ONAP Dublin DDF and OPNFV Gambia Plugfest Joint Report

Results and lessons from the fourth ONAP Developer Design Forum (DDF) and sixth OPNFV Plugfest, January 8-11, 2019.

Please direct any questions to **lfn-info@linuxfoundation.org**.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The fourth ONAP DDF and sixth OPNFV Plugfest were co-located at the Nokia facility in Nozay, France. The event spanned four days from January 8-11, 2019.

The focus of this joint event was to bring commercial vendors and open source community members together to plan the upcoming ONAP Dublin release, perform testing and integration of the OPNFV Gambia release, and foster collaboration between the ONAP and OPNFV communities. The combined event was attended by 213 individuals from 55 organizations that included 11 end-users and 11 research and nonprofit organizations.

An important outcome of the joint event was the collaboration between the OPNFV and ONAP communities and there was interest in both communities to come together and leverage each other's work. Joint activities ranged from extending the OPNFV Verified Program (OVP) to verify ONAP VNF compliance; using OPNFV test tools such as Functest, Yardstick, and Dovetail for ONAP; adopting the OPNFV CI pipeline for ONAP; and collaborating around cloud native and edge computing technologies.

The ONAP DDF and OPNFV Plugfest had their separate activities as well. The ONAP DDF featured numerous parallel tracks covering presentations on topics such as production deployment, real world experience, edge computing, Dublin release planning, blueprints, modeling, cloud native computing, and testing. The key highlights of the DDF were Orange's presentation on their use of ONAP for a production use case, China Mobile's ONAP experience, expanding ONAP to automate edge computing (or multi-access edge computing, i.e. MEC), and the desire to harmonize ONAP with standards organizations and other relevant open source projects.

The OPNFV Plugfest focused on running interop testing against the Gambia release. Multiple vendors provided local and remote access to hardware that was used by both open source project members and proprietary software vendors. The onsite availability of project technical leads and other experts shrank what might have taken weeks into just days. Issues were also found and resolved rapidly for the same reason. The OPNFV Plugfest also included a Hackfest—a design summit style event with presentations around edge computing, cloud native computing, continuous integration (CI), testing, feature/installer projects, and other community discussions.

JOINT ACTIVITIES

Having both ONAP and the OPNFV community members together offered numerous opportunities for collaborative work at a rapid pace. Below is a summary of the activities:

OVP Scope Expansion to Verify VNFs

The OPNFV Verified Program (OVP) currently covers the NFVI/VIM layers. Expanding the scope of OVP by using VNF SDK (including the VNF Test Platform or VTP initiative), VNF Validation Program (VVP), and VNF Requirements projects will allow OVP to cover ONAP VNF compliance as well. This was an active area of collaboration with numerous dedicated sessions and demos. There were discussions on the categories of OVP badges and the strengthening of the test suite over time. Initially the test suite might simply be limited to static offline package inspections, but over time it can be enriched with lifecycle testing, functional testing, and ultimately performance testing. There were several discussions on the tooling — a combination of VTP and OPNFV Dovetail — that will be used to create the compliance verification program platform, marketplace, and portal.

OPNFV Test Tools for ONAP

The ONAP community sees value in OPNFV test frameworks such as Dovetail, Functest, and Yardstick. For example, ONAP can take advantage of Functest's light footprint. By using the Functest framework to test ONAP, Orange created a 10x smaller test container compared to the ONAP test VM.

There were discussions on setting up a task force to help ONAP further move towards automated testing. Next, there was a presentation that showed how the Yardstick NSB tool can be used to validate the performance of a VNF before onboarding it onto ONAP. An OPNFV SampleVNF (L2 Forwarder) was used for this purpose. Finally, there was a discussion around how OPNFV test tools could be used to validate the NFVI/VIM layer before running ONAP tests to create trust in the underlying infrastructure.

OPNFV CI Pipeline for ONAP

Similar to OPNFV test tools topic, there were also discussions around using the OPNFV CI pipeline for the ONAP project to evolve from waterfall testing to a CI methodology. This will help ONAP move to a more agile model.

Cloud Native Collaboration

Using a service mesh such as Istio for ONAP can provide numerous benefits such as improved visibility. OPNFV Clover builds a cloud native framework using Istio (see more on Clover in the OPNFV Plugfest section), and therefore ONAP can collaborate with Clover. A demo was also shown where a service mesh was injected into ONAP SDC project's 14 containers. While running the SDC workflow, SDC traffic parameters such as service response times, URLs, status codes, and more were monitored. In the future, Clover can be used to add features such as traffic policies, content-based routing, and authentication.

Edge Computing Collaboration

There was a session providing an overview of StarlingX, an OpenStack project for edge devices with a focus on low latency, security, and ease of installation. Some StarlingX use cases are vRAN, vCPE, and MEC. StarlingX is complaint with OPNFV and fully supported by ONAP.

ONAP DDF ACTIVITIES

The goal of ONAP Developer Design Forums is to help plan future releases. This particular DDF was focused on the upcoming Dublin release.

In addition to activities directly related to release planning such as requirements, architecture, testing, and planning, there were also sessions around production deployment, real world experience, Casablanca release demos, ONAP blueprints, and harmonization with other open source projects and standards organizations. The discussions roughly fit into the following categories:

Production Deployment

A highlight of the DDF was Orange's presentation on their first real life operational implementation of ONAP. In phase 1 of the ONAP PITEC Robot implementation, Orange monitored the quality of network management system access in Poland, Slovakia, Belgium, Spain, and Romania. A subset of ONAP projects (e.g. Policy, A&AI, VES collector, DMaaP) were used along with other open source components to onboard and instantiate PITEC probe VNFs and collect measurements results through the VES collector and DMaaP. Orange's key observation from this experience is to take a simple use case and deploy it using ONAP rather than waiting for a complex one.

Real World Experience

China Mobile shared their ONAP lab experience where they have a 2 level network topology using 5 infrastructure PODs. By relying on an 8 member team and 73 pieces of hardware, China Mobile deployed vCPE and CCVPN blueprints based on the Casablanca release.

Additionally, Nokia showed two ONAP demos (see Nokia Demos section below). Next, community members demonstrated the design and deployment of a Mobile Content Cloud (MCC) network service using ONAP. There was also a presentation on commercial NFVO products and what this means in terms of ONAP requirements. Finally, a presentation discussed the various issues faced when deploying the Clearwater IMS network service using ONAP, and how ONAP can close those gaps.

Edge Computing

Edge computing was an area of several active discussions. With edge, ONAP has the potential to expand its value beyond its current functionality. One session discussed how to bring analytics capabilities closer to the user. This requires automation of the analytics framework, collection of edge NFVI/VNF analytics data, interfacing with AI/ML training and inference engines, and interoperating with other third party applications. Next there were discussions on a fine grained placement service that would enhance workload placement across distributed datacenters. There were related discussions on a distributed ONAP deployment with OOM/k8s and managing MEC applications with ONAP.

Requirements, Architecture, and Planning

As expected, bulk of the DDF energy was focused on defining the next release. Some of the key architecture issues were around service mesh, distributed edge analytics, fine-grained placement services, k8s cloud region support, increased modularity, ETSI alignment, allotted network function, joint discussions with the modeling team, orchestration scenarios, and the creation of a TOSCA task force. The community also discussed current challenges with ONAP and opportunities to improve the project. Some such areas were improved documentation, blueprints that can be more accessible (e.g. the VoLTE blueprint is difficult to deploy for a general user since it includes proprietary VNFs), improved marketing, easier deployment, a simpler Policy interface, lifecycle management improvements, reduced ONAP footprint, closure of orchestration gaps, and improved quality. The group also took advantage of community members' presence to discuss release engineering improvements and housekeeping issues.

Additionally, a number of specific discussion areas were as follows:

SDO/Open Source Harmonization
The interest in harmonizing ONAP with the relevant ETSI, TMForum, MEF, and 3GPP standards is high. Survey results from several service providers showed interest from every polled operator in alignment with ETSI standards such as SOL003 and SOL005[1]. There was also a session on harmonizing ONAP models with the ETSI Open Source Mano (OSM) project. Having common models will reduce effort for both operators and VNF vendors. A separate session mapped the ONAP vCPE network service descriptor (NSD) to SOL001 NSD to find differences and gaps. This work resulted in 3 recommendations and follow-on discussion. See additional harmonization discussion in the "orchestration and lifecycle management" section below.

---

[1] SOL001 = NS Descriptor, SOL003 = NFVO to VNFM interface, SOL004 = VNF Package , SOL005 = OSS to NFVO interface

Orchestration and Lifecycle Management

A presentation on the Service Orchestrator (SO) component of ONAP summarized the current functionality of SO, features in Casablanca, and upcoming functionality in Dublin such as modularization, improved monitoring, better documentation, testing improvements, and improvements resulting from other ONAP components in the areas of ETSI compliance, Hardware Platform Awareness (HPA), PNF support, and dynamic recipe onboarding. In a related presentation, a proposal for an SO VNFM adapter in Dublin was discussed. This would allow SO to directly interface with a sVNFM supporting the ETSI SOL003 interface specification. Potential future support for SOL001 and SOL004 was also discussed.

The VF-C controller/orchestrator project had a similar session where the team discussed Casablanca functionality and reviewed the Dublin roadmap. Roadmap topics included increased support for ETSI standards such as SOL005 NBI (VF-C already supports SOL003), database separation from stateless containers, and inventory mapping. In a related session, the group discussed the pros and cons of consolidating numerous existing TOSCA parsers into a unified microservice. The Usecase UI (UUI) project, a GUI for VF-C, also conducted a roadmap discussion focusing on FCAPS for VNF/VM, CCVPN blueprint enhancements, and multi-language support.

The area of lifecycle management was also covered where ways to overcome complexity, poor documentation, and lack of network service independence were discussed.

Control Loop Automation & Network Data Analytics

The Linux Foundation PNDA project will extend its initial integration in the Casablanca release through integration with DCAE for application deployment support via helm. PNDA 5.0, also integrated with the MEF LSO big data reference platform, includes producer/consumer APIs, Kafka bus, HDFS/OpenTSDB/HBase, Spark & Spark Streaming, Jupyter notebooks, Impala based SQL query engine, Grafana time-series visualization, and more. Next, the Policy and DCAE teams discussed their Dublin backlog that includes items such as a new Policy Lifecycle API that create, read and delete functionality for models, templates and policies and using Helm to deploy additional DCAE components. Finally, the control loop subcommittee discussed specific workflows and interactions between SDC (including DCAE-DS), CLAMP, Policy, and DCAE for Dublin.

ONAP Deployment

A session was dedicated to the topic of offline deployment of ONAP to cater to organizations with internet access restricted by security policies. A complete methodology to do an offline installation was presented. A separate presentation discussed techniques to make ONAP container images Multi-Architecture compliant, adding ARM support.

Security

There were a number of active discussions on security. The security subcommittee presented their report along with a list of Dublin requirements. 70% of ONAP projects pass Level 2[2], or a Silver Core Infrastructure Initiative (CII) badge. For subsequent releases, topics such as VNF package security, 5G use case security, security by design, vulnerability review, and secure communication were discussed. Specifically, security related backlog for Dublin was also reviewed. A related session looked at ways of assessing security risk in ONAP. The presentation reviewed core concepts, definitions, and a hypothetical risk assessment example. Finally a presentation on PGP key management hygiene covered PGP-related vulnerabilities and review of best practices around managing vulnerability reporting.

NFVI/VIM (NFV Cloud)

One of the more important ONAP southbound interfaces is to the NFV infrastructure (NFVI)/Virtualized Infrastructure Manager (VIM) — simply known as the NFV cloud. During the DDF, current Multicloud project features were reviewed along with upcoming Dublin features such as support for StarlingX, Kubernetes, and Azure. An additional session discussed the need for hardware acceleration — SmartNIC, FPGA, or GPU — for blueprints such as CCVPN, and how acceleration management is required in conjunction with HPA. There were additional cloud related discussions that have already been in the edge computing section above.

In addition to the above areas, there were discussions on S3P or platform maturity (security, stability, scalability, performance, resilience, manageability, usability) and resulting requirements.

Blueprints

Both new and existing ONAP blueprints[3] were discussed with respect to the Dublin release. A new Broadband Service along with existing CCVPN, 5G, and vCPE blueprints were covered. The roadmap for Change Management blueprint, that cuts across most ONAP use cases, was also discussed.

Broadband Service (BBS): This blueprint will use ONAP for the design, provisioning, lifecycle management, and service assurance of broadband services. In the first phase, multi-Gigabit Internet Connectivity services based on PON (Passive Optical Network) access technology will be used. The blueprint covers new scenarios such as nomadic

---

[2] Level 2 or CII Silver badge means all internal communication is encrypted, with role-based access control and authorization for all calls

[3] Blueprints are more commonly referred to as use cases in the community. However, we prefer to use the term "blueprint" since ONAP use cases have mistakenly been construed as the only use cases ONAP can support. This is obviously not the case; ONAP can be used for any NFV/SDN use case within reason.

ONT (Optical Network Terminal) and service subscription plan changes. BBS will show how ONAP can orchestrate services across different locations (e.g. Central Office, Core) and technology domains (e.g. Access, Edge).

5G: 5G remains an area of active innovation within the ONAP community. Network slicing is an important component of 5G that will be introduced in Dublin and beyond. In the Dublin release the focus will be on RAN slicing, with initial support for two slice types: mobile broadband and ultra low latency with high reliability. The team is also studying the impact of end-to-end slicing. 5G, and other blueprints, also require physical network function (PNF) support. For this reason PNF pre-onboarding, onboarding, and PNF packaging were discussed in detail. Next, the need for fault management metadata and performance management dictionary artifacts was discussed. Another presentation talked about the 3GPP bulk performance management data handling in the Casablanca release through a new file collector in DCAE. Finally, there was a presentation on configuring xNFs (VNFs/PNFs) and upgrading PNFs using NETCONF.

CCVPN: In addition to a Casablanca release CCVPN blueprint demo, the team discussed Dublin work items and priorities such as service change management that will allow customers to dynamically add branch sites or value-added services (e.g. vFW) on-demand, ability for third party analytics applications to trigger ONAP control loop, and SD-WAN multisite service creation. There was also discussion on CCVPN E-LAN service blueprint for Dublin. This would offer enterprise customers point-to-point or multipoint connectivity. Service creation, deployment, change, and OAM (operations, administration, and management) phases were all covered.

vCPE: The vCPE blueprint is of particular interest because it is a complex blueprint that is easily accessible to users given that all the constituent VNFs are open source. For this reason, the presenters talked about automating both the design and deployment phases of the vCPE blueprint by using APIs, shell commands, Python code, and Robot scripts.

Change Management: Change management is a blueprint that deals with update, upgrade, and more complex scenarios such as VNF package change. It is an ongoing blueprint with some of the basic work already completed, with more complex scenarios being rolled out over subsequent releases. A presentation on change management provided the current status of this blueprint and future plans.

Modeling

ONAP is a model driven system with well-defined models for several design and deployment artifacts. This allows a user to change platform behavior without having to resort to programming. In addition to the modeling discussions from the "Requirements, Architecture, and Planning" section, the Modeling subcommittee presented current status and future recommendations. Recommendations included providing requirements to ETSI, adopting SOL001 Type extension method, and updating ONAP to support TOSCA grammar v1.1 and v1.2. The subcommittee also discussed VNF configuration data and its impact to modeling. Moreover, two additional topics were around the requirement to onboard network service descriptor (NSD) in SDC and harmonizing NSD models with ETSI SOL001. Finally, new modeling requirements arising from the CCVPN blueprint were discussed as well.

Cloud Native

There is a strong desire amongst community members to support k8s regions and cloud native network functions (CNFs) enabling smaller, edge-friendly footprints. Different approaches were discussed to fill gaps such as VM support and networking using k8s with Virtlet, Multus, OVN, SR-IOV, and Flannel. An alternative using k8s with KubeVirt, Multus, and ClusterAPI was also presented. Even so, there are gaps in lifecycle management of VNFs and networking that need to be closed for widespread adoption of cloud native methodologies.

Distinct from using cloud native techniques for VNFs and network services, is using cloud native technologies for ONAP itself. There were discussions on making ONAP more cloud native through modularization, database separation from stateless services, and using a Service Mesh (see Clover discussion).

Testing

In addition to the discussions around OPNFV and ONAP test tool collaboration, a couple of other interesting testing related sessions were on a third party open source testing platform called 5GTANGO V&V and an ONAP test lab presentation. 5GTANGO V&V is an existing test platform, meant for validating 5G networks, that works with OSM and can be integrated with ONAP. It focuses on VNFs, network services, and packages and can supplement VNFSDK/VTP. Next, WindRiver presented their ONAP lab that can be used by community members, along with learnings from the lab.
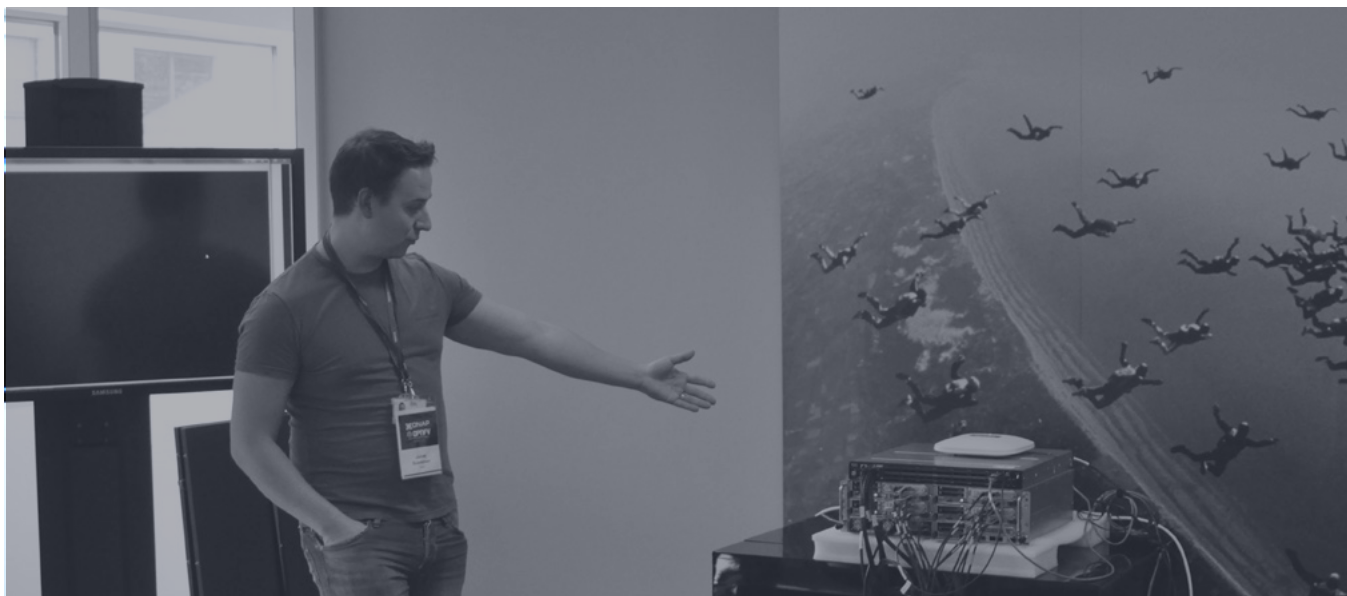
OPNFV PLUGFEST ACTIVITIES

The main focus of the Plugfest was to test various hardware and third-party software products, open source and proprietary, against the latest OPNFV Gambia release. The immediate availability of subject matter experts allowed for successful integration and productive testing.

OPNFV Plugfest Lab and Hardware Resources

Nokia, Intel, and Lenovo generously made hardware available to Plugfest attendees:

Nokia Cloud Stack Infra for Realtime (NCIR) was made available locally.

- 1 x AirFrame Open Edge hardware chassis
- 5 x AirFrame Open Edge server blades with single socket Intel Xeon SP with 20 cores 256 GB memory, 2 x 25Gb NICs
- 1 x AirFrame OR18 switch Z9100ON, 32x 100GbE

Figure 1: Nokia Cloud Stack Infra for Realtime (NCIR)

NOKIA also made a POD available remotely from Espoo, Finland (https://wiki.opnfv.org/display/pharos/Nokia+Hosting):

- 6 x AirFrame OR18 Nodes (3 control, 2 compute, and one jump host)
- 1 x AirFrame OR18 switch Z9100ON, 32x 100GbE
- 1 x AirFrame OR18 switch S3048ON, 48x 1GbE
- 1 x AirFrame OR18 PSU for power shelf
- 1 x OR Rack

Intel POD 14 was made available remotely from Hillsboro, Oregon (https://wiki.opnfv.org/display/pharos/Intel+POD14):

• 5 Servers: 2xE5-2699 CPU, 64-128GB RAM, SSD storage, 2 x 10 GbE, 2 x 1 GbE
• AG07-EXT-1 1GbE switch
• AG07-IZ1-1 10GbE switch
• StarlingX 2018-11 software

Lenovo made a POD available remotely from Morrisville, North Carolina (https://wiki.opnfv.org/display/EVNT/Lenovo+Fraser+Plugfest+Page):

• Controller nodes: 2 x SR630 servers, 384GB RAM, 2 x 480 GB SSD, 2 x 2TB NVMe, 2 x 10GbE, 4 x 1GbE LOM
• Compute nodes: 2 x SR650 servers, 384GB RAM, 2 x 480 GB SSD, 2 x 2TB NVMe, 2 x 10GbE, 4 x 1GbE LOM
• Lenovo NE2572 25G ToR switch
• Lenovo G8052 1G ToR switch

OPNFV Plugfest Testing

The table below provides a high-level testing summary of the OPNFV Plugfest activity:

Hardware	OPNFV Installer or Commercial Software	Testing
Nokia Open Edge	NCIR OpenStack	Dovetail, Functest
Nokia Open Rack	Apex	OPNFV + ONAP VNF SDK testing
Intel	StarlingX 2018-11	Functest, Dovetail, ONAP Casablanca testing
Lenovo	WindRiver Titanium Cloud R5	Functest, Dovetail, ONAP Casablanca testing

Table 1: Summary of Plugfest Testing Activities

The bulk of the testing was against Dovetail given the interest around the OPNFV Verified Program (OVP). As evident from the testing, there is a strong interest amongst third party NFVI/VIM vendors to be compliant with OPNFV and to go beyond compliance by using OPNFV test tools to further validate their software products. These testing activities also uncovered several issues that have already been or are being addressed:

Project	Types of issues
Functest	Documentation errors
Dovetail/OVP	Documentation errors
Dovetail	Patch https://gerrit.opnfv.org/gerrit/66055 was verified

Table 2: Issues Reported

OPNFV Hackfest

The OPNFV Plugfest also included a Hackfest portion that consisted of design summit like presentations and discussions. The presentations spanned five areas: edge cloud, cloud native, CI/testing, feature/installer projects, and community discussions.

Edge Computing

China Mobile shared their edge cloud experience where they conducted a live experimental trial network across 4 major cities using 9 vendors. The trial included OpenStack, ONAP, multi-cloud management, and hardware acceleration. The presentation shared China Mobile's test process and initial learning. Next, a session discussed a lighter weight Pharos POD specification for the edge as the current specification is potentially too heavy. Finally, an intern from International Institute of Information Technology, Hyderabad presented a PoC of a cloud native edge cloud using k8s and OPNFV Clover to run video streaming and AI/ML applications.

Cloud Native

The OPNFV Clover project has made great strides in progressing the state of cloud native NFV. In a session, the team introduced OPNFV Clover to the broader community. The presentation highlighted the original goal of Clover, what was completed in the Fraser release and resulting learnings, and how these lessons helped shape Clover's focus and direction in the Gambia release and beyond. The session covered various technical aspects and a demo of the Clover visibility engine and tracing module.

CI/Testing

Continuous integration and testing were a popular topic of discussion.

The Functest team presented how the project has evolved to test both OpenStack and k8s. Functest now includes OpenStack Patrole, Barbican, Shaker, and VNF testing (vEPC, vIMS, vRouter). The Functest team also conducted their 2019 roadmap planning. Next, the VSPERF team discussed results of their long duration and cross-NUMA testing. They also presented the containerization of VSPERF that reduces the overall footprint. Finally, the Yardstick Network Service Benchmarking (NSB) team presented how to benchmark VNFs using NSB. They also discussed the new VNFs covered by NSB in the Gambia release and future roadmap plans.

Additionally, the Cross-Community Continuous Integration (XCI) team discussed how to integrate Airship with XCI. As XCI aims to bring upstream components into OPNFV from their master branches, the OpenStack Helm (OSH) component of Airship shows promise to rapidly bring OSH upstream innovation to OPNFV community members. Next, an intern from Channabasaveshwara Institute of Technology, India presented an investigation of AI in testing and result analysis, specifically for the Bottlenecks project.

Feature/Installer Projects

There were active discussions around service assurance (Doctor, OpenStack Fenix), installers (Compass GUI), and SDN (SFC on OVN). The Doctor team provided a rolling maintenance and enhanced fault management demonstration that incorporated OpenStack Fenix, faster alarm reporting, and ETSI FEAT03 IFA006 harmonization. An additional session provided an architectural and technical overview of the OpenStack Fenix project — an infrastructure administration tool to run maintenance and upgrade workflows. Next, an intern from the University of Melbourne discussed web UI improvements to the Compass installer by porting it to Angular.js along with other enhancements. Finally, an intern from Queen's University presented his project that incorporated service function chaining (SFC) into the OVN project.

Community Discussions

Taking advantage of being face to face, community members also conducted internal discussions such as the Gambia retrospective where issues ranging from test case database, documentation, installer integration with OpenStack, scenario integration, stable branch window, tagging, and others topics were discussed. The release and documentation teams had discussions on their roadmap, process improvements, and related topics.

NOKIA DEMOS

The community is grateful to Nokia for providing the venue for the event. In addition to the OPNFV Plugfest and ONAP DDF, Nokia provided 5 demos:

Nokia NetAct Configuration Integrated with ONAP: In this demo Nokia's NetAct product provided configuration management functionality by interfacing with the ONAP APP-C module. The intent of this demo was to show value on top of ONAP, by leveraging ONAP as a platform for network management. The demo configured Nokia's TAS VNF, with APP-C to Nokia TAS communication over NETCONF/YANG.

VES Agent for Prometheus System: Nokia demonstrated a VES agent that runs as a VNF and translates Prometheus events to DCAE events.

Shared Data Layer/SDM Expert: Nokia has built a Shared Data Layer, SDL (a virtualized solution), that extracts static and dynamic subscriber information from legacy elements such as HSS, EPC, AAA, etc. SDM Expert is a VNF that pulls data from SDL that can be further processed for a variety of purposes to glean subscriber insights. This demo showed these software components in action.

Nokia AirFrame Edge Server Demo: In this demo, Nokia showed how augmented reality works in real time when users fetch data for augmented reality from the edge server.

Nokia Network Slice Demo: A stadium use case was demonstrated, wherein network resources were reserved (end-to-end network slice) for the audience to upload selfies with cell phones over a Wi-Fi connection.

PARTICIPANTS

The following companies participated in the combined event. Many thanks to all the participants.

Name	Description	URL
Aarna Networks	ONAP products and services	aarnanetworks.com
Affirmed Networks	VNF vendor	affirmednetworks.com
Amdocs	Software and services provider to communications and media companies	amdocs.com
Arm	CPU architecture provider	arm.com
AT&T	Telecommunications service provider	att.com
Bell Canada	Telecommunications service provider	bell.ca
Cachengo	Predictive storage for machine learning	cachengo.com
China Mobile	Telecommunications service provider	www.chinamobileltd.com
Cisco	Communications and information technology product vendor	cisco.com
CIT Gubbi	Technology university based in India	cittumkur.org
Dell	Provider of technology products and services	dell.com
DENSO	Supplier of advanced automotive technology, systems and components	www.denso.com
Deutsche Telekom	Telecommunications service provider	telekom.com
DOCOMO Euro-Labs	Research organization contributing to the evolution of future mobile systems	docomoeurolabs.de
Ecode Networks	Products, solutions, services, and training around Network Orchestration	ecodenetworks.com
Ericsson	Network equipment vendor providing communication technology and services	ericsson.com
Fujitsu	Provider of technology products and services	fujitsu.com
Google	Organizer of world's information and making it universally accessible and useful	google.com
HCL	Provider of IT services	hcl.com
Huawei	Networking and telecom equipment vendor	huawei.com
IBM	Provider of technology products and services	ibm.com
iconectiv	Provider of solutions to the interconnection of networks, devices and applications	iconectiv.com
IIIT Hyderabad	International Institute of Information Technology is an engineering and research institution located in India	iiit.ac.in
Intel	Semiconductor and computing vendor	intel.com

Name	Description	URL
Intracom Telecom	Global telecommunication systems and solutions vendor	intracom-telecom.com
Juniper	Provider of high-performance network solutions.	juniper.net
KDDI	Telecommunications service provider	kddi.com
Keysight Technologies	Helps companies accelerate innovation to connect and secure the world	keysight.com
The Linux Foundation	Non-profit organization that accelerates open technology development and commercial adoption	linuxfoundation.org
Mirantis	Cloud services and products	mirantis.com
NEC	Provides integration of IT and network technologies	nec.com
Netcracker	Services and software products for communication and cable service providers	netcracker.com
Nina Entrepreneurship & Management	Focus on creating new business in the IT and high-technology industry	corporate-office-44682.business.site
Nokia	Communications and information technology company	nokia.com
Nokia Bell Labs	Research organization with a focus on networking technology	bell-labs.com
OpenStack Foundation	Open source software foundation	openstack.org/foundation
Orange	Telecommunications service provider	orange.com
Queen's University	A Canadian research university	queensu.ca
Red Hat	Provider of open source software solutions	redhat.com
Samsung	Consumer electronics and technology vendor	samsung.com
Santé Canada	Organization responsible for helping Canadians maintain and improve their health	canada.ca/fr/sante-canada.html
Sorbonne University	Public university in France	sorbonne-universite.fr
Suntec Global Consultants	Real-time customer engagement orchestration and contextual products	www.suntecgroup.com
Swisscom	Telecommunications service provider	swisscom.ch
Tata Communications	Telecommunications service provider	tatacommunications.com
Telecom Italia	Telecommunications service provider	telecomitalia.com
Tech Mahindra	Provider of IT services, outsourcing, and IT consulting	techmahindra.com
Thales Group	Provider of high technology solutions	thalesgroup.com
Tieto	Software and services company	tieto.com
UNH-IOL	Independent Interoperability and conformance lab	iol.unh.edu
University of Melbourne	Research intensive university in Australia	unimelb.edu.au
Verizon	Telecommunications service provider	verizon.com
VMware	Compute, cloud, networking and security, and digital workspace software provider	vmware.com
Vodafone	Telecommunications service provider	vodafone.com
Wind River	Embedded and open source software	windriver.com

Table 3: Participating Organizations

CONCLUSION

The joint fourth ONAP DDF and sixth OPNFV Plugfest was a significant event for the industry as two LF Networking projects were able to collaborate at an unprecedented level and achieve outputs greater than a sum of the parts. The design and testing activities moved the state of SDN/NFV towards greater automation and testing.

Announcements for future events will be made on wiki.lfnetworking.org/display/LN/Technical+Community+Events, the onap-discuss mailing list (lists.onap.org/g/onap-discuss), and the opnfv-tech-discuss mailing list (lists.opnfv.org/g/opnfv-tech-discuss). Please join us!

REFERENCES

ONAP project
OPNFV project
Links to presentations and Zoom session recordings