ONEedge.io

A Software-defined Edge Computing Solution

D2.2. Solution Framework - b

Solution Framework Incremental Report

Version 1.1

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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 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 First Innovation Cycle (M4-M9). 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 Second Innovation Cycle (M10-M15) as part of our plans to meet the project's milestones.

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Document History

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1.0	31/7/2020	Submitted	First final version of the D2.2 report
1.1	14/1/2021	Submitted	Clarify main aim of this report and remove contents available in D2.1 in order to meet the recommendations of the reviewer

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

Executive Summary

Document D2.2, released in M9 at the end of the First Innovation Cycle, is the first 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 First Innovation Cycle (M4-M9), as well as a brief review of the priorities for the Second Innovation Cycle (M10-M15).

During the First Innovation Cycle (M4-M9), the project mostly focused on those software requirements needed to achieve our first milestone in M9, which is the base functionality needed for a single-host edge deployment. The work carried out during this First Innovation Cycle involved software requirements from components CPNT1, CPNT2, CPNT3, CPNT4 and CPNT5, with a special focus on laying the technological foundation of ONEedge as an extension built upon OpenNebula. These are some of the main new features that have been implemented as part of this process:

- Development of a new tool to achieve fully automatic EdgeNebula upgrades.
- A new driver to interact with Firecracker VMM.
- Redesign and implementation of a new monitoring system.
- Improvement of the network interface with VMware services.
- Extended functionality for NUMA support.
- OneFlow being re-written to improve scalability and response time.
- Improvement of the Graphical User Interface (Sunstone).
- Improvement of the Amazon EC2 and Packet drivers.
- Several extensions of the Infrastructure Provision and Deployment tools.
- Better support for deploying a Kubernetes cluster.
- New integration with the Docker Hub marketplace.
- New version of the Kubernetes appliance.

These new features are described in report D3.4 “Software Source”, with the specifications and design of the new components being described in detail in document D3.1 “Software Report”. The testing process and certification infrastructure are described in D4.1 “Infrastructure Report”. The use cases demonstrating the new features developed in the First Innovation Cycle are described in D4.4 “Deployment of Validation Cases and Demonstrations”.

The present incremental report (Deliverable D2.2) includes a section with the priorities for the Second Innovation Cycle (M10-M15).

This Deliverable has been released at the end of the First Innovation Cycle (M4-M9), and will be followed by additional incremental reports to be produced by the end of each of the remaining business and product innovation cycles (M15, M21).

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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, M15 and M21 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 (D2.2) of the Solution Framework Report is to provide an updated report of the agile methodology at the end of the First Innovation Cycle (M4-M9). This document offers details about the fulfillment of the software requirements and about the completed features for the main architectural components, and the prioritization of features for the Second Innovation Cycle (M10-M15) as part of our plans to meet the project's milestones. These new features are described in report D3.4 "Software Source", with the specifications and design of the new components being described in detail in document D3.1 "Software Report". The testing process and certification infrastructure are described in D4.1 "Infrastructure Report". The use cases demonstrating the new features developed in the First Innovation Cycle are described in D4.4 "Deployment of Validation Cases and Demonstrations".

Section 2 in this document describes the software requirements that have been addressed during the First Innovation Cycle (M4-M9) in order to achieve the first milestone of the project. Section 3 briefly describes the priorities for the Second Innovation Cycle (M10-M15) in order to achieve the second milestone of the project. This report ends with a conclusion section.

2. Work Done in First Innovation Cycle (M4-M9)

During the First Innovation Cycle (M4-M9), the project mostly focused on those software requirements needed to achieve our first milestone in M9, which is the base functionality needed for a single-host edge deployment. No feedback from early users and partners has been included here mainly due to the fact that Deliverable D2.2 has been submitted immediately after the release of the first software version.

Period	Summary	Main Results
M1-M9	First release and commercialization plan as OpenNebula extension	• Solution meets the needs of single-host edge deployments • Solution is distributed as an extension to OpenNebula • Solution can be demonstrated in an operational environment • At least 5 users

The work carried out during this First Innovation Cycle has involved the software requirements of components CPNT1, CPNT2, CPNT3, CPNT4 and CPNT5, with a special focus on laying the technological foundation of ONEedge. Some of these new features include:

- To be able to achieve the fully automatic EdgeNebula upgrades, a mechanism has been implemented to allow automatic upgrades of configuration files to the new versions. New configuration upgrade mechanism is provided via a new dedicated CLI tool `onecfg` and is part of EdgeScape.
- A new driver to interact with Firecracker VMM has been implemented. This allows ONEedge to support light VMs called microVMs.
- The monitoring system was redesigned to enable better scalability and to reduce the CLI response times under heavy load.
- The capabilities of ONEedge to interface with VMware services has been improved to extend its networking capabilities. The new drivers can define virtual networks and security groups leveraging the VMware native capabilities (NSX-t & NSX-v).
- Fine grain NUMA placement is needed to optimize the performance of some VM workloads, especially VNFs. We have extended the functionality of OpenNebula to control how VM resources are mapped onto the hypervisor ones.
- OneFlow core has been re-written to improve scalability and response time.
- Improvement of the Graphical User Interface (Sunstone).
- Improvement of the Amazon EC2 and Packet drivers.
- Provisioning tools have been improved for better resilience to the errors by multi-staged handling of error situations.
- Provisioning tools to deploy virtualization clusters in the Edge data centers have been extended to create more complete deployments in the EdgeNebula with new entities for end users.
- Provision templates have been extended with examples of complete deployment specifications of fully usable clusters.

- Better support for deploying a Kubernetes cluster.
- New integration with the Docker Hub marketplace. This integration allows to easily import these Docker Hub images into an OpenNebula cloud.
- Kubernetes appliance in the OpenNebula marketplace has been updated (including minor enhancements) to version 1.18.3. The updated appliance can add more nodes to the cluster at any time using the OpenNebula contextualization process.

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 5.12 'Firework')[2] was publicly released on June 15, 2020 with the components described in D3.4 "Software Source". The specifications and design of the new components are described in detail in document D3.1 "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 D4.1 "Infrastructure Report". The use cases demonstrating the new features developed in the First Innovation Cycle are described in D4.4 "Deployment of Validation Cases and Demonstrations".

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

2.1. Edge Instance Manager (CPNT1)

SR1.2. Automatic Product Upgrade
Status: IN PROGRESS
Completed Tasks: Mechanism for automated upgrade of configurations of EdgeStack components was implemented (tool `onecfg`) and released as part of EdgeScape (OneScape).

2.2. Edge Workload Orchestration and Management (CPNT2)

SR2.1. Integration with Serverless Hypervisor
Status: DONE
Completed Tasks: A new driver to interact with Firecracker VMM has been implemented. This allows ONEedge to support microVMs. The support is complete and includes basic operations (create, terminate, power-off, …) as well as a complete integration with the storage network stack (file based datastores) and network stack (linux bridge based drivers). Additional ONEedge features VNC support and contextualization support for Firecracker microVMs.

[2] https://opennebula.io/firework/

SR2.3. Secure and Scalable Distributed Monitoring
Status: DONE
Completed Tasks: A new monitoring architecture is now in place. The new monitor architecture follows a push approach where the nodes send information to the monitor front-end. It also features a modular probe system with multiple timeouts, and decouples the monitor workflow from the system. The result is a monitor system that scales better and supports high-latency and public network links.

SR2.5. Integration with Remote VMware vCenter Service
Status: DONE
Completed Tasks: The capabilities of ONEedge to interface with VMware services has been improved to extend its networking capabilities. The new drivers can define virtual networks and security groups leveraging the VMware native capabilities (NSX-t & NSX-v)

SR2.6. VNF Support
Status: DONE
Completed Tasks: ONEedge can allocate and schedule VMs with specific NUMA topologies. The drivers have been extended to define the virtual server topology including NUMA nodes, cores per node, and memory por node. Additionally, the monitor system includes specific probes to gather the host topology to optimize the placement of the virtual nodes. The scheduler of ONEedge now considers NUMA allocation status to place NUMA-enabled VMS. Finally, KVM drivers have been extended to support DPDK data-plane for Open vSwitch bridges.

SR2.8. Complete Service Flows
Status: IN PROGRESS
Completed Tasks: OneFlow core has been rewritten to improve its scalability. The current version uses an asynchronous update mechanism to update the VM status, thus greatly improving response times as well as the overall scalability of the Service management component. Also, Flow description has been extended to include the ability to co-allocate networks together with the service VM. The lifecycle of these networks is also managed by OneFlow.

SR2.9. Web UI extensions
Status: IN PROGRESS

Completed Tasks: The UI has been extended to include the new features developed in this cycle. In particular: OneFlow has been re-design to include a flexible network definition tab; Host and VM information now shows the NUMA topology and allocation status. Also a special view has been developed to include NSX information and usage.

2.3. Edge Provider Selection (CPNT3)

SR3.4 Driver Maintenance Process

Status: IN PROGRESS

Completed Tasks: The OpenNebula oneprovision component has been extended to allow for the management of remote edge clusters using bare metal offerings from Amazon EC2 and Packet. These drivers will lay the basis to build an acceptance and certification process as well as the needed testing framework and documentation.

2.4. Edge Infrastructure Provision and Deployment (CPNT4)

SR4.1. Reliable Edge Resource Provision

Status: IN PROGRESS

Completed Tasks: Provisioning tools were improved for better resilience to the errors by multi-staged handling of error situations (called as failover combinations). Prototype of background cleaner of orphaned deployments (running hosts without clear connection to the deployments in the inventory) is currently under testing and evaluation.

SR4.2. Usability, Functionality and Scalability of Provision

Status: IN PROGRESS

Completed Tasks: Provisioning tools were extended to create more complete deployments with new entities for end users. Such deployment can be created based on a combination of multiple descriptors within a single deployment process. Also, can contain entities created for direct use by end users (e.g. VM images and templates, multi-VM deployments descriptors).

SR4.3. Provision Template for Reference Architectures

Status: IN PROGRESS

Completed Tasks: Provision templates were extended with examples of complete deployment specifications of fully usable clusters. The example specifications can be used by experienced cloud administrators to easily create ready-to-use clusters with a single run of provisioning tools.

2.5. Edge Apps Marketplace (CPNT5)

SR5.2. Built-in Management of Application Containers Engine
Status: IN PROGRESS
Completed Tasks: The Kubernetes appliance allows for single master deployment within OpenNebula. It can also be deployed as a OneFlow service, which lays off the foundation for a elastic Kubernetes cluster using OneFlow elasticity rules.

SR5.3. Integration with Application Containers Marketplace
Status: IN PROGRESS
Completed Tasks: Leveraging the new firecracker support in OpenNebula, a new marketplace offering all the Docker Hub[3] applications have been added to OpenNebula 5.12. Any docker application can therefore be instantiated in an OpenNebula cloud, backed by a microVM in a fully transparent way.

SR5.4. New Edge Applications Marketplace Entries
Status: DONE
Completed Tasks: Kubernetes appliance in the OpenNebula marketplace has been updated (including minor enhancements) to version 1.18.3. The updated appliance can add more nodes to the cluster at any time using the OpenNebula contextualization process. This allows for the deployment of helm charts thanks to K8s. This coupled with the Docker Hub integration in SR5.3 renders this SR as fully met.

[3] https://hub.docker.com

3. Priorities for Second Innovation Cycle (M10-M15)

During the Second Innovation Cycle, the project will focus on those software requirements needed to achieve our second milestone in M15, which is the functionality required to meet the needs of a multi-host edge deployment.

Period	Summary	Main Results
M10-M15	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

As part of the Second Innovation Cycle, we will be consolidating the existing Edge Computing User Group. The main objective of this platform is to share new developments and ideas, getting feedback from our users, and collaborating closely on building robust Edge Computing capabilities into OpenNebula that respond to the changing demands that real users face as part of a fast-changing technological environment. The Edge Computing User Group is helping us to expand the collection of potential use cases that could benefit from reduced latency and flexible resource distribution, providing us with informal feedback and helping us identify possible synergies and collaborations with other industry actors.

As part of the process by which we are gathering updated feedback from industry and reviewing the application of our technology to real business cases, OpenNebula Systems joined the GAIA-X project back in March 2020. Led by the German and French governments, and on the basis of a large pan-european community of public and private stakeholders at national and European level, the GAIA-X initiative aims to achieve an open, federated, secure and trustworthy data and cloud infrastructure for Europe. The main objective of GAIA-X is to answer the needs of European industry in terms of digital sovereignty while promoting innovation and competitiveness. It is planning to do so by reducing technological dependencies and fostering competition among providers, thus enabling the stakeholders to exercise their sovereignty in data-driven business models and data ecosystems.

OpenNebula, as the only EU-based IaaS project in the GAIA-X community and driven by the many potential synergies between the ONEedge project and GAIA-X, is participating in several working groups within Workstream 2 ‘Technical implementation’ (i.e. Interconnection and Network, Federated Catalog, and Self-Description), which is concerned with providing the technical definition of the required reference architecture and to describe the basic technical functionalities of the data infrastructure. As a pioneering open source project in Europe, OpenNebula is contributing to GAIA-X with its expertise in distributed and federated cloud environments, hyperconverged cloud infrastructures, complex storage and virtual networking architectures, management and automation tools for large cloud deployments, and Edge Computing.

The First Innovation Cycle has been focused on laying the technological foundation of ONEedge. The main pillars needed in orchestration and management (CNPT 2) are almost done and basic functionalities have been made developed to enable application marketplaces at edge locations. The Second Innovation Cycle focus is two-folded. First, we want to prioritize the

deployment and provision of edge infrastructures (CPNT4). This is a key aspect for ONEedge and now we can build our vision on top of the features implemented as part of the First Innovation Cycle. The second software requirement we will concentrate on in the next cycle is Edge instance management (CPNT1). This component is essential to deliver the ONEedge product and its commercialization.

4. 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 D2.2) provides a description of the software requirements that have been addressed as part of the First Innovation Cycle (M4-M9), as well as a brief review of the priorities for the Second Innovation Cycle (M10-M15).

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