SMO Architecture and Open Source Implementation

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Background and Acknowledgments

• Speaker background
  ■ AT&T (Bell) Labs, STL, Rutgers WINLAB
  ■ ONAP/LFN, O-RAN WG1, O-RAN SC
  ■ Member: LFN TAC, ONAP TSC

• Acknowledgment:
  ■ This presentation is partly based on the following ONAP/OSC/O-RAN presentation:
    OSC/ONAP SMO Framework: Exploring interactions among SMO-related projects in OSC and ONAP,
  ■ This presentation incorporates input/ideas from interactions with teams in O-RAN SC, ONAP, O-RAN, Rutgers WINLAB including: Andrea Buldorini, Rittwik Jana, John Keeney, David Kinsey, Seshu Mudiganti, Timo Perala, Ivan Seskar, Martin Skorupski, Joseph Thaliath, Tracy van Brakle
Talk Outline

• SMO in O-RAN Architecture
• Ongoing SMO Architecture standardization discussion
• Importance of Open Source
• SMO-related Open Source Projects (OSC, ONAP focus)
• Alignment and synergy in Open Source
• Conclusion
O-RAN Architecture: User, Control, Management Plane

Service Management and Orchestration Framework (SMO)

- Other SMO Functions
- Non-RT RIC
- rApps
- Near-RT RIC
- xApps

O-RAN Management & Control Plane

OFH-MP

O-RU

O-DU

O-CU-CP

O-CU-UP

Core

Internet

Legend
- O-RAN defined interface
- 3GPP defined interface
- Interface out of scope of O-RAN (OAD v10.00)

End-to-end User & Control Plane

Ref: O-RAN Architecture Description. O-RAN.WG1.OAD-R003-v09.00
Focus on role of SMO in O-RAN Architecture..

Service Management and Orchestration Framework (SMO)

- Other SMO Functions
- rApps
  - Non-RT RIC

External System Providing data to the SMO

Legend:
- O-RAN defined interface
- 3GPP defined interface
-interface out of scope of O-RAN (OAD v10.00)

Ref: 1) O-RAN Architecture Description. O-RAN.WG1.QAD-R003-v10.00
Role of SMO - RAN domain management

- Responsible for RAN domain management and non-real-time control, optimization, automation
- Includes Non-Real Time RIC which provides:
  - Support for rApp applications (via R1)
  - Non-real-time intelligent control, optimization, radio resource mgmnt and other functions
- Policy-based guidance to Near-RT RIC (via A1)
- FCAPS support to O-RAN Network functions (via O1) and to O-RU (via OFH-MP interface)
  - PM, FM, CM, File management
  - Software management
- O-Cloud Management, Orchestration and Workflow Management (via O2 interface)
  - Discovery and administration of O-Cloud Resources
  - Scale-in, Scale-out, FCAPS for O-Cloud
- Interfaces to external systems
  - OSS/BSS, transport, core, other RAN networks
SMO-Related O-RAN Standardization (June 2023 specs)

- **WG1** – Overall architecture
- **WG2** – Non-RT RIC, A1 interface
- **WG10** – O1 interface (CU/DU FCAPS)
- **WG4** – OFH-MP interface (RU FCAPS)
- **WG6** – Orchestration of Cloud infrastructure (O2-ims) and Network Functions (O2-dms)

**No WG covering entire SMO**
- Internal SMO architecture not specified
- Details of “Other SMO Functions” implied but not specified

**Legend**
- O-RAN defined interface
- 3GPP defined interface
- Interface out of scope of O-RAN (OAD v10.00)

Ref: 1) O-RAN Architecture Description. O-RAN.WG1.OAD-R003-v10.00, 2) https://www.o-ran.org/about
SMO-Related O-RAN Standardization (including ongoing work)

- WG1 – Overall architecture
- WG2 – Non-RT RIC, A1 interface
- WG10 – O1 interface (CU/DU FCAPS)
- WG4 – OFH-MP interface (RU FCAPS)
- WG6 – Orchestration of Cloud infrastructure (O2-ims) and Network Functions (O2-dms)

- WG1 Decoupled SMO Architecture Technical Report (ongoing work)
  - Internal details within SMO
  - SMO Functions (SMOF)
  - SMO Services (SMOS)

Ref: 1) O-RAN Architecture Description. O-RAN.WG1.OAD-R003-v10.00 2) O-RAN Decoupled SMO Architecture Decoupled SMO Architecture TR-R003-v01.00
O-RAN WG1 Decoupled SMO Technical Report

• Ongoing study in O-RAN WG1 Architecture Task Group
  • Decoupling of functions within SMO architecture
  • Objective: Define reference architecture for SMO, identify SMO functions and interfaces which are candidate for standardization

• Consensus till now:
  • SMO architecture is service-based – included in WG1 OAD v09
  • Definition of SMO Functions (SMOF) which offer SMO Services (SMOS) included in WG1 OAD v09
  • SMO Services identified and described:
    • Non-RT RIC
    • RAN NF (Network Function) OAM (FM, PM, CM)
    • Service Management and Exposure (SME)
    • Data Management and Exposure (DME)
    • O-Cloud resources management and orchestration (NFO, FOCOM)
    • Topology Exposure and Inventory Management (TE&IV)

• This is ongoing work – changes and more details to be expected

Source: WG1 ATG recommendations on SMO architecture assumptions in use cases and requirements definition, Feb 2023.
Current draft view of O-RAN SMO Architecture (June 2023) – Active ongoing work

Ref: O-RAN Decoupled SMO Architecture Decoupled SMO Architecture TR-R003-v01.00.09
SMO-Related Open-source Projects

- Open-source projects are very important for the O-RAN ecosystem
  - Openly accessible implementation of standards/pre-standards
  - Foster use of innovative software best practices
  - Provide insights and input for standardization
  - Enabler for research, pre-standards/standards collaboration
  - Enabler for university hands-on education, pipeline of talent pool, workforce training
  - Enabler for innovation in rApp ecosystem

- O-RAN Alliance Open Source Focus Group (OSFG)
  - Recognizes important of open-source projects
  - Provides guidance, co-ordination for O-RAN related open source

- Linux Foundation/Linux Foundation Networking
  - O-RAN SC, ONAP, Nephio, Sylva, 5G Super BluePrint, etc.

- O1 and OFH-MP compliant end-to-end RAN options important for SMO-related work

- End-to-end 5G open source solutions: e.g., OAI, srsRAN
  - Enable end-to-end instantiation – pre-O-RAN 5G work with ongoing work to support O-RAN
O-RAN Architecture: User, Control, Management Plane

Service Management and Orchestration Framework (SMO)

rApps

Non-RT RIC

Near-RT RIC

xApps

Other SMO Functions

O-RAN Mgmnt/Control Plane

O-RU

OFH

CUS/M-P

O-DU

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O-CU-UP

Core

External System providing data to the SMO

External System

Legend

O-RAN defined interface
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End-to-end User/Control Plane

Ref: O-RAN Architecture Description. O-RAN.WG1.OAD-R003-v09.00
Example instances of O-RAN OSFG Super Wireless RAN BluePrint

O1, OFH-MP necessary for management plane

SMO-Related Projects in O-RAN SC and ONAP

• O-RAN Software Community (OSC)
  • Open-source project under auspices of O-RAN Alliance – guided by OSFG
  • Early focus on RAN (Near-RT RIC, OFH, RU, DU, CU) – later expansion to SMO

• ONAP - Network automation technologies for cloud-based networks, including focus on 5G/O-RAN
  • Several projects directly relevant to SMO – cloud-based automation, policy, orchestration, database, son and slicing use cases, etc.
  • Early work was pre-O-RAN – continuous effort to align to O-RAN

• OSC/ONAP harmonization – continuous process with increased attention

• Open source projects in SMO space tend to be modular components
  • Examples: oam/sdnr, ves, non-rt-ric, a1, control loop
  • Work is aligned with standards where available
  • Also includes pre-standards work – aligned with trends in standards discussions

Synergy/alignment for SMO-related open source projects

- There is consensus in OSC and ONAP at TOC/TSC level:
  - SMO-related work in OSC and ONAP should align with trends in SMO-related discussion in O-RAN Alliance, especially WG1 SMO Decoupled Architecture TR
  - Avoid duplication, improve synergy and collaboration between OSC and ONAP
- Build on existing OSC/ONAP harmonization – improve interworking and alignment
  - oam (o1, ofh-mp), sdn-c, ves collector, pm handler
  - aimlfw, dmaap/kafka, policy, cps db
  - non-rt-ric (a1, r1, rapp)
  - smo (o2), so
  - intent

Current draft view of O-RAN SMO Architecture (June 2023) – Active ongoing work

Ref: O-RAN Decoupled SMO Architecture Decoupled SMO Architecture TR-R003-v01.00.09
OSC and ONAP projects related to SMO (draft, expect changes)

Relevant projects
- int
- smo-pkg
- dcae
- oof?
- sdc?
- security-framework
- 5gson
- e2e-slicing

Notes:
- Figure is meant to explore alignment to O-RAN architecture
- Each red/blue label is an osc/onap open source project/component
- We may/do not have or need 1:1 mapping between projects and architecture blocks

ONAP 5G SON Use Case

Data Analysis, SON Algorithm

SON Handler MS

OOF

Policy

REST API

FM/PM DB

DES

MS

Data Lake

FM, PM, CM

OOF

TBDMT

NCMP

CPS DB

DMaP

O1

Ref: https://wiki.onap.org/display/DW/R12+SON+Use+Case

RAN control loop design prior to O-RAN rApp, R1

SDN-R (SDN-C)

A1 PMS

SLI

A1 Policy

O1

Simulated RAN

Aligned with O-RAN interfaces

RAN-Sim

RAN App

CU/DU

Control Loop

A1

A1 Policy

Config Change

CM

FM, PM, CM

RAN configuration datastore

Ref: https://wiki.onap.org/display/DW/R12+SON+Use+Case
OSC RAN PM Measurement

Components

Data Flow

Source: https://docs.o-ran-sc.org/projects/o-ran-sc-nonrtric-plt-ranpm/en/latest/overview.html#data-flow
OSC Non-RT-RIC project (Rel H)

SMO interaction example: AIMLFW, Non-RT RIC, OAM

Summary

• SMO is a critical part of the O-RAN Architecture
• Ongoing work in O-RAN on Decoupled SMO Architecture
• Ongoing SMO-related open-source implementations (e.g., OSC, ONAP) – important for ecosystem
• Momentum in alignment/synergy of SMO-related open-source projects – improves efficiency
• Contributions to open-source is encouraged
THANK YOU
Northbound Interface (NBI) towards OSS, BSS and other

Design-Time
- VNFM Validation
  - VNFM
  - VNFM SDK

Run-Time
- Interfaces
  - Portal NG
  - Live-Case UI (LUI)
  - External APIs
  - CLI

Manage ONAP
- ONAP Operation Manager (OOM)

Shared Services
- Security Framework
- Optimization Framework (OOP)
- Config. Persistence Service (CPS)
- Logging Framework

Service Design & Creation (SDC)
- Service/VM Design
- VNFM Onboarding
- Workflow Designer
- Catalog

Utilities
- ONAP Shared Utilities
  - VNFM Controller SDK (CCSDK)
  - Model Utilities

Managed Environment
- External Systems
  - 3rd Party Controllers
  - VNFM
  - EMS

- Network Function Layer
  - VNF

- Hypervisor / OS Layer
  - OpenStack
  - Commercial VM
  - Kubernetes
  - Public Cloud

Color Legend:
- Design
- Orchestration & Management
- Operations
- Entirety of ONAP Components
- Unmaintained ONAP Component

Ref: https://docs.onap.org/en/latest/platform/architecture/
OSC SMO proposal for O2
(Integration options with other open-source projects)

Source: https://wiki.o-ran-sc.org/download/attachments/1179971/Ocloud-operator.pdf?version=1&modificationDate=1681909851825&api=v2