ALLSEEN ALLIANCE

AllJoyn™: enabling the Internet of Everything

Technical Overview

Marcello Lioy

Qualcomm Connected Experiences, Inc.

What is AllJoyn?

An Open Source API Framework For the Internet of Everything

A way devices and applications publish APIs over a network in a standard way

Why APIs?

- Because this is what software developers understand and work with every day

These APIs are the functionality that the “things” on the network expose to other “things”

- E.g. temperature, time of day, etc.…
- Services and/or devices can compose these APIs to provide whatever set of functionality they require
- The APIs are critical to interoperability between devices and services

How do applications know what APIs are available?

- AllJoyn provides application discovery and fine-grained discovery of the APIs supported by applications
- This is accomplished in a platform and radio-link agnostic way

Overview

AllJoyn implements a “distributed software bus”

- The bus provides the “medium” that enables AllJoyn applications to communicate via published APIs
  - Applications may be firmware on microcontrollers, mobile device “apps” or traditional applications on PCs/servers
- Applications publishing APIs are services, while those consuming the APIs are clients
  - An application can be both a service and a client: this is makes AllJoyn a peer-to-peer system
- Communication is via messages that map directly to APIs in high-level programming languages

Bus formation is ad hoc

- Based on discovery of applications/services
- Abstracts link-specific discovery mechanisms

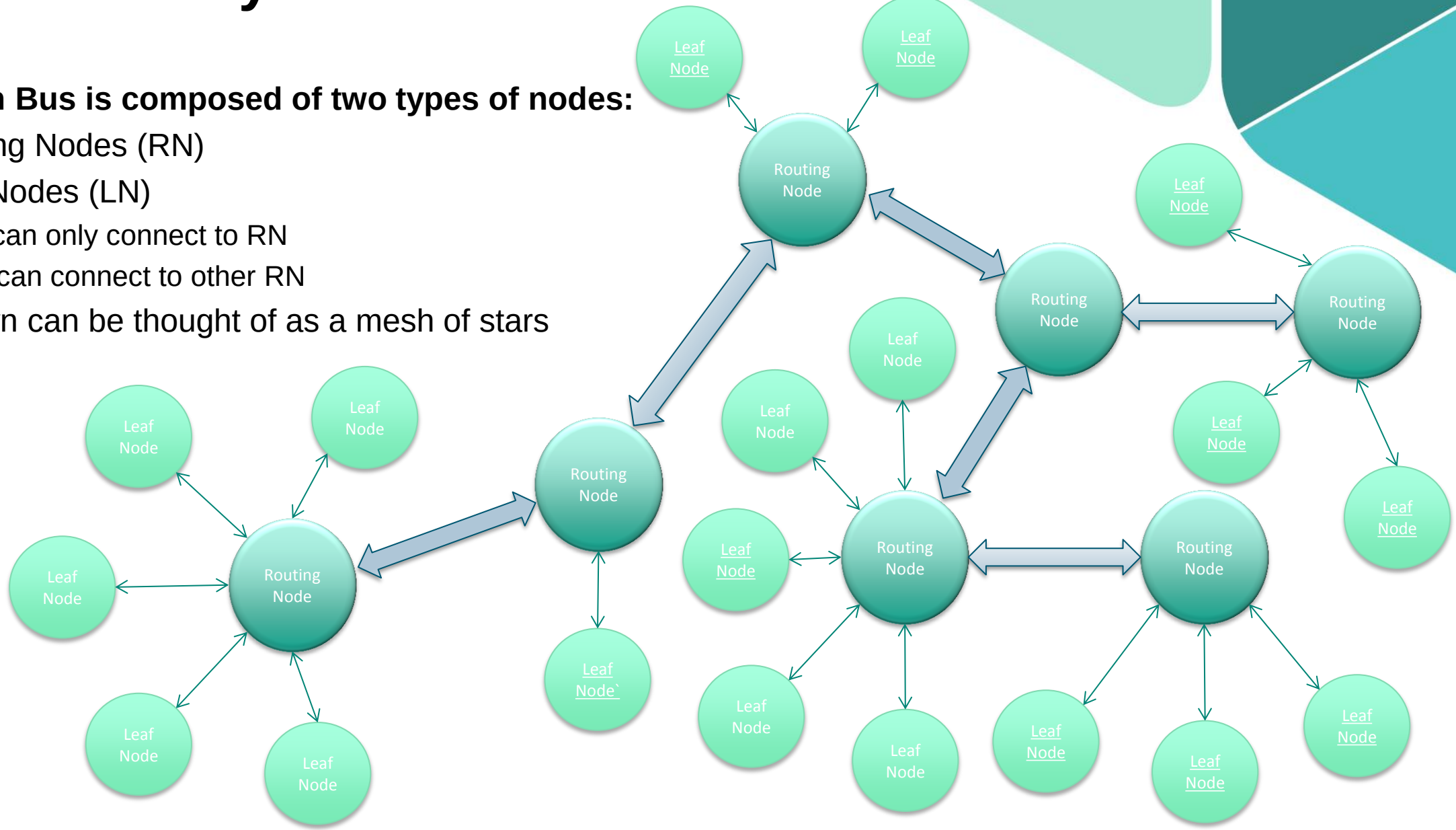
Protocol is network-independent

- Wire protocol is based on the D-Bus wire-protocol with extensions
- Can run over Wi-Fi, Wi-Fi Direct, Ethernet, PLC and Bluetooth
  - Could likely run over others

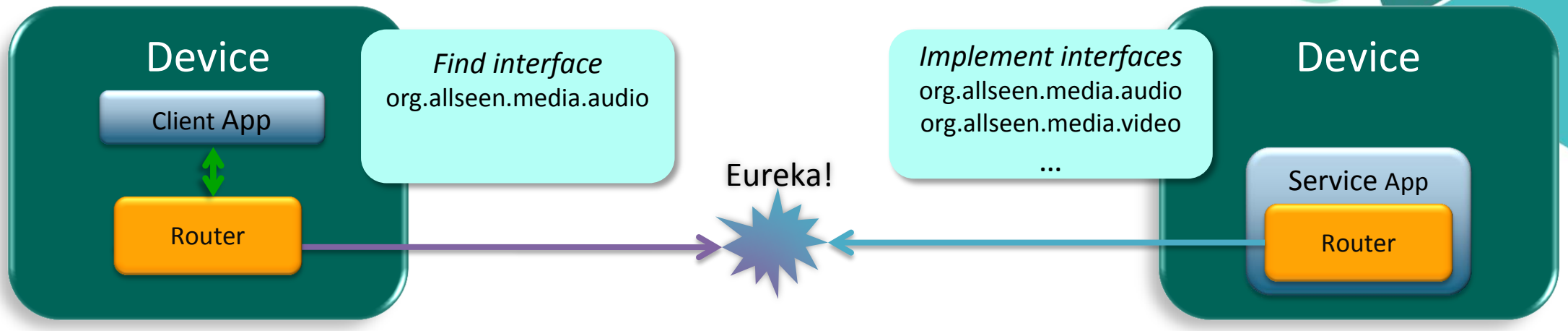
High Level System Architecture

AllJoyn Bus is composed of two types of nodes:

- Routing Nodes (RN)
- Leaf Nodes (LN)
  - LN can only connect to RN
  - RN can connect to other RN
- AllJoyn can be thought of as a mesh of stars



Ad Hoc Bus Formation: Discovery



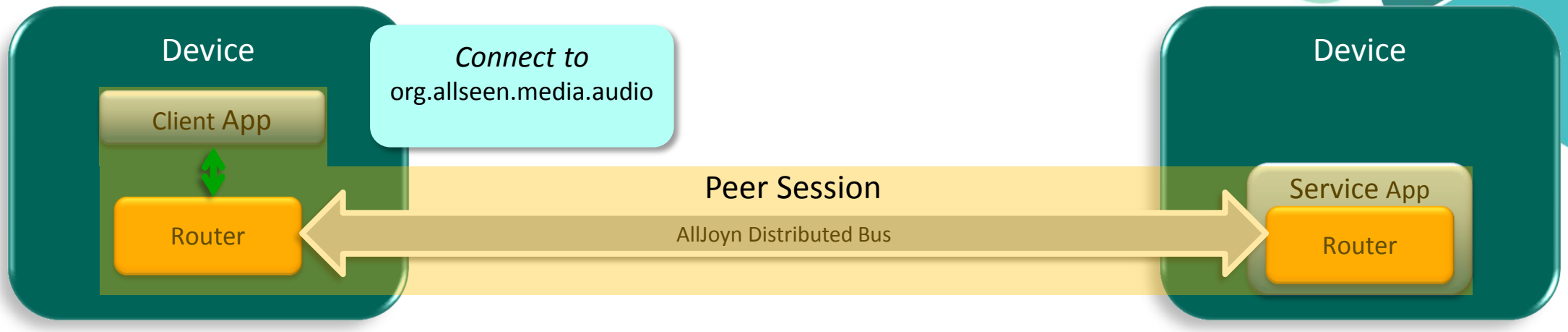
Interface descriptions contained in About message

- Services advertise, and Clients find, About messages
- connect to advertisers supporting desired interfaces

Actual discovery mechanism is transport dependent:

- On Wi-Fi, PLC, Ethernet: lightweight IP multicast protocol
- On Wi-Fi Direct: would use pre-association discovery

Ad Hoc Bus Formation: Session Creation



Session creation will cause Routing Nodes to connect and extend the bus

- Once connected, buses merge and have a single shared namespace
- Peers can discover when other peers join or leave the bus
- Peers can interact via their APIs
- Session reference counting keeps device-to-device connections alive
- Multicast events can be sent to all peers in the session

Software Components

AllJoyn Software Framework: High-level architecture

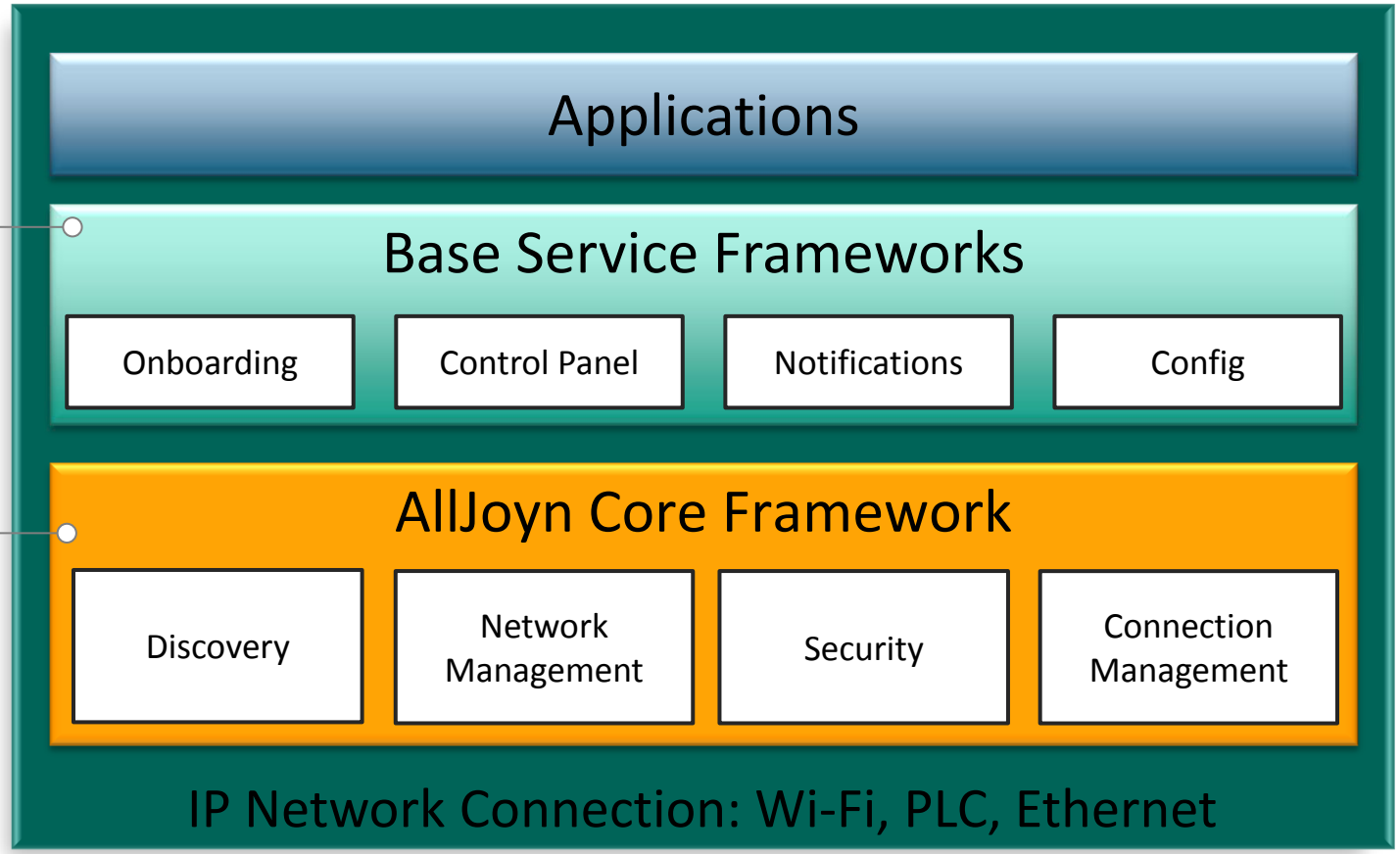
A comprehensive software communication framework

AllJoyn Service Frameworks

- Interoperable, cross-platform building blocks for common IoE functionality
- Audio, onboarding, control, notifications etc.

AllJoyn Core Framework

- Two main components:
  - Client Library and Router
- These provide the core functionality:
- Discovery, connectivity, security
- Language bindings, interoperability
- Dynamic network intelligence



Software Components

AllJoyn has two main architectural components: the Client Library and the Router

Client Library

- This is referred to as a Client Library because all AllJoyn applications are clients of the router
  - This is true regardless of if, in their application context, they are exposing services, or are clients of other services
  - Applications are peers if they implement both client and service functionality
- The Client Library is what software developers interact with: the API set of the AllJoyn SDK
- There are two implementations of the Client Library: the **Standard Client** (SC) and the **Thin Client** (TC)

- The SC is targeted at applications running in HLOS environments
  - The SDK APIs for the SC provide a high level of abstraction, and allow complex multi-threaded applications
  - Native implementation is in C++ and there are a number of language bindings for various platforms available

- The TC is targeted at applications that would reside on deeply embedded devices (i.e. device firmware)
  - Targets a very minimal memory (RAM and ROM) footprint,
  - Implemented in C, with no other language bindings
  - TC depends on a Routing Node running elsewhere, likely off device

Software Components: Router

Router

- Any node containing the router is a Routing Node
- The router is built using the Standard Client library, and so must run on an HLOS
- This can be deployed as a standalone daemon/service or integrated with the SC in an application
  - The only platforms on which standalone functionality is currently supported are Linux-based, such as OpenWRT
- The Router functionality consists of bus management and routing AllJoyn messages
  - Bus management includes
    - Managing the namespace: application addressing over the bus
    - Cross-device communication: discovering services and connecting to the routing node supporting that service on behalf leaf nodes
  - Message routing consists of delivering messages between applications, or to the router itself
    - AllJoyn control signaling also uses AllJoyn messages

- Routing Nodes do the “heavy lifting” in the Alljoyn system
- Leaf Nodes depend on Routing Nodes to interact with other nodes

Software Components: Language Bindings

Standard Client Library supports multiple language bindings

- Java binding available, compatible with Dalvik
- Objective C binding is available for use on iOS and MacOS
- Managed C++, C#, WinJS, and Visual Basic are available for use in Windows 8 style applications
- Unity + C Binding available for use on Android
- NPAPI binding for JavaScript is available

– All of the bindings are currently wrappers around the native C++ implementation

– Same object model for all bindings

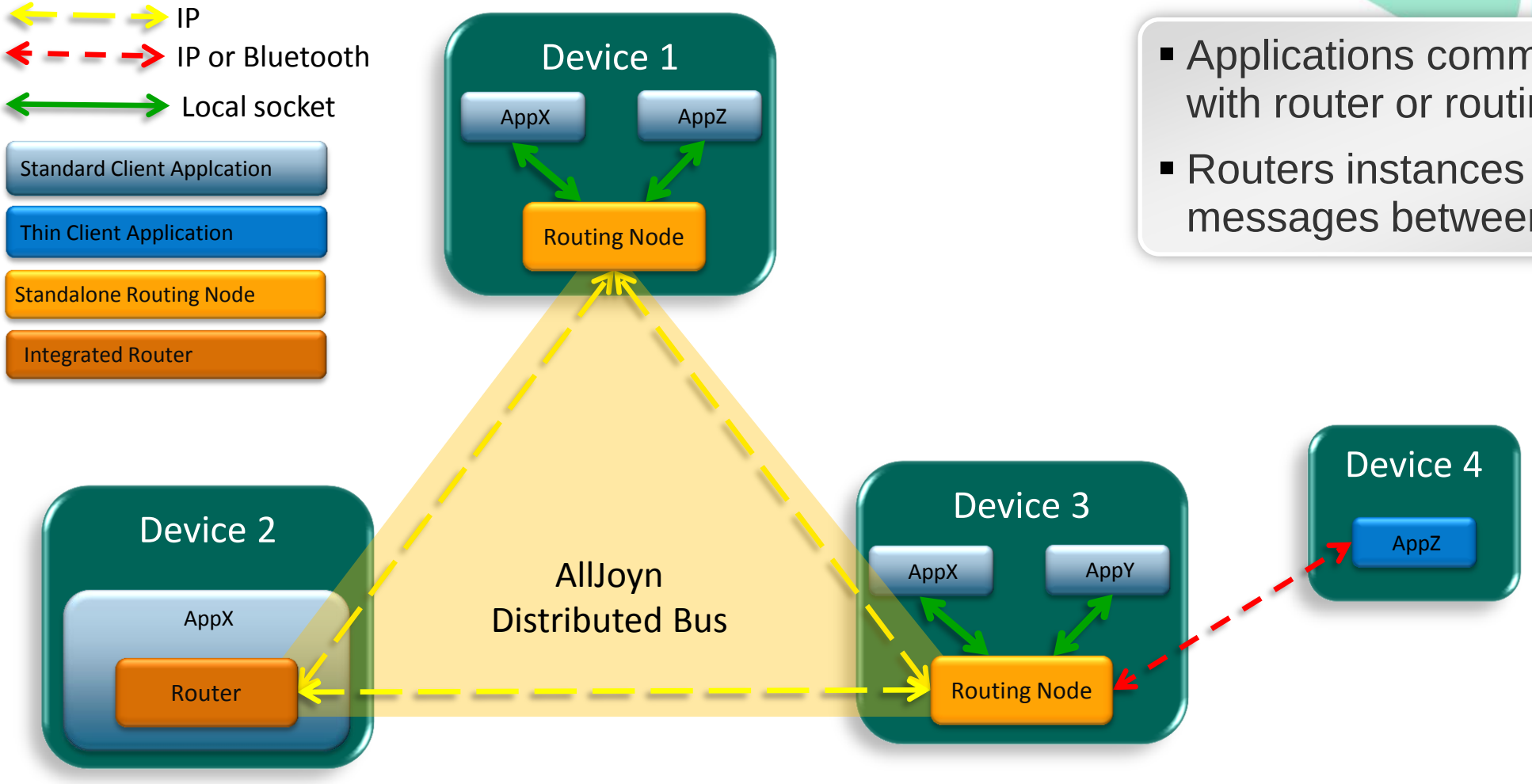
– Seamless interoperability between applications written in different languages

Thin Client Library only supports C

– Most appropriate language for embedded RTOS development

– Other language wrappers around the C implementation being investigated

Components deployed in AllJoyn Distributed Bus



- Applications communicate with router or routing node
- Routers instances deliver messages between devices

AllJoyn SDK Concepts

Exposing Functionality

AllJoyn applications expose their functionality via APIs implemented in objects

- Most applications will expose only a single object
- Object hierarchies are supported if required by application model
  - AllJoyn will create parent objects automatically if application object is not the root

Objects implement one or more interfaces

- These are the APIs that can be discovered using About

Interfaces are composed of members, which fall into three categories

- Methods – classic OO object interaction
- Signals – asynchronous event notification
  - Can be broadcast, multicast, or point-to-point
  - Can also send a Sessionless Signal: a broadcast signal that doesn't require an application session to be delivered
- Properties – data members
  - These are accessed by built-in get/set methods

All of this information can be introspected remotely

AllJoyn SDK Concepts

Connecting-to and Using the Bus

Bus Attachment is required to interact with/over the bus

– They are the application's presence on the AllJoyn Bus

– They provide the root (/) of the object hierarchy

Objects are published to local Bus Attachment

– Object path names look like file paths

- e.g. /Games/chess

Proxy Objects

– Local representation of a remote object

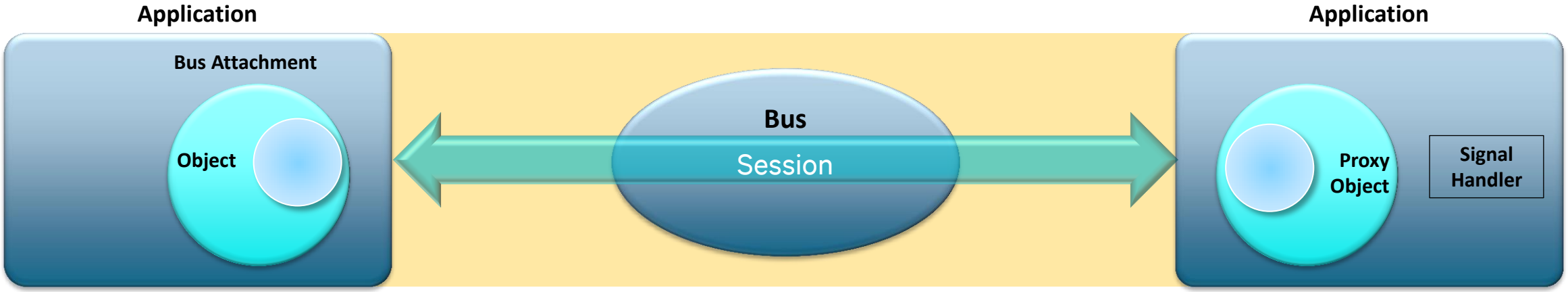
Signal handlers are registered with the Bus Attachment

– Registered by applications to take action when a signal is received

Sessions

– Flow controlled connections between applications

– Can be point-to-point or multipoint



AllJoyn SDK Concepts

Method Calls and Signals

Method Calls are made by using Proxy Objects

– This results in a method call message being sent to the object the proxy object represents

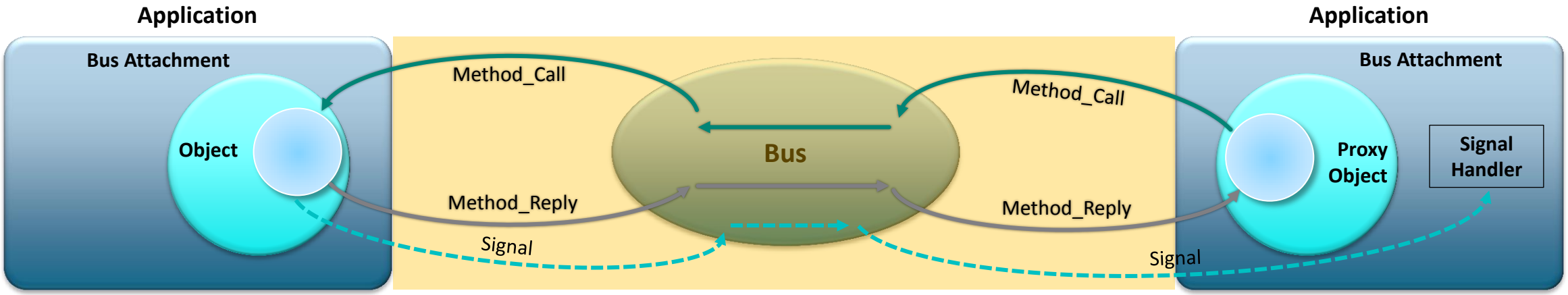
– Method handler is invoked to execute method and generate the reply

– The method reply is sent by the object back to the proxy object

Signals are emitted by Objects and consumed by Signal Handlers

– Sessionless signals work the same way, but do not require the application to create a session

- They are broadcast and are delivered to any app interested in receiving sessionless signals
- Only a single instance of a signal will be sent, i.e. if the same signal is emitted multiple times, only the last will be delivered
  - Useful for sending isochronous data, such as state updates



AllJoyn SDK Concepts

Object Model

As stated earlier, the Object model is similar for all language bindings

- Create a **`BusAttachment`** to connect to the bus
- Create **`BusInterface`**(s) that will be implemented by **`BusObjects`**
- Create and register **`BusObject`**(s) with the **`BusAttachment`**
- **`BusObjects`** handle remote method calls and emit Signals
- Applications call methods on remote objects using **`ProxyBusObjects`**
- Applications register Signal handlers with **`BusAttachment`**

Security Concepts

Design of Security Framework

Authentication and encryption is designed to be app-to-app

- Trust relationship established between the applications*
  - There is no trust relationship established at the device level
- The Router is not involved other than to route the messages
- Device pairing not required unless the transport requires it

Security is enabled per interface

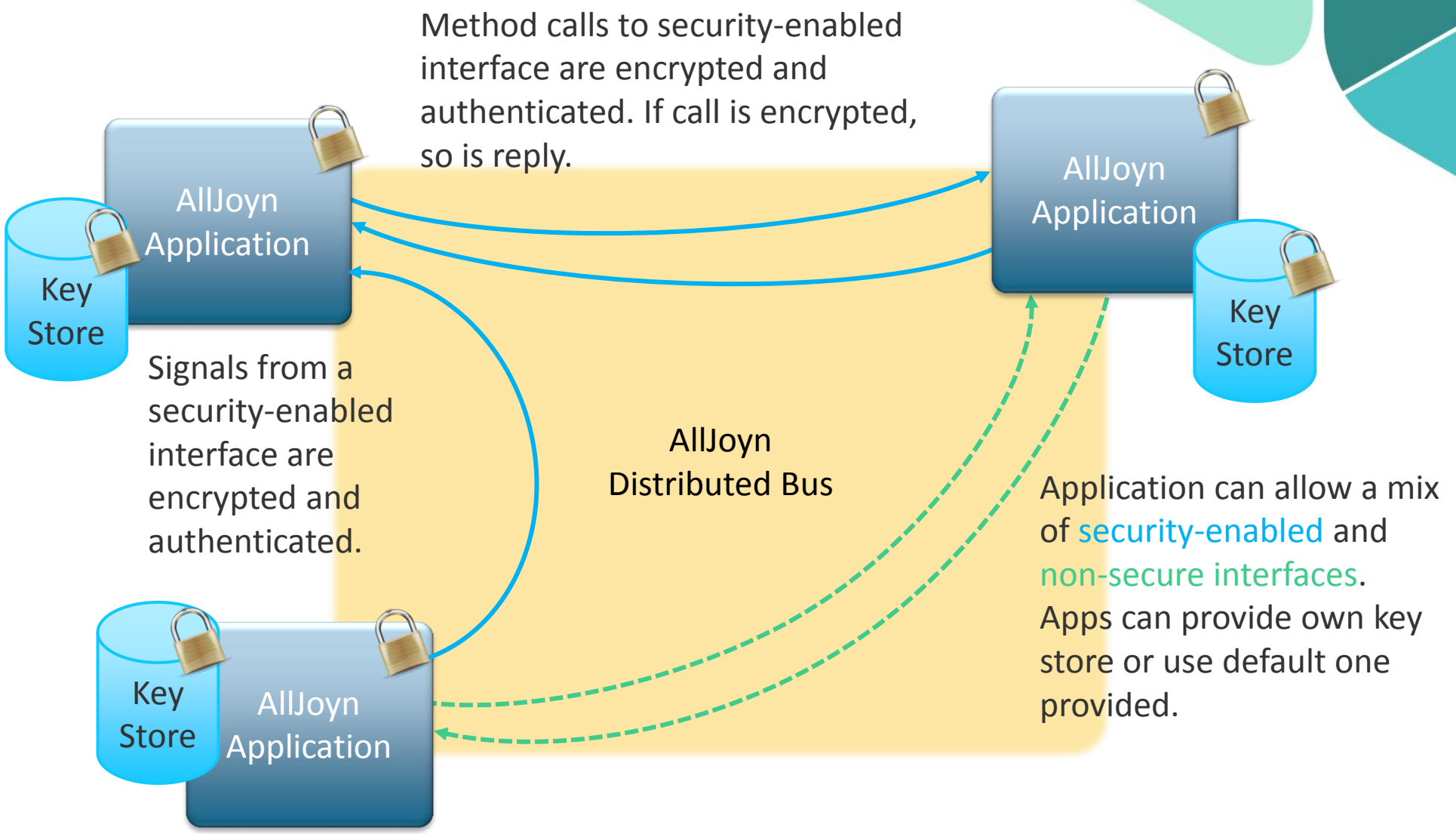
- Authentication and key exchange initiated on demand
- Applications can have a mixture of secured interfaces and open interfaces

Security-enabled interface

- Authentication is required to make method calls
- Authentication required to receive signals
- All messages are encrypted
  - Regardless of authentication mechanism, encryption always uses same AES-128 CCM algorithm

*** Applications could be firmware of embedded device**

Security Model – Authentication and Encryption



Built-In Authentication Mechanisms

Four mechanisms supported

– Mechanism negotiated using SASL protocol

– Mechanism chosen by application developer

– Most mechanisms adapted from TLS protocols per RFC 5256

Simple Pin-code pairing

– Specifically for Thin Client applications that lack resources to support big-number arithmetic

Pin-code SRP

– Pairing with a single-use password using Secure Remote Password protocol

Logon SRP

– User name and password using Secure Remote Password protocol

– Password required every time peers connect

Certificate-based

– RSA public key authentication and X.509 certificate-based

– Trust relationship lasts while certificate valid

Base Services

AllJoyn Base Services for fundamental use cases

- Standard AllJoyn building blocks for generically useful services
  - Onboarding
  - Notifications
  - Control Panel
  - Config
- Accelerate application and device development

Onboarding Service

Onboarding

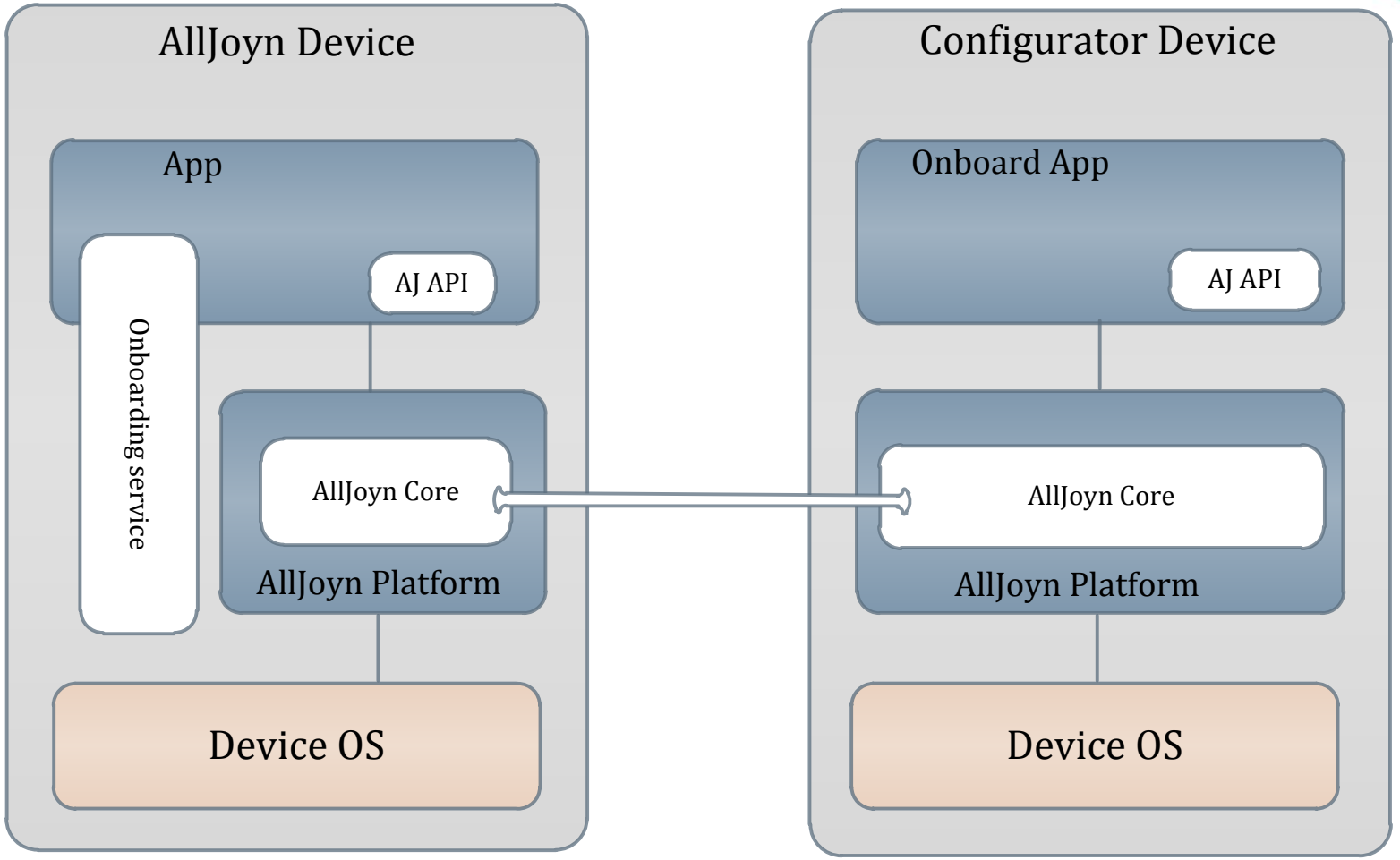
Provides a standard way to get devices onto a WiFi Network

- Onboarder is an application running on a smart device
- Onboardee is the device to be added to the WiFi network

Basic flow

- Onboarder discovers device that needs to be onboarded
- Connects to it, and provides configuration information
- Onboardee verifies it can connect
  - Informs onboarder that it has been successful or not

Onboarding Service



Notification Service Framework

AllJoyn Notifications Service Framework

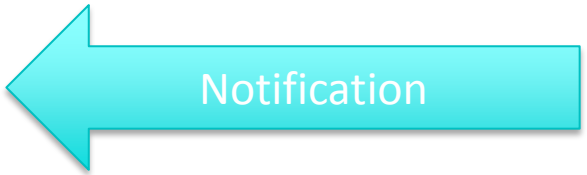
Simple, standardized interface for sending and receiving human-readable messages

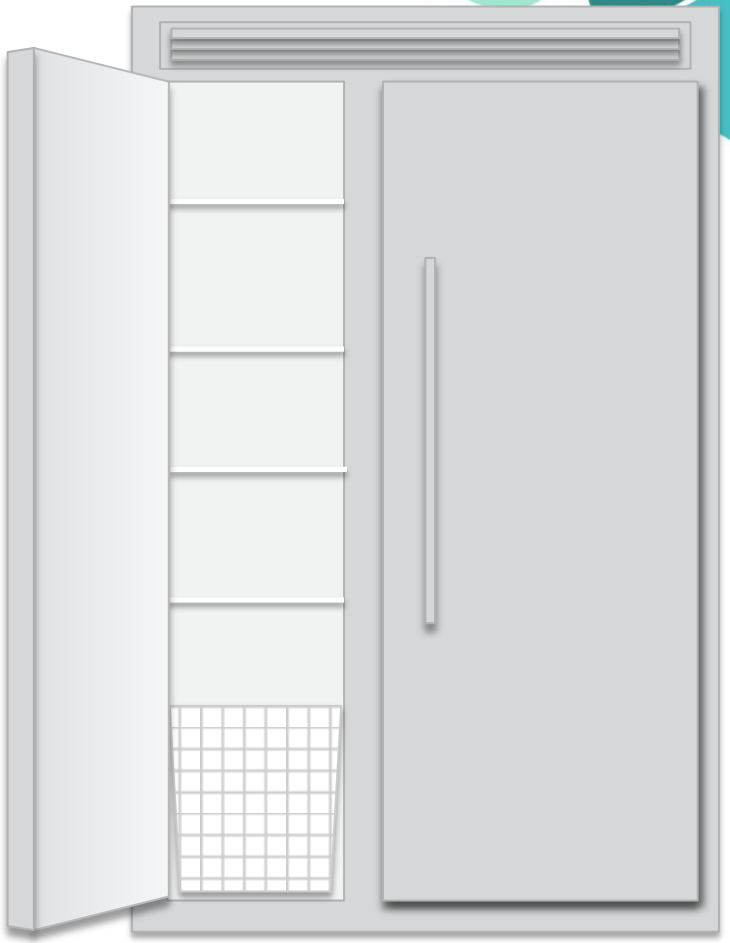
- Contents are text
  - Possible to reference image, audio, video: application can fetch media using reference
- Works across devices, operating systems and connection types
  - WiFi, Ethernet, PLC, etc…
- Producer (sender) can assign priority to notification
- Consumer (receiver) can configure preferences on types of notifications it receives

Examples

- Refrigerator could send a notification that freezer door has been left open for more than 2 minutes
  - This could be rendered on any producer: mobile device, TV, set top box, etc…
- Washing machine can send a notification when wash cycle is complete

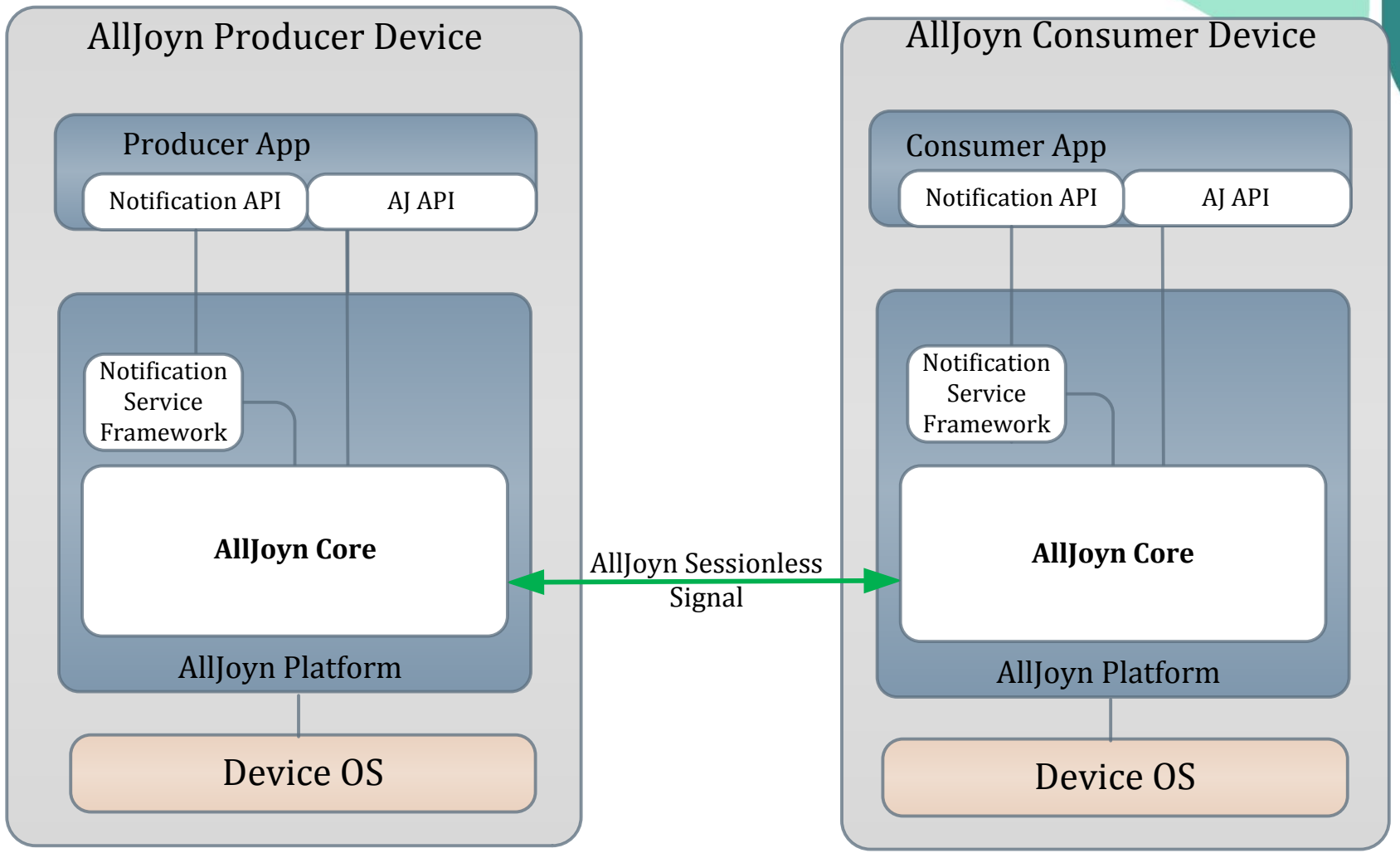
Notification Service Framework Example





- Freezer door left open for > 5 minutes
- Refrigerator emits notification
- TV renders it
  - Could also be rendered on a mobile device

Notification Service



Control Panel Service Framework

Control Panel Service Framework

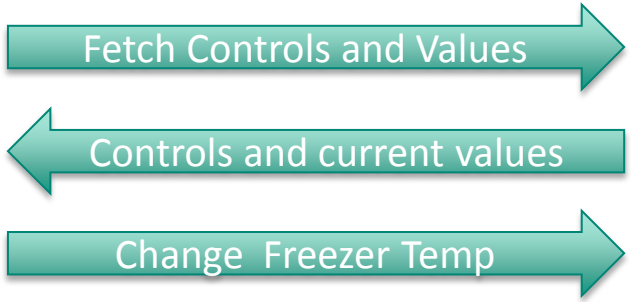
Infrastructure for exposing user interfaces for devices remotely

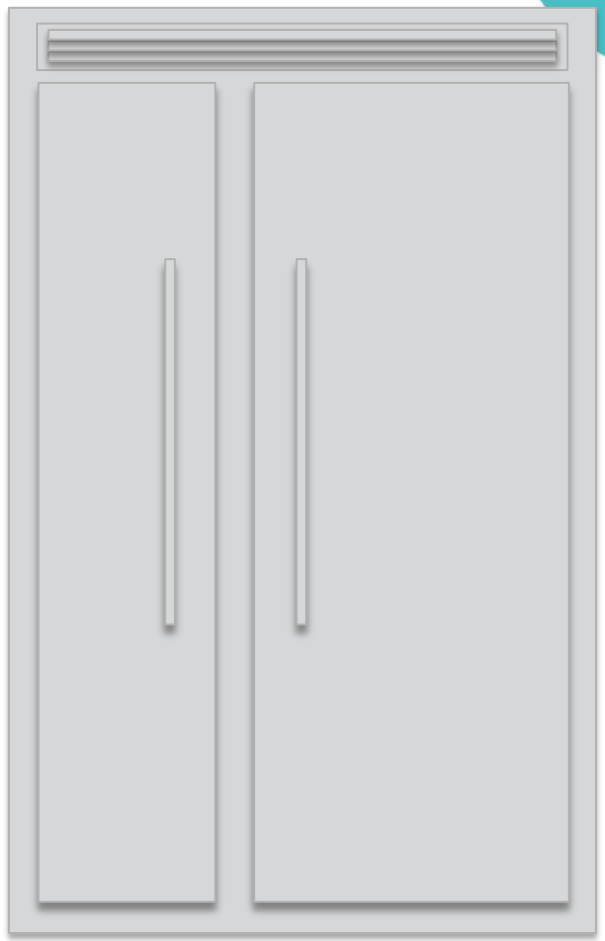
- Model is there is a controller and a controllee
- Controlee exposes it's UI using the framework,
- Controller renders the UI and sends control commands back to controllee base on UI input
- Defined such that any control application using the framework can render a controllee exposed UI
  - That is a generic app can control any type of devices that exposes controls using this framework

Examples

- After receiving a notification that the oven has been on Broil for 5 minutes a user could bring up the ovens control panel and change the setting to "bake at 250" to keep the food warm
- A user could check the current values of a refrigerator (including current temperature) and modify the settings to make things hotter or colder as needed.

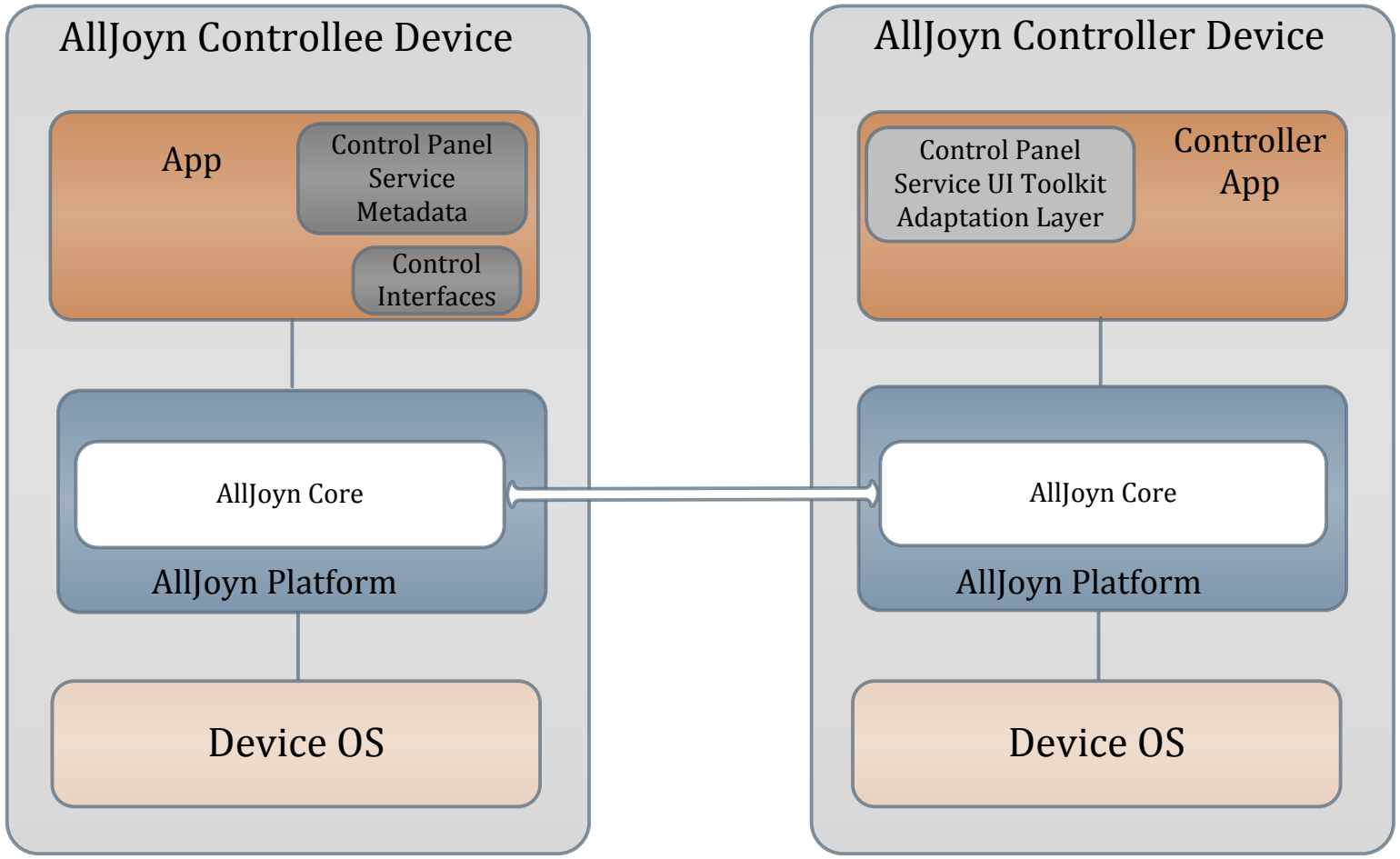
Control Panel Service Framework Example





- After detecting refrigerator
- Mobile device fetches the controls and values
- On receipt it renders them on the display
- Freezer temperature changed on mobile
- Change in the temperature is reported to refrigerator

Control Panel Service High Level Architecture

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Вопросы?
Spørsmål?
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Domande?
Questions?
Vragen?
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Thank You!