Introduction

- ATIS OS-IoT (Open Source – Internet of Things) is an open source platform to support the oneM2M IoT standard
- OS-IoT has a unique focus in the oneM2M software ecosystem which is to support lightweight client applications that can be deployed on constrained devices
- Using OS-IoT simplifies the development of oneM2M applications
- OS-IoT allows developers to focus on differentiating and value-added features, not just protocol issues
oneM2M standard and the IoT Ecosystem

• The global oneM2M standard provides a common middleware layer for open, secure and interoperable IoT applications

• IoT value realized from oneM2M includes:
  – Scaling and manageability of large deployments
  – Security and information access control
  – Interoperable platform across multiple vendors and verticals
  – Aggregation of data from multiple silos

• oneM2M is foreseen as having significant potential value in a number of industrial and consumer applications such as Smart Cities, eHealth, Smart Grid.

• As a founding Partner of oneM2M, ATIS recognized that Open Source implementations of the standards would complement oneM2M specifications, drive adoption, and enhance commercial value
oneM2M and Lightweight Clients

• Analysis by ATIS members and an industry survey highlighted a support need for lightweight clients. Example constraints:
  – Constrained compute resources: limited CPU power, limited memory
  – Limited electrical power: e.g. battery powered devices designed for multi-year operation

• Lightweight clients are required for many IoT applications, e.g.:
  – smart metering, smart city/transport, and wearables

• OS-IoT offers portable, lightweight, open source oneM2M client framework to support the adoption of oneM2M in lightweight clients.
OS-IoT Core Concept:
Client Library and Demo Applications

• OS-IoT library provides application-independent support of oneM2M client functions for signalling to the server.
• Demo applications show operation of library and act as a template for third-parties to develop their own work.
• OS-IoT provides an open resource-oriented API between applications and library.
• Library and application are compliant to oneM2M standards and pre-integrated with open oneM2M servers.

Enabling application developers to quickly build oneM2M support.
OS-IoT Participation

- Open to both ATIS members and non-members
- Project leader:
  - Farrokh Khatibi (Qualcomm)
- A range of companies from different parts of the ecosystem have participated during the lifecycle of the work.
OS-IoT Projects

OS-IoT C++ Library for Linux
oneM2M support on light/medium platforms. Rich set of client resource types.

OS-IoT C Library for BG96/ThreadX
oneM2M support directly on the cellular IoT module for very lightweight data collection applications.

OS-IoT Upper Tester
Framework for automatic conformance testing of oneM2M AEs.

OS-IoT OCF to oneM2M Bridge for Linux
OS-IoT C++ Library for Linux
OS-IoT Support for Key oneM2M Application Building Blocks

- **Discovery**
  To Find Data

- **Cloud & Home**
  Cloud Data Storage

- **Subscribe/Notify**
  To Trigger Device Actions

- **Cloud & Home**
  Cloud Data Retrieval

- **Security and Policy Management**
OS-IoT Architectural Overview

- Custom IoT Application
  - Resource Oriented API
  - Parsing, Serialization and Protocols
    - JSON
    - XML
    - HTTP/HTTPS

- Operating System
- HW Platform

- Physical sensors and actuators
- oneM2M Infrastructure
  - Interoperability tested with
    - oneM2M Client Device
    - Mobius
    - open mtc
    - IoTDM
    - Fraunhofer
OS-IoT C++ Library - Supported Platforms

• OS-IoT library supports a wide range of Linux based platforms
  – Could also be ported to other operating systems

• Tested platforms:
  – ’96boards’ DragonBoard 410c (Qualcomm Snapdragon, ARM Cortex A53 CPU)
  – Raspberry Pi Zero and other family members (32 bit ARM)
  – PC x64

• Tested OSs:
  – Ubuntu version 14, 16 and 18
  – Linaro for the 96Boards open platform
  – Raspbian for Raspberry Pi
Initial Release – September 2017

• Core set of oneM2M Application Entity (AE) features:
  – CRUD operations for main oneM2M resources
  – Subscribe/Notify

• Live demo of OS-IoT example applications:
  – oneM2M standards compliant smart lighting application
  – Interworking between oneM2M and commercial ZigBee Light Link system
  – Platform portability between X64 and ARM

Demonstrated the concept of an open, interoperable oneM2M client library.
Expanded Capabilities and Applications

• Feature additions:
  – oneM2M standards compliant HTTPS protocol security to support access to public cloud oneM2M Common Service Entities (CSEs)
  – Home Appliance Information Model (HAIM) support for standard appliance resource types
  – Subscribe/notify efficiency improvements
  – Resource discovery

• Event participation:
  – oneM2M developers event in Japan
  – oneM2M interop. event, Washington DC

Continuous improvement to broaden application and enhance robustness and usability.
oneM2M Interop Event, July 2018

- In total 122 interop test cases based on oneM2M specification TS-0013 (Interop Testing) were run with four different oneM2M servers:
  - Eclipse OM2M
  - Interdigital Chordant
  - KETI Ocean
  - Fraunhofer OpenMTC

- All tests for supported functionality passed at the event
  - A few areas were found where the servers needed small modifications to comply with oneM2M specifications

- Additional informal testing beyond the scope of standard oneM2M tests also took place:
  - Home Appliance Information Model
  - Certificate-based oneM2M security
OS-IoT C++ Library Demo Applications

**Command-Line Application**
- Supports commands to exercise OS-IoT library
- Package includes test scripts for oneM2M standard functional tests and extended test cases

**Smart Lighting Demo**
- Runs OS-IoT on a lighting controller (switch) and simulated lamp
- Interoperates with open-source oneM2M servers

**Cloud Based Data Collection Demo**
- Data collection device running OS-IoT transmits data over WiFi or Cellular
- Hosted web application uses OS-IoT to pull data from oneM2M server
- Supports public oneM2M cloud servers
OS-IoT C Library for BG96/ThreadX
OS-IoT On Embedded Cellular Modules (BG96/ThreadX)

- Highly efficient C implementation
- Optimized functionality for data collection devices
- Optimized use of hardware for reduced Bill of Materials (BoM)
- Support for Power Saving Mode (PSM) to optimize power needs
- Security and Policy Management
OS-IoT Leverages Open Cellular IoT Modules

Conventional Closed Cellular Module Client Architecture

- Cellular IoT Module
  - Real-Time OS (RTOS)
  - e.g. AT Commands/PPP over Virtual Serial

- Application CPU
  - Custom IoT Application
  - OS-IoT Library
  - Application OS

- Peripheral interface
  - e.g. I2C, GPIO, ADC

- Sensor and Actuator Hardware

Cost-optimized, Open Cellular Module Client Architecture

- Cellular IoT Module
  - Custom IoT Application
  - OS-IoT Library
  - Real-Time OS (RTOS)

- Peripheral interface
  - e.g. I2C, GPIO, ADC

- Sensor and Actuator Hardware

Combining functions on to one platform

- Lower cost from eliminating application CPU from Bill of Materials (BoM).
- Lower power consumption from eliminating hardware and integrating application with cellular module power saving mode.
- Smaller devices by reducing part count.
OS-IoT on Embedded Cellular Modules - Platform

• Integrated cellular IoT modems with accessible application SDKs and support for NB-IoT and LTE-Cat M1 are now available.

• OS-IoT C Library adapted from C++ version
  – Evolves and simplifies API for user in C, but retains same concepts

• Test platform is Quectel BG96 module based on the Qualcomm 9206 chipset

• Build files for ThreadX Version 3 Dynamic Application Module (DAM) to run directly on BG96

• Uses Native APIs on module for HTTP and HTTPS

• Tested on GSM and NB-IoT. Testing planned for LTE CAT M1
OS-IoT on Embedded Cellular Modules - Features

- Target application space is data reporting applications. For example:
  - Environmental monitors
  - Smart meters
  - Health trackers
  - Package tracking
- Support for core oneM2M resource types needed for data reporting applications
- Includes support for HTTPS security and onboarding of security credentials
- Demo application showing periodic collection of data and reporting
- Compatible with cellular power saving mode (PSM) features
- BG96 used for development, but portable to other modules with similar capabilities
OS-IoT Upper Tester
Upper Tester Context

- oneM2M is seeking to develop the certification of oneM2M devices (AEs)
- oneM2M work includes:
  - Defining the testing framework and message structures
  - Defining AE certifications profiles
- The target audience is AE developers who will benefit from open-source support (code, libraries, tools) to make their AEs testable, a precursor to certification.
OS-IoT Testing Framework

Test System (e.g. ETSI/Spirent) -> CSE Simulator

Upper Tester

Implementation Under Test (IUT) Component

utPort (TS-0019)
JSON over HTTP

OneM2M Mca Interface

AT Command Interface over serial port

AE

Implementation Under Test
OS-IoT on BG96

OneM2M
Testing Profile and Options

• A common interface based on AT Commands has been implemented in the BG96 library and Upper Tester
• The Upper Tester supports Profile #3 from oneM2M TS-0025

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<td>AE/GEN/00002/00001</td>
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<td>Create &lt;container&gt; with no attribute set</td>
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<tr>
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<td>AE/DMR/00002</td>
<td>AE/DMR/00002/00001</td>
<td>Create &lt;contentInstance&gt; with mandatory attributes</td>
</tr>
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OS-IoT OCF to oneM2M Bridge for Linux
OS-IoT Support for Home Appliance Information Model (HAIM)

- oneM2M has adopted the Home Appliance Information Model (HAIM) as a standard for semantic representations of home appliances
- HAIM modelling is compatible with other IoT standards – e.g. OCF
- HAIM separates appliance information from the protocol used to transmit that information
  - Support of HAIM will allow clients using OS-IoT to seamlessly integrate with other HAIM appliances and appliance controllers (e.g., apps)
  - Using HAIM also allows OS-IoT to be used in interworking bridges that connect different appliance-centric IoT standards
- The OS-IoT Linux library supports HAIM device resource types
  - Interop tested with oneM2M CSEs that also have HAIM support
Open Connectivity Foundation (OCF) Interworking

• OCF is a standard for proximal IoT interoperability at the appliance level, including a suite of Smart Home applications.
  – OCF/ATIS agreement to collaborate in developing a demo of seamless interoperability

• OS-IoT has developed a demo of a Bridge or “Interworking Proxy Entity (IPE)” that maps OCF devices in to the oneM2M HAIM ecosystem
  – Bridge was demonstrated at OCF Technical Face to Face meeting
  – OCF responded to this work by advancing their standard on OCF/oneM2M interworking to an earlier release and enabling this kind of asymmetric bridge
OCF/oneM2M Bridge Network Architecture

Discover OCF devices and create corresponding oneM2M resources.

Process oneM2M state-change notifications and map to OCF states.

Simulated OCF device from OCF deviceBuilder application

OCF lightdevice

OCF/oneM2M Bride

OCF Client

IoTivity C++ Library

C++ IPE App

oneM2M AE

Library

oneM2M CSE

e.g. Eclipse OM2M

oneM2M Controller AE

Mca

Mca
Summary

- OS-IoT is the targeted platform to support oneM2M on a variety of lightweight clients
- Using OS-IoT can simplify the development of IoT devices and improve interoperability within the oneM2M ecosystem
- Choice of libraries for different requirements:
  - C++ library with richer feature set for more capable platforms
  - C library with focussed feature set for tightly constrained platforms and embedded cellular IoT modules
- Packages include demo applications to give practical examples of how to use library
- Open source means adaptable, portable and expandable to meet different applications

www.os-iot.org

- Source code
- Test suites
- Example applications
- Documentation
OS-IoT Key Features

Open Source
OS-IoT is Open Source for community and commercial application.

oneM2M v2 Compliant
OS-IoT supports oneM2M version 2 compliant Application Entity (AE) capabilities.

Platform Independent
OS-IoT provides a high degree of platform independence and potential to support constrained devices.

Simple API
OS-IoT provides a simple, resource-oriented API to interact with oneM2M ecosystems.

Interoperable
OS-IoT is interoperable with oneM2M ecosystem components including OM2M, IoTDM and oneMPOWER.