ONEedge.io

A Software-defined Edge Computing Solution

D2.3. Solution Framework - c

Solution Framework Incremental Report

Version 1.0

10 March 2021

Abstract

ONEedge is a platform for extending private cloud orchestration capabilities to resources at the edge. It is built upon OpenNebula and applies a distributed cloud model to dynamically, and on-demand, build and manage private edge clouds to run edge applications. The aim of this second incremental version of the Solution Framework Report (D2.1)—which describes the framework's use cases, architecture, requirements and validation process—is to provide an updated report on the Agile methodology at the end of the Second Innovation Cycle (M10-M16). This document offers details about the fulfillment of the software requirements and the completed features for the main architectural components, and about the prioritization of features for the Third Innovation Cycle (M17-M23) as part of our plans to meet the project's milestones.

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Document History

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1.0	10/3/2021	Submitted	First final version of the D2.3 report

[1] A deliverable can be in one of these stages: Draft, Peer-Reviewed, Submitted and Approved.

Executive Summary

Document D2.3, released in M16 at the end of the Second Innovation Cycle, is the second incremental version of the Solution Framework Report (D2.1) in WP2 “User Success Management”. This report provides a description of the software requirements that have been addressed as part of the project’s Second Innovation Cycle (M10-M16), as well as a brief review of the priorities for the Third Innovation Cycle (M17-M23).

During the Second Innovation Cycle (M10-M16), the project mostly focused on those software requirements needed to achieve our second milestone in M16, which is the base functionality needed for a multi-host edge deployment.

The work carried out during this Second Innovation Cycle involved software requirements from components CPNT1, CPNT2, CPNT3, CPNT4 and CPNT5, with a special focus on the edge instance management (CPNT1) and the deployment and provision of edge infrastructures (CPNT4). These are some of the main new features that have been implemented as part of this process:

- First version of OpenNebula deployment architecture based on application containers, with automatic upgrade and rollback of ONEedge instances, and their basic monitoring and control.
- New 3-tier replica storage datastore for edge clusters.
- First version of backup system for VM disks.
- New version of OneFlow engine with enhanced functionality, reliability and scalability.
- Improvements in Graphical User Interface to expose new functionality.
- First version of Edge Provider Catalog Service as part of the new edge provisioning interface.
- First version of tests to certify the provider drivers for AWS and Packet/Equinix.
- New Edge Catalog Web interface as part of new Graphical User Interface, Provision FireEdge.
- Provision tools redesigned to use Terraform and the cloud database and multi-tenancy.
- Development of provision templates to implement ONEedge reference infrastructure.
- Development of new drivers for host provision based on Terraform.
- Development of new drivers for IP address management in AWS and Packet/Equinix clouds.
- Development of new drivers for networking to provide private networking based on VXLAN and EVPN BGP extensions.
- New Graphical User Interface, Provision FireEdge, for Edge resource Provision.
- Support for OneFlow templates and importing of multiple images in the Marketplace.
- New Kubernetes appliance images and template in the Marketplace.
- Enhanced integration with Docker Hub allowing ONEedge to orchestrate containers on virtual machines.
- First prototype of a self-service portal on top of an ONEedge.

These new features are described in report D3.5 “Software Source”, with the specifications and design of the new components being described in detail in document D3.2 “Software Report”. The testing process and certification infrastructure are described in D4.2 “Infrastructure Report”. The use cases demonstrating the new features developed in the First Innovation Cycle are described in D4.5 “Deployment of Validation Cases and Demonstrations”.

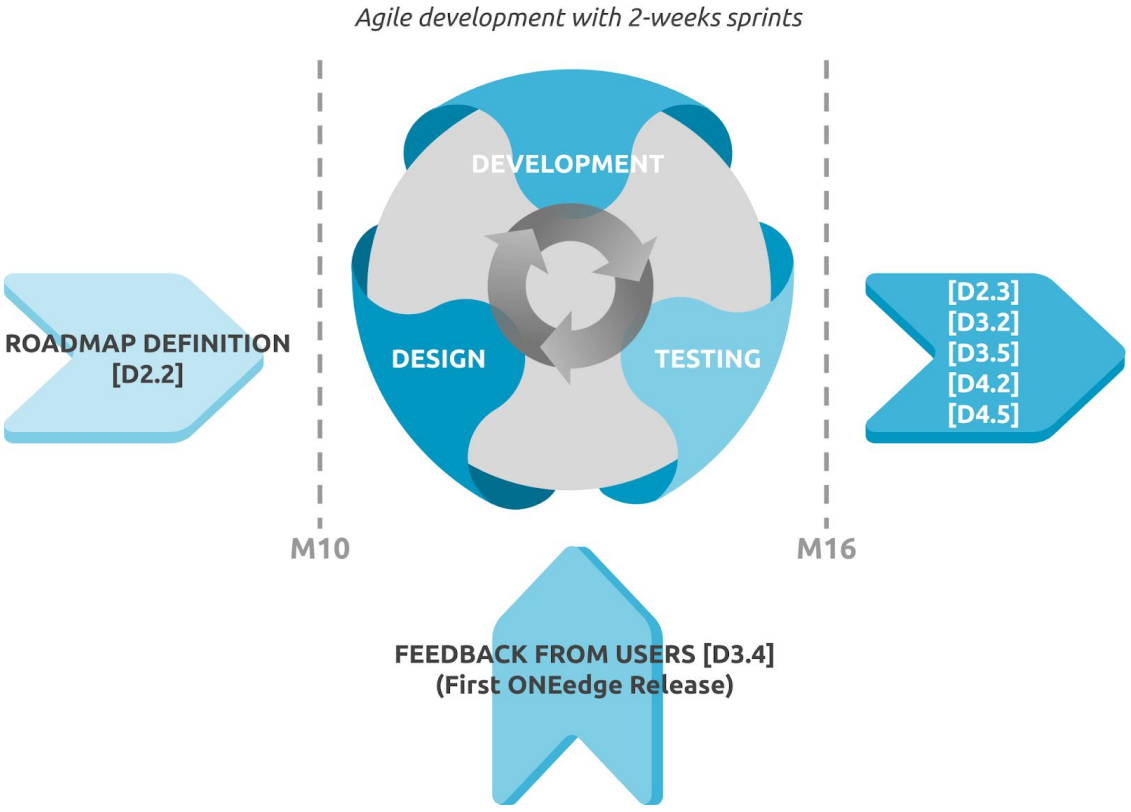
The present incremental report (Deliverable D2.3) includes a section with the priorities for the Third Innovation Cycle (M17-M23).

This Deliverable has been released at the end of the Second Innovation Cycle (M10-M16), and will be followed by an additional incremental report to be produced by the end of the remaining business and product innovation cycle (M23).

Table of Contents

1. Introduction

The initial version of the Solution Framework Report (Deliverable D2.1), released in M3 after the initial framework definition phase, describes the use cases and user requirements that are guiding the innovative development of ONEedge, defines the main components of this edge computing platform, identifies the main software requirements derived from user requirements, and explains the test cases, methods and demonstration scenarios that are being employed for the verification of the new edge computing features. An incremental version of this report will be released at the end of each development cycle at M9, M16 and M23 with a summary of the work done and priorities for the next cycle, as well as an incremental definition, if necessary, of use cases and requirements (T2.1), framework and architecture (T2.2), and verification suite (T2.3). However, as the ONEedge project deals with a software solution that is close to commercialization, and not a research prototype, no changes in the framework architecture are expected nor desirable at this late TRL stage, as that scenario would probably bring along a significant disruption to the implementation plans of the framework.



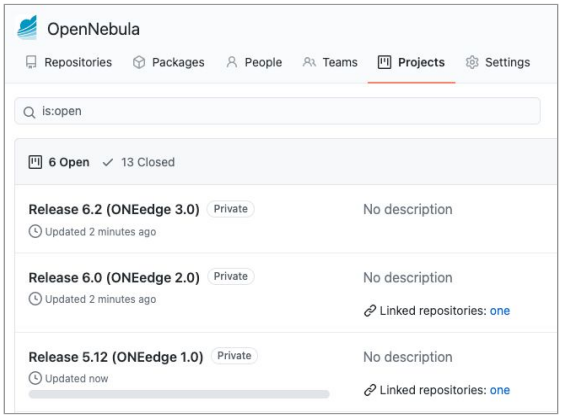
The aim of this incremental version (D2.3) of the Solution Framework Report is to provide an updated report of the Agile methodology in M16 at the end of the Second Innovation Cycle (M10-M16). It contains

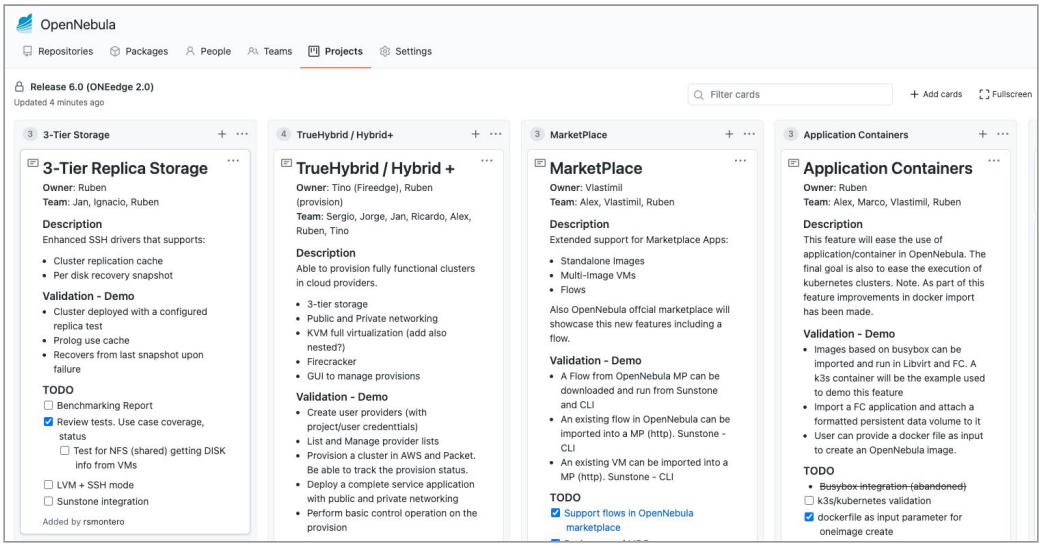
- A description of feedback (Section 2) collected during the Second Innovation Cycle (M10-M16) from early users of the first software version released in M9 after the end of the First Innovation Cycle (M4-M9). This feedback has generated new requirements (Section 2.1) and extensions to existing requirements (Section 2.2) for the Second and the Third Innovation Cycles.

- An up-to-date overview (Section 3) of the readiness and maturity level of each component of the ONEedge architecture in M16 at the end of the Second Innovation Cycle (M10-M16).
- A description of the software requirements (Section 4) that have been addressed as part of the project's Second Innovation Cycle (M10-M16) in order to achieve the second milestone of the project and those in progress, including a description of the pending tasks for completion.
- A brief review (Section 5) of the priorities for the Third Innovation Cycle (M17-M23) in order to achieve the third milestone of the project. This report ends with a conclusion section.

More details about the features developed are provided in report D3.5 "Software Source", with the specifications and design of the new components being described in detail in document D3.2 "Software Report". The testing process and certification infrastructure are described in D4.2 "Infrastructure Report". The use cases demonstrating the new features developed in the First Innovation Cycle are described in D4.5 "Deployment of Validation Cases and Demonstrations".

In order to implement an Agile approach, ONEedge uses GitHub Projects to track GitHub Issues, Pull Requests, and Notes. It provides a kanban-style board for managing work, and coordinating across separate code repositories. All the tasks for the internal development sprints are listed in one place by using an extension of what developers are already used to: GitHub Issues and Pull Requests that can be grouped in Milestones.





2. Overall Development Status

This section provides an overview of the readiness and maturity level of each component of the ONEedge architecture at the end of the Second Innovation Cycle. The table below shows the status of each software requirement following a simple color code: ✔ for completed activities and ⏱ for activities in progress. Please, note that:

- Section 8 "Software Requirements" of report D2.1 "Solution Framework" identifies the software requirements and lists the general tasks associated with each of the main components of the ONEedge architecture. Following an Agile approach, the specific tasks involved in the implementation of each of the software requirements are re-evaluated at the beginning of each Innovation Cycle.
- Section 4 of this document describes the tasks completed in the Second Innovation Cycle (M10-M16) and those in progress, including a description of the pending tasks for completion.
- The new software components corresponding to completed and in progress software requirements are described in report D3.5 "Software Source", with the specifications and design of the new components being described in detail in document D3.2 "Software Report". The testing process and certification infrastructure are described in D4.2 "Infrastructure Report". The use cases demonstrating the new features developed in the First Innovation Cycle are described in D4.5 "Deployment of Validation Cases and Demonstrations".

Software Requirements	IC1	IC2	IC3
Edge Instance Manager (CPNT1)			
SR1.1. Simple Product Deployment		⏱	
SR1.2. Automatic Product Upgrade	⏱	⏱	
SR1.3. Instance Management		⏱	
SR1.4. Subscription Management			
SR1.5. Web Control Interface (GUI)			
Edge Workload Orchestration and Management (CPNT2)			
SR2.1. Integration with Serverless Hypervisor	✔		
SR2.2. Specialized Cache Datastore		✔	
SR2.3. Secure and Scalable Distributed Monitoring	✔		
SR2.4. Virtual Machine Management Operations: Backups		⏱	
SR2.5. Integration with Remote VMware vCenter Service	✔		
SR2.6. VNF Support	✔		
~~SR2.7. Support for Flows in Marketplace~~ **[Redundant → SR5.1]**			
SR2.8. Complete Service Flows	⏱	✔	

SR2.9. Web UI extensions	⏱	✔
SR2.10. LXC virtualization drivers for OpenNebula **[NEW]**		✔
Edge Provider Selection (CPNT3)		
SR3.1. Edge Provider Catalog Service		⏱
SR3.2. Edge Resource Latency Calculator Filter		
SR3.3. Edge Resource Cost Calculator Filter		
SR3.4. Driver Maintenance Process	⏱	⏱
SR3.5. Edge Catalog Web Interface		✔
Edge Infrastructure Provision and Deployment (CPNT4)		
SR4.1. Reliable Edge Resource Provision	⏱	✔
SR4.2. Usability, Functionality and Scalability of Provision	⏱	⏱
SR4.3. Provision Template for Reference Architectures	⏱	✔
SR4.4. Inter-edge Networking Deployment Scenario		
SR4.5. Drivers for Host Provision		⏱
SR4.6. Drivers for IP Address Management		✔
SR4.7. Drivers for Network Drivers and Helpers		✔
SR4.8. GUI for Edge Resource Provision		✔
Edge Apps Marketplace (CPNT5)		
SR5.1. Edge Applications and Services in Marketplace		✔
SR5.2. Built-in Management of Application Containers Engine	⏱	⏱
SR5.3. Integration with Application Containers Marketplace	⏱	✔
SR5.4. New Edge Applications Marketplace Entries	✔	
SR5.5. Edge Market GUI Developments		⏱

3. Feedback and Software Requirements Revision

As expected, the public release of the first version of software components produced during the First Innovation Cycle, and its use in testing environments by some early OpenNebula users, has generated valuable feedback from the Community. This feedback has either been incorporated straightaway into the development of the Second Innovation Cycle, or is scheduled to be addressed during the Third Innovation Cycle. This section summarizes the main contributions organized by Software Requirements:

SR	Description	Cycle
SR2.10	[NEW] System containers based on LXC to avoid lock-in in edge clusters on virtualized resources	2
SR4.5	Support Google Cloud for resource provisioning	3
SR4.5	Improve integration with AWS Wavelength for 5G applications	3
SR4.5	Support DigitalOcean for resource provisioning	3
SR4.8	Use Guacamole remote SSH console to troubleshoot bare-metal remote provisioning	2
SR5.2	Automatic deployment of K3s clusters at edge resources	2
SR5.2	Integration with Rancher Fleet for application management	3
SR5.3	VM/Container image creation based on user-provided Dockerfiles	2

3.1. New Requirements

SR2.10. LXC virtualization drivers for OpenNebula

Feedback: One of the main demands from users have been the support of VMs for the deployment of the edge clusters. The reason of this request is two-fold:

- Broaden the range of providers that can be used with ONEedge. Bare metal instances are not offered by all providers, being able to also use virtualized hosts to execute ONEedge workloads will increase the applicability of the solution.
- Better price-performance ratio. Virtualized hosts are cheaper than their metal counterparts while offering enough performance for specific use cases and workloads, e.g. testing and development.

Description: Implement virtualization drivers that interact with the LXC system container engine.

- Full action operation set, including deploy, terminate, and resume options.
- Develop custom storage mappers for LXC.
- Integrate the drivers with container images and marketplaces.
- Adapt Sunstone interface to LXC drivers.
- Add support for LXC to miniONE.

3.2. Extensions to Existing Requirements

SR4.5. Drivers for Host Provision

Feedback: A significant portion of the first users have declared their interest in using ONEedge with some providers not initially supported by the product. In particular, we have received requests to support Google Cloud Platform (GCP), DigitalOcean or even specific edge services like AWS Wavelength.

Description: Improvements to host provision drivers and their interface.

- Improve logging and progress reporting from drivers.
- Extend types of operations with hosts (e.g. disk attach/detach).

Extension: Implement

- Support Google Cloud for resource provisioning
- Support DigitalOcean for resource provisioning
- Improve integration with AWS Wavelength for 5G applications

SR4.8. GUI for Edge Resource Provision

Feedback: Troubleshooting the correct deployment of the edge platforms and their inclusion in the existing edge cloud sometimes require a hands on debug session. For these cases, an SSH session is the preferred method for system administrators. We've extended the requirements of the GUI for Edge Resource Provision to include this functionality, served through the Apache Guacamole gateway.

Description: Integration within FireEdge GUI.

- New OneProvvision GUI extension.
- Update OpenNebula host interface for state control operations (power-off/on).
- Asynchronous background jobs runner.

Extensions: Add SSH capabilities for

- Use Guacamole remote SSH console to troubleshoot bare metal remote provisioning.
- Implement credential management to enable SSH sessions.

SR5.2. Built-in Management of Application Containers Engine

Feedback: Full fledged Kubernetes clusters can be too expensive to run on the edge. While some use cases may require it, we have realized during the execution of the project so far that most use cases can be met with lightweight distributions like K3s,[2] the Rancher Labs CNCF-compliant implementation of Kubernetes. The advantages of K3s is a much lower footprint, as well as ease of installation and update due to its single binary approach.

Description: Built-in management of Kubernetes clusters.

- Kubernetes managed controller functionality with automatic upgrades and credential provisioning.

[2] https://k3s.io/

- Implement easy worker node addition/subtraction to the Kubernetes cluster, based optionally on elasticity rules.

Extension: Built-in management of K3s clusters.
- Automatic deployment of K3s clusters at edge resources.
- Integration with Rancher Fleet for application management.

SR5.3. Integration with Application Containers Marketplace

Feedback: Developers are used to create and distribute container images based on a *lingua franca* description based on the DockerFile language. Users have highlighted the convenience of creating images in ONEedge using DockerFile descriptions. This will ease the integration of ONEedge with their current workflows and will speed up significantly content distribution to edge deployments.

Description: End users should be able to easily submit Kubernetes apps from popular marketplaces.
- Develop application container marketplace proxying to helm charts official marketplace.
- Integrate Kubernetes controller management in the ONEedge GUI (new Sunstone tab).
- Application Container management in OpenNebula.

Extensions: Add support for DockerFile image creation
- Include DockerFile support for image creation in Image based Datastores drivers
- Extend the CLI common one image to use/edit dockerfiles
- Extend Sunstone image dialog to accept dockerfiles

3.3. Redundant/Merged Requirements

SR2.7. Support for Flows in Marketplace

This software requirement has been made redundant by SR5.1

SR4.6. Drivers for IP Address Management
SR4.7. Drivers for Network Drivers and Helpers

The SR4.6 functionality has been superseded by SR4.7

4. Work Done in Second Innovation Cycle (M10-M16)

During the Second Innovation Cycle (M10-M16), the project mostly focused on those software requirements needed to achieve our second milestone in M16, which is the base functionality needed for a multi-host edge deployment.

Period	Summary	Main Results
M10-M16	Second release and commercialization plan as OpenNebula extension	• Solution meets the needs of multi-host edge deployments • Solution is distributed as an extension to OpenNebula • Solution can be demonstrated in an operational environment • At least 15 users

The work carried out during this Second Innovation Cycle has involved the software requirements of components CPNT1, CPNT2, CPNT3, CPNT4 and CPNT5, with a special focus on the edge instance management (CPNT1) and the deployment and provision of edge infrastructures (CPNT4). Some of these new features include:

- First version of OpenNebula deployment architecture based on application containers that will vastly simplify the deployment process of ONEedge.
- First approach for automatic upgrade and rollback of ONEedge instances within the containerized installation.
- First approach for monitoring and control of ONEedge instances through OpenNebula health check reporting about state and automatic recovering actions.
- New 3-tier replica storage datastore for edge clusters with replica hosts to cache disk images, speed up image transfer to the hypervisors, and perform periodic snapshots for VM disk recovery in case of failure.
- First version of backup system for VM disks that implements user-defined basic backup policies and supports multiple datastore backends.
- New version of OneFlow engine with enhanced functionality, reliability and scalability for execution of multi-VM services at edge locations.
- Improvements in Graphical User Interface to expose new functionality.
- First version of Edge Provider Catalog Service as part of the new edge provisioning interface and certification of a reduced number of facilities, instance types and operating systems.
- Definition of first version of tests to certify the provider drivers for AWS and Packet/Equinix that will be the basis of the DDK for the certification framework.
- Edge Catalog Web interface as part of new Graphical User Interface, Provision FireEdge, to fully deploy and manage provisions on the edge and automatically enroll them in an edge cloud.
- Provision tools redesigned to use Terraform to interact with the remote edge providers.
- Provision tools refactored to use cloud database and multi-tenancy, and incorporate virtualized resources.
- Development of provision templates to implement ONEedge reference infrastructure with specific roles to set up host resources, datastore and virtual networks.
- Development of new drivers for host provision based on Terraform that include logging and progress reporting.

- Development of new drivers for IP address management in AWS and Packet/Equinix clouds that allow a more secure and transparent VM network access.
- Development of new drivers for networking to provide private networking based on VXLAN and EVPN BGP extensions.
- New Graphical User Interface, Provision FireEdge, for Edge resource Provision.
- Support for OneFlow templates and importing of multiple images in the Marketplace to allow the easy deployment of multi-VM services on edge resources.
- New Kubernetes appliance images and templates in the Marketplace to deploy elastic Kubernetes clusters on edge resources in one click.
- Enhanced integration with Docker Hub allowing ONEedge to orchestrate containers on virtual machines without requiring Kubernetes so improving efficiency, simplicity, security and isolation.
- First prototype of a self-service portal to deploy and manage applications on top of an ONEedge based on FireEdge backend.

These features have been developed in a coordinated way between WP3 and WP4. The new software components and extensions to meet the software requirements have been specified and developed within the work package WP3, and the new functionality has been tested, verified and demonstrated within WP4. Some of the software requirements involved the development of appliances and the automation of infrastructure deployment and configuration are performed as well as part of WP4.

A new software version (OpenNebula 6.0 “Mutara”)[3] was released as Beta on March 1, 2021, with the components described in D3.5 “Software Source”. The specifications and design of the new components are described in detail in document D3.2 “Software Report”.

We have also worked heavily in the infrastructure and in the development of use cases. The testing process and certification infrastructure are described in D4.2 “Infrastructure Report”. The use cases demonstrating the new features developed in the First Innovation Cycle are described in D4.5 “Deployment of Validation Cases and Demonstrations”.

The following section summarizes the work that has been done as part of the Second Innovation Cycle, including the completed tasks associated with each component and its software requirements, as well as the current statue of those SRs.

4.1. Edge Instance Manager (CPNT1)

SR1.1. Simple Product Deployment
Status: IN PROGRESS
Completed Tasks: New type of edge stack deployment architecture based on application containers, which vastly simplifies the deployment process. All required dependencies are bundled within a distributed all-in-one container image and internally dynamically (re)configured to work together on instantiation.

[3] https://opennebula.io/opennebula-6-0-mutara-beta-is-out/

Pending Tasks: Deployment of HA-ready OneFlow services (avoid the need to stop them in some scenarios, VIP) and cross-deployment remote connections to custom SSH ports.

SR1.2. Automatic Product Upgrade

Status: IN PROGRESS

Completed Tasks: Upgrade of edge stack and its dependencies is simplified and reduced only to the change of newer container image (introduced in SR1.1) the software runs from. On instantiation, the bootstrap mechanism inside the image ensures the parts which need upgrade (e.g., database) are upgraded automatically or rolled back on failure.

Pending Tasks: Upgrades automation for deployments created by mechanism/tools from SR1.1.

SR1.3. Instance Management

Status: IN PROGRESS

Completed Tasks: Containerized edge stack deployment provides a new way to control the managed services including a (health check) reporting about the state to the management tools. On error conditions, the automatic recovery actions are triggered. Base deployment is customized via a set of environment parameters. Individual OneFlow services can be configured by a newly developed (onecfg patch) mechanism to update any relevant configuration by the end-user in a unified way.

Pending Tasks: Include observability - see deployment status - and control service states.

4.2. Edge Workload Orchestration and Management (CPNT2)

SR2.2. Specialized Cache Datastore

Status: DONE

Completed Tasks: SSH drivers have been extended to include cache replication nodes per cluster. A cluster can have multiple replica nodes to cache disk images and speed up image transfer to the hypervisors. In order to improve the reliability of the edge clusters the replica-cache datastore also performs periodic snapshots of VM disks. In case of failure, VMs are able to restart from the last available snapshot in the cache. Cache management, distribution and housekeeping have been implemented in an automatic way. Images use a lazy distribution algorithm to copy disk images to cluster location when needed. No API extensions were needed to be added to interact with the cache.

SR2.4. Virtual Machine Management Operations: Backups

Status: IN PROGRESS

Completed Tasks: Users are able to define backup policies per VM disks. A backup policy is defined in a simple way and it includes a frequency (e.g. every 2 days), and a retention policy (e.g. keep the last 3 backups). Backups are copied to special datastore locations using the marketplace subsystem in OpenNebula, which allows for HTTP over filesystem and S3 backends. Restore procedure also provided.

Pending Tasks: Ability to define frequency and retention policy of backups.

~~SR2.7. Support for Flows in Marketplace~~ [REDUNDANT → SR5.1]

Status: See SR5.1 below

Completed Tasks: See SR5.1 below

SR2.8. Complete Service Flows

Status: DONE

Completed Tasks: OneFlow internal engine has been rewritten from scratch to improve its capabilities and functionality:

- Make use of event message bus to trigger scalability and state changes
- Improved concurrency of OneFlow operations.
- Reduce the number of OpenNebula API calls.
- VM and OneFlow state reconciliation, to implement recovery and re-initialization processes.
- Integration of Virtual Network management associated to a OneFlow
- Add update operations for scalability rules.

SR2.9. Web UI extensions

Status: DONE

Completed Tasks: Graphical User Interface has been extended to accommodate the features developed for 6.0, including:

- Re-designed OneFlow interface.
- Extended Host tab.
- Extended Virtual Machine tab.

SR2.10. LXC virtualization drivers for OpenNebula [NEW]

Completed Tasks: Implementation of the virtualization drivers that interact with the LXC system container engine:

- Full action operation set, including deploy, terminate, and resume options.

- Develop custom storage mappers for LXC.
- Integrate the drivers with container images and marketplaces.
- Adapt Sunstone interface to LXC drivers.
- Add support for LXC to miniONE.

4.3. Edge Provider Selection (CPNT3)

SR3.1. Edge Provider Catalog Service

Status: IN PROGRESS

Completed Tasks: As part of the Provisioning Interface, a static set of providers (expressed in yaml files) will be included. Packet and Amazon EC2 provider drivers are available with certified facilities, instance types and Operating Systems. These yaml files define the data model of the providers, which will be persistent in the following release into a DB and accessible through a backend implementing an API.

Pending Tasks: Define automatic driver install from public Edge Catalog or, alternatively, use the OpenNebula package to distribute the catalog as a fixed set of yaml files.

SR3.4 Driver Maintenance Process

Status: IN PROGRESS

Completed Tasks: A comprehensive set of tests to certify the provider drivers for AWS and Packet/Equinix are available. These tests will be the basis of the DDK local testing framework and a key component of the acceptance and certification process.

Pending Tasks: Generalize the certification tests, describe certification process , and improve integration guides.

SR3.5 Edge Catalog Web Interface

Status: DONE

Completed Tasks: New CPI component based on nodeJS/React. It will allow creation and management of providers based on a set of templates (from SR3.1). The CPI interface will feature a clean, non cluttered, on-point interface with the minimal feature set needed to fully deploy and manage provisions on the edge and automatically enroll them in the edge cloud.

4.4. Edge Infrastructure Provision and Deployment (CPNT4)

SR4.1. Reliable Edge Resource Provision

Status: DONE

Completed Tasks: OneProvision is now based on terraform drivers to interact with the underlying cloud infrastructures. Terraform state is used to track the provision state of Edge resources and perform clean-up and retry operations in a reliable way. All CI/CD tests have been updated to incorporate reliability use cases.

SR4.2. Usability, Functionality and Scalability of Provision

Status: IN PROGRESS

Completed Tasks: OneProvision has been rewritten from scratch to incorporate the requirements of ONEedge, in particular:

- Provision are first-class entities that are stored in the main OpenNebula state database.
- Provision incorporates same access control mechanisms as other OpenNebula objects
- A new provider entity has been added and decoupled from the provision.
- The provision template has been extended to incorporate virtualized resources
- All provision entities may refer to terraform description files to allocate cloud resources.

Pending Tasks: Develop Edge location update and better bootstrap of provisions.

SR4.3. Provision Template for Reference Architectures

Status: DONE

Completed Tasks: ONEedge includes ansible playbooks to implement the reference architecture that make use of the main features developed in SR2. It includes specific roles to set up host resources, datastore and virtual networks.

SR4.5. Drivers for Host Provision

Status: IN PROGRESS

Completed Tasks: The addition of the Terraform based drivers has improved the logging and progress reporting to the user by leveraging terraform features.

Pending Tasks: Add additional providers and produce a document and technical guide to include new providers.

SR4.6. Drivers for IP Address Management

Status: DONE

Completed Tasks: As part of SR4.7 IPAM drivers have been rewritten for Packet and AWS clouds. The IPAM drivers and the internal hypervisor network implementation has been redesigned to allow a more secure and transparent VM network access. Network address

translation NAT is no longer needed in the new version. As a result SR4.6 functionality has been superseded by SR4.7

SR4.7. Drivers for Network Drivers and Helpers

Status: DONE

Completed Tasks: A new set of drivers have been developed to ease the integration across cloud providers. It includes new IPAM drivers for Amazon AWS. Additionally a generic method to provide private networking based on VXLAN and EVPN BGP extensions is now in place. This private network mechanism is generic and works in different providers.

SR4.8. GUI for Edge Resource Provision

Status: DONE

Completed Tasks: New CPI component based on nodeJS/React. It will allow creation and management of provisions based on a set of templates (from SR4.3).

4.5. Edge Apps Marketplace (CPNT5)

SR5.1. Edge Applications and Services in Marketplace

Status: DONE

Completed Tasks: The set of marketplace drivers, as well as the market* CLI commands and Sunstone marketplace tabs, allow registering and importing VMs with multiple images and full OneFlow Templates (multi-VM services). Hence, the time to deploy a fully featured service on a scratch OpenNebula installation is greatly reduced.

SR5.2. Built-in Management of Application Containers Engine

Status: IN PROGRESS

Completed Tasks: The Kubernetes marketplace appliance can be used on a OneFlow service to deploy an elastic Kubernetes cluster. The appliance is parametrized through the contextualization process. At a later version, this contextualization process for the K8s appliance will be integrated into the Graphical Interfaces.

Pending Tasks: Define elasticity rules to react to Kubernetes load.

SR5.3. Integration with Application Containers Marketplace

Status: DONE

Completed Tasks: DockerHub integration has been enhanced in the second innovation cycle, allowing the deployment of Docker images available in Docker hub. This has been implemented without Kubernetes as the orchestrator, but rather with OpenNebula managing the docker apps as firecracker/KVM or qemu/KVM virtual machines, offering the isolation and security capabilities of virtualization.

SR5.5. Edge Market GUI Developments

Status: IN PROGRESS

Completed Tasks: A technology preview of FireEdge, a self service portal to deploy and manage applications on top of an OpenNebula cloud, will be included. It won't be ready for production but it will showcase: ability to create a full application (using a graph interface) based on VM Templates and containers (which can be mixed) and deploy it on-prem or over a provision created with the CPI.

Pending Tasks: Include support for Docker files, additional VM operations: lifecycle, console access, snapshots, and ability to manage individual VMs.

5. Priorities for Third Innovation Cycle (M17-M23)

During the Third Innovation Cycle, the project will focus on those software requirements needed to achieve our third milestone in M23, which is the functionality required to meet the needs of a standalone ONEedge platform service.

Period	Summary	Main Results
M17-M23	Release as standalone distribution	• Solution meets networking & storage integration • Solution is distributed as a standalone distribution • Solution can be demonstrated in an operational environment • At least 20 users

While the First Innovation Cycle developed mainly the technological foundation of ONEedge (CPNT2), the Second Innovation Cycle has focused on developing the necessary features for edge instance management (CPNT1) and deployment and provision of edge infrastructures (CPNT4). Thanks to this effort, the new software version is the first integrated solution that brings simplicity and automation to build true hybrid and edge cloud environments. The software provides unified management of IT infrastructure and applications that avoids vendor lock-in, reduces complexity, resource consumption and operational costs, while providing a simple solutions for users to manage:

- **Any Application:** Combine containerized applications from Kubernetes and Docker Hub ecosystems with virtual machine workloads in a common shared environment to offer the best of both worlds: mature virtualization technology and orchestration of application containers.
- **Any Infrastructure:** Unlock the power of a true hybrid, edge and multi-cloud platform by combining private cloud with infrastructure resources from third-party virtual and bare-metal cloud providers such as AWS, Microsoft Azure and Packet (Equinix Metal).
- **Any Time:** Add and remove automatically new clusters in order to meet peaks in demand, or to implement fault tolerant strategies or latency requirements.

This is essential to deliver the ONEedge product and its commercialization. **We expect more valuable feedback from users now that the new ONEedge features can be easily installed and used as part of the recently-released OpenNebula 6.0 "Mutara".**

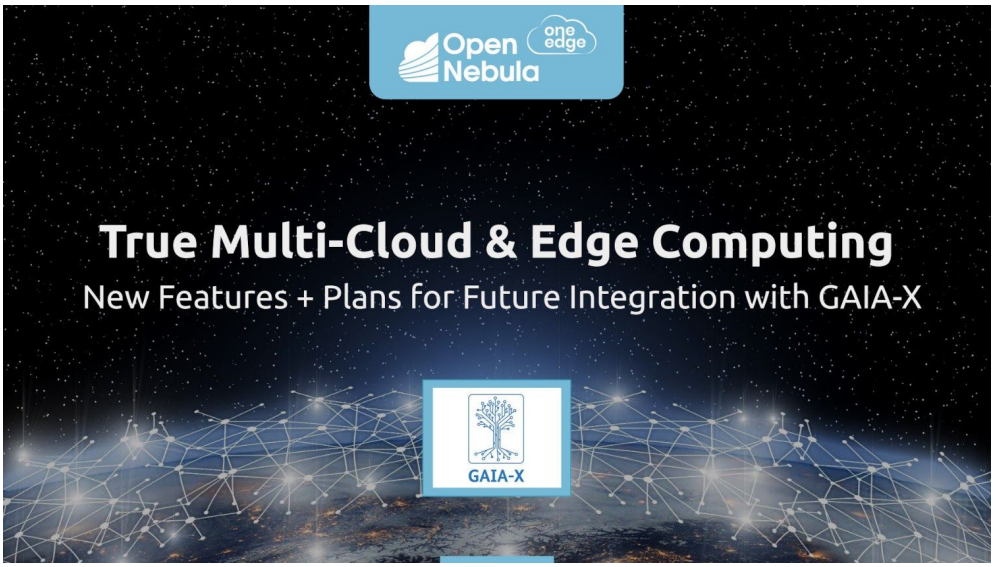
As part of the Second Innovation Cycle, as outlined in D2.2 Solution Framework, we have been working with the members of our **Edge Computing User Group**. The objective of this platform is to share new developments and ideas and to get feedback from those OpenNebula corporate users interested in contributing to build robust Edge Computing capabilities into the new versions of OpenNebula. The members of the Edge Computing User Group are providing us with informal feedback and helping us identify possible synergies and collaborations with other industry actors.

As announced in late November 2020, OpenNebula Systems has joined the GAIA-X project as a Day-1 Member of the **GAIA-X AISBL**,[4] the international non-profit association that is going to provide a formal structure to this initiative, coordinating the efforts of the GAIA-X Community,

[4] https://opennebula.io/opennebula-joins-gaia-x/

promoting international cooperation, and developing the necessary regulatory frameworks and rules to ensure the interoperability and reliability of the providers, services and data sources made available through GAIA-X. This announcement took place during the GAIA-X Summit (Nov 18-19, 2020), an event that marked an important milestone for the project. As a result of our participation in the GAIA-X project we are reviewing the application of our technology to real business cases and gathering updated feedback from industry.

Despite the slight delay in producing OpenNebula 6.0, we are planning to carry out a number of presentations and live demonstrations within the context of GAIA-X. The first of those events has already taken place in late February and in this occasion we have presented the ONEedge project and the new features in OpenNebula 6.0 to the GAIA-X Minimum Viable Product (MVP) Working Group, including an outline of our plans for future integration with GAIA-X edge resource. Given that this Community group is leading the development of the pilot implementations of GAIA-X and its different components (i.e. Federated Catalog), this event is already providing us extremely useful feedback and orientation for us to ensure a smooth integration with GAIA-X in the future and to help us position ONEedge as the most advanced European open source framework for Edge Computing.



In October 2020, OpenNebula Systems joined the **Linux Foundation** and the **Cloud Native Computing Foundation** (CNCF)[5] as a way to promote ONEedge and establish new collaborations and channels for feedback from the open source community and relevant vendors and end-users interested in containers technologies and Edge Computing: "We are delighted to welcome OpenNebula to CNCF as a new Silver Member, and look forward to their contributions towards enabling better support for Kubernetes deployments at the edge," said Priyanka Sharma, General Manager of CNCF.

One of our first actions as new members of the CNCF has been to contribute to the CNCF Webinar Series with an on-demand webinar (publication scheduled for focused on ONEedge and showcasing how to deploy Kubernetes clusters based on K3s at the edge using OpenNebula's new Edge Computing features.[6]

[5] https://opennebula.io/opennebula-joins-cncf/
[6] https://community.cncf.io/events/details/cncf-cncf-online-programs-presents-cncf-on-demand-webinar-deploying-k3s-at-the-edge-for-multiplayer-gaming/

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OpenNebula joins Cloud Native Computing Foundation (CNCF) as Silver Member

November 16, 2020 07:45 AM Eastern Standard Time

MADRID--(BUSINESS WIRE)--With the release in June of version 5.12 "Firework", OpenNebula went a step further to offer a pioneering approach that merges the strengths of an open source Cloud Management Platform with the many benefits of container technologies. Now, by joining the Cloud Native Computing Foundation (CNCF), OpenNebula confirms its commitment to support the deployment and management of containerized applications and Kubernetes clusters, both on premises and through its support for hybrid and edge cloud computing.

"We are delighted to welcome OpenNebula to CNCF as a new Silver Member, and look forward to their contributions towards enabling better support for Kubernetes deployments at the edge"

Thanks to its cutting-edge integration with Firecracker, the new virtualization technology developed by Amazon Web Services (AWS) and widely used as part of its Fargate and Lambda services, OpenNebula has managed to bridge the gap between two technological worlds, leaving behind the traditional dilemma between using containers—lighter but with weaker security—or Virtual Machines—with strong security but high overhead.

In mid-November 2020, OpenNebula Systems also joined **LF Edge**. LF Edge, launched by the Linux Foundation in January 2019, is a new umbrella organization that aims to establish open, interoperable frameworks for edge computing independent of hardware, silicon, cloud, or operating system. With its focus on open source and Edge Computing, LF Edge is the perfect platform for us to both promote ONEedge and obtain valuable feedback from relevant vendors and end-users: "***We are delighted to join the LF Edge community as part of our ONEedge initiative***", said Constantino Vazquez, Chief Operations Officer, OpenNebula. "OpenNebula, which has traditionally been used for Private Clouds, has now become a True Hybrid Cloud platform with a number of powerful features for making deployments at the edge much easier for organizations that want to rely on open source technologies and retain the freedom of being able to use on-demand the providers, locations and resources that they really need."

AP

PRESS RELEASE: Paid content from PR Newswire

LF Edge Ecosystem Grows, Adds New Members and New Cross-Community Integrations

January 14, 2021

LF EDGE

Press release content from PR Newswire. The AP news staff was not involved in its creation.

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SAN FRANCISCO, Jan. 14, 2021 /PRNewswire/ -- LF Edge, an umbrella organization within the Linux Foundation that aims to establish an open, interoperable framework for edge computing independent of hardware, silicon, cloud, or operating system, today announced continued ecosystem momentum with the addition of four new general members (FII, HCL, OpenNebula, and Robin.io) and one new Associate member (Shanghai Open Source Information Technology Association). Additionally, Home Edge has released its third platform update with new Data Storage and Mult-NAT Edge Device Communications (MNDEC) features.

On the other hand, and according to our experience, the future of open source, from the perspective of business, is running a cloud. This is, making the software valuable through a

cloud service. **The main ONEedge commercial product will not be the ONEedge open source software itself but an on-demand Edge Cloud Platform service**, built on top of the ONEedge extensions to OpenNebula and fully managed by OpenNebula Systems, through which companies will be able to easily build their distributed edge environments, using resources from existing edge, telco and cloud providers.

The plan is to have this independent standalone commercial product available at the end of the third innovation cycle (M23). Consequently during the Third Innovation Cycle, we will concentrate on the component for edge provider selection (CPNT3) and the completion and integration of all components to release a first version of the On-demand Edge Cloud Platform service. Moreover, during the Third Innovation Cycle and during the Final Phase, we will be developing campaigns that are specific only to the ONEedge commercial solution and not to be incorporated into OpenNebula. These include tools needed for deployment, 24/7 health monitoring, alerting, troubleshooting and upgrades.

6. Conclusions and Next Steps

The initial version of the Solution Framework Report (Deliverable D2.1), released in M3 after the initial framework definition phase, describes the use cases that are guiding the development of the project, identifies the main user requirements derived from these use cases, and defines the architecture of the ONEedge management platform. From the user requirements, we have extracted the list of software requirements and functional gaps that are being implemented as part of the development of the several components of the ONEedge management platform, and the methods and scenarios that are being used to verify their fulfillment. This incremental report (Deliverable D2.3) provides a description of the software requirements that have been addressed as part of the Second Innovation Cycle (M10-M16), as well as a brief review of the priorities for the Third Innovation Cycle (M17-M23).

The new software components and extensions that are being implemented in order to meet the software requirements are specified and developed within the work package WP3, with the new functionality being tested, verified and demonstrated within WP4. Some of the software requirements involve the development of appliances and the automation of infrastructure deployment and configuration that will be performed as well as part of WP4.

This is the second incremental version of the Solution Framework Report, which will be followed at the end of the next innovation cycle by an additional release providing an analysis of fulfillment of verification tests and scenarios in the cycle and improvements in the architecture and its components, if needed.