	1	Slice suitable for the handling of 5G enhanced Mobile Broadband.
URLLC	2	Slice suitable for the handling of ultra- reliable low latency communications.
MIoT	3	Slice suitable for the handling of massive IoT.
V2X	4	Slice suitable for the handling of V2X services.

NOTE: The support of all standardised SST values is not required in a PLMN. Services indicated in this table for each SST value can also be supported by means of other SSTs.

Table 1: 5G User Equipment (UE) Service Access Identities Configuration

Access Identity number	UE configuration
0	UE is not configured with any parameters from this table
1 (NOTE 1)	UE is configured for Multimedia Priority Service (MPS)
2 (NOTE 2)	UE is configured for Mission Critical Service (MCS).
3	UE for which Disaster Condition applies (note 4)
4-10	Reserved for future use
11 (NOTE 3)	Access Class 11 is configured in the UE.
12 (NOTE 3)	Access Class 12 is configured in the UE.
13 (NOTE 3)	Access Class 13 is configured in the UE.
14 (NOTE 3)	Access Class 14 is configured in the UE.
15 (NOTE 3)	Access Class 15 is configured in the UE.

NOTE 1: Access Identity 1 is used by UEs configured for MPS, in the PLMNs where the configuration is valid. The PLMNs where the configuration is valid are HPLMN, PLMNs equivalent to HPLMN, and visited PLMNs of the home country.
Access Identity 1 is also valid when the UE is explicitly authorized by the network based on specific configured PLMNs inside and outside the home country.

NOTE 2: Access Identity 2 is used by UEs configured for MCS, in the PLMNs where the configuration is valid. The PLMNs where the configuration is valid are HPLMN or PLMNs equivalent to HPLMN and visited PLMNs of the home country. Access Identity 2 is also valid when the UE is explicitly authorized by the network based on specific configured PLMNs inside and outside the home country.

NOTE 3: Access Identities 11 and 15 are valid in Home PLMN only if the EHPLMN list is not present or in any EHPLMN. Access Identities 12, 13 and 14 are valid in Home PLMN and visited PLMNs of home country only. For this purpose, the home country is defined as the country of the MCC part of the IMSI.

NOTE 4: The configuration is valid for PLMNs that indicate to potential Disaster Inbound Roamers that the UEs can access the PLMN. See clause 6.31.

Table 2: 5G User Equipment (UE) Service Access Categories Configuration

Access Category number	Conditions related to UE	Type of access attempt
0	All	MO signalling resulting from paging
1 (NOTE 1)	UE is configured for delay tolerant service and subject to access control for Access Category 1, which is judged based on relation of UE's HPLMN and the selected PLMN.	All except for Emergency, or MO exception data
2	All	Emergency
3	All except for the conditions in Access Category 1.	MO signalling on NAS level resulting from other than paging
4	All except for the conditions in Access Category 1.	MMTEL voice (NOTE 3)
5	All except for the conditions in Access Category 1.	MMTEL video
6	All except for the conditions in Access Category 1.	SMS
7	All except for the conditions in Access Category 1.	MO data that do not belong to any other Access Categories (NOTE 4)
8	All except for the conditions in Access Category 1	MO signalling on RRC level resulting from other than paging
9	All except for the conditions in Access Category 1	MO IMS registration related signalling (NOTE 5)
10 (NOTE 6)	All	MO exception data
11-31		Reserved standardized Access Categories
32-63 (NOTE 2)	All	Based on operator classification

NOTE 1: The barring parameter for Access Category 1 is accompanied with information that define whether Access Category applies to UEs within one of the following categories:
a) UEs that are configured for delay tolerant service;
b) UEs that are configured for delay tolerant service and are neither in their HPLMN nor in a PLMN that is equivalent to it;
c) UEs that are configured for delay tolerant service and are neither in the PLMN listed as most preferred PLMN of the country where the UE is roaming in the operator-defined PLMN selector list on the SIM/USIM, nor in their HPLMN nor in a PLMN that is equivalent to their HPLMN.
When a UE is configured for EAB, the UE is also configured for delay tolerant service. In case a UE is configured both for EAB and for EAB override, when upper layer indicates to override Access Category 1, then Access Category 1 is not applicable.

NOTE 2: When there are an Access Category based on operator classification and a standardized Access Category to both of which an access attempt can be categorized, and the standardized Access Category is neither 0 nor 2, the UE applies the Access Category based on operator classification. When there are an Access Category based on operator classification and a standardized Access Category to both of which an access attempt can be categorized, and the standardized Access Category is 0 or 2, the UE applies the standardized Access Category.

NOTE 3: Includes Real-Time Text (RTT).

NOTE 4: Includes IMS Messaging.

NOTE 5: Includes IMS registration related signalling, e.g. IMS initial registration, re-registration, and subscription refresh.

NOTE 6: Applies to access of a NB-IoT-capable UEto a NB-IOT cell connected to 5GC when the UE is authorized to send exception data.

Table 3: Performance Requirements for High Data Rate and Traffic Density Scenarios

	Scenario	Experienced data rate (DL)	Experienced data rate (UL)	Area traffic capacity (DL)	Area traffic capacity (UL)	Overall user density	Activity factor	UE speed	Coverage
1	Urban macro	50 Mbit/s	25 Mbit/s	100 Gbit/s/km^2 (note 4)	50 Gbit/s/km^2 (note 4)	10 000/km^2	20 %	Pedestrians and users in vehicles (up to 120 km/h	Full network (note 1)
2	Rural macro	50 Mbit/s	25 Mbit/s	1 Gbit/s/km^2 (note 4)	500 Mbit/s/km^2 (note 4)	100/km^2	20 %	Pedestrians and users in vehicles (up to 120 km/h	Full network (note 1)
3	Indoor hotspot	1 Gbit/s	500 Mbit/s	15 Tbit/s/km^2	2 Tbit/s/km^2	250 000/km^2	note 2	Pedestrians	Office and residential (note 2) (note 3)
4	Broadband access in a crowd	25 Mbit/s	50 Mbit/s	[3,75] Tbit/s/km^2	[7,5] Tbit/s/km^2	[500 000]/km^2	30 %	Pedestrians	Confined area
5	Dense urban	300 Mbit/s	50 Mbit/s	750 Gbit/s/km^2 (note 4)	125 Gbit/s/km^2 (note 4)	25 000/km^2	10 %	Pedestrians and users in vehicles (up to 60 km/h)	Downtown (note 1)
6	Broadcast-like services	Maximum 200 Mbit/s (per TV channel)	N/A or modest (e.g. 500 kbit/s per user)	N/A	N/A	[15] TV channels of [20 Mbit/s] on one carrier	N/A	Stationary users, pedestrians and users in vehicles (up to 500 km/h)	Full network (note 1)
7	High-speed train	50 Mbit/s	25 Mbit/s	15 Gbit/s/train	7,5 Gbit/s/train	1 000/train	30 %	Users in trains (up to 500 km/h)	Along railways (note 1)
8	High-speed vehicle	50 Mbit/s	25 Mbit/s	[100] Gbit/s/km^2	[50] Gbit/s/km^2	4 000/km^2	50 %	Users in vehicles (up to 250 km/h)	Along roads (note 1)
9	Airplanes connectivity	15 Mbit/s	7,5 Mbit/s	1,2 Gbit/s/plane	600 Mbit/s/plane	400/plane	20 %	Users in airplanes (up to 1 000 km/h)	(note 1)

NOTE 1: For users in vehicles, the UE can be connected to the network directly, or via an on-board moving base station.
NOTE 2: A certain traffic mix is assumed; only some users use services that require the highest data rates [2].
NOTE 3: For interactive audio and video services, for example, virtual meetings, the required two-way end-to-end latency (UL and DL) is 2-4 ms while the corresponding experienced data rate needs to be up to 8K 3D video [300 Mbit/s] in uplink and downlink.
NOTE 4: These values are derived based on overall user density. Detailed information can be found in [10].
NOTE 5: All the values in this table are targeted values and not strict requirements.

Table 4: Performance Requirements for Horizontal and Vertical Positioning Service Levels

Positioning service level	Absolute(A) or Relative(R) positioning	Accuracy (95 % confidence level)		Positioning service availability	Positioning service latency	Coverage, environment of use and UE velocity		
		Horizontal Accuracy	Vertical Accuracy (note 1)			5G positioning service area	5G enhanced positioning service area (note 2)	
							Outdoor and tunnels	Indoor
1	A	10 m	3 m	95 %	1 s	Indoor - up to 30 km/h Outdoor (rural and urban) up to 250 km/h	NA	Indoor - up to 30 km/h
2	A	3 m	3 m	99 %	1 s	Outdoor (rural and urban) up to 500 km/h for trains and up to 250 km/h for other vehicles	Outdoor (dense urban) up to 60 km/h Along roads up to 250 km/h and along railways up to 500 km/h	Indoor - up to 30 km/h
3	A	1 m	2 m	99 %	1 s	Outdoor (rural and urban) up to 500 km/h for trains and up to 250 km/h for other vehicles	Outdoor (dense urban) up to 60 km/h Along roads up to 250 km/h and along railways up to 500 km/h	Indoor - up to 30 km/h
4	A	1 m	2 m	99,9 %	15 ms	NA	NA	Indoor - up to 30 km/h
5	A	0,3 m	2 m	99 %	1 s	Outdoor (rural) up to 250 km/h	Outdoor (dense urban) up to 60 km/h Along roads and along railways up to 250 km/h	Indoor - up to 30 km/h
6	A	0,3 m	2 m	99,9 %	10 ms	NA	Outdoor (dense urban) up to 60 km/h	Indoor - up to 30 km/h
7	R	0,2 m	0,2 m	99 %	1 s	Indoor and outdoor (rural, urban, dense urban) up to 30 km/h Relative positioning is between two UEs within 10 m of each other or between one UE and 5G positioning nodes within 10 m of each other (note 3)		

NOTE 1: The objective for the vertical positioning requirement is to determine the floor for indoor use cases and to distinguish between superposed tracks for road and rail use cases (e.g. bridges).

NOTE 2: Indoor includes location inside buildings such as offices, hospital, industrial buildings.

NOTE 3: 5G positioning nodes are infrastructure equipment deployed in the service area to enhance positioning capabilities (e.g. beacons deployed on the perimeter of a rendezvous area or on the side of a warehouse).

Table 5: UE to Satellite Propagation Delay

	UE to satellite Delay [ms]		One-Way Max propagation delay [ms]
	Min	Max	
LEO	3	15	30
MEO	27	43	90
GEO	120	140	280

Table 6: Performance Requirements for Satellite Access

Scenario	Experienced data rate (DL)	Experienced data rate (UL)	Area traffic capacity (DL) (note 1)	Area traffic capacity (UL) (note 1)	Overall user density	Activity factor	UE speed	UE type
Pedestrian (note 2)	[1] Mbit/s	[100] kbit/s	1,5 Mbit/s/km^2	150 kbit/s/km^2	[100]/km^2	[1,5] %	Pedestrian	Handheld
Public safety	[3,5] Mbit/ss	[3,5] Mbit/s	TBD	TBD	TBD	N/A	100 km/h	Handheld
Vehicular connectivity (note 3)	50 Mbit/s	25 Mbit/s	TBD	TBD	TBD	50 %	Up to 250 km/h	Vehicle mounted
Airplanes connectivity (note 4)	360 Mbit/s/ plane	180 Mbit/s/ plane	TBD	TBD	TBD	N/A	Up to 1000 km/h	Airplane mounted
Stationary	50 Mbit/s	25 Mbit/s	TBD	TBD	TBD	N/A	Stationary	Building mounted
Narrowband IoT connectivity	[2] kbit/s	[10] kbit/s	8 kbit/s/km^2	40 kbit/s/km^2	[400]/km2	[1] %	[Up to 100 km/h]	IoT

Note 1: Area capacity is averaged over a satellite beam.
Note 2: Data rates based on Extreme long-range coverage target values in clause 6.17.2. User density based on rural area in Table 7.1-1.
Note 3: Based on Table 7.1-1
Note 4: Based on an assumption of 120 users per plane 15/7.5 Mbit/s data rate and 20 % activity factor per user
Note 5: All the values in this table are targeted values and not strict requirements.
Note 6: Performance requirements for all the values in this table should be analyzed independently for each scenario.

Table 7: Performance Requirements for Highly Reliable Machine Type Communication

Profile	Characteristic parameter					Influence quantity					
	Communication service availability: target value in %	Communication service reliability (Mean Time Between Failure)	End-to-end latency: maximum	Bit rate	Direction	Message Size [byte]	Transfer Interval	Survival Time	UE speed (km/h)	# of UEs connection	Service Area
Medical monitoring (note 2)	> 99,9999	<1 year (>> 1 month)	< 100 ms	< 1 Mbit/s	Uplink	~ 1000	50 ms	Transfer Interval	< 500	$10/km^2$ to $1000/km^2$	Country wide including rural areas and deep indoor. (note 1)

NOTE 1: "deep indoor" term is meant to be places like e.g. elevators, building's basement, underground parking lot, …

NOTE 2: These performance requirements aim energy-efficient transmissions performed using a device powered with a 3.3V battery of capacity < 1000 mAh that can last at least 1 month without recharging and whereby the peak current for transmit operations stays below 50 mA.

Table 8 KPI Table for additional High Data Rate and Low Latency Service

Use Cases	Characteristic parameter (KPI)			Influence quantity		
	Max allowed end-to-end latency	Service bit rate: user-experienced data rate	Reliability	# of UEs	UE Speed	Service Area (note 2)
Cloud/Edge/Split Rendering (note 1)	5 ms (i.e. UL+DL between UE and the interface to data network) (note 4)	0,1 to [1] Gbit/s supporting visual content (e.g. VR based or high definition video) with 4K, 8K resolution and up to120 frames per second content.	99,99 % in uplink and 99,9 % in downlink (note 4)	-	Stationary or Pedestrian	Countrywide
Gaming or Interactive Data Exchanging (note 3)	10ms (note 4)	0,1 to [1] Gbit/s supporting visual content (e.g. VR based or high definition video) with 4K, 8K resolution and up to120 frames per second content.	99,99 % (note 4)	≤ [10]	Stationary or Pedestrian	20 m x 10 m; in one vehicle (up to 120 km/h) and in one train (up to 500 km/h)
Consumption of VR content via tethered VR headset (note 6)	[5 to 10] ms (note 5)	0,1 to [10] Gbit/s (note 5)	[99,99 %]	-	Stationary or Pedestrian	–

NOTE 1: Unless otherwise specified, all communication via wireless link is between UEs and network node (UE to network node and/or network node to UE) rather than direct wireless links (UE to UE).
NOTE 2: Length x width (x height).
NOTE 3: Communication includes direct wireless links (UE to UE).
NOTE 4: Latency and reliability KPIs can vary based on specific use case/architecture, e.g. for cloud/edge/split rendering, and may be represented by a range of values.
NOTE 5: The decoding capability in the VR headset and the encoding/decoding complexity/time of the stream will set the required bit rate and latency over the direct wireless link between the tethered VR headset and its connected UE, bit rate from 100 Mbit/s to [10] Gbit/s and latency from 5 ms to 10 ms.
NOTE 6: The performance requirement is valid for the direct wireless link between the tethered VR headset and its connected UE.

Table 9: Key Performance for UE to Network Relaying

Scenario	Max. data rate (DL)	Max. data rate (UL)	End-to-end latency (note 7)	Area traffic capacity (DL)	Area traffic capacity (UL)	Area user density	Area	Range of a single hop (note 8)	Estimated number of hops
InHome Scenario (note 1)	1 Gbit/s	500 Mbit/s	10 ms	5 Gbit/s/ home	2 Gbit/s /home	50 devices /house	10 m x 10m – 3 floors	10 m indoor	2 to 3
Factory Sensors (note 2)	100 kbit/s	5 Mbit/s	50 ms to 1 s	1 Gbit/s /factory	50 Gbit/s /factory	10000 devices /factory	100 m x 100 m	30 m indoor / metallic	2 to 3
Smart Metering (note 3)	100 bytes / 15 mins	100 bytes / 15 mins	10 s	200 x 100 bytes / 15 mins /hectare	200 x 100 bytes / 15 mins /hectare	200 devices /hectare	100 m x 100 m	> 100 m indoor / deep indoor	2 to 5
Containers (note 4)	100 bytes / 15 mins	100 bytes / 15 mins	10 s	15000 x 100 bytes / 15 mins /ship	15000 x 100 bytes / 15 mins /ship	15000 containers /ship	400 m x 60 m x 40 m	> 100 m indoor / outdoor / metallic	3 to 9
Freight Wagons	100 bytes / 15 mins	100 bytes / 15 mins	10 s	200 x 100 bytes / 15 mins /train	200 x 100 bytes / 15 mins /train	120 wagons /train	1 km	> 100 m outdoor / tunnel	10 to 15
Public Safety (note 5)	12 Mbit/s	12 Mbit/s	30 ms	20 Mbit/s /building	40 Mbit/s /building	30 devices /building	100 m x 100 m – 3 floors	> 50 m indoor (floor or stairwell)	2 to 4
Wearables (note 6)	10 Mbit/s	10 Mbit/s	10 ms	20 Mbit/s per 100 m²	20 Mbit/s per 100 m²	10 wearables per 100 m²	10 m x 10 m	10 m indoor / outdoor	1 to 2

NOTE 1: Area traffic capacity is determined by high bandwidth consuming devices (e.g. ultra HD TVs, VR headsets), the number of devices has been calculated assuming a family of 4 members.
NOTE 2: Highest data rate assumes audio sensors with sampling rate of 192 kHz and 24 bits sample size.
NOTE 3: Three meters (gas, water, electricity) per house, medium density of 50 to 70 houses per hectare.
NOTE 4: A large containership with a mix of 20 foot and 40 foot containers is assumed.
NOTE 5: A mix of MCPTT, MCVideo, and MCData is assumed. Average 3 devices per firefighter / police officer, of which one video device. Area traffic based on 1080 p, 60 fps is 12 Mbit/s video, with an activity factor of 30% in uplink (30% of devices transmit simultaneously at high bitrate) and 15% in downlink.
NOTE 6: Communication for wearables is relayed via a UE. This relay UE may use a further relay UE.
NOTE 7: End-to-end latency implies that all hops are included.
NOTE 8: 'Metallic' implies an environment with a lot of metal obstructions (e.g. machinery, containers). 'Deep indoor' implies that there may be concrete walls / floors between the devices.
NOTE 9: All the values in this table are example values and not strict requirements.

Latency needs to support example Use Cases (UCs) from Vertical Industries

Services/ Use cases	Automotive use cases	Transport, logistics, IoT use cases	Health and wellness, smart cities use cases	Media and entertainment
Description	Expand detectable range beyond on board sensor capability by sharing views or detected objects among traffic participants, coordinate trajectories among vehicles, sharing coarse driving intention, real-time remote operation of vehicles	Real-time sensing, reporting, feedback, control, remote, asset tracking, monitoring; context-aware services, recommendations at shopping mall, airport	Live video feed (4K, 8K, 3D for remote healthcare (consultation, monitoring) and assisted surgery, real-time commands to control medical devices for treatment (e.g. medication, surgery); remote monitoring, surveillance and guidance for citizens and law enforcement officers.	Media production services based on aggregation of various media feeds at servers; real-time peer-to-peer or server-client sharing of data (object information) for collaborative gaming, live streaming at live events
Latency	For mid/long-term environment modelling (dynamic high-definition digital map update): Not critical (100 ms end-to-end) For short term environment modelling (sensor sharing): <20 ms end-to-end For cooperation (coordinated control): - <3 ms end-to-end for platooning , - <10 ms end-to-end for cooperative manoeuvres , - <100 ms end-to-end for coarse driving intention For remote vehicle operation: 10-30 ms end-to-end	For massive connectivity for time-critical sensing and feedback: <30 ms end–to-end. For remote drone operation and cooperative farm machinery: 10-30 ms end-to-end Real-time control for discrete automation: ≤1 ms end-to-end	For real-time video/ telepresence/augmented reality for remote healthcare and assisted surgery, for monitoring and guidance (smart cities): 100 ms end-to-end Real-time command and control for remote medication and surgery: 10-100 ms end-to-end For smart grid: - <5 ms end-to-end for transmission/grid backbone, - <50 ms end-to-end for distribution/grid backhaul, Time-critical sensing and feedback for smart cities: 30 ms end-to-end	For live streaming in crowded areas, services for media production, augmented reality for collaborative gaming etc.: 20 ms end–to-end

Table 11: Standardized 5QI to QoS Characteristics mapping

5QI Value	Resource Type	Default Priority Level	Packet Delay Budget (NOTE 3)	Packet Error Rate	Default Maximum Data Burst Volume (NOTE 2)	Default Averaging Window
1	GBR (NOTE 1)	20	100 ms (NOTE 11, NOTE 13)	10^{-2}	N/A	2000 ms
2		40	150 ms (NOTE 11, NOTE 13)	10^{-3}	N/A	2000 ms
3		30	50 ms (NOTE 11, NOTE 13)	10^{-3}	N/A	2000 ms
4		50	300 ms (NOTE 11, NOTE 13)	10^{-6}	N/A	2000 ms
65 (NOTE 9, NOTE 12)		7	75 ms (NOTE 7, NOTE 8)	10^{-2}	N/A	2000 ms
66 (NOTE 12)		20	100 ms (NOTE 10, NOTE 13)	10^{-2}	N/A	2000 ms
67 (NOTE 12)		15	100 ms (NOTE 10, NOTE 13)	10^{-3}	N/A	2000 ms
75 (NOTE 14)						
71		56	150 ms (NOTE 11, NOTE 13, NOTE 15)	10^{-6}	N/A	2000 ms
72		56	300 ms (NOTE 11, NOTE 13, NOTE 15)	10^{-4}	N/A	2000 ms
73		56	300 ms (NOTE 11, NOTE 13, NOTE 15)	10^{-8}	N/A	2000 ms
74		56	500 ms (NOTE 11, NOTE 15)	10^{-8}	N/A	2000 ms
76		56	500 ms (NOTE 11, NOTE 13, NOTE 15)	10^{-4}	N/A	2000 ms
5	Non-GBR (NOTE 1)	10	100 ms NOTE 10, NOTE 13)	10^{-6}	N/A	N/A
6		60	300 ms (NOTE 10, NOTE 13)	10^{-6}	N/A	N/A
7		70	100 ms (NOTE 10, NOTE 13)	10^{-3}	N/A	N/A

Discrete automation – Motion Control

Industrial Factory Automation - Closed-Loop Control Applications.

e.g. Motion Control of Robots, Machine Tools, as well as Packaging and Printing Machines.

The pertinent standard suite is IEC 61158. Note that clock synchronization is an integral part of fieldbuses used for motion control.

In motion control applications, a controller interacts with a large number of sensors and actuators (e.g. up to 100), which are integrated in a manufacturing unit. The resulting sensor/actuator density is often very high (up to 1 m^{-3}). Many such manufacturing units may have to be supported within close proximity within a factory (e.g. up to 100 in automobile assembly line production).

The Cycle Time can be as low as 2 ms, setting stringent E2E Latency constraints on telegram forwarding (1 ms).

The communication service has also to be highly available (99,9999%).

Service area and connection density

Factory halls can be rather large and even quite high. We set the upper limit at 1000 x 1000 x 30 m.

Ref.: 3GPP TS 22.261 Service Requirements for 5G, Sept., 2020: 36

Main SCEF Capabilities

A) Applying AAA to the 3rd Party/Enterprises API's use (and in particular Accounting)
- vital for Charging & therein new revenues) for the Enterprise (SCS/AS) use of the API (dedicated SCEF T8 interface)

B) Use of Externa Id (e.g "name-of-device@domain.com").
- no need/requirement to use the UE MSISDN as an Id, enhancement/improvement of Security.

C) NIDD (Non IP Data Delivery) Capability
- extending the NAS Protocol to communicate from the UE via MME and SCEF with the SCS/AS and avoid using resource demanding IP Protocol for sending small data messages over the Control Plane (CP).

D) New Services Capabilities
- **e.g.** functions such as "Network Configuration Parameters" enabling Enterprises SCS/AS to use the Network Functions e.g. for UE **PSM** (*Power Save Mode*), **DRX** (*Discontinuous Reception*), **TAU** (less *Tracking Area Updates*).

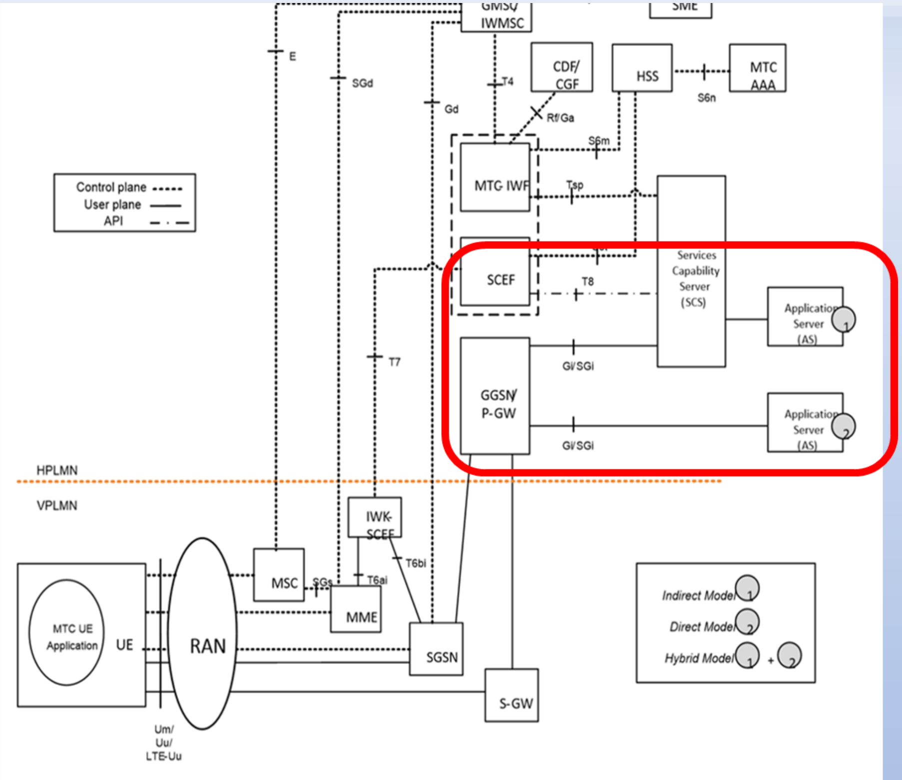


Figure 4.2-1b: 3GPP Architecture for Machine-Type Communication (Roaming)

Summary of 3GPP SCEF Services

1. The APIs enable many use cases for applications by the Enterprise.

2. Device Trigger Delivery

3. Sponsored Data

4. UE Reachability and Monitoring

5. Inform 3rd Party of Network Issues and set QoS for the UE session

6. UE Footprint

7. 3rd Party Interaction for UE Patterns

8. Group Message Delivery

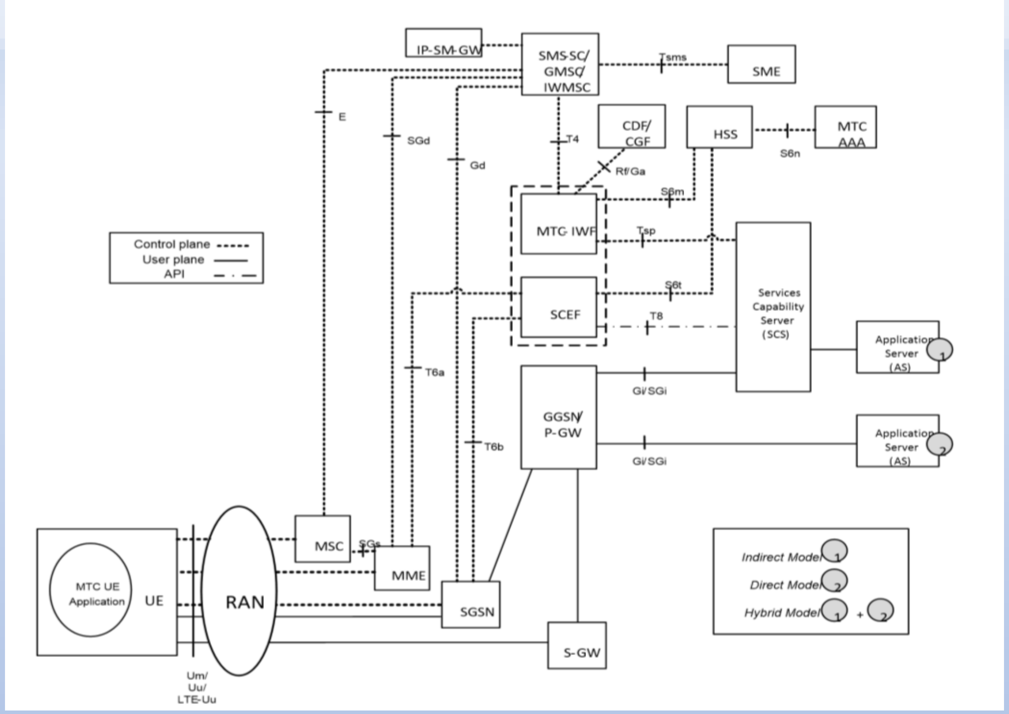
9. Background Data Transfer

10. Packet Flow Descriptor (PFD) Management

11. MSISDN-less MO-SMS

12. Enhanced Coverage Restriction Control

13. Network Configuration Parameters



3GPP 5G SCEF/SCS for IoT Platform integrated with IoT SL across 10 UCs - 1

Functional mapping between 3GPP and oneM2M

Figure 5.2-1 shows an Architecture and Functional mapping for the 3GPP Trust Domain which describes how oneM2M Functional Entities may access Features and Services that are exposed by 3GPP.

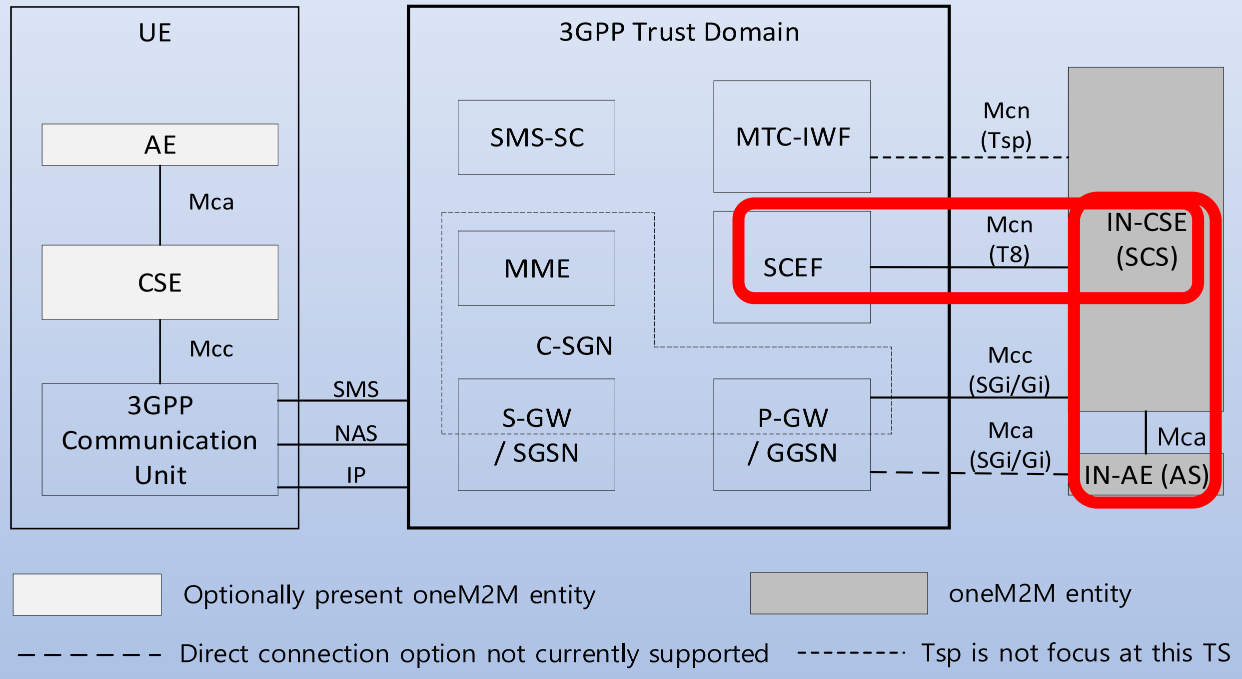


Figure 5.2-1: oneM2M Interfaces to the underlying 3GPP Network

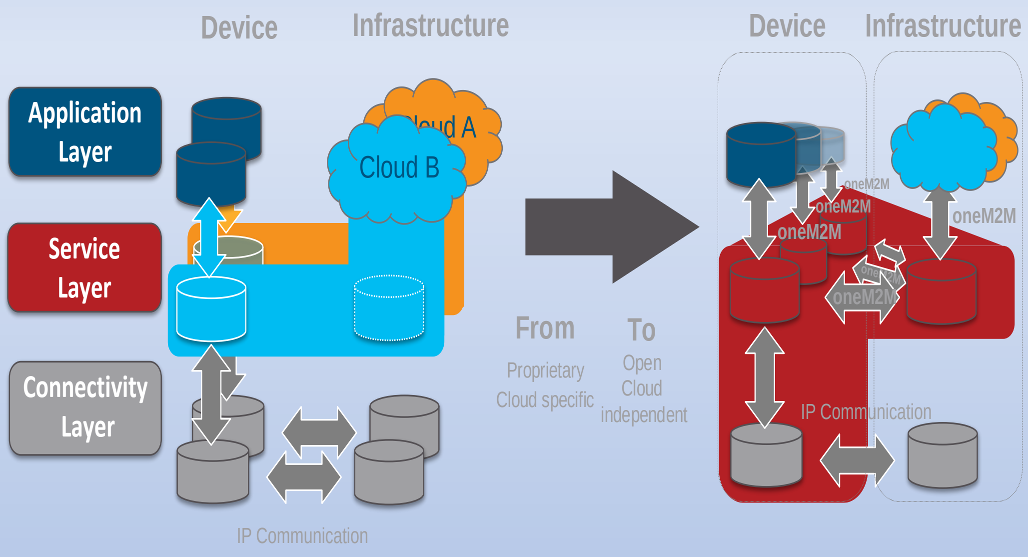


Figure 5.1.1-3: Cloud provider independent

Several implementation options for the placement of the oneM2M IN-CSE relative to the SCEF and the underlying 3GPP network are envisioned. In all implementations, the SCEF always resides within 3GPP domain.

In some options the IN-CSE and the SCEF are deployed by a MNO and are both part of the operator domain. In other options the SCEF is part of the 3GPP domain and the IN-CSE is not part of the operator domain.

In all options, services within the IN-CSE may access the network services that are exposed by the SCEF via the T8 reference point APIs.

oneM2M Service Layer (SL) - Horizontal Architecture providing a Common Framework for IoT,

Fig 5.1-1: oneM2M Layered Model

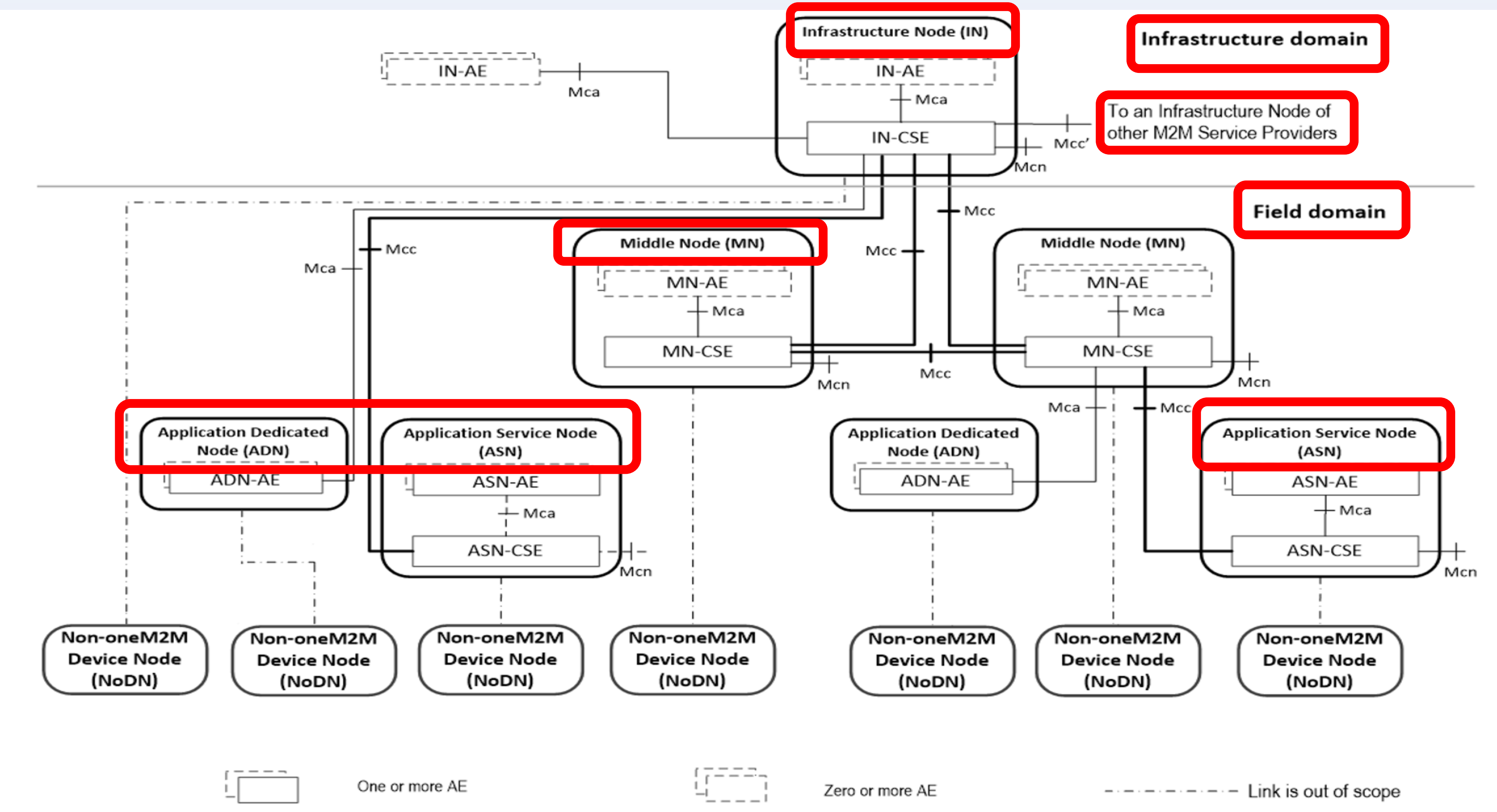


Figure 6.1-1: Configurations supported by oneM2M Architecture

oneM2M Service Layer (SL) - Horizontal Architecture providing a Common Framework for IoT,

oneM2M has identified a **Set of Common Functionalities**, that are **applicable to all the IoT domains**.

Think of these functions as a large toolbox with special tools to solve a number of IoT problems across many different domains. The oneM2M CSFs are applicable to different IoT UCs in different industry domains.

oneM2M has standardized how these Functions are being executed, i.e. is has defined Uniform APIs to access these Functions.

Figure 6.2.0-1 shows a grouping of these Functions into a few different scopes.

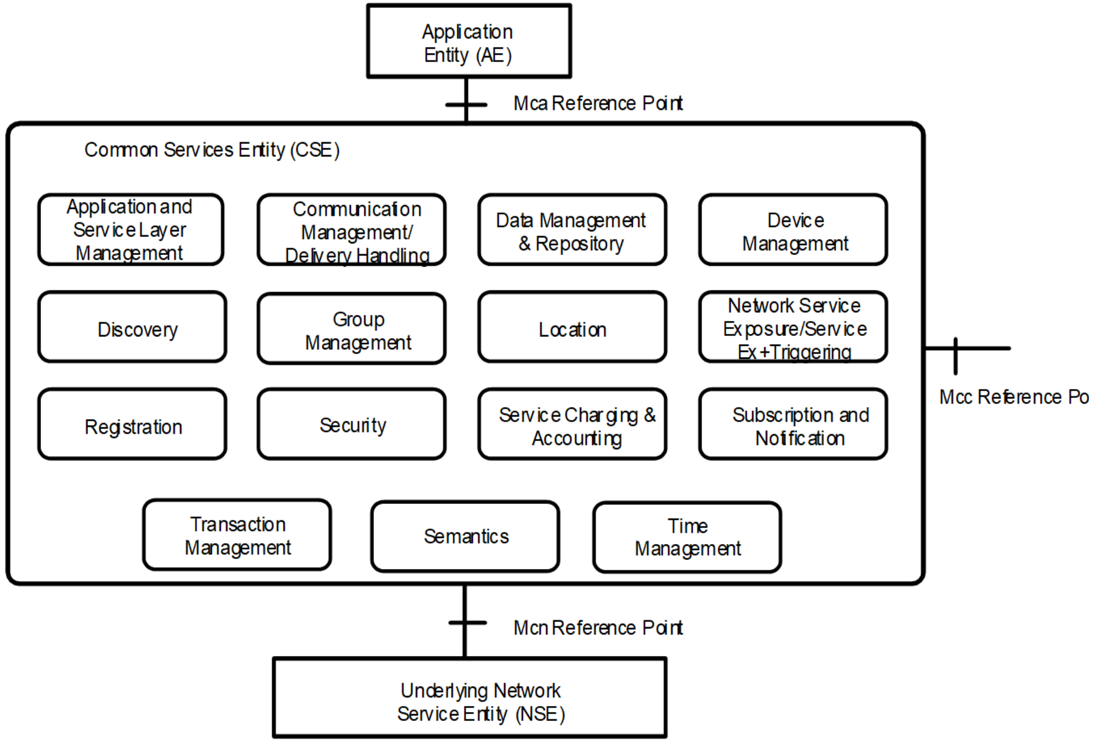


Fig. 6.2.0-1: Common Service Functions

SAREF - Smart Applications REFerence Ontology

SAREF is the Reference Ontology for Smart Applications and contains recurring concepts that are used in several Domains. SAREF has a close relation with the oneM2M Base Ontology, for which a mapping is defined in clause 5.

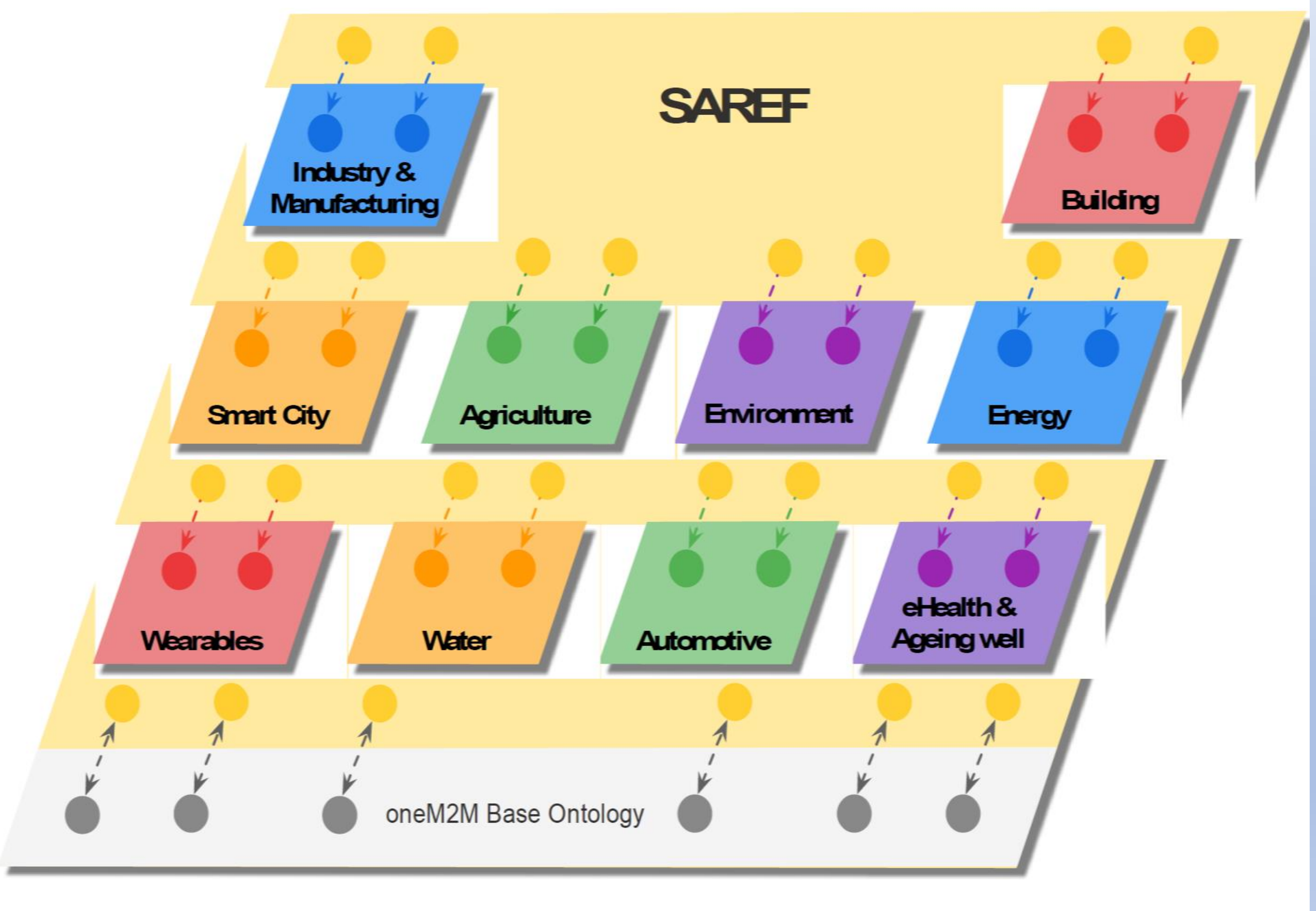


Figure 11: SAREF and its extensions

oneM2M IoT SL Platform Layered Model and Cloud provider Independent

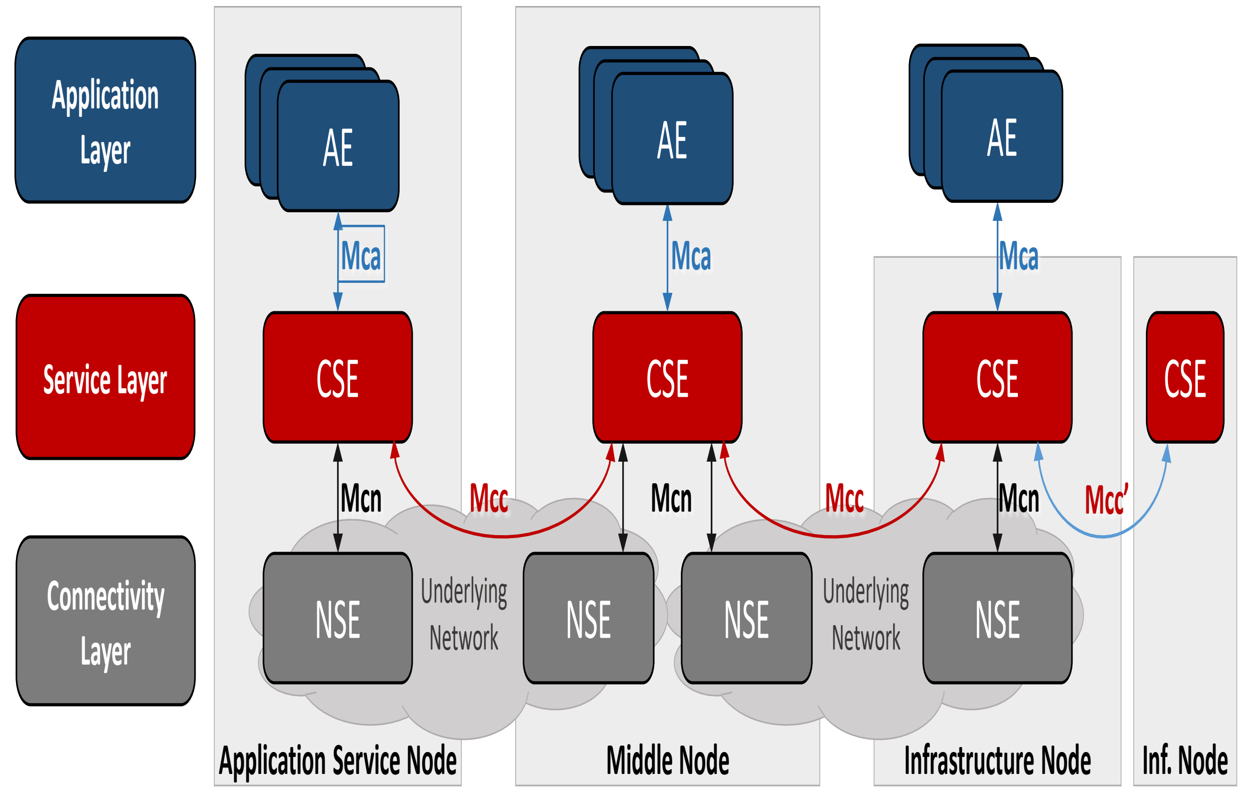


Figure 5.1.2-1: oneM2M Layered Model

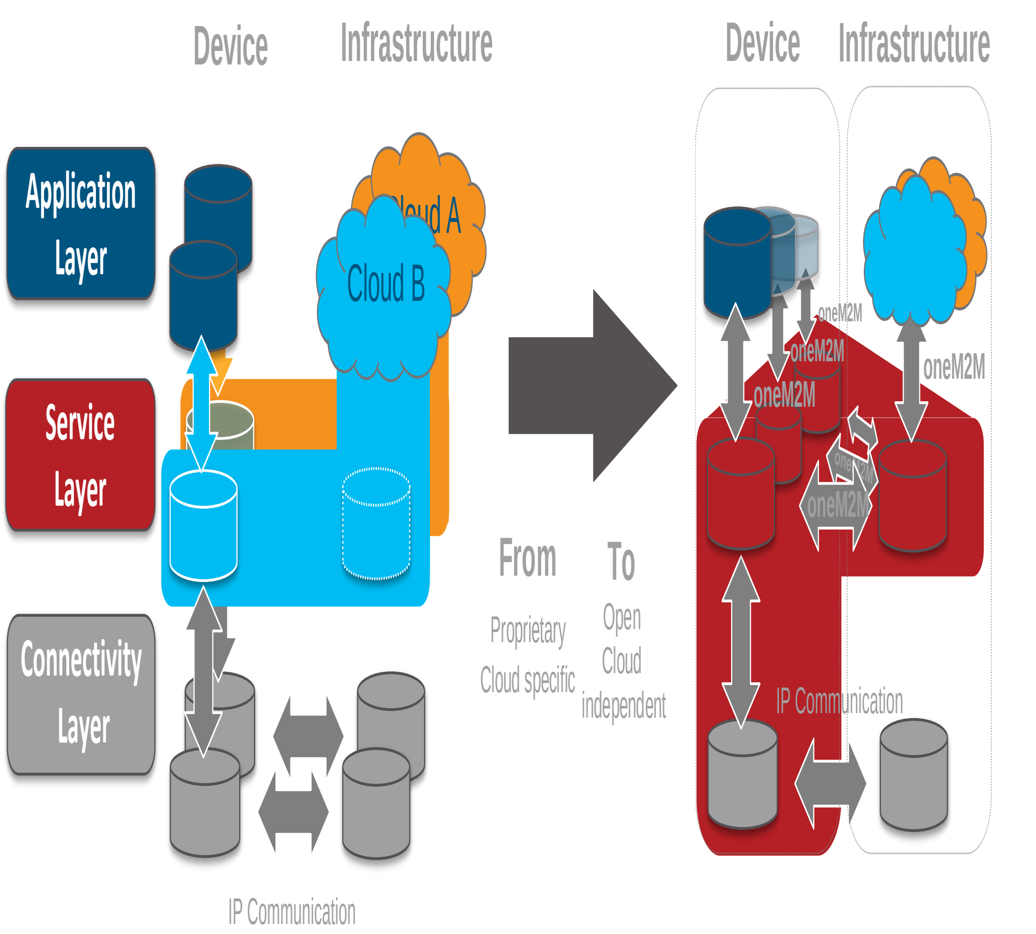


Figure 5.1.1-3: Cloud provider independent

oneM2M Service Layer (SL) - Horizontal Architecture providing a Common Framework for IoT,

Fig 5.1-1: oneM2M Layered Model

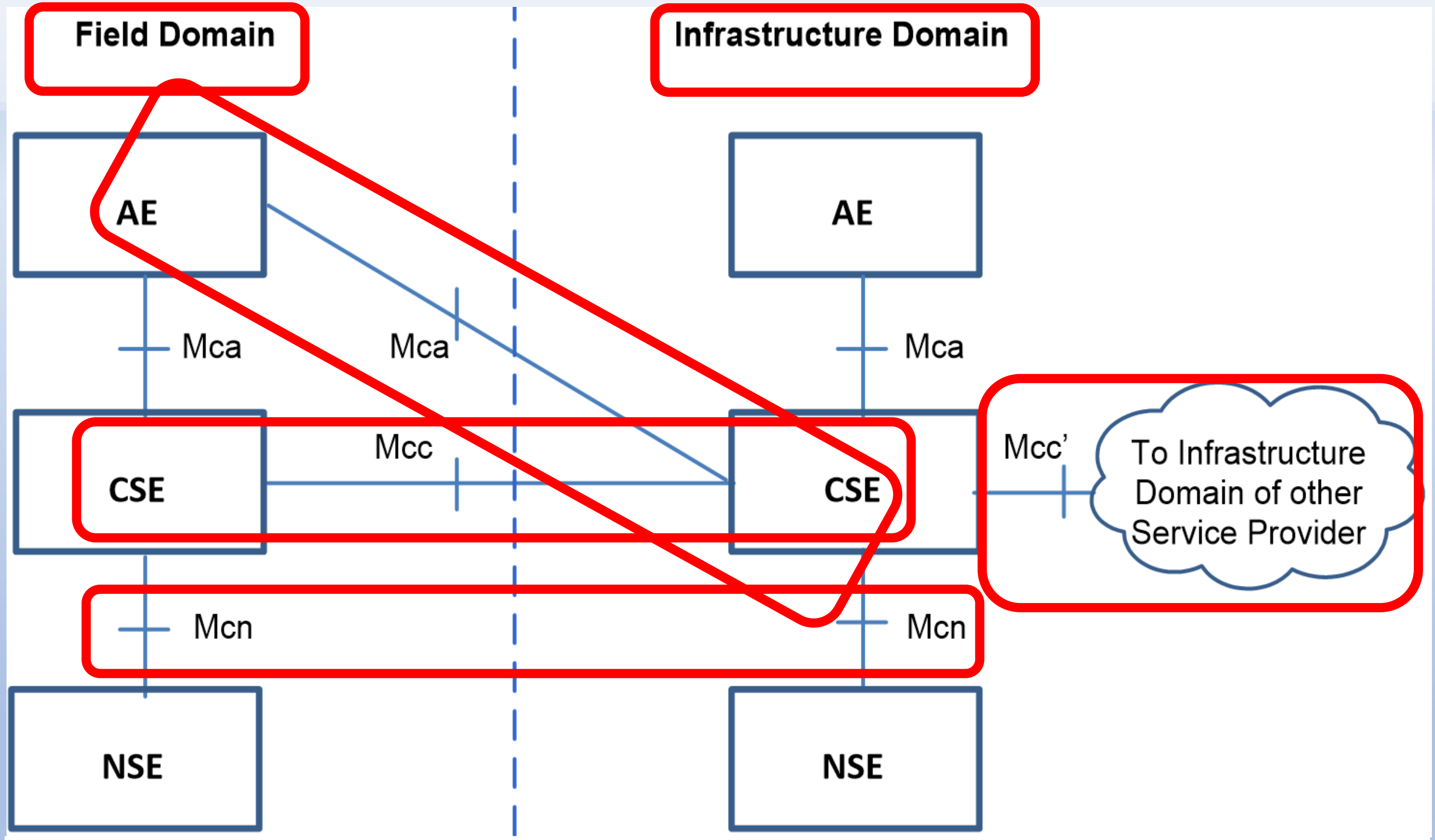
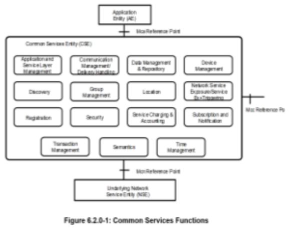


Figure 5.2.1-1: oneM2M Functional Architecture

Ref oneM2M TS 001 Functional Architecture Rel 4 Nov 2020: 23, 26

oneM2M Functional Architecture



6.2 Common Services Functions

This clause describes the services provided by the Common Services Layer in the M2M System. Such services reside within a CSE and are referred to as Common Services Functions (CSFs). The CSFs provide services to the AEs via the Mca reference point and to other CSEs via the Mcc reference point. CSEs interact with the NSE via the Mcn reference point. An instantiation of a CSE in a Node comprises a subset of the CSFs from the CSFs described in the present document.

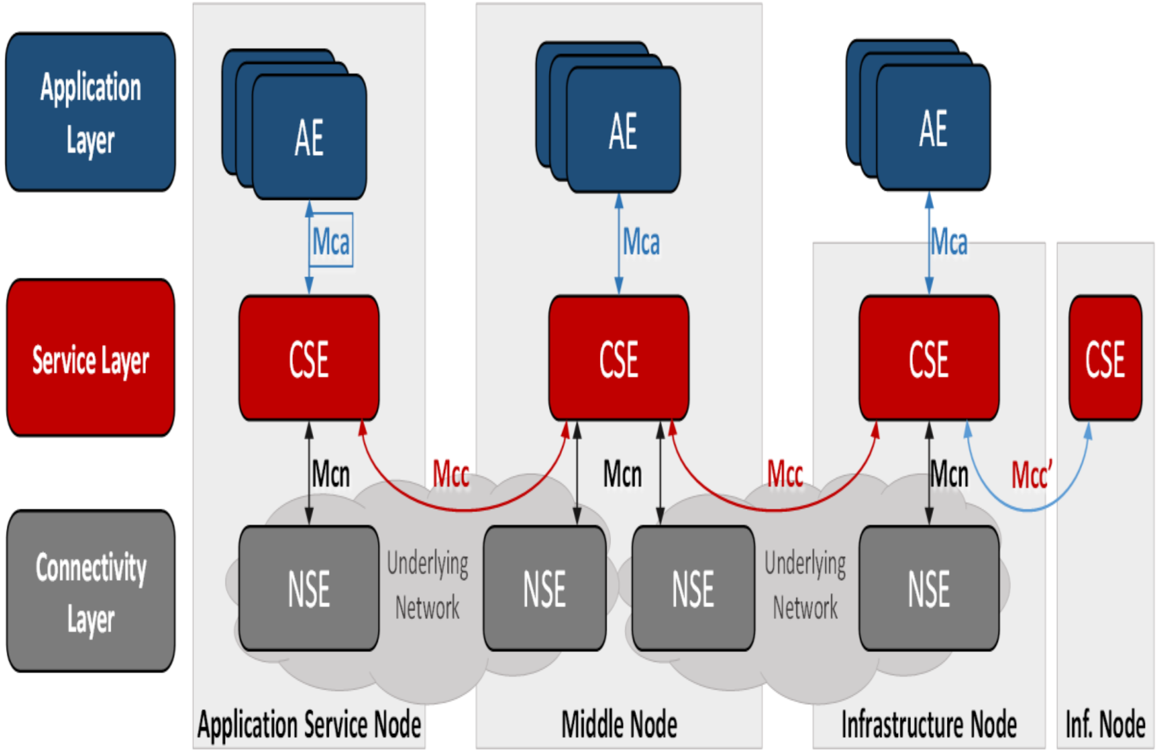


Figure 5.1.2-1: oneM2M Layered Model

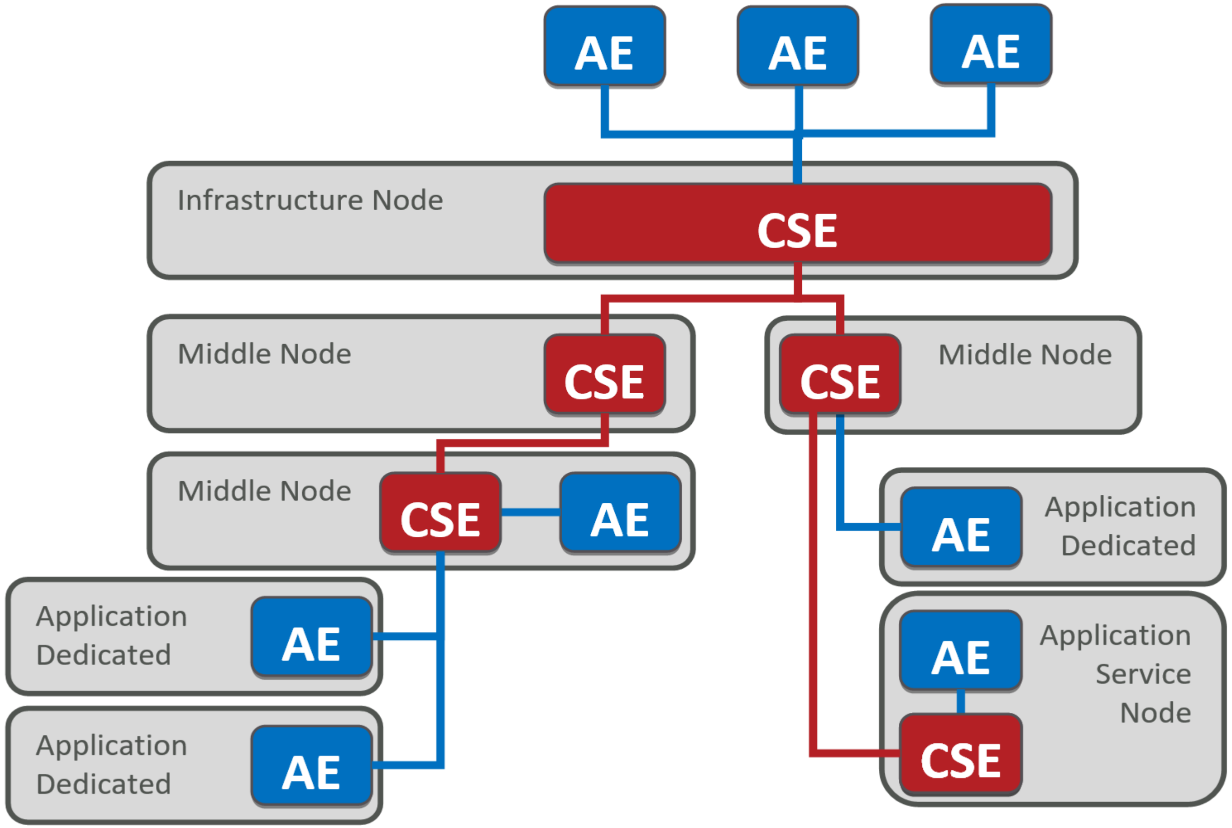
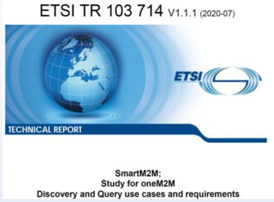


Figure 5.1.2-3: oneM2M node topology

Ref.: oneM2M TR 057 Getting started with oneM2M: May 2019: 10-12



Semantic discovery in presence of a "Network" of M2M Service Providers (M2MSPs)

The oneM2M system should integrate already Standardized Ontology extensions to the current oneM2M Ontology to cope with new specific domains (e.g. SAREF Core and its extensions SAREF4BLDG, SAREF4ENVI, SAREF4ENERGY , SAREF4CITY, SAREF4AGRI, SAREF4WATER

2) Based on Semantic information, the oneM2M System shall take routing decisions for forwarding a received ASDQ. The semantic information will allow the oneM2M system to maximize and to accelerate the semantic discovery process.

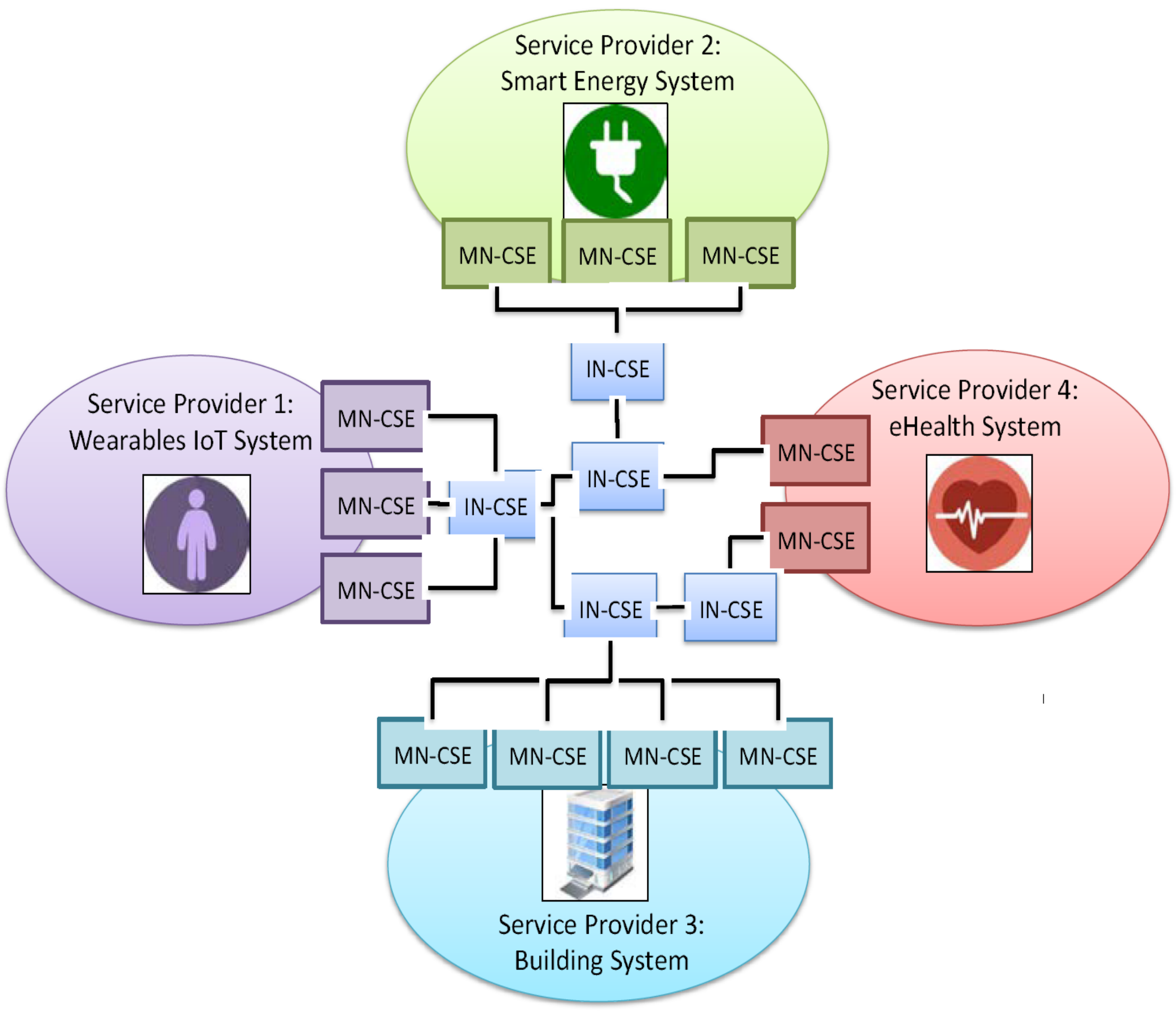


Figure 6.9-1: Semantic Recommendation in CSEs for Discovery

ETSI SmartM2M TR 103 714 Discovery & Query UCs & Requirem July 2020: 20

Semantic discovery in presence of a "Network" of M2M Service Providers (M2MSPs)

ASD within distributed network of CSEs belonging a single Service Provider & across different IoT Service Providers.

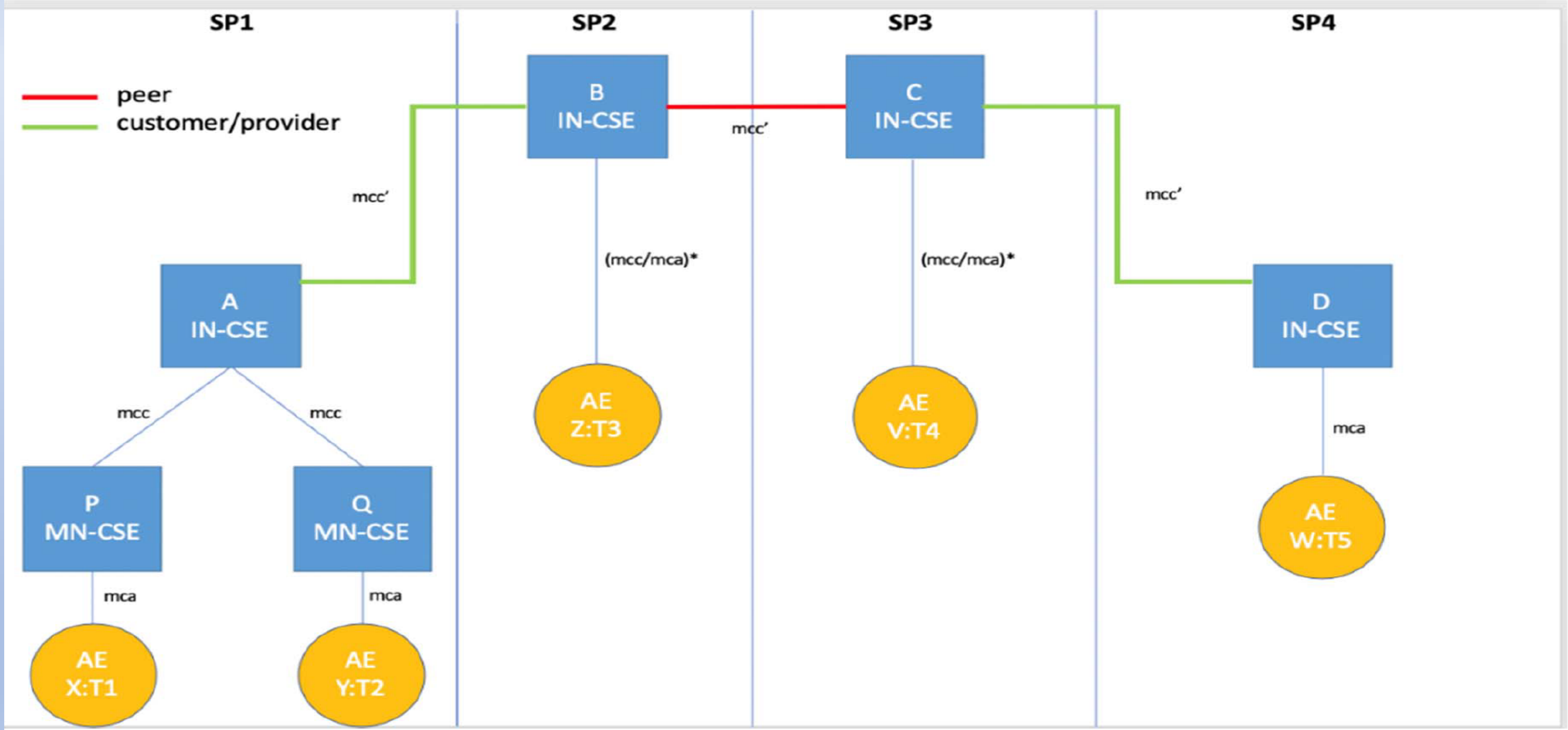


Figure 5.4-1: Pre-condition topology

5 Use Case - Semantic discovery in presence of a "network" of M2M SP

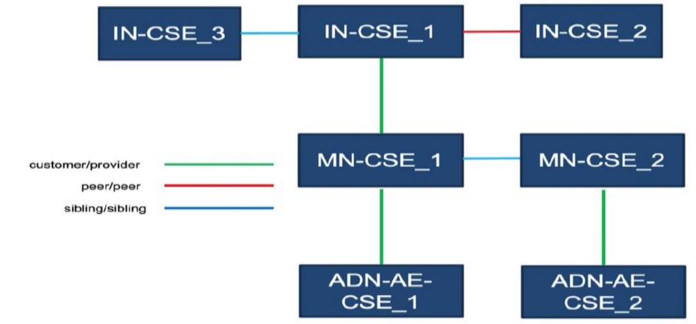


Figure 7.2.1-1: C2P and P2P and S2S CSE relationships

Table 7.2.6-2: Upgrading the adjacent SRT CSEs with the new y AE-THERMOMETERS

CSEcust1 TYPE	URI	CSE CUSTOMERS	CSE PEERS	CSE PROVIDERS
THERMOMETER	URI_v, URI_w	...	...	(CSE, #_+y)

CSEcust2 TYPE	URI	CSE CUSTOMERS	CSE PEERS	CSE PROVIDERS
THERMOMETER	URI_z	...	...	(CSE, #_+y)

CSEpeer TYPE	URI	CSE CUSTOMERS	CSE PEERS	CSE PROVIDERS
THERMOMETER	URI_a	...	(CSE, #_+y)	...

CSEprov TYPE	URI	CSE CUSTOMERS	CSE PEERS	CSE PROVIDERS
THERMOMETER	URI_b, URI_c, URI_d	(CSE, #_+y)	...	...

Table 7.2.7-1: SRT with Recommendation System

TYPE	BUCKETS[TYPE]	CSE CUSTOMERS	CSE PEERS	CSE PROVIDERS
THERMOMETER	CSE_1 ... CSE_q	(CSE_1, #cu_1) ... (CSE_x, #cu_m)	(CSE_1, #pe_1) ... (CSE_y, #pe_m)	(CSE_1, #pr_1) ... (CSE_z, #pr_m)
WATER_VALVE	CSE_1 ... CSE_r	(CSE_1, #cu_1) ... (CSE_x, #cu_n)	(CSE_1, #pe_1) ... (CSE_y, #pe_n)	(CSE_1, #pr_1) ... (CSE_z, #pr_n)
AIR_POLLUTION_STATION	CSE_1 ... CSE_s	(CSE_1, #cu_1) ... (CSE_x, #cu_p)	(CSE_1, #pe_1) ... (CSE_y, #pe_p)	(CSE_1, #pr_1) ... (CSE_z, #pr_p)

5 Use Case - Semantic discovery in presence of a "Network" of M2M Service Providers (M2MSP)

7.10 Potential Requirements for the oneM2M system

The following potential requirements are additional to the ones already identified in clauses 5 and 6.

1) Advanced Semantic Discovery shall support queries written with specific domain ontologies, e.g. SAREF.

2) Advanced Semantic Discovery shall support semantic reasoning between the baseline oneM2M ontology and the identified domain specific ontologies, e.g. SAREF. As example, if a query is looking for a oneM2M device observing Celsius temperature, then the Advanced Semantic Discovery would potentially return a SAREF temperature sensor.

3) Advanced Semantic Discovery shall provide capabilities to identify multiple set of targets, and a multiplicity of searches (e.g. by setting parameters or filters).

4) The oneM2M Access Control Policy shall include discovery permissions to support Advanced Semantic Discovery. When an Advanced Semantic Discovery is performed by the oneM2M System, it shall operate according to the indications associated with the desired information.

It is also expected that:

- The solution would be based an evolution of the current oneM2M architecture and functionality and would reuse existing standard ontology mechanisms e.g. considering the SAREF standard developed in ETSI TC SmartM2M (which is also aligned with the W3C ontology approach). This intends to assure also a smooth interworking with relevant non-oneM2M solutions.

- The solution would be complete and will be a part of the oneM2M core functions, to avoid the need of ad hoc applications designed to expand the oneM2M functionality with the risk of being implemented with different flavours.

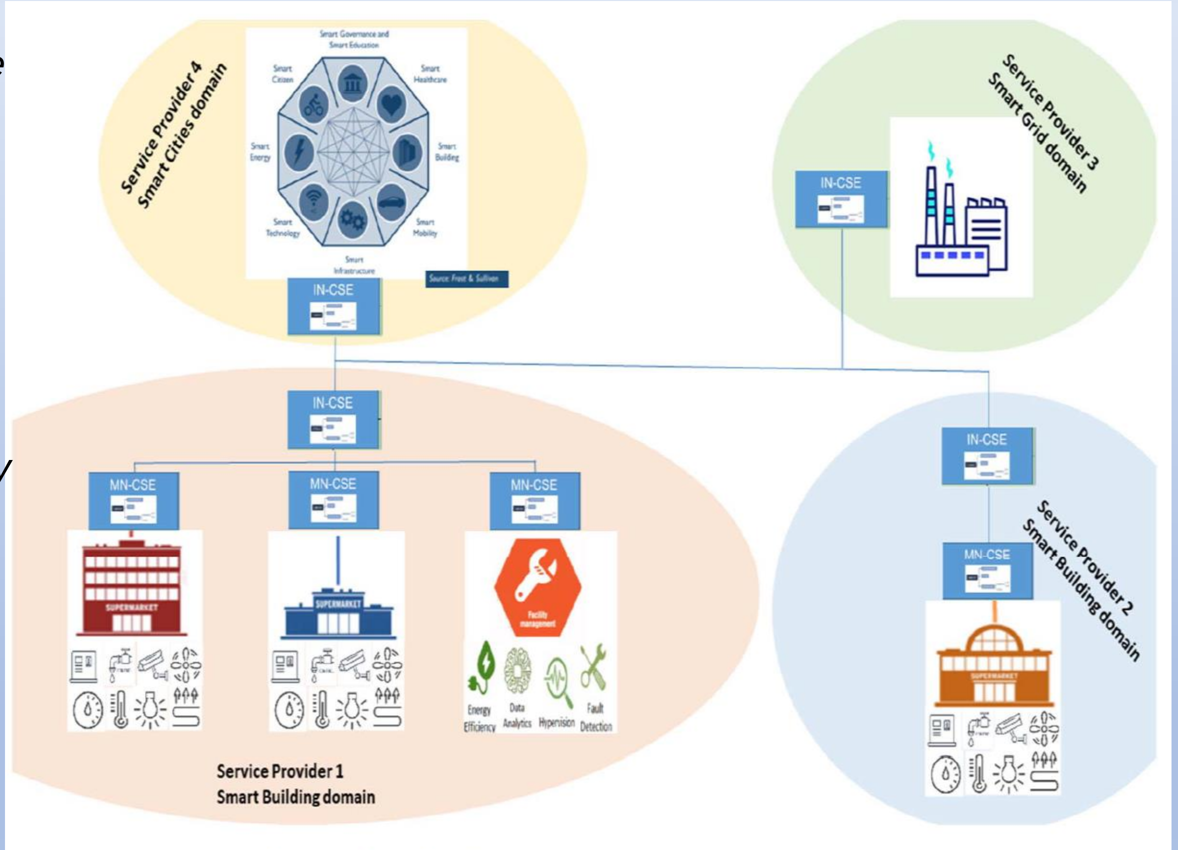


Figure 7.9-1: Facility management of a supermarket chain

ETSI SmartM2M TR 103 714 Discovery & Query UCs & Requirem July 2020: 23

5 Use Case - Semantic discovery in presence of a "network" of M2M Service Providers (M2MSP)

8 Use Case - Healthcare network and clinical knowledge administration

This use case looks at the semantic discovery requirements through a networking environment between people with disease (patients), the elderly, who want to live an independent life while remaining in their homes, special invalid people with a high risk of falling in their homes, doctors/care taking people, people practicing fitness exercises to improve their health, and institutions/organizations, who manage a clinical knowledge & information data basis or analyses of patient data.

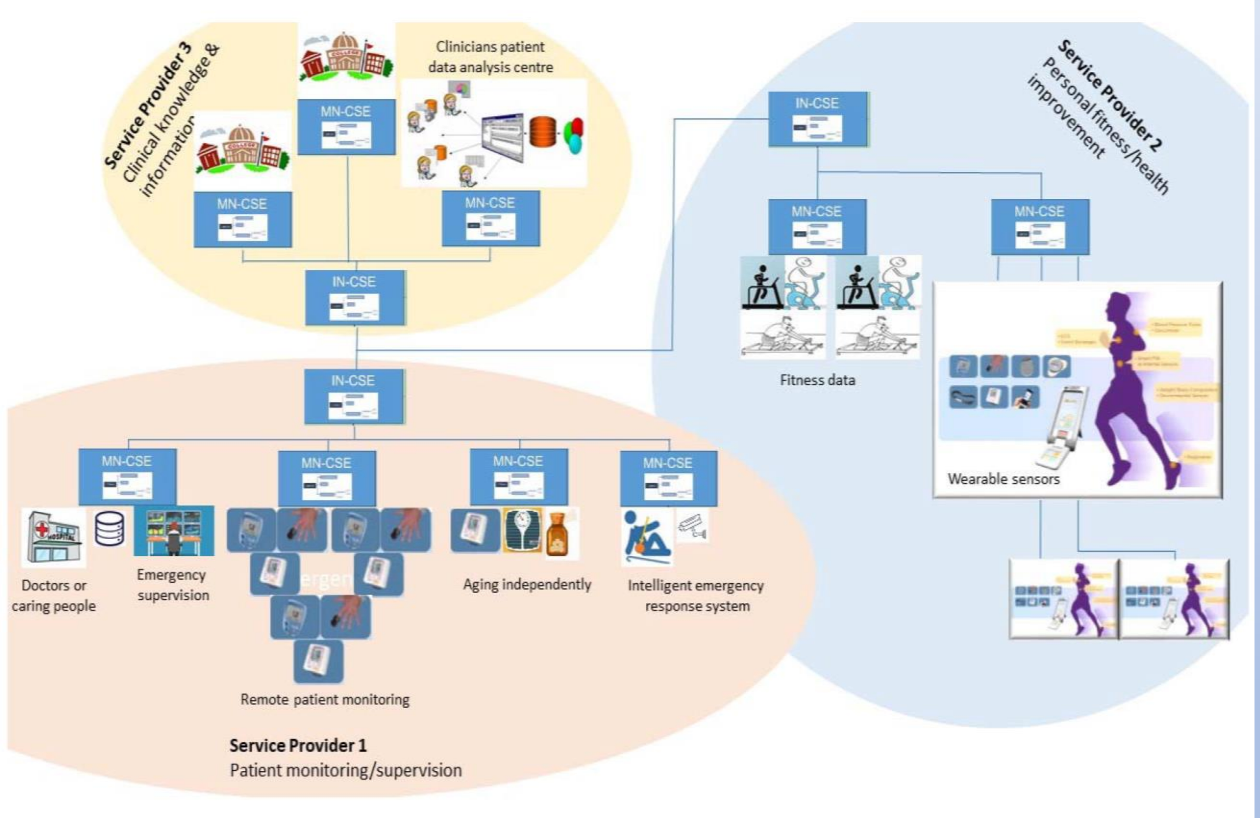
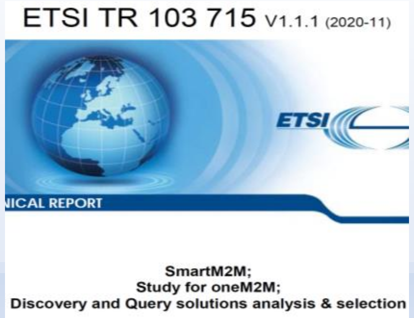


Figure 8.9-1: Healthcare network and clinical knowledge administration

5 Use Case - Semantic discovery in presence of a "network" of M2M Service Providers (M2MS


ETSI TR 103 715 V1.1.1 (2020-11)

ETSI

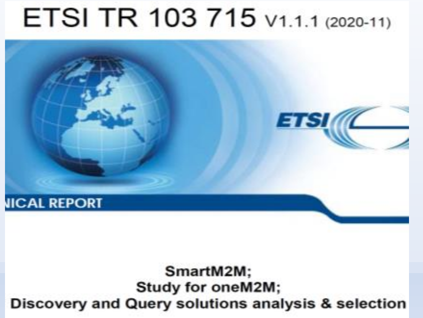
NICAL REPORT

SmartM2M;
Study for oneM2M;
Discovery and Query solutions analysis & selection

5 Use Case - Semantic discovery in presence of a "network" of M2M Service Providers (M2MS

5.2 Resource in oneM2M

5.2.1 Resource involved in Semantic Resource Descriptor



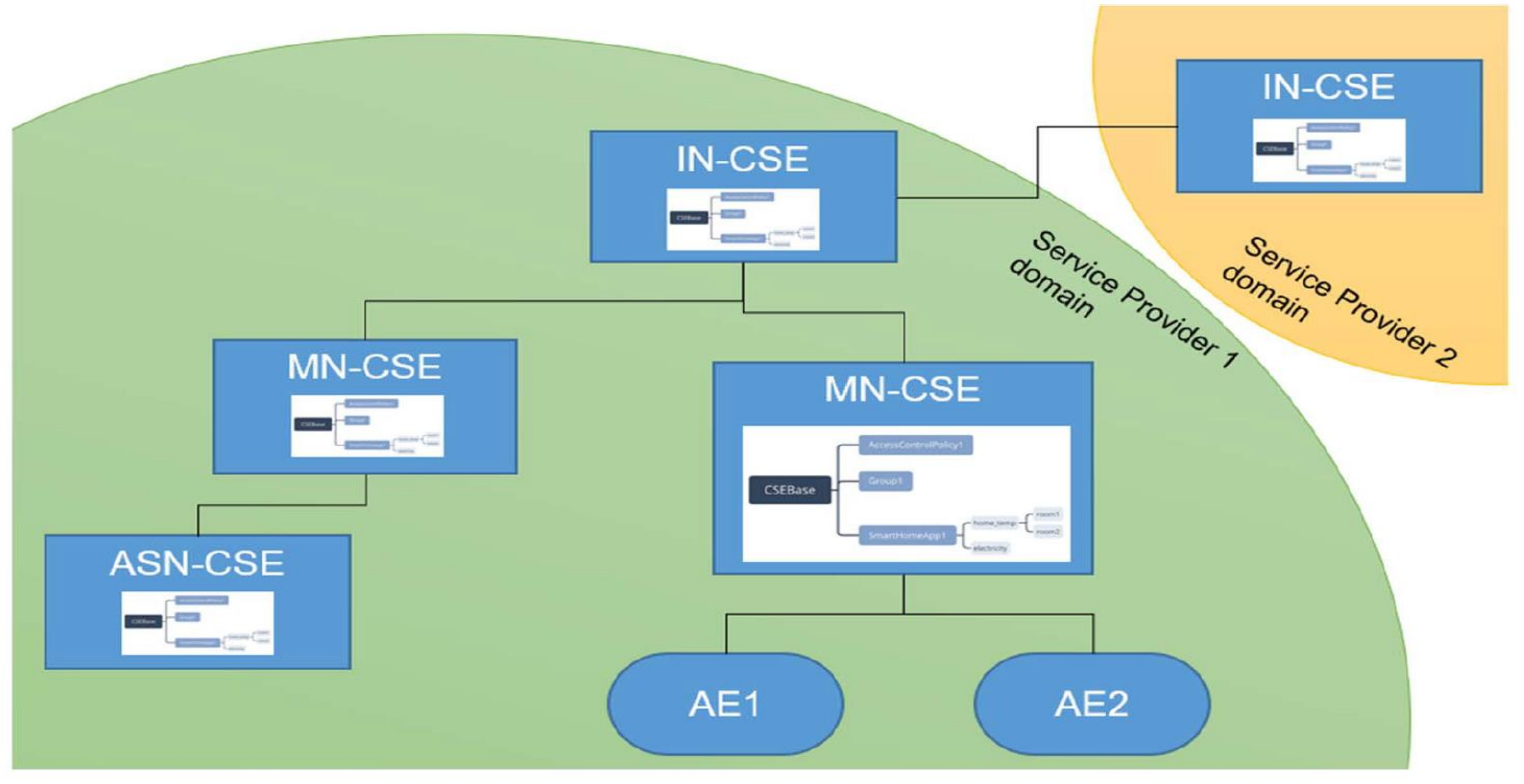
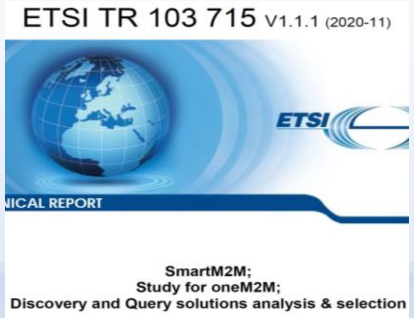


Figure 5.2.2-1: Platform and resource distribution in oneM2M



5 Use Case - Semantic discovery in presence of a "network" of M2M Service Providers (M2MS

5.2 Resource in oneM2M

5.2.1 Resource involved in Semantic Resource Descriptor

5.3 Discovery query languages

5.3.1 oneM2M syntactic discovery query language

Figure 5.3.1-1 provides the resource tree and discovery example. In the diagram, the discovery arrow illustrates that the discovery request targets "Humidity" resource and it contains the **Filter Criteria** (short name "fc"). Then the resources that apply the discovery will be the two as child and grandchild of the "Humidity" resource.

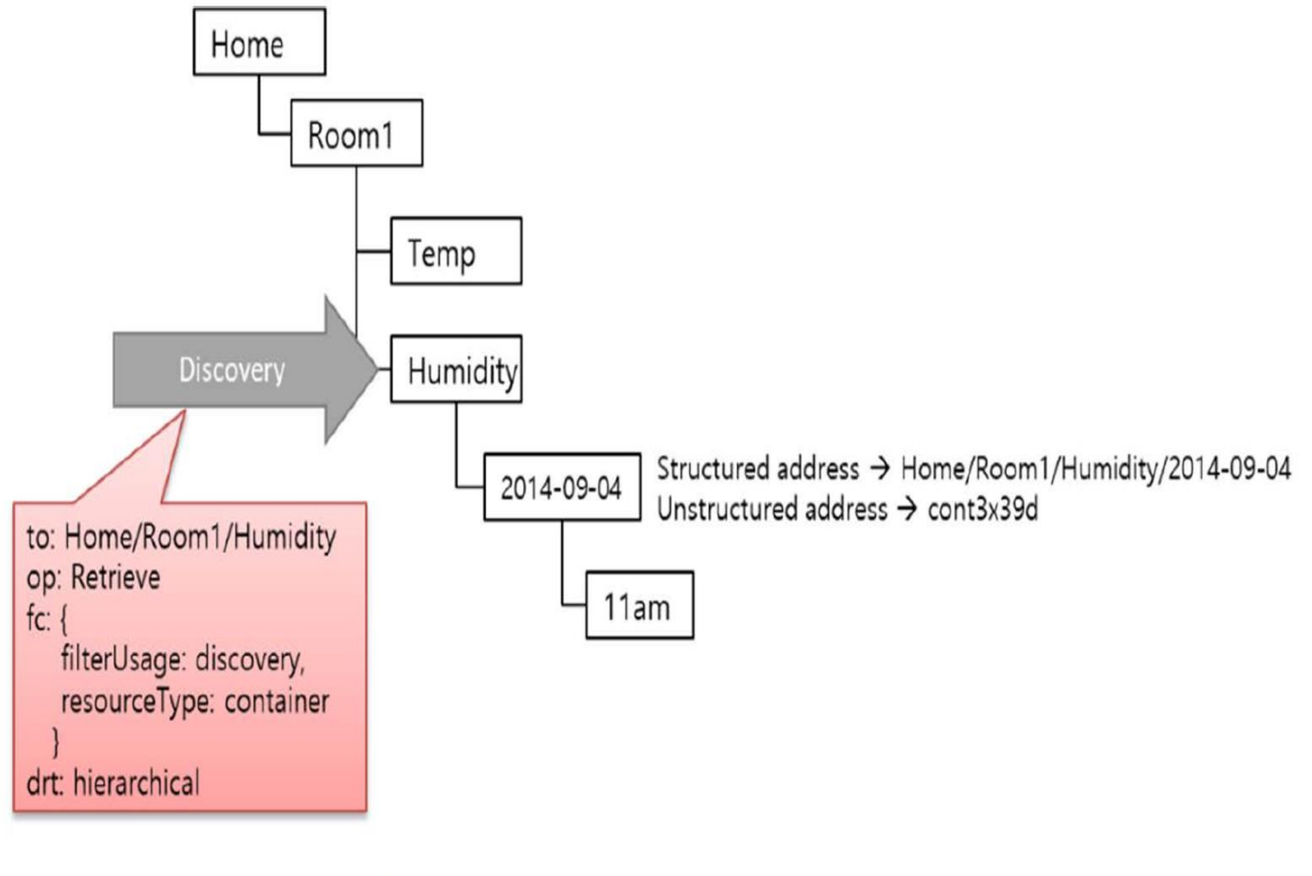
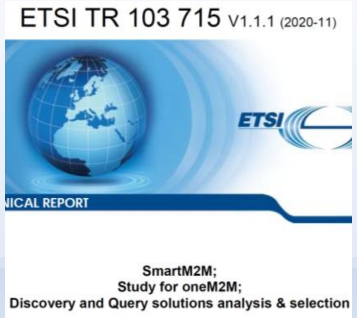


Figure 5.3.1-1: oneM2M resource tree and discovery

Semantic discovery in presence of a "network" of M2M Service Providers (M2MSPs)



Ontologies and their OWL representations are used in oneM2M to provide syntactic and semantic interoperability of the oneM2M System with External Systems.

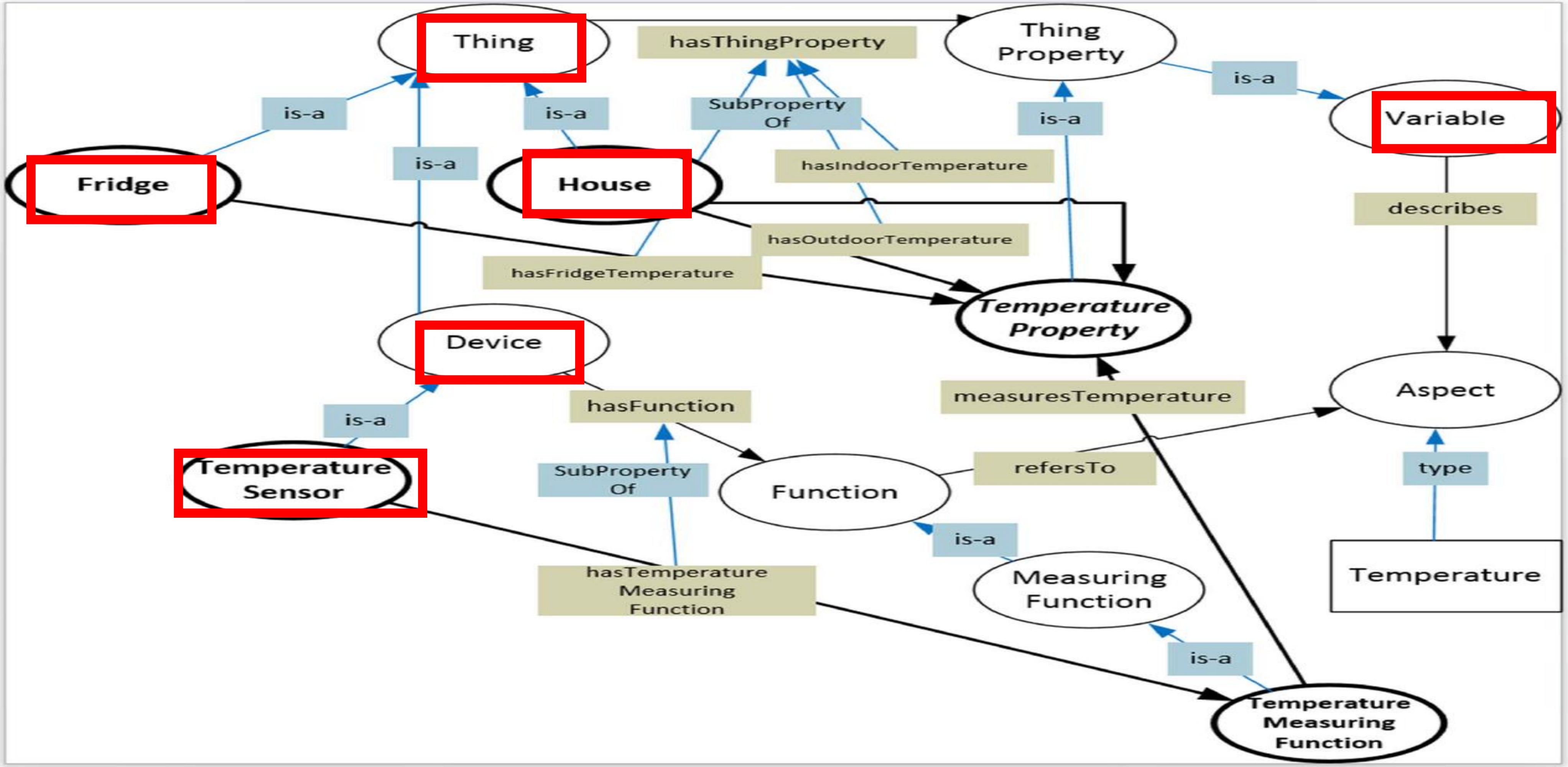


Figure 5.4.1-1: Example of mapping on the oneM2M Base Ontology

5 UC - Semantic discovery in presence of a "network" of M2M Service Providers (M2MS

5.5.3 oneM2M discovery (semantic and non-semantic)

Non-semantic/Syntactic discovery

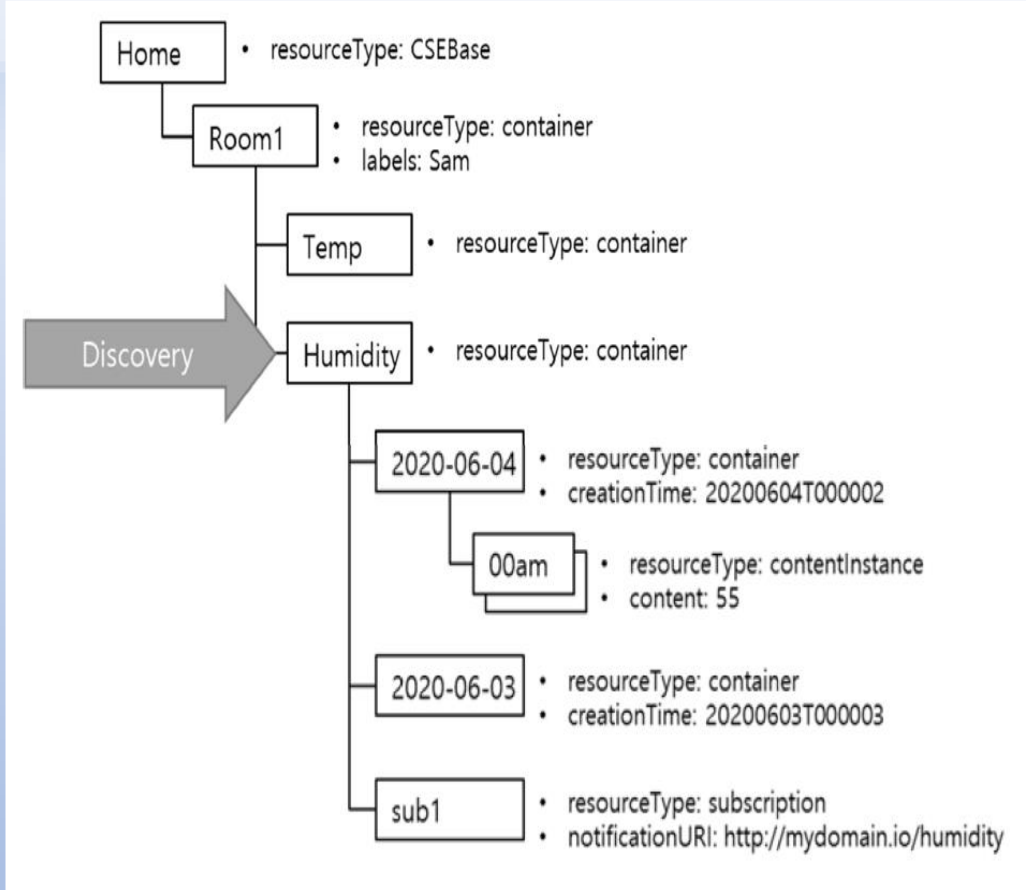


Figure 5.5.3.1-1: oneM2M resource tree example

Semantic discovery

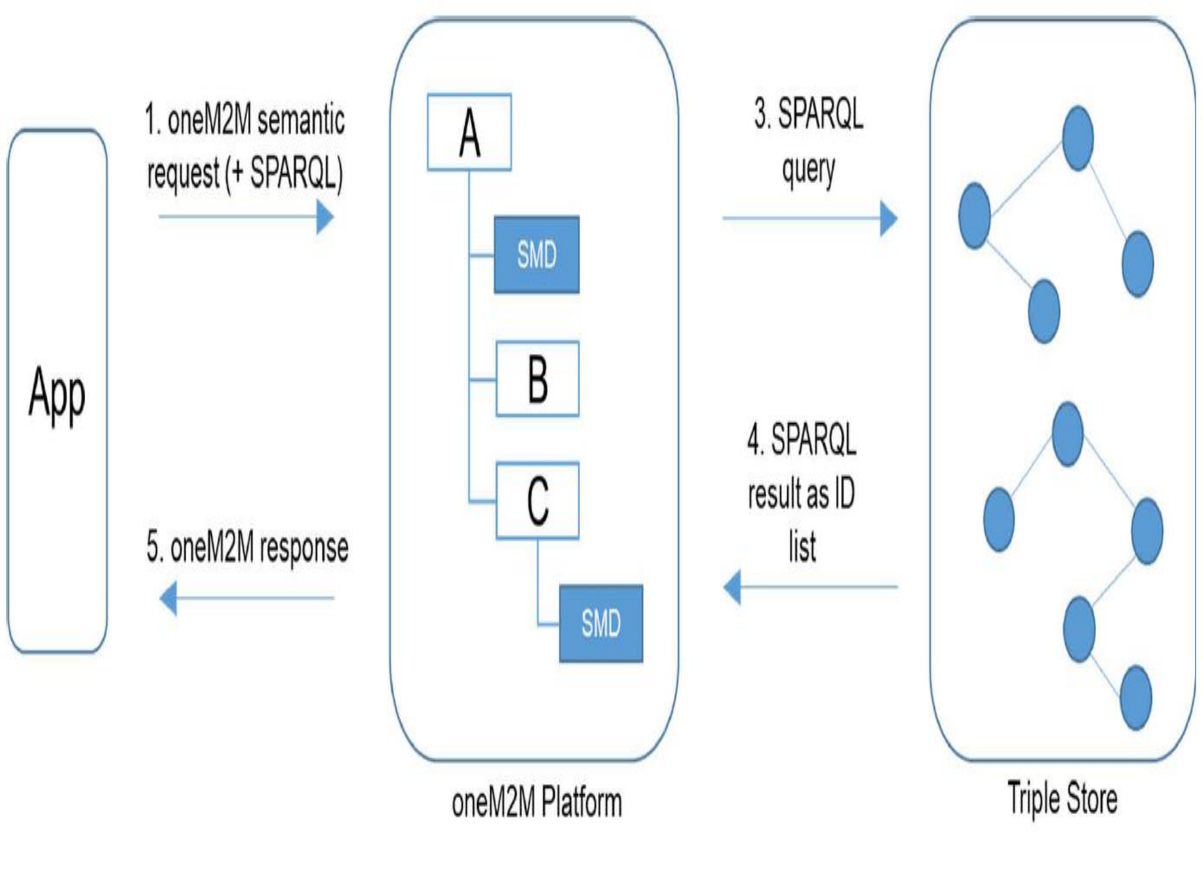
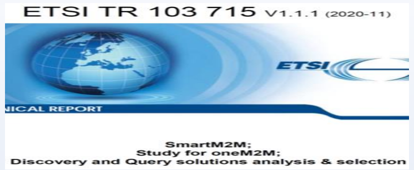


Figure 5.5.3.2-1: oneM2M semantic discovery procedure

Advanced Semantic Discovery (ASD) - 1



Semantic Discovery in presence of a "Network" of M2M Service Providers (M2MSPs)

The Advanced Semantic Discovery aims to discover AEs (also called Resources) that are registered/announced to some CSEs.

The ASD could start from any AE, even these ones not belonging to the same Trusted Domain.

The ASD differs from the usual one present in oneM2M in the sense that one (or many) AE could be searched for even without knowing its identifier, but just knowing its TYPE or ONTOLOGY membership, as shown in Figure 6.3.1-1.

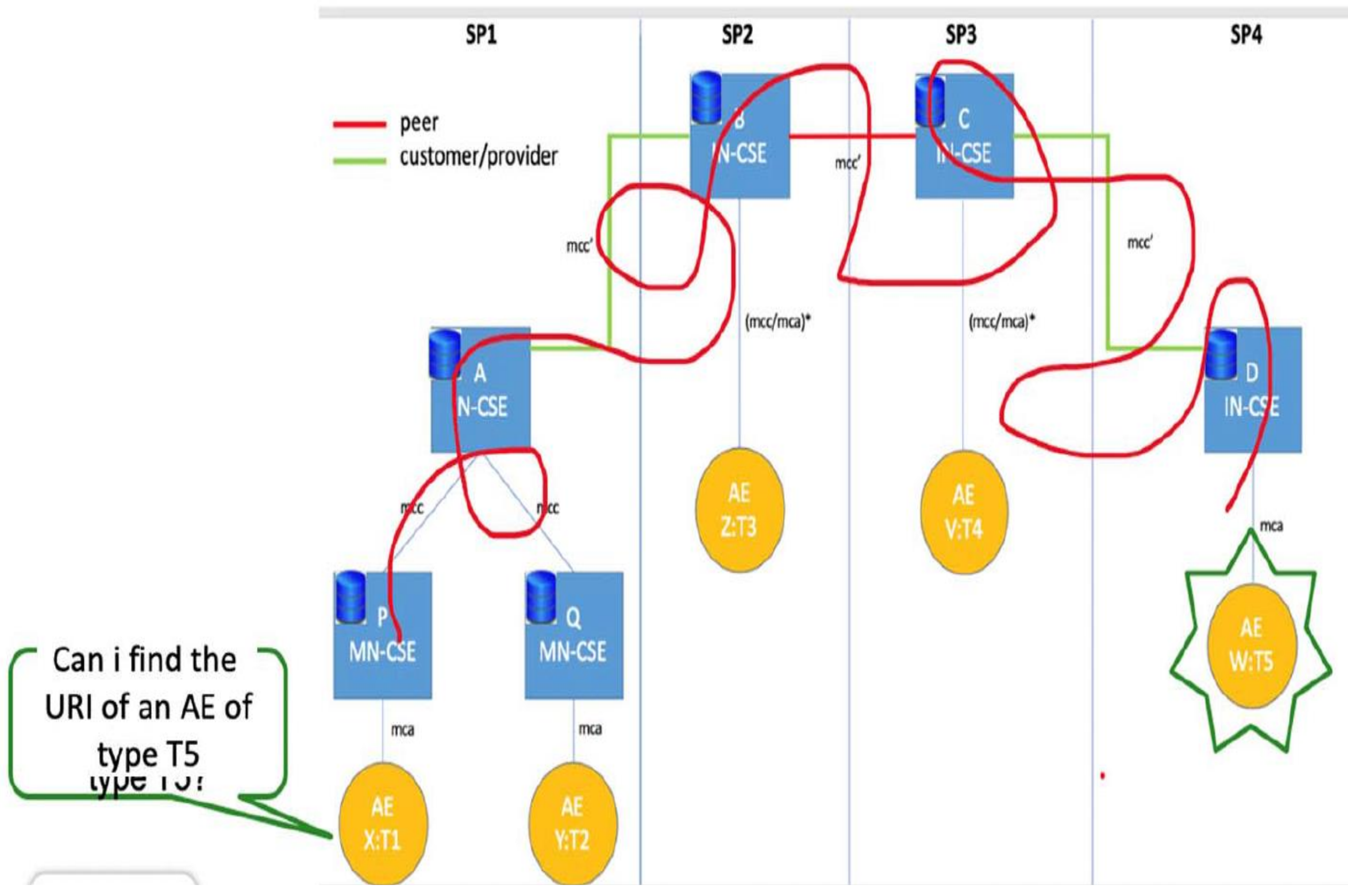
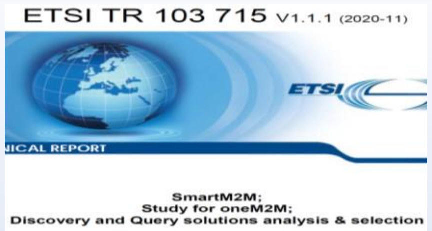


Fig. 6.3.1-1 Advanced Semantic Discovery (ASD) in one image

Semantic discovery in presence of a "network" of M2M Service Providers (M2MSPs) - 2



Advanced Semantic Discovery (ASD)

Figure 6.3.2-1 describes oneM2M as-is Semantic Discovery involving multiple CSEs.

propagated to other CSEs.

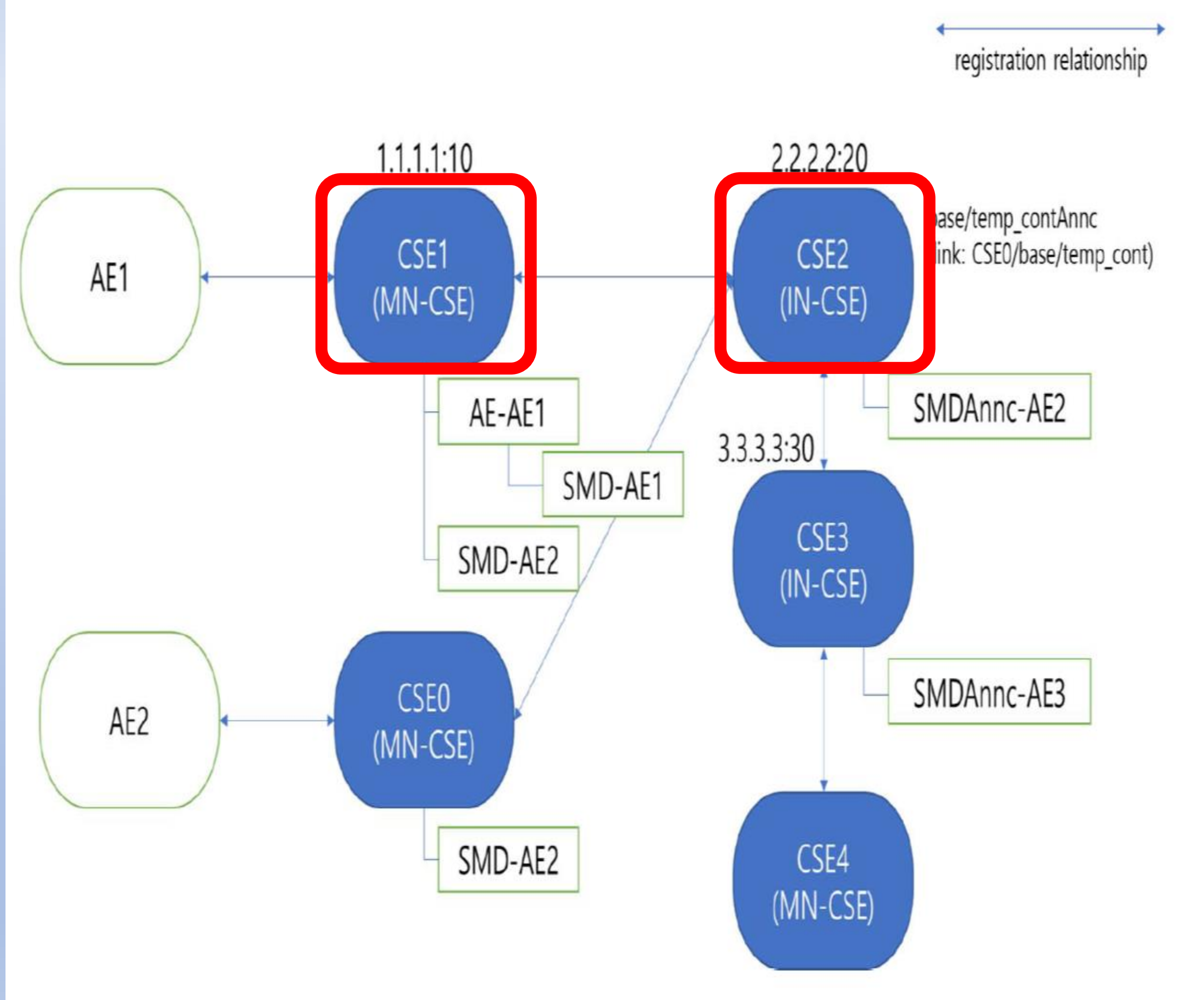


Figure 6.3.2-1: Actual oneM2M limited discovery routing in one slide

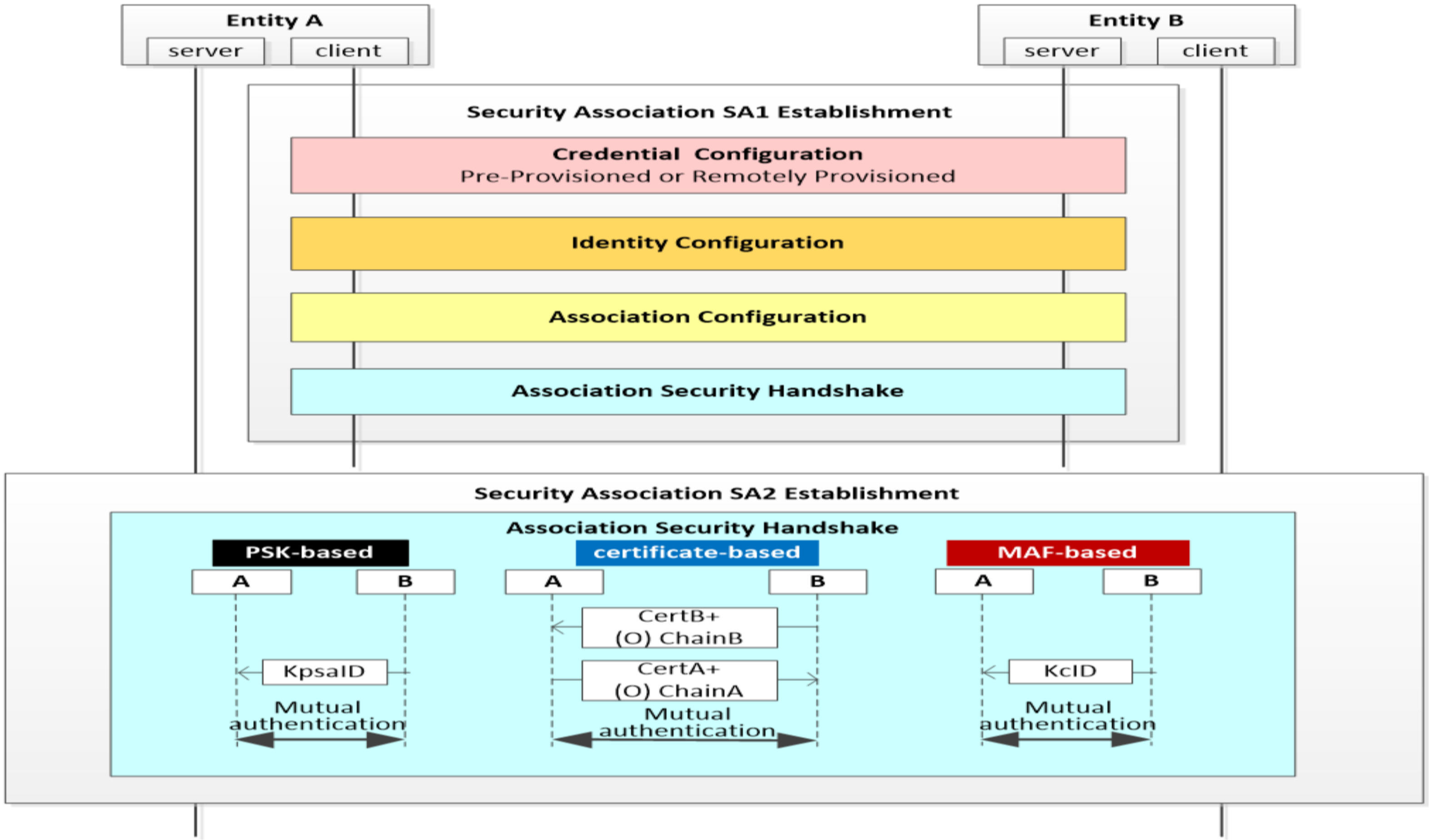


Figure 8.2.1-2: Security Associations for request reachable entities

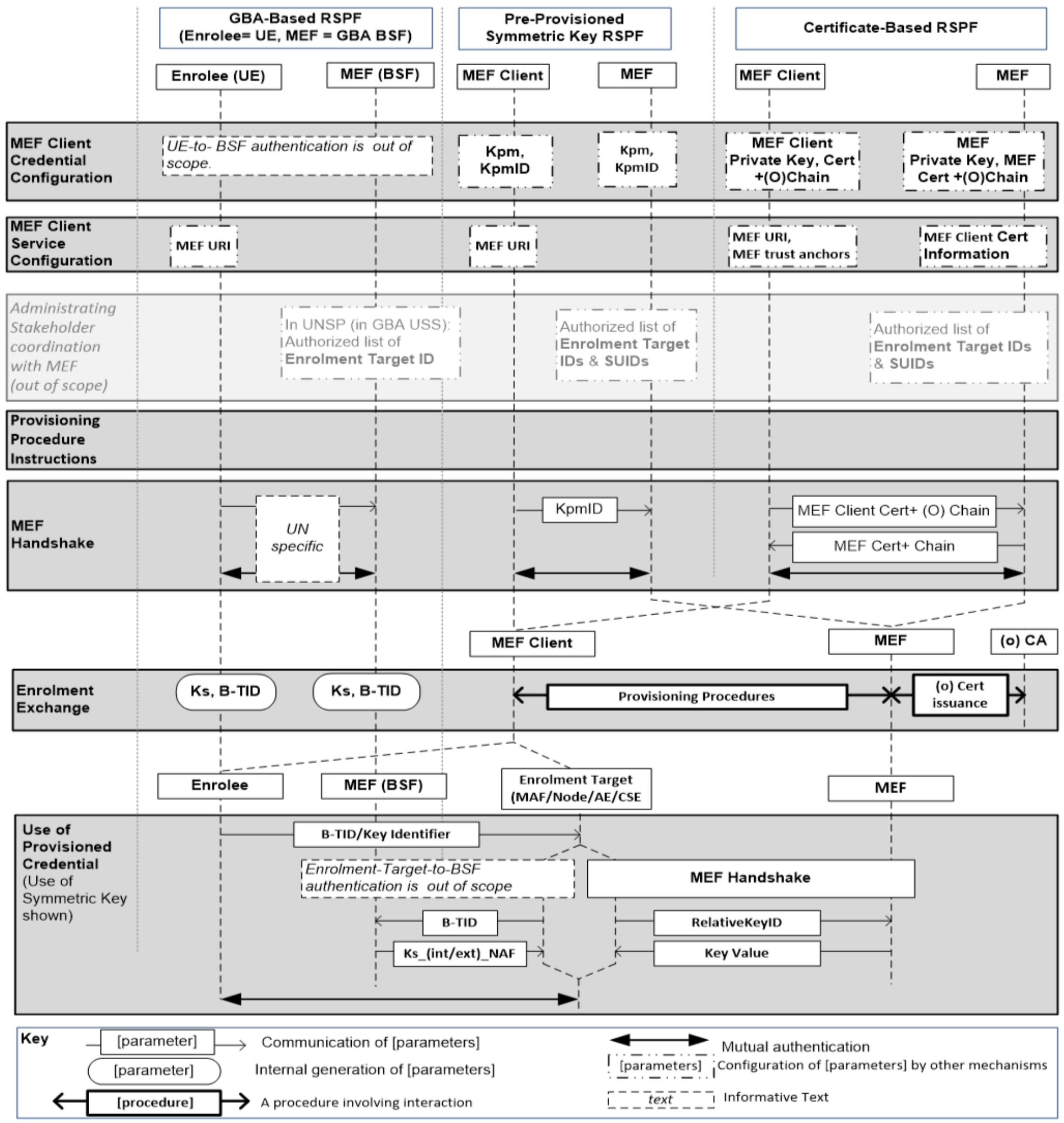


Figure 8.3.1.2-1: Overview of the Remote Security Provisioning Frameworks supported by oneM2M

5 Use Case - Semantic discovery in presence of a "network" of M2M Service Providers (M2MS

Ref ETSI oneM2M ASD webinar Luigi Liguori Jan 2021:

oneM2M Semantic Support and Discovery - Ontology Mapping

The Ontology Mapping Task performed by

=> Create Operation or

⇒ Update Operation against an

⇒ *<ontologyMapping>* resource on a Hosting CSE.

A Retrieve operation against the same *<ontologyMapping>* resource shall be used to get the result of ontology mapping. A Delete operation against a *<ontologyMapping>* resource shall follow the basic procedure as specified in clause [1].

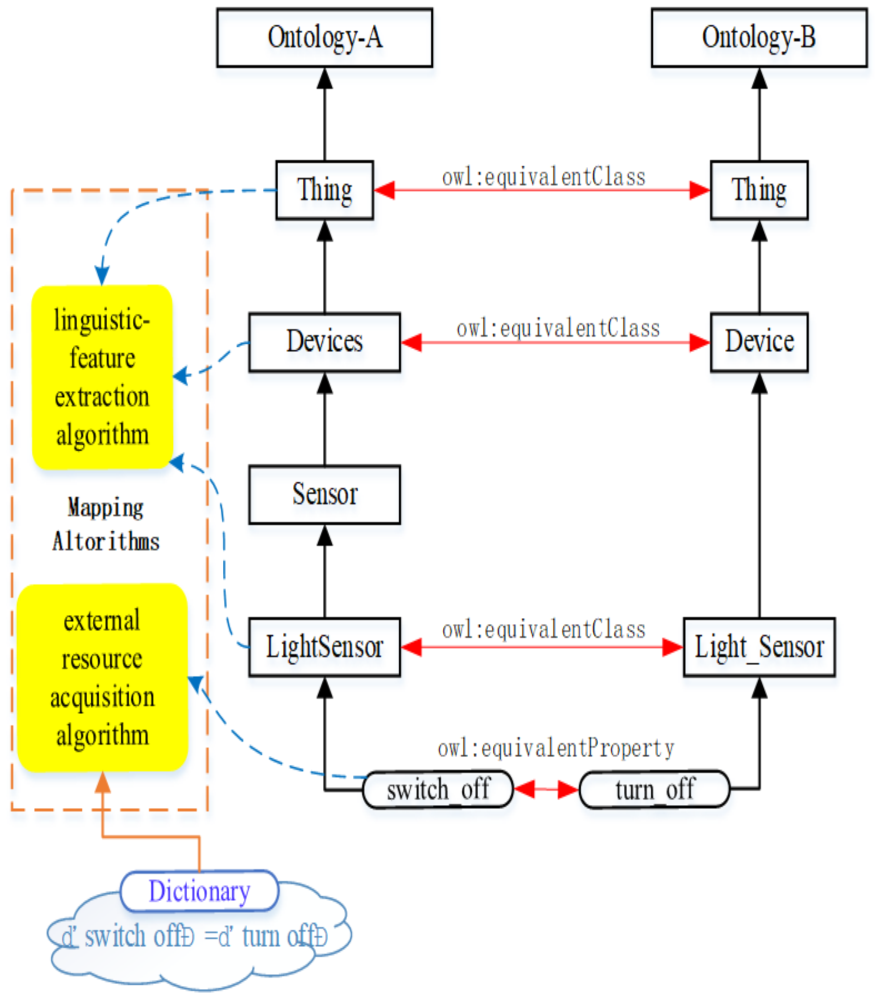


Figure 6.10.2-2: Example of the mapping result between ontology A and ontology B

Ref.: ETSI oneM2M TS 0034 Rel 4 Semantic Support, Jan 2020: 28

Context Information Management CIM - NGSI-LD API

The CIM API allows Users to:

- Provide,
- Consume
- Subscribe

→ **> Context Information**

Close to Real-time Access to Information coming from many different Sources (not only IoT Data Sources).

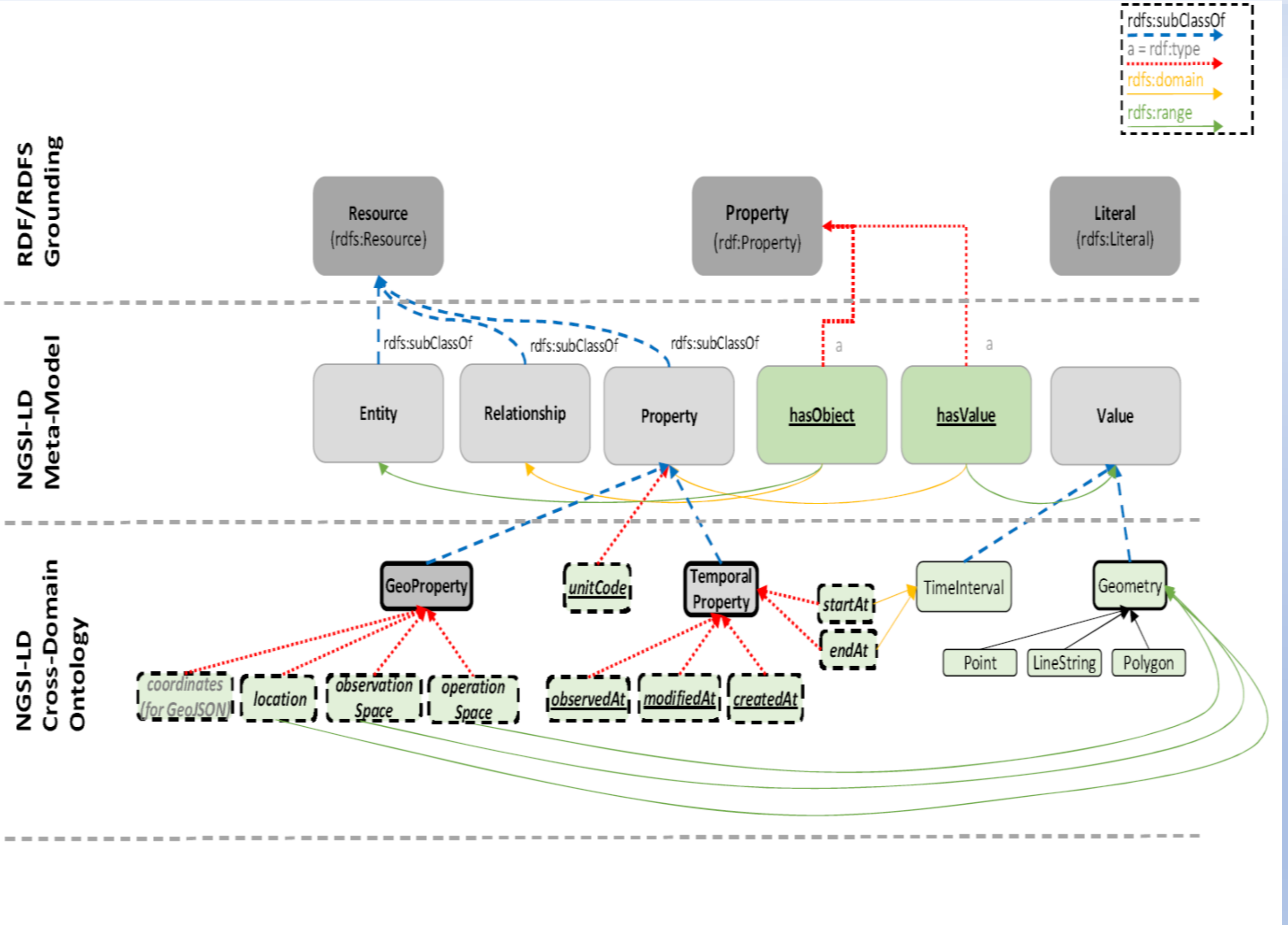


Figure 4.2.3-1: NGSI-LD Core Meta-Model plus the Cross-Domain Ontology

Ref.: : ETSI GS CIM 009 CIM NGSI-LD API, Aug 2020: 15, 24

B.1 Mapping to oneM2M

oneM2M is a partnership project for IoT (originally defined as "machine to machine communication" in the Telecom world). OneM2M provides an OWL ontology that can be partially mapped to the ISG CIM cross-domain ontology, as illustrated in Figure B.1.

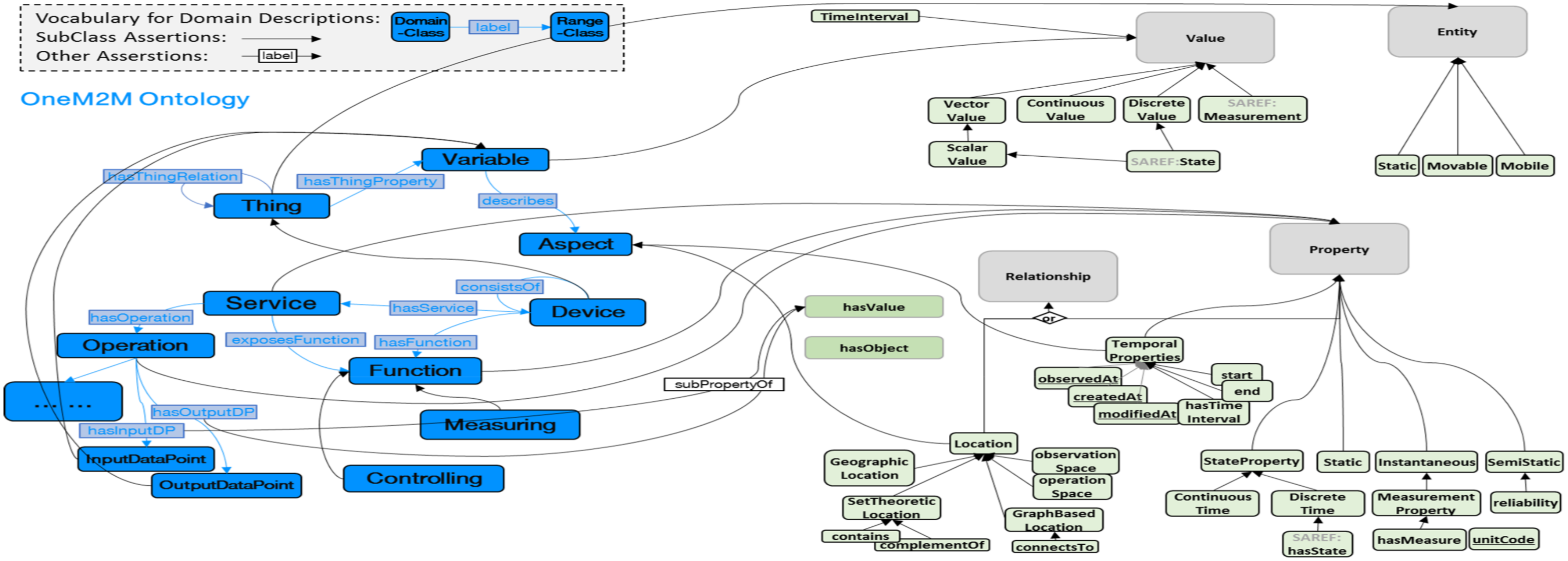


Fig. B. 1: Mapping NGSI - LD Meta - model and Cross-Domain Ontology to oneM2M Base Ontology

ML Classification

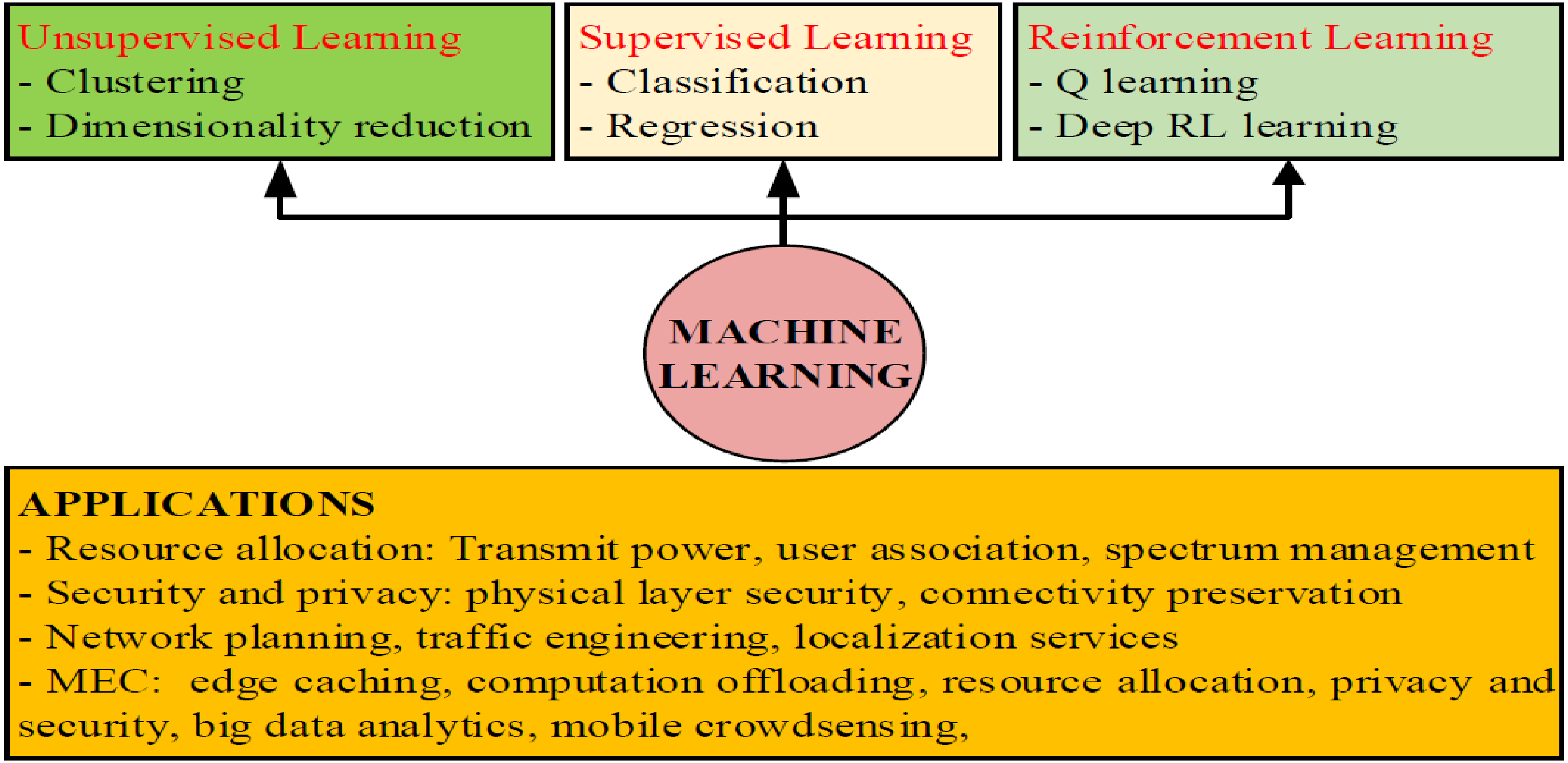


Fig. 11: Classification and applications of ML in mobile and wireless networking.

Ref.: IEEE A Survey of Multi-Access Edge Computing (MEC) in 5G and Beyond, Jan., 2020: 30

Data Processing Chain Machine Learning - (ML)

The life cycle for ML can be considered to have the following Stages:

1) Data acquisition
2) Data curation
3) Model design
4) Software Build
5) Train
6) Test
7) Deployment
8) Updates

Stages 4), 5) and 6) (Build, Train, Test) can together be considered as an iterative implementation cycle.

In the ML lifecycle, the Training phase can be considered as the most critical, since it is this stage that establishes the baseline behaviour of the system.

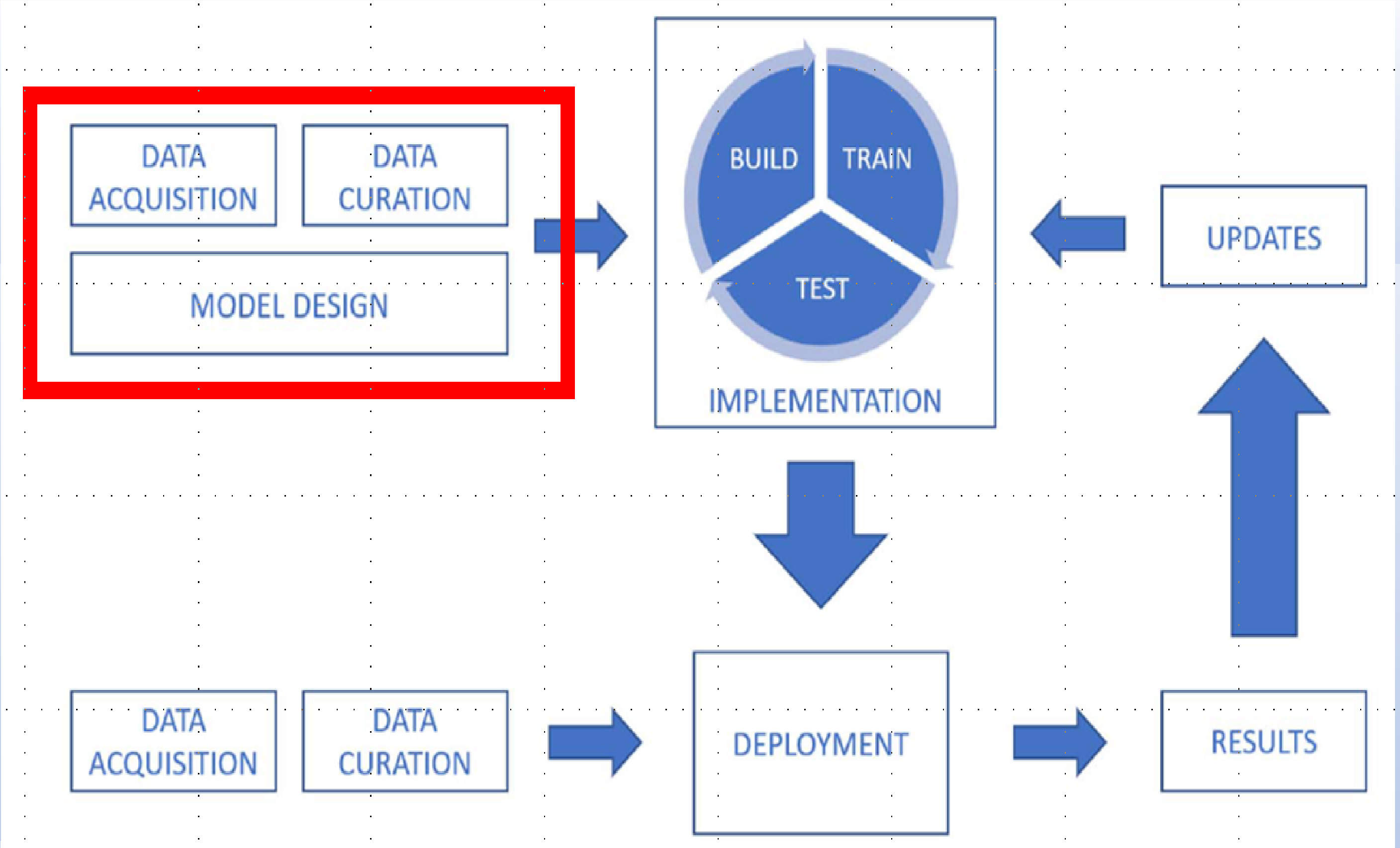


Fig. Typical Machine Learning (ML) Lifecycle

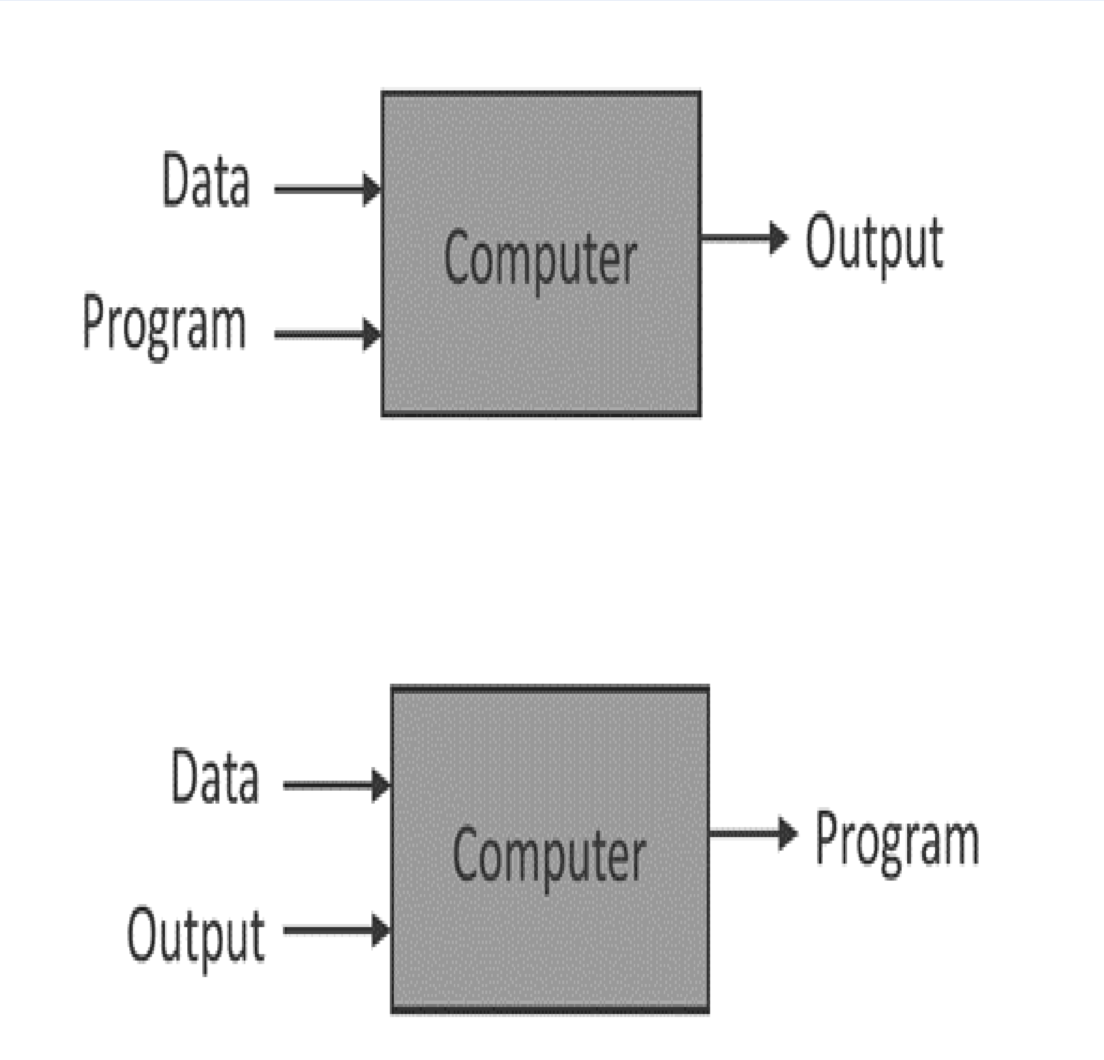
Table 1: Challenges in confidentiality, integrity and availability in the machine learning lifecycle

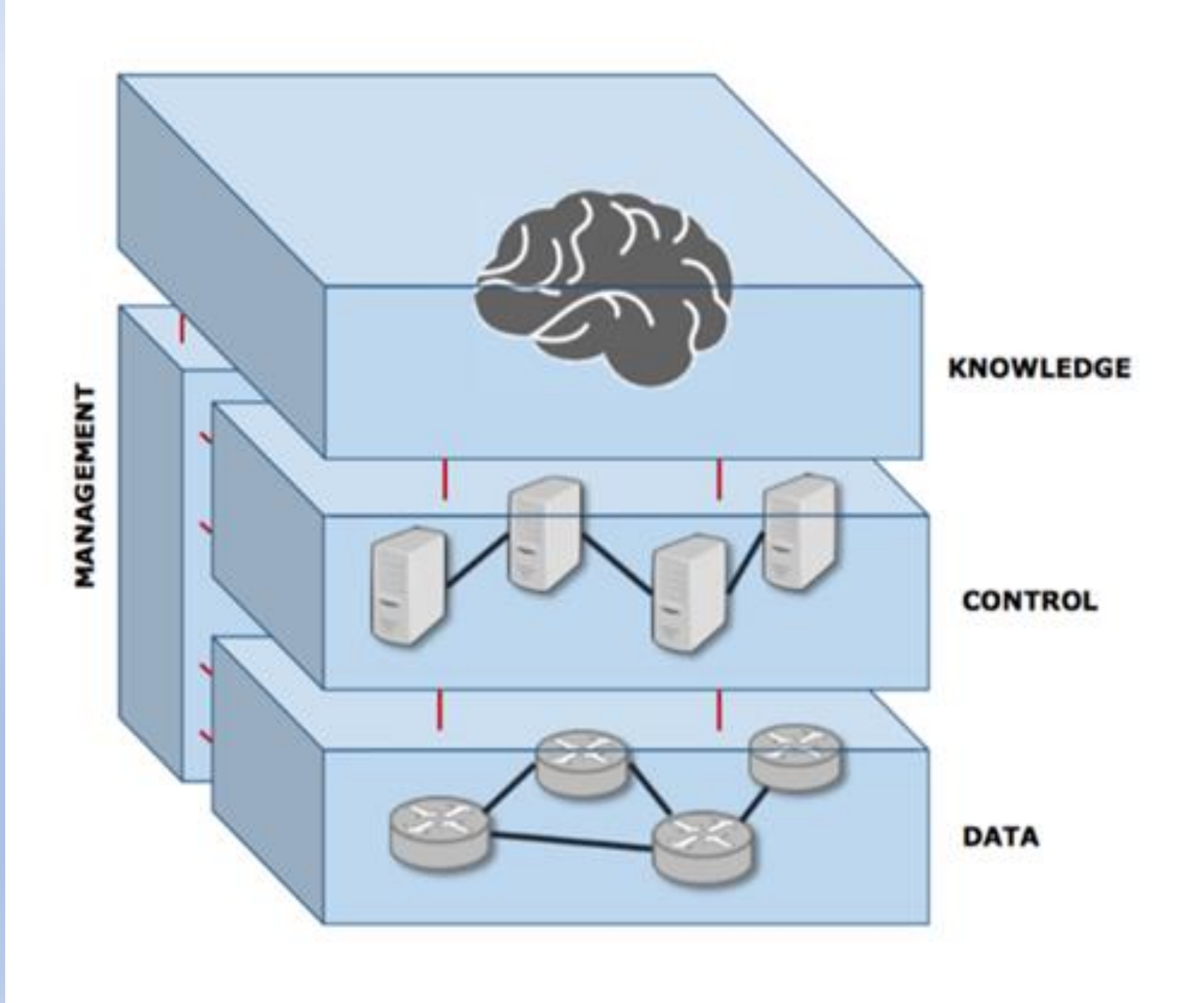
Clause	Lifecycle Phase	Issues
4.3.2	Data Acquisition	Integrity
4.3.3	Data Curation	Integrity
4.3.4	Model Design	Generic issues only
4.3.5	Software Build	Generic issues only
4.3.6	Train	Confidentiality, Integrity, Availability
4.3.7	Test	Availability
4.3.8	Deployment	Confidentiality, Integrity, Availability
4.3.9	Upgrades	Integrity, Availability

ETSI GR SAI 004 Dec 2020: 11

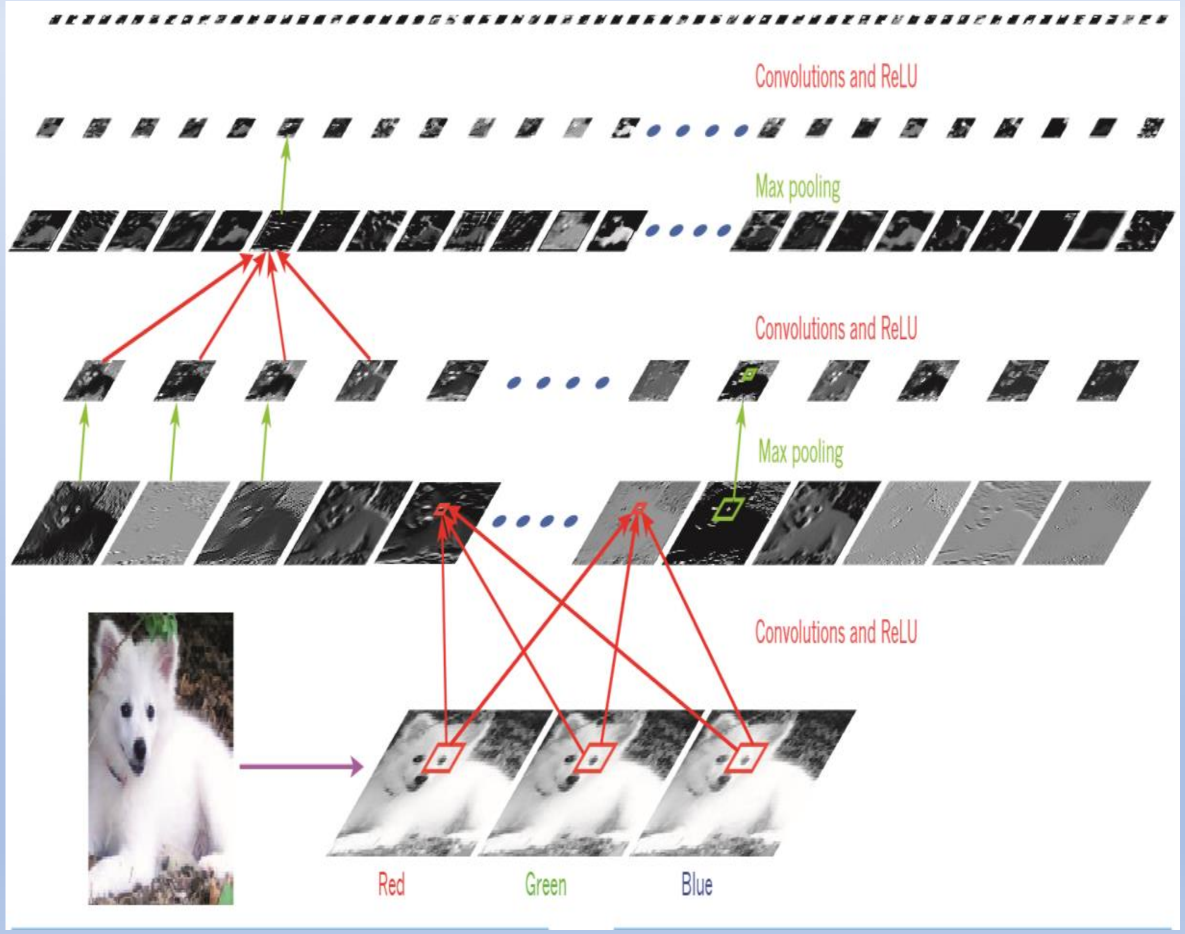
1. "5G Network Mobility at "Cell" & "Cloud" Edge - NGMN WP Feb 2015 - 4

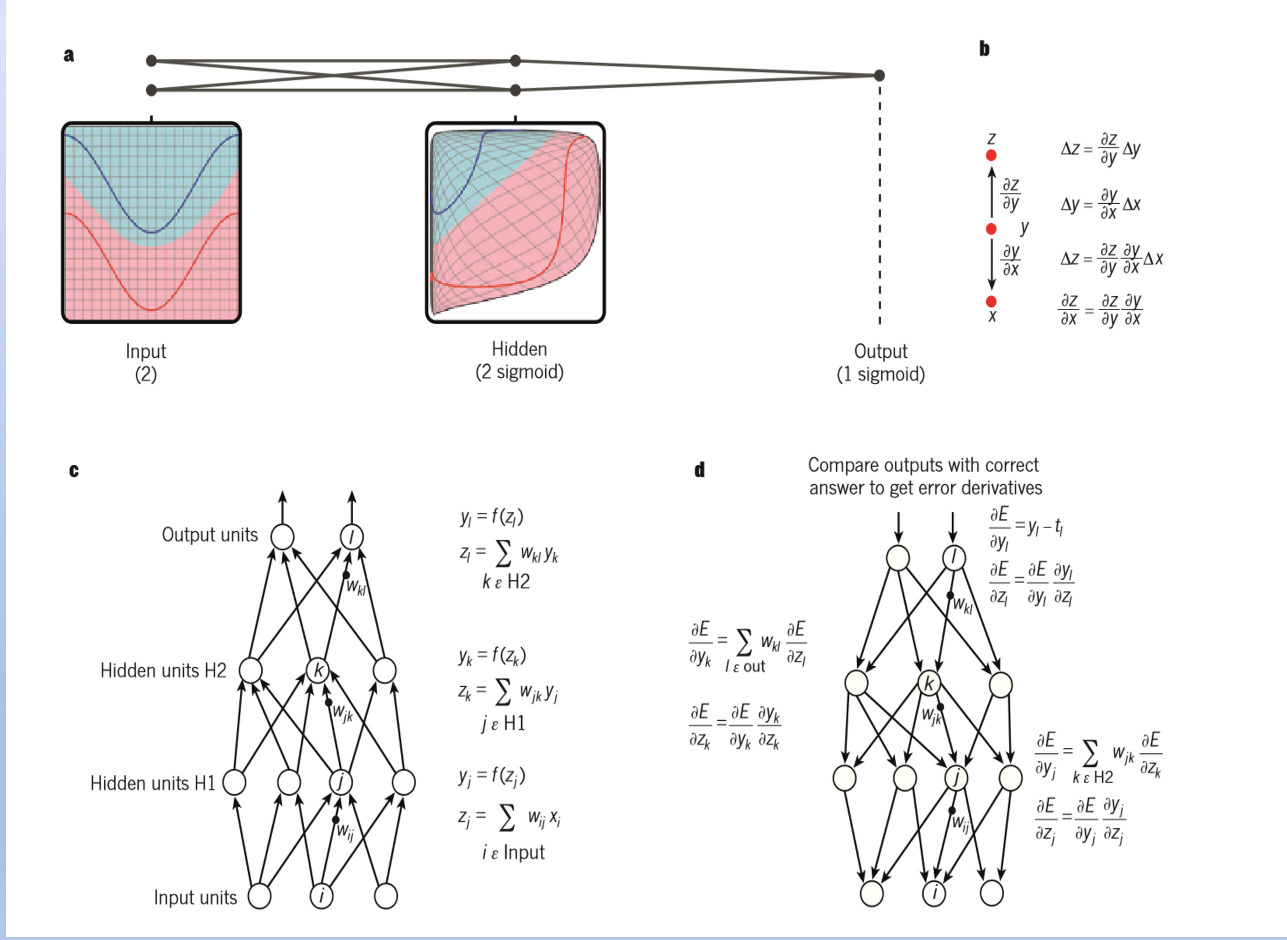
KDN – TMF





1. "5G Network Mobility at "Cell" & "Cloud" Edge - NGMN WP Feb 2015 - 4





Self-Transfer Optimization Network

Deep Reinforcement Learning Framework

A DRL framework similar to the one proposed in [i.60] is considered, but modified in such a way that it learns the mapping between the network environment measurements (given as inputs) and the optimization actions/decisions (given as outputs), where the corresponding system performance metrics are mapped as rewards.

The DRL model consists of at least convolutional layers and fully connected layers, where the convolutional layers are used to capture the temporal and spatial correlations of the network environment, while the fully connected layers are used for reducing the dimension to the required dimension of the output actions. Figure 28 gives an example of the DRL model with two convolutional layers and two fully connected layers.

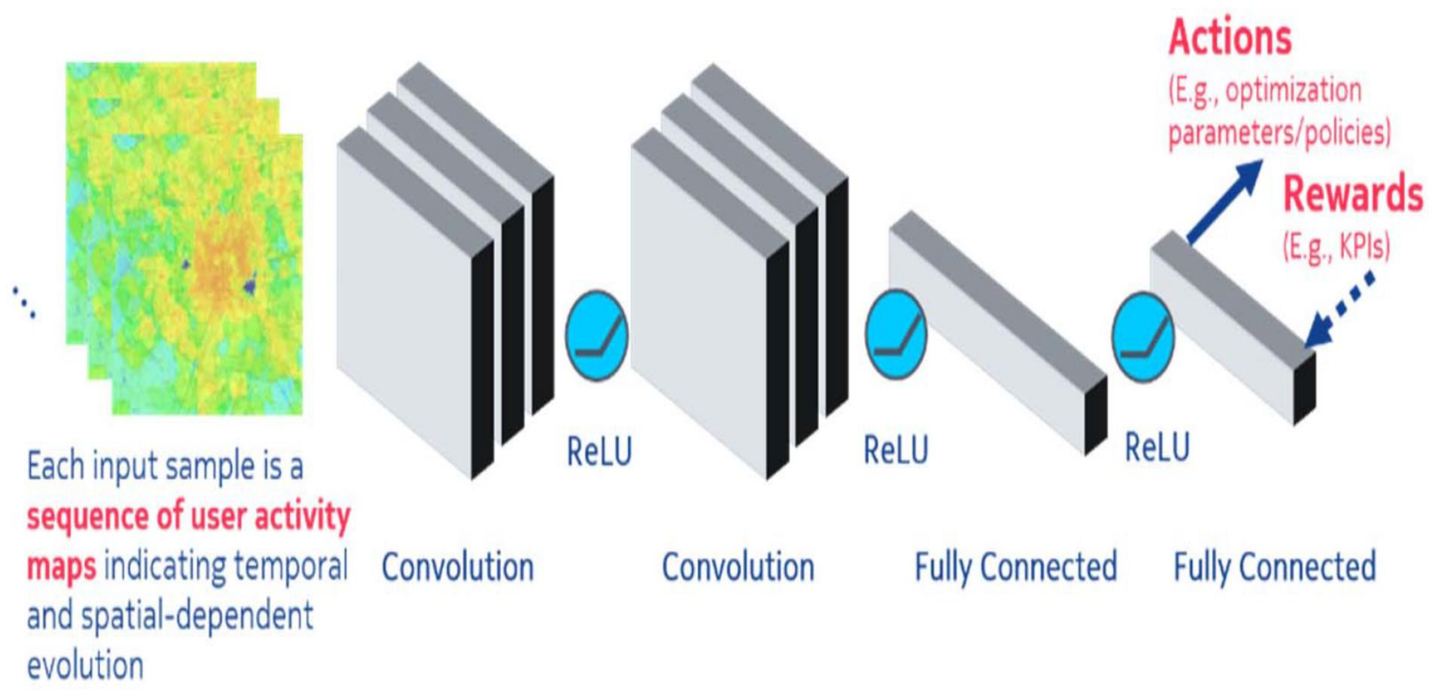
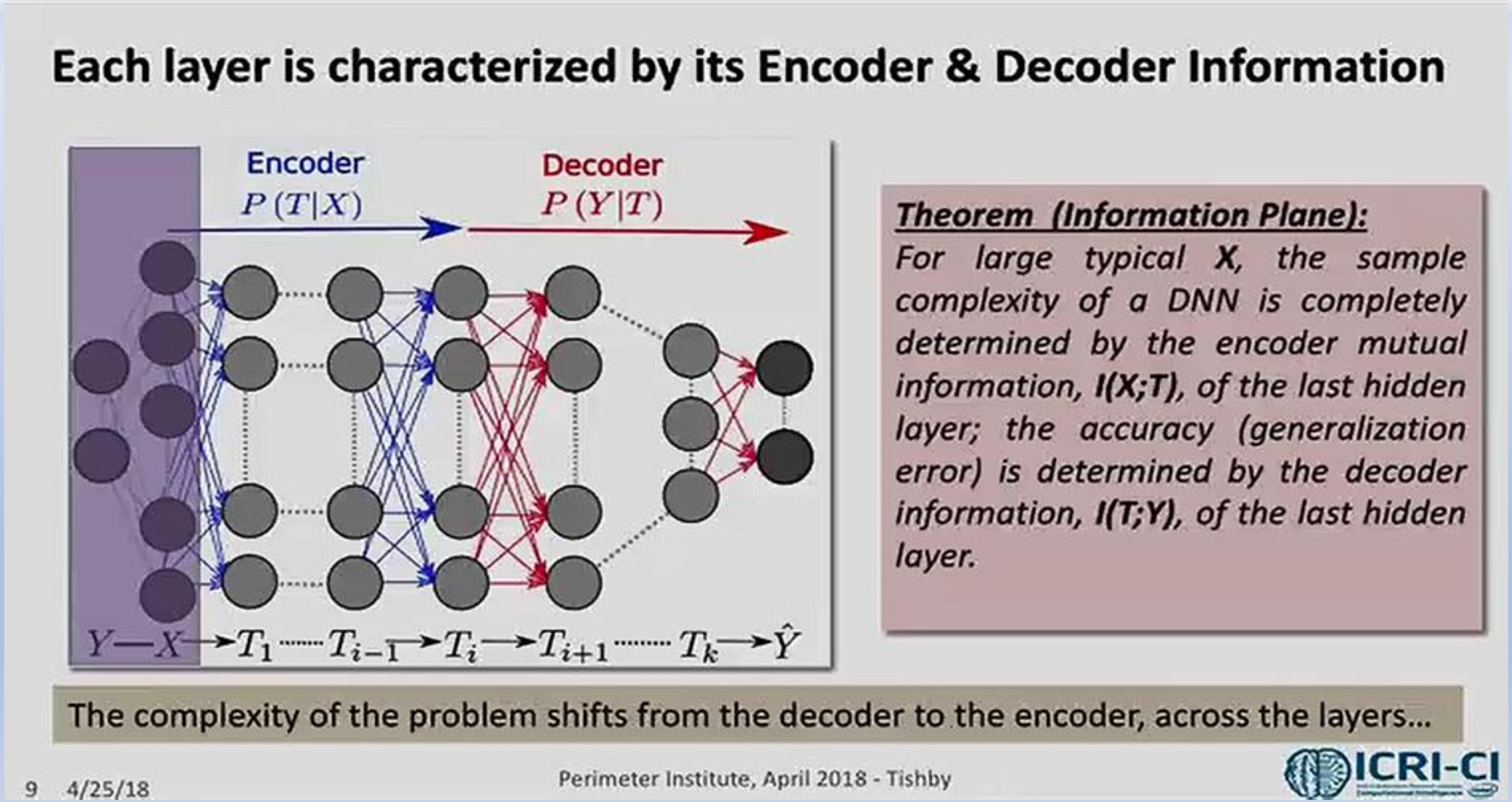


Fig 28 An example of DRL Deep Reinforced Learning Network

1. "5G Network Mobility at "Cell" & "Cloud" Edge - NGMN WP Feb 2015 - 4



ETSI ENI Architecture for Closed -Loop Network Operations & Management enabled by AI/ML Techniques

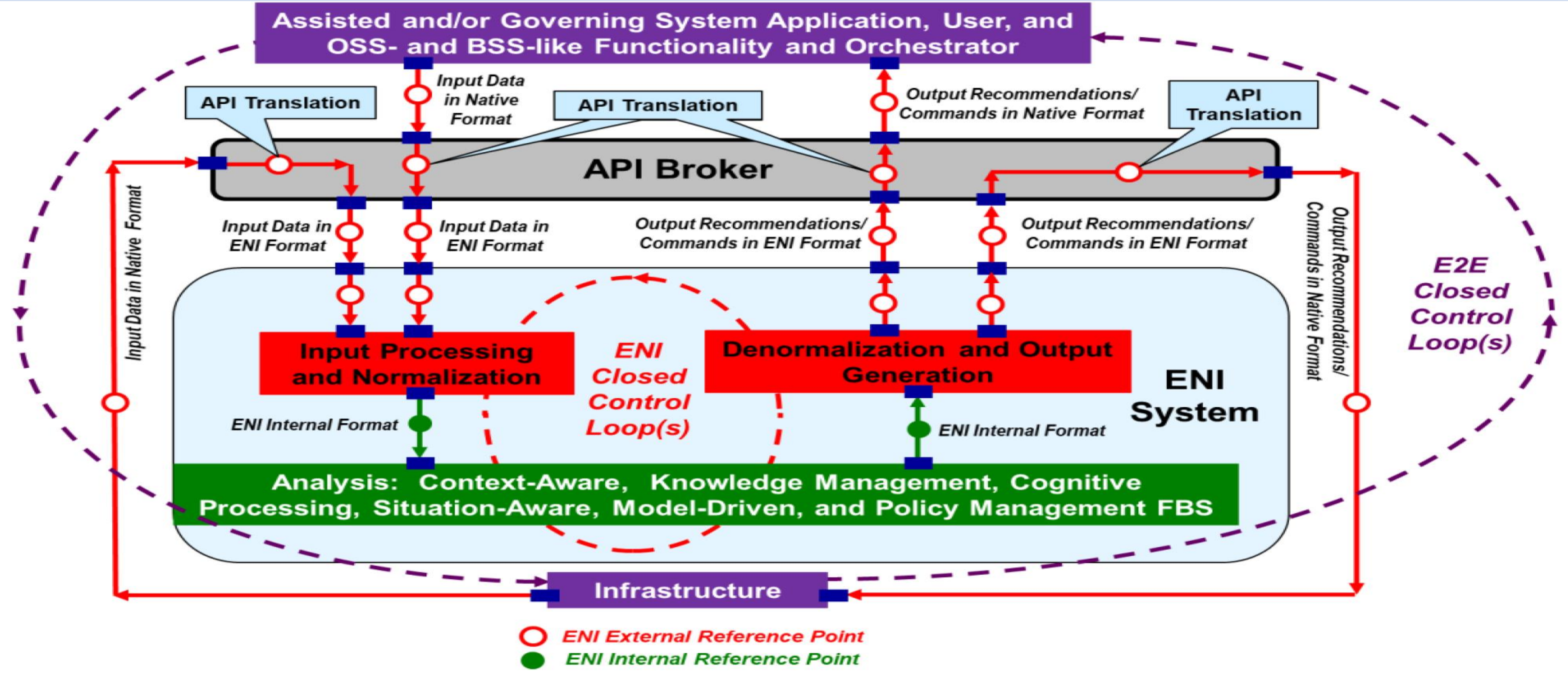


Figure 3: High-Level Functional Architecture of ENI when an API Broker is used

Ref.: ETSI WP Network Transform., Orchestration & Service Management, Oct. 2019: 9-10

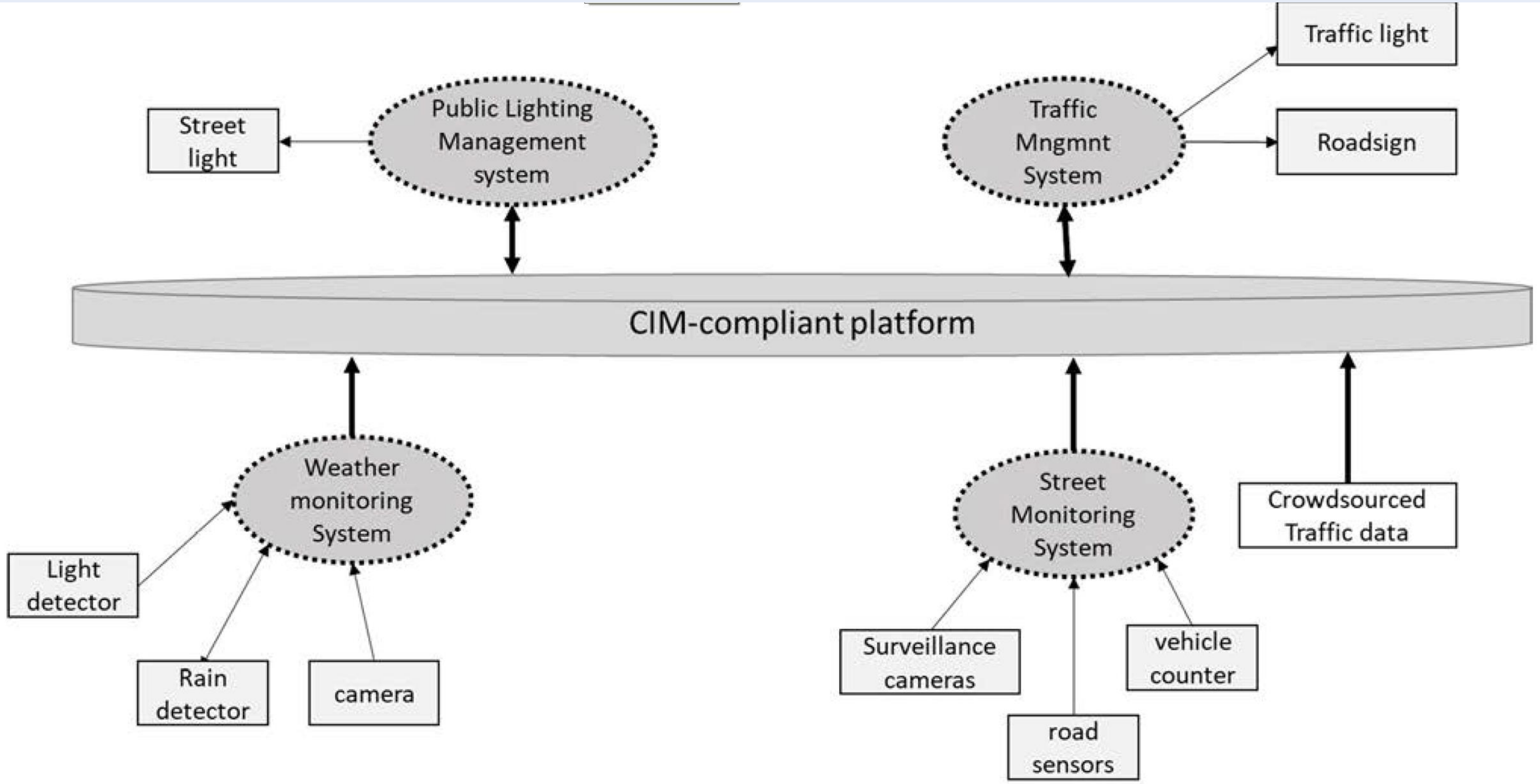


Figure 7.2.2-1: Context Information Exchange between Agents and Data Sources/Actuators in Smart Street Lighting Use Case

Ref: ETSI CIM GR 002 Use Cases July 2019: 25

Mapping CIM cross - domain NGSI - LD to oneM2M OWL

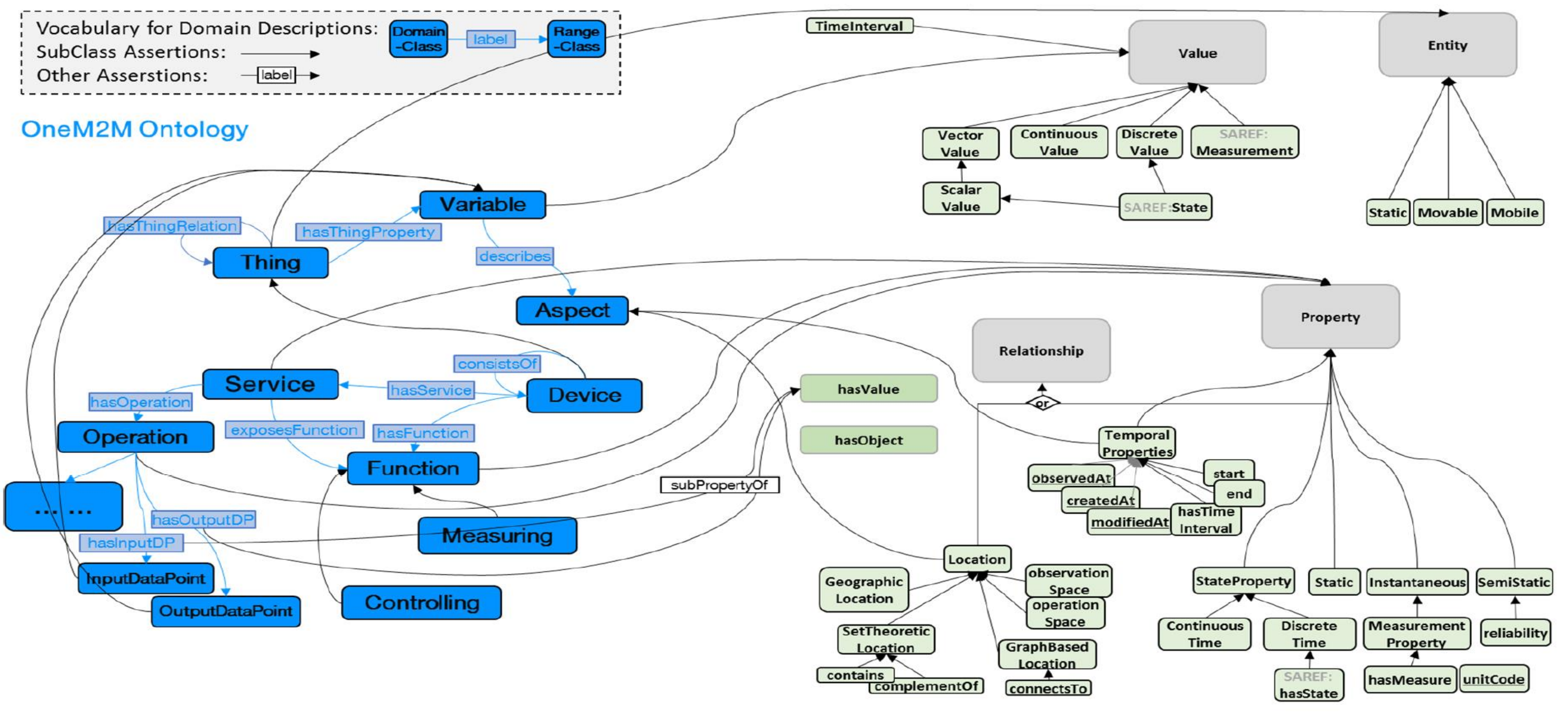


Figure B.1: Mapping NGSI-LD meta-model and cross-domain ontology to oneM2M base ontology

Ref: ETSI CIM GS 006 Information Model MOD0 July 2019: 31

Mapping NGSI - LD cross domain Ontology to SAREF

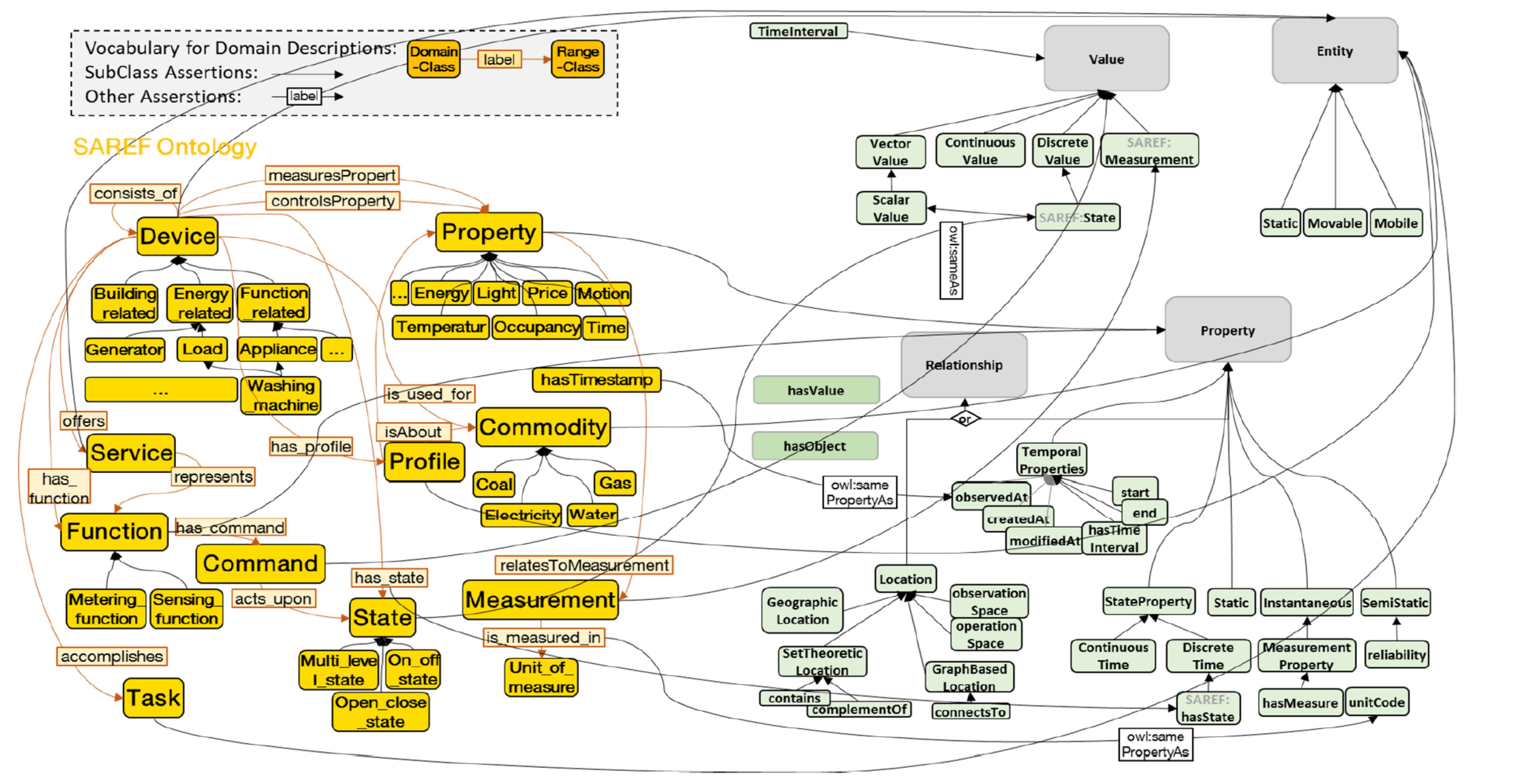


Figure B.4: Mapping NGSI-LD to SAREF

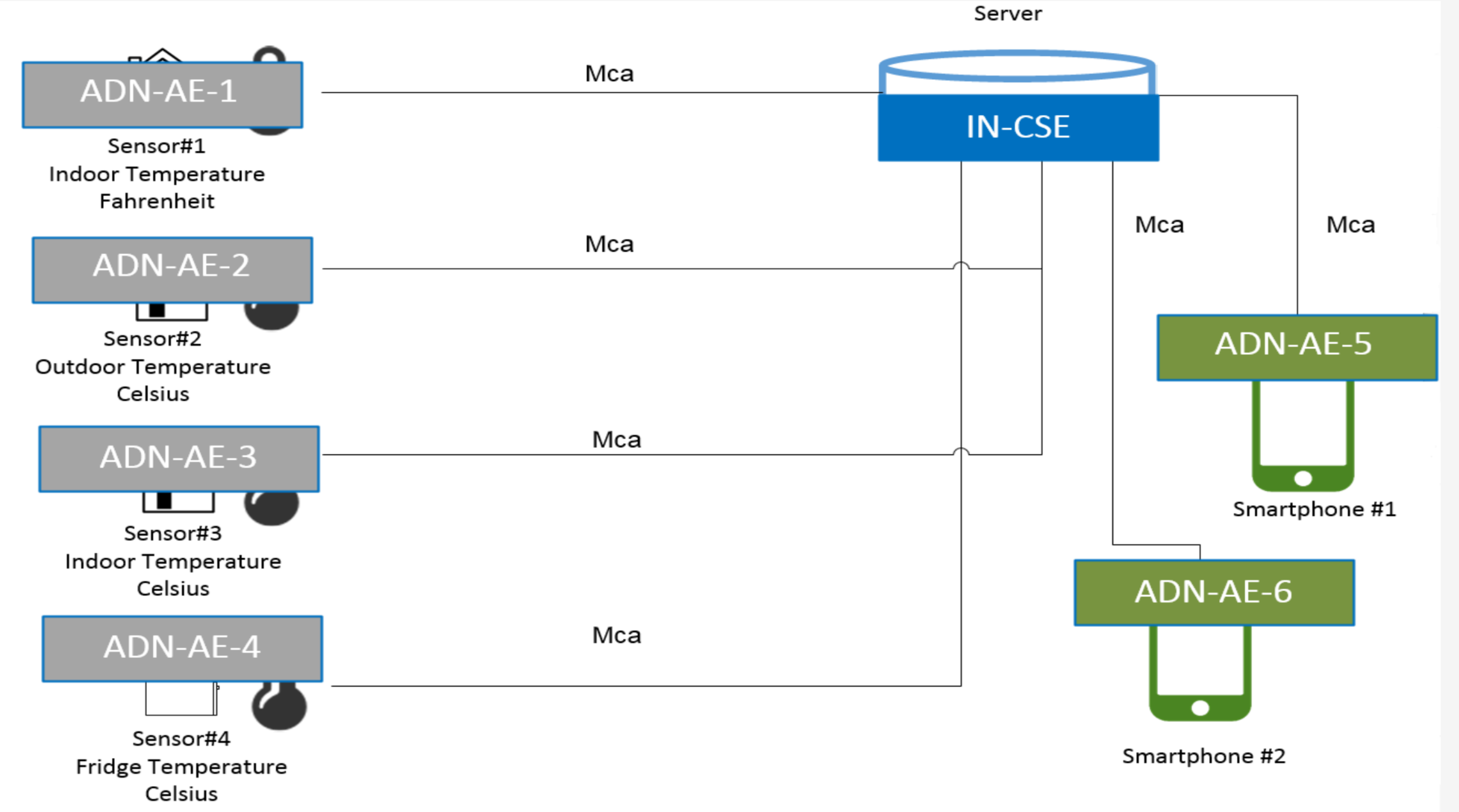
Ref: ETSI CIM GS 006 Information Model MOD0 July 2019: 34

Two (2) Questions on APIs:

Nr. 1 APIs: Type and Functions - **HOW?**

IoT

oneM2M Semantics Support



oneM2M functional architecture of semantic annotation and discovery use case

Ref.: oneM2M TR 0045 Semantics support,

oneM2M Semantics Support

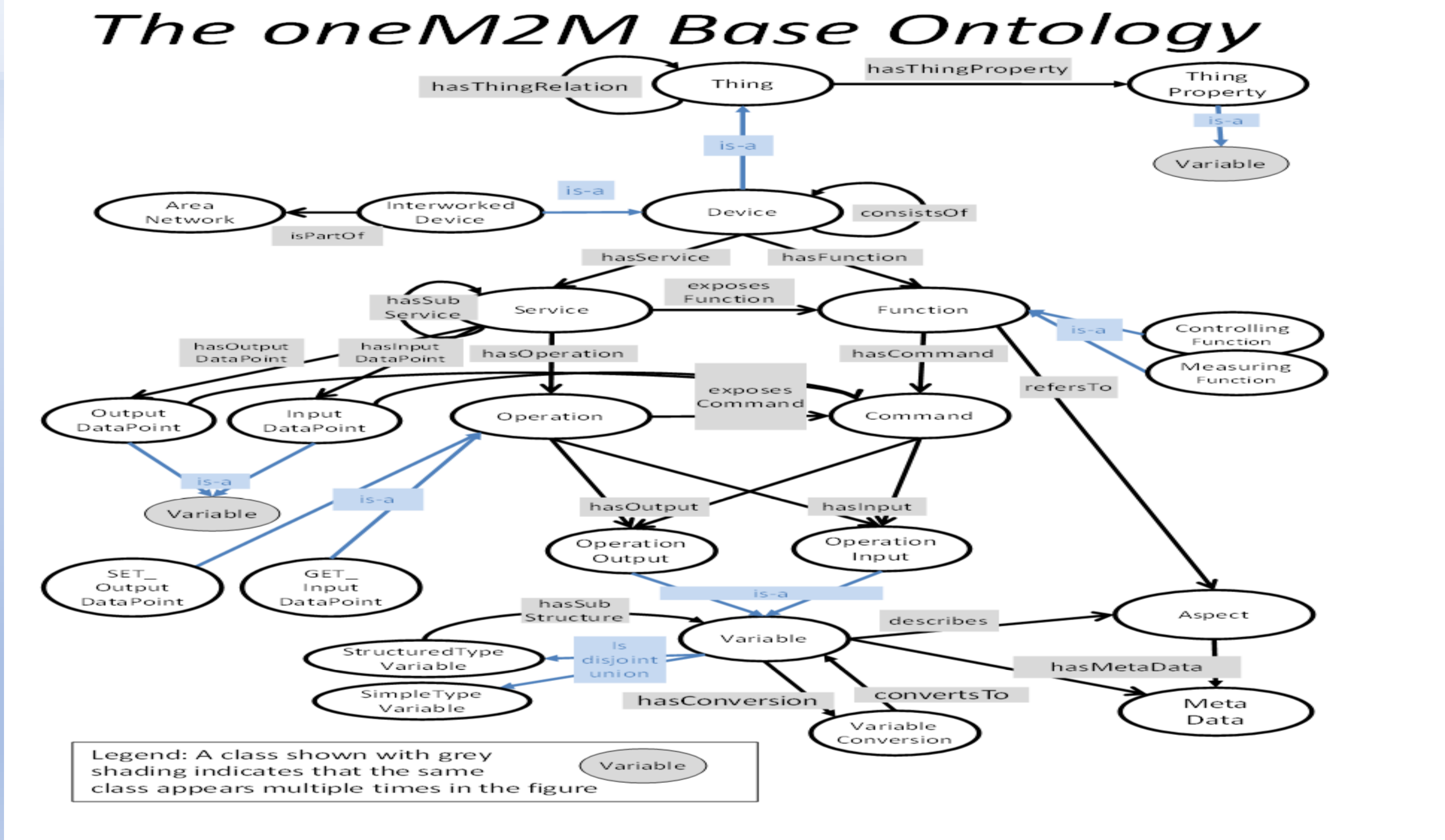


Figure 1: The oneM2M Base Ontology

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 13

oneM2M Semantics Support

6 Description of Classes and Properties

6.1 Classes

6.1.1 Class: Thing

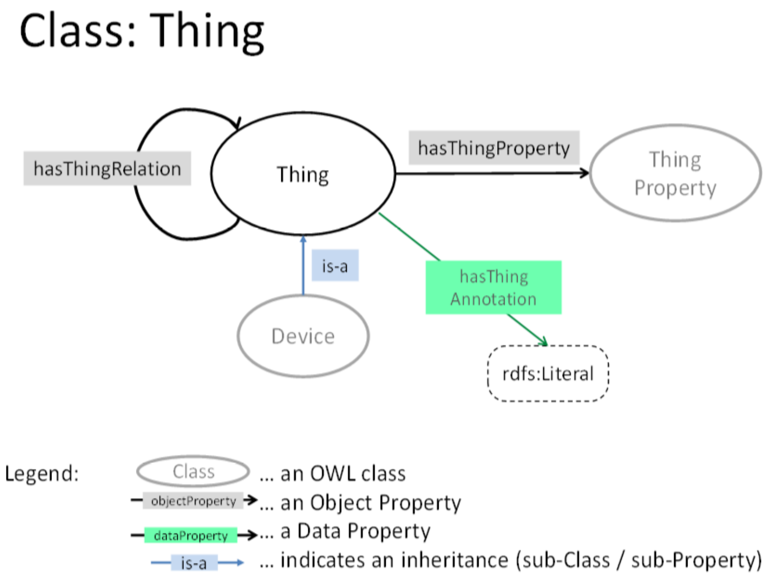


Figure 2: Thing

Description

- A **Thing** in oneM2M (Class: Thing) is an entity that can be identified in the oneM2M System.
  A Thing that is not a Device is not able to communicate electronically with its environment. However, the sub-class of Thing that ***is*** able to interact electronically is called a "Device".
  A Thing may have ThingProperties (Object Property: hasThingProperty). A Thing can have relations to other things (Object Property: hasThingRelation).
  Since a Thing that is not a Device is not able to communicate electronically it cannot influence the value of its ThingProperties or being influenced by it. Similarly a Thing cannot document its - real-world - relationships (via hasThingRelation) to other Things.

6.1.2 Class: ThingProperty

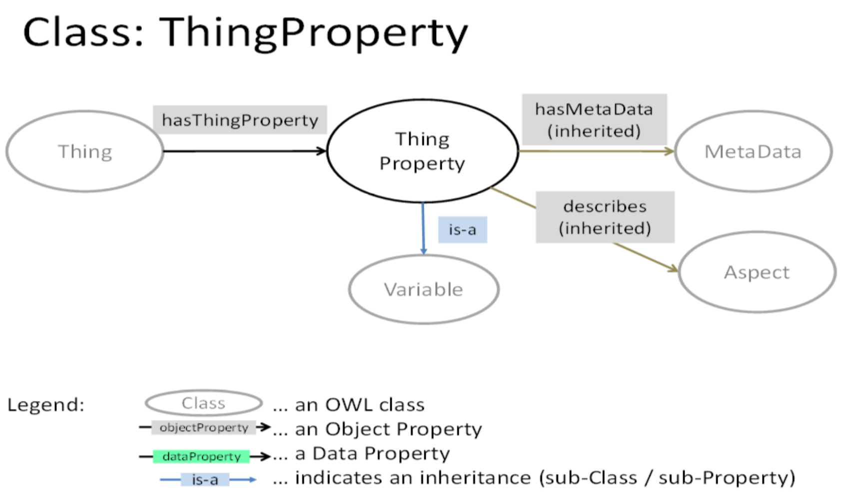


Figure 3: ThingProperty

Description

- A **ThingProperty** (Class: ThingProperty) denotes a property of a Thing. A ThingProperty can e.g. be observed or influenced by devices, or it constitutes static data about a Thing.
  E.g. the indoor temperature of the room could be a ThingProperty of a Thing "room".
  A ThingProperty of a thing can describe a certain Aspect, e.g. the indoor temperature describes the Aspect "Temperature" that could be measured by a temperature sensor.
  A ThingProperty of a Thing can have meta data.
- The class ThingProperty is a sub-class of the Variable class.

Object Properties

This Class is the domain Class of Object Property:

- describes (range Class: Aspect)
  (inherited from class: Variable)

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 17 - 18

oneM2M Semantics Support

6.1.3 Class: Aspect

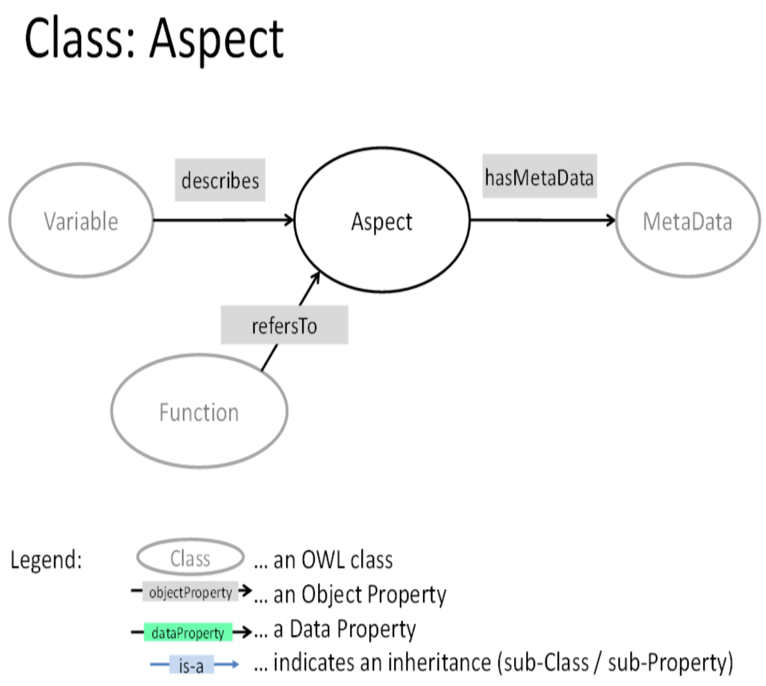


Figure 4: Aspect

Description

- An **Aspect** (Class: Aspect) describes the real-world aspect that a Function relates to. Aspect is also used to describe the quality or kind of a Variable.
  The Aspect could be a (physical or non-physical) entity or it could be a quality.

6.1.4 Class: MetaData

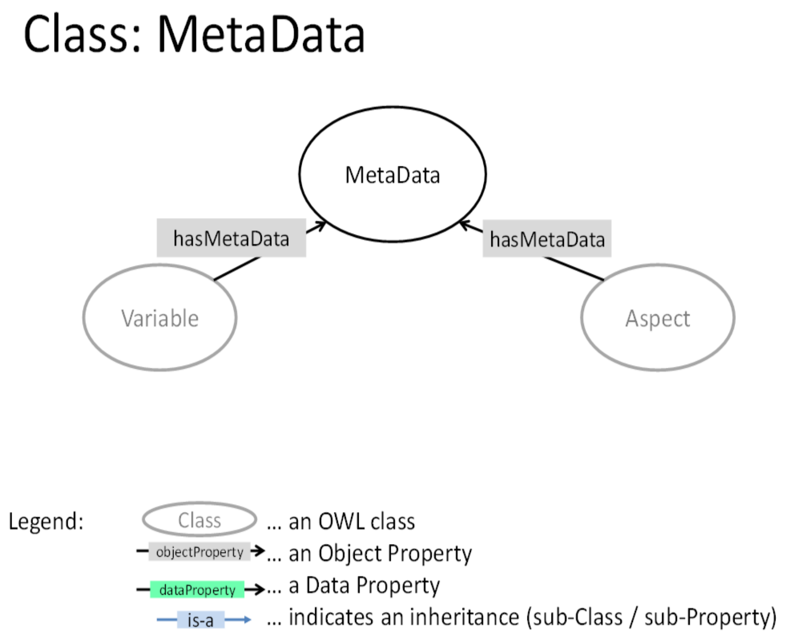


Figure 5: MetaData

Description

- **MetaData** (Class: MetaData) contain data (like units, precision-ranges …) about a Variable or about an Aspect.
  E.g. the indoor temperature could have as meta data an individual "Celsius_Scale" that specifies that the temperature needs to be understood as degrees Celsius.

Object Properties

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 20 - 21

oneM2M Semantics Support

6.1.5 Class: Device

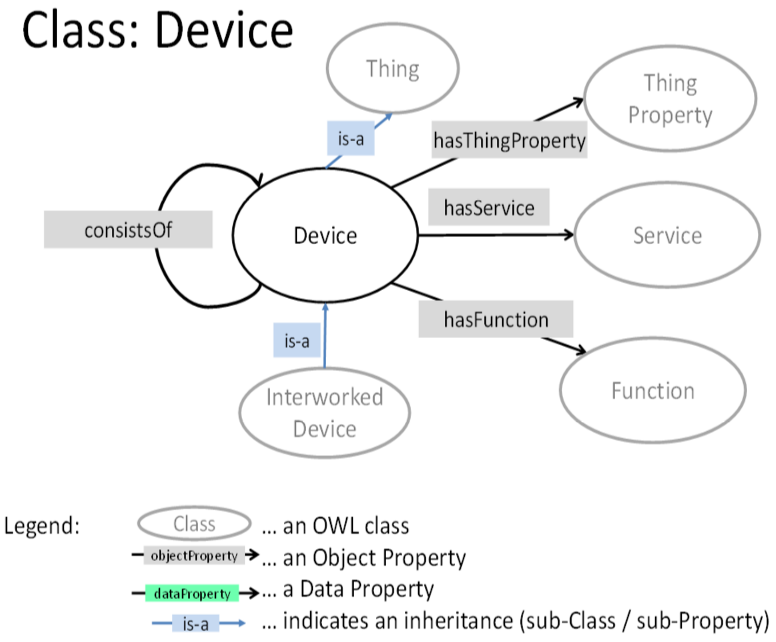


Figure 6: Device

Description

- A **Device** (Class: Device) is a Thing (a sub-class of class:Thing) that is designed to accomplish a particular task via the Functions the Device performs.
  A Device can be able to interact electronically with its environment via a network. A Device contains some logic and is producer and/or consumer of data that are exchanged via its Services with other oneM2M entities (Devices, Things) in the network. A Device may be a physical or non-physical entity.
  A Device interacts through the DataPoints and/or Operations of its Services:

6.1.6 Class: InterworkedDevice

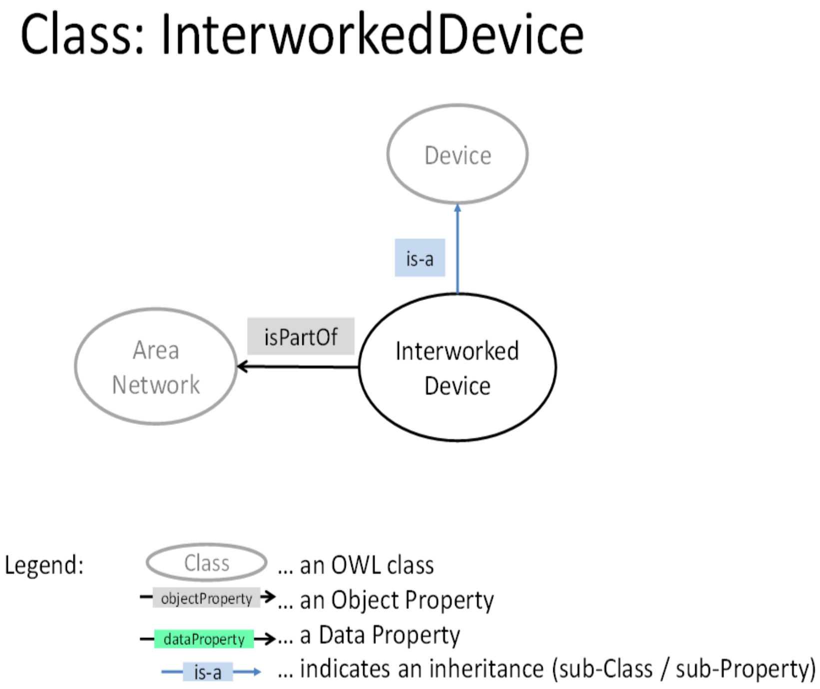


Figure 7: InterworkedDevice

Description

- An **InterworkedDevice** (Class: InterworkedDevice) is a Device - e.g. in an Area Network - that does not support oneM2M interfaces and can only be accessed from the oneM2M System by communicating with a "proxied" (virtual) device that has been created by an Interworking Proxy Entity.

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 20 - 21

oneM2M Semantics Support

6.1.7 Class: AreaNetwork

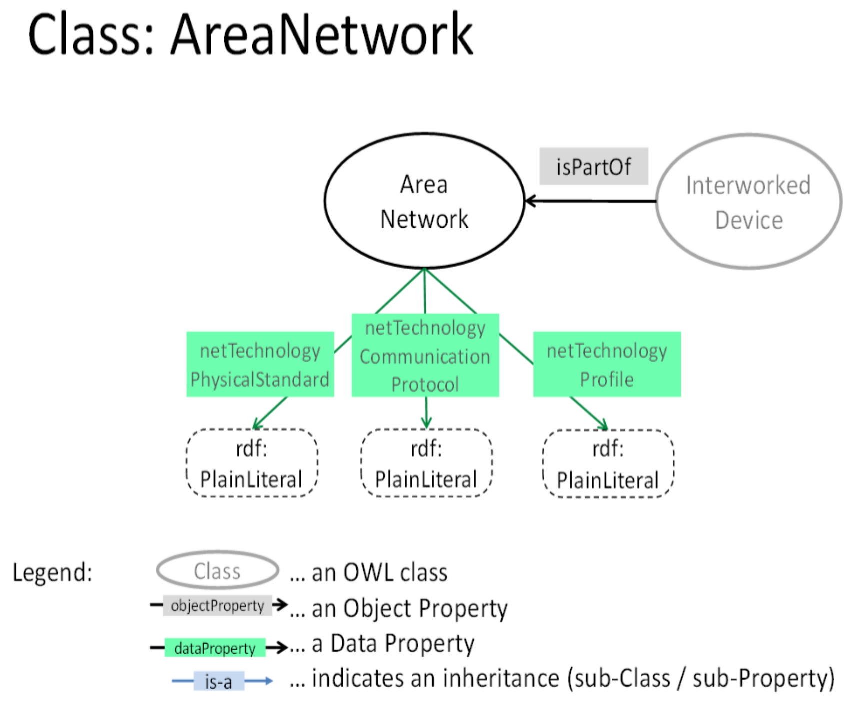


Figure 8: AreaNetwork

Description

- An **AreaNetwork** (Class: AreaNetwork) is a Network that provides data transport services between an Interworked Device and the oneM2M System. Different area Networks can use heterogeneous network technologies that may or may not support IP access.

6.1.8 Class: Service

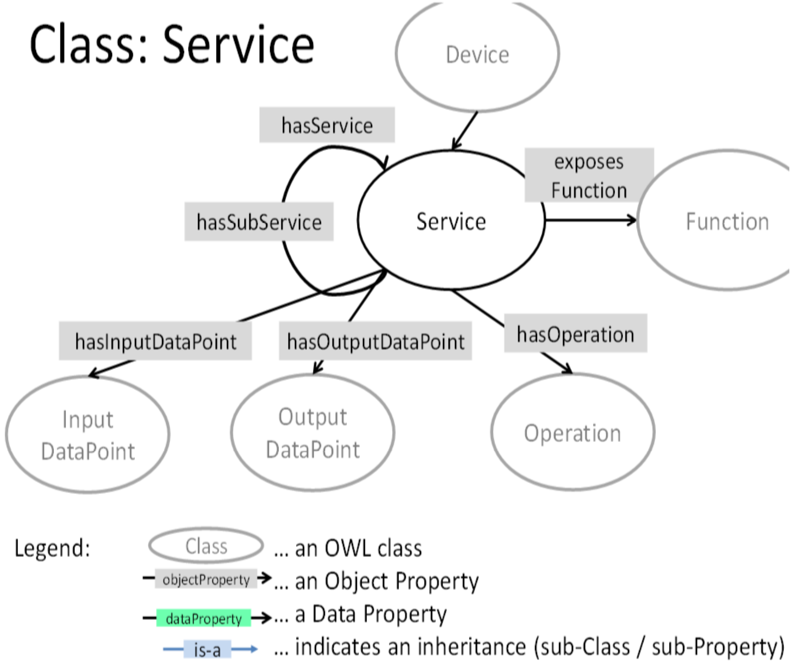


Figure 9: Service

Description

- A **Service** (Class: Service) is an electronic representation of a Function in a network. The Service exposes the Function to the network and makes it discoverable, registerable and remotely controllable in the network.
  A Service is offered by a device that wants (a certain set of) its Functions to be discoverable, registerable, remotely controllable by other devices in the network.
  A Service can expose one or more Functions and a Function can be exposed by one or more Services.

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 20 - 21

oneM2M Semantics Support

6.1.9 Class: Function

6.1.9.0 General description

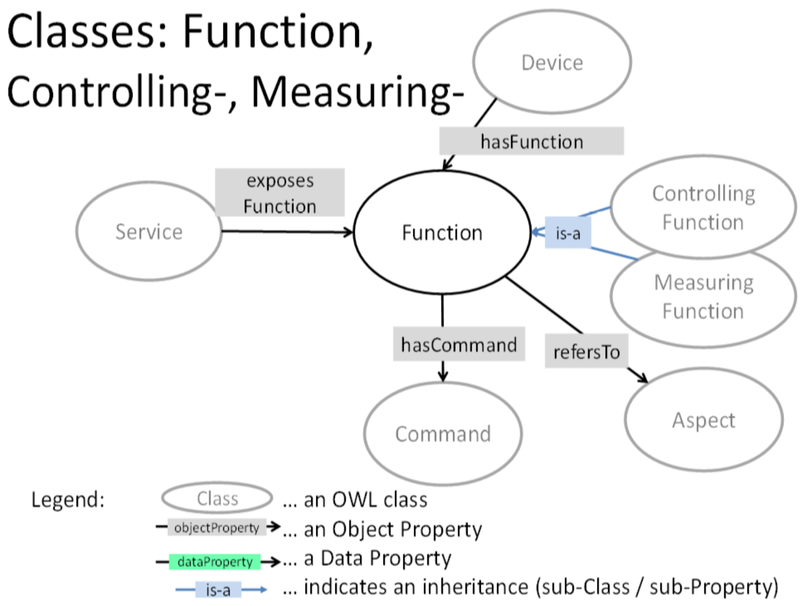


Figure 10: Function

Description

- A **Function** (Class: Function) represents a particular function necessary to accomplish the task for which a Device is designed. A device can be designed to perform more than one Function. The Function exhibits the - human understandable - meaning what the device "*does*".
- A Function refers to (e.g. observes or influences) some real-world aspect(s), that can be modelled as a Cla Aspect.

6.1.10 Class: Operation

6.1.10.0 General description

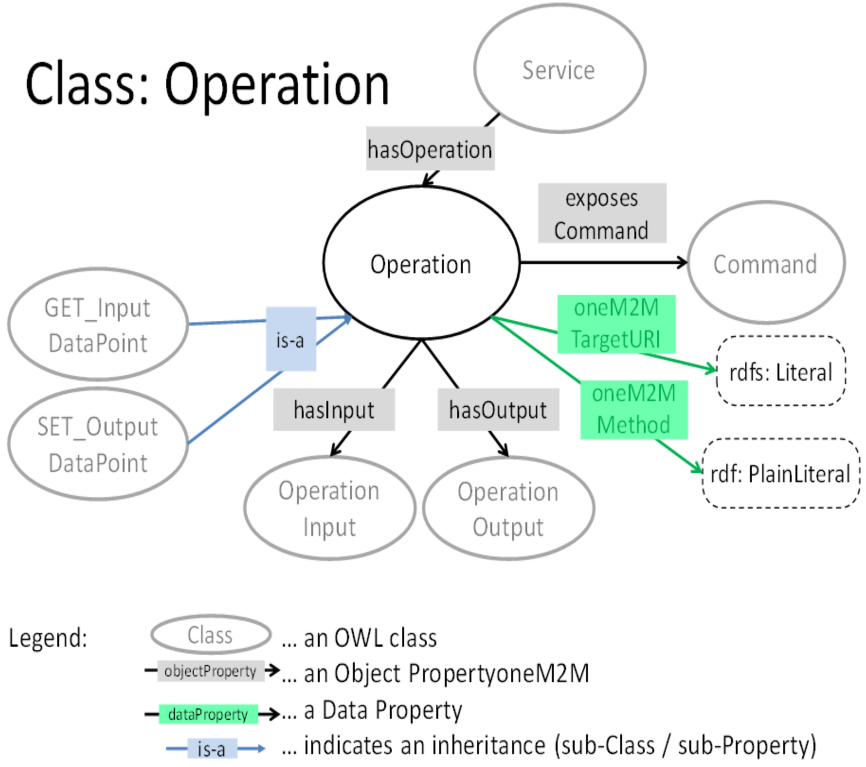


Figure 11: Operation

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 20 - 21

oneM2M Semantics Support

6.1.11 Class: Command

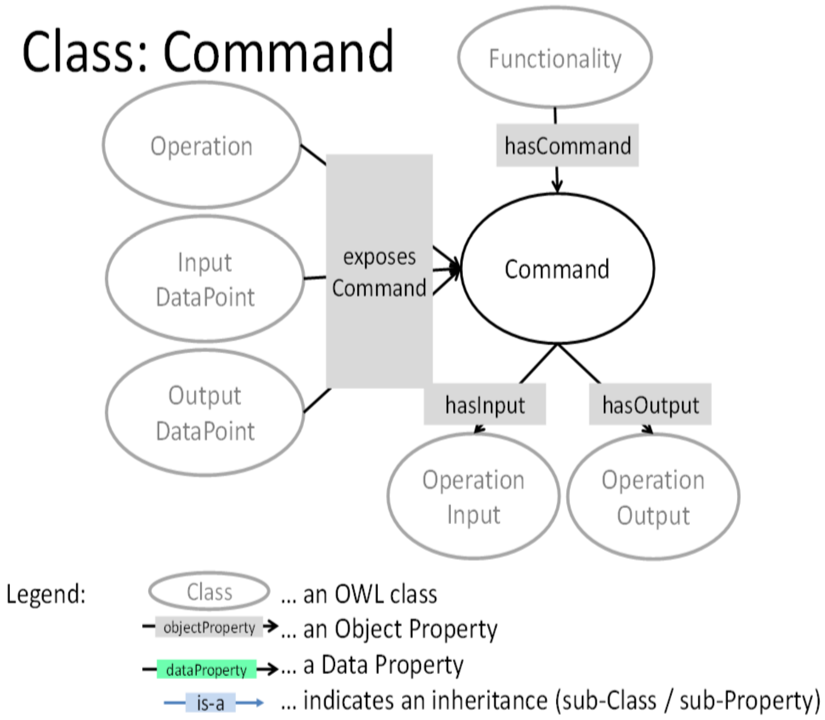


Figure 12: Command

Description

- A **Command** (Class: Command) represents an action that can be performed to support the Function. A Command is the -human understandable - name of that action that is invoked in a device or is reported by the

6.1.12 Class: OperationInput

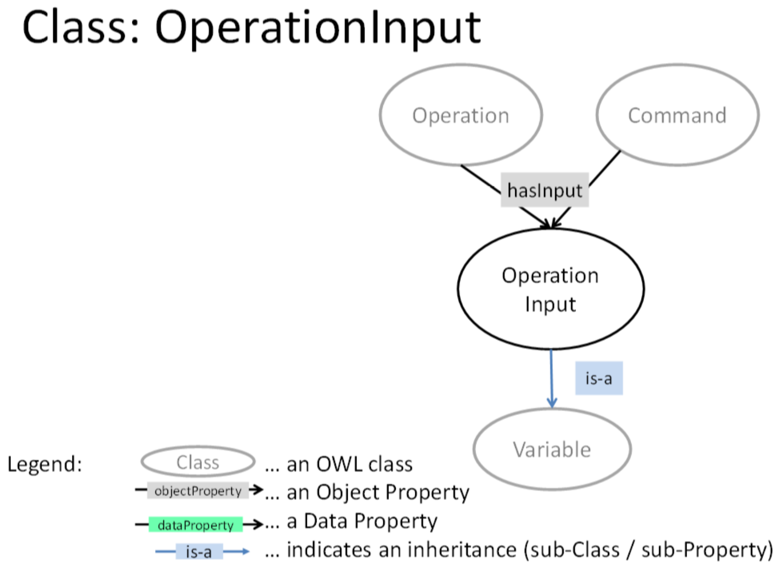


Figure 13: OperationInput

Description

- **OperationInput** (Class: OperationInput) describes an input of an Operation of a Service. OperationInput also describes the input of a Command:
  - OperationInput is transient. An instance of OperationInput is deleted when the instance of its Operation is deleted.
  - An Operation/Command may have multiple OperationInputs and/or OperationOutputs. If an instance of an Operation is invoked then the input value to that Operation shall be an instance of its OperationInput class.

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 20 - 21

oneM2M Semantics Support

6.1.16 Class: Variable

6.1.16.0 General description

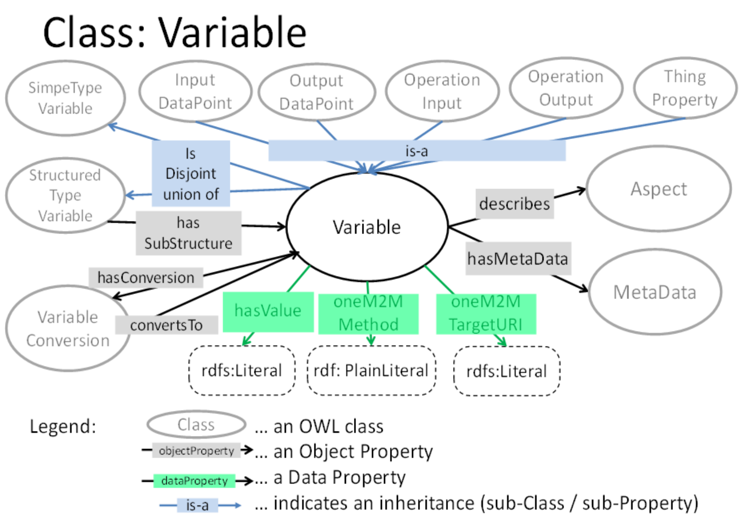


Figure 17: Variable

Description

- A **Variable** (Class: Variable) constitutes a super class to the following classes: ThingProperty, OperationInput, OperationOutput, InputDataPoint, OutputDataPoint. Additionally, class:Variable is the disjoint union of classes: SimpleTypeVariable and StructuredTypeVariable, i.e. any member of class:Variable is also member of either SimpleTypeVariable or StructuredTypeVariable.
  The members of class:Variable are entities that store some data (e.g. integers, text, etc., or structured data) that can change over time. These data of the Variable usually describe some real-world Aspects (e.g. a temperature) and can have MetaData (e.g. units, precision, etc.).

6.1.16.2 Class: StructuredTypeVariable

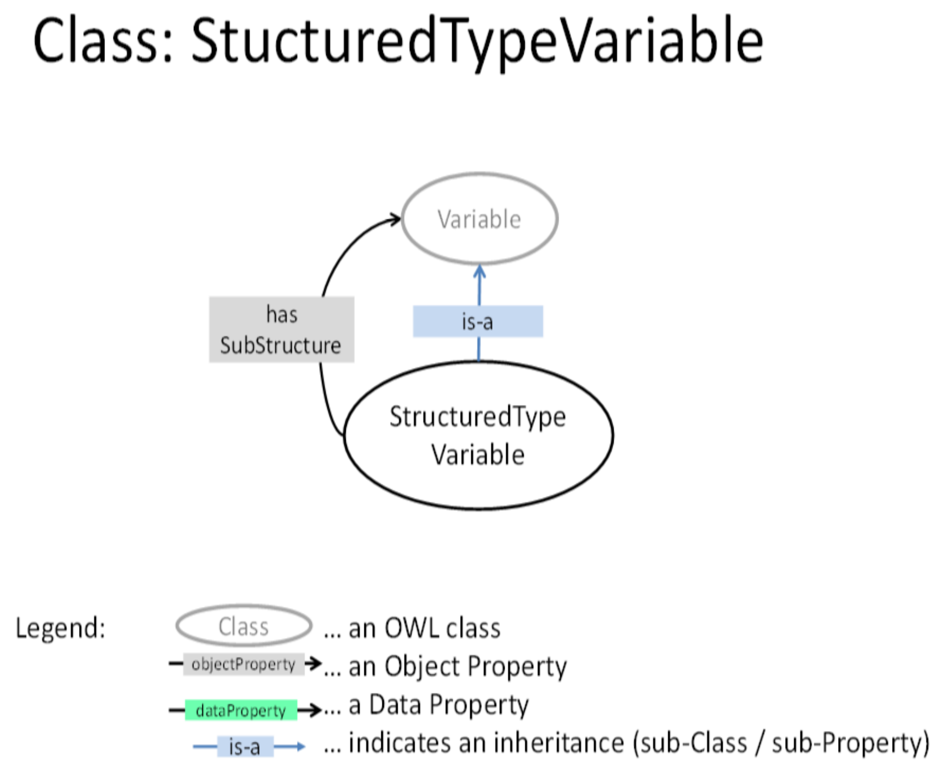


Figure 19: Variable

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 41

oneM2M Semantics Support

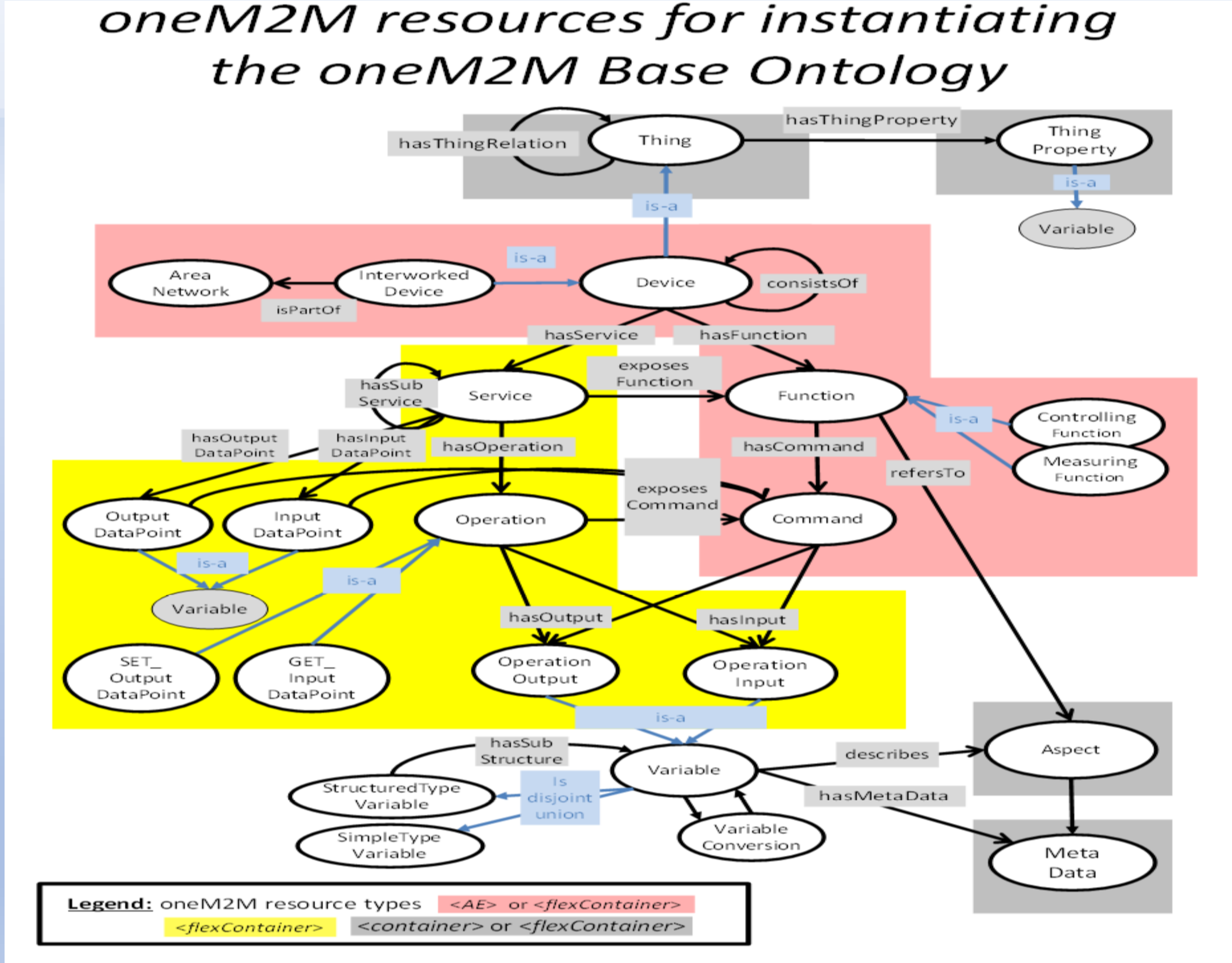


Figure 21: oneM2M instantiation of the Base Ontology

Ref.: oneM2M TS 0012 Base Ontology Feb 2019: 60

Annex 4 - 3GPP 5G SCEF/SCS for IoT Platform integrated with IoT SL across 10 UCs - 3

5.2 Mapping between SAREF and oneM2M Base Ontology

Figure 12 shows the mapping between SAREF and the oneM2M Base Ontology.

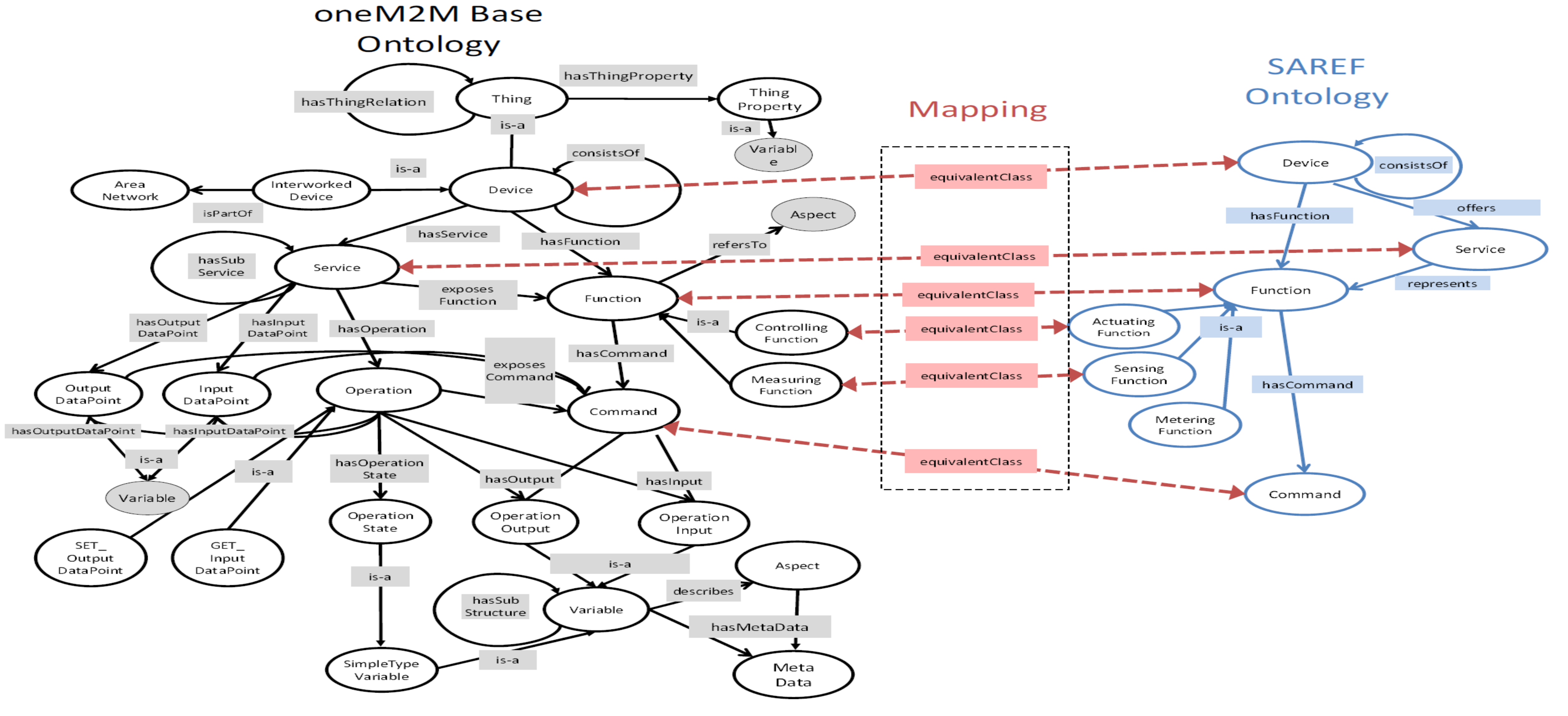
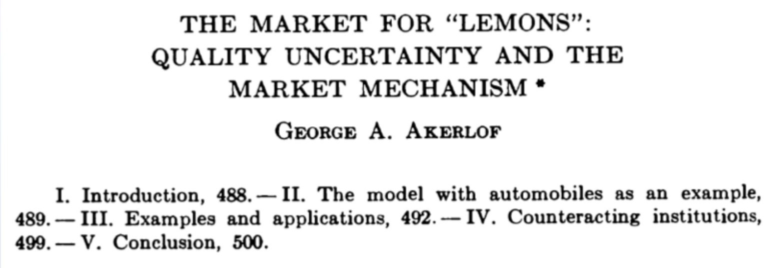


Figure 12: Mapping between SAREF and the oneM2M Base Ontology

Commercial

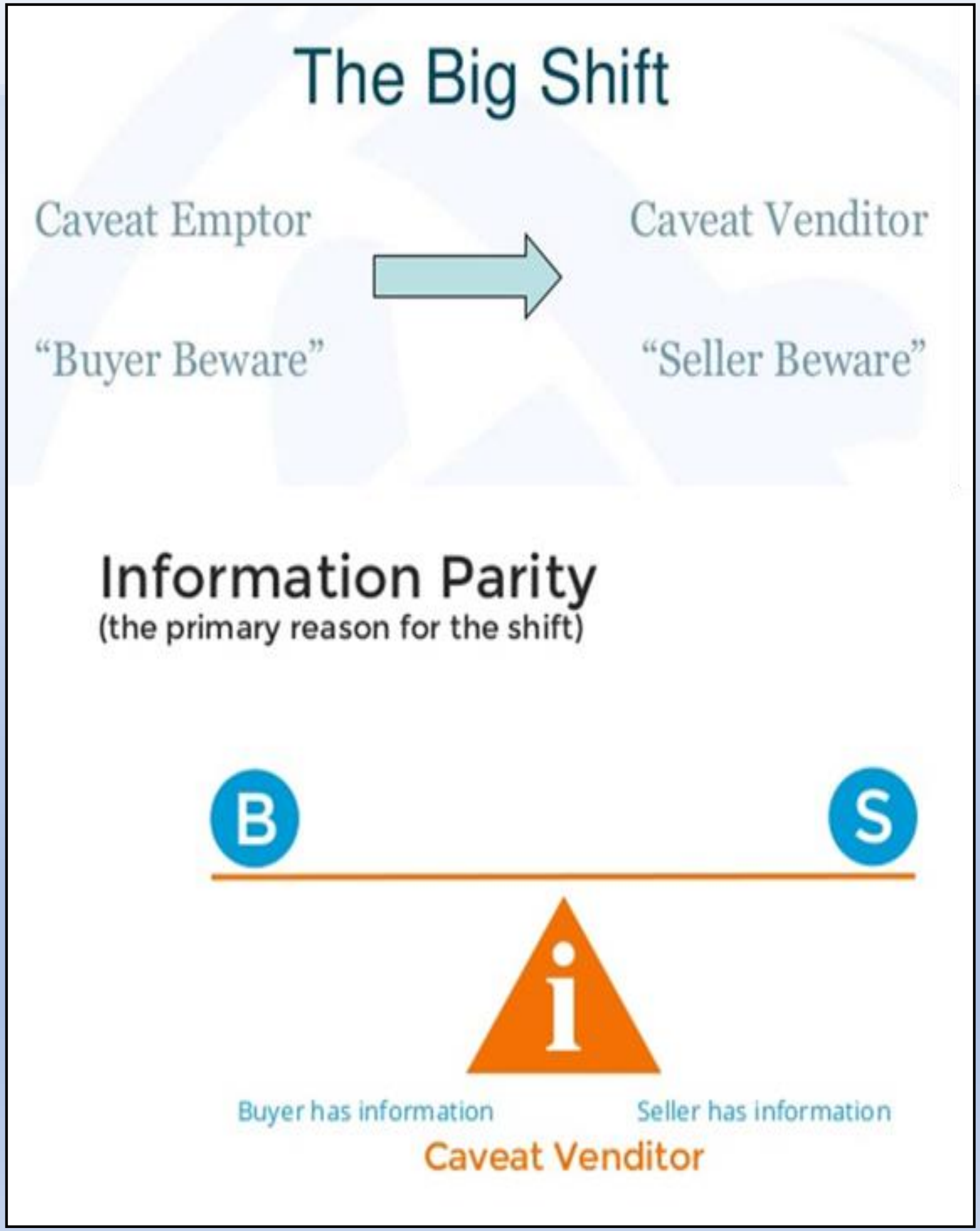
The Big Shift - from "Caveat Emptor" to "Caveat Venditor" - 1



THE MARKET FOR "LEMONS": QUALITY UNCERTAINTY AND THE MARKET MECHANISM *

GEORGE A. AKERLOF

I. Introduction, 488. — II. The model with automobiles as an example, 489. — III. Examples and applications, 492. — IV. Counteracting institutions, 499. — V. Conclusion, 500.



When Information is Ubiquitous:

shift from **Information Inequality** to **Information Paritiy**

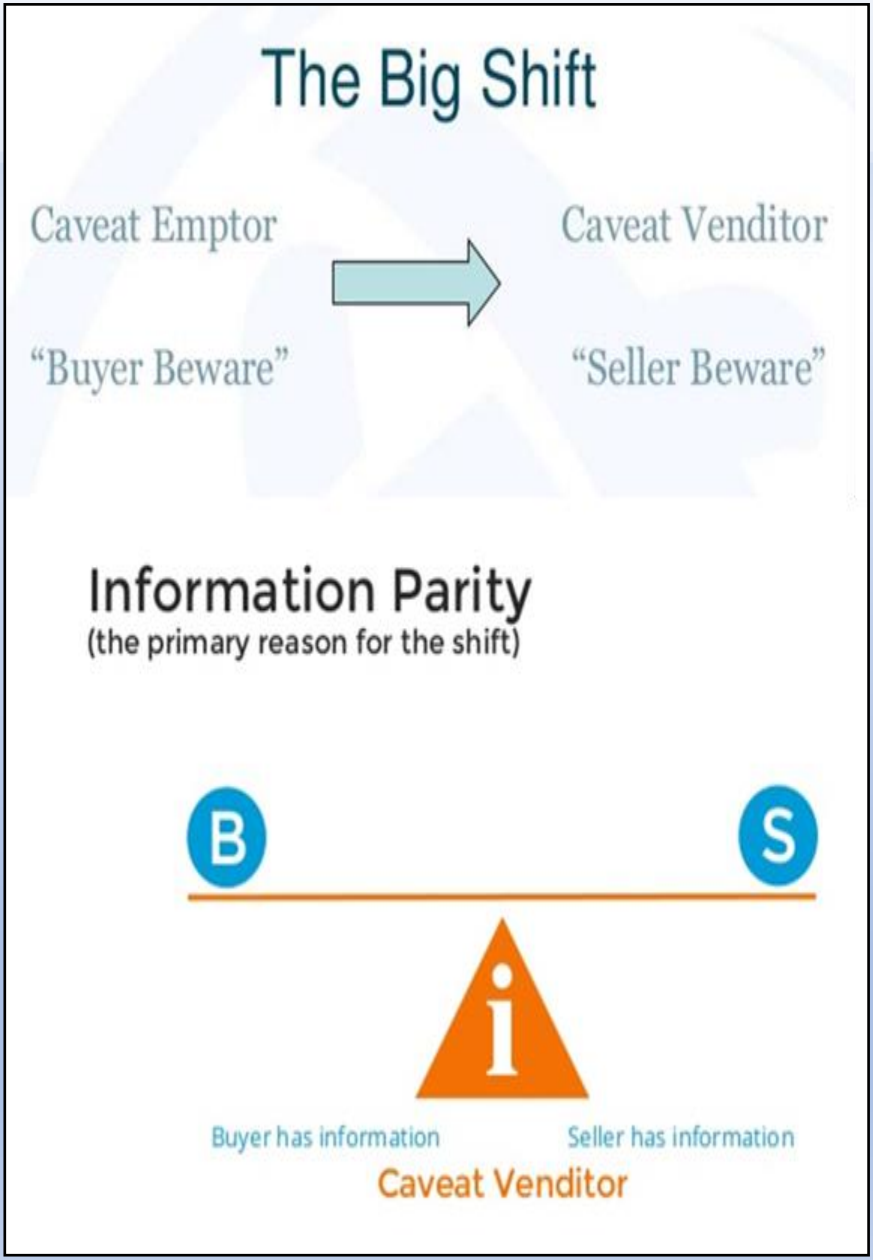
No longer enough

just to be able to Answer to Questions on Product/Solution/ Services

and/or present Platforms, Solutions, Services, Standards ...

Ref.: D.Pink, D-ve, 2012

The Big Shift - from "Caveat Emptor" to "Caveat Venditor" - 2



When Information is Ubiquitous

The Value of undertaking the role of "Unbiased Business Partner"

Shift in assigned importance **from "Problem - Solving" to**

"Problem-Identification/ Finding"

Ask the "Right Questions"

- to Identify Current Issues/Problems, curate the Vast Amount of Information &

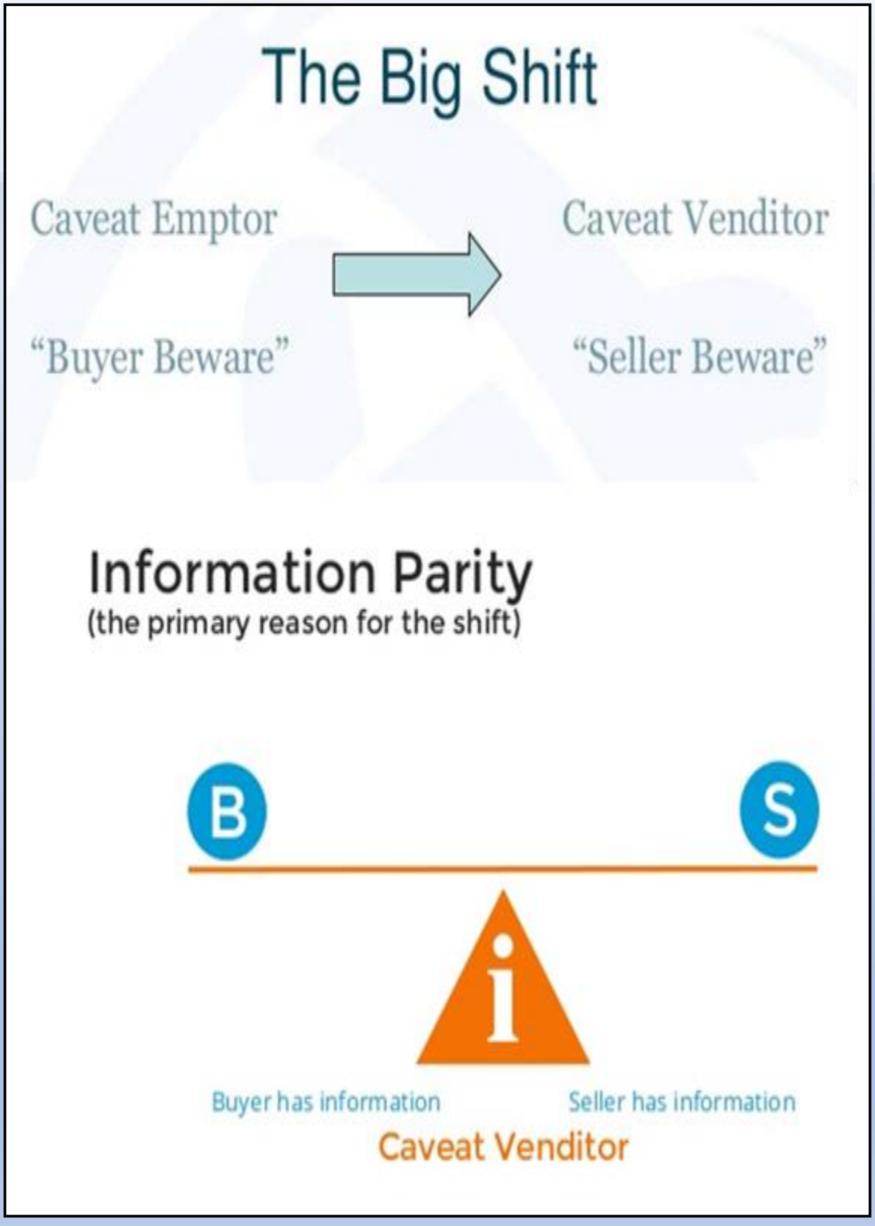
- **Ability to Hypothesize/Clarify on Future** Problems, Inter-Dependencies

- **Outline Future Multi-Vendor Inter- Operability & Scalability**

- **Ground for Personalized, Business Model and Agile Service Deployment.**

Ref.: D.Pink, D-ve, 2012

The Big Shift - from "Caveat Emptor" to "Caveat Venditor" - 3



To see what the Problem is before jumping in to Resolve it

Problem Solving Approach turns upside down Two (2) "Traditional Sales Skills:

A) From "Access Information" to "Curating Information":
- Sorting - out through massive amount of Data
- Presenting the most Relevant & Clarifying Aspects

B) From "Answering Questions" to "Asking Questions" to:

Uncover => Possibilities
Surfacing Latent Issues
Unexpected problems

C) Apply "Contrast Principle" (R. Cialdini) & move from "Upselling" to "Upserving"

Most Important Question:

"Compared to What"? => Value

Ref.: D.Pink, D-ve, 2012

GAIN Model and Fallacies of Data - 2

Three (3) Fallacies of Data

1. The Fallacy of Active vs Passive Data.

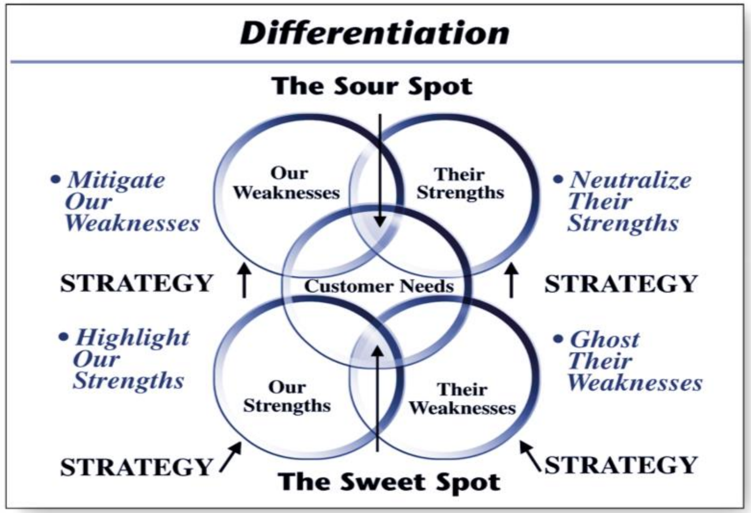
Growing companies start to ***generate Operations-related Data*** **(Active Data),** which can seduce with its apparent objectivity.

2. The Fallacy of Surface Growth

In consumer relationships, Corporations *focus their energies on driving growth by selling to existing Customers additional products* .

3. The Fallacy of Conforming/Non-Conforming Data

focus on generating data that conforms to pre - existing notions, that inherently hinders/blinds from emerging/new opportunities beyond their perspective.



Positive (Sweet Spot) and negative (Sour Spot) differentiation exists only in the context of the customer's needs. Then Middle and Endgame strategies are implemented to grow the Sweet Spot and shrink the Sour Spot.

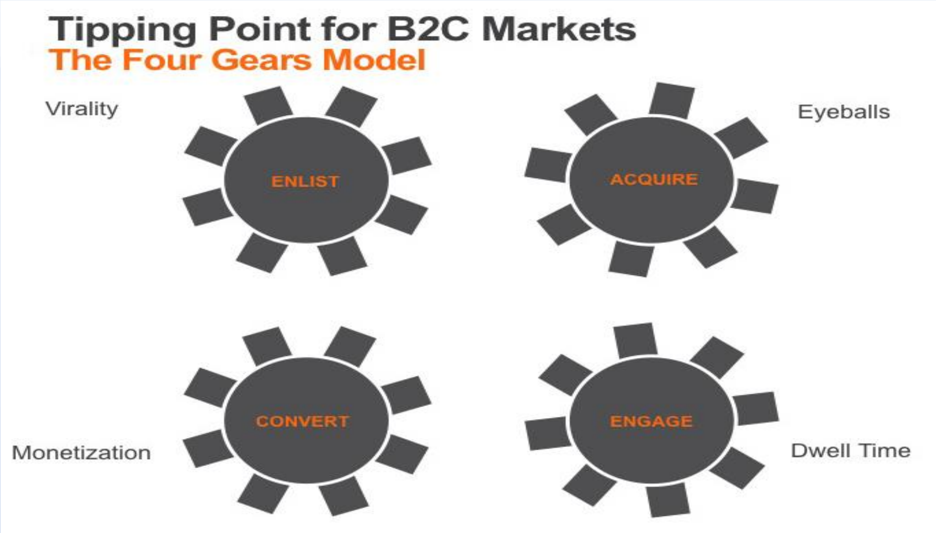
B2C/B2B Technology Adoption Phases - Business Model

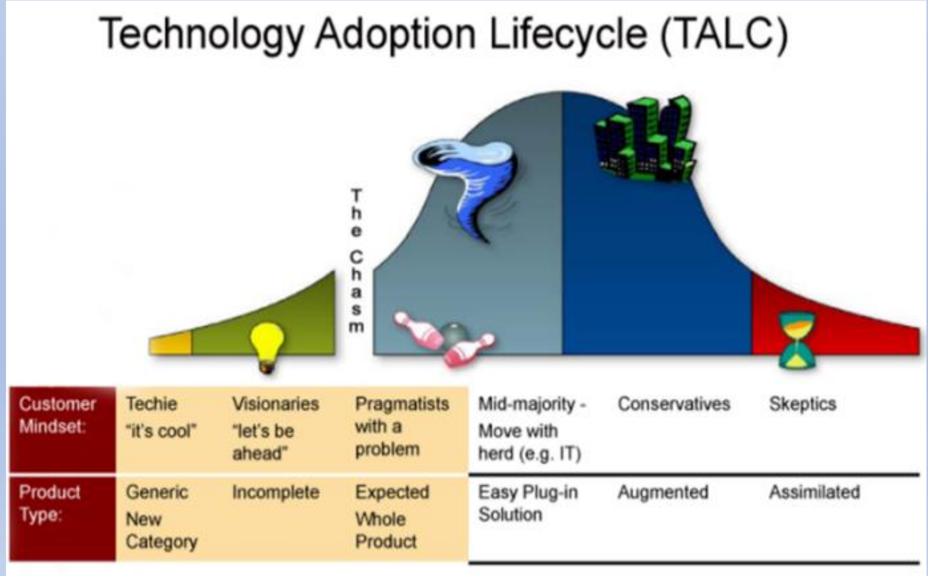
1. Engage Users

2. Develop Traffic

3. Identify the Loyal Users

4. Monetize (by charging the Loyal Users)





Ref.: G. Moore, 2013

Summary - 1 Video presentations:

1. "My APIs are the best". They are proprietary, but they are the best".

2. Repeating the mistakes done in the past while deploying New Technologies without changing the Business Framework

3. "Products are Packages of Emphasis from Technologies on the rise".

Summary - 2

1. How? or What/Why?

2. Package of Emphasis? or Emphasis?

3. Satisfy a Need? or Provides Progress?
within Social and Emotional Context?

Comments, Remarks, Questions?