IoTivity – Connecting Things in IoT

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Agenda

- Overview of IoT, OIC & IoTivity
- IoT Stack, Topologies & Protocol
- IoTivity Architecture
- Programming IoTivity Core APIs
- Programming IoTivity Service APIs
- Demo

Overview


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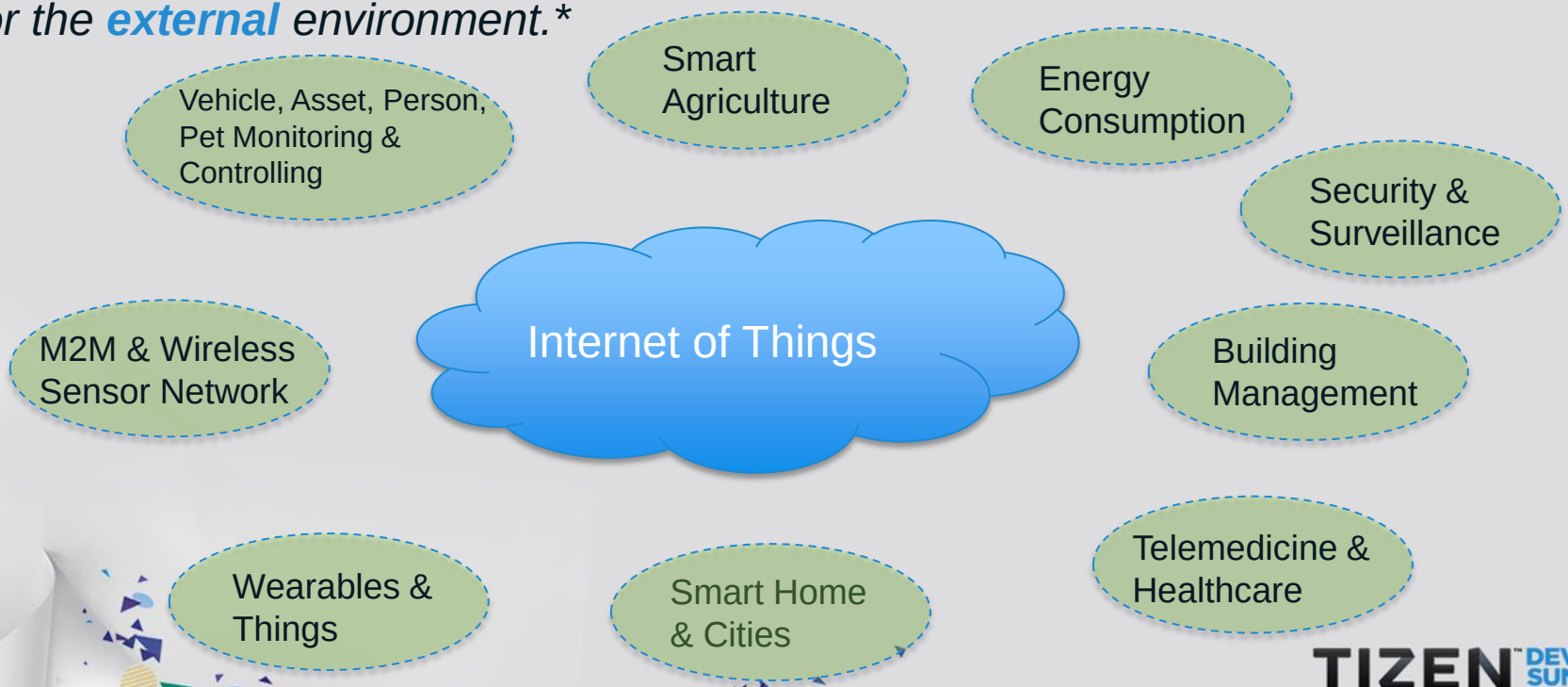
Internet of Things – What is it?

*The Internet of Things is the **network of physical objects** that contains embedded technology to **communicate** and **sense or interact** with the objects' **internal** state or the **external** environment.**



*Gartner, July 2014

What is making IoT possible?

- H/W Miniaturization & Lower BOM Cost
- Advancements in Sensor Technology
- Low Power Connectivity Technologies
- IP as key Interoperability Protocol
- Devices ability to run on battery for longer duration (> 5 years)

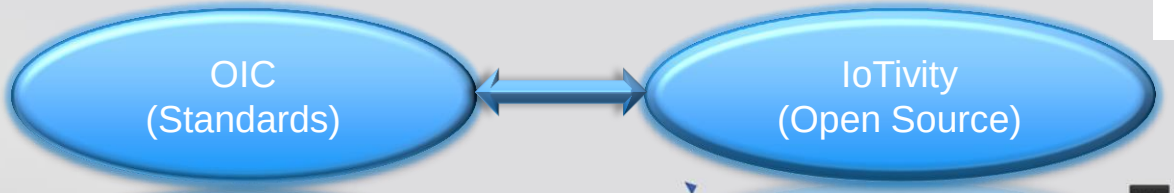
What is hindering IoT?

- Non IP based standards technology resulting in limited Interoperability
- Proprietary Protocols & Technologies
- Licensing issues
- Companies creating “Closed Ecosystem” (Zero or limited Interoperability with other Vendor devices)
- Low adoption of Open Standards by various Industry Consortiums
- Security & Privacy concerns
- Dilemma in “Ownership” of Data from variety of IoT devices
- Lack of Strong Certification for ensuring Protocol & Application Profile Interoperability

Need **Standards** & **Reference Implementation** which cater to these issues

OIC & IoTivity

- **Open Interconnect Consortium (OIC)**
  - Founded by Leading Technology Companies including Cisco, GE, Intel,, MediaTek & Samsung
  - Defines standards for connectivity requirements
  - Ensures interoperability of billions of Internet of Things (IoT) devices.
- **IoTivity**
  - An open source software framework implementing OIC Standards
  - Ensures seamless device-to-device connectivity to address the emerging needs of the Internet of Things.

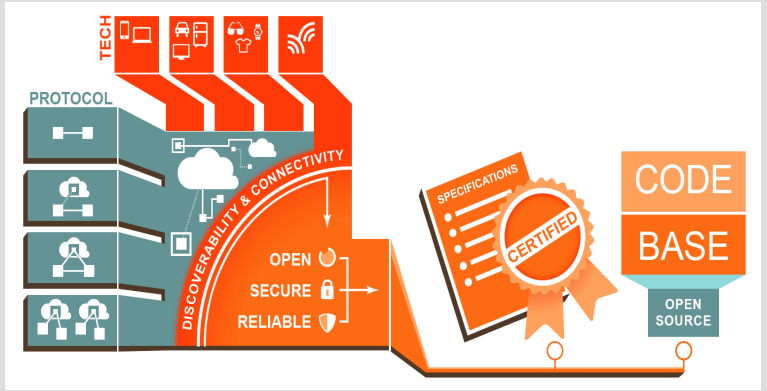


Key Focus of OIC

- OIC Standards addresses multiple vertical domains including Home Automation, Automotive, Enterprise, HealthCare, Industrial scenarios

- Initial focus on Smart Home & Office solutions

- Adopt Open Standards like IETF when applicable & standardize on areas, not addressed

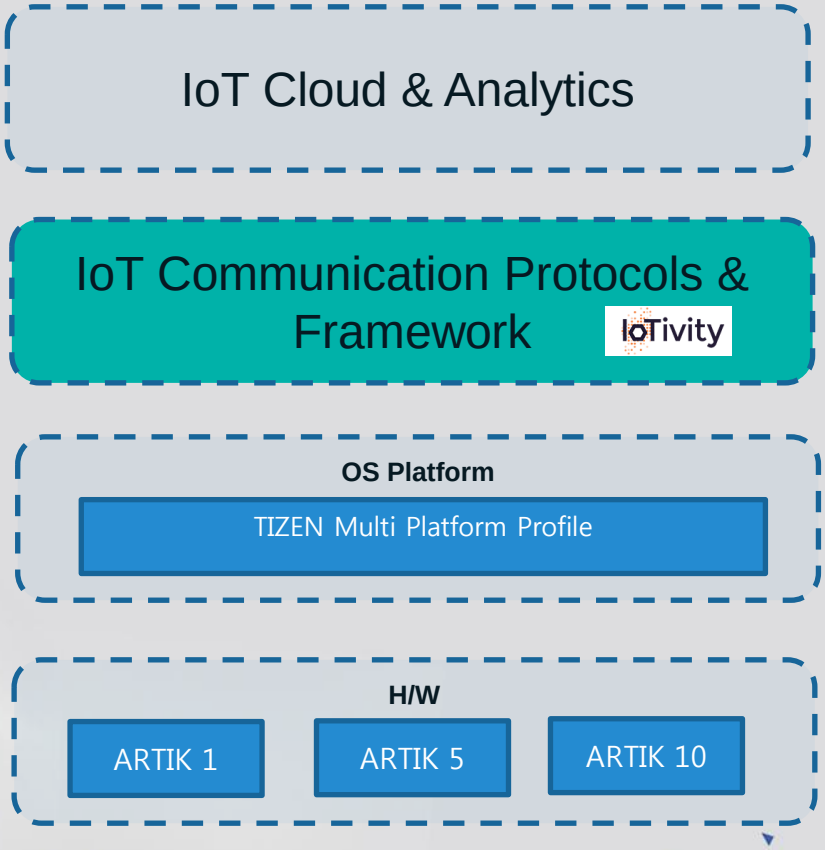


http://openinterconnect.org/

Key Focus of IoTivity

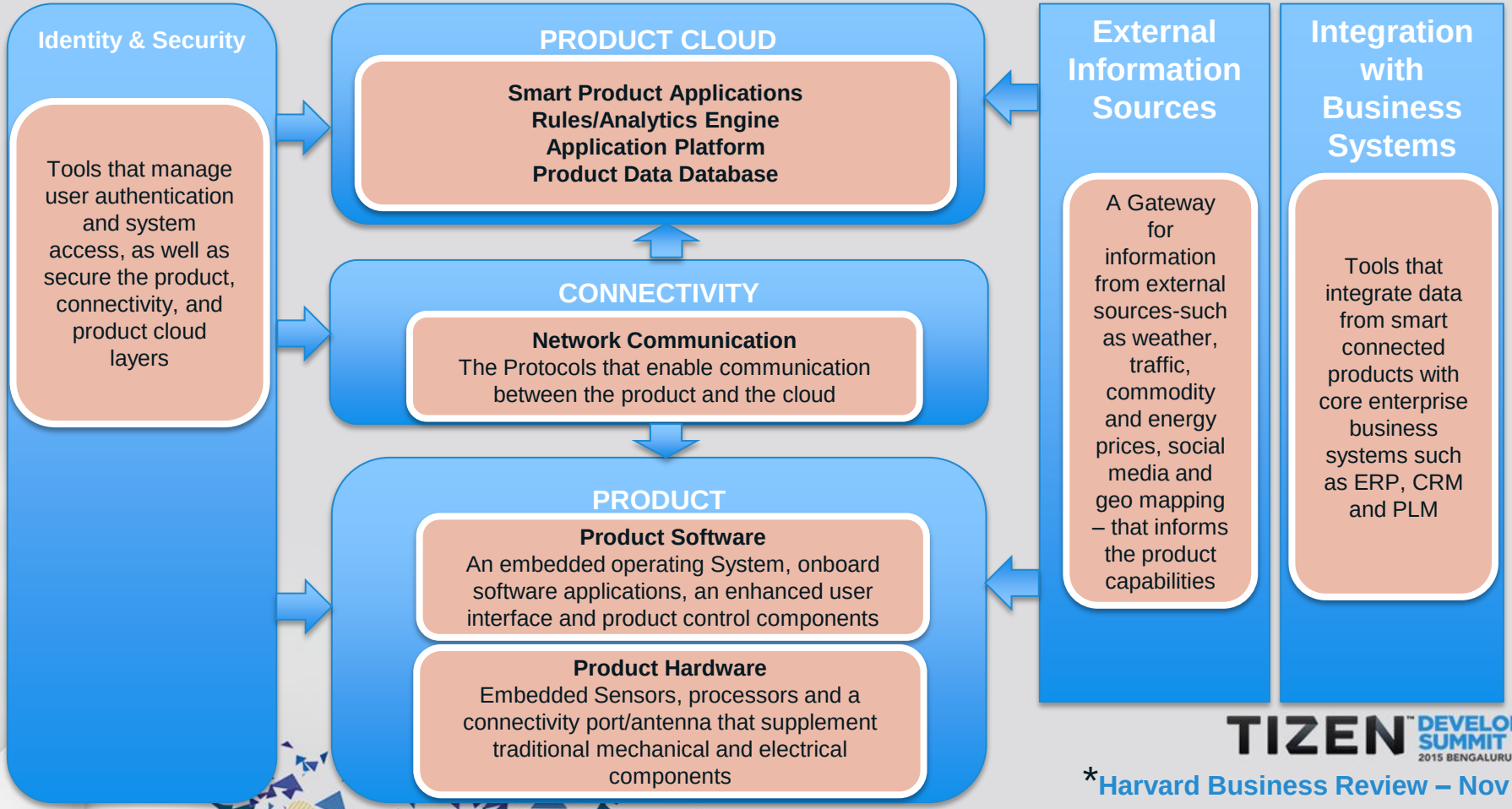
- Open Source Framework implementing OIC Standards
- Licensed under Apache License Version 2.0
- Available on TIZEN, Android, Arduino, Linux(Ubuntu) Platforms
- Provide APIs at 2 Levels
  - IoTivity Base
  - IoTivity Services

TIZEN IoT Ecosystem



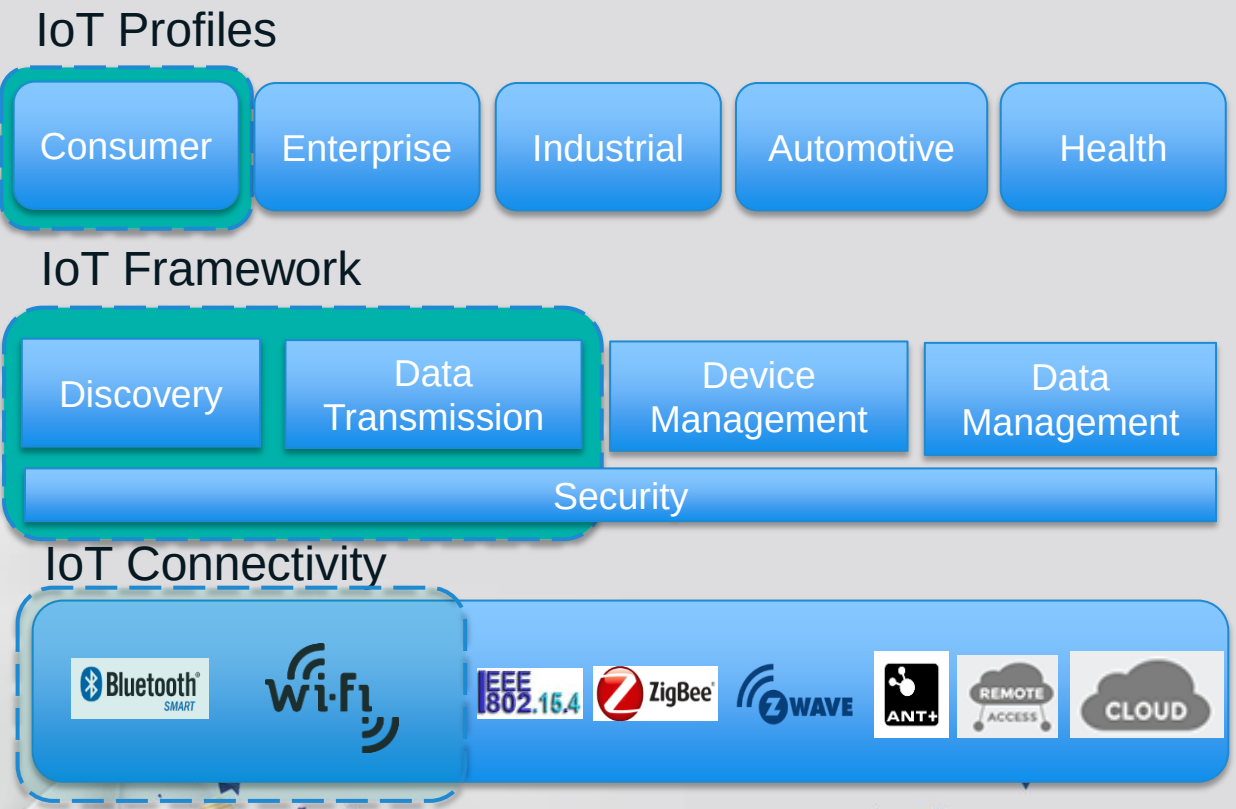
IoT Stack, Topologies & Protocol

IoT Technology Stack – End to End - Executive View*



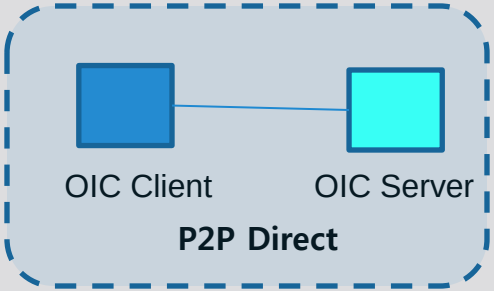
*Harvard Business Review – Nov 2014

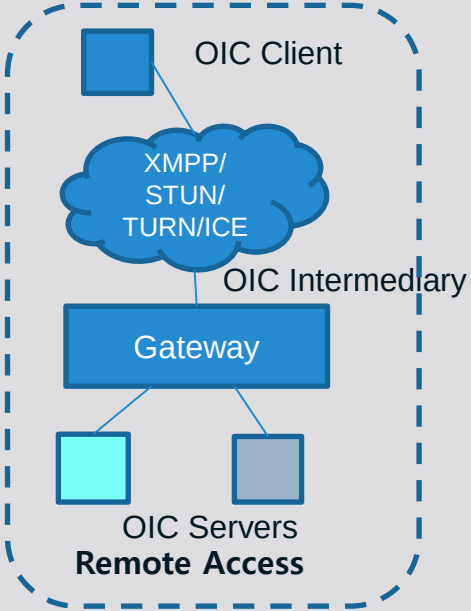
IoT Technology Stack – Technical View

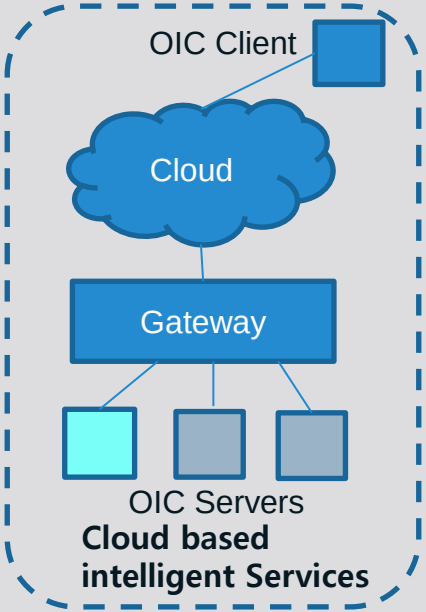


- Common Solution
- Established Protocols
- Security & Identity
- Standardized Profiles
- Interoperability
- Innovation Opportunities
- Necessary connectivity

OIC – Topologies





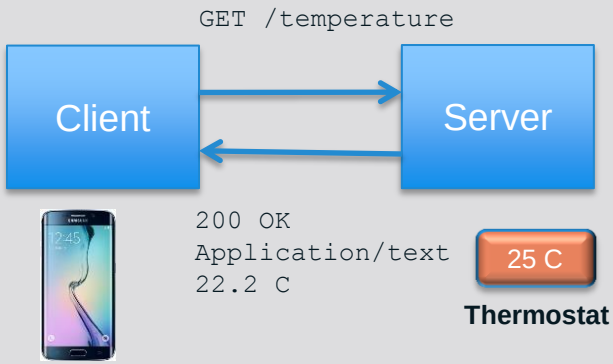


Smart Device

Smart Appliance

Sensors, Wearables

Concept of Resource & RESTful Architecture

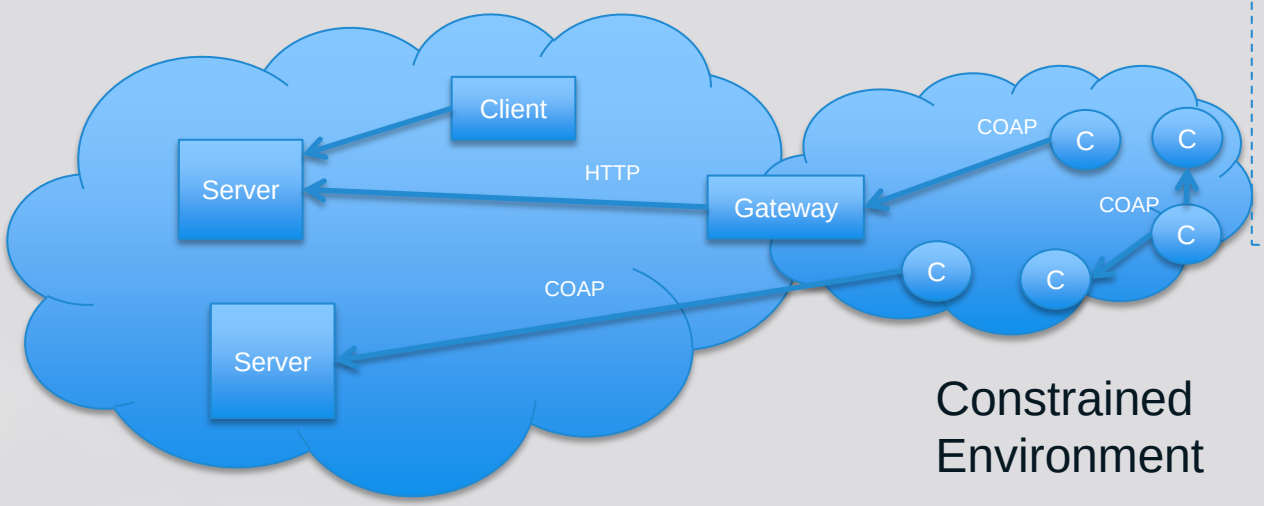


- Client-Server
- Stateless
- Cache
- Uniform Interface
- Layered System

REST Principles

Resource: Any information that can be named
e.g. Document, Image, a collection of other resources, non-virtual objects (Things)

Constrained Application Protocol (CoAP)



CoAP

- Open IETF Standard (RFC 7252)
- Compact 4 Byte Header
- UDP (Default), SMS, TCP Support
- Strong DTLS Security
- Asynchronous Subscription
- Built-In Discovery

Constrained Environments – What is it?

- Limitations on Code Size (ROM/Flash)
- Size of State & Buffers (RAM)
- Processing Power (CPU)
- Power Consumption
- User Interface & Accessibility in deployment

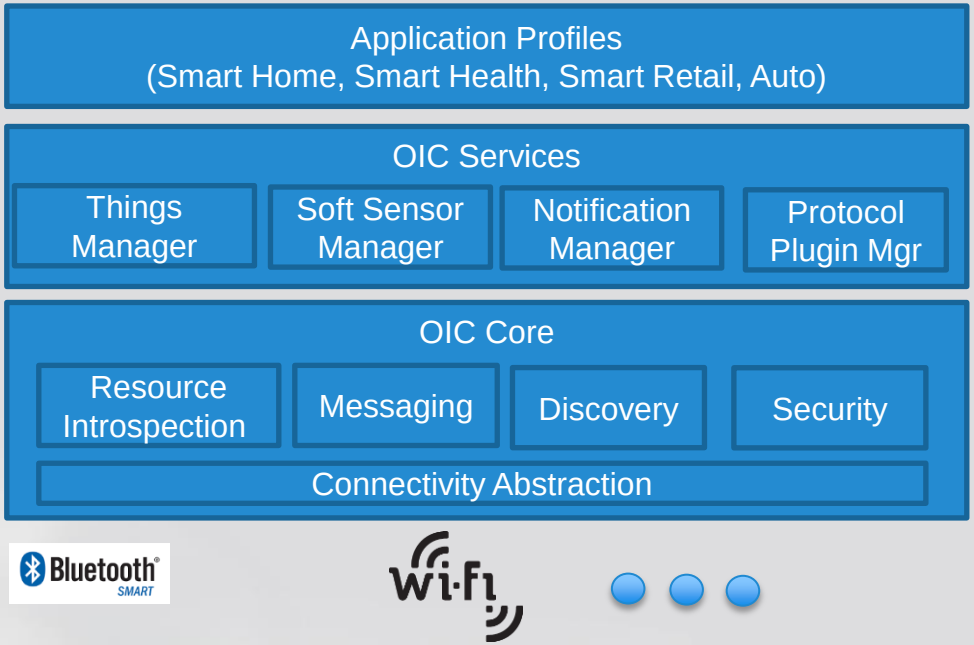
Constrained Nodes

- Low achievable bitrate/throughput
- High packet loss & high variability of packet loss (delivery rate)
- Highly asymmetric link characteristics
- Severe penalties for using larger packets
- Limits on reachability over time
- Lack of advanced services such as IP multicast

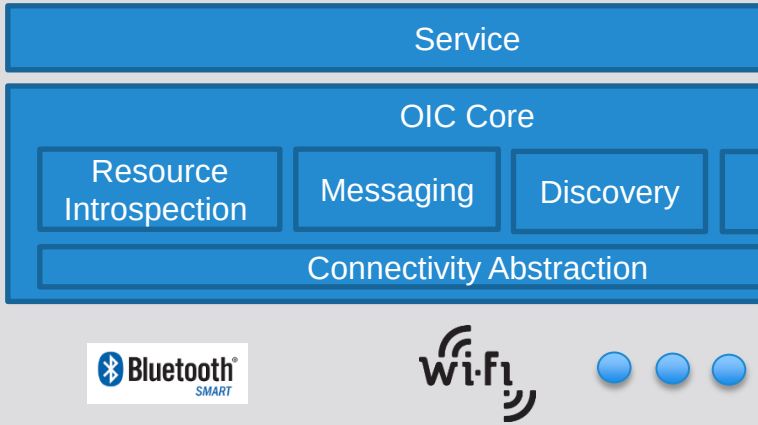
Constrained Networks

IoTivity Architecture

IoTivity – High Level Architecture



Smart Devices (OIC Clients)
(Smartphone, SmartTV, SmartHub etc)

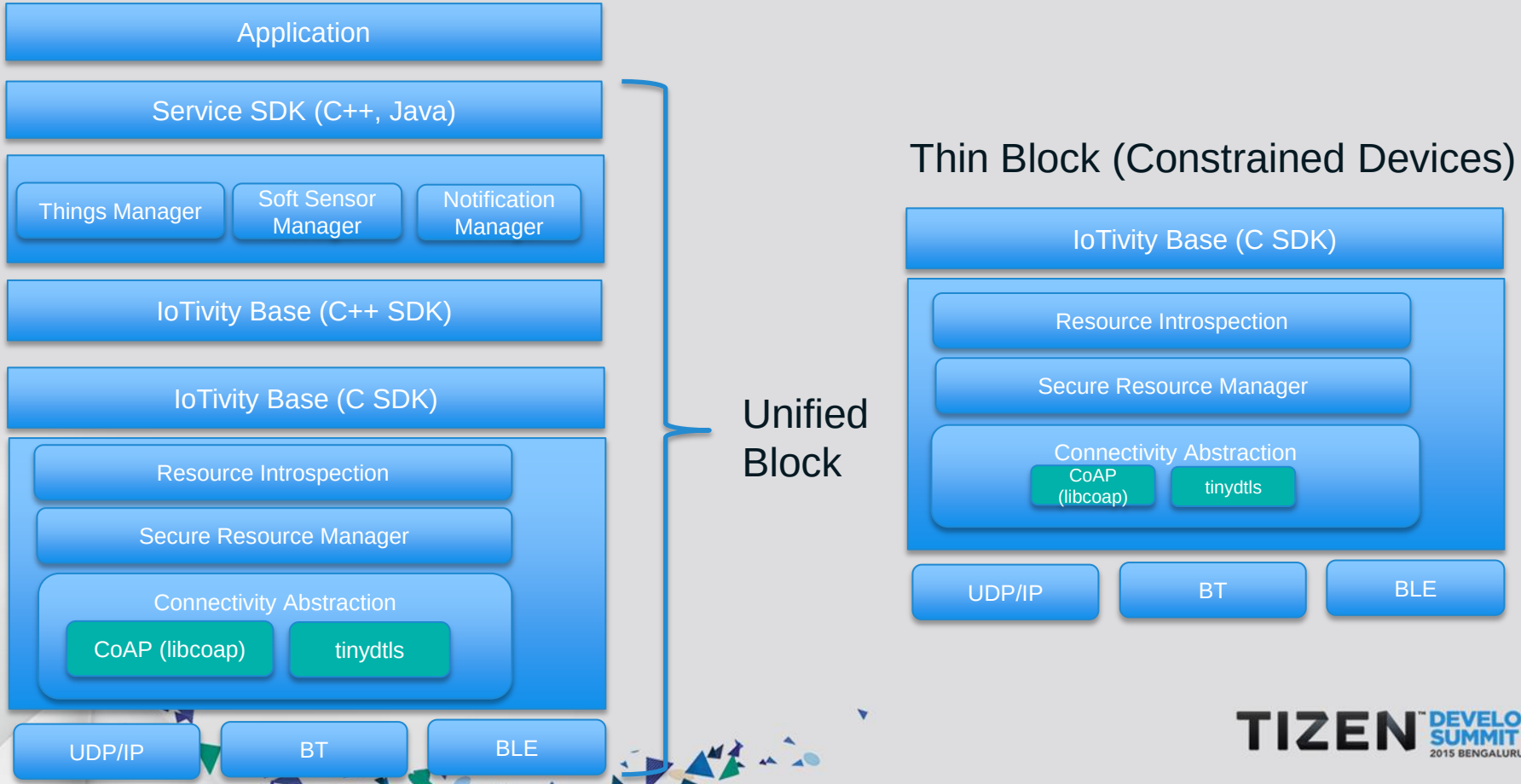


Thin Device (OIC Server)
(Thermostat, Motion Sensor etc)

IoTivity Framework – Key Functionality

Functionality	Description
Discovery	IoTivity discovery supports multiple discovery mechanisms for devices and resources in proximity and remotely
Data Transmission	IoTivity data transmission supports information exchange and control based on a messaging and streaming model
Data Management	IoTivity data management supports the collection, storage and analysis of data from various resources.
Device Management	IoTivity device management supports configuration, provisioning and diagnostics of devices.

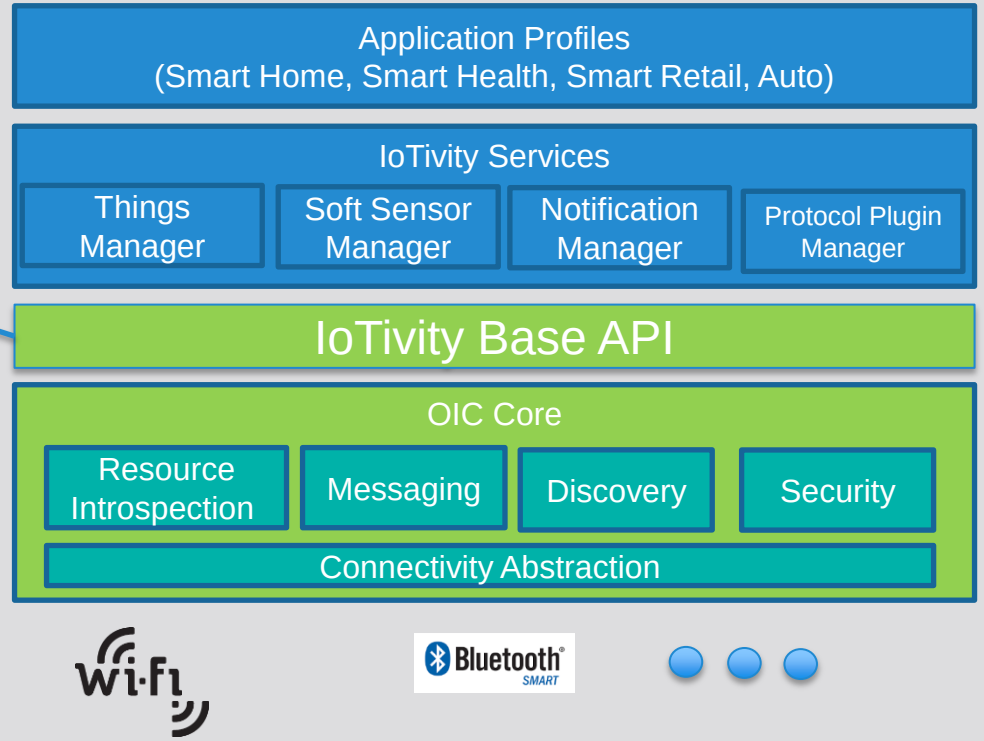
IoTivity Module View



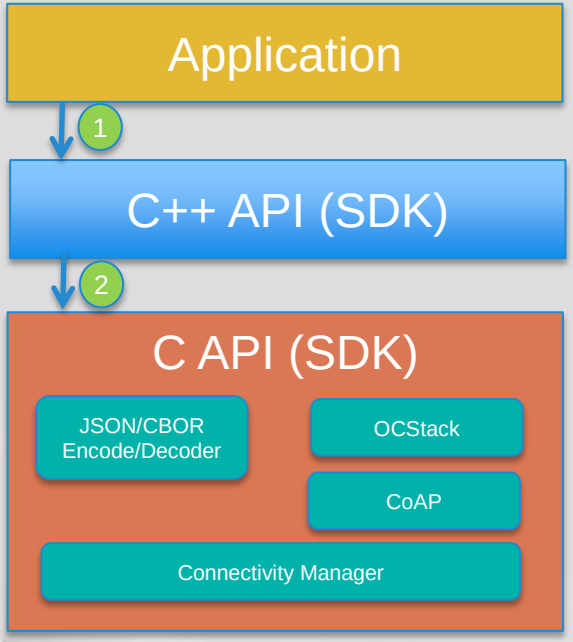
Programming IoTivity Core APIs

Steps involved in using IoTivity Core API

- Registering a Resource
- Finding a Resource
- Querying a Resource State
- Setting a Resource State
- Observing Resource State



Registering a Resource – Call Flow



Resource URI

Resource Type

```
OCPlatform::registerResource(resourceHandle, "/light/1", "core.light",
                             "oic.if.baseline", entityHandlerCb,
                             OC_DISCOVERABLE | OC_OBSERVABLE);
```

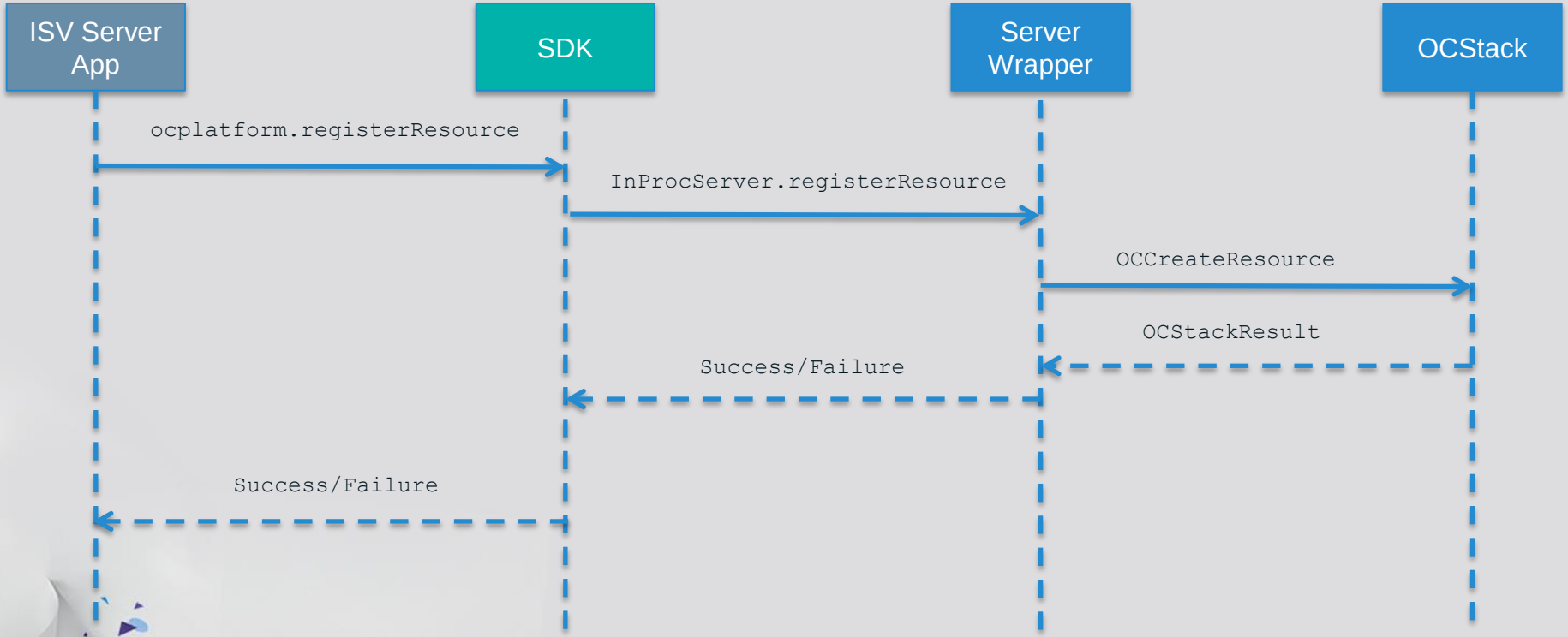
Resource Interface

Entity Handler

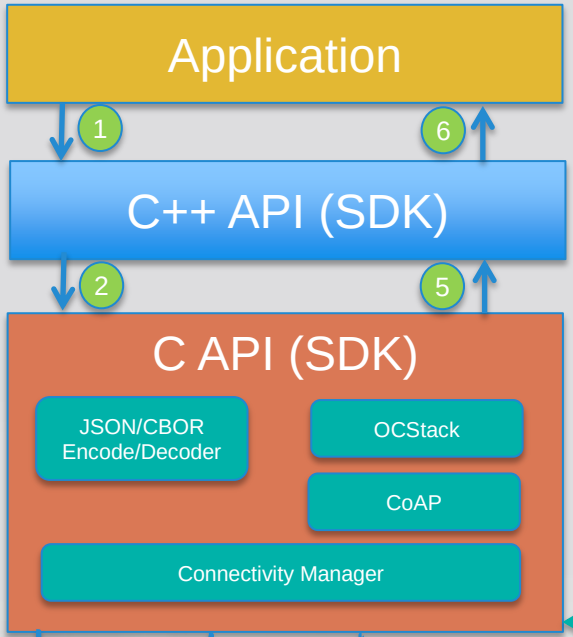
Resource Property

```
OCCreateResource(resourceHandle, resourceTypeName.c_str(),
                 resourceInterface.c_str(), resourceURI.c_str(),
                 EntityHandlerWrapper, NULL, resourceProperties);
```

Registering a Resource – Sequence Diagram



Finding a Resource – Call Flow



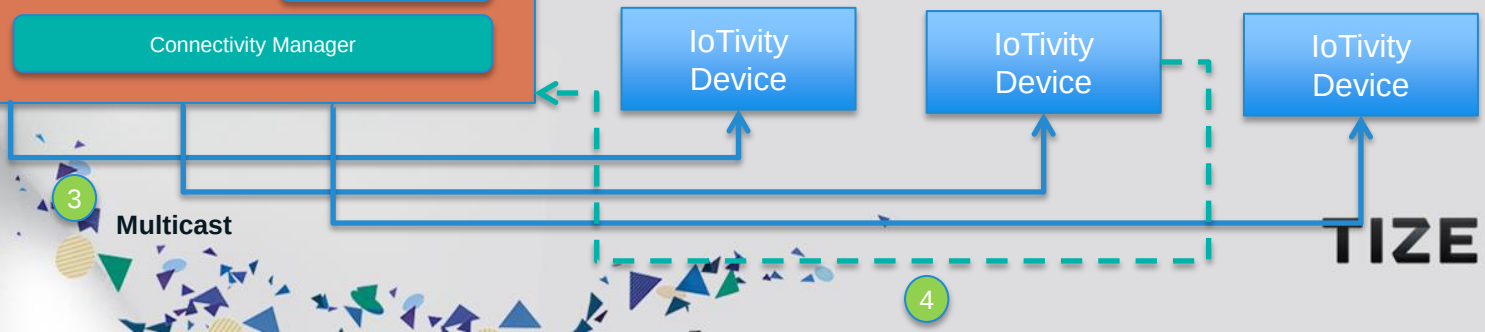

```
OCPlatform::findResource(host, "/light/1", connectivityType,
                         resourceHandlerCb);
```

```
OCDoResource(resourceHandle, OC_REST_GET, "/light/1", 0, payLoad,
connectivityType, qos, &cbData, headerOptions, numOptions);
```

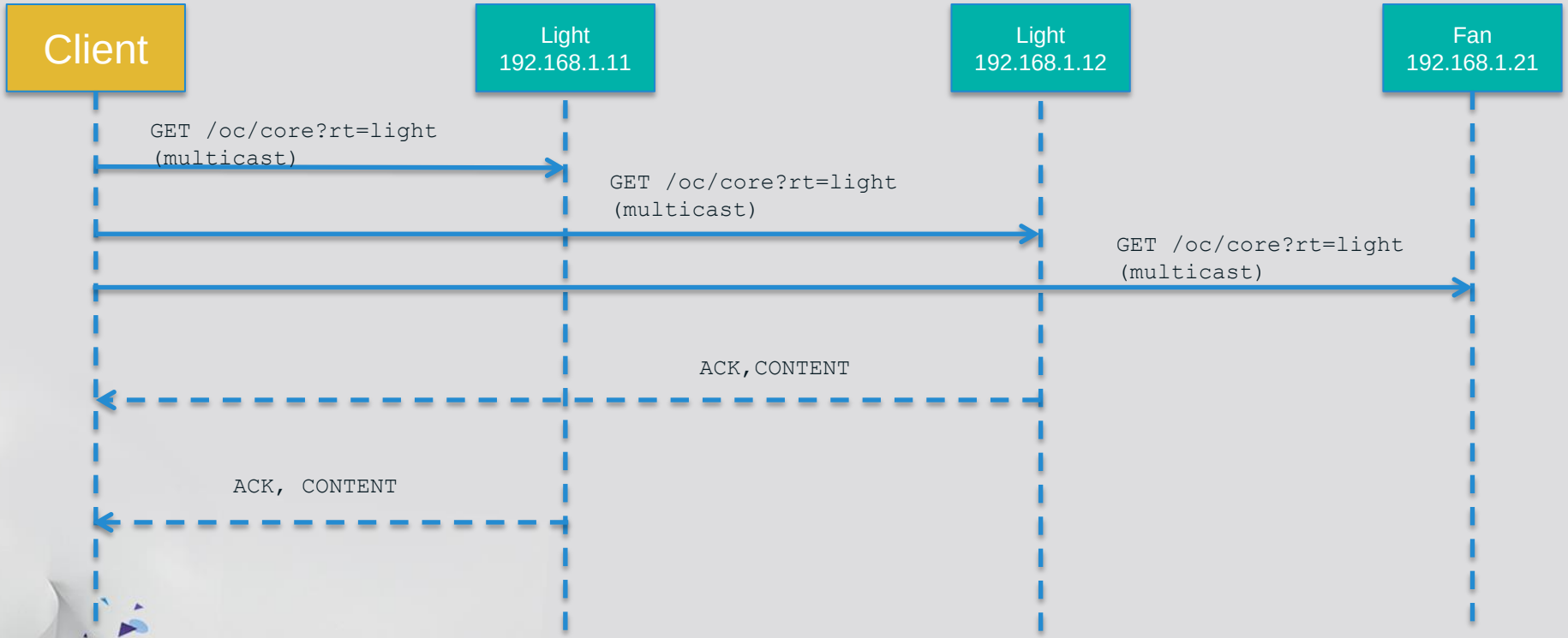
```
CASendRequest(endPoint, &requestInfo);
```

Sends a multicast query

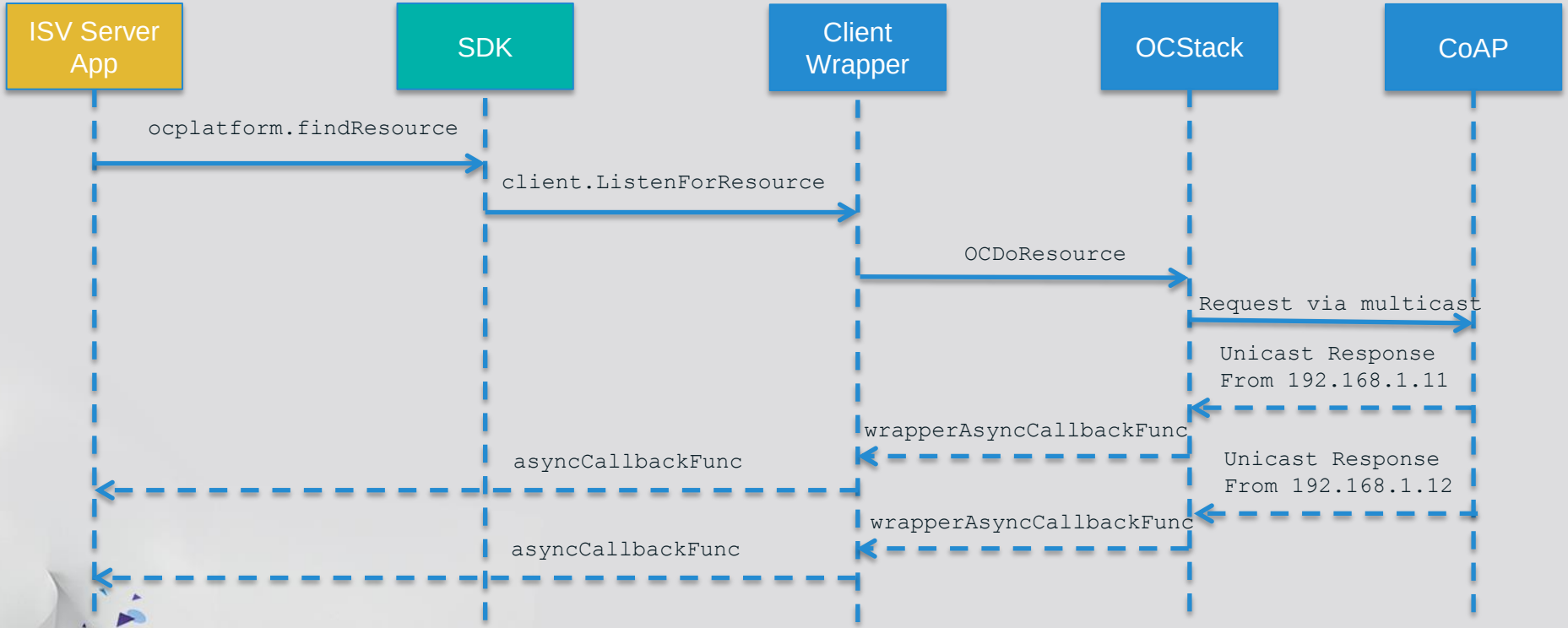
//Devices that matches the query answers as indicated below



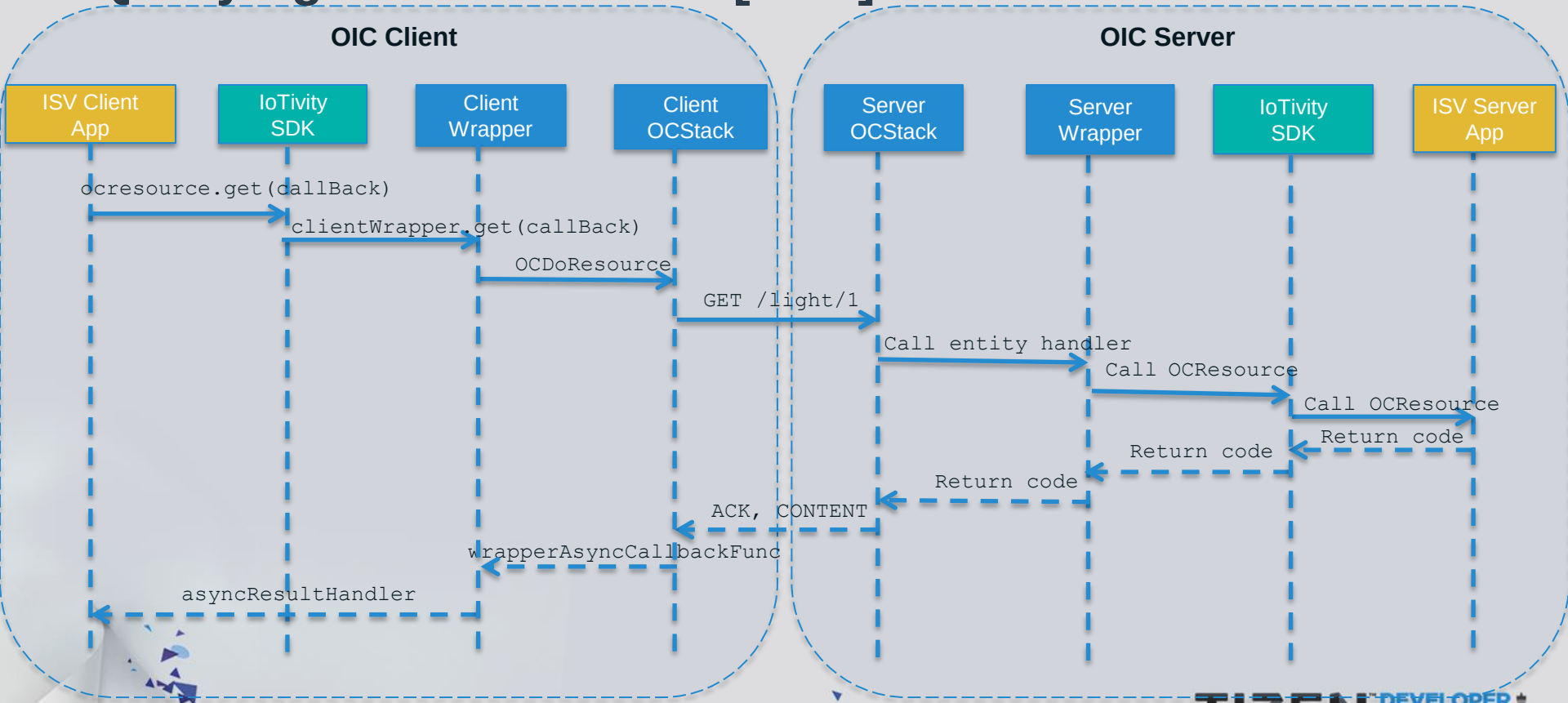
Finding a Resource – System Sequence Diagram



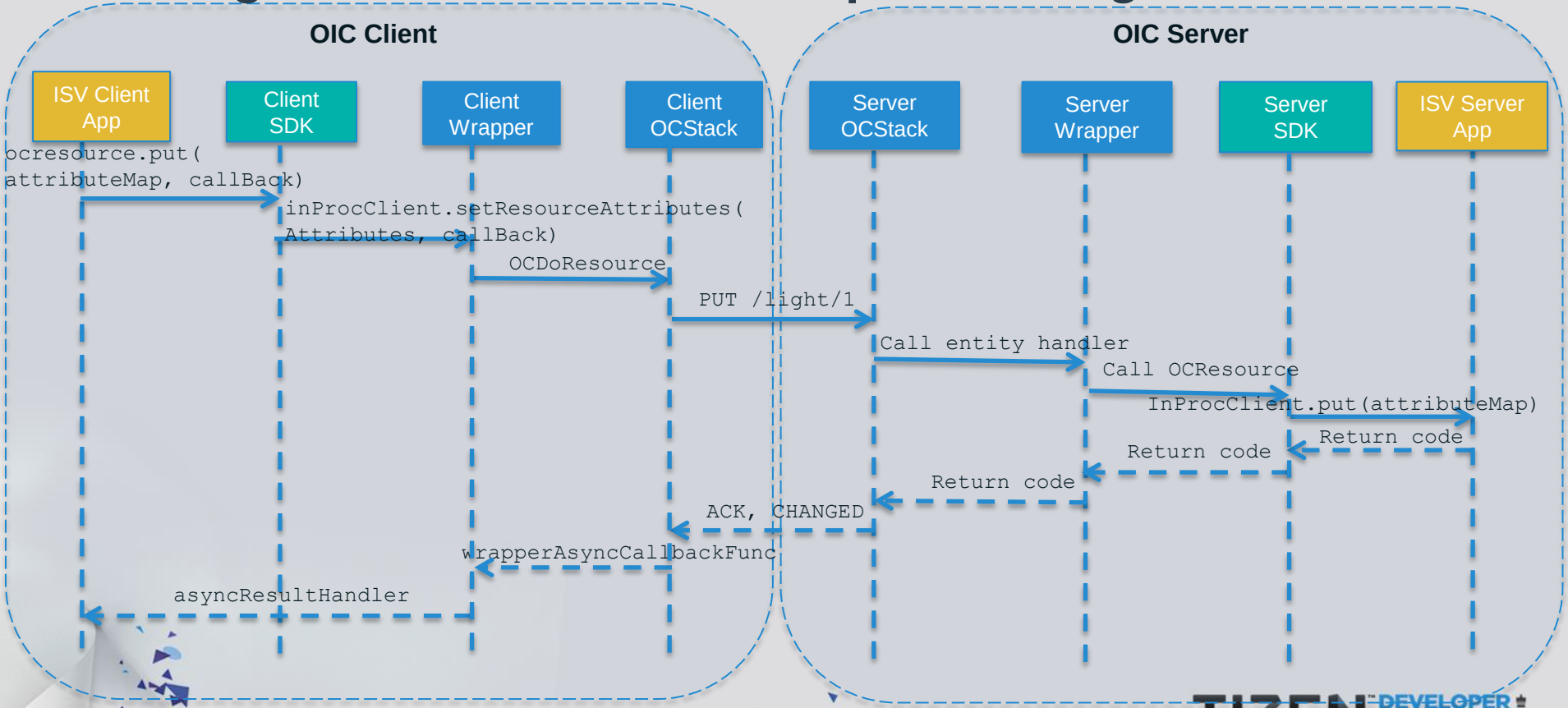
Finding a Resource – Sequence Diagram



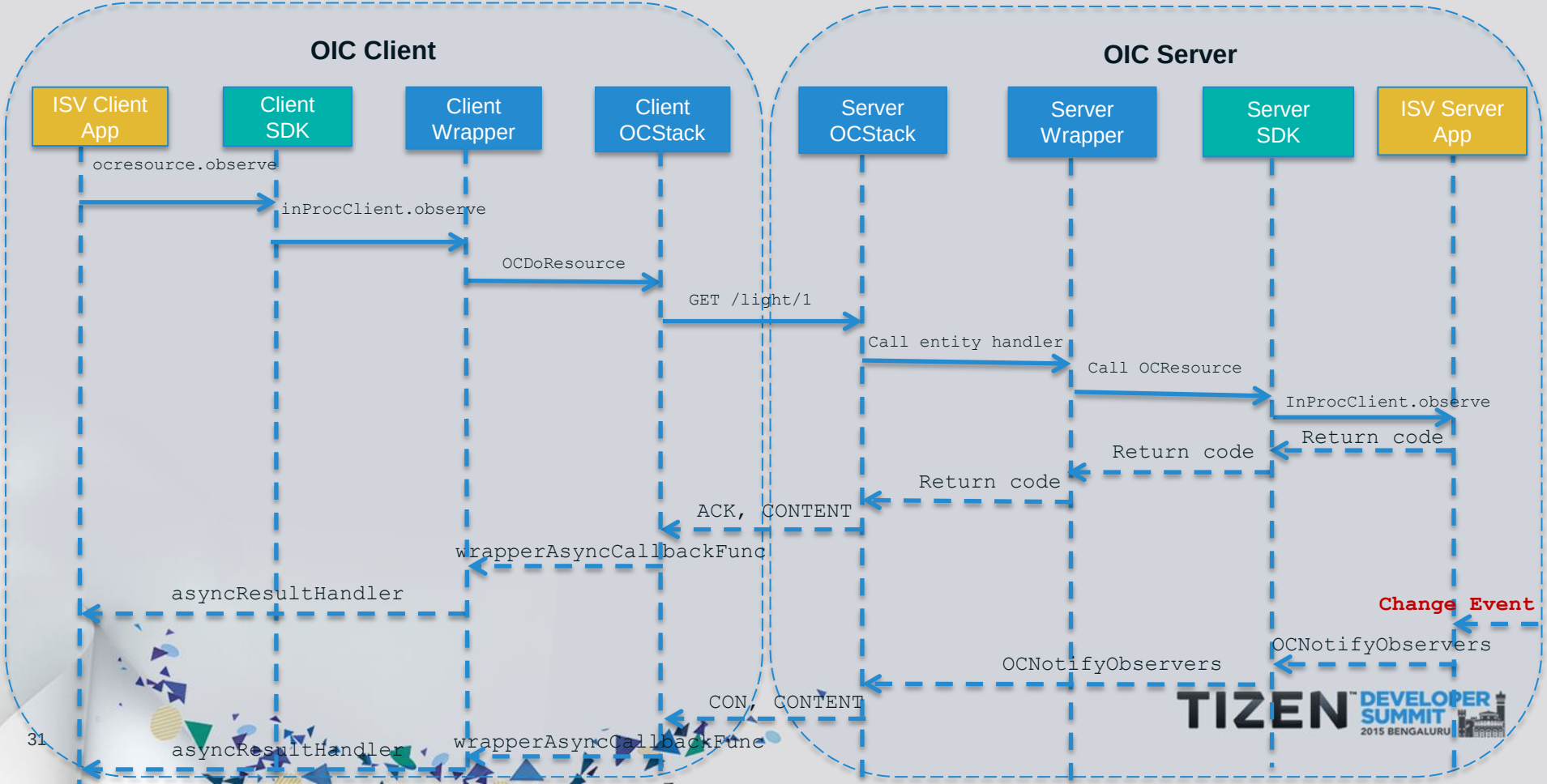
Querying Resource State [GET]



Setting a Resource State – Sequence Diagram



Observing Resource State



Programming IoTivity Service APIs

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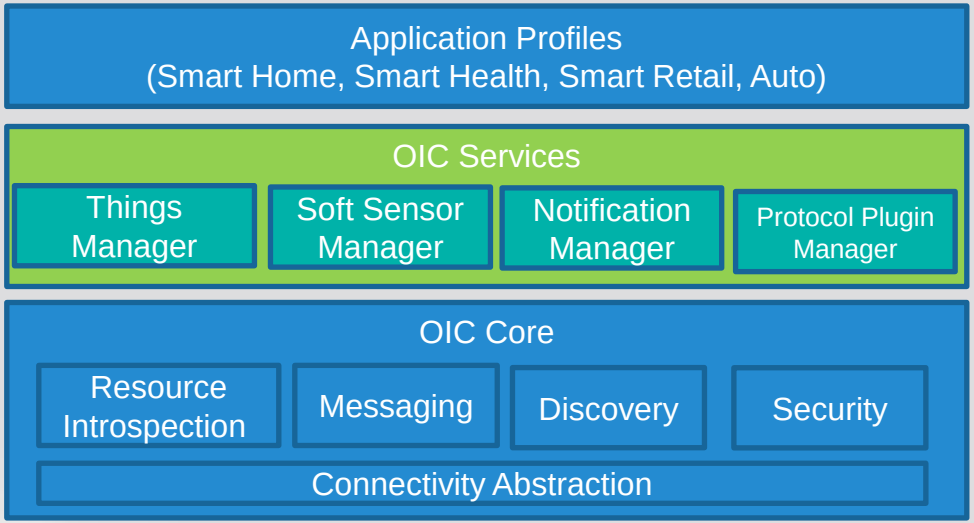
IoTivity Services

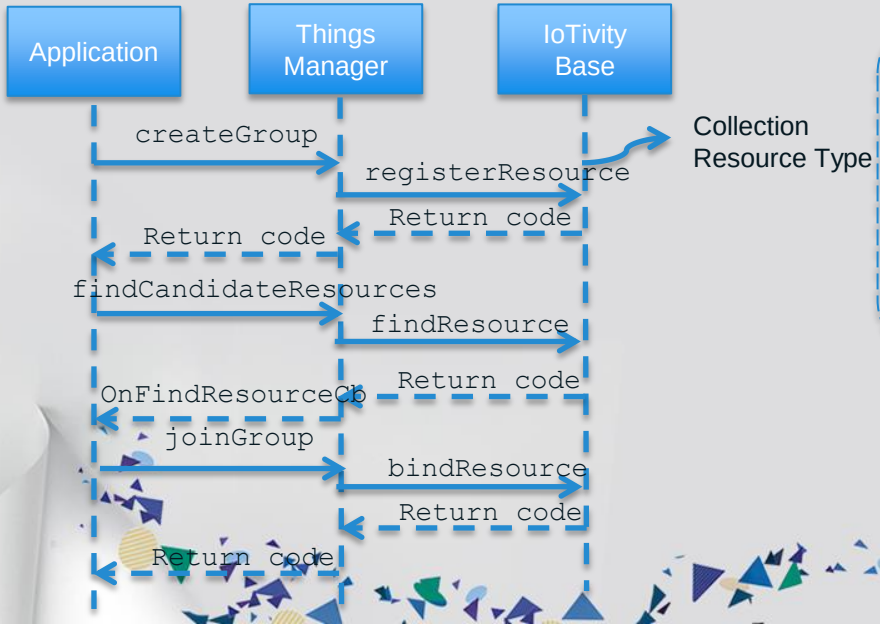


- Provide common set of functionalities to app development
- Provide easy, scalable access to applications & resources

IoTivity Service	Description
Things Manager	Group Creation & Management
Soft Sensor Manager	Sensor Data Collection, Aggregation & Fusion
Notification Manager	Provides resource hosting function
Protocol Plugin Manager	Communication with non IoTivity devices

Things Manager

- **Group Management**
  - ✓ Find candidate devices to form a group
  - ✓ Create a group of found devices
  - ✓ Create a group action for the group
  - ✓ Execute the group action



Collection Resource Type

Action Set

Action Set Name

Delay/Step of Time Delay

Type of Group Action (normal, scheduled, recursive)

```
OutofHome*10 1
*uri=coap//10.251.44.228:49858/a/light|power=on*
uri=coap://10.252.44.221:49458/b/aircon|power=off
```

Things Manager – Configuration & Diagnostics

- **Things Configuration**
  - ✓ Server Side - Bootstrapping requisite information from a bootstrap server to access other IoT services
  - ✓ Client Side – Getting/Updating system configuration parameters from/to multiple remote things

- **Things Diagnostics**
  - ✓ Factory reset to restore all configuration parameters to default one
  - ✓ Reboot to request a system rebooting

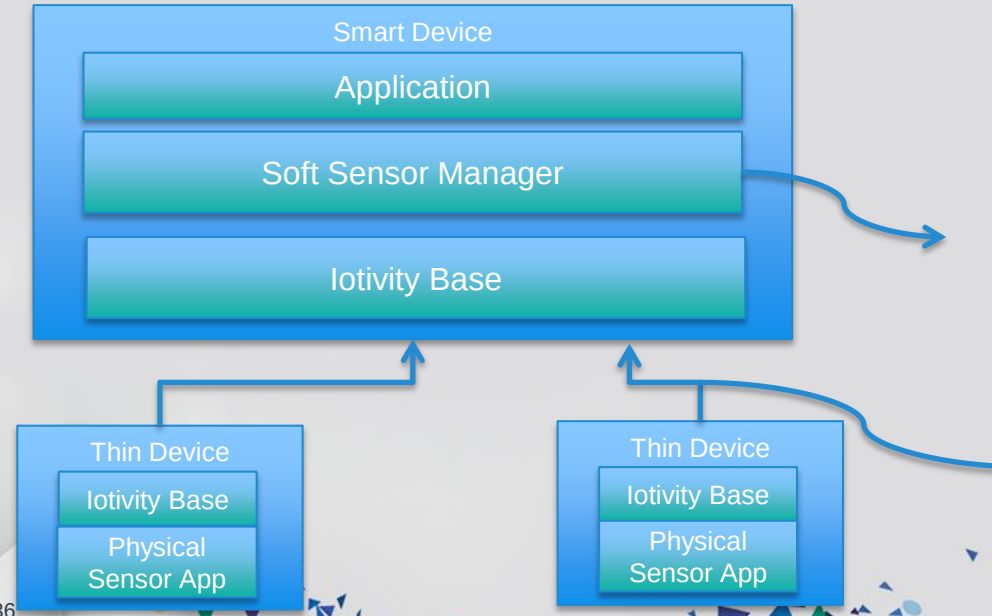
Soft Sensor Manager

- Helps in observing changes to Physical Sensors
- Allows developers to create Soft Sensor
- Utilizes data from multiple physical sensors to make sense of data from end user perspective. E.g. DiscomfortIndex

Calculate
“Discomfort Index”

Humidity Sensor

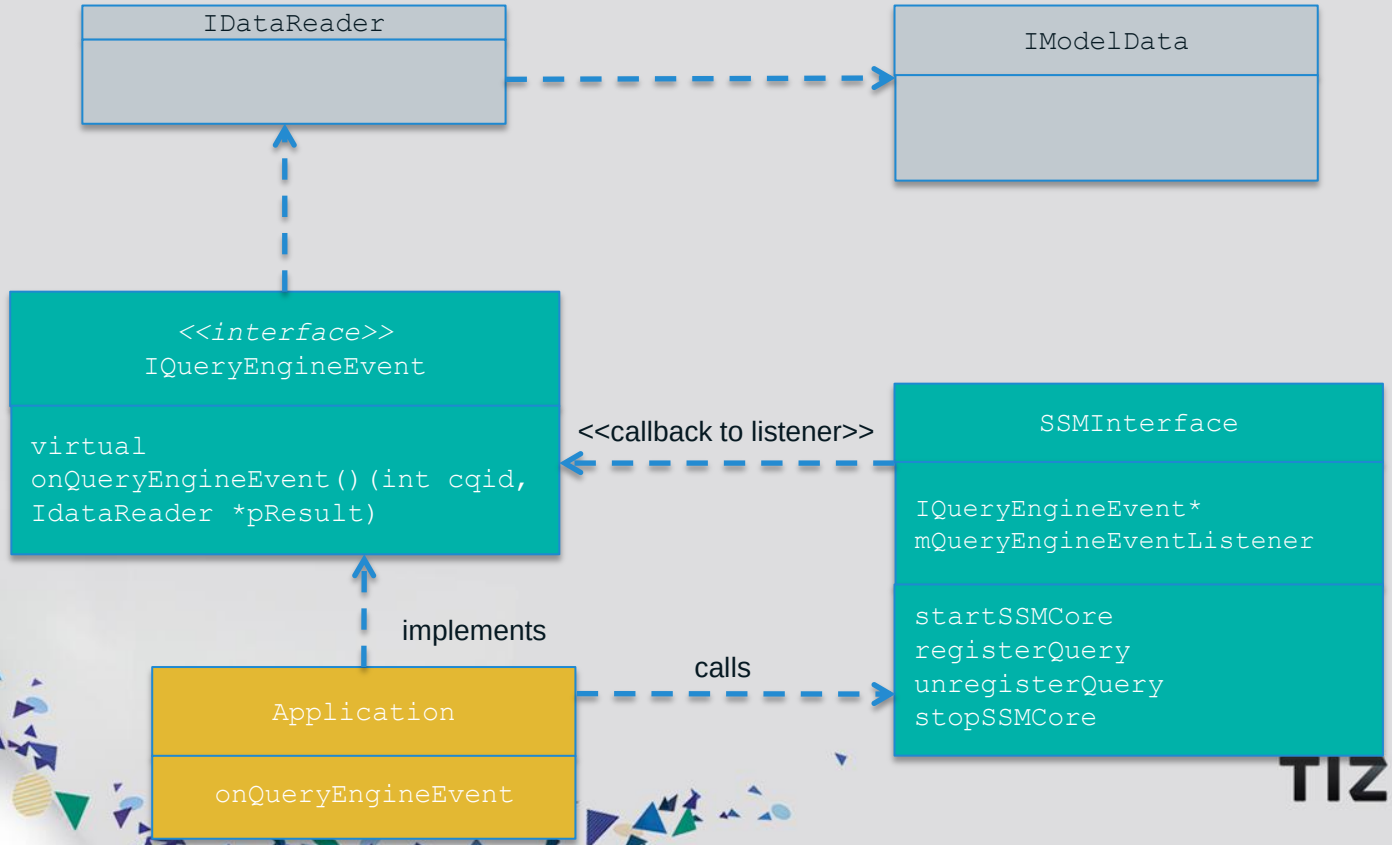
Temperature Sensor



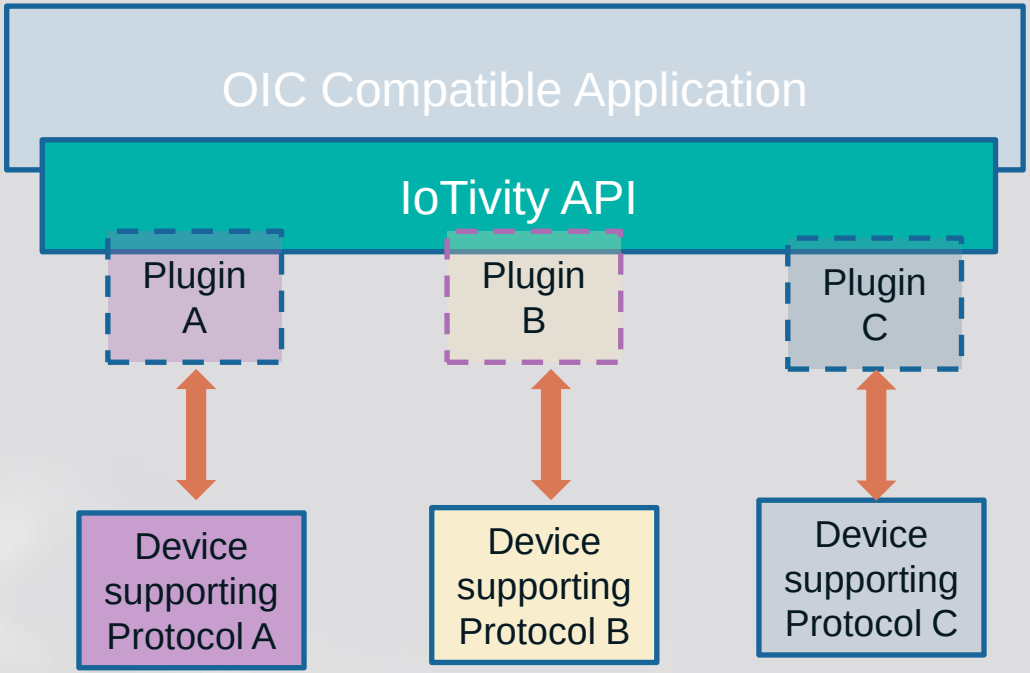
Aggregation &
Sensor Data Fusion

Raw Sensor Data

Soft Sensor Manager – SDK Class Diagram

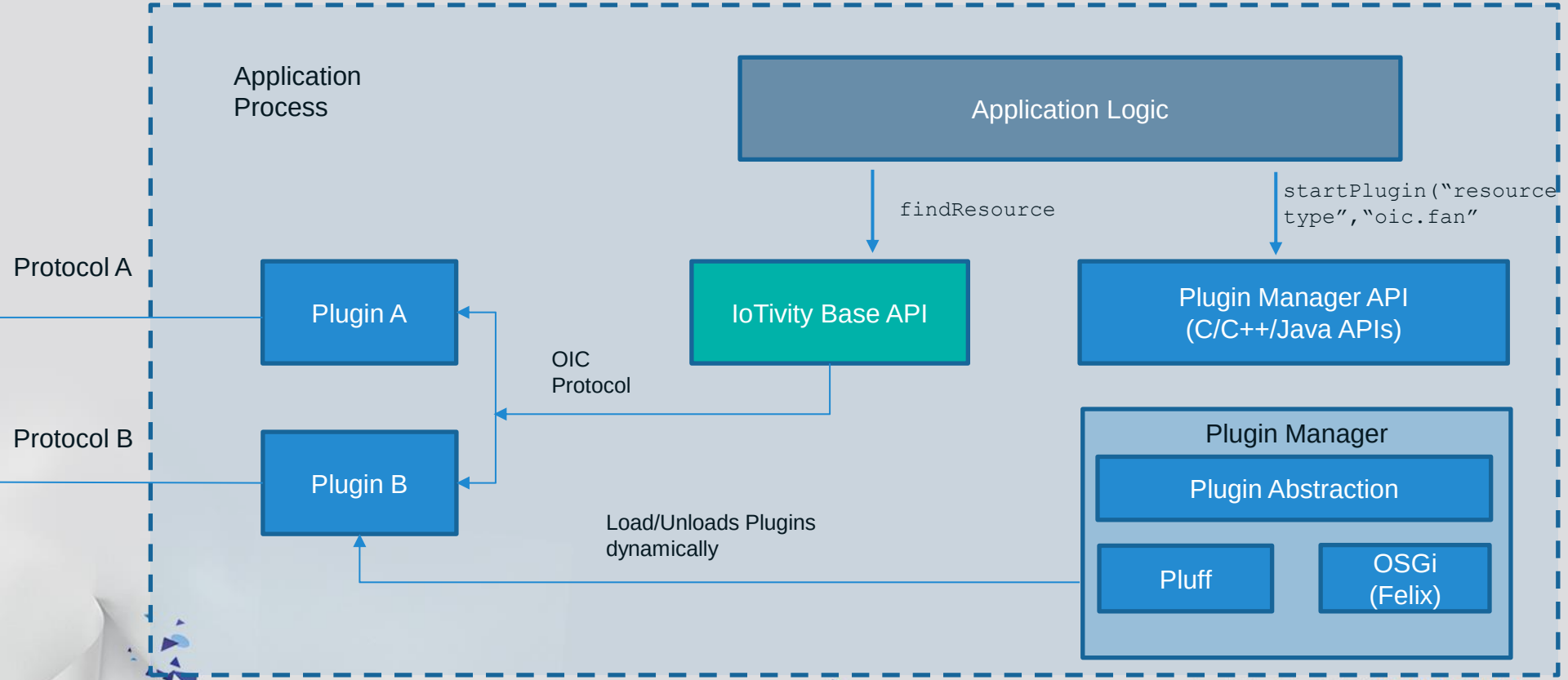


Protocol Plugin Manager



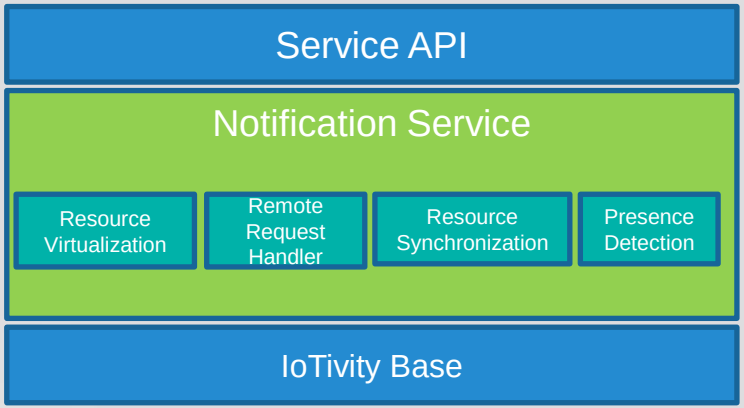
- Allows OIC compliant Applications to communicate with non OIC device protocols
- Uses Plugin Manager APIs to find, start, stop plugins
- Uses IoTivity APIs to find and operate on resources similar to interaction with OIC device

Protocol Plugin Manager – Overall Flow

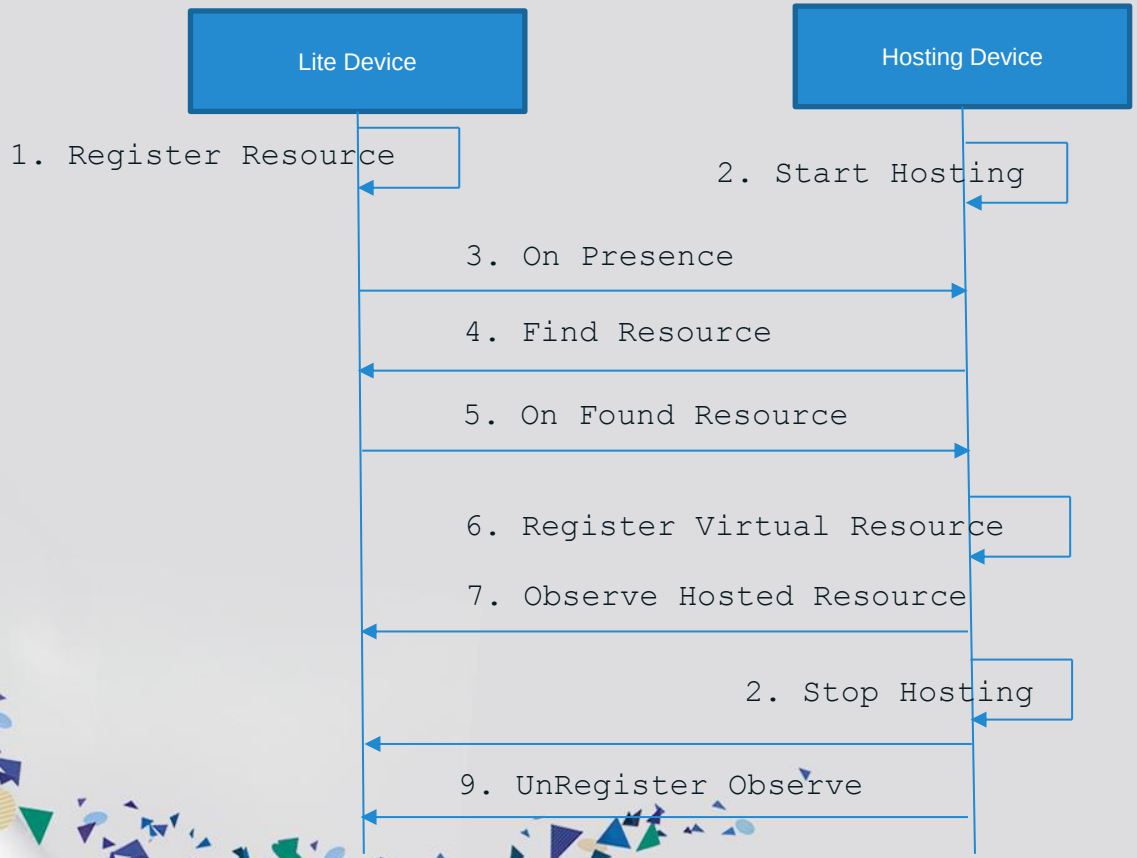


Notification Manager

- Service on Unconstrained device host resources for other Lite/Thin devices
- Hosting device mirrors resources from other Lite devices by Observing the presence & changes in other sources



Notification Manager – System Sequence Diagram



OIC & IoTivity – Road Ahead

Feature	Description
IoTivity Security	• Filter Resource requests • Access control of resources • Secure Transmission of data across variety of IoT devices
Device Onboarding & Provisioning	• Connect Out-of-box device without UI onto network & provisioning
IPv6 & 6LowPAN support	• Supporting IPv6 and 6LoWPAN as part of IoTivity Connectivity Abstraction
AV Streaming	• Audio Video Streaming
Blockwise Transfer	• Send/Receive of Larger data over IoTivity Stack
Routing through Heterogeneous transports	• Routing of packets across variety of connectivities
Data Interface to Cloud	• Actuation of devices from Cloud Apps, Collection of Sensor Data in Cloud

Summary

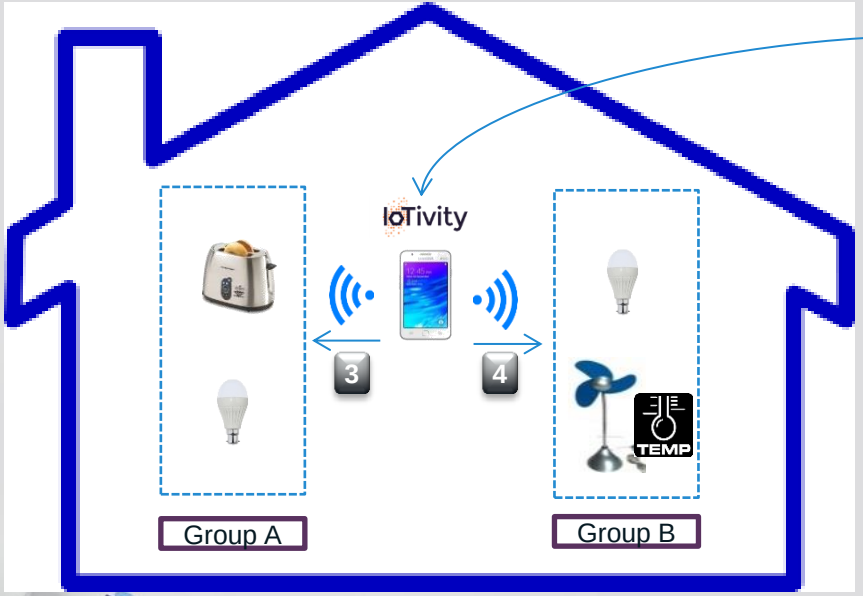
- IoT Landscape, Roles of OIC & IoTivity
- Understanding the big picture in IoT including various topologies
- Architectural Principles & Key Protocols adopted by OIC & IoTivity
- High Level Architecture of IoTivity Stack & types of Deployment
- Programming using IoTivity Base APIs
- Programming using IoTivity Service APIs
- Ongoing & Future work

Usecase Description

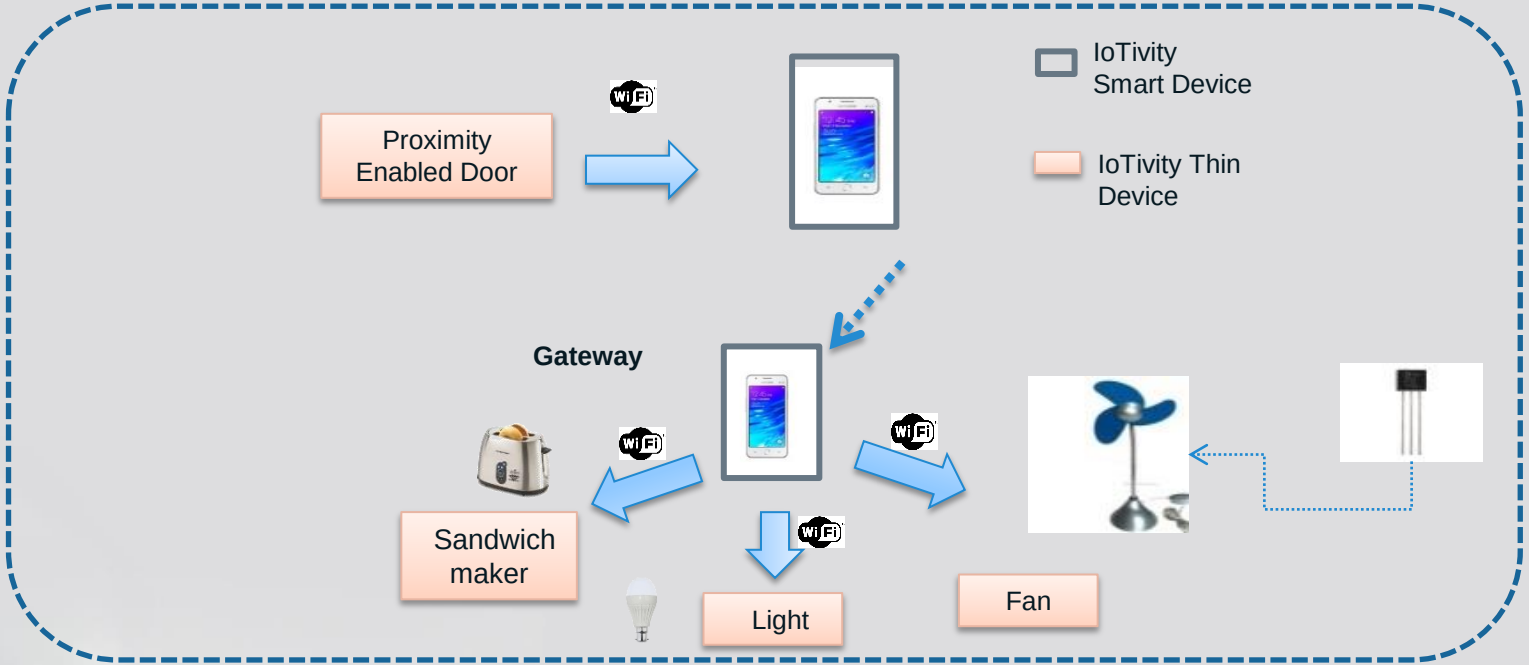
- As, Bob’s car approaches home, proximity sensor sense his presence & garage door opens automatically
- As Bob approaches main door, it gets unlocked after exchanging appropriate credentials
- Meanwhile Bob’s Z1 phone connects with home gateway and turns on group of devices like light and fan based on his preset preference
- Based on increase in temperature, the fan in room is started

- Same scenario is executed with another group of devices for another user , with their preferences

Use Case Pictorially!



Demo Setup



Demo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Thank you


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