NIST Big Data Interoperability Framework

Volume 8: Reference Architecture Interfaces

Wo L Chang

Gregor von Laszewski

Editor

laszewski@gmail.com

https://github.com/cloudmesh/cloudmesh-nist

June 20, 2019 - 09:12 AM

Created by Cloudmesh & Cyberaide Bookmanager, https://github.com/cyberaide/bookmanager

NIST Big Data Interoperability Framework: Volume 8, Reference Architecture Interfaces

Editor: Gregor von Laszewski, Working Group co-Chair: Wo Chang

NIST Big Data Interoperability Framework: Volume 8, Reference Architecture Interfaces

NIST Big Data Interoperability Framework: Volume 8, Reference Architecture Interfaces

NIST Special Publication 1500-9

NIST Big Data Interoperability Framework: Volume 8, Reference Architecture Interfaces

NIST Big Data Public Working Group
Reference Architecture Subgroup

July 2019

This publication is available free of charge from:
https://doi.org/10.6028/NIST.SP.1500-9

National Institute of Standards and Technology
U.S. Department of Commerce

NIST Special Publication 1500-9

NIST Big Data Interoperability Framework: Volume 8, Reference Architecture Interfaces

NIST Big Data Public Working Group (NBD-PWG)
Definitions and Taxonomies Subgroup
Information Technology Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

This publication is available free of charge from:
https://doi.org/10.6028/NIST.SP.1500-9

July 2019

U.S. Department of Commerce
Wilbur L. Ross, Jr., Secretary

National Institute of Standards and Technology
Walter Copan, NIST Director and Undersecretary of Commerce for Standards and Technology

Abstract

This document summarizes interfaces that are instrumental for the interaction with Clouds, Containers, and High Performance Computing (HPC) systems to manage virtual clusters to support the NIST Big Data Reference Architecture (NBDRA). The REpresentational State Transfer (REST) paradigm is used to define these interfaces, allowing easy integration and adoption by a wide variety of frameworks.

Big Data is a term used to describe extensive datasets, primarily in the characteristics of volume, variety, velocity, and/or variability. While opportunities exist with Big Data, the data characteristics can overwhelm traditional technical approaches, and the growth of data is outpacing scientific and technological advances in data analytics. To advance progress in Big Data, the NIST Big Data Public Working Group (NBD-PWG) is working to develop consensus on important fundamental concepts related to Big Data. The results are reported in the ***NIST Big Data Interoperability Framework (NBDIF)*** series of volumes. This volume, Volume 8, uses the work performed by the NBD-PWG to identify objects instrumental for the NIST Big Data Reference Architecture (NBDRA) which is introduced in the NBDIF: Volume 6, ***Reference Architecture***.

Keywords

Adoption; barriers; implementation; interfaces; market maturity; organizational maturity; project maturity; system modernization.

Acknowledgements

This document reflects the contributions and discussions by the membership of the NBD-PWG, cochaired by Wo Chang (NIST ITL), Bob Marcus (ET-Strategies), and Chaitan Baru (San Diego Supercomputer Center; National Science Foundation). For all versions, the Subgroups were led by the following people: Nancy Grady (SAIC), Natasha Balac (SDSC), and Eugene Luster (R2AD) for the Definitions and Taxonomies Subgroup; Geoffrey Fox (Indiana University) and Tsegereda Beyene (Cisco Systems) for the Use Cases and Requirements Subgroup; Arnab Roy (Fujitsu), Mark Underwood (Krypton Brothers; Synchrony Financial), and Akhil Manchanda (GE) for the Security and Privacy Subgroup; David Boyd (InCadence Strategic Solutions), Orit Levin (Microsoft), Don Krapohl (Augmented Intelligence), and James Ketner (AT&T) for the Reference Architecture Subgroup; and Russell Reinsch (Center for Government Interoperability), David Boyd (InCadence Strategic Solutions), Carl Buffington (Vistronix), and Dan McClary (Oracle), for the Standards Roadmap Subgroup, Gregor von Laszewski (Indiana University) for the Interface Subgroup.

The following milestone releases exist:

- Version 2.1: A previous volume used the definitions of the schema based on examples only. It was easier to read but only included the definition of the resources and not the interaction with the resources. This volume was in place until June 2018.
- Version 2.2: This version was significantly changed and used OpenAPI 2.0 to

specify the interfaces between the various services and components.
- Version 3.1.1: The version includes significant improvements of the object specifications but are still using OpenAPI 2.0.
- Version 3.2.0: All specifications have been updated to OpenAPI 3.0.2. Significant updates have been done to a number of specifications.

The editors for these documents are:

- Gregor von Laszewski (Indiana University)
- Wo Chang (NIST).

Laurie Aldape (Energetics Incorporated) and Elizabeth Lennon (NIST) provided editorial assistance across all NBDIF volumes.

NIST SP 1500-9, Draft NIST Big Data Interoperability Framework: Volume 8, Reference Architecture Interfaces, Version 2 has been collaboratively authored by the NBD-PWG. As of the date of publication, there are over six hundred NBD-PWG participants from industry, academia, and government. Federal agency participants include the National Archives and Records Administration (NARA), National Aeronautics and Space Administration (NASA), National Science Foundation (NSF), and the U.S. Departments of Agriculture, Commerce, Defense, Energy, Census, Health and Human Services, Homeland Security, Transportation, Treasury, and Veterans Affairs.

NIST would like to acknowledge the specific contributions to this volume, during Version 1 and/or Version 2 activities. ***Contributors*** are members of the NIST Big Data Public Working Group who dedicated great effort to prepare and gave substantial time on a regular basis to research and development in support of this document. This includes the following NBD-PWG members:

- Gregor von Laszewski, Indiana University
- Wo Chang, National Institute of Standard and Technology,
- Fugang Wang, Indiana University
- Geoffrey C. Fox, Indiana University
- Shirish Joshi, Indiana University
- Badi Abdul-Wahid, formerly Indiana Univresity
- Alicia Zuniga-Alvarado, Consultant
- Robert C. Whetsel, DISA/NBIS
- Pratik Thakkar, Philips

Executive Summary

The ***NIST Big Data Interoperability Framework (NBDIF): Volume 8, Reference Architecture Interfaces*** document was prepared by the NIST Big Data Public Working Group (NBD-PWG) Reference Architecture Subgroup to identify interfaces in support of the NIST Big Data Reference Architecture (NBDRA). The interface define resources that are part of the

NBDRA. These resources are formulated in OpenAPI 3.0.2 format and can be easily integrated into a REpresentational State Transfer (REST) framework or an object-based framework.

The resources were categorized in groups that are identified by the NBDRA set forward in the ***NBDIF: Volume 6, Reference Architecture*** document. While the ***NBDIF: Volume 3, Use Cases and General Requirements*** document provides ***application***-oriented high-level use cases, the use cases defined in this document are subsets of them and focus on ***interface*** use cases. The interface use cases are not meant to be complete examples, but showcase why the resource has been defined. Hence, the interfaces use cases are only representative, and do not encompass the entire spectrum of Big Data usage. All the interfaces were openly discussed in the working group [1]. Additions to the interfaces are welcome and the NBD-PWG is open to discuss any contributions.

The ***NIST Big Data Interoperability Framework (NBDIF)*** was released in three versions, which correspond to the three stages of the NBD-PWG work. Version 3 (current version) of the NBDIF volumes resulted from Stage 3 work with major emphasis on the validation of the NBDRA Interfaces and content enhancement. Stage 3 work built upon the foundation created during Stage 2 and Stage 1. The current effort documented in this volume reflects concepts developed within the rapidly evolving field of Big Data. The three stages (in reverse order) aim to achieve the following with respect to the NIST Big Data Reference Architecture (NBDRA):

- Stage 1: Identify the high-level Big Data reference architecture key components, which are technology-, infrastructure-, and vendor-agnostic.
- Stage 2: Define general interfaces between the NBDRA components; and
- Stage 3: Validate the NBDRA by building Big Data general applications through the general interfaces;

The NBDIF consists of nine volumes, each of which addresses a specific key topic, resulting from the work of the NBD-PWG. The nine volumes are as follows:

- Volume 1, Definitions [2]
- Volume 2, Taxonomies [3]
- Volume 3, Use Cases and General Requirements [4]
- Volume 4, Security and Privacy [5]
- Volume 5, Architectures White Paper Survey [6]
- Volume 6, Reference Architecture [7]
- Volume 7, Standards Roadmap [8]
- Volume 8, Reference Architecture Interfaces (this volume) [9]
- Volume 9, Adoption and Modernization [10]

During Stage 1, Volumes 1 through 7 were conceptualized, organized and written. The finalized Version 1 documents can be downloaded from the V1.0 Final Version page of the NBD-PWG website [11].

During Stage 2, the NBD-PWG developed Version 2 of the NBDIF Version 1 volumes, with the exception of Volume 5, which contained the completed architecture survey work that was

used to inform Stage 1 work of the NBD-PWG. The goals of Version 2 were to enhance the Version 1 content, define general interfaces between the NBDRA components by aggregating low-level interactions into high-level general interfaces, and demonstrate how the NBDRA can be used. As a result of the Stage 2 work, the need for NBDIF Volume 8 and NBDIF Volume 9 were identified and the two new volumes were created. Version 2 of the NBDIF volumes, resulting from Stage 2 work, can be downloaded from the V2.0 Final Version page of the NBD-PWG website [12].

This document is the result of Stage 3 work of the NBD-PWG. Coordination of the group is conducted on the NBD-PWG web page [1].

1 INTRODUCTION

1.1 BACKGROUND

There is broad agreement among commercial, academic, and government leaders about the potential of Big Data to spark innovation, fuel commerce, and drive progress. Big Data is the common term used to describe the deluge of data in today's networked, digitized, sensor-laden, and information-driven world. The availability of vast data resources carries the potential to answer questions previously out of reach, including the following:

- How can a potential pandemic reliably be detected early enough to intervene?
- Can new materials with advanced properties be predicted before these materials have ever been synthesized?
- How can the current advantage of the attacker over the defender in guarding against cybersecurity threats be reversed?

There is also broad agreement on the ability of Big Data to overwhelm traditional approaches. The growth rates for data volumes, speeds, and complexity are outpacing scientific and technological advances in data analytics, management, transport, and data user spheres.

Despite widespread agreement on the inherent opportunities and current limitations of Big Data, a lack of consensus on some important fundamental questions continues to confuse potential users and stymie progress. These questions include the following:

- How is Big Data defined?
- What attributes define Big Data solutions?
- What is new in Big Data?
- What is the difference between Big Data and ***bigger data*** that has been collected for years?
- How is Big Data different from traditional data environments and related applications?
- What are the essential characteristics of Big Data environments?
- How do these environments integrate with currently deployed architectures?
- What are the central scientific, technological, and standardization challenges that need to be addressed to accelerate the deployment of robust, secure Big Data solutions?

Within this context, on March 29, 2012, the White House announced the Big Data Research and Development Initiative (The White House Office of Science and Technology Policy, "Big Data is a Big Deal," ***OSTP Blog***, accessed February 21, 2014 [13]. The initiative's goals include helping to accelerate the pace of discovery in science and engineering, strengthening national security, and transforming teaching and learning by improving analysts' ability to extract knowledge and insights from large and complex collections of digital data.

Six federal departments and their agencies announced more than $200 million in commitments spread across more than 80 projects, which aim to significantly improve the tools and techniques needed to access, organize, and draw conclusions from huge volumes of digital data. The initiative also challenged industry, research universities, and nonprofits to join with the federal government to make the most of the opportunities created by Big Data.

Motivated by the White House initiative and public suggestions, the National Institute of Standards and Technology (NIST) accepted the challenge to stimulate collaboration among industry professionals to further the secure and effective adoption of Big Data. As a result of NIST's Cloud and Big Data Forum held on January 15–17, 2013, there was strong encouragement for NIST to create a public working group for the development of a Big Data Standards Roadmap. Forum participants noted that this roadmap should define and prioritize Big Data requirements, including interoperability, portability, reusability, extensibility, data usage, analytics, and technology infrastructure. In doing so, the roadmap would accelerate the adoption of the most secure and effective Big Data techniques and technology.

On June 19, 2013, the NIST Big Data Public Working Group (NBD-PWG) was launched with extensive participation by industry, academia, and government from across the nation. The scope of the NBD-PWG involves forming a community of interests from all sectors—including industry, academia, and government—with the goal of developing consensus on definitions, taxonomies, secure reference architectures, security and privacy, and, from these, a standards roadmap. Such a consensus would create a vendor-neutral, technology- and infrastructure-independent framework that would enable Big Data stakeholders to identify and use the best analytics tools for their processing and visualization requirements on the most suitable computing platform and cluster, while also allowing added value from Big Data service providers.

The ***NIST Big Data Interoperability Framework (NBDIF)*** was released in three versions, which correspond to the three stages of the NBD-PWG work. Version 3 (current version) of the NBDIF volumes resulted from Stage 3 work with major emphasis on the validation of the NBDRA Interfaces and content enhancement. Stage 3 work built upon the foundation created during Stage 2 and Stage 1. The current effort documented in this volume reflects concepts developed within the rapidly evolving field of Big Data. The three stages (in reverse order) aim to achieve the following with respect to the NIST Big Data Reference Architecture (NBDRA).

Stage 3: Validate the NBDRA by building Big Data general applications through the general interfaces; Stage 2: Define general interfaces between the NBDRA components; and Stage 1: Identify the high-level Big Data reference architecture key components, which are technology-, infrastructure-, and vendor-agnostic.

The NBDIF consists of nine volumes, each of which addresses a specific key topic, resulting from the work of the NBD-PWG. The nine volumes are as follows:

- Volume 1, Definitions [2]
- Volume 2, Taxonomies [3]
- Volume 3, Use Cases and General Requirements [4]

- Volume 4, Security and Privacy [5]
- Volume 5, Architectures White Paper Survey [6]
- Volume 6, Reference Architecture [7]
- Volume 7, Standards Roadmap [8]
- Volume 8, Reference Architecture Interfaces (this volume) [9]
- Volume 9, Adoption and Modernization [10]

During Stage 1, Volumes 1 through 7 were conceptualized, organized and written. The finalized Version 1 documents can be downloaded from the V1.0 Final Version page of the NBD-PWG website [11].

During Stage 2, the NBD-PWG developed Version 2 of the NBDIF Version 1 volumes, with the exception of Volume 5, which contained the completed architecture survey work that was used to inform Stage 1 work of the NBD-PWG. The goals of Version 2 were to enhance the Version 1 content, define general interfaces between the NBDRA components by aggregating low-level interactions into high-level general interfaces, and demonstrate how the NBDRA can be used. As a result of the Stage 2 work, the need for NBDIF Volume 8 and NBDIF Volume 9 were identified and the two new volumes were created. Version 2 of the NBDIF volumes, resulting from Stage 2 work, can be downloaded from the V2.0 Final Version page of the NBD-PWG website [12].

1.2 Scope and Objectives of the Reference Architectures Subgroup

Reference architectures provide "an authoritative source of information about a specific subject area that guides and constrains the instantiations of multiple architectures and solutions" [14]. Reference architectures generally serve as a foundation for solution architectures and may also be used for comparison and alignment of instantiations of architectures and solutions.

The goal of the NBD-PWG Reference Architecture Subgroup is to develop an open reference architecture for Big Data that achieves the following objectives:

- Provides a common language for the various stakeholders;
- Encourages adherence to common standards, specifications, and patterns;
- Provides consistent methods for implementation of technology to solve similar problem sets;
- Illustrates and improves understanding of the various Big Data components, processes, and systems, in the context of a vendor- and technology-agnostic Big Data conceptual model;
- Provides a technical reference for U.S. government departments, agencies, and other consumers to understand, discuss, categorize, and compare Big Data solutions; and
- Facilitates analysis of candidate standards for interoperability, portability, reusability, and extendibility.

The NBDRA is a high-level conceptual model crafted to serve as a tool to facilitate open discussion of the requirements, design structures, and operations inherent in Big Data. The

NBDRA is intended to facilitate the understanding of the operational intricacies in Big Data. It does not represent the system architecture of a specific Big Data system, but rather is a tool for describing, discussing, and developing system-specific architectures using a common framework of reference. The model is not tied to any specific vendor products, services, or reference implementation, nor does it define prescriptive solutions that inhibit innovation.

The NBDRA does not address the following:

- Detailed specifications for any organization's operational systems;
- Detailed specifications of information exchanges or services; and
- Recommendations or standards for integration of infrastructure products.

The goals of the Subgroup were realized throughout the three planned phases of the NBD-PWG work, as outlined in Section 1.3.

1.3 Report Production

The ***NBDIF: Volume 8, References Architecture Interfaces*** is one of nine volumes, whose overall aims are to define and prioritize Big Data requirements, including interoperability, portability, reusability, extensibility, data usage, analytic techniques, and technology infrastructure to support secure and effective adoption of Big Data. The overall goals of this volume are to define and specify interfaces to implement the Big Data Reference Architecture. This volume arose from discussions during the weekly NBD-PWG conference calls. Topics included in this volume began to take form in Phase 2 of the NBD-PWG work. During the discussions, the NBD-PWG identified the need to specify a variety of interfaces.

Phase 3 work, which built upon the groundwork developed during Phase 2, included an early specification based on resource object specifications that provided a simplified version of an API interface design.

1.4 Report Structure

To enable interoperability between the NBDRA components, a list of well-defined NBDRA interfaces is needed. These interfaces are documented in this volume. To introduce them, the NBDRA structure will be followed, focusing on interfaces that allow bootstrapping of the NBDRA. The document begins with a summary of requirements that will be integrated into our specifications. Subsequently, each section will introduce a number of objects that build the core of the interface addressing a specific aspect of the NBDRA. A selected number of ***interface use cases*** will be showcased to outline how the specific interface can be used in a reference implementation of the NBDRA. Validation of this approach can be achieved while applying it to the application use cases that have been gathered in the ***NBDIF: Volume 3, Use Cases and Requirements*** document. These application use cases have considerably contributed towards the design of the NBDRA. Hence the expectation is that: (1) the interfaces can be used to help implement a Big Data architecture for a specific use case; and (2) the proper

implementation. This approach can facilitate subsequent analysis and comparison of the use cases.

The organization of this document roughly corresponds to the process used by the NBD-PWG to develop the interfaces. Following the introductory material presented in Section 1, the remainder of this document is organized as follows:

- Section 2 presents the interface requirements;
- Section 3 presents the specification paradigm that is used;
- Section 4 presents several objects grouped by functional use while providing a summary table of selected proposed objects in Section 4.1.

While each NBDIF volume was created with a specific focus within Big Data, all volumes are interconnected. During creation, the volumes gave and/or received input from other volumes. Broad topics (e.g., definition, architecture) may be discussed in several volumes with the discussion circumscribed by the volume's particular focus. Arrows shown in Figure 1 indicate the main flow of input/output. Volumes 2, 3, and 5 (blue circles) are essentially standalone documents that provide output to other volumes (e.g., to Volume 6). These volumes contain the initial situational awareness research. Volumes 4, 7, 8, and 9 (green circles) primarily received input from other volumes during the creation of the particular volume. Volumes 1 and 6 (red circles) were developed using the initial situational awareness research and continued to be modified based on work in other volumes. These volumes also provided input to the green circle volumes.

Figure 1: NBDIF Documents Navigation Diagram Provides Content Flow Between Volumes

2 NBDRA INTERFACE REQUIREMENTS

The development of a Big Data reference architecture requires a thorough understanding of current techniques, issues, and concerns. To this end, the NBD-PWG collected use cases to gain an understanding of current applications of Big Data, conducted a survey of reference architectures to understand commonalities within Big Data architectures in use, developed a taxonomy to understand and organize the information collected, and reviewed existing technologies and trends relevant to Big Data. The results of these NBD-PWG activities were used in the development of the NBDRA (Figure 2) and the interfaces presented herein. Detailed descriptions of these activities can be found in the other volumes of the ***NBDIF***.

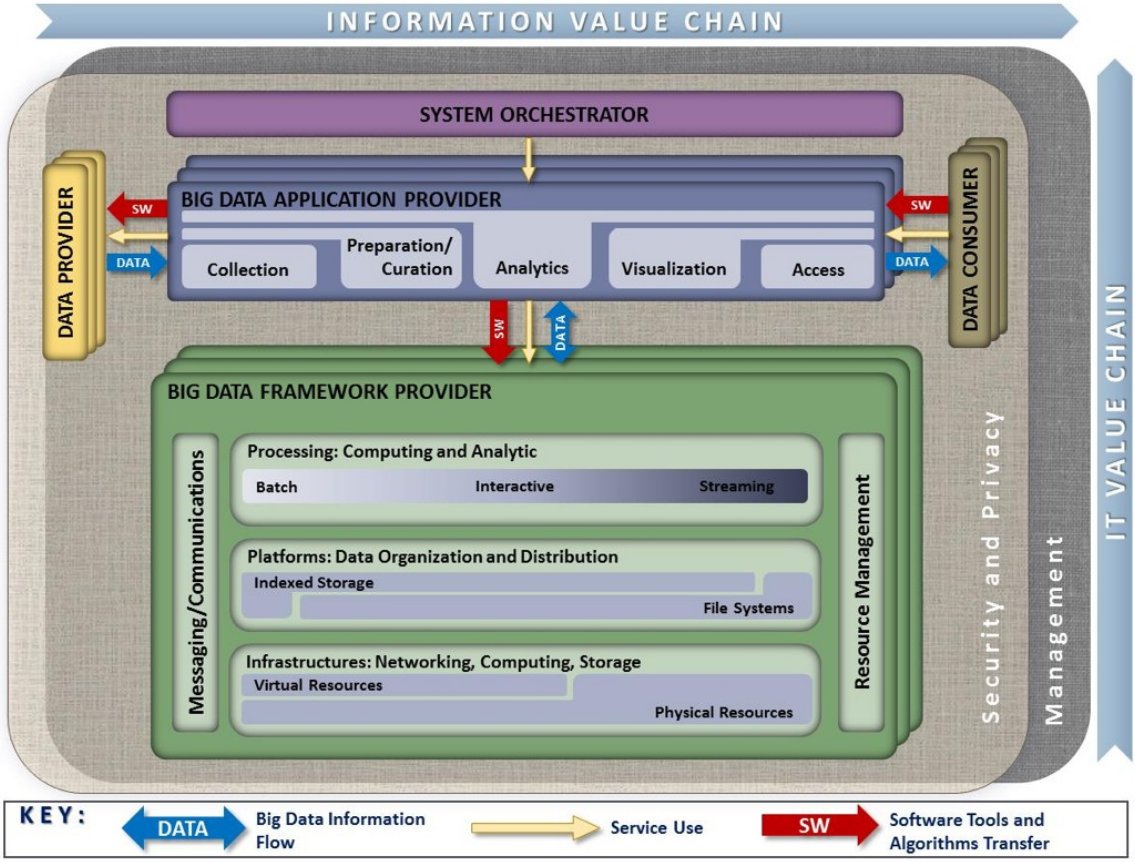

Figure 2: NIST Big Data Reference Architecture (NBDRA)

This vendor-neutral, technology- and infrastructure-agnostic conceptual model, the NBDRA, is shown in Figure 2 and represents a Big Data system composed of five logical functional components connected by interoperability interfaces (i.e., services). Two fabrics envelop the components, representing the interwoven nature of management and security and privacy with all five of the components. These two fabrics provide services and functionality to the five main roles in the areas specific to Big Data and are crucial to any Big Data solution. Note: None of the terminology or diagrams in these documents is intended to be normative or to

imply any business or deployment model. The terms ***provider*** and ***consumer*** as used are descriptive of general roles and are meant to be informative in nature.

The NBDRA is organized around five major roles and multiple sub-roles aligned along two axes representing the two Big Data value chains: the Information Value (horizontal axis) and the Information Technology (IT; vertical axis). Along the Information Value axis, the value is created by data collection, integration, analysis, and applying the results following the value chain. Along the IT axis, the value is created by providing networking, infrastructure, platforms, application tools, and other IT services for hosting of and operating the Big Data in support of required data applications. At the intersection of both axes is the Big Data Application Provider role, indicating that data analytics and its implementation provide the value to Big Data stakeholders in both value chains. The term ***provider*** as part of the Big Data Application Provider and Big Data Framework Provider is there to indicate that those roles provide or implement specific activities and functions within the system. It does not designate a service model or business entity.

The DATA arrows in Figure 2 show the flow of data between the system's main roles. Data flows between the roles either physically (i.e., by value) or by providing its location and the means to access it (i.e., by reference). The SW arrows show transfer of software tools for processing of Big Data ***in situ***. The Service Use arrows represent software programmable interfaces. While the main focus of the NBDRA is to represent the run-time environment, all three types of communications or transactions can happen in the configuration phase as well. Manual agreements (e.g., service-level agreements) and human interactions that may exist throughout the system are not shown in the NBDRA.

Detailed information on the NBDRA conceptual model is presented in the ***NBDIF: Volume 6, Reference Architecture*** document.

Prior to outlining the specific interfaces, general requirements are introduced and the interfaces are defined.

2.1 High-Level Requirements of the Interface Approach

This section focuses on the high-level requirements of the interface approach that are needed to implement the reference architecture depicted in Figure 2.

2.1.1 Technology- and Vendor-Agnostic

Due to the many different tools, services, and infrastructures available in the general area of Big Data, an interface ought to be as vendor-independent as possible, while, at the same time, be able to leverage best practices. Hence, a methodology is needed that allows extension of interfaces to adapt and leverage existing approaches, but also allows the interfaces to provide merit in easy specifications that assist the formulation and definition of the NBDRA.

2.1.2 Support of Plug-In Compute Infrastructure

As Big Data is not just about hosting data, but about analyzing data, the interfaces provided herein must encapsulate a rich infrastructure environment that is used by data scientists. This includes the ability to integrate (or plug-in) various compute resources and services to provide the necessary compute power to analyze the data. These resources and services include the following:

- Access to hierarchy of compute resources from the laptop/desktop, servers, data clusters, and clouds;
- The ability to integrate special-purpose hardware such as graphics processing units (GPUs) and field-programmable gate arrays (FPGAs) that are used in accelerated analysis of data; and
- The integration of services including microservices that allow the analysis of the data by delegating them to hosted or dynamically deployed services on the infrastructure of choice.

2.1.3 Orchestration of Infrastructure and Services

From review of the use case collection, presented in the ***NBDIF: Volume 3, Use Cases and General Requirements*** document [4], the need arose to address the mechanism of preparing suitable infrastructures for various use cases. As not every infrastructure is suited for every use case, a custom infrastructure may be needed. As such, this document is not attempting to deliver a single deployed NBDRA, but allow the setup of an infrastructure that satisfies the particular use case. To achieve this task, it is necessary to provision software stacks and services while orchestrating their deployment and leveraging infrastructures. It is not the focus of this document to replace existing orchestration software and services, but provide an interface to them to leverage them as part of defining and creating the infrastructure. Various orchestration frameworks and services could therefore be leveraged, even as part of the same framework, and work in orchestrated fashion to achieve the goal of preparing an infrastructure suitable for one or more applications.

2.1.4 Orchestration of Big Data Applications and Experiments

The creation of the infrastructure suitable for Big Data applications provides the basic computing environment. However, Big Data applications may require the creation of sophisticated applications as part of interactive experiments to analyze and probe the data. For this purpose, the applications must be able to orchestrate and interact with experiments conducted on the data while assuring reproducibility and correctness of the data. For this purpose, a ***System Orchestrator*** (either the data scientists or a service acting on behalf of the data scientist) is used as the command center to interact on behalf of the Big Data Application Provider to orchestrate dataflow from Data Provider, carry out the Big Data application life cycle with the help of the Big Data Framework Provider, and enable the Data Consumer to consume Big Data processing results. An interface is needed to describe these interactions and

to allow leveraging of experiment management frameworks in scripted fashion. A customization of parameters is needed on several levels. On the highest level, application-motivated parameters are needed to drive the orchestration of the experiment. On lower levels, these high-level parameters may drive and create service-level agreements, augmented specifications, and parameters that could even lead to the orchestration of infrastructure and services to satisfy experiment needs.

2.1.5 Reusability

The interfaces provided must encourage reusability of the infrastructure, services, and experiments described by them. This includes (1) reusability of available analytics packages and services for adoption; (2) deployment of customizable analytics tools and services; and (3) operational adjustments that allow the services and infrastructure to be adapted while at the same time allowing for reproducible experiment execution.

2.1.6 Execution Workloads

One of the important aspects of distributed Big Data services can be that the data served is simply too big to be moved to a different location. Instead, an interface could allow the description and packaging of analytics algorithms, and potentially also tools, as a payload to a data service. This can be best achieved, not by sending the detailed execution, but by sending an interface description that describes how such an algorithm or tool can be created on the server and be executed under security considerations (integrated with authentication and authorization in mind).

2.1.7 Security and Privacy Fabric Requirements

Although the focus of this document is not security and privacy, which are documented in the ***NBDIF: Volume 4, Security and Privacy*** [5], the interfaces defined herein must be capable of integration into a secure reference architecture that supports secure execution, secure data transfer, and privacy. Consequently, the interfaces defined herein can be augmented with frameworks and solutions that provide such mechanisms. Thus, diverse requirement needs stemming from different use cases addressing security need to be distinguished. To contrast that the security requirements between applications can vary drastically, the following example is provided. Although many of the interfaces and their objects to support Big Data applications in physics are similar to those in healthcare, they differ in the integration of security interfaces and policies. While in physics the protection of data is less of an issue, it is a stringent requirement in healthcare. Thus, deriving architectural frameworks for both may use largely similar components, but addressing security issues will be very different. The security of interfaces may be addressed in other documents. In this document, they are considered an advanced use case showcasing that the validity of the specifications introduced here is preserved, even if security and privacy requirements differ vastly among application use cases.

2.2 Component-Specific Interface Requirements

This section summarizes the requirements for the interfaces of the NBDRA components. The five components are listed in Figure 2 and addressed in Section 2.2.1 (System Orchestrator Interface Requirements) and Section 2.2.4 (Big Data Application Provider to Big Data Framework Provider Interface) of this document. The five main functional components of the NBDRA represent the different technical roles within a Big Data system and are the following:

- System Orchestrator: Defines and integrates the required data application activities into an operational vertical system (see Section 2.2.1);
- Data Provider: Introduces new data or information feeds into the Big Data system (see Section 2.2.2);
- Data Consumer: Includes end users or other systems that use the results of the Big Data Application Provider (see Section 2.2.3);
- Big Data Application Provider: Executes a data life cycle to meet security and privacy requirements as well as System Orchestrator-defined requirements (see Section 2.2.4);
- Big Data Framework Provider: Establishes a computing framework in which to execute certain transformation applications while protecting the privacy and integrity of data (see Section 2.2.5); and
- Big Data Application Provider to Framework Provider Interface: Defines an interface between the application specification and the provider (see Section 2.2.6).

2.2.1 System Orchestrator Interface Requirements

The System Orchestrator role includes defining and integrating the required data application activities into an operational vertical system. Typically, the System Orchestrator involves a collection of more specific roles, performed by one or more actors, which manage and orchestrate the operation of the Big Data system. These actors may be human components, software components, or some combination of the two. The function of the System Orchestrator is to configure and manage the other components of the Big Data architecture to implement one or more workloads that the architecture is designed to execute. The workloads managed by the System Orchestrator may be assigning/provisioning framework components to individual physical or virtual nodes at the lower level, or providing a graphical user interface that supports the specification of workflows linking together multiple applications and components at the higher level. The System Orchestrator may also, through the Management Fabric, monitor the workloads and system to confirm that specific quality of service requirements is met for each workload, and may elastically assign and provision additional physical or virtual resources to meet workload requirements resulting from changes/surges in the data or number of users/transactions. The interface to the System Orchestrator must be capable of specifying the task of orchestration the deployment, configuration, and the execution of applications within the NBDRA. A simple vendor-neutral specification to coordinate the various parts either as simple parallel language tasks or as a workflow specification is needed to facilitate the overall coordination. Integration of existing tools and services into the System Orchestrator as extensible interfaces is desirable.

2.2.2 Data Provider Interface Requirements

The Data Provider role introduces new data or information feeds into the Big Data system for discovery, access, and transformation by the Big Data system. New data feeds are distinct from the data already in use by the system and residing in the various system repositories. Similar technologies can be used to access both new data feeds and existing data. The Data Provider actors can be anything from a sensor, to a human inputting data manually, to another Big Data system. Interfaces for data providers must be able to specify a data provider so it can be located by a data consumer. It also must include enough details to identify the services offered so they can be pragmatically reused by consumers. Interfaces to describe pipes and filters must be addressed.

2.2.3 Data Consumer Interface Requirements

Like the Data Provider, the role of Data Consumer within the NBDRA can be an actual end user or another system. In many ways, this role is the mirror image of the Data Provider, with the entire Big Data framework appearing like a Data Provider to the Data Consumer. The activities associated with the Data Consumer role include the following:

- Search and Retrieve,
- Download,
- Analyze Locally,
- Reporting,
- Visualization, and
- Data to Use for Their Own Processes.

The interface for the data consumer must be able to describe the consuming services and how they retrieve information or leverage data consumers.

2.2.4 Big Data Application Interface Provider Requirements

The Big Data Application Provider role executes a specific set of operations along the data life cycle to meet the requirements established by the System Orchestrator, as well as meeting security and privacy requirements. The Big Data Application Provider is the architecture component that encapsulates the business logic and functionality to be executed by the architecture. The interfaces to describe Big Data applications include interfaces for the various subcomponents including collections, preparation/curation, analytics, visualization, and access. Some of the interfaces used in these subcomponents can be reused from other interfaces, which are introduced in other sections of this document. Where appropriate, application-specific interfaces will be identified and examples provided with a focus on use cases as identified in the ***NBDIF: Volume 3, Use Cases and General Requirements***.

2.2.4.1 Collection

In general, the collection activity of the Big Data Application Provider handles the interface with the Data Provider. This may be a general service, such as a file server or web server configured by the System Orchestrator to accept or perform specific collections of data, or it may be an application-specific service designed to pull data or receive pushes of data from the Data Provider. Since this activity is receiving data at a minimum, it must store/buffer the received data until it is persisted through the Big Data Framework Provider. This persistence need not be to physical media but may simply be to an in-memory queue or other service provided by the processing frameworks of the Big Data Framework Provider. The collection activity is likely where the extraction portion of the Extract, Transform, Load (ETL)/Extract, Load, Transform (ELT) cycle is performed. At the initial collection stage, sets of data (e.g., data records) of similar structure are collected (and combined), resulting in uniform security, policy, and other considerations. Initial metadata is created (e.g., subjects with keys are identified) to facilitate subsequent aggregation or look-up methods.

2.2.4.2 Preparation

The preparation activity is where the transformation portion of the ETL/ELT cycle is likely performed, although analytics activity will also likely perform advanced parts of the transformation. Tasks performed by this activity could include data validation (e.g., checksums/hashes, format checks), cleaning (e.g., eliminating bad records/fields), outlier removal, standardization, reformatting, or encapsulating. This activity is also where source data will frequently be persisted to archive storage in the Big Data Framework Provider and provenance data will be verified or attached/associated. Verification or attachment may include optimization of data through manipulations (e.g., deduplication) and indexing to optimize the analytics process. This activity may also aggregate data from different Data Providers, leveraging metadata keys to create an expanded and enhanced data set.

2.2.4.3 Analytics

The analytics activity of the Big Data Application Provider includes the encoding of the low-level business logic of the Big Data system (with higher-level business process logic being encoded by the System Orchestrator). The activity implements the techniques to extract knowledge from the data based on the requirements of the vertical application. The requirements specify the data processing algorithms to produce new insights that will address the technical goal. The analytics activity will leverage the processing frameworks to implement the associated logic. This typically involves the activity providing software that implements the analytic logic to the batch and/or streaming elements of the processing framework for execution. The messaging/communication framework of the Big Data Framework Provider may be used to pass data or control functions to the application logic running in the processing frameworks. The analytic logic may be broken up into multiple modules to be executed by the processing frameworks which communicate, through the messaging/communication framework, with each other and other functions instantiated by the Big Data Application Provider.

2.2.4.4 Visualization

The visualization activity of the Big Data Application Provider prepares elements of the processed data and the output of the analytic activity for presentation to the Data Consumer. The objective of this activity is to format and present data in such a way as to optimally communicate meaning and knowledge. The visualization preparation may involve producing a text-based report or rendering the analytic results as some form of graphic. The resulting output may be a static visualization and may simply be stored through the Big Data Framework Provider for later access. However, the visualization activity frequently interacts with the access activity, the analytics activity, and the Big Data Framework Provider (processing and platform) to provide interactive visualization of the data to the Data Consumer based on parameters provided to the access activity by the Data Consumer. The visualization activity may be completely application-implemented, leverage one or more application libraries, or may use specialized visualization processing frameworks within the Big Data Framework Provider.

2.2.4.5 Access

The access activity within the Big Data Application Provider is focused on the communication/interaction with the Data Consumer. Like the collection activity, the access activity may be a generic service such as a web server or application server that is configured by the System Orchestrator to handle specific requests from the Data Consumer. This activity would interface with the visualization and analytic activities to respond to requests from the Data Consumer (who may be a person) and uses the processing and platform frameworks to retrieve data to respond to Data Consumer requests. In addition, the access activity confirms that descriptive and administrative metadata and metadata schemes are captured and maintained for access by the Data Consumer and as data is transferred to the Data Consumer. The interface with the Data Consumer may be synchronous or asynchronous in nature and may use a pull or push paradigm for data transfer.

2.2.5 Big Data Provider Framework Interface Requirements

Data for Big Data applications are delivered through data providers. They can be either local providers, data contributed by a user, or distributed data providers, data on the Internet. This interface must be able to provide the following functionality:

- Interfaces to files,
- Interfaces to virtual data directories,
- Interfaces to data streams, and
- Interfaces to data filters.

2.2.5.1 Infrastructures Interface Requirements

This Big Data Framework Provider element provides all the resources necessary to host/run the

activities of the other components of the Big Data system. Typically, these resources consist of some combination of physical resources, which may host/support similar virtual resources. The NBDRA needs interfaces that can be used to deal with the underlying infrastructure to address networking, computing, and storage.

2.2.5.2 Platforms Interface Requirements

As part of the NBDRA platforms, interfaces are needed that can address platform needs and services for data organization, data distribution, indexed storage, and file systems.

2.2.5.3 Processing Interface Requirements

The processing frameworks for Big Data provide the necessary infrastructure software to support implementation of applications that can deal with the volume, velocity, variety, and variability of data. Processing frameworks define how the computation and processing of the data is organized. Big Data applications rely on various platforms and technologies to meet the challenges of scalable data analytics and operation. A requirement is the ability to interface easily with computing services that offer specific analytics services, batch processing capabilities, interactive analysis, and data streaming.

2.2.5.4 Crosscutting Interface Requirements

Several crosscutting interface requirements within the Big Data Framework Provider include messaging, communication, and resource management. Often these services may be hidden from explicit interface use as they are part of larger systems that expose higher-level functionality through their interfaces. However, such interfaces may also be exposed on a lower level in case finer-grained control is needed. The need for such crosscutting interface requirements will be extracted from the ***NBDIF: Volume 3, Use Cases and General Requirements*** document.

2.2.5.5 Messaging/Communications Frameworks

Messaging and communications frameworks have their roots in the High Performance Computing environments long popular in the scientific and research communities. Messaging/Communications Frameworks were developed to provide application programming interfaces (APIs) for the reliable queuing, transmission, and receipt of data.

2.2.5.6 Resource Management Framework

As Big Data systems have evolved and become more complex, and as businesses work to leverage limited computation and storage resources to address a broader range of applications and business challenges, the requirement to effectively manage those resources has grown significantly. While tools for resource management and ***elastic computing*** have expanded and

matured in response to the needs of cloud providers and virtualization technologies, Big Data introduces unique requirements for these tools. However, Big Data frameworks tend to fall more into a distributed computing paradigm, which presents additional challenges.

2.2.6 Big Data Application Provider to Big Data Framework Provider Interface

The Big Data Framework Provider typically consists of one or more hierarchically organized instances of the components in the NBDRA IT value chain (Figure 2). There is no requirement that all instances at a given level in the hierarchy be of the same technology. In fact, most Big Data implementations are hybrids that combine multiple technology approaches to provide flexibility or meet the complete range of requirements, which are driven from the Big Data Application Provider.

3 Specification Paradigm

This section summarizes the elementary specification paradigm.

3.1 Hybrid and Multiple Frameworks

To avoid vendor lock-in, Big Data systems must be able to deal with hybrid and multiple frameworks. This is not only true for Clouds, containers, DevOps, but also for components of the NBDRA.

3.2 Design by Resource-Oriented Architecture

A resource-oriented architecture represents a software architecture and programming paradigm for designing and developing software in the form of resources. It is often associated with ***REpresentational State Transfer (REST)*** interfaces. The resources are software components which can be reused in concrete reference implementations. The service specification is conducted with OpenAPI, allowing use to provide it in a very general form that is independent of the framework or computer language in which the services can be specified. Note that OpenAPI defines services in REST The previous version only specified the resource objects.

3.3 Design by Example

To accelerate discussion among the NBD-PWG members, contributors to this document are encouraged to also provide the NBD-PWG with examples.

3.4 Version Management

Previous work that shaped the current version of this volumes and are documented In GitHub [15] with prior versions of Volume 8 [16][17] and Cloudmesh [18] in support of the NIST Big Data Architecture Framework [1].

During the design phase and development period of each version of this document, enhancements are managed through GitHub and community contributions are managed via GitHub issues. This allows preservation of the history of this document. When a new version is ready, the version will be tagged in GitHub. Older versions will, through this process, also be available as historical documents. Discussions about objects in written form are communicated as GitHub issues.

3.5 Interface Compliancy

Due to the easy extensibility of the resource objects specified in this document and their

interfaces, it is important to introduce a terminology that allows the definition of interface compliancy. We define three levels of interface compliance as follows:

- Full Compliance: These are reference implementations that provide full compliance to the objects defined in this document. A version number is added to assure that the snapshot in time of the objects is associated with the version. A full complient framework implements all objects.

- Partial Compliance: These are reference implementations that provide partial compliance to the objects defined in this document. A version number will is added to assure that the snapshot in time of the objects is associated with the version. This reference implementation implements a partial list of the objects and interfaces. A document is to be added that specifies the differences to a full complient implementation.

- Extended Compliance: In addition to full and partial compliance additional resources can be identified while documenting additional resource objects and interfaces that are not included in the current specification. The extended complience document can lead to additional improvements of the current specification.

3.6 REFERNCE IMPLEMENTATIONS

Documents generated during a reference implementation can be forwarded to the Reference Architecture Subgroup for further discussion and for possible future modifications based on additional practical user feedback.

4 SPECIFICATION

The specifications in this section are provided through an automated document creation process using the actual OpenAPI specifications yaml files as the source. All OpenAPI specifications located in the cloudmesh/cloudmesh-nist/spec/ directory in GitHub [19].

Limitations of the current implementation are as follows. It is a demonstration that showcases the generation of a fully functioning REST service based on the specifications provided in this document. However, it is expected that scalability, distribution of services, and other advanced options need to be addressed based on application requirements.

4.1 LIST OF SPECIFICATIONS

The following table lists the current set of resource objects that are defined in this draft. Additional objects are also available in GitHub [19].

Table 1 shows the list of currently included specification in this version of the document.

Table 1: Specifications

Service	Version	Date	Reference	Section
Alias	3.2.0	17-06-2019		Section 4.6.1
Account	3.2.0	17-06-2019		Section 4.5.3
Containers	3.2.0	17-06-2019		Section 4.10.1
Database	3.2.0	17-06-2019		Section 4.7.3
Default	3.2.0	17-06-2019		Section 4.6.3
Deployment	3.2.0	17-06-2019		Section 4.15.1
File	3.2.0	17-06-2019		Section 4.7.1
Filter	3.2.0	17-06-2019		Section 4.14.2
Flavor	3.2.0	17-06-2019		Section 4.9.2
Image	3.2.0	17-06-2019		Section 4.9.1
MapReduce	3.2.0	17-06-2019		Section 4.11.1
Microservice	3.2.0	17-06-2019		Section 4.12.1
Nic	3.2.0	17-06-2019		Section 4.9.5
Network of Nodes	3.2.0	17-06-2019		Section 4.8.2
Organization	3.2.0	17-06-2019		Section 4.5.1
Public Key Store	3.2.0	17-06-2019		Section 4.5.4
Queue	3.2.0	17-06-2019		Section 4.8.4

Replica	3.2.0	17-06-2019		Section 4.7.2
Reservation	3.2.0	17-06-2019		Section 4.13.1
Scheduler	3.2.0	17-06-2019		Section 4.8.3
Secgroup	3.2.0	17-06-2019		Section 4.9.4
Stream	3.2.0	17-06-2019		Section 4.14.1
Timestamp	3.2.0	17-06-2019		Section 4.4.1
User	3.2.0	17-06-2019		Section 4.5.2
Variables	3.2.0	17-06-2019		Section 4.6.2
Virtual Cluster	3.2.0	17-06-2019		Section 4.8.1
Virtual Directory	3.2.0	17-06-2019		Section 4.7.4
Virtual Machine	3.2.0	17-06-2019		Section 4.9.3

Figure 3 shows the provider view of the specification resources.

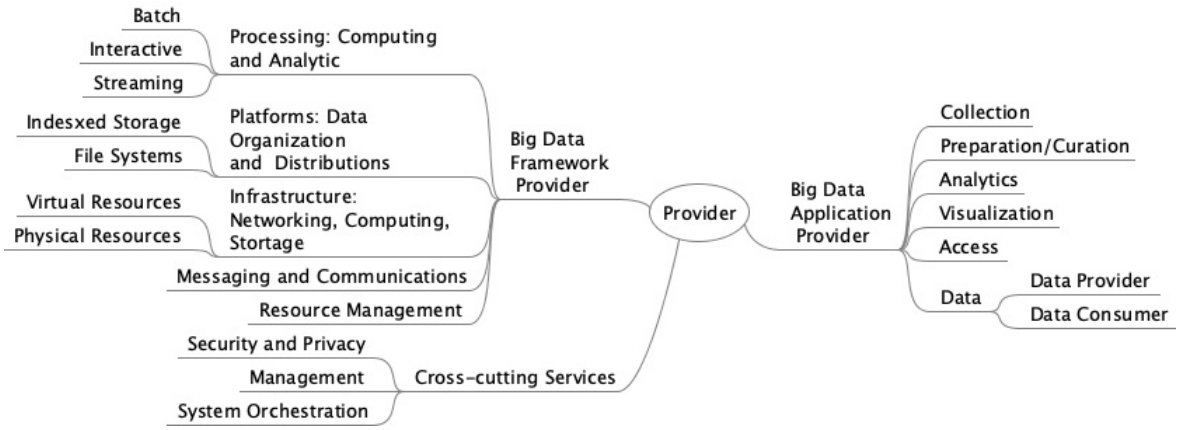

Figure 3: Provider view

Figure 4 shows the resources view of the specification resources.

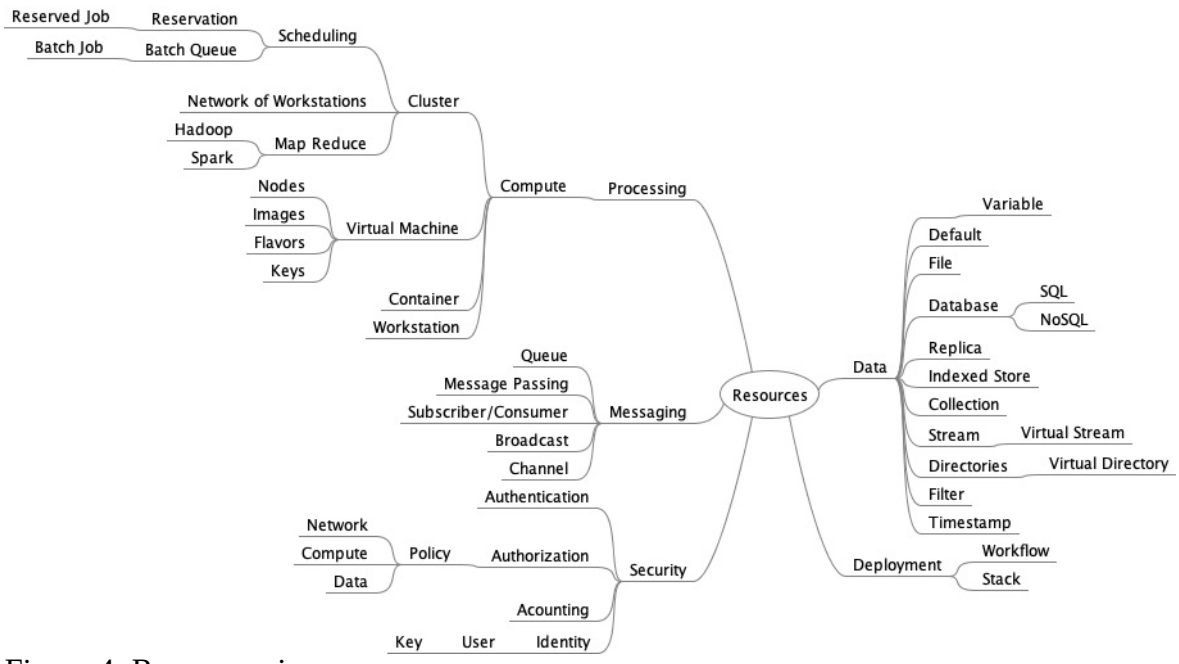

Figure 4: Resource view

4.2 Authentication

Mechanisms are not included in this specification to manage authentication to external services. However, the working group has shown multiple solutions to this as part of cloudmesh. This includes the posibility of a

- ***Local configuration file:*** A configuration file is managed locally to allow access to the clouds. It is the designer's responsibility not to expose such credentials.
- ***Session based authentication:*** No passwords are stored in the configuration file and access is granted on a per session basis where the password needs to be entered.
- ***Service based authentication:*** The authentication is delegated to an external process. The service that acts on behalf of the user needs to have access to the appropriate cloud provider credentials

An example for a configuration file is provided at [20].

4.3 Status Codes and Error Responses

In case of an error or a successful response, the response header contains a HTTP code (see https://tools.ietf.org/html/rfc7231). The response body usually contains the following:

- The HTTP response code;
- An accompanying message for the HTTP response code; and
- A field or object where the error occurred.

Table 1: HTTP Response Codes

HTTP Response	Operation D	escription
200 Ok	GET, PUT, DELETE	No error, operation successful.
201 Created	POST	Successful creation of a resource.
204 No Content	GET, PUT, DELETE	Successful but no content.
400 Bad Request	GET, POST, PUT, DELETE	The request could not be understood.
401 Unauthorized	GET, POST, PUT, DELETE	User must authorize.
403 Forbidden	GET, POST, PUT, DELETE	The request has been refused due to authorization failure.
404 Not Found	GET, POST, PUT, DELETE	The requested resource could not be found.
405 Not Allowed	GET, POST, PUT, DELETE	The method is not allowed on the resource.
500 Server Error	GET, POST PUT	Internal Server error.

In the specification such responses are indicated and if an simple response is returned the term ***Message*** is used.

Resources

4.4 TIMESTAMP

Timestamps can be used in conjunction with andy server side implementation of the interfaces. It can be useful to return information about when a particular resource has been created, updated, or accessed. To simplify the specification in the document we have not explicitly listed that a timestamp is part of the reource, but we can assume it may be added as part of the service implementation. To obtain an example timestamp a simple get function is provided.

4.4.1 Timestamp

Data often needs to be time stamped to indicate when it has been accessed, created, or modified. All objects defined in this document will have, in their final version, a timestamp. The date-time string is defined in RFC3339.

4.4.1.1 Schema Timestamp

Reference:

Property	Type	Description
accessed	string(date-time)	The time stamp when the object was last accessed
created	string(date-time)	The time stamp when the object was created
modified	string(date-time)	The time stamp when the object was modified

4.4.1.2 Paths

HTTP	Path	Summary
get	/timestamp	Returns the timestamp

4.4.1.2.1 /timestamp

4.4.1.2.1.1 GET /timestamp

Returns the timestamp

Responses

Code	Description	Schema
200	The current time and date	string

4.4.1.3 timestamp.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Timestamp
  description: |-

    Data often needs to be time stamped to indicate when it has been
    accessed, created, or modified. All objects defined in this
    document will have, in their final version, a timestamp.
    The date-time string is defined in
    [RFC3339](https://xml2rfc.ietf.org/public/rfc/html/rfc3339.html#anchor14).

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
```

```
  - url: /cloudmesh/v3
paths:
  /timestamp:
    get:
      summary: Returns the timestamp
      description: Returns the timestamp
      responses:
        '200':
          description: The current time and date
          content:
            application/json:
              schema:
                type: string
                example: 1985-04-12T23:20:50.52Z
components:
  schemas:
    Timestamp:
      type: object
      description: the timestamp
      properties:
        accessed:
          type: string
          format: date-time
          description: The time stamp when the object was last accessed
          example: 1985-04-12T23:20:50.52Z
        created:
          type: string
          format: date-time
          description: The time stamp when the object was created
          example: 1985-04-12T23:20:50.52Z
        modified:
          type: string
          format: date-time
          description: The time stamp when the object was modified
          example: 1985-04-12T23:20:50.52Z
```

4.5 IDENTITY

As part of services an identity often needs to be specified. In addition, such persons [21] are often part of groups. Thus, three important terms related to the identity are distinguished as follows:

- Organization: The information representing an Organization that manages a Big Data Service (Section 4.5.1)
- Group: A group that a person may belong to that is important to define access to services (included in Section 4.5.1)
- User: The information identifying the profile of a person (Section 4.5.2)

4.5.1 Organization

An important concept in many services is the management of a group of users in an organization. Within an organization we distinguish different groups of users. Groups can be used to charachterize roles users can fulfill. Users can belong to multiple groups. Such groups can also be used to specify access rights to services.

4.5.1.1 Schema Organization

Reference:

Property	Type	Description
name	string	Name of the organization

users	array[User]	List of users

4.5.1.2 Schema Group

Reference:

Property	Type	Description
name	string	The name of the group
description	string	The description of the group
users	array[string]	The user names that are members of the group

4.5.1.3 Paths

HTTP	Path	Summary
get	/organization	Returns a list of organizations
get	/organization/{name}	Returns the named organization
put	/organization/{name}	Uploads an organization to the list of organizations
delete	/organization/{name}	Deletes the named organization
get	/organization/{name}/user	Returns all users of the organization
get	/organization/{name}/user/{user}	Returns the specific user of that organization
put	/organization/{name}/user/{user}	Updates or adds a user in the organization
delete	/organization/{name}/user/{user}	Delete an user in the organization
get	/organization/{name}/group/	Returns all group names
get	/organization/{name}/group/{group}	Returns the specific group of that organization
put	/organization/{name}/group/{group}	Updates or adds a group in the organization
delete	/organization/{name}/group/{group}	Delete a group in the organization

put	/organization/{name}/group/{group}/{user}	Updates or adds a user name to the group
delete	/organization/{name}/group/{group}/{user}	Delete a user in the group

4.5.1.3.1 /organization

4.5.1.3.1.1 GET /organization

Returns a list of all organizations

Responses

Code	Description	Schema
200	The list of organizations	array[Organization]
401	Not authorized	String

4.5.1.3.2 /organization/{name}

4.5.1.3.2.1 GET /organization/{name}

Returns an organization by name

Responses

Code	Description	Schema
200	Retruning the information of the organization	Organization
401	Not authorized	String
404	The named organization could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String

4.5.1.3.2.2 PUT /organization/{name}

Uploads an organization to the list of organizations

Responses

Code	Description	Schema
200	Organization created or updated	String
401	Not authorized	String
404	The organization could not be found	String

Request Body

Located in	Description	Required	Schema
Body	The organization to be uploaded	True	Organization

4.5.1.3.2.3 DELETE /organization/{name}

Deletes an organization by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named organization could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String

4.5.1.3.3 /organization/{name}/user

4.5.1.3.3.1 GET /organization/{name}/user

Returns all users of the organization

Responses

Code	Description	Schema
200	The organization	Organization
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String

4.5.1.3.4 /organization/{name}/user/{user}

4.5.1.3.4.1 GET /organization/{name}/user/{user}

Returns the specific user of that organization

Responses

Code	Description	Schema
200	The user	User
401	Not authorized	String
404	The organization or user could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String
user	path	The user name	True	String

4.5.1.3.4.2 PUT /organization/{name}/user/{user}

Updates or adds a user in the organization

Responses

Code	Description	Schema
200	User added sucessfully	String
401	Not authorized	String
404	The organization or user could not be found\	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String

user	path	The user name	True	String

Request Body

Located in	Description	Required	Schema
Body	The user to be uploaded	True	User

4.5.1.3.4.3 DELETE /organization/{name}/user/{user}

Delete an user in the organization

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The organization or user could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String
user	path	The user name	True	String

4.5.1.3.5 /organization/{name}/group/

4.5.1.3.5.1 GET /organization/{name}/group/

Returns all group names

Responses

Code	Description	Schema
200	Returning the information of the group	array[String]
400	No group found	String
401	Not authorized	String
404	The organization or group could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String

4.5.1.3.6 /organization/{name}/group/{group}

4.5.1.3.6.1 GET /organization/{name}/group/{group}

Returns the specific group of that organization

Responses

Code	Description	Schema
200	The group	Group
401	Not authorized	String
404	The organization or group could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String
group	path	The group name	True	String

4.5.1.3.6.2 PUT /organization/{name}/group/{group}

Updates or adds a group in the organization

Responses

Code	Description	Schema
200	Group added sucessfully	String
401	Not authorized	String
404	The organization or group could not be found	String

Parameters

Name	Located in	Description	Required	Schema

name	path	The name of the group	True	String
group	path	The group name	True	String

4.5.1.3.6.3 DELETE /organization/{name}/group/{group}

Delete a group in the organization

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The organization or group could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String
group	path	The group name	True	String

4.5.1.3.7 /organization/{name}/group/{group}/{user}

4.5.1.3.7.1 PUT /organization/{name}/group/{group}/{user}

Updates or adds a user name to the group

Responses

Code	Description	Schema
200	User added sucessfully	String
401	Not authorized	String
404	The organization, group, or user could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the group	True	String
group	path	The group name	True	String

user	path	The user name	True	String

4.5.1.3.7.2 DELETE /organization/{name}/group/{group}/{user}

Delete a user in the group

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The organization, group, or user could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the organization	True	String
group	path	The group name	True	String
user	path	The user name	True	String

4.5.1.4 organization.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Organization
  description: |-

    An important concept in many services is the management of a group
    of users in an organization. Within an organization we distinguish
    different groups of users. Groups can be used to charachterize roles
    users can fulfill. Users can belong to multiple groups. Such groups can
    also be used to specify access rights to services.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /organization:
    get:
      tags:
        - Organization
      summary: Returns a list of organizations
      description: Returns a list of all organizations
      operationId: cloudmesh.organization.list
      responses:
        '200':
          description: The list of organizations
          content:
            application/json:
              schema:
                type: array
```

```
              items:
                $ref: '#/components/schemas/Organization'
      '401':
        description: Not authorized
/organization/{name}:
  get:
    tags:
      - Organization
    summary: Returns the named organization
    description: Returns an organization by name
    operationId: cloudmesh.organization.find_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
    responses:
      '200':
        description: Retruning the information of the organization
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Organization'
      '401':
        description: Not authorized
      '404':
         description: The named organization could not be found
  put:
    tags:
      - Organization
    summary: Uploads an organization to the list of organizations
    description: Uploads an organization to the list of organizations
    operationId: cloudmesh.organization.add
    requestBody:
      description: The organization to be uploaded
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Organization'
    responses:
      '200':
        description: Organization created or updated
      '401':
        description: Not authorized
      '404':
        description: The organization could not be found
  delete:
    tags:
      - Organization
    summary: Deletes the named organization
    description: Deletes an organization by name
    operationId: cloudmesh.organization.delete_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
      '404':
         description: The named organization could not be found
/organization/{name}/user:
  get:
    tags:
      - Organization
    summary: Returns all users of the organization
    description: Returns all users of the organization
    operationId: cloudmesh.organization.user.list
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
    responses:
      '200':
        description: The organization
        content:
          application/json:
            schema:
```

```
              $ref: "#/components/schemas/Organization"
      '401':
        description: Not authorized
/organization/{name}/user/{user}:
  get:
    tags:
      - Organization
    summary: Returns the specific user of that organization
    description: Returns the specific user of that organization
    operationId: cloudmesh.organization.user.get_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
      - name: user
        description: The user name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: The user
        content:
          application/json:
            schema:
              $ref: "user.yaml#/components/schemas/User"
      '401':
        description: Not authorized
      '404':
        description: The organization or user could not be found
  put:
    tags:
      - Organization
    summary: Updates or adds a user in the organization
    description: Updates or adds a user in the organization
    operationId: cloudmesh.organization.user.add
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
      - name: user
        description: The user name
        in: path
        required: true
        schema:
          type: string
    requestBody:
      description: The user to be uploaded
      required: true
      content:
        application/json:
          schema:
            $ref: 'user.yaml#/components/schemas/User'
    responses:
      '200':
        description: User added sucessfully
      '401':
        description: Not authorized
      '404':
        description: The organization or user could not be found\
  delete:
    tags:
      - Organization
    summary: Delete an user in the organization
    description: Delete an user in the organization
    operationId: cloudmesh.organization.user.delete
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
      - name: user
        description: The user name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: Deletion successful
```

```
      '401':
        description: Not authorized
      '404':
        description: The organization or user could not be found
/organization/{name}/group/:
  get:
    tags:
      - Organization
    summary: Returns all group names
    description: Returns all group names
    operationId: cloudmesh.organization.group.list
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
    responses:
      '200':
        description: Returning the information of the group
        content:
          application/json:
            schema:
              type: array
              items:
                type: string
      '400':
         description: No group found
      '401':
        description: Not authorized
      '404':
         description: The organization or group could not be found
/organization/{name}/group/{group}:
  get:
    tags:
      - Organization
    summary: Returns the specific group of that organization
    description: Returns the specific group of that organization
    operationId: cloudmesh.organization.group.get_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
      - name: group
        description: The group name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: The group
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/Group"
      '401':
        description: Not authorized
      '404':
        description: The organization or group could not be found
  put:
    tags:
      - Organization
    summary: Updates or adds a group in the organization
    description: Updates or adds a group in the organization
    operationId: cloudmesh.organization.group.add
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the group
      - name: group
        description: The group name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: Group added sucessfully
      '401':
        description: Not authorized
      '404':
```

```
        description: The organization or group could not be found
  delete:
    tags:
      - Organization
    summary: Delete a group in the organization
    description: Delete a group in the organization
    operationId: cloudmesh.organization.greop.delete
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
      - name: group
        description: The group name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
      '404':
        description: The organization or group could not be found
/organization/{name}/group/{group}/{user}:
  put:
    tags:
      - Organization
    summary: Updates or adds a user name to the group
    description: Updates or adds a user name to the group
    operationId: cloudmesh.organization.group.user.add
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the group
      - name: group
        description: The group name
        in: path
        required: true
        schema:
          type: string
      - name: user
        description: The user name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: User added sucessfully
      '401':
        description: Not authorized
      '404':
        description: The organization, group, or user could not be found
  delete:
    tags:
      - Organization
    summary: Delete a user in the group
    description: Delete a user in the group
    operationId: cloudmesh.organization.greop.delete.user
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the organization
      - name: group
        description: The group name
        in: path
        required: true
        schema:
          type: string
      - name: user
        description: The user name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: Deletion successful
      '401':
```

```
        description: Not authorized
      '404':
        description: The organization, group, or user could not be found
components:
  schemas:
    Organization:
      type: object
      properties:
        name:
          description: Name of the organization
          type: string
        users:
          description: List of users
          type: array
          items:
            $ref: "user.yaml#/components/schemas/User"
    Group:
      type: object
      description: The groups
      properties:
        name:
          type: string
          description: The name of the group
        description:
          type: string
          description: The description of the group
        users:
          description: The user names that are members of the group
          type: array
          items:
            type: string
```

4.5.2 User

Services need to specify which users have access to them. User information can be reused in other services and organized in a virtual organization. A user can be added to a named list of users within this organization. A group associated with the user can be used to augment users to be part of one or more groups.

4.5.2.1 Schema User

Reference:

Property	Type	Description
username	string	The unique username associated with the user
firstname	string	The firstname of the user
lastname	string	The lastname of the user
email	string	The email of the user
comment	string	A comment regarding the user
publickey	string	The public key of the user

4.5.2.2 Paths

HTTP	Path	Summary
get	/user	Returns a list of users

get	/user/{name}	Returns the named user
put	/user/{name}	Uploads a user to the list of users
delete	/user/{name}	Deletes the named user

4.5.2.2.1 /user

4.5.2.2.1.1 GET /user

Returns a list of all users

Responses

Code	Description	Schema
200	The list of users	array[User]
401	Not authorized	String

4.5.2.2.2 /user/{name}

4.5.2.2.2.1 GET /user/{name}

Returns an user by name

Responses

Code	Description	Schema
200	Returning the information of the user	User
401	Not authorized	String
404	The named user could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the user	True	String

4.5.2.2.2.2 PUT /user/{name}

Uploads a user to the list of users

Responses

Code	Description	Schema
200	User updated	String
401	Not authorized	String
404	The named user could not be found	String

Request Body

Located in	Description	Required	Schema
Body	The user to be uploaded	True	User

4.5.2.2.2.3 DELETE /user/{name}

Deletes an user by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named user could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the user	True	String

4.5.2.3 user.yaml

```
openapi: "3.0.2"
info:
  version: "3.2.0"
  x-date: 17-06-2019
  x-status: defined
  title: User
  description: |-

    Services need to specify which users have access to them. User
    information can be reused in other services and organized in a virtual
    organization. A user can be added to a named list of users within this
    organization. A group associated with the user can be used to augment
    users to be part of one or more groups.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: Cloudmesh User
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
```

```
paths:
  /user:
    get:
      tags:
        - User
      summary: Returns a list of users
      description: Returns a list of all users
      operationId: cloudmesh.user.list
      responses:
        '200':
          description: The list of users
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/User'
        '401':
          description: Not authorized
  /user/{name}:
    get:
      tags:
        - User
      summary: Returns the named user
      description: Returns an user by name
      operationId: cloudmesh.user.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the user
      responses:
        '200':
          description: Returning the information of the user
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/User'
        '401':
          description: Not authorized
        '404':
           description: The named user could not be found
    put:
      tags:
        - User
      summary: Uploads a user to the list of users
      description: Uploads a user to the list of users
      operationId: cloudmesh.user.add
      requestBody:
        description: The user to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/User'
      responses:
        '200':
          description: User updated
        '401':
          description: Not authorized
        '404':
           description: The named user could not be found
    delete:
      tags:
        - User
      summary: Deletes the named user
      description: Deletes an user by name
      operationId: cloudmesh.user.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the user
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named user could not be found
components:
  schemas:
    User:
      type: object
      properties:
```

```
      username:
        type: string
        description: The unique username associated with the user
      firstname:
        type: string
        description: The firstname of the user
      lastname:
        type: string
        description: The lastname of the user
      email:
        type: string
        description: The email of the user
      comment:
        type: string
        description: A comment regarding the user
      publickey:
        type: string
        description: The public key of the user
```

4.5.3 Account

To charge the use of resources accounting can be used. Accounting can be implemented on a variety of resources, such as users, groups or organizations. It is up to the implementer to provide rules and cost for it. If neededvvmultiple accounting resources can be implemented.

4.5.3.1 Schema Account

Reference: ☁

Property	Type	Description
name	string	name of account
description	string	the purpose of the account
charge	integer	The current chare of the account
unit	string	the unit in which the account is charged and the charge value is stored

4.5.3.2 Paths

HTTP	Path	Summary
get	/account	Returns a the accounts
get	/account/{name}	Returns the named account
put	/account/{name}	Set the value of a account
delete	/account/{name}	Deletes the named account

4.5.3.2.1 /account

4.5.3.2.1.1 GET /account

Returns the accounts

Responses

Code	Description	Schema
200	The list of accounts	array[Account]
401	Not authorized	String

4.5.3.2.2 /account/{name}

4.5.3.2.2.1 GET /account/{name}

Returns the named account

Responses

Code	Description	Schema
200	Returning the information of the account	Account
401	Not authorized	String
404	The named account could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the account	True	String

4.5.3.2.2.2 PUT /account/{name}

Set the value of the named account

Responses

Code	Description	Schema
200	Account updated or created	String
400	Error updating account	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The account and its value	True	Account

4.5.3.2.2.3 DELETE /account/{name}

Deletes a account by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named account could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the account	True	String

4.5.3.3 account.yaml

```{include=./spec/account.yaml}

## 4.5.4 Public Key Store

Many services and frameworks use Secure Shell (SSH) keys to authenticate. This service allows the convenient storage of the public keys.

4.5.4.1 Schema Key

Reference:

| Property | Type | Description |
|---|---|---|
| name | string | The name of the public key |
| value | string | The value of the public key |
| kind | string | The key kind such as rsa, dsa |
| group | string | An optional group name allowing to group keys to create custom key groups within the public key store |
| comment | string | A comment for the public key |
| uri | string | The uri of the public key if any |
```

fingerprint	string	The fingerprint of the public key

4.5.4.2 Paths

HTTP	Path	Summary
get	/key	Returns a list of keys
get	/key/{name}	Returns the named key
put	/key/{name}	Set a key
delete	/key/{name}	Deletes the named key

4.5.4.2.1 /key

4.5.4.2.1.1 GET /key

Returns a list of all keys

Responses

Code	Description	Schema
200	The list of keys	array[Key]
401	Not authorized	String

4.5.4.2.2 /key/{name}

4.5.4.2.2.1 GET /key/{name}

Returns a key by name

Responses

Code	Description	Schema
200	Returning the information of the key	Key
401	Not authorized	String
404	The named key could not be found	String

Parameters

Name	Located in	Description	Required	Schema

name	path	The name of the key	True	String

4.5.4.2.2.2 PUT /key/{name}

Sets the named key

Responses

Code	Description	Schema
200	Key updated	String
401	Not authorized	String
404	The named key could not be found	String

Request Body

Located in	Description	Required	Schema
Body	The new key to create	True	Key

4.5.4.2.2.3 DELETE /key/{name}

Deletes a key by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named key could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the key	True	String

4.5.4.3 publickeystore.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Public Key Store
```

```
  description: |-

    Many services and frameworks use Secure Shell (SSH) keys to
    authenticate. This service allows the convenient storage of the
    public keys.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /key:
    get:
      tags:
        - Key
      summary: Returns a list of keys
      description: Returns a list of all keys
      operationId: cloudmesh.key.list
      responses:
        '200':
          description: The list of keys
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Key'
        '401':
          description: Not authorized
  /key/{name}:
    get:
      tags:
        - Key
      summary: Returns the named key
      description: Returns a key by name
      operationId: cloudmesh.key.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the key
      responses:
        '200':
          description: Returning the information of the key
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Key'
        '401':
          description: Not authorized
        '404':
           description: The named key could not be found
    put:
      tags:
        - Key
      summary: Set a key
      description: Sets the named key
      operationId: cloudmesh.key.add
      requestBody:
        description: The new key to create
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Key'
      responses:
        '200':
          description: Key updated
        '401':
          description: Not authorized
        '404':
          description: The named key could not be found
    delete:
      tags:
        - Key
      summary: Deletes the named key
      description: Deletes a key by name
      operationId: cloudmesh.key.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
```

```
            type: string
          description: The name of the key
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named key could not be found
components:
  schemas:
    Key:
      type: object
      description: the public key
      properties:
        name:
          type: string
          description: The name of the public key
        value:
          type: string
          description: The value of the public key
        kind:
          type: string
          description: The key kind such as rsa, dsa
        group:
          type: string
          description: An optional group name allowing to group keys to create
                       custom key groups within the public key store
        comment:
          type: string
          description: A comment for the public key
        uri:
          type: string
          description: The uri of the public key if any
        fingerprint:
          type: string
          description: The fingerprint of the public key
```

4.6 Variable, Defualt, and Alias

4.6.1 Alias

Often a user has the desire to create a custom name for an object. An alias allows to do that while while assosication auser defined name or ***alias*** to a previouly used name. The aliases could be shared with other users. A name could have one or more aliases.

4.6.1.1 Schema Alias

Reference: ☁

Property	Type	Description
name	string	The name of the alias
source	string	The original unique object name

4.6.1.2 Paths

HTTP	Path	Summary
get	/alias	Returns a list of aliases
get	/alias/{name}	Returns the named alias

put	/alias/{name}	Set an alias
delete	/alias/{name}	Deletes the named alias

4.6.1.2.1 /alias

4.6.1.2.1.1 GET /alias

Returns a list of all aliases

Responses

Code	Description	Schema
200	The list of aliasses	array[Alias]
400	No alias found	String
401	Not authorized	String

4.6.1.2.2 /alias/{name}

4.6.1.2.2.1 GET /alias/{name}

Returns an alias by name

Responses

Code	Description	Schema
200	Returning the information of the alias	Alias
401	Not authorized	String
404	The named alias could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the alias	True	String

4.6.1.2.2.2 PUT /alias/{name}

Sets the named alias

Responses

Code	Description	Schema
200	Alias updated or created	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The new alias to create	True	Alias

4.6.1.2.2.3 DELETE /alias/{name}

Deletes an alias by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named alias could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the alias	True	String

4.6.1.3 alias.yaml

```
openapi: '3.0.2'
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Alias
  description: |-

    Often a user has the desire to create a custom name for an object. An
    alias allows to do that while while assosication auser defined name or
    *alias* to a previouly used name. The aliases could be shared with other
    users. A name could have one or more aliases.

  termsOfService: 'https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt'
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /alias:
    get:
```

```
    tags:
      - Alias
    summary: Returns a list of aliases
    description: Returns a list of all aliases
    operationId: cloudmesh.alias.list
    responses:
      '200':
        description: The list of aliasses
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: '#/components/schemas/Alias'
      '400':
         description: No alias found
      '401':
        description: Not authorized
  /alias/{name}:
    get:
      tags:
        - Alias
      summary: Returns the named alias
      description: Returns an alias by name
      operationId: cloudmesh.alias.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the alias
      responses:
        '200':
          description: Returning the information of the alias
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Alias'
        '401':
          description: Not authorized
        '404':
           description: The named alias could not be found
    put:
      tags:
        - Alias
      summary: Set an alias
      description: Sets the named alias
      operationId: cloudmesh.alias.add
      requestBody:
        description: The new alias to create
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Alias'
      responses:
        '200':
          description: Alias updated or created
        '401':
          description: Not authorized
    delete:
      tags:
        - Alias
      summary: Deletes the named alias
      description: Deletes an alias by name
      operationId: cloudmesh.alias.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the alias
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named alias could not be found
components:
  schemas:
    Alias:
      type: object
      description: the alias
      properties:
        name:
          type: string
```

```
        description: The name of the alias
      source:
        type: string
        description: The original unique object name
```

4.6.2 Variables

Variables are a simple string key value storage to store simple values. Each variable can have a datatype, so that it can be used for serialization into other formats. Internally they are storred as strings.

4.6.2.1 Schema Variable

Reference:

Property	Type	Description
name	string	Name of the variable
value	string	Value of the variable
description	string	A description of the variable
datatype	string	The data type of the variable which can be used for serialization

4.6.2.2 Paths

HTTP	Path	Summary
get	/variable	Returns a the variables
get	/variable/{name}	Returns the named variable
put	/variable/{name}	Set the value of a variable
delete	/variable/{name}	Deletes the named variable

4.6.2.2.1 /variable

4.6.2.2.1.1 GET /variable

Returns the variables

Responses

Code	Description	Schema
200	The list of variables	array[Variable]
400	No variable found	String

4.6.2.2.2 /variable/{name}

4.6.2.2.2.1 GET /variable/{name}

Returns the named variable

Responses

Code	Description	Schema
200	Returning the information of the variable	Variable
401	Not authorized	String
404	The named variable could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the variable	True	String

4.6.2.2.2.2 PUT /variable/{name}

Set the value of the named variable

Responses

Code	Description	Schema
200	Variable updated or created	String
400	Error updating variable	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The variable and its value	True	Variable

4.6.2.2.2.3 DELETE /variable/{name}

Deletes a variable by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named variable could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the variable	True	String

4.6.2.3 variables.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Variables
  description: |-

    Variables are a simple string key value storage to store simple
    values. Each variable can have a datatype, so that it can be used for
    serialization into other formats. Internally they are storred as strings.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /variable:
    get:
      tags:
        - Variable
      summary: Returns a the variables
      description: Returns the variables
      operationId: cloudmesh.variable.list
      responses:
        '200':
          description: The list of variables
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Variable'
        '400':
           description: No variable found
  /variable/{name}:
    get:
      tags:
        - Variable
      summary: Returns the named variable
      description: Returns the named variable
      operationId: cloudmesh.variable.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the variable
      responses:
        '200':
```

```
          description: Returning the information of the variable
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Variable'
        '401':
          description: Not authorized
        '404':
           description: The named variable could not be found
    put:
      tags:
        - Variable
      summary: Set the value of a variable
      description: Set the value of the named variable
      operationId: cloudmesh.variable.add
      requestBody:
        description: The variable and its value
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Variable'
      responses:
        '200':
          description: Variable updated or created
        '400':
          description: Error updating variable
        '401':
          description: Not authorized
    delete:
      tags:
        - Variable
      summary: Deletes the named variable
      description: Deletes a variable by name
      operationId: cloudmesh.variable.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the variable
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named variable could not be found
components:
  schemas:
    Variable:
      type: object
      description: the variables
      properties:
        name:
          type: string
          description: Name of the variable
        value:
          type: string
          description: Value of the variable
        description:
          type: string
          description: A description of the variable
        datatype:
          type: string
          description: The data type of the variable which can be used for
                       serialization
```

4.6.3 Default

A default is a special variable that has a context associated with it. This allows one to define values that can be easily retrieved based on the associated context. For example, a default could be the image name for a cloud where the context is defined by the cloud name.

4.6.3.1 Schema Default

Reference: ☁

Property	Type	Description
name	string	The name of the default
value	string	The value of the default
context	string	The context of the default

4.6.3.2 Paths

HTTP	Path	Summary
get	/default	Returns a list of defaults
get	/default/{name}	Returns the named default
put	/default/{name}	Set a default
delete	/default/{name}	Deletes the named default

4.6.3.2.1 /default

4.6.3.2.1.1 GET /default

Returns a list of all defaults

Responses

Code	Description	Schema
200	The list of defaults	array[Default]
401	Not authorized	String

4.6.3.2.2 /default/{name}

4.6.3.2.2.1 GET /default/{name}

Returns a default by name

Responses

Code	Description	Schema
200	Returning the information of the default	Default
401	Not authorized	String
404	The named default could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the default	True	String

4.6.3.2.2.2 PUT /default/{name}

Sets the named default

Responses

Code	Description	Schema
200	Default updated or created	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The new default to create	True	Default

4.6.3.2.2.3 DELETE /default/{name}

Deletes a default by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named default could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the default	True	String

4.6.3.3 default.yaml

```
openapi: "3.0.2"
info:
```

```
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Default
  description: |-

    A default is a special variable that has a context associated with
    it. This allows one to define values that can be easily retrieved
    based on the associated context. For example, a default could be
    the image name for a cloud where the context is defined by the
    cloud name.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /default:
    get:
      tags:
        - Default
      summary: Returns a list of defaults
      description: Returns a list of all defaults
      operationId: cloudmesh.default.list
      responses:
        '200':
          description: The list of defaults
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Default'
        '401':
          description: Not authorized
  /default/{name}:
    get:
      tags:
        - Default
      summary: Returns the named default
      description: Returns a default by name
      operationId: cloudmesh.default.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the default
      responses:
        '200':
          description: Returning the information of the default
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Default'
        '401':
          description: Not authorized
        '404':
           description: The named default could not be found
    put:
      tags:
        - Default
      summary: Set a default
      description: Sets the named default
      operationId: cloudmesh.default.add
      requestBody:
        description: The new default to create
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Default'
      responses:
        '200':
          description: Default updated or created
        '401':
          description: Not authorized
    delete:
      tags:
        - Default
      summary: Deletes the named default
      description: Deletes a default by name
      operationId: cloudmesh.default.delete_by_name
```

```
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the default
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named default could not be found
components:
  schemas:
    Default:
      type: object
      description: the defaults
      properties:
        name:
          type: string
          description: The name of the default
          example: "image"
        value:
          type: string
          description: The value of the default
          example: "m1.medium"
        context:
          type: string
          description: The context of the default
          example: "cloud.vm.flavor"
```

4.7 Data Management

4.7.1 Filestore

A file store is a resource allowing storage of data as a traditional file. A file store can contanin any number of files with additional attributes describing the file. A file store is located on the physical server. It contains access to the content of the file. This contrasts virtual directories that are just pointers to files, which could include files located in different file stores. A virtual directory also doe snot contain the content of the file, but just a pointer where to find the file.

4.7.1.1 Schema File

Reference:

Property	Type	Description
name	string	The name of the file
endpoint	string	The location of the file
checksum	string	The checksum of the file
size	integer	The size of the file in byte
content	string(binary)	the content of the file

4.7.1.2 Paths

HTTP	Path	Summary

get	/file	Returns a list of files in the file store
get	/file/{name}	Returns the named file in the file store
put	/file/{name}	Uploads a file to the list of files in the file store
delete	/file/{name}	Deletes the named file in the file store

4.7.1.2.1 /file

4.7.1.2.1.1 GET /file

Returns a list of all files

Responses

Code	Description	Schema
200	The list of files	array[File]
401	Not authorized	String

4.7.1.2.2 /file/{name}

4.7.1.2.2.1 GET /file/{name}

Returns an file by name in the file store

Responses

Code	Description	Schema
200	Returning the information of the file store	File
401	Not authorized	String
404	The named file could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the file	True	String

4.7.1.2.2.2 PUT /file/{name}

Uploads a file to the list of files in the file store

Responses

Code	Description	Schema
200	File updated or created	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The file to be uploaded	True	File

4.7.1.2.2.3 DELETE /file/{name}

Deletes an file by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named file could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the file	True	String

4.7.1.3 filestore.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: File
  description: |-

    A file store is a resource allowing storage of data as a traditional file.
    A file store can contanin any number of files with additional attributes
    describing the file. A file store is located on the physical  server. It
    contains access to the content of the file. This contrasts virtual
    directories that are just pointers to files, which could include files
    located in different file stores. A  virtual directory also doe snot
    contain the content of the file, but just a pointer where to find the file.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
```

```
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /file:
    get:
      tags:
        - File
      summary: Returns a list of files in the file store
      description: Returns a list of all files
      operationId: cloudmesh.file.list
      responses:
        '200':
          description: The list of files
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/File'
        '401':
          description: Not authorized
  /file/{name}:
    get:
      tags:
        - File
      summary: Returns the named file in the file store
      description: Returns an file by name in the file store
      operationId: cloudmesh.file.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the file
      responses:
        '200':
          description: Returning the information of the file store
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/File'
        '401':
          description: Not authorized
        '404':
          description: The named file could not be found
    put:
      tags:
        - File
      summary: Uploads a file to the list of files in the file store
      description: Uploads a file to the list of files in the file store
      operationId: cloudmesh.file.add
      requestBody:
        description: The file to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/File'
      responses:
        '200':
          description: File updated or created
        '401':
          description: Not authorized
    delete:
      tags:
        - File
      summary: Deletes the named file in the file store
      description: Deletes an file by name
      operationId: cloudmesh.file.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the file
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
          description: The named file could not be found
components:
  schemas:
    File:
      type: object
      description: an object representing a file
```

```
    properties:
      name:
        type: string
        description: The name of the file
      endpoint:
        type: string
        description: The location of the file
      checksum:
        type: string
        description: The checksum of the file
      size:
        type: integer
        description: The size of the file in byte
      content:
        type: string
        format: binary
        description: the content of the file
```

4.7.2 Replica

In many distributed systems, it is important that a file can be replicated among different systems to provide faster access. It is important to provide a mechanism to trace the pedigree of the file while pointing to its original source. A replica will point to a file in a file store and store the contents in the file store instead of the replica. The replica is just a pointer.

4.7.2.1 Schema Replica

Reference:

Property	Type	Description
name	string	The name of the replica
filename	string	The original filename
endpoint	string	The location of the file
checksum	string	The checksum of the file
size	integer	The size of the file in byte

4.7.2.2 Paths

HTTP	Path	Summary
get	/replica	Returns a list of replicas
get	/replica/{name}	Returns the named replica
put	/replica/{name}	Uploads a replica to the list of replicas
delete	/replica/{name}	Deletes the named replica

4.7.2.2.1 /replica

4.7.2.2.1.1 GET /replica

Returns a list of all replicas

Responses

Code	Description	Schema
200	The list of replicas	array[Replica]
401	Not authorized	String

4.7.2.2.2 /replica/{name}

4.7.2.2.2.1 GET /replica/{name}

Returns an replica by name

Responses

Code	Description	Schema
200	Returning the information of the replica	Replica
401	Not authorized	String
404	The named replica could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the replica	True	String

4.7.2.2.2.2 PUT /replica/{name}

Uploads a replica to the list of replicas

Responses

Code	Description	Schema
200	Replica updated or created	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema

Body	The replica to be uploaded	True	Replica

4.7.2.2.2.3 DELETE /replica/{name}

Deletes an replica by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named replica could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the replica	True	String

4.7.2.3 replica.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Replica
  description: |-

    In many distributed systems, it is important that a file can be
    replicated among different systems to provide faster access. It is
    important to provide a mechanism to trace the pedigree of the file
    while pointing to its original source. A replica will point to a file in
    a file store and store the contents in the file store instead of the
    replica. The replica is just a pointer.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /replica:
    get:
      tags:
        - Replica
      summary: Returns a list of replicas
      description: Returns a list of all replicas
      operationId: cloudmesh.replica.list
      responses:
        '200':
          description: The list of replicas
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Replica'
        '401':
          description: Not authorized
```

```
  /replica/{name}:
    get:
      tags:
        - Replica
      summary: Returns the named replica
      description: Returns an replica by name
      operationId: cloudmesh.replica.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the replica
      responses:
        '200':
          description: Returning the information of the replica
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Replica'
        '401':
          description: Not authorized
        '404':
          description: The named replica could not be found
    put:
      tags:
        - Replica
      summary: Uploads a replica to the list of replicas
      description: Uploads a replica to the list of replicas
      operationId: cloudmesh.replica.add
      requestBody:
        description: The replica to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Replica'
      responses:
        '200':
          description: Replica updated or created
        '401':
          description: Not authorized
    delete:
      tags:
        - Replica
      summary: Deletes the named replica
      description: Deletes an replica by name
      operationId: cloudmesh.replica.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the replica
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
          description: The named replica could not be found
components:
  schemas:
    Replica:
      type: object
      description: An entry representing a file replica record
      properties:
        name:
          type: string
          description: The name of the replica
        filename:
          type: string
          description: The original filename
        endpoint:
          type: string
          description: The location of the file
        checksum:
          type: string
          description: The checksum of the file
        size:
          type: integer
          description: The size of the file in byte
```

4.7.3 Database

The database specification allows to register a database and perform elementary operations to use this database. We distinguish actions related to the registration, the adding of a schema, the insertion of data and the query of data. The data base is defined by a name an endpoint (e.g., host, port), and a protocol used (e.g., SQL, MongoDB, graphgl, and others).

4.7.3.1 Schema Database

Reference:

Property	Type	Description
name	string	Name of the database
description	string	Description of the database
endpoint	string	Endpoint of the database
kind	string	the kind of the database

4.7.3.2 Schema Schema

Reference:

Property	Type	Description
name	string	Name of the database
description	string	Description of the database
kind	string	The kind of the definition
content	string	The schema associated with the table or collection

4.7.3.3 Schema Record

Reference:

Property	Type	Description
status	string	The status of the reurn
result	string	The result of the quesry in json string format

4.7.3.4 Schema Query

Reference:

Property	Type	Description

status	string	The query string

4.7.3.5 Paths

HTTP	Path	Summary
get	/database	Returns all databases
get	/database/{name}/schema	Get the list of the schema
put	/database/{name}/schema	Upload a schema
delete	/database/{name}/schema	Deletes a database from the list of databases
get	/database/{name}	Query the named database
put	/database/{name}	add data to the table or collection
delete	/database/{name}	Delete the objects matching the query

4.7.3.5.1 /database

4.7.3.5.1.1 GET /database

Returns all databases

Responses

Code	Description	Schema
200	List of databases	array[Database]
401	Not authorized	String
404	Named database not found	String

4.7.3.5.2 /database/{name}/schema

4.7.3.5.2.1 GET /database/{name}/schema

Responses

Code	Description	Schema
200	successfully returned the schema	array[Schema]
401	Not authorized	String
404	Named database not found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	Name of the schema	True	String

4.7.3.5.2.2 PUT /database/{name}/schema

Responses

Code	Description	Schema
200	successfully returned the list	Schema
401	Not authorized	String
404	Named database not found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	Name of the database	True	String

4.7.3.5.2.3 DELETE /database/{name}/schema

Deletes a database from the list of databases

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	Named database not found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	Name of the database	True	String

4.7.3.5.3 /database/{name}

4.7.3.5.3.1 GET /database/{name}

Query the named database

Responses

Code	Description	Schema
200	Successfull query	array[Record]
401	Not authorized	String
404	Named database not found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	Name of the database	True	String
query	query	Database Query	True	Query

4.7.3.5.3.2 PUT /database/{name}

Responses

Code	Description	Schema
200	successfully uploaded	Record
401	Not authorized	String
404	Named database not found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	Name of the database	True	String

Request Body

Located in	Description	Required	Schema
Body	Record to be uploaded	True	Record

4.7.3.5.3.3 DELETE /database/{name}

Responses

Code	Description	Schema
200	Successfull query	array[Record]
401	Not authorized	String
404	Named database not found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	Name of the database	True	String
query	query	Database Query	True	Query

4.7.3.6 database.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Database
  description: |-

    The database specification allows to register a database and perform
    elementary operations to use this database. We distinguish actions
    related to the registration, the adding of a schema, the insertion of
    data and the query of data. The data base is defined by a name an endpoint
    (e.g., host, port), and a protocol used (e.g., SQL, MongoDB, graphgl, and
     others).

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /database:
    get:
      tags:
        - "Database Registry"
      summary: Returns all databases
      description: Returns all databases
      operationId: cloudmesh.database.get
      responses:
        '200':
          description: List of databases
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: "#/components/schemas/Database"
        '401':
          description: Not authorized
        '404':
          description: Named database not found
  /database/{name}/schema:
    get:
      tags:
      - "Database Schema"
      summary: Get the list of the schema
      description: ""
      operationId: "cloudmesh.database.get.schema"
      parameters:
        - name: name
          description: Name of the schema
          in: path
          required: true
          schema:
```

```
          type: string
    responses:
      '200':
        description: "successfully returned the schema"
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: "#/components/schemas/Schema"
      '401':
        description: Not authorized
      '404':
        description: Named database not found
  put:
    tags:
    - "Database Schema"
    summary: "Upload  a schema"
    description: ""
    operationId: "cloudmesh.database.put.schema"
    parameters:
      - name: name
        description: Name of the database
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: "successfully returned the list"
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/Schema"
      '401':
        description: Not authorized
      '404':
        description: Named database not found
  delete:
    tags:
      - "Database Registry"
    summary: Deletes a database from the list of databases
    description: Deletes a database from the list of databases
    operationId: cloudmesh.database.delete
    parameters:
      - name: name
        description: Name of the database
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
      '404':
        description: Named database not found
/database/{name}:
  get:
    tags:
    - "Database Data"
    summary: Query the named database
    description: Query the named database
    operationId: "cloudmesh.database.data.get"
    parameters:
      - name: name
        description: Name of the database
        in: path
        required: true
        schema:
          type: string
      - in: query
        name: query
        description: Database Query
        required: true
        schema:
          $ref: '#/components/schemas/Query'
    responses:
      '200':
        description: Successfull query
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: "#/components/schemas/Record"
      '401':
        description: Not authorized
```

```
        '404':
          description: Named database not found
    put:
      tags:
      - "Database Data"
      summary: "add data to the table or collection"
      description: ""
      operationId: "cloudmesh.database.data.put"
      parameters:
        - name: name
          description: Name of the database
          in: path
          required: true
          schema:
            type: string
      requestBody:
        description: Record to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: "#/components/schemas/Record"
      responses:
        '200':
          description: "successfully uploaded"
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/Record"
        '401':
          description: Not authorized
        '404':
          description: Named database not found
    delete:
      tags:
      - "Database Data"
      summary: "Delete the objects matching the query"
      description: ""
      operationId: "cloudmesh.database.data.delete"
      parameters:
        - name: name
          description: Name of the database
          in: path
          required: true
          schema:
            type: string
        - name: query
          description: Database Query
          in: query
          required: true
          schema:
            $ref: '#/components/schemas/Query'
      responses:
        '200':
          description: Successfull query
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: "#/components/schemas/Record"
        '401':
          description: Not authorized
        '404':
          description: Named database not found
components:
  schemas:
    Database:
      type: object
      description: Defines a database object as an entry
      properties:
        name:
          type: string
          description: Name of the database
        description:
          type: string
          description: Description of the database
        endpoint:
          type: string
          description: Endpoint of the database
        kind:
          type: string
          description: the kind of the database
    Schema:
      type: object
      description: Defines a database
      properties:
        name:
          type: string
```

```
        description: Name of the database
      description:
        type: string
        description: Description of the database
      kind:
        type: string
        description: The kind of the definition
      content:
         type: string
         description: The schema associated with the table or collection
  Record:
    type: object
    description: The result of a query
    properties:
      status:
        type: string
        description: The status of the reurn
      result:
        type: string
        description: The result of the quesry in json string format
  Query:
    type: object
    description: The  query
    properties:
      status:
        type: string
        description: The query string
```

4.7.4 Virtual Directory

A virtual directory is a collection of files, replicas, streams or other virtual directories.

4.7.4.1 Schema Virtualdirectory

Reference:

Property	Type	Description
name	string	The name of the virtual directory
description	string	Description of the virtual directory
host	string	Remote host of the virtual directory
location	string	Remote location, e.g., a directory with full path on a host
protocol	string	Access protocol (e.g. HTTP, FTP, SSH, etc.)
credential	object	Credential to access

4.7.4.2 Paths

HTTP	Path	Summary
get	/virtualdirectory	Returns a list of virtual directories
get	/virtualdirectory/{name}	Returns the named virtual directory
put	/virtualdirectory/{name}	Uploads a virtual directory to the list of virtual directories

delete	/virtualdirectory/{name}	Deletes the named virtual directory
get	/virtualdirectory/{name}/{filename}	Returns the specific file of that virtual directory
put	/virtualdirectory/{name}/{filename}	Updates or adds a virtual file in the virtual directory
delete	/virtualdirectory/{name}/{filename}	Delete an user in the virtual directory

4.7.4.2.1 /virtualdirectory

4.7.4.2.1.1 GET /virtualdirectory

Returns a list of all virtual directories

Responses

Code	Description	Schema
200	The list of virtual directories	array[Virtualdirectory]
401	Not authorized	String

4.7.4.2.2 /virtualdirectory/{name}

4.7.4.2.2.1 GET /virtualdirectory/{name}

Returns an virtual directory by name

Responses

Code	Description	Schema
200	Returning the information of the virtual directory	Virtualdirectory
401	Not authorized	String
404	The named virtual directory could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual directory	True	String

4.7.4.2.2.2 PUT /virtualdirectory/{name}

Uploads a virtual directory to the list of virtual directories

Responses

Code	Description	Schema
200	Virtual directory updated or created	String
401	Not authorized	String
404	The named virtual directory could not be found	String

Request Body

Located in	Description	Required	Schema
Body	The virtual directory to be uploaded	True	Virtualdirectory

4.7.4.2.2.3 DELETE /virtualdirectory/{name}

Deletes an virtual directory by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named virtual directory could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual directory	True	String

4.7.4.2.3 /virtualdirectory/{name}/{filename}

4.7.4.2.3.1 GET /virtualdirectory/{name}/{filename}

Returns the specific file of that virtual directory

Responses

Code	Description	Schema
200	upload sucessful	File
401	Not authorized	String
404	The named virtual directory or file could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual directory	True	String
filename	path	The filename	True	String

4.7.4.2.3.2 PUT /virtualdirectory/{name}/{filename}

Updates or adds a virtual file in the virtual directory

Responses

Code	Description	Schema
200	User added sucessfully	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual directory	True	String
filename	path	The filename	True	String

Request Body

Located in	Description	Required	Schema
Body	The user to be uploaded	True	File

4.7.4.2.3.3 DELETE /virtualdirectory/{name}/{filename}

Delete an user in the virtual directory

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named virtual directory or file could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual directory	True	String
filename	path	The filename	True	String

4.7.4.3 virtualdirectory.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Virtual Directory
  description: |-

    A virtual directory is a collection of files, replicas, streams or other
    virtual directories.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup Service
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /virtualdirectory:
    get:
      tags:
        - Virtual directory
      summary: Returns a list of virtual directories
      description: Returns a list of all virtual directories
      operationId: cloudmesh.virtual directory.list
      responses:
        '200':
          description: The list of virtual directories
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Virtualdirectory'
        '401':
          description: Not authorized

  /virtualdirectory/{name}:
    get:
      tags:
        - Virtual directory
      summary: Returns the named virtual directory
      description: Returns an virtual directory by name
      operationId: cloudmesh.virtualdirectory.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the virtual directory
      responses:
        '200':
          description: Returning the information of the virtual directory
```

```
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Virtualdirectory'
      '401':
        description: Not authorized
      '404':
        description: The named virtual directory could not be found
  put:
    tags:
      - Virtual directory
    summary: Uploads a virtual directory to the list of virtual directories
    description: Uploads a virtual directory to the list of virtual directories
    operationId: cloudmesh.virtual directory.add
    requestBody:
      description: The virtual directory to be uploaded
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Virtualdirectory'
    responses:
      '200':
        description: Virtual directory updated or created
      '401':
        description: Not authorized
      '404':
        description: The named virtual directory could not be found
  delete:
    tags:
      - Virtual directory
    summary: Deletes the named virtual directory
    description: Deletes an virtual directory by name
    operationId: cloudmesh.virtualdirectory.delete_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the virtual directory
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
      '404':
        description: The named virtual directory could not be found
/virtualdirectory/{name}/{filename}:
  get:
    tags:
      - Virtual directory
    summary: Returns the specific file of that virtual directory
    description: Returns the specific file of that virtual directory
    operationId: cloudmesh.virtualdirectory.file.get_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the virtual directory
      - name: filename
        description: The filename
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: upload sucessful
        content:
          application/json:
            schema:
              $ref: "filestore.yaml#/components/schemas/File"
      '401':
        description: Not authorized
      '404':
        description: The named virtual directory or file could not be found
  put:
    tags:
      - Virtual directory
    summary: Updates or adds a virtual file  in the virtual directory
    description: Updates or adds a virtual file in the virtual directory
    operationId: cloudmesh.virtualdirectory.file.add
    parameters:
      - name: name
        in: path
        required: true
```

```
          schema:
            type: string
          description: The name of the virtual directory
        - name: filename
          description: The filename
          in: path
          required: true
          schema:
            type: string
      requestBody:
        description: The user to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: "filestore.yaml#/components/schemas/File"
      responses:
        '200':
          description: User added sucessfully
        '401':
          description: Not authorized
      '404':
        description: The named virtual directory or file could not be found
    delete:
      tags:
        - Virtual directory
      summary: Delete an user in the virtual directory
      description: Delete an user in the virtual directory
      operationId: cloudmesh.virtualdirectory.file.delete
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the virtual directory
        - name: filename
          description: The filename
          in: path
          required: true
          schema:
            type: string
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
          description: The named virtual directory or file could not be found
components:
  schemas:
    Virtualdirectory:
      type: object
      description: the virtual directory
      properties:
        name:
          description: The name of the virtual directory
          type: string
        description:
          description: Description of the virtual directory
          type: string
        host:
          description: Remote host of the virtual directory
          type: string
        location:
          description: Remote location, e.g., a directory with full path on a
            host
          type: string
        protocol:
          description: Access protocol (e.g. HTTP, FTP, SSH, etc.)
          type: string
        credential:
          description: Credential to access
          type: object
```

4.8 Compute Management - Virtual Clusters

4.8.1 Virtual Cluster

A Virtual Cluster is modeled as manager node, and one or more compute nodes. The manager

node usually serves as a login node and can be accessed from outside via a public IP. The compute nodes are connected to the manager node via a private, usually high performance (high throughput and low latency) network and thus accessible only from the manager node. To use the virtual cluster, login to the manager node, and from there one can login to any compute node, or submit a job to run on the compute nodes.

4.8.1.1 Schema Virtualcluster

Reference:

Property	Type	Description
name	string	The name of the virtual cluster
description	string	A description of the virtual cluster
owner	string	Username of the owner of the virtual cluster
manager	Node	Manager node of the virtual cluster
nodes	array[Node]	List of nodes of the virtual cluster

4.8.1.2 Schema Node

Reference:

Property	Type	Description
name	string	Name of the node
state	string	Power state of the node
ncpu	integer	Number of virtual CPUs of the node
ram	string	RAM size of the node
disk	string	Disk size of the node
nics	array[NIC]	List of network interfaces of the node

4.8.1.3 Schema NIC

Reference:

Property	Type	Description
mac	string	MAC address of the node
ip	string	IP address of the node

4.8.1.4 Paths

HTTP	Path	Summary
get	/virtualcluster	Returns a list of virtual clusters
get	/virtualcluster/{name}	Returns the named virtual cluster
put	/virtualcluster/{name}	Uploads an virtual cluster to the list of virtual clusters
delete	/virtualcluster/{name}	Deletes the named virtual cluster
get	/virtualcluster/{name}/{node}	Node of the named virtual cluster
put	/virtualcluster/{name}/{node}	Updates or adds a node to the virtual cluster
delete	/virtualcluster/{name}/{node}	Delete a node in the virtual cluster

4.8.1.4.1 /virtualcluster

4.8.1.4.1.1 GET /virtualcluster

Returns a list of all virtual clusters

Responses

Code	Description	Schema
200	The list of virtual clusters	array[Virtualcluster]
401	Not authorized	String

4.8.1.4.2 /virtualcluster/{name}

4.8.1.4.2.1 GET /virtualcluster/{name}

Returns an virtual cluster by name

Responses

Code	Description	Schema
200	Returning the information of the virtual cluster	Virtualcluster
401	Not authorized	String
404	The named virtual cluster could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual cluster	True	String

4.8.1.4.2.2 PUT /virtualcluster/{name}

Uploads an virtual cluster to the list of virtual clusters

Responses

Code	Description	Schema
200	Virtual cluster updated or created	String
401	Not authorized	String
404	The named virtual cluster could not be found	String

Request Body

Located in	Description	Required	Schema
Body	The virtual cluster to be uploaded	True	Virtualcluster

4.8.1.4.2.3 DELETE /virtualcluster/{name}

Deletes an virtual cluster by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named virtual cluster could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual cluster	True	String

4.8.1.4.3 /virtualcluster/{name}/{node}

4.8.1.4.3.1 GET /virtualcluster/{name}/{node}

Returns the specific node of the named virtual cluster. If the node name is manager, the manager node is used. A compute node can not be named manager

Responses

Code	Description	Schema
200	Node info	Node
401	Not authorized	String
404	The named virtual cluster or node could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual cluster	True	String
node	path	The node name	True	String

4.8.1.4.3.2 PUT /virtualcluster/{name}/{node}

Updates or adds a node to the virtual cluster. If the node name is manager, the manager node is uploaded.

Responses

Code	Description	Schema
200	Node added sucessfully	String
401	Not authorized	String
404	The named virtual cluster or node could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual cluster	True	String
node	path	The node name	True	String

Request Body

Located in	Description	Required	Schema
Body	The node to be uploaded	True	Node

4.8.1.4.3.3 DELETE /virtualcluster/{name}/{node}

Delete a node in the virtual cluster

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named virtual cluster or node could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the virtual cluster	True	String
node	path	The node name	True	String

4.8.1.5 virtualcluster.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Virtual Cluster
  description: |-

    A Virtual Cluster is modeled as manager node, and one or more
    compute nodes. The manager node usually serves as a login node and
    can be accessed from outside via a public IP. The compute nodes are
    connected to the manager node via a private, usually high performance (high
    throughput and low latency) network and thus accessible only from the
    manager node. To use the virtual cluster, login to the manager node, and
    from there one can login to any compute node, or submit a job to run on the
    compute nodes.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup Service
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /virtualcluster:
    get:
      tags:
        - Virtual cluster
      summary: Returns a list of virtual clusters
      description: Returns a list of all virtual clusters
      operationId: cloudmesh.virtualcluster.list
      responses:
        '200':
          description: The list of virtual clusters
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Virtualcluster'
        '401':
          description: Not authorized
```

```
/virtualcluster/{name}:
  get:
    tags:
      - Virtual cluster
    summary: Returns the named virtual cluster
    description: Returns an virtual cluster by name
    operationId: cloudmesh.virtualcluster.find_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the virtual cluster
    responses:
      '200':
        description: Returning the information of the virtual cluster
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Virtualcluster'
      '401':
        description: Not authorized
      '404':
        description: The named virtual cluster could not be found
  put:
    tags:
      - Virtual cluster
    summary: Uploads an virtual cluster to the list of virtual clusters
    description: Uploads an virtual cluster to the list of virtual clusters
    operationId: cloudmesh.virtualcluster.add
    requestBody:
      description: The virtual cluster to be uploaded
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Virtualcluster'
    responses:
      '200':
        description: Virtual cluster updated or created
      '401':
        description: Not authorized
      '404':
        description: The named virtual cluster could not be found
  delete:
    tags:
      - Virtual cluster
    summary: Deletes the named virtual cluster
    description: Deletes an virtual cluster by name
    operationId: cloudmesh.virtualcluster.delete_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the virtual cluster
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
      '404':
        description: The named virtual cluster could not be found
/virtualcluster/{name}/{node}:
  get:
    tags:
      - Virtual cluster
    summary: Node of the named virtual cluster
    description: Returns the specific node of the named virtual cluster. If
                 the node name is manager, the manager node is used. A
                 compute node can not be named manager
    operationId: cloudmesh.virtualcluster.node.get_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the virtual cluster
      - name: node
        description: The node name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
```

```
          description: Node info
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/Node"
        '401':
          description: Not authorized
        '404':
          description: The named virtual cluster or node could not be found
    put:
      tags:
        - Virtual cluster
      summary: Updates or adds a node to the virtual cluster
      description: Updates or adds a node to the virtual cluster. If
        the node name is manager, the manager node is uploaded.
      operationId: cloudmesh.virtualcluster.node.add
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the virtual cluster
        - name: node
          description: The node name
          in: path
          required: true
          schema:
            type: string
      requestBody:
        description: The node to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Node'
      responses:
        '200':
          description: Node added sucessfully
        '401':
          description: Not authorized
        '404':
          description: The named virtual cluster or node could not be found
    delete:
      tags:
        - Virtual cluster
      summary: Delete a node in the virtual cluster
      description: Delete a node in the virtual cluster
      operationId: cloudmesh.virtualcluster.node.delete
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the virtual cluster
        - name: node
          description: The node name
          in: path
          required: true
          schema:
            type: string
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
          description: The named virtual cluster or node could not be found
components:
  schemas:
    Virtualcluster:
      type: object
      properties:
        name:
          description: The name of the virtual cluster
          type: string
        description:
          type: string
          description: A description of the virtual cluster
        owner:
          type: string
          description: Username of the owner of the virtual cluster
        manager:
          description: Manager node of the virtual cluster
          $ref: "#/components/schemas/Node"
        nodes:
          description: List of nodes of the virtual cluster
          type: array
```

```
        items:
          $ref: "#/components/schemas/Node"
  Node:
    type: object
    properties:
      name:
        type: string
        description: Name of the node
      state:
        type: string
        description: Power state of the node
      ncpu:
        type: integer
        description: Number of virtual CPUs of the node
      ram:
        type: string
        description: RAM size of the node
      disk:
        type: string
        description: Disk size of the node
      nics:
        type: array
        description: List of network interfaces of the node
        items:
          $ref: "#/components/schemas/NIC"
  NIC:
    type: object
    properties:
      mac:
        type: string
        description: MAC address of the node
      ip:
        type: string
        description: IP address of the node
```

4.8.2 Network of Nodes

A Network of Nodes (NON) contains a number of compute nodes that are connected by a network and can be reached from each other. The concept is a generalization of the term Network of Workstations. In contrast to a Virtual Cluster it doe snot have a dedicated manager node. Network of nodes can be real or virtual. The same security context can be used to authenticate to all nodes in the network of nodes. This is typically done with a public keystore in which all keys are stored that allow access to the nodes.

4.8.2.1 Schema Non

Reference:

Property	Type	Description
name	string	The name of the network of nodes
description	string	A description of the network of nodes
nodes	array[Node]	List of nodes of the network of nodes

4.8.2.2 Paths

HTTP	Path	Summary
get	/non	Returns a list of network of nodess
		Uploads a network of nodes to the list of

put	/non/{name}	network of nodess

get	/non/{name}/publickeystore	Returns the information of the keystore
delete	/non/{name}/publickeystore	Deletes the keystore
put	/non/{name}/publickeystore	Adds a keystore
get	/non/{name}/node	Returns the named network of nodes
delete	/non/{name}/node	Deletes the named network of nodes
get	/non/{name}/node/{node}	Node of the named network of nodes
put	/non/{name}/node/{node}	Updates or adds a node to the network of nodes
delete	/non/{name}/node/{node}	Delete a node in the network of nodes

4.8.2.2.1 /non

4.8.2.2.1.1 GET /non

Returns a list of all network of nodess

Responses

Code	Description	Schema
200	The list of network of nodess	array[Non]
401	Not authorized	String

4.8.2.2.2 /non/{name}

4.8.2.2.2.1 PUT /non/{name}

Uploads a network of nodes to the list of network of nodess

Responses

Code	Description	Schema
200	Network of nodes updated or created.	String
400	Error updating network of nodes	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The network of nodes to be uploaded	True	Non

4.8.2.2.3 /non/{name}/publickeystore

4.8.2.2.3.1 GET /non/{name}/publickeystore

Returns a network of nodes by name

Responses

Code	Description	Schema
200	Returning the information of the network of nodes	string
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network of nodes	True	String

4.8.2.2.3.2 DELETE /non/{name}/publickeystore

Deletes a network of nodes by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network of nodes	True	String

4.8.2.2.3.3 PUT /non/{name}/publickeystore

Updates or adds a node to the network of nodes.

Responses

Code	Description	Schema
200	Node keystore added sucessfully	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network of nodes	True	String

4.8.2.2.4 /non/{name}/node

4.8.2.2.4.1 GET /non/{name}/node

Returns a network of nodes by name

Responses

Code	Description	Schema
200	Returning the information of the node	Non
401	Not authorized	String
404	The named network of nodes could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network of nodes	True	String

4.8.2.2.4.2 DELETE /non/{name}/node

Deletes a network of nodes by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named network of nodes could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network of nodes	True	String

4.8.2.2.5 /non/{name}/node/{node}

4.8.2.2.5.1 GET /non/{name}/node/{node}

Returns the specific node of the named network of nodes.

Responses

Code	Description	Schema
200	Node info	Node
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network of nodes	True	String
node	path	The node name	True	String

4.8.2.2.5.2 PUT /non/{name}/node/{node}

Updates or adds a node to the network of nodes

Responses

Code	Description	Schema
200	Node added sucessfully	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network of nodes	True	String

node	path	The node name	True	String

Request Body

Located in	Description	Required	Schema
Body	The node to be uploaded	True	Node

4.8.2.2.5.3 DELETE /non/{name}/node/{node}

Delete a node in the network of nodes

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network of nodes	True	String
node	path	The node name	True	String

4.8.2.3 non.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Network of Nodes
  description: |-

    A Network of Nodes (NON) contains a number of compute nodes that are
    connected by a network and can be reached from each other. The concept is a
    generalization of the term Network of Workstations. In contrast to a
    Virtual Cluster it doe snot have a dedicated manager node. Network of
    nodes can be real or virtual. The same security context can be used to
    authenticate to all nodes in the network of nodes. This is typically done
    with a public keystore in which all keys are stored that allow access to
    the nodes.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup Service
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /non:
    get:
      tags:
```

```
      - Network of nodes
    summary: Returns a list of network of nodess
    description: Returns a list of all network of nodess
    operationId: cloudmesh.non.list
    responses:
      '200':
        description: The list of network of nodess
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: '#/components/schemas/Non'
      '401':
        description: Not authorized
/non/{name}:
  put:
    tags:
      - Network of nodes
    summary: Uploads a network of nodes to the list of network of nodess
    description: Uploads a network of nodes to the list of network of nodess
    operationId: cloudmesh.non.add
    requestBody:
      description: The network of nodes to be uploaded
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Non'
    responses:
      '200':
        description: Network of nodes updated or created.
      '400':
        description: Error updating network of nodes
      '401':
        description: Not authorized
/non/{name}/publickeystore:
  get:
    tags:
      - Non
    summary: Returns the information of the keystore
    description: Returns a network of nodes by name
    operationId: cloudmesh.non.keystore.find_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the network of nodes
    responses:
      '200':
        description: Returning the information of the network of nodes
        content:
          application/json:
            schema:
              type: string
              description: the endpoint of the publickeystore
      '401':
        description: Not authorized
  delete:
    tags:
      - Network of nodes
    summary: Deletes the keystore
    description: Deletes a network of nodes by name
    operationId: cloudmesh.non.keystore.delete
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the network of nodes
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
  put:
    tags:
      - Network of nodes
    summary: Adds a keystore
    description: Updates or adds a node to the network of nodes.
    operationId: cloudmesh.non.keystore.add
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
```

```
        description: The name of the network of nodes
    responses:
      '200':
        description: Node keystore added sucessfully
      '401':
        description: Not authorized
/non/{name}/node:
  get:
    tags:
      - Non
    summary: Returns the named network of nodes
    description: Returns a network of nodes by name
    operationId: cloudmesh.non.find_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the network of nodes
    responses:
      '200':
        description: Returning the information of the node
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Non'
      '401':
        description: Not authorized
      '404':
        description: The named network of nodes could not be found
  delete:
    tags:
      - Network of nodes
    summary: Deletes the named network of nodes
    description: Deletes a network of nodes by name
    operationId: cloudmesh.non.delete_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the network of nodes
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
      '404':
        description: The named network of nodes could not be found
/non/{name}/node/{node}:
  get:
    tags:
      - Network of nodes
    summary: Node of the named network of nodes
    description: Returns the specific node of the named network of nodes.
    operationId: cloudmesh.non.node.get_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the network of nodes
      - name: node
        description: The node name
        in: path
        required: true
        schema:
          type: string
    responses:
      '200':
        description: Node info
        content:
          application/json:
            schema:
              $ref: "virtualcluster.yaml#/components/schemas/Node"
      '401':
        description: Not authorized
  put:
    tags:
      - Network of nodes
    summary: Updates or adds a node to the network of nodes
    description: Updates or adds a node to the network of nodes
    operationId: cloudmesh.non.node.add
    parameters:
      - name: name
        in: path
```

```
          required: true
          schema:
            type: string
          description: The name of the network of nodes
        - name: node
          description: The node name
          in: path
          required: true
          schema:
            type: string
      requestBody:
        description: The node to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: "virtualcluster.yaml#/components/schemas/Node"
      responses:
        '200':
           description: Node added sucessfully
        '401':
          description: Not authorized
    delete:
      tags:
        - Network of nodes
      summary: Delete a node in the network of nodes
      description: Delete a node in the network of nodes
      operationId: cloudmesh.non.node.delete
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the network of nodes
        - name: node
          description: The node name
          in: path
          required: true
          schema:
            type: string
      responses:
        '200':
           description: Deletion successful
        '401':
          description: Not authorized
components:
  schemas:
    Non:
      type: object
      properties:
        name:
          description: The name of the network of nodes
          type: string
        description:
          type: string
          description: A description of the network of nodes
        nodes:
          description: List of nodes of the network of nodes
          type: array
          items:
            $ref: "virtualcluster.yaml#/components/schemas/Node"
```

4.8.3 Scheduler

The queue is a special scheduler that allows tasks to be scheduled witle doing queue policies, such as LIFO, FIFO, and so on. A queue returns the next task to be executed. Tasks can be added and deleted.

4.8.3.1 Schema Task

Reference:

Property	Type	Description
name	string	Name of the scheduler

user	string	The username the task belongs to
description	string	The description of the task
kind	string	The kind of the task
content	string	The content of the task

4.8.3.2 Schema Policy

Reference:

Property	Type	Description
name	string	Name of the scheduler policy
description	string	The description of the policy
kind	string	The kind of the policy
parameters	string	parameters to define the behaviour of the scheduler

4.8.3.3 Paths

HTTP	Path	Summary
get	/task	Returns a list of tasks
get	/task/{name}	Returns the named task
put	/task/{name}	Uploads a task to the list of tasks
delete	/task/{name}	Deletes the named task
get	/policy	Returns the policy
put	/policy	Uploads the policy

4.8.3.3.1 /task

4.8.3.3.1.1 GET /task

Returns a list of all tasks

Responses

Code	Description	Schema
200	The list of tasks	array[Task]
400	No tasks found	String
401	Not authorized	String

4.8.3.3.2 /task/{name}

4.8.3.3.2.1 GET /task/{name}

Returns an task by name

Responses

Code	Description	Schema
200	Returning the information of the task	Task
400	No task found	String
401	Not authorized	String
404	The named task could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the task	True	String
operation	query	ERROR: description missing	False	String

4.8.3.3.2.2 PUT /task/{name}

Uploads a task to the list of tasks

Responses

Code	Description	Schema
200	Task updated	String
400	Error updating task.	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the task	True	String

Request Body

Located in	Description	Required	Schema
Body	The task to be uploaded	True	Task

4.8.3.3.2.3 DELETE /task/{name}

Deletes an task by name

Responses

Code	Description	Schema
200	Deletion successful	String
400	No task found	String
401	Not authorized	String
404	The named task could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the task	True	String

4.8.3.3.3 /policy

4.8.3.3.3.1 GET /policy

Returns the polocy

Responses

Code	Description	Schema
200	The policy	array[Policy]
400	No tasks found	String
401	Not authorized	String

4.8.3.3.3.2 PUT /policy

Uploads a task to the list of tasks

Responses

Code	Description	Schema
200	Task updated	String
400	Error updating task	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The Policy	True	Policy

4.8.3.4 scheduler.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Scheduler
  description: |-

    The queue is a special scheduler that allows tasks to be scheduled
    witle doing queue policies, such as LIFO, FIFO, and so on.
    A queue returns the next task to be executed. Tasks can be added
     and
    deleted.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3/scheduler
paths:
  /task:
    get:
      tags:
        - Task
      summary: Returns a list of tasks
      description: Returns a list of all tasks
      operationId: cloudmesh.task.list
      responses:
        '200':
          description: The list of tasks
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Task'
        '400':
          description: No tasks found
        '401':
          description: Not authorized
  /task/{name}:
    get:
      tags:
        - Task
      summary: Returns the named task
      description: Returns an task by name
      operationId: cloudmesh.task.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the task
        - in: query
          name: operation
```

```
        schema:
          type: string
          enum:
            - info
            - pop
    responses:
      '200':
        description: Returning the information of the task
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Task'
      '400':
        description: No task found
      '401':
        description: Not authorized
      '404':
        description: The named task could not be found
  put:
    tags:
      - Task
    summary: Uploads a task to the list of tasks
    description: Uploads a task to the list of tasks
    operationId: cloudmesh.task.add
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the task
    requestBody:
      description: The task to be uploaded
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Task'
    responses:
      '200':
        description: Task updated
      '400':
        description: Error updating task.
      '401':
        description: Not authorized
  delete:
    tags:
      - Task
    summary: Deletes the named task
    description: Deletes an task by name
    operationId: cloudmesh.task.delete_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the task
    responses:
      '200':
        description: Deletion successful
      '400':
        description: No task found
      '401':
        description: Not authorized
      '404':
        description: The named task could not be found
/policy:
  get:
    tags:
      - Task
    summary: Returns the policy
    description: Returns the polocy
    operationId: cloudmesh.task.policy.list
    responses:
      '200':
        description: The policy
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: '#/components/schemas/Policy'
      '400':
        description: No tasks found
      '401':
        description: Not authorized
  put:
    tags:
```

```
      - Task
    summary: Uploads the policy
    description: Uploads a task to the list of tasks
    operationId: cloudmesh.task.policy.add
    requestBody:
      description: The Policy
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Policy'
    responses:
      '200':
        description: Task updated
      '400':
        description: Error updating task
      '401':
        description: Not authorized
components:
  schemas:
    Task:
      type: object
      description: The scheduler
      properties:
        name:
          type: string
          description: Name of the scheduler
        user:
          type: string
          description: The username the task belongs to
        description:
          type: string
          description: The description of the task
        kind:
          type: string
          description: The kind of the task
        content:
          type: string
          description: The content of the task
    Policy:
      type: object
      description: The policy of the scheduler
      properties:
        name:
          type: string
          description: Name of the scheduler policy
        description:
          type: string
          description: The description of the policy
        kind:
          type: string
          description: The kind of the policy
        parameters:
          type: string
          description: parameters to define the behaviour of the scheduler
```

4.8.4 Queue

The queue is a special scheduler that allows tasks to be scheduled witle doing queue policies, such as LIFO, FIFO, and so on. A queue returns the next task to be executed. Tasks can be added and deleted.

4.8.4.1 Schema Task

Reference:

Property	Type	Description
name	string	name of the scheduler
user	string	the username the task belongs to
description	string	The description of the task

kind	string	The kind of the task

4.8.4.2 Schema Policy

Reference:

Property	Type	Description
name	string	name of the scheduler policy
description	string	The description of the policy
kind	string	The kind of the policy
parameters	string	parameters to define the behaviour of the scheduler

4.8.4.3 Paths

HTTP	Path	Summary
get	/task	Returns a list of tasks
get	/task/{name}	Returns the named task
put	/task/{name}	Uploads a task to the list of tasks
delete	/task/{name}	Deletes the named task
get	/policy	Returns the policy found
put	/policy	Uploads the policy

4.8.4.3.1 /task

4.8.4.3.1.1 GET /task

Returns a list of all tasks

Responses

Code	Description	Schema
200	The list of tasks	array[Task]
401	Not authorized	String

4.8.4.3.2 /task/{name}

4.8.4.3.2.1 GET /task/{name}

Returns an task by name

Responses

Code	Description	Schema
200	Returning the information of the task	Task
401	Not authorized	String
404	The named task could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the task	True	String
operation	query	Show the task but do not remove it from the queue	False	String

4.8.4.3.2.2 PUT /task/{name}

Uploads a task to the list of tasks

Responses

Code	Description	Schema
200	Task updated	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the task	True	String

Request Body

Located in	Description	Required	Schema
Body	The task to be uploaded	True	Task

4.8.4.3.2.3 DELETE /task/{name}

Deletes an task by name

Responses

Code	Description	Schema
200	Deletion successful	String
400	Error to delete the task	String
401	Not authorized	String
404	The named task could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the task	True	String

4.8.4.3.3 /policy

4.8.4.3.3.1 GET /policy

Returns the policy

Responses

Code	Description	Schema
200	The policy	array[Policy]
401	Not authorized	String

4.8.4.3.3.2 PUT /policy

Uploads a task to the list of tasks

Responses

Code	Description	Schema
200	Task updated	String
400	Error updating	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The policy to be uploaded	True	Policy

4.8.4.4 queue.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Queue
  description: |-

    The queue is a special scheduler that allows tasks to be scheduled
    witle doing queue policies, such as LIFO, FIFO, and so on.
    A queue returns the next task to be executed. Tasks can be added
     and
    deleted.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3/scheduler
paths:
  /task:
    get:
      tags:
        - Task
      summary: Returns a list of tasks
      description: Returns a list of all tasks
      operationId: cloudmesh.task.list
      responses:
        '200':
          description: The list of tasks
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Task'
        '401':
          description: Not authorized
  /task/{name}:
    get:
      tags:
        - Task
      summary: Returns the named task
      description: Returns an task by name
      operationId: cloudmesh.task.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the task
        - in: query
          name: operation
          description: Show the task but do not remove it   from the queue
          schema:
            type: string
            enum:
              - info
      responses:
        '200':
          description: Returning the information of the task
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Task'
        '401':
          description: Not authorized
        '404':
          description: The named task could not be found
    put:
      tags:
        - Task
```

```
      summary: Uploads a task to the list of tasks
      description: Uploads a task to the list of tasks
      operationId: cloudmesh.task.add
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the task
      requestBody:
        description: The task to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Task'
      responses:
        '200':
          description: Task updated
        '401':
          description: Not authorized
    delete:
      tags:
        - Task
      summary: Deletes the named task
      description: Deletes an task by name
      operationId: cloudmesh.task.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the task
      responses:
        '200':
          description: Deletion successful
        '400':
          description: Error to delete the task
        '401':
          description: Not authorized
        '404':
          description: The named task could not be found
  /policy:
    get:
      tags:
        - Task
      summary: Returns the policy found
      description: Returns the policy
      operationId: cloudmesh.task.policy.list
      responses:
        '200':
          description: The policy
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Policy'
        '401':
          description: Not authorized
    put:
      tags:
        - Task
      summary: Uploads the policy
      description: Uploads a task to the list of tasks
      operationId: cloudmesh.task.policy.add
      requestBody:
        description: The policy to be uploaded
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Policy'
      responses:
        '200':
          description: Task updated
        '400':
          description: Error updating
        '401':
          description: Not authorized
components:
  schemas:
    Task:
      type: object
      description: the scheduler
      properties:
        name:
```

```
        type: string
        description: name of the scheduler
      user:
        type: string
        description: the username the task belongs to
      description:
        type: string
        description: The description of the task
      kind:
        type: string
        description: The kind of the task
  Policy:
    type: object
    description: The policy of the scheduler
    properties:
      name:
        type: string
        description: name of the scheduler policy
      description:
        type: string
        description: The description of the policy
      kind:
        type: string
        description: The kind of the policy
      parameters:
        type: string
        description: parameters to define the behaviour of the scheduler
```

4.9 Compute Management - Virtual Machines

This section summarizes a basic interface specification of virtual machines.

4.9.1 Image

To execute virtual machines, we need an image that specifies the details of the operating system.

4.9.1.1 Schema Image

Reference:

Property	Type	Description
name	string	A unique name of the image
cloud	string	The name of the cloud
label	string	A label that can be defined by the user for the image
description	string	A description for the image
osType	string	The OS type of the image
osVersion	string	The OS version of the image
status	string	The status of the image
progress	integer	The loading progress percentage of the image
visibility	string	The visibility of the image
requirement	Requirements	Minimum requirement to run the image

4.9.1.2 Schema Requirements

Reference:

Property	Type	Description
size	integer	Minimum disk size in bytes required for the image
ram	integer	Minimum ram size in bytes to run the image
cpu	string	CPU required to run the image
cores	integer	Minimum number of cores

4.9.1.3 Paths

HTTP	Path	Summary
get	/image/{cloud}	Returns a list of images for the cloud
get	/image/{cloud}/{name}	Returns the named image
put	/image/{cloud}/{name}	Add a image
delete	/image/{cloud}/{name}	Deletes the named image

4.9.1.3.1 /image/{cloud}

4.9.1.3.1.1 GET /image/{cloud}

Returns a list of all images

Responses

Code	Description	Schema
200	The list of images	array[Image]
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String

4.9.1.3.2 /image/{cloud}/{name}

4.9.1.3.2.1 GET /image/{cloud}/{name}

Returns a image by name

Responses

Code	Description	Schema
200	Returning the information of the image	Image
401	Not authorized	String
404	The named image could not be found	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String
name	path	The name of the image	True	String

4.9.1.3.2.2 PUT /image/{cloud}/{name}

Sets the named image

Responses

Code	Description	Schema
200	Image updated or created	String
401	Not authorized	String
404	The named image could not be found	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String

Request Body

Located in	Description	Required	Schema
Body	The image to add or modify	True	Image

4.9.1.3.2.3 DELETE /image/{cloud}/{name}

Deletes a image by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named image could not be found	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String
name	path	The name of the image	True	String

4.9.1.4 image.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Image
  description: |-

    To execute virtual machines, we need an image that specifies the
    details of the operating system.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /image/{cloud}:
    get:
      tags:
        - Image
      summary: Returns a list of images for the cloud
      description: Returns a list of all images
      operationId: cloudmesh.image.list
      parameters:
        - name: cloud
          in: path
          required: true
          schema:
            type: string
          description: The name of the cloud
      responses:
        '200':
          description: The list of images
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Image'
        '401':
          description: Not authorized
  /image/{cloud}/{name}:
    get:
      tags:
        - Image
```

```
      summary: Returns the named image
      description: Returns a image by name
      operationId: cloudmesh.image.find_by_name
      parameters:
        - name: cloud
          in: path
          description: The name of the cloud
          required: true
          schema:
            type: string
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the image
      responses:
        '200':
          description: Returning the information of the image
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Image'
        '401':
          description: Not authorized
        '404':
           description: The named image could not be found
    put:
      tags:
        - Image
      summary: Add a image
      description: Sets the named image
      operationId: cloudmesh.image.add
      parameters:
        - name: cloud
          in: path
          required: true
          schema:
            type: string
          description: The name of the cloud
      requestBody:
        description: The image to add or modify
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Image'
      responses:
        '200':
          description: Image updated or created
        '401':
          description: Not authorized
        '404':
          description: The named image could not be found
    delete:
      tags:
        - Image
      summary: Deletes the named image
      description: Deletes a image by name
      operationId: cloudmesh.image.delete_by_name
      parameters:
        - name: cloud
          description: The name of the cloud
          in: path
          required: true
          schema:
            type: string
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the image
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named image could not be found
components:
  schemas:
    Image:
      type: object
      properties:
        name:
          type: string
          description: A unique name of the image
        cloud:
```

```
        type: string
        description: The name of the cloud
      label:
        type: string
        description: A label that can be defined by the user for the image
      description:
        type: string
        description: A description for the image
      osType:
        type: string
        description: The OS type of the image
      osVersion:
        type: string
        description: The OS version of the image
      status:
        type: string
        description: The status of the image
      progress:
        type: integer
        description: The loading progress percentage of the image
      visibility:
        description: The visibility of the image
        type: string
      requirement:
        $ref: "#/components/schemas/Requirements"
        description: Minimum requirement to run the image
  Requirements:
    type: object
    properties:
      size:
        type: integer
        description: Minimum disk size in bytes required for the image
      ram:
        type: integer
        description: Minimum ram size in bytes to run the image
      cpu:
        type: string
        description: CPU required to run the image
      cores:
        type: integer
        description:  Minimum number of cores
```

4.9.2 Flavor

The flavor specifies elementary information about a virtual machine or compute node. This information includes name, id, label, ram size, swap size, disk space, availability of ephemeral disk, available bandwidth, price value, cloud name. Flavors and the corresponding information are essential to size a virtual cluster appropriately.

4.9.2.1 Schema Flavor

Reference:

Property	Type	Description
name	string	Name of the flavor
id	string	The id of the flavor for the named cloud
label	string	A label that a user can set for this flavor
description	string	A description for the flavor
ram	integer	Number of bytes used for the image in RAM
swap	integer	Number of bytes used for the image in SWAP
disk	integer	Number of bytes used for the disk
ephemeral_disk	boolean	

		Specifies whether the flavor features an ephemeral disk
bandwidth	integer	Bandwidth of the node
price	number	Price for the flavor
cloud	string	Name of the cloud this flavor is used in

4.9.2.2 Paths

HTTP	Path	Summary
get	/flavor/{cloud}	Returns a list of flavors for the cloud
get	/flavor/{cloud}/{name}	Returns the named flavor
put	/flavor/{cloud}/{name}	Add a flavor
delete	/flavor/{cloud}/{name}	Deletes the named flavor

4.9.2.2.1 /flavor/{cloud}

4.9.2.2.1.1 GET /flavor/{cloud}

Returns a list of all flavors

Responses

Code	Description	Schema
200	The list of flavors	array[Flavor]
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String

4.9.2.2.2 /flavor/{cloud}/{name}

4.9.2.2.2.1 GET /flavor/{cloud}/{name}

Returns a flavor by name

Responses

Code	Description	Schema
200	Returning the information of the flavor	Flavor
401	Not authorized	String
404	The named flavor could not be found	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String
name	path	The name of the flavor	True	String

4.9.2.2.2.2 PUT /flavor/{cloud}/{name}

Sets the named flavor

Responses

Code	Description	Schema
200	Flavor updated	String
401	Not authorized	String
404	The named flavor could not be found	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String

Request Body

Located in	Description	Required	Schema
Body	The flavor to add or modify	True	Flavor

4.9.2.2.2.3 DELETE /flavor/{cloud}/{name}

Deletes a flavor by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named flavor could not be found	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String
name	path	The name of the flavor	True	String

4.9.2.3 flavor.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Flavor
  description: |-

    The flavor specifies elementary information about a virtual machine
    or compute node. This information includes name, id, label, ram size,
    swap size, disk space, availability of ephemeral disk, available
    bandwidth, price value, cloud name. Flavors and the corresponding
    information are essential to size a
    virtual cluster appropriately.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /flavor/{cloud}:
    get:
      tags:
        - Flavor
      summary: Returns a list of flavors for the cloud
      description: Returns a list of all flavors
      operationId: cloudmesh.flavor.list
      parameters:
        - name: cloud
          in: path
          required: true
          schema:
            type: string
          description: The name of the cloud
      responses:
        '200':
          description: The list of flavors
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Flavor'
        '401':
          description: Not authorized
  /flavor/{cloud}/{name}:
    get:
      tags:
        - Flavor
      summary: Returns the named flavor
      description: Returns a flavor by name
      operationId: cloudmesh.flavor.find_by_name
      parameters:
```

```
      - name: cloud
        in: path
        description: The name of the cloud
        required: true
        schema:
          type: string
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the flavor
    responses:
      '200':
        description: Returning the information of the flavor
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Flavor'
      '401':
        description: Not authorized
      '404':
         description: The named flavor could not be found
  put:
    tags:
      - Flavor
    summary: Add a flavor
    description: Sets the named flavor
    operationId: cloudmesh.flavor.add
    parameters:
      - name: cloud
        in: path
        required: true
        schema:
          type: string
        description: The name of the cloud
    requestBody:
      description: The flavor to add or modify
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Flavor'
    responses:
      '200':
        description: Flavor updated
      '401':
        description: Not authorized
      '404':
        description: The named flavor could not be found
  delete:
    tags:
      - Flavor
    summary: Deletes the named flavor
    description: Deletes a flavor by name
    operationId: cloudmesh.flavor.delete_by_name
    parameters:
      - name: cloud
        description: The name of the cloud
        in: path
        required: true
        schema:
          type: string
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the flavor
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
      '404':
         description: The named flavor could not be found
components:
  schemas:
    Flavor:
      type: object
      description: The flavor
      properties:
        name:
          type: string
          description: Name of the flavor
        id:
          type: string
          description: The id of the flavor for the named cloud
        label:
```

```
      type: string
      description: A label that a user can set for this flavor
    description:
      type: string
      description: A description for the flavor
    ram:
      type: integer
      description: Number of bytes used for the image in RAM
    swap:
      type: integer
      description: Number of bytes used for the image in SWAP
    disk:
      type: integer
      description: Number of bytes used for the disk
    ephemeral_disk:
      type: boolean
      description: Specifies whether the flavor features an ephemeral disk
    bandwidth:
      type: integer
      description: Bandwidth of the node
    price:
      type: number
      description: Price for the flavor
    cloud:
      type: string
      description: Name of the cloud this flavor is used in
```

4.9.3 Virtual Machine

Vm is used to manage virtual machines.

4.9.3.1 Schema Vm

Reference:

Property	Type	Description
provider	string	Name of the provider
name	string	the unique name of the virtual machine
image	string	the image name for the virtual machine
flavor	string	the flavor name for the virtual machine
region	string	an optional region
state	string	The state of the virtual machine
private_ips	string	The private IPs
public_ips	string	The public IPS
metadata	string	The meta data passed along to the virtual machine

4.9.3.2 Paths

HTTP	Path	Summary
get	/vm/{cloud}	Returns a list of virtual machines for the cloud
get	/vm/{cloud}/{name}	Returns the named virtual machine
put	/vm/{cloud}/{name}	Add a virtual machine

delete	/vm/{cloud}/{name}	Deletes the named virtual machine

4.9.3.2.1 /vm/{cloud}

4.9.3.2.1.1 GET /vm/{cloud}

Returns a list of all virtual machines

Responses

Code	Description	Schema
200	The list of virtual machines	array[Vm]
400	No Vm found	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String

4.9.3.2.2 /vm/{cloud}/{name}

4.9.3.2.2.1 GET /vm/{cloud}/{name}

Returns a virtual machine by name

Responses

Code	Description	Schema
200	Returning the information of the virtual machine	Vm
400	Error updating virtual machine	String
401	Not authorized	String
404	The named virtual machine or cloud could not be found	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String
name	path	The name of the virtual machine	True	String

4.9.3.2.2.2 PUT /vm/{cloud}/{name}

Sets the named virtual machine

Responses

Code	Description	Schema
200	Vm updated	String
400	Error updating virtual machine	String
401	Not authorized	String
404	The named virtual machine or cloud could not be found	String

Parameters

Name	Located in	Description	Required	Schema
cloud	path	The name of the cloud	True	String

Request Body

Located in	Description	Required	Schema
Body	The virtual machine to add or modify	True	Vm

4.9.3.2.2.3 DELETE /vm/{cloud}/{name}

Deletes a virtual machine by name

Responses

Code	Description	Schema
200	Deletion successful	String
400	Error updating virtual machine	String
401	Not authorized	String
404	The named virtual machine or cloud could not be found	String

Parameters

Name	Located in	Description	Required	Schema

cloud	path	The name of the cloud	True	String
name	path	The name of the virtual machine	True	String

4.9.3.3 vm.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Virtual Machine
  description: |-

    Vm is used to manage virtual machines.

  termsOfService: https://github.com/cloudmesh-community/nist/blob/master/LICENSE.txt
  contact:
    name: NIST BDRA Interface Subgroup Service
    url: https://cloudmesh-community.github.io/nist/spec/
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /vm/{cloud}:
    get:
      tags:
        - Vm
      summary: Returns a list of virtual machines for the cloud
      description: Returns a list of all virtual machines
      operationId: cloudmesh.vm.list
      parameters:
        - name: cloud
          in: path
          required: true
          schema:
            type: string
          description: The name of the cloud
      responses:
        '200':
          description: The list of virtual machines
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Vm'
        '400':
           description: No Vm found
        '401':
          description: Not authorized
  /vm/{cloud}/{name}:
    get:
      tags:
        - Vm
      summary: Returns the named virtual machine
      description: Returns a virtual machine by name
      operationId: cloudmesh.vm.find_by_name
      parameters:
        - name: cloud
          in: path
          description: The name of the cloud
          required: true
          schema:
            type: string
        - name: name
          in: path
          description: The name of the virtual machine
          required: true
          schema:
            type: string
      responses:
        '200':
          description: Returning the information of the virtual machine
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Vm'
        '400':
          description: Error updating virtual machine
        '401':
          description: Not authorized
```

```
        '404':
          description: The named virtual machine or cloud could not be found
    put:
      tags:
        - Vm
      summary: Add a virtual machine
      description: Sets the named virtual machine
      operationId: cloudmesh.vm.add
      parameters:
        - name: cloud
          in: path
          required: true
          schema:
            type: string
          description: The name of the cloud
      requestBody:
        description: The virtual machine to add or modify
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Vm'
      responses:
        '200':
          description: Vm updated
        '400':
          description: Error updating virtual machine
        '401':
          description: Not authorized
        '404':
          description: The named virtual machine or cloud could not be found
    delete:
      tags:
        - Vm
      summary: Deletes the named virtual machine
      description: Deletes a virtual machine by name
      operationId: cloudmesh.vm.delete_by_name
      parameters:
        - name: cloud
          description: The name of the cloud
          in: path
          required: true
          schema:
            type: string
        - name: name
          in: path
          description: The name of the virtual machine
          required: true
          schema:
            type: string
      responses:
        '200':
          description: Deletion successful
        '400':
           description: Error updating virtual machine
        '401':
          description: Not authorized
        '404':
           description: The named virtual machine or cloud could not be found
components:
  schemas:
    Vm:
      type: object
      properties:
        provider:
          type: string
          description: Name of the provider
        name:
          type: string
          description: the unique name of the virtual machine
        image:
          type: string
          description: the image name for the virtual machine
        flavor:
          type: string
          description: the flavor name for the virtual machine
        region:
          type: string
          description: an optional region
        state:
          type: string
          description: The state of the virtual machine
        private_ips:
          type: string
          description: The private IPs
        public_ips:
          type: string
          description: The public IPS
        metadata:
```

```
        type: string
        description: The meta data passed along to the virtual machine
```

4.9.4 Secgroup

A security group defines the incoming and outgoing security rules which can then be assigned to a node. The connection to and from the node will be determined by the security group rules, in addition to any other possible rules applied on network devices or from the instance's firewall settings. A security group may have one or multiple rules and a node may be associated with one or more security groups.

4.9.4.1 Schema Secgroup

Reference:

Property	Type	Description
name	string	Name of the security group
description	string	Describes what the security group is for
rules	array[SecGroupRule]	List of Security group rules

4.9.4.2 Schema SecGroupRule

Reference:

Property	Type	Description
name	string	Unique name of the rule
ingress	boolean	The defined security group rule is for ingress if True
egress	boolean	The defined security group rule is for egress if True
remote_group	string	Name of the group if the rule is defined by group instead of IP range
protocol	string	The protocol used such as TCP, UDP, ICMP
from_port	integer	Port range starting port
to_port	integer	Port range ending port
cidr	string	The source or destination network in CIDR notation,

4.9.4.3 Paths

HTTP	Path	Summary
get	/secgroup	Returns all security groups

get	/secgroup/{name}	Return the security group by name
post	/secgroup/{name}	Create the named security group
get	/secgroup/{name}/rule/{rule}	Get an existing rule from the specified security group
put	/secgroup/{name}/rule/{rule}	Create or update specified security group
delete	/secgroup/{name}/rule/{rule}	Delete an existing rule from the specified security group

4.9.4.3.1 /secgroup

4.9.4.3.1.1 GET /secgroup

Returns all security groups

Responses

Code	Description	Schema
200	security group information	array[Secgroup]
401	Not authorized	String

4.9.4.3.2 /secgroup/{name}

4.9.4.3.2.1 GET /secgroup/{name}

Return the security group by name

Responses

Code	Description	Schema
200	security group information	Secgroup
401	Not authorized	String
404	The named security group could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	name of the security group	True	String

4.9.4.3.2.2 POST /secgroup/{name}

Create a new named security group

Responses

Code	Description	Schema
201	Created	String
400	The group could not be created	String
401	Not authorized	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the security group to create	True	String

4.9.4.3.3 /secgroup/{name}/rule/{rule}

4.9.4.3.3.1 GET /secgroup/{name}/rule/{rule}

Create a new rule in security group

Responses

Code	Description	Schema
200	The security group rule definition info	Secgrouprule
401	Not authorized	String
404	The named security group or role could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The named of the security group from which the rule will be deleted	True	String
rule	path	The rule to be added	True	String

4.9.4.3.3.2 PUT /secgroup/{name}/rule/{rule}

Create a new rule in security group

Responses

Code	Description	Schema
200	Created	String
401	Not authorized	String
404	The named security group or role could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the new security group to create	True	String

Request Body

Located in	Description	Required	Schema
Body	The new security group rule to create	True	SecGroupRule

4.9.4.3.3.3 DELETE /secgroup/{name}/rule/{rule}

Create a new rule in security group

Responses

Code	Description	Schema
200	Deleted sucessfully	String
401	Not authorized	String
404	The named security group or role could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The named secgroup	True	String
rule	path	The secgroup rule	True	String

4.9.4.4 secgroup.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Secgroup
  description: |-

   A security group defines the incoming and outgoing security rules
   which can then be assigned to a node. The connection to and from the node
   will be determined by the security group rules, in addition to any other
   possible rules applied on network devices or from the instance's firewall
   settings. A security group may have one or multiple rules and a node may be
   associated with one or more security groups.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /secgroup:
    get:
      tags:
      - Security group
      summary: Returns all security groups
      description: Returns all security groups
      operationId: cloudmesh.secgroup.get
      responses:
        '200':
          description: security group information
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: "#/components/schemas/Secgroup"
        '401':
          description: Not authorized
  /secgroup/{name}:
    get:
      tags:
      - Security group
      summary: Return the security group by name
      description: Return the security group by name
      operationId: cloudmesh.secgroup.get_by_name
      parameters:
        - name: name
          description: name of the security group
          in: path
          required: true
          schema:
            type: string
      responses:
        '200':
          description: security group information
          content:
            application/json:
              schema:
                $ref: "#/components/schemas/Secgroup"
        '401':
          description: Not authorized
        '404':
          description: The named security group could not be found
    post:
      tags:
      - Security group
      summary: Create the named security group
      description: Create a new named security group
      operationId: cloudmesh.secgroup.create
      parameters:
        - in: path
          name: name
          required: true
          description: The name of the security group to create
          schema:
            type: string
      responses:
        '201':
          description: Created
        '400':
```

```
          description: The group could not be created
        '401':
          description: Not authorized
  /secgroup/{name}/rule/{rule}:
    get:
      tags:
      - Security group
      summary: Get an existing rule from the specified security group
      description: Create a new rule in security group
      operationId: cloudmesh.secgroup.get_rule
      parameters:
        - in: path
          name: name
          required: true
          description: The named of the security group from which the rule will be deleted
          schema:
            type: string
        - in: path
          name: rule
          required: true
          description: The rule to be added
          schema:
            type: string
      responses:
        '200':
          description: The security group rule definition info
          content:
            application/json:
              schema:
                  $ref: "#/components/schemas/SecGroupRule"
        '401':
          description: Not authorized
        '404':
          description: The named security group or role could not be found
    put:
      tags:
      - Security group
      summary: Create or update specified security group
      description: Create a new rule in security group
      operationId: cloudmesh.secgroup.add_rule
      parameters:
        - in: path
          name: name
          required: true
          description: The name of the new security group to create
          schema:
            type: string
      requestBody:
        description: The new security group rule to create
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/SecGroupRule'
      responses:
        '200':
          description: Created
        '401':
          description: Not authorized
        '404':
          description: The named security group or role could not be found
    delete:
      tags:
      - Security group
      summary: Delete an existing rule from the specified security group
      description: Create a new rule in security group
      operationId: cloudmesh.secgroup.delete_rule
      parameters:
        - in: path
          name: name
          required: true
          description: The named secgroup
          schema:
            type: string
        - in: path
          name: rule
          required: true
          description: The secgroup rule
          schema:
            type: string
      responses:
        '200':
          description: Deleted sucessfully
        '401':
          description: Not authorized
        '404':
          description: The named security group or role could not be found
components:
  schemas:
```

```
  Secgroup:
    type: object
    description: the security group object
    properties:
      name:
        type: string
        description: Name of the security group
      description:
        type: string
        description: Describes what the security group is for
      rules:
        type: array
        description: List of Security group rules
        items:
          $ref: "#/components/schemas/SecGroupRule"
  SecGroupRule:
    type: object
    description: security group rule
    properties:
      name:
        type: string
        description: Unique name of the rule
      ingress:
        type: boolean
        description: The defined security group rule is for ingress if True
      egress:
        type: boolean
        description: The defined security group rule is for egress if True
      remote_group:
        type: string
        description: Name of the group if the rule is defined by group
                     instead of IP range
      protocol:
        type: string
        description: The protocol used such as TCP, UDP, ICMP
        example: TCP
      from_port:
        type: integer
        description: Port range starting port
      to_port:
        type: integer
        description: Port range ending port
      cidr:
        type: string
        description: The source or destination network in CIDR notation,
        example: 129.79.0.0/16
```

4.9.5 Nic

A resource store Network Interface Controller (NIC) information.

4.9.5.1 Schema Nic

Reference:

Property	Type	Description
name	string	Name of the network interface controller
kind	string	Kind of the network interface controller (wifi, WAN, …)
mac	string	The mac address
ip	string	The IP address
mask	string	The network mask
broadcast	string	The broadcast address
gateway	string	The gateway address
mtu	integer	The MTU of the NIC

bandwidth	integer	The bandwidth in bps

4.9.5.2 Paths

HTTP	Path	Summary
get	/nic	Returns a list of network interface controllers
get	/nic/{name}	Returns the named network interface controller
put	/nic/{name}	Set a network interface controller
delete	/nic/{name}	Deletes the named network interface controller

4.9.5.2.1 /nic

4.9.5.2.1.1 GET /nic

Returns a list of all network interface controllers

Responses

Code	Description	Schema
200	The list of network interface controllers	array[Nic]
401	Not authorized	String

4.9.5.2.2 /nic/{name}

4.9.5.2.2.1 GET /nic/{name}

Returns a network interface controller by name

Responses

Code	Description	Schema
200	Returning the information of the network interface controller	Nic
401	Not authorized	String
404	The named network interface controller could not be found	String

Parameters

Name	Located in	Description	Required	Schema

name	path	The name of the network interface controller	True	String

4.9.5.2.2.2 PUT /nic/{name}

Sets the named network interface controller

Responses

Code	Description	Schema
200	Nic updated	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The new nic to create or update	True	Nic

4.9.5.2.2.3 DELETE /nic/{name}

Deletes a network interface controller by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named network interface controller could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the network interface controller	True	String

4.9.5.3 nic.yaml

```
openapi: "3.0.2"
info:
```

```
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Nic
  description: |-

    A resource store Network Interface Controller (NIC) information.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /nic:
    get:
      tags:
        - Nic
      summary: Returns a list of network interface controllers
      description: Returns a list of all network interface controllers
      operationId: cloudmesh.nic.list
      responses:
        '200':
          description: The list of network interface controllers
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Nic'
        '401':
          description: Not authorized
  /nic/{name}:
    get:
      tags:
        - Nic
      summary: Returns the named network interface controller
      description: Returns a network interface controller by name
      operationId: cloudmesh.nic.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the network interface controller
      responses:
        '200':
          description: Returning the information of the network interface controller
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Nic'
        '401':
          description: Not authorized
        '404':
           description: The named network interface controller could not be found
    put:
      tags:
        - Nic
      summary: Set a network interface controller
      description: Sets the named network interface controller
      operationId: cloudmesh.nic.add
      requestBody:
        description: The new nic to create or update
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Nic'
      responses:
        '200':
          description: Nic updated
        '401':
          description: Not authorized
    delete:
      tags:
        - Nic
      summary: Deletes the named network interface controller
      description: Deletes a network interface controller by name
      operationId: cloudmesh.nic.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
```

```
            type: string
          description: The name of the network interface controller
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named network interface controller could not be found
components:
  schemas:
    Nic:
      type: object
      description: The network interface controller
      properties:
        name:
          type: string
          description: Name of the network interface controller
        kind:
          type: string
          description: Kind of the network interface controller (wifi, WAN, ...)
        mac:
          type: string
          description: The mac address
        ip:
          type: string
          description: The IP address
        mask:
          type: string
          description: The network mask
        broadcast:
          type: string
          description: The broadcast address
        gateway:
          type: string
          description: The gateway address
        mtu:
          type: integer
          description: The MTU of the NIC
        bandwidth:
          type: integer
          description: The bandwidth in bps
```

4.10 Compute Management - Containers

4.10.1 Containers

Numerous different containers are likely to be created and handling them becomes more and more time consuming as their number increases. This service helps to solve that issue by storing containers and their corresponding information.

4.10.1.1 Schema Container

Reference:

Property	Type	Description
name	string	Name of the container
version	string	Version of the container
label	string	Label of the container
type	string	Type of the container
definition	string	Definition or manifest of the container
imgURI	string	URI of the container

tags	array[string]	Tags of the container

4.10.1.2 Paths

HTTP	Path	Summary
get	/container	Returns a list of containers
get	/container/{name}	Returns the named container
put	/container/{name}	Set an container
delete	/container/{name}	Deletes the named container

4.10.1.2.1 /container

4.10.1.2.1.1 GET /container

Returns a list of all containers

Responses

Code	Description	Schema
200	The list of containerses	array[Container]
401	Not authorized	String

4.10.1.2.2 /container/{name}

4.10.1.2.2.1 GET /container/{name}

Returns an container by name

Responses

Code	Description	Schema
200	Returning the information of the container	Container
400	No Container found	String
401	Not authorized	String
404	The named container could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the container	True	String

4.10.1.2.2.2 PUT /container/{name}

Sets the named container

Responses

Code	Description	Schema
200	Container updated	String
401	Not authorized	String
400	Error updating container	String

Request Body

Located in	Description	Required	Schema
Body	The new container to create	True	Container

4.10.1.2.2.3 DELETE /container/{name}

Deletes an container by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named container could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the container	True	String

4.10.1.3 containers.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
```

```
  x-date: 17-06-2019
  x-status: defined
  title: Containers
  description: |-

    Numerous different containers are likely to be created and handling them
    becomes more and more time consuming as their number increases. This service
    helps to solve that issue by storing containers and their corresponding
    information.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /container:
    get:
      tags:
        - Container
      summary: Returns a list of containers
      description: Returns a list of all containers
      operationId: cloudmesh.container.list
      responses:
        '200':
          description: The list of containerses
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Container'
        '401':
          description: Not authorized
  /container/{name}:
    get:
      tags:
        - Container
      summary: Returns the named container
      description: Returns an container by name
      operationId: cloudmesh.container.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the container
      responses:
        '200':
          description: Returning the information of the container
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Container'
        '400':
           description: No Container found
        '401':
          description: Not authorized
        '404':
           description: The named container could not be found
    put:
      tags:
        - Container
      summary: Set an container
      description: Sets the named container
      operationId: cloudmesh.container.add
      requestBody:
        description: The new container to create
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Container'
      responses:
        '200':
          description: Container updated
        '401':
          description: Not authorized
        '400':
          description: Error updating container
    delete:
      tags:
        - Container
      summary: Deletes the named container
```

```
      description: Deletes an container by name
      operationId: cloudmesh.container.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the container
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named container could not be found
components:
  schemas:
    Container:
      type: object
      description: A record representing a container
      properties:
        name:
          type: string
          description: Name of the container
        version:
          type: string
          description: Version of the container
        label:
          type: string
          description: Label of the container
        type:
          type: string
          description: Type of the container
        definition:
          type: string
          description: Definition or manifest of the container
        imgURI:
          type: string
          description: URI of the container
        tags:
          type: array
          description: Tags of the container
          items:
            type: string
```

4.11 Compute Management - Map Reduce

4.11.1 Microservice

A service to store the information of a mapreduce deployment definition. All of the attributes are stored as Strings.

4.11.1.1 Schema Map

Reference:

Property	Type	Description
name	string	The name of the map function
kind	string	The kind in which the specification is provided
content	string	The kind in which the specification is provided

4.11.1.2 Schema Reduce

Reference:

Property	Type	Description
name	string	The name of the reduce function
kind	string	The kind in which the specification is provided
content	string	The kind in which the specification is provided

4.11.1.3 Schema Data

Reference:

Property	Type	Description
name	string	The name of the data
content	string	The content of tehe data

4.11.1.4 Paths

HTTP	Path	Summary
get	/mapreduce	Returns the data identified by the mapreduce resource
get	/mapreduce/{name}	Returns the data identified by the map and function
put	/mapreduce/map/{name}	Create or update the map function
get	/mapreduce/map/{name}	Returns the data identified bythe map function
put	/mapreduce/reduce/{name}	Create or update the reduce function
get	/mapreduce/reduce/{name}	Returns the data identified bythe reduce function

4.11.1.4.1 /mapreduce

4.11.1.4.1.1 GET /mapreduce

Returns the data identified by the mapreduce resource

Responses

Code	Description	Schema

200	mapreduce names	array[String]
401	Not authorized	String

4.11.1.4.2 /mapreduce/{name}

4.11.1.4.2.1 GET /mapreduce/{name}

Returns the data identified bythe reduce function.

Responses

Code	Description	Schema
200	The data identified by reduce	array[Data]
401	Not authorized	String
404	The resource could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the function	True	String

4.11.1.4.3 /mapreduce/map/{name}

4.11.1.4.3.1 PUT /mapreduce/map/{name}

Create or update the map function

Responses

Code	Description	Schema
200	The map function was created or updated	String
401	Not authorized	String
404	The resource could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the function	True	String

Request Body

Located in	Description	Required	Schema
Body	The new default to create	True	Map

4.11.1.4.3.2 GET /mapreduce/map/{name}

Returns the data identified bythe map function

Responses

Code	Description	Schema
200	The data identified by map	array[Data]
401	Not authorized	String
404	The resource could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the function	True	String

4.11.1.4.4 /mapreduce/reduce/{name}

4.11.1.4.4.1 PUT /mapreduce/reduce/{name}

Create or update the reduce function

Responses

Code	Description	Schema
200	The reduce function was created or updated	String
401	Not authorized	String
404	The resource could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the function	True	String

Request Body

Located in	Description	Required	Schema
Body	The new default to create	True	Reduce

4.11.1.4.4.2 GET /mapreduce/reduce/{name}

Returns the data identified bythe reduce function

Responses

Code	Description	Schema
200	The data identified by reduce	array[Data]
401	Not authorized	String
404	The resource could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the function	True	String

4.11.1.5 mapreduce.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: MapReduce
  description: |-

    A service to store the information of a mapreduce deployment definition.
    All of the attributes are stored as Strings.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /mapreduce:
    get:
      tags:
      - mapreduce
      summary: Returns the data identified by the mapreduce resource
      description: Returns the data identified by the mapreduce resource
      operationId: cloudmesh.mapreduce.list
      responses:
        '200':
          description: mapreduce names
          content:
            application/json:
              schema:
                type: array
                items:
```

```
                type: string
      '401':
        description: Not authorized
/mapreduce/{name}:
  get:
    tags:
      - mapreduce
    summary: Returns the data identified by the map and function
    description: Returns the data identified bythe reduce function.
    operationId: cloudmesh.mapreduce.get
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the function
    responses:
      '200':
        description: The data identified by reduce
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: '#/components/schemas/Data'
      '401':
        description: Not authorized
      '404':
        description: The resource could not be found
/mapreduce/map/{name}:
  put:
    tags:
      - mapreduce
    summary: Create or update the map function
    description: Create or update the map function
    operationId: cloudmesh.mapreduce.map.put
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the function
    requestBody:
      description: The new default to create
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Map'
    responses:
      '200':
        description: The map function was created or updated
      '401':
        description: Not authorized
      '404':
        description: The resource could not be found
  get:
    tags:
      - mapreduce
    summary: Returns the data identified bythe map function
    description: Returns the data identified bythe map function
    operationId: cloudmesh.mapreduce.map.get
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the function
    responses:
      '200':
        description: The data identified by map
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: '#/components/schemas/Data'
      '401':
        description: Not authorized
      '404':
        description: The resource could not be found
/mapreduce/reduce/{name}:
  put:
    tags:
      - mapreduce
    summary: Create or update the reduce function
```

```
      description: Create or update the reduce function
      operationId: cloudmesh.mapreduce.reduce.put
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the function
      requestBody:
        description: The new default to create
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Reduce'
      responses:
        '200':
          description: The reduce function was created or updated
        '401':
          description: Not authorized
        '404':
          description: The resource could not be found
    get:
      tags:
        - mapreduce
      summary: Returns the data identified bythe reduce function
      description: Returns the data identified bythe reduce function
      operationId: cloudmesh.mapreduce.reduce.get
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the function
      responses:
        '200':
          description: The data identified by reduce
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Data'
        '401':
          description: Not authorized
        '404':
          description: The resource could not be found
components:
  schemas:
    Map:
      type: object
      description: The specification of the map function
      properties:
        name:
          type: string
          description: The name of the map function
        kind:
          type: string
          description: The kind in which the specification is provided
        content:
          type: string
          description: The kind in which the specification is provided
    Reduce:
      type: object
      description: The specification of the reduce function
      properties:
        name:
          type: string
          description: The name of the reduce function
        kind:
          type: string
          description: The kind in which the specification is provided
        content:
          type: string
          description: The kind in which the specification is provided
    Data:
      type: object
      description: The specification of the function
      properties:
        name:
          type: string
          description: The name of the data
        content:
          type: string
          description: The content of tehe data
```

4.12 Compute Management - Functions

4.12.1 Microservice

As part of microservices, a function with parameters that can be invoked has been defined.

4.12.1.1 Schema Microservice

Reference:

Property	Type	Description
name	string	Name of the microservice
endpoint	string	The end point of the microservice
function	string	The function the microservice represents
description		The description of the microservice

4.12.1.2 Paths

HTTP	Path	Summary
get	/microservice	Returns a list of microservicees
get	/microservice/{name}	Returns the named microservice
put	/microservice/{name}	Set an microservice
delete	/microservice/{name}	Deletes the named microservice

4.12.1.2.1 /microservice

4.12.1.2.1.1 GET /microservice

Returns a list of all microservicees

Responses

Code	Description	Schema
200	The list of microserviceses	array[Microservice]
401	Not authorized	String

4.12.1.2.2 /microservice/{name}

4.12.1.2.2.1 GET /microservice/{name}

Returns the named microservice

Responses

Code	Description	Schema
200	Returns the microservice	Microservice
401	Not authorized	String
404	The named microservice could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the microservice	True	String

4.12.1.2.2.2 PUT /microservice/{name}

Sets the named microservice

Responses

Code	Description	Schema
200	Microservice updated	String
400	Error updating microservice	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The new microservice to create	True	Microservice

4.12.1.2.2.3 DELETE /microservice/{name}

Deletes an microservice by name

Responses

Code	Description	Schema

200	Deletion successful	String
400	Error deleting microservice	String
401	Not authorized	String
404	The named microservice could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the microservice	True	String

4.12.1.3 microservice.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Microservice
  description: |-

    As part of microservices, a function with parameters that can be
    invoked has been defined.

  termsOfService: "https://github.com/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /microservice:
    get:
      tags:
        - Microservice
      summary: Returns a list of microservicees
      description: Returns a list of all microservicees
      operationId: cloudmesh.microservice.list
      responses:
        '200':
          description: The list of microserviceses
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Microservice'
        '401':
          description: Not authorized
  /microservice/{name}:
    get:
      tags:
        - Microservice
      summary: Returns the named microservice
      description: Returns the named microservice
      operationId: cloudmesh.microservice.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the microservice
      responses:
        '200':
          description: Returns the microservice
          content:
            application/json:
              schema:
```

```
              $ref: '#/components/schemas/Microservice'
       '401':
         description: Not authorized
       '404':
          description: The named microservice could not be found
   put:
     tags:
       - Microservice
     summary: Set an microservice
     description: Sets the named microservice
     operationId: cloudmesh.microservice.add
     requestBody:
       description: The new microservice to create
       required: true
       content:
         application/json:
           schema:
             $ref: '#/components/schemas/Microservice'
     responses:
       '200':
         description: Microservice updated
       '400':
         description: Error updating microservice
       '401':
         description: Not authorized
   delete:
     tags:
       - Microservice
     summary: Deletes the named microservice
     description: Deletes an microservice by name
     operationId: cloudmesh.microservice.delete_by_name
     parameters:
       - name: name
         in: path
         required: true
         schema:
           type: string
         description: The name of the microservice
     responses:
       '200':
         description: Deletion successful
       '400':
         description: Error deleting microservice
       '401':
         description: Not authorized
       '404':
          description: The named microservice could not be found
components:
  schemas:
    Microservice:
      type: object
      description: The microservice
      properties:
        name:
          type: string
          description: Name of the microservice
        endpoint:
          type: string
          description: The end point of the microservice
        function:
          type: string
          description: The function the  microservice represents
        description:
          type string:
          description: The description of the microservice
```

4.13 Reservation

4.13.1 Reservation

Some services may consume a considerable amount of resources, necessitating the reservation of resources.

4.13.1.1 Schema Reservation

Reference:

Property	Type	Description
name	string	Name of the reservation
service	string	The name of the service for which the reservation is applied
description	string	The description of the reservation
start	string(date)	The start time and date
end	string(date)	The end time and date

4.13.1.2 Paths

HTTP	Path	Summary
get	/reservation	Returns a list of reservations
get	/reservation/{name}	Returns the named reservation
put	/reservation/{name}	Uploads a reservation to the list of reservations
delete	/reservation/{name}	Deletes the named reservation

4.13.1.2.1 /reservation

4.13.1.2.1.1 GET /reservation

Returns a list of all reservations

Responses

Code	Description	Schema
200	The list of reservations	array[Reservation]
400	No Reservations found	String

4.13.1.2.2 /reservation/{name}

4.13.1.2.2.1 GET /reservation/{name}

Returns an reservation by name

Responses

Code	Description	Schema
200	Returning the information of the reservation	Reservation

400	No reservation found	String
401	Not authorized	String
404	The named reservation could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the reservation	True	String

4.13.1.2.2.2 PUT /reservation/{name}

Uploads a reservation to the list of reservations

Responses

Code	Description	Schema
200	Reservation updated	String
400	Error updating reservation	String

Request Body

Located in	Description	Required	Schema
Body	The reservation to be uploaded	True	Reservation

4.13.1.2.2.3 DELETE /reservation/{name}

Deletes an reservation by name

Responses

Code	Description	Schema
200	Deletion successful	String
400	No reservation found	String
401	Not authorized	String
404	The named reservation could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the reservation	True	String

4.13.1.3 reservation.yaml

```
openapi: '3.0.2'
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Reservation
  description: |-

    Some services may consume a considerable amount of resources,
    necessitating the reservation of resources.

  termsOfService: 'https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt'
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /reservation:
    get:
      tags:
        - Reservation
      summary: Returns a list of reservations
      description: Returns a list of all reservations
      operationId: cloudmesh.reservation.list
      responses:
        '200':
          description: The list of reservations
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Reservation'
        '400':
          description: No Reservations found
  /reservation/{name}:
    get:
      tags:
        - Reservation
      summary: Returns the named reservation
      description: Returns an reservation by name
      operationId: cloudmesh.reservation.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the reservation
      responses:
        '200':
          description: Returning the information of the reservation
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Reservation'
        '400':
          description: No reservation found
        '401':
          description: Not authorized
        '404':
          description: The named reservation could not be found
    put:
      tags:
        - Reservation
      summary: Uploads a reservation to the list of reservations
      description: Uploads a reservation to the list of reservations
      operationId: cloudmesh.reservation.add
      requestBody:
        description: The reservation to be uploaded
        required: true
        content:
          application/json:
```

```
          schema:
            $ref: '#/components/schemas/Reservation'
      responses:
        '200':
          description: Reservation updated
        '400':
          description: Error updating reservation
    delete:
      tags:
        - Reservation
      summary: Deletes the named reservation
      description: Deletes an reservation by name
      operationId: cloudmesh.reservation.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the reservation
      responses:
        '200':
          description: Deletion successful
        '400':
          description: No reservation found
        '401':
          description: Not authorized
        '404':
          description: The named reservation could not be found
components:
  schemas:
    Reservation:
      type: object
      description: The reservation
      properties:
        name:
          type: string
          description: Name of the reservation
        service:
          type: string
          description: The name of the service for which the reservation is
                       applied
        description:
          type: string
          description: The description of the reservation
        start:
          type: string
          format: date
          description: The start time and date
        end:
          type: string
          format: date
          description: The end time and date
```

4.14 Data Streams

4.14.1 Stream

The stream object describes a data flow, providing information about the rate and number of items exchanged while issuing requests to the stream. A stream may return data items in a specific format that is defined by the stream.

4.14.1.1 Schema Stream

Reference:

Property	Type	Description
name	string	Name of the stream
format	string	Format of the stream

rate	integer	The rate of messages
limit	integer	The limit of items send
endpoint	string	The endpoint of the stream
protocol	string	DThe definition of the protocol used

4.14.1.2 Paths

HTTP	Path	Summary
get	/stream	Returns a list of streams
get	/stream/{name}	Returns the named stream
put	/stream/{name}	Set an stream
delete	/stream/{name}	Deletes the named stream

4.14.1.2.1 /stream

4.14.1.2.1.1 GET /stream

Returns a list of all streams

Responses

Code	Description	Schema
200	The list of streamses	array[Stream]
400	No Stream found	String
401	Not authorized	String

4.14.1.2.2 /stream/{name}

4.14.1.2.2.1 GET /stream/{name}

Returns an stream by name

Responses

Code	Description	Schema
200	Returning the information of the stream	Stream
401	Not authorized	String
404	The named stream could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the stream	True	String

4.14.1.2.2.2 PUT /stream/{name}

Sets the named stream

Responses

Code	Description	Schema
200	Stream updated	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The new stream to create	True	Stream

4.14.1.2.2.3 DELETE /stream/{name}

Deletes an stream by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named stream could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the stream	True	String

4.14.1.3 stream.yaml

```
openapi: "3.0.2"
info:
```

```
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Stream
  description: |-

   The stream object describes a data flow, providing information
   about the rate and number of items exchanged while issuing requests
   to the stream. A stream may return data items in a specific format
   that is defined by the stream.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /stream:
    get:
      tags:
        - Stream
      summary: Returns a list of streams
      description: Returns a list of all streams
      operationId: cloudmesh.stream.list
      responses:
        '200':
          description: The list of streamses
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Stream'
        '400':
           description: No Stream found
        '401':
          description: Not authorized
  /stream/{name}:
    get:
      tags:
        - Stream
      summary: Returns the named stream
      description: Returns an stream by name
      operationId: cloudmesh.stream.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the stream
      responses:
        '200':
          description: Returning the information of the stream
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Stream'
        '401':
          description: Not authorized
        '404':
          description: The named stream could not be found
    put:
      tags:
        - Stream
      summary: Set an stream
      description: Sets the named stream
      operationId: cloudmesh.stream.add
      requestBody:
        description: The new stream to create
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Stream'
      responses:
        '200':
          description: Stream updated
        '401':
          description: Not authorized
    delete:
      tags:
        - Stream
      summary: Deletes the named stream
      description: Deletes an stream by name
```

```
      operationId: cloudmesh.stream.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the stream
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named stream could not be found
components:
  schemas:
    Stream:
      type: object
      description: The stream
      properties:
        name:
          type: string
          description: Name of the stream
        format:
          type: string
          description: Format of the stream
        rate:
          type: integer
          description: The rate of messages
        limit:
          type: integer
          description: The limit of items send
        endpoint:
          type: string
          description: The endpoint of the stream
        protocol:
          type: string
          description: DThe definition of the protocol used
```

4.14.2 Filter

Filters can operate on a variety of objects and reduce the information received based on a search criterion.

4.14.2.1 Schema Filter

Reference:

Property	Type	Description
name	string	Name of the filter
function	string	The function used to filter the data in the stream
kind	string	The filter kind or type

4.14.2.2 Paths

HTTP	Path	Summary
get	/filter	Returns a list of filteres
get	/filter/{name}	Returns the named filter
put	/filter/{name}	Set an filter

delete	/filter/{name}	Deletes the named filter

4.14.2.2.1 /filter

4.14.2.2.1.1 GET /filter

Returns a list of all filteres

Responses

Code	Description	Schema
200	The list of filterses	array[Filter]
401	Not authorized	String

4.14.2.2.2 /filter/{name}

4.14.2.2.2.1 GET /filter/{name}

Returns an filter by name

Responses

Code	Description	Schema
200	Returning the information of the filter	Filter
401	Not authorized	String
404	The named filter could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the filter	True	String

4.14.2.2.2.2 PUT /filter/{name}

Sets the named filter

Responses

Code	Description	Schema
200	Filter updated	String

401	Not authorized	String
400	Error updating filter	String

Request Body

Located in	Description	Required	Schema
Body	The new filter to create	True	Filter

4.14.2.2.2.3 DELETE /filter/{name}

Deletes an filter by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named filter could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the filter	True	String

4.14.2.3 filter.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Filter
  description: |-

    Filters can operate on a variety of objects and reduce the
    information received based on a search criterion.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /filter:
    get:
      tags:
        - Filter
      summary: Returns a list of filteres
      description: Returns a list of all filteres
      operationId: cloudmesh.filter.list
```

```
    responses:
      '200':
        description: The list of filterses
        content:
          application/json:
            schema:
              type: array
              items:
                $ref: '#/components/schemas/Filter'
      '401':
        description: Not authorized
  /filter/{name}:
    get:
      tags:
        - Filter
      summary: Returns the named filter
      description: Returns an filter by name
      operationId: cloudmesh.filter.find_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the filter
      responses:
        '200':
          description: Returning the information of the filter
          content:
            application/json:
              schema:
                $ref: '#/components/schemas/Filter'
        '401':
          description: Not authorized
        '404':
           description: The named filter could not be found
    put:
      tags:
        - Filter
      summary: Set an filter
      description: Sets the named filter
      operationId: cloudmesh.filter.add
      requestBody:
        description: The new filter to create
        required: true
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Filter'
      responses:
        '200':
          description: Filter updated
        '401':
          description: Not authorized
        '400':
          description: Error updating filter
    delete:
      tags:
        - Filter
      summary: Deletes the named filter
      description: Deletes an filter by name
      operationId: cloudmesh.filter.delete_by_name
      parameters:
        - name: name
          in: path
          required: true
          schema:
            type: string
          description: The name of the filter
      responses:
        '200':
          description: Deletion successful
        '401':
          description: Not authorized
        '404':
           description: The named filter could not be found
components:
  schemas:
    Filter:
      type: object
      description: The filter
      properties:
        name:
          type: string
          description: Name of the filter
        function:
          type: string
          description: The function used to filter the data
            in the stream
        kind:
```

```
        type: string
        description: The filter kind or type
```

4.15 Deployment

4.15.1 Deployment

A resource to store software deployments. The deployment is formulated in aspecification file. To distinguish the format of the specification file a kind is used. In case the specification uses an external service an endpoint to the service can be used and the name of the specification is used to identify the deployment.

4.15.1.1 Schema Deployment

Reference:

Property	Type	Description
name	string	The name of the deployment
kind	string	The kind of the deployment
specification	string	The specification of the deployment
endpoint	string	The location of the deployment service
endpointname	string	in case an endpoint is used, the endpointname is used to uniquly identify the deployment within the endpoint defined service

4.15.1.2 Paths

HTTP	Path	Summary
get	/deployment	Returns a list of deploymentes
get	/deployment/{name}	Returns the named deployment
put	/deployment/{name}	Set an deployment
delete	/deployment/{name}	Deletes the named deployment

4.15.1.2.1 /deployment

4.15.1.2.1.1 GET /deployment

Returns a list of all deploymentes

Responses

Code	Description	Schema
200	The list of deploymentses	array[Deployment]
401	Not authorized	String

4.15.1.2.2 /deployment/{name}

4.15.1.2.2.1 GET /deployment/{name}

Returns an deployment by name

Responses

Code	Description	Schema
200	Returning the information of the deployment	Deployment
401	Not authorized	String
404	The named deployment could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the deployment	True	String

4.15.1.2.2.2 PUT /deployment/{name}

Sets the named deployment

Responses

Code	Description	Schema
200	Deployment updated	String
401	Not authorized	String

Request Body

Located in	Description	Required	Schema
Body	The new deployment to create	True	Deployment

4.15.1.2.2.3 DELETE /deployment/{name}

Deletes an deployment by name

Responses

Code	Description	Schema
200	Deletion successful	String
401	Not authorized	String
404	The named deployment could not be found	String

Parameters

Name	Located in	Description	Required	Schema
name	path	The name of the deployment	True	String

4.15.1.3 deployment.yaml

```
openapi: "3.0.2"
info:
  version: 3.2.0
  x-date: 17-06-2019
  x-status: defined
  title: Deployment
  description: |-

    A resource to store software deployments. The deployment is formulated in
    aspecification file. To distinguish the format of the specification file
    a kind is used. In case the specification uses an external service an
    endpoint to the service can be used and the name of the specification is
    used to identify the deployment.

  termsOfService: "https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt"
  contact:
    name: NIST BDRA Interface Subgroup
    url: https://cloudmesh-community.github.io/nist
  license:
    name: Apache 2.0
    url: https://github.com/cloudmesh/cloudmesh-nist/blob/master/LICENSE.txt
servers:
  - url: /cloudmesh/v3
paths:
  /deployment:
    get:
      tags:
        - Deployment
      summary: Returns a list of deploymentes
      description: Returns a list of all deploymentes
      operationId: cloudmesh.deployment.list
      responses:
        '200':
          description: The list of deploymentses
          content:
            application/json:
              schema:
                type: array
                items:
                  $ref: '#/components/schemas/Deployment'
        '401':
          description: Not authorized
  /deployment/{name}:
    get:
      tags:
        - Deployment
      summary: Returns the named deployment
      description: Returns an deployment by name
      operationId: cloudmesh.deployment.find_by_name
      parameters:
        - name: name
          in: path
```

```
        required: true
        schema:
          type: string
        description: The name of the deployment
    responses:
      '200':
        description: Returning the information of the deployment
        content:
          application/json:
            schema:
              $ref: '#/components/schemas/Deployment'
      '401':
        description: Not authorized
      '404':
        description: The named deployment could not be found
  put:
    tags:
      - Deployment
    summary: Set an deployment
    description: Sets the named deployment
    operationId: cloudmesh.deployment.add
    requestBody:
      description: The new deployment to create
      required: true
      content:
        application/json:
          schema:
            $ref: '#/components/schemas/Deployment'
    responses:
      '200':
        description: Deployment updated
      '401':
        description: Not authorized
  delete:
    tags:
      - Deployment
    summary: Deletes the named deployment
    description: Deletes an deployment by name
    operationId: cloudmesh.deployment.delete_by_name
    parameters:
      - name: name
        in: path
        required: true
        schema:
          type: string
        description: The name of the deployment
    responses:
      '200':
        description: Deletion successful
      '401':
        description: Not authorized
      '404':
        description: The named deployment could not be found
components:
  schemas:
    Deployment:
      type: object
      description: the deployment
      properties:
        name:
          type: string
          description: The name of the deployment
        kind:
          type: string
          description: The kind of the deployment
        specification:
          type: string
          description: The specification of the deployment
        endpoint:
          type: string
          description: The location of the deployment service
        endpointname:
          type: string
          description: in case an endpoint is used, the endpointname is used
                       to uniquly identify the deployment within the
                       endpoint defined service
```

5 Acronyms and Terms

The following acronyms and terms are used in this volume.

ACID

Atomicity, Consistency, Isolation, Durability

API

Application Programming Interface

ASCII

American Standard Code for Information Interchange

BASE

Basically Available, Soft state, Eventual consistency

Container

See http://csrc.nist.gov/publications/drafts/800-180/sp800-180_draft.pdf

Cloud Computing

The practice of using a network of remote servers hosted on the Internet to store, manage, and process data, rather than a local server or a personal computer. See http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf.

DevOps

A clipped compound of software DEVelopment and information technology OPerationS

Deployment

The action of installing software on resources

HTTP

HyperText Transfer Protocol HTTPS HTTP Secure

Hybrid

Cloud See http://nvlpubs.nist.gov/nistpubs/Legacy/SP/nistspecialpublication800-145.pdf.

IaaS

Infrastructure as a Service SaaS Software as a Service

ITL

Information Technology Laboratory

Microservice Architecture

Is an approach to build applications based on many smaller modular services. Each module supports a specific goal and uses a simple, well-defined interface to communicate with other sets of services.

NBD-PWG

NIST Big Data Public Working Group

NBDRA

NIST Big Data Reference Architecture

NBDRAI

NIST Big Data Reference Architecture Interface

NIST

National Institute of Standards and Technology

OS

Operating System

REST

REpresentational State Transfer

Replica

A duplicate of a file on another resource to avoid costly transfer costs in case of frequent access.

Serverless Computing

Serverless computing specifies the paradigm of function as a service (FaaS). It is a cloud computing code execution model in which a cloud provider manages the function deployment and utilization while clients can utilize them. The charge model is based on

execution of the function rather than the cost to manage and host the VM or container.

Software Stack

A set of programs and services that are installed on a resource to support applications.

Virtual File System

An abstraction layer on top of a distributed physical file system to allow easy access to the files by the user or application.

Virtual Machine

A VM is a software computer that, like a physical computer, runs an operating system and applications. The VM is composed of a set of specification and configuration files and is backed by the physical resources of a host.

Virtual Cluster

A virtual cluster is a software cluster that integrate either VMs, containers, or physical resources into an agglomeration of compute resources. A virtual cluster allows users to authenticate and authorize to the virtual compute nodes to utilize them for calculations. Optional high-level services that can be deployed on a virtual cluster may simplify interaction with the virtual cluster or provide higher-level services.

Workflow

The sequence of processes or tasks

WWW

World Wide Web

BIBLIOGRAPHY

[1] NIST, “Big Data Public Working Group (NBD-PWG).” [Online]. Available: https://bigdatawg.nist.gov/

[2] W. L. Chang (Co-Chair), N. Grady (Subgroup Co-chair), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 1, Big Data Definitions (NIST SP 1500-1 VERSION 3),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Jul. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[3] W. L. Chang (Co-Chair), N. Grady (Subgroup Co-chair), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 2, Big Data Taxonomies (NIST SP 1500-2 VERSION 3),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Jul. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[4] W. L. Chang (Co-Chair), G. Fox (Subgroup Co-chair), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 3, Big Data Use Cases and General Requirements (NIST SP 1500-3 VERSION 3),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Jul. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[5] W. L. Chang (Co-Chair), A. Roy (Subgroup Co-chair), M. Underwood (Subgroup Co-chair), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 4, Big Data Security and Privacy (NIST SP 1500-4 VERSION 3),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Jul. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[6] W. L. Chang (Co-Chair), S. Mishra (Editor), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 5, Big Data Architectures White Paper Survey (NIST SP 1500-5 VERSION 1),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Sep. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[7] W. L. Chang (Co-Chair), D. Boyd (Subgroup Co-chair), O. Levin (Version 1 Subgroup Co-Chair), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 6, Big Data Reference Architecture (NIST SP 1500-6 VERSION 3),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Jul. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[8] W. L. Chang (Co-Chair), R. Reinsch (Subgroup Co-chair), D. Boyd (Version 1 Subgroup Co-chair), C. Buffington (Version 1 Subgroup Co-chair), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 7, Big Data Standards Roadmap

(NIST SP 1500-7 VERSION 3),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Jul. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[9] W. L. Chang (Co-Chair), G. von Laszewski (Editor), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 8, Big Data Reference Architecture Interfaces (NIST SP 1500-9 VERSION 2),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Jul. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[10] W. L. Chang (Co-Chair), R. Reinsch (Subgroup Co-chair), C. Austin (Editor), and NIST Big Data Public Working Group, “NIST Big Data Interoperability Framework: Volume 9, Adoption and Modernization (NIST SP 1500-10 VERSION 2),” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Jul. 2019 [Online]. Available: https://bigdatawg.nist.gov/show_InputDoc.php

[11] NIST, “V1.0 final version page of the nbd-pwg website.” Web Page, Sep-2015 [Online]. Available: https://bigdatawg.nist.gov/V1_output_docs.php

[12] NIST, “21.0 final version page of the nbd-pwg website.” Web Page, Sep-2015 [Online]. Available: https://bigdatawg.nist.gov/V2_output_docs.php

[13] The White House Office of Science and Technology Policy, “Big Data is a Big Deal.” OSTP Blog, Feb-2014 [Online]. Available: http://www.whitehouse.gov/blog/2012/03/29/big-data-big-deal

[14] Department of Defense, “The dodaf architecture framework version 2.02,” Department of Defense, Report 2.02, Apr. 2010 [Online]. Available: https://dodcio.defense.gov/library/dod-architecture-framework/

[15] G. von Laszewski, “NIST bdra vol 8. GitHub issues.” GitHub, Jun-2019 [Online]. Available: https://github.com/cloudmesh/cloudmesh-nist/issues

[16] G. von Laszewski, “Nist bdra volume 8 github history.” GitHub, Jun-2019 [Online]. Available: https://github.com/cloudmesh/cloudmesh-nist/commits/master/docs/nistvol8-2.epub

[17] G. von Laszewski ***et al.***, “NIST big data interoperability framework: Volume 8, reference architecture interfaces,” National Institute of Standards; Technology (NIST), Gaithersburg, MD, Special Publication (NIST SP), Oct. 2015 [Online]. Available: https://github.com/cloudmesh/cloudmesh-nist/raw/master/history/NIST.SP.1500-9.pdf

[18] G. von Laszewski, F. Wang, B. Abdul-Wahid, H. Lee, G. C. Fox, and and Wo Chang, “Cloudmesh in support of the nist big data architecture framework,” Indiana University, 2017 [Online]. Available: https://github.com/cyberaide/nist/blob/master/vonLaszewski-nist.pdf

[19] G. von Laszewski, “NIST bdra vol 8. OpenAPI specifications.” GitHub, Jun-2019

[Online]. Available: https://github.com/cloudmesh-community/nist/tree/master/spec

[20] G. von Laszewski, “Configuration file example: Coudmesh4.yaml.” GitHub, Jun-2019 [Online]. Available: https://github.com/cloudmesh/cloudmesh-cloud/blob/master/cloudmesh/etc/cloudmesh4.yaml

[21] Internet2 Middleware Architecture Committee for Education, “EduPerson object class specification,” Internet2, 2016, 201602, Mar. 2016 [Online]. Available: http://software.internet2.edu/eduperson/internet2-mace-dir-eduperson-201602.html