LF Home Edge
- Extended Introduction

Samsung

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Home Edge Computing ?

In home appliances, the available H/W resources (CPU, Memory, Storage, etc.) are limited, but the user services require more and more resources.
Single device is difficult to provide high-quality services due to computing resource constraints.

Dist. Service Execution

Multiple Device

Feel so good !!

Edge Orchestration

High quality service using low/high-end device collaboration

Dist. Data Handling

Multiple Device

" I can wait"

Edge Orchestration

Faster with more devices

Enhance Device Service

Camera

Ping notifications tell you when your kids get home from school

Sara is home

..by using 3-D sensors and machine learning capabilities

[Access Detection]   [Human/Animal Distinction]

Add premium service to your device
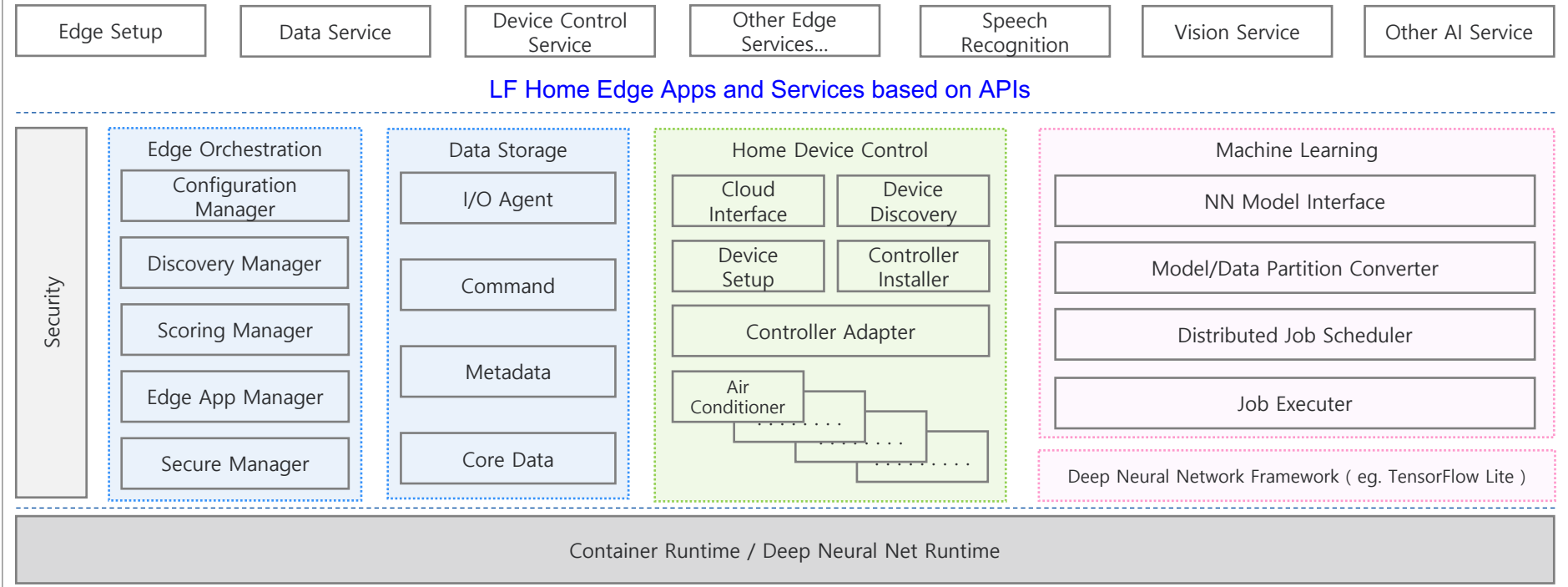
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Tech. Requirement

The Home Edge Project will offer an edge computing open source platform for various use cases in the home, meeting the technical demands of products and services such as:

› Dynamic device / service discovery at Home Edge

› Distributed machine learning

› Multi-vendor interoperability

› Security and data privacy of users

› QoS guarantee in various dynamic conditions (e.g. devices On or Off)

Requirements : Home Edge

Key Features	Description
Edge Orchestration	- Find edge devices/services - Monitor device resource to choose best one - Service offloading - service lifecycle management
Data Storage	- Collect and share data for home devices - Provide persistent storage
Home Device Control	- Discovery home devices in local network - Control home devices - Provide interface between cloud and home devices
Machine Learning	- Execute neural network model using neural network Framework - Allocate distributed job and manage scheduling
Security	- Provide function to secure peer to peer communication - Protect user data

High-Level Platform Architecture

Edge Setup	Data Service	Device Control Service	Other Edge Services...	Speech Recognition	Vision Service	Other AI Service

LF Home Edge Apps and Services based on APIs

Security

Edge Orchestration

- Configuration Manager
- Discovery Manager
- Scoring Manager
- Edge App Manager
- Secure Manager

Data Storage

- I/O Agent
- Command
- Metadata
- Core Data

Home Device Control

Cloud Interface	Device Discovery
Device Setup	Controller Installer

Controller Adapter

Air Conditioner . . . .

Machine Learning

- NN Model Interface
- Model/Data Partition Converter
- Distributed Job Scheduler
- Job Executer

Deep Neural Network Framework (eg. TensorFlow Lite)

Container Runtime / Deep Neural Net Runtime

Legend

| Edge Service	Device Control	AI	Runtime Engine

* Samsung seed code is based on EdgeX Foundry that is able to provide real-time, locality, and user privacy for various use cases, initially focused on Orchestration and storage.

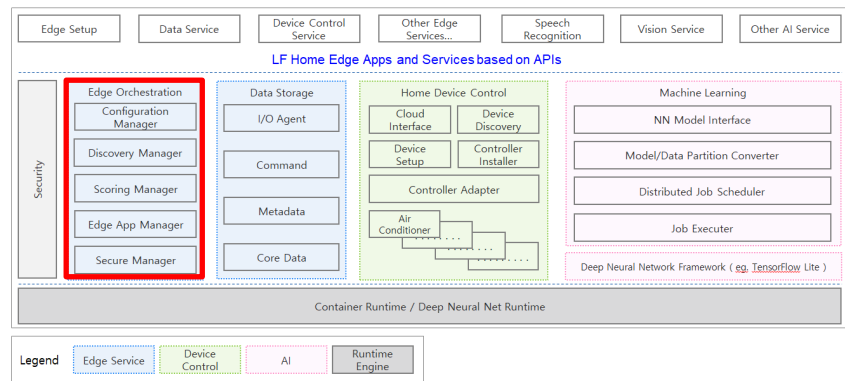# Module Description (1/5)

Edge Orchestration Module

› <u>Configureration Manager :</u>
Services need to register their information to use edge orchestration.
These info is used to process each distributed service.

› <u>Discovery Manager :</u>
Find the home edge devices and their services.
Default is local network. NAT Traversal also can be supported

› <u>Scoring Manager:</u>
Check the available (computing) resource and scoring for each registered service
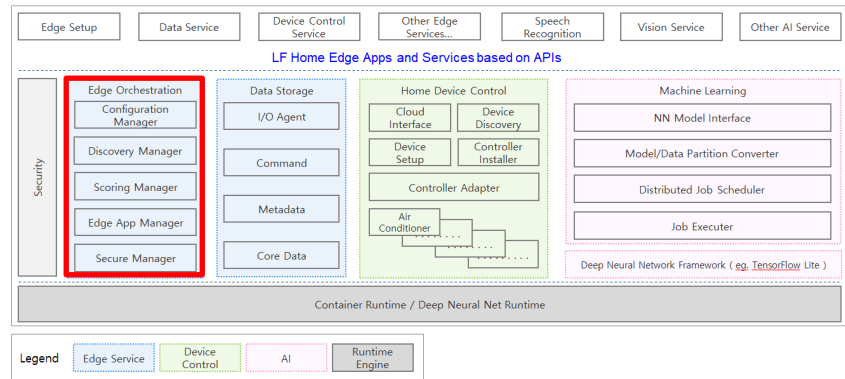
Module Description (1/5)

Edge Orchestration Module (Cont'd)

› <u>Edge App Manager</u>:
Handle command to execute application on a remote device and notify status. Manage executed application's life-cycle.

› <u>Secure Manager</u>:
Encrypt & decrypt data between orchestration to orchestration. Provide simple method to identify user's device.

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Data Storage Module

› <u>Core Data</u> :
Provides a persistent storage on the Home Edge device for those collected data from its connected home devices (CE device, sensor, thing) and services.

› <u>Metadata</u> :
Has knowledge about the ID / profile / data of the connected home devices (CE, sensor, thing) and services.

› <u>I/O Agent</u> : Provides an API for accessing the data storage.

› <u>Command</u> : Provides a method for getting specific data from the data storage of the Home Edge device by rule-based approach.
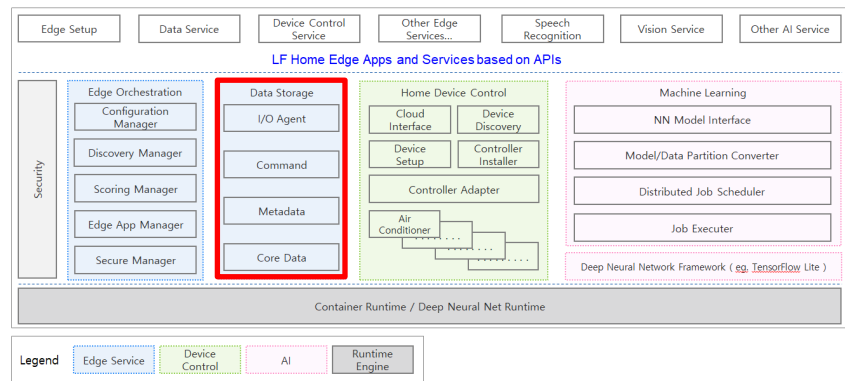
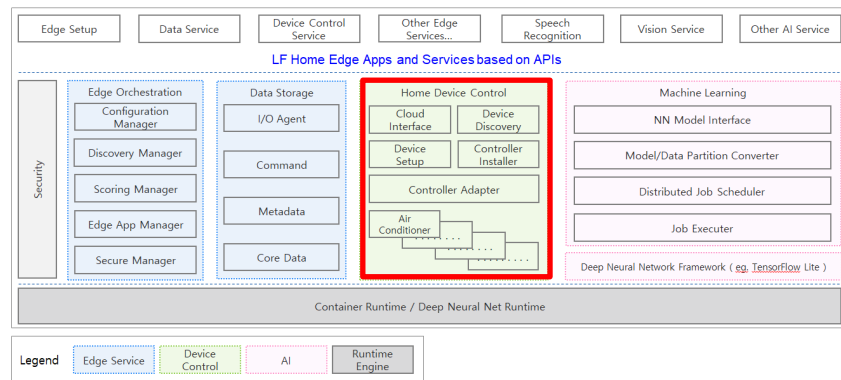# Module Description (3/5)

Home Device Control Module

› <u>Cloud Interface</u> :
Provides the interface between cloud services and each home devices in a user's home network.

› <u>Device Discovery</u> :
Finds the connected home devices from the Home Edge device, when the connected home device is found for the first time, their client service will be installed by Controller Installer.

› <u>Device Setup</u> : Sets the required network information of the connected home device for making it join a user's home network.
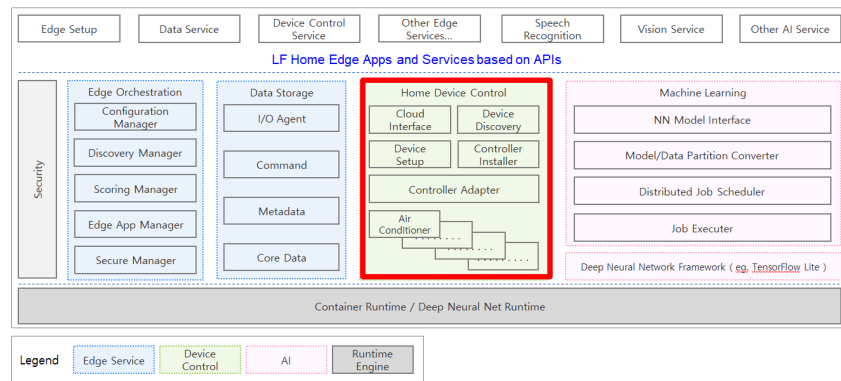
Module Description (3/5)

Home Device Control Module (Cont'd)

› <u>Controller Installer</u> :
Installs a client service of the discovered connected home device.

› <u>Controller Adapter</u> :
Provides unified APIs for the control of the connected home devices.

› <u>Home Device Client</u> : Controls the connected home devices (e.g. user's refrigerator, washing machine, light bulb, door-lock, HVAC, and temperature sensor).

Module Description (4/5)

Machine Learning Module

› <u>Neural Network Model Interface</u> : Provides APIs for inference and recognition using (distributed) neural network processing.

› <u>Model Partition Converter</u> : Divides model for distributed neural network processing.

› <u>Distributed Job Scheduler</u> : Schedules and allocates distributed job.

› <u>Job Executer</u> : Executes distributed job on the Home Edge device using Deep Neural Network Framework.
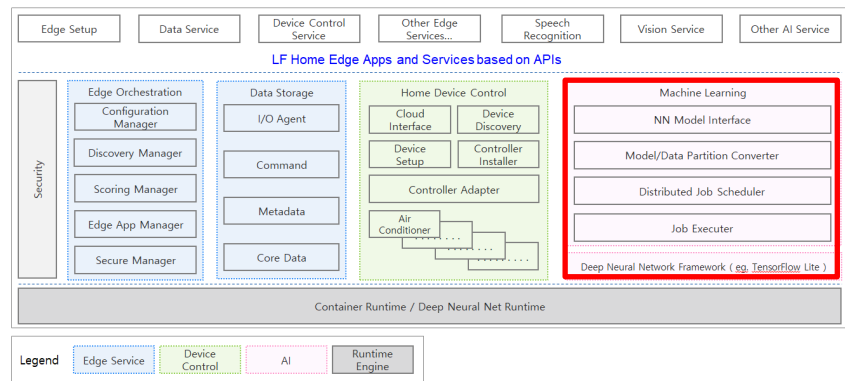
Module Description (5/5)
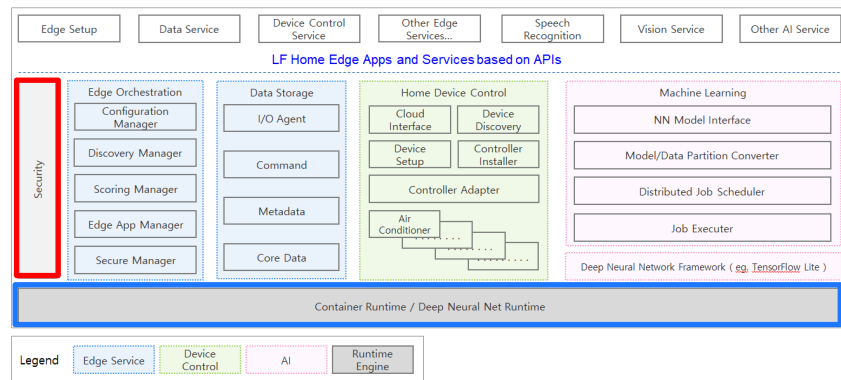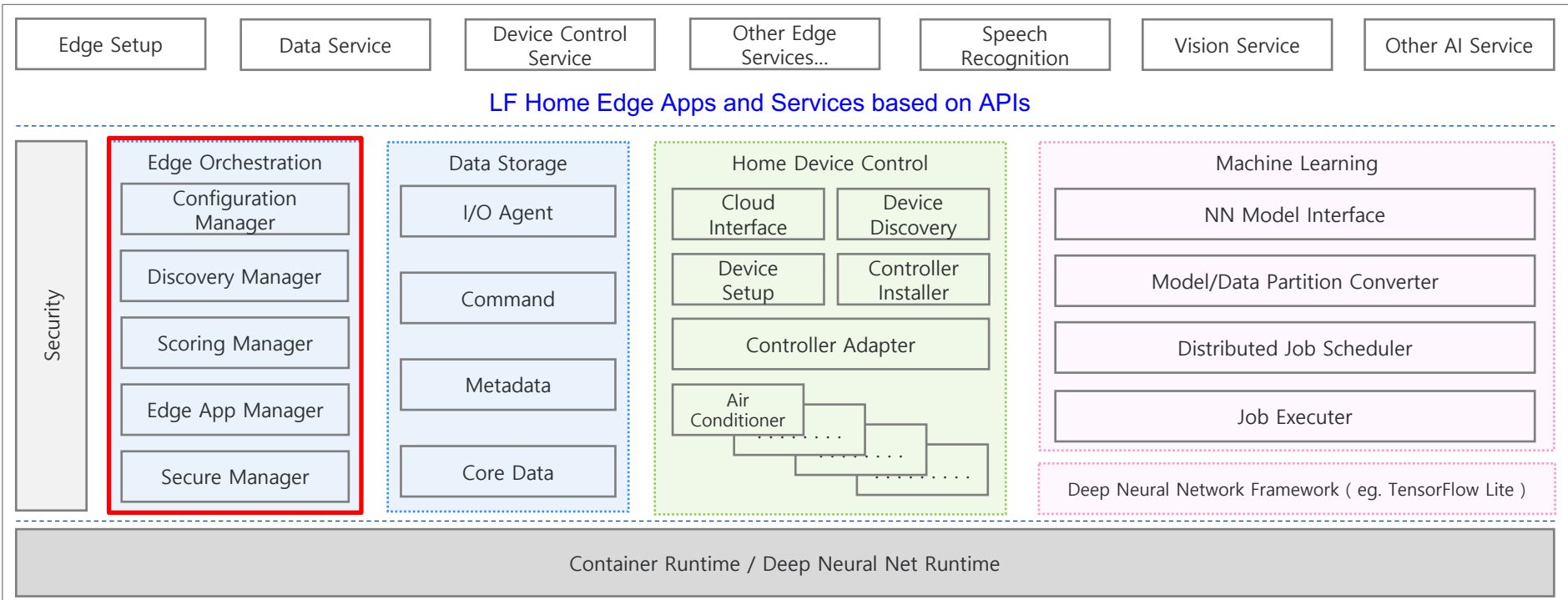
Security Module

› Security Module provides security features that the Home Edge devices and services should have to provide, such as secure on-boarding, Certificate, AAA, encryption/decryption of the message protocols, and so on.

Deep Neural Network Framework

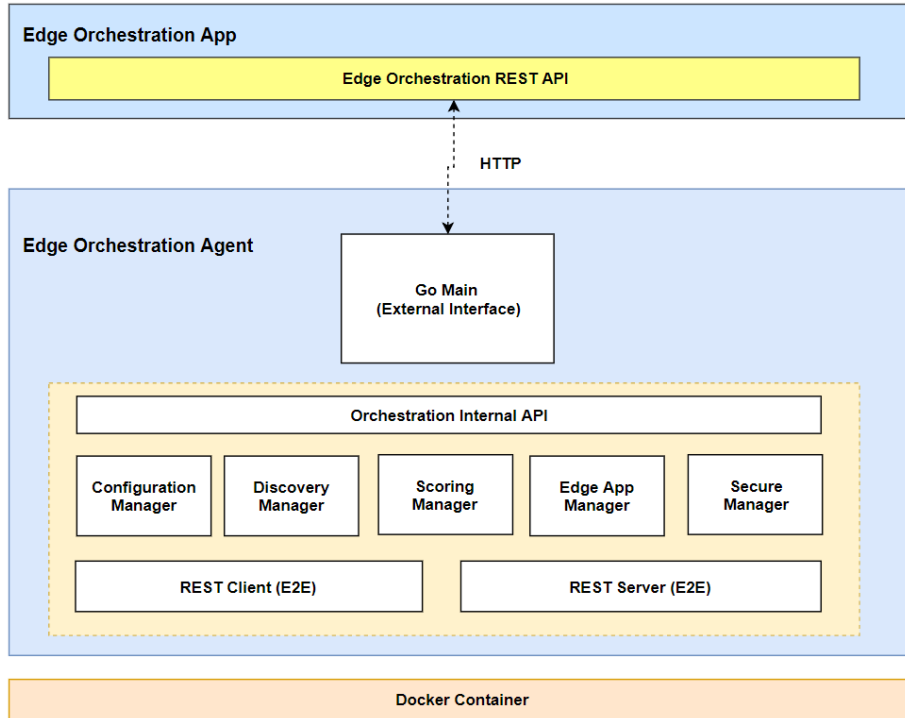› Deep Neural Network Framework provides dataflow programming framework for machine learning such as TensorFlow Lite.

High-Level Platform Architecture

Edge Setup	Data Service	Device Control Service	Other Edge Services…	Speech Recognition	Vision Service	Other AI Service

LF Home Edge Apps and Services based on APIs

Security

Edge Orchestration
- Configuration Manager
- Discovery Manager
- Scoring Manager
- Edge App Manager
- Secure Manager

Data Storage
- I/O Agent
- Command
- Metadata
- Core Data

Home Device Control
- Cloud Interface
- Device Discovery
- Device Setup
- Controller Installer
- Controller Adapter
- Air Conditioner

Machine Learning
- NN Model Interface
- Model/Data Partition Converter
- Distributed Job Scheduler
- Job Executer
- Deep Neural Network Framework (eg. TensorFlow Lite)

Container Runtime / Deep Neural Net Runtime

Legend

Edge Service	Device Control	AI	Runtime Engine

Current Status & Coverage of Alpha Release

› Current Status

  › Configuration Manager : set configuration for registration

  › Discovery Manager : local network (using mDNS-SD)

  › Scoring Manager : measuring resources (CPU, Memory, NW Bandwidth)

  › Edge App Manager : remote service execution, notify status

  › Secure Manager : data encryption & decryption

› Alpha Release (~June. 2019)

  › orchestration modules are under verification

  › add more functionalities

  › handle exception cases

Edge Orchestration Architecture

Edge Orchestration App

Edge Orchestration REST API

HTTP

Edge Orchestration Agent

Go Main
(External Interface)

Orchestration Internal API

| Configuration Manager | Discovery Manager | Scoring Manager | Edge App Manager | Secure Manager |

REST Client (E2E)

REST Server (E2E)

Docker Container

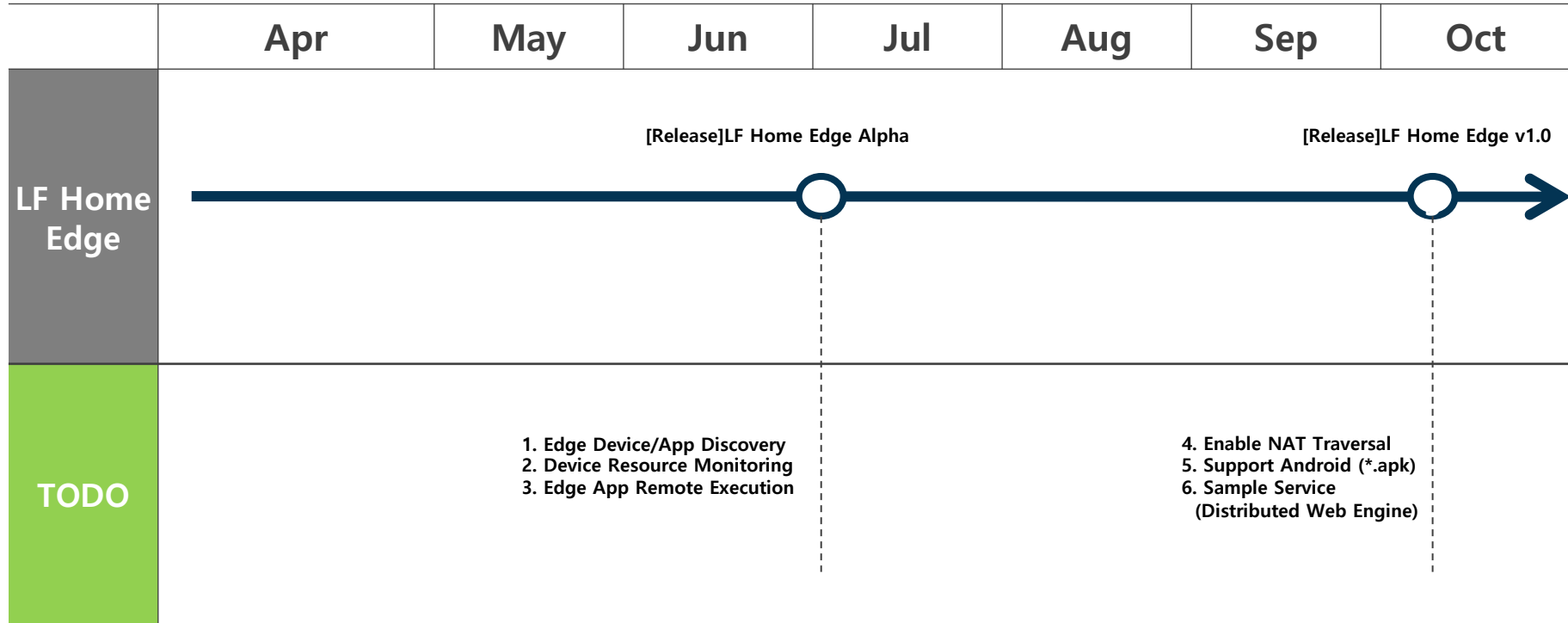| Term	Definition
Edge (Orchestration) Agent	Core service for performing functions of Edge Orchestration
Edge Device	Devices that provide services of Edge Orchestration
Edge App	Application using Edge Orchestration Agent
Device Resource	Resource available on the device (e.g. CPU, Memory, Storage, NW Throughput, NW Bandwidth)
Device Resource Scoring	Criteria for measuring of device idle resources (by each Edge App)

IPC / Network
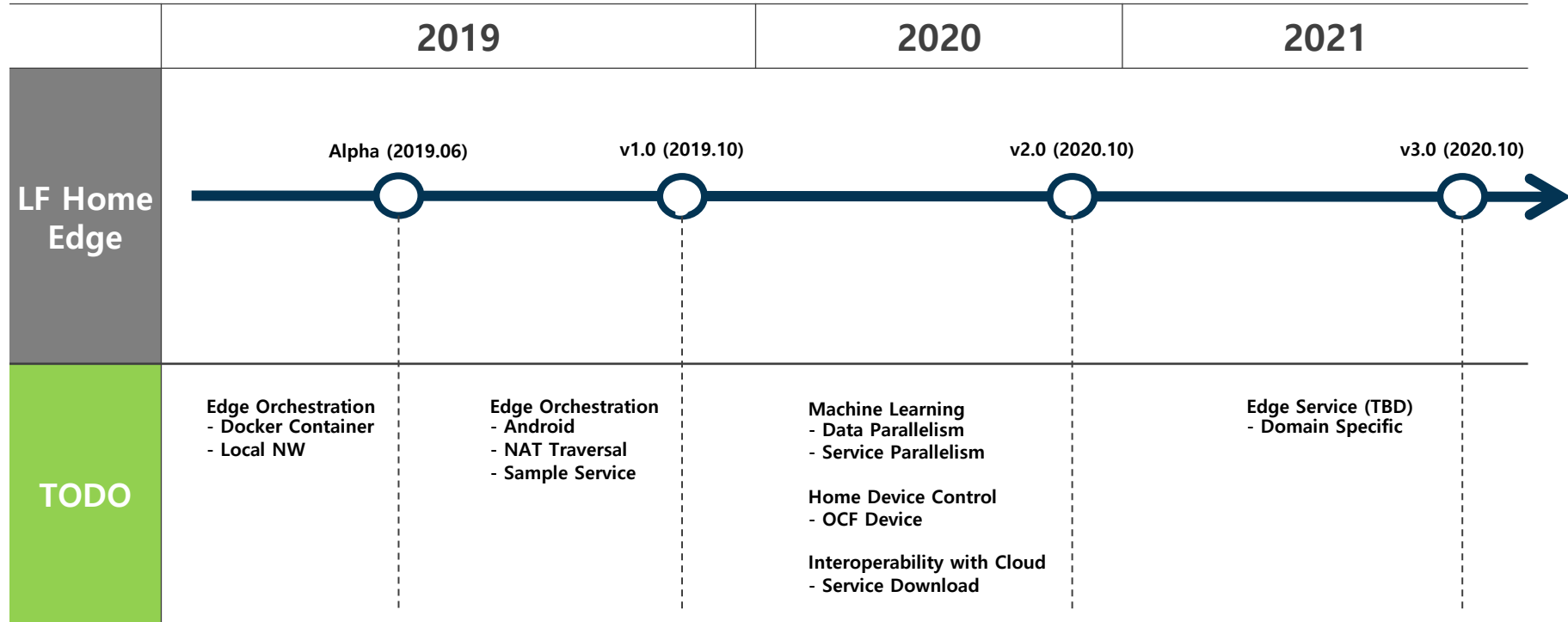
Edge Orchestration Core (Go)

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Orchestration to Orchestration API

Category		Method	URI
Discovery	Status	GET	/api/v1/discoverymgr/devices
		POST	/api/v1/discoverymgr/devices
		POST	/api/v1/discoverymgr/devices/TXT
Edge Service (App)	Execute	POST	/api/v1/servicemgr/services
	Status	POST	/api/v1/servicemgr/services/notification/{serviceid}
Scoring	scorevalue	GET	/api/v1/scoringmgr/score/{appname}

RoadMap 2019 (Edge Orchestration)

	Apr	May	Jun	Jul	Aug	Sep	Oct

LF Home Edge

[Release]LF Home Edge Alpha

[Release]LF Home Edge v1.0

TODO

1. Edge Device/App Discovery
2. Device Resource Monitoring
3. Edge App Remote Execution

4. Enable NAT Traversal
5. Support Android (*.apk)
6. Sample Service
   (Distributed Web Engine)

RoadMap

	2019	2020	2021
LF Home Edge	Alpha (2019.06) v1.0 (2019.10)	v2.0 (2020.10)	v3.0 (2020.10)
TODO	Edge Orchestration - Docker Container - Local NW Edge Orchestration - Android - NAT Traversal - Sample Service	Machine Learning - Data Parallelism - Service Parallelism Home Device Control - OCF Device Interoperability with Cloud - Service Download	Edge Service (TBD) - Domain Specific

LF Home Edge

F2F meeting during ONS

Edge Orchestration (1/2)

Assignment of "Master" edge device among multiple edge devices at home

› Sharing resource with all edge devices, when a new one is added to the network.

› Assignment of "Master" edge after analyzing current resource status and capability about all the edge devices.

	TV	Fridge	AI Speaker
Always ON	O	O	O
CPU	1.7 GHz	1.3 GHz	**2.2 GHz**
Core Number	4	4	**8**
Memory	2.0 GB	4.0 GB	1.8 GB
Idle Memory	400 MB	700 MB	**1 GB**

< Example on Master Edge Device Assignment >

① Resource Sharing

Fridge (Edge)

② **Edge Master Assign**

③ Edge Master Assignment Noti.

AI Speaker (Master Edge)

TV (Edge)

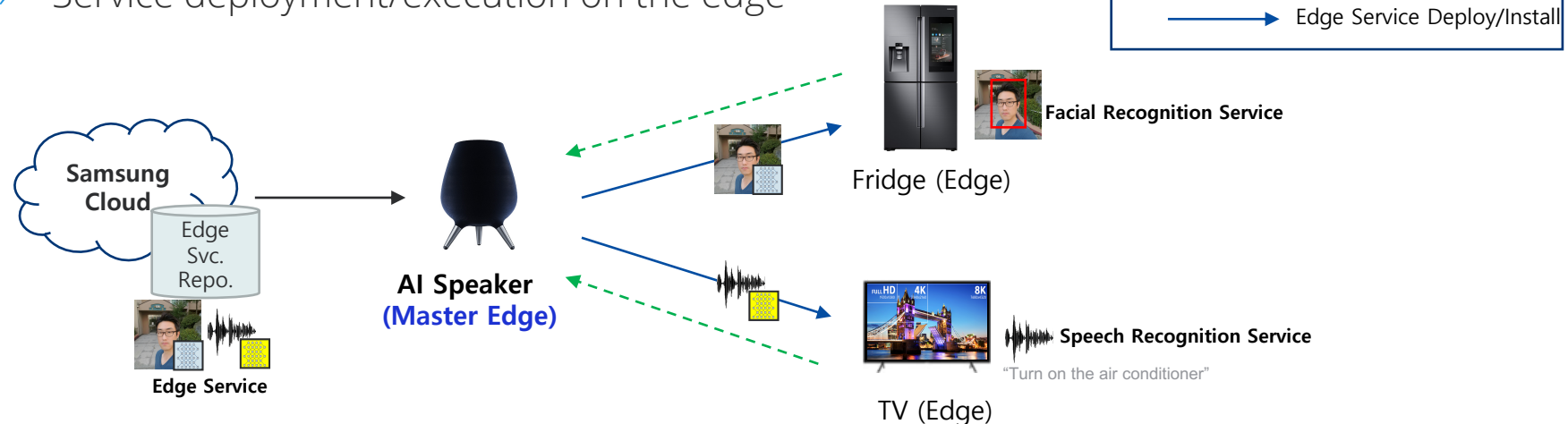① Resource Sharing
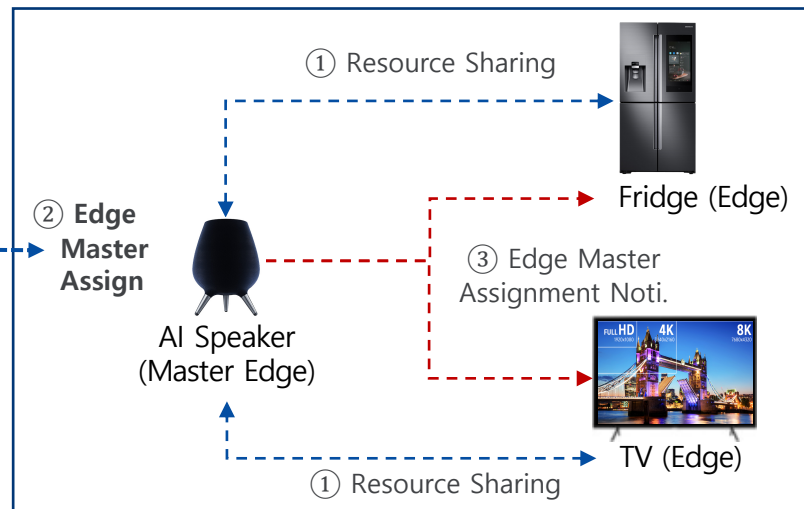
< Master Edge Device Assignment Process >

Edge Orchestration (2/2)

Service deployment/execution/scheduling based on real-time resource status

› Real-time resource monitoring of all edge devices at home

› Edge service searching and download stored in the cloud

› Service deployment/execution on the edge

Legend
- - - - ▶ CPU, RAM, Disk Monitor
────▶ Edge Service Download
────▶ Edge Service Deploy/Install

Samsung Cloud

Edge Svc. Repo.

Edge Service

AI Speaker
(Master Edge)

Fridge (Edge)

Facial Recognition Service

TV (Edge)

Speech Recognition Service

"Turn on the air conditioner"

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Data Parallelism

Optimization on elapsed time of inference through multi edge devices at home

› Execution of the same ML service to multi edge devices

› Distributed transmission of input data into multi edge devices

› Data distribution transmission scheduling based on edge device resource

Input Data

ML Model
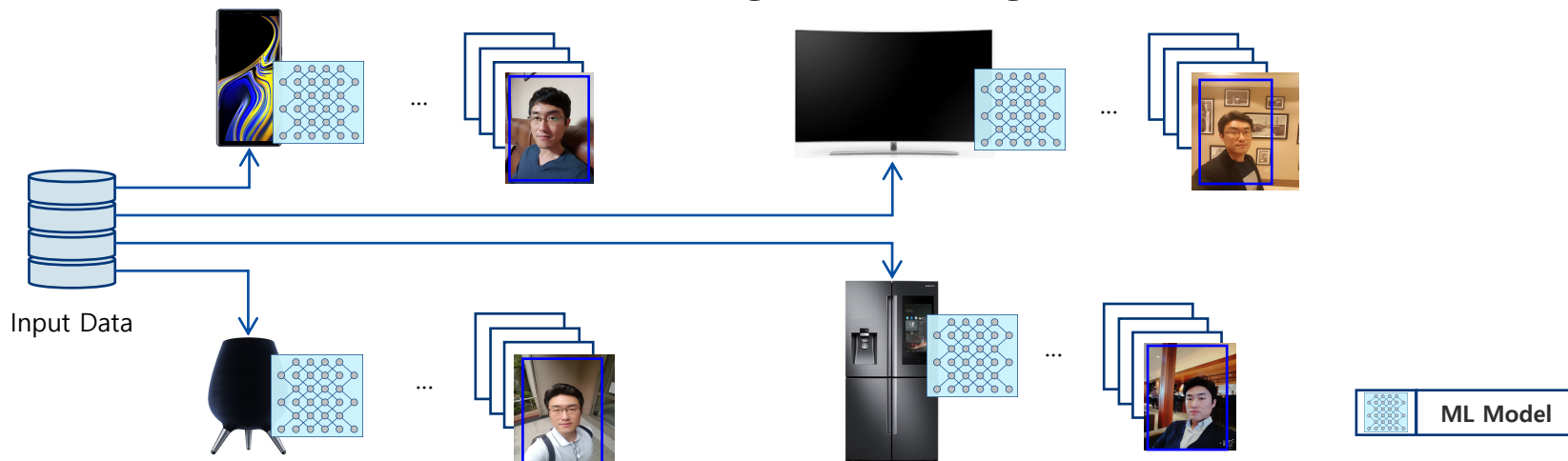
< Data Parallelism (Data Parallelism, using same model) >

Service Parallelism

Parallel service processing through multi edge devices

› Simultaneous execution of variant ML services into multi edge devices

› Transmission of all input data into multi edge devices

› Model deployment scheduling based on edge device resource

Dog Extraction

Bicycle Extraction

Input Data

Car Extraction

Tree Extraction
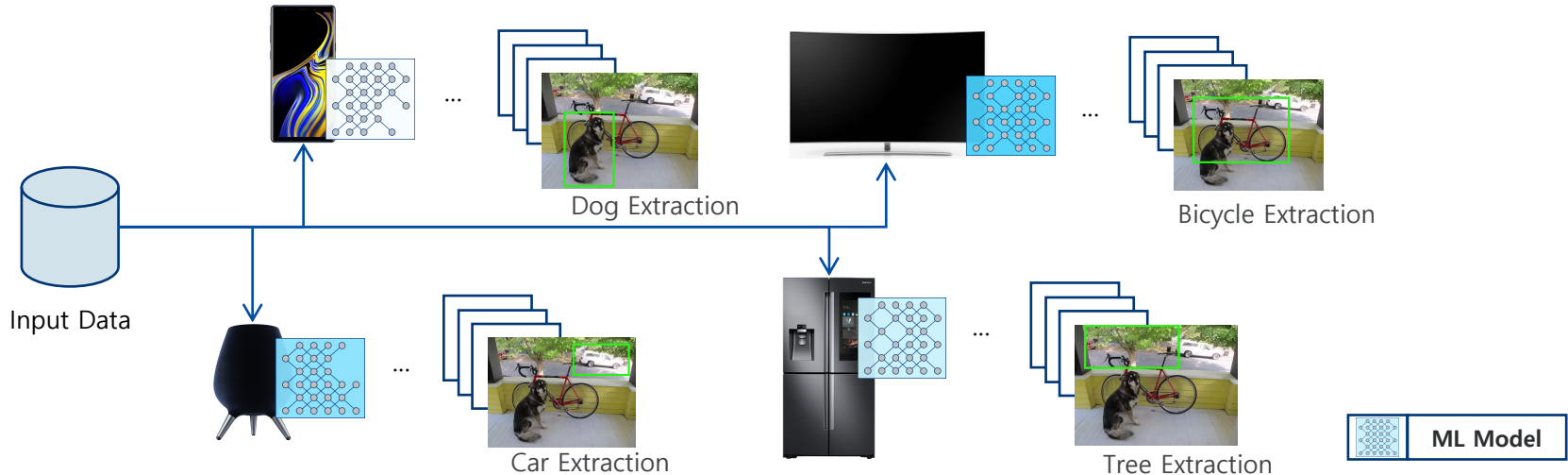
ML Model

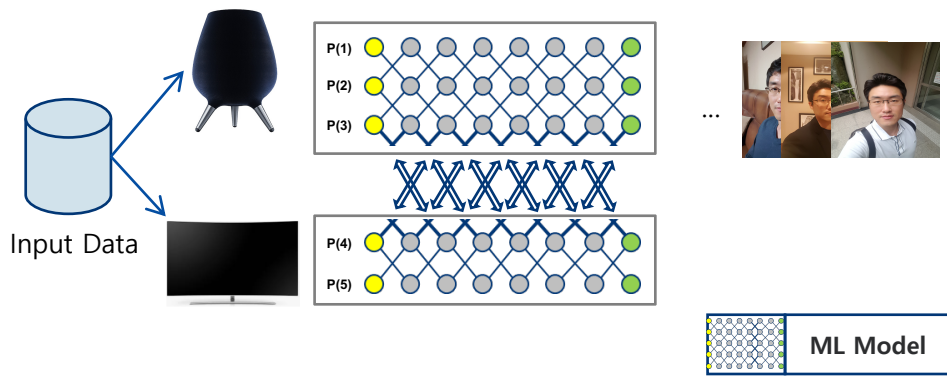**< Service Parallelism (using same data, different model) >**

Model Parallelism

ML inference / model learning through multi edge devices

› Distribution and execution of a single ML model from multi edge devices

› Model partition w.r.t. the size of ML model, cost of communication, resource
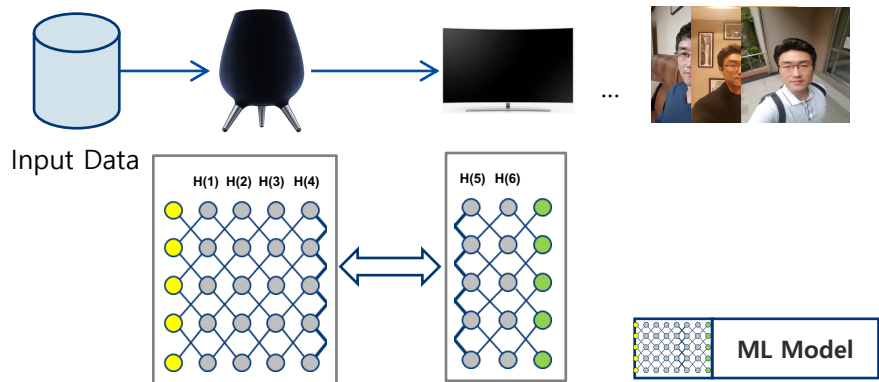
< 4:2 Layer Partition >

< 3:2 Feature Partition Model >

Executive Summary

Where : Intel Santa Clara Office, 08:00 ~ 12:00 on April 2nd.

Material : https://wiki.lfedge.org/pages/viewpage.action?pageId=4624102

Agenda

› Overview of Home Edge Project

› Use cases driving the design / implementation of Home Edge Project

› Deeper dive on the project connecting use cases with functionality

› Home Edge possible candidates or Blueprint

› Possible collaboration with other projects in LF Edge and members

› AoB

Edge Orchestration (Master Edge)

› Intelligent Master Edge Assignment : Beyond policy ➔ pattern thru learning.

› Intelligent connectivity management : to bridge the various connectivity at home.

› Flexible negotiation : for the Master Edge Assignment via given various situations.

› Resource sharing including wireless (e.g. 5G) channel condition : for optimized routing.

Distributed & Parallel ML

› Learning from the Home Edge Device : as well as from the cloud.

› ML application expansion : to devices control & contents subscription as a user's pattern.

Highlight – Requirement Feedback (2/4)

Home Edge Profile

› A clearer guideline for <u>minimum memory footprint & storage size</u>.

› Definition & functionalities for <u>Edge Device other than CE devices</u> (e.g. doorlock).

› <u>Multi-tier (level) Edge profile</u> : and features, use cases, architecture, and common layer.

APIs

› <u>API document (before seed code release)</u> : for the collaboration items in the community.

› Clarifying the <u>API development and management</u> relationship with EdgeX and others.

Data Privacy Policy

› <u>Multi-level policy management</u> : e.g. TV (contents – more sensitive) vs. A/C (temp. control).

Highlight – Requirement Feedback (3/4)

Enabler with Telco Business (if necessary)

› Possibility to propose a <u>new Blueprint to Akraino</u> : 5G Home Service use cases [WIP].

› <u>Numeric verification</u> to prove the tech. benefit : e.g. latency, computing power, etc.

Container Runtime Alternatives

› Support container runtime alternatives (or updates) : <u>possibility to co-work with EVE</u>.

› <u>OS and runtime definition</u> for the better technical understanding.

Ecosystem (Marketplace)

› <u>Container deployment infra.</u> beyond DockerHub as marketplace (w/ Certification).

› <u>Open platform</u> : to grant 3rd party to access the Home Edge for enabling their services.

Highlight – Requirement Feedback (4/4)

Operational

› <u>WG per use case</u> as well as the platform modules (technical) : use case mining.

› Direction : collection of gap analysis, tech. requirement → roadmap v2.0 → v1.0 release

  › Designated pages for the gap analysis, tech. requirement gathering.