

# Cloudmesh REST Interface for Virtual Clusters

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Draft v0.0.1, April 18, 2017

This document summarizes a number of objects that are instrumental for the interaction with Clouds, Containers, and HPC systems to manage virtual clusters. TBD

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**Keywords:** CCloudmesh, REST, NIST

<https://github.com/cloudmesh/rest/tree/master/docs>

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## 95 1. INTRODUCTION

96 In this document we summarize elementary objects that are  
97 important to for the NBDRA.

### 98 1.1. Lessons Learned

99 TBD

### 100 1.2. Hybrid Cloud

101 TBD

### 102 1.3. Design by Example

103 To accelerate discussion among the team we use an approach  
104 to define objects and its interfaces by example. These exam-  
105 ples are than taken in a later version of the document and a  
106 schema is generated from it. The schema will be added in  
107 its complete form to the appendix B. While focusing first on  
108 examples it allows us to speed up our design and simplifies

109 discussions of the objects and interfaces eliminating getting  
110 lost in complex syntactical specifications. The process and  
111 specifications used in this document will also allow us to  
112 automatically create a implementation of the objects that can  
113 be integrated into a reference architecture as provided by for  
114 example the cloudmesh client and rest project [? ].

115 An example object will demonstrate our approach. The  
116 following object defines a JSON object representing a user.

Listing 1.1: User profile

```

1 {
2   "profile": {
3     "description": "The Profile of a user",
4     "uuid": "jshdjkdh...",
5     "context": "resource",
6     "email": "laszewski@gmail.com",
7     "firstname": "Gregor",
8     "lastname": "von Laszewski",
9     "username": "gregor"
10  }
11 }
```

117 Such an object can be transformed to a schema specifica-  
118 tion while introspecting the types of the original example.  
119 The resulting schema object follows the Cerberus [? ] speci-  
120 fication and looks for our object as follows:

```

profile = {
  'description': { 'type': 'string'},
  'email': { 'type': 'email' },
  'firstname': { 'type': 'string'},
  'lastname': { 'type': 'string' },
  'username': { 'type': 'string' }
}
```

122 As mentioned before, the AppendixB will list the schema  
123 that is automatically created from the definitions.

### 124 1.4. Tools to Create the Specifications

125 The tools to create the schema and object are all available  
126 opensource and are hosted on github. It includes the follow-  
127 ing repositories:

128 **cloudmesh.common**

129 <https://github.com/cloudmesh/cloudmesh.common>

130 **cloudmesh.cmd5**

131 <https://github.com/cloudmesh/cloudmesh.cmd5>

132 **cloudmesh.rest**

133 <https://github.com/cloudmesh/cloudmesh.rest>

134 **cloudmesh/evegenie**

135 <https://github.com/cloudmesh/evegenie>

### 136 1.5. Installation of the Tools

137 The current best way to install the tools is from source. A  
138 convenient shell script conducting the install is located at:

139 TBD

140 Once we have stabilized the code the package will be  
141 available from pypi and can be installed as follows:

```

pip install cloudmesh.rest
pip install cloudmesh.evegenie
```

## 1.6. Document Creation

It is assumed that you have installed all the tools. TO create the document you can simply do

```
git clone https://github.com/cloudmesh/cloudmesh.rest
cd cloudmesh.rest/docs
make
```

This will produce in that directory a file called object.pdf containing this document.

## 1.7. Conversion to Word

We found that it is inconvenient for the developers to maintain this document in Microsoft Word as typically is done for other documents. This is because the majority of the information contains specifications that are directly integrated in a reference implementation, as well as that the current majority of contributors are developers. We would hope that editorial staff provides direct help to improve this document, which even can be done through the github Web interface and does not require any access either to the tools mentioned above or the availability of L<sup>A</sup>T<sub>E</sub>X.

The files are located at:

- <https://github.com/cloudmesh/cloudmesh.rest/tree/master/docs>

## 1.8. Interface Compliancy

Due to the extensibility of our interfaces it is important to introduce a terminology that allows us to define interface compliancy. We define it as follows

**Full Compliance:** These are reference implementations that provide full compliance to the objects defined in this document. A version number will be added to assure the snapshot in time of the objects is associated with the version. This reference implementation will implement all objects.

**Partially Compliance:** These are reference implementations that provide partial compliance to the objects defined in this document. A version number will be added to assure the snapshot in time of the objects is associated with the version. This reference implementation will implement a partial list of the objects. A document is accompanied that lists all objects defined, but also lists the objects that are not defined by the reference architecture.

**Full and extended Compliance:** These are interfaces that in addition to the full compliance also introduce additional interfaces and extend them.

## 2. USER AND PROFILE

In a multiuser environment we need a simple mechanism of associating objects and data to a particular person or group. While we do not want to replace with our efforts more elaborate solutions such as proposed by eduPerson (<http://software.internet2.edu/eduperson/internet2-mace-dir-eduperson-201602.html>) or others [? ], we need a very simple way of distinguishing users. Therefore we have introduced a number of simple objects including a profile and a user.

## 2.1. Profile

A profile is simple the most elementary information to distinguish a user profile. It contains name and e-mail information. It may have an optional uuid and/or use a unique e-mail to distinguish a user.

Listing 2.1: User profile

```
{
  "profile": {
    "description": "The Profile of a user",
    "uuid": "jshdjkdh...",
    "context": "resource",
    "email": "laszewski@gmail.com",
    "firstname": "Gregor",
    "lastname": "von Laszewski",
    "username": "gregor"
  }
}
```

## 2.2. User

In contrast to the profile a user contains additional attributes that define the role of the user within the system.

Listing 2.2: user

```
{
  "user": {
    "uuid": "jshdjkdh...",
    "context": "resource",
    "email": "laszewski@gmail.com",
    "firstname": "Gregor",
    "lastname": "von Laszewski",
    "username": "gregor",
    "roles": ["admin", "user"]
  }
}
```

## 2.3. Organization

An important concept in many applications is the management of a group of users in a virtual organization. This can be achieved through two concepts. First, it can be achieved while using the profile and user resources itself as they contain the ability to manage multiple users as part of the REST interface. The second concept is to create a virtual organization that lists all users of this virtual organization. The third concept is to introduce groups and roles either as part of the user definition or as part of a simple list similar to the organization

Listing 2.3: user

```
{
  "organization": {
    "users": [
      "objectid:user"
    ]
  }
}
```

## 2.4. Group/Role

A group contains a number of users. It is used to manage authorized services.

Listing 2.4: group

```
{
  "group": {
    "name": "users",
    "description": "This group contains all
    ↪ users",
    "users": [
      "objectid:user"
    ]
  }
}
```

A role is a further refinement of a group. Group members can have specific roles. A good example is that ability to formulate a group of users that have access to a repository. However the role defines more specifically read and write privileges to the data within the repository.

Listing 2.5: role

```
{
  "role": {
    "name": "editor",
    "description": "This role contains all
    ↪ editors",
    "users": [
      "objectid:user"
    ]
  }
}
```

## 3. DATA

Data for Big Data applications are delivered through data providers. They can be either local providers contributed by a user or distributed data providers that refer to data on the internet. At this time we focus on an elementary set of abstractions related to data providers that offer us to utilize variables, files, virtual data directories, data streams, and data filters.

**Variables** are used to hold specific contents that is associated in programming language as a variable. A variable has a name, value and type.

**Default** is a special type of variable that allows adding of a context. defaults can than created for different contexts.

**Files** are used to represent information collected within the context of classical files in an operating system.

**Streams** are services that offer the consumer a stream of data. Streams may allow the initiation of filters to reduce the amount of data requested by the consumer Stream Filters operate in streams or on files converting them to streams

**Batch Filters** operate on streams and on files while working in the background and delivering as output Files

**Virtual directories** and non-virtual directories are collection of files that organize them. For our initial purpose the distinction between virtual and non-virtual directories is non-essential and we will focus on abstracting all directories to be virtual. This could mean that the files are physically hosted on different disks. However, it is important to note that virtual data directories can hold more than files, they can also contain data streams and data filters.

### 3.1. Var

variables are used to store a simple values. Each variable can have a type. The variable value format is defined as string to allow maximal probability. The type of the value is also provided.

Listing 3.1: var

```
{
  "var": {
    "name": "name of the variable",
    "value": "the value of the variable as
    ↪ string",
    "type": "the datatype of the variable such
    ↪ as int, str, float, ..."
  }
}
```

### 3.2. Default

A default is a special variable that has a context associated with it. This allow su to define values that can be easily retrieved based on its context. A good example for a default would be the image name for a cloud where the context is defined by the cloud name.

Listing 3.2: default

```
{
  "default": {
    "value": "string",
    "name": "string",
    "context": "string - defines the context
    ↪ of the default (user, cloud, ...)"
  }
}
```

### 3.3. File

A file is a computer resource allowing to store data that is being processed. The interface to a file provides the mechanism to appropriately locate a file in a distributed system. Identification include the name, and andpoint, the checksum and the size. Additional parameters such as the lasst access time could be stored also. As such the Interface only describes the location of the file

The **file** object has *name*, *endpoint* (location), *size* in GB, MB, Byte, *checksum* for integrity check, and last *accessed* timestamp.

Listing 3.3: file

```
{
  "file": {
    "name": "report.dat",
```

```

4      "endpoint":
↪   "file://gregor@machine.edu:/data/report.dat",
5      "checksum":
↪   {"md5": "8c324f12047dc2254b74031b8f029ad0"},
6      "accessed": "1.1.2017:05:00:00:EST",
7      "created": "1.1.2017:05:00:00:EST",
8      "modified": "1.1.2017:05:00:00:EST",
9      "size": ["GB", "Byte"]
10   }
11 }

```

### 3.4. File Alias

A file could have one alias or even multiple ones.

Listing 3.4: file alias

```

1 {
2   "file_alias": {
3     "alias": "report-alias.dat",
4     "name": "report.dat"
5   }
6 }

```

### 3.5. Replica

In many distributed systems, it is of importance that a file can be replicated among different systems in order to provide faster access. It is important to provide a mechanism that allows to trace the pedigree of the file while pointing to its original source

Listing 3.5: replica

```

1 {
2   "replica": {
3     "name": "replica_report.dat",
4     "replica": "report.dat",
5     "endpoint":
↪   "file://gregor@machine.edu:/data/replica_report.dat",
6     "checksum": {
7       "md5":
↪   "8c324f12047dc2254b74031b8f029ad0"
8     },
9     "accessed": "1.1.2017:05:00:00:EST",
10    "size": [
11      "GB",
12      "Byte"
13    ]
14  }
15 }

```

### 3.6. Virtual Directory

A collection of files or replicas. A virtual directory can contain an number of entities including files, streams, and other virtual directories as part of a collection. The element in the collection can either be defined by uuid or by name.

Listing 3.6: virtual directory

```

1 {
2   "virtual_directory": {
3     "name": "data",

```

```

4     "endpoint": "http://.../data/",
5     "protocol": "http",
6     "collection": [
7       "report.dat",
8       "file2"
9     ]
10  }
11 }

```

### 3.7. Database

A **database** could have a name, an *endpoint* (e.g., host:port), and protocol used (e.g., SQL, mongo, etc.).

Listing 3.7: database

```

1 {
2   "database": {
3     "name": "data",
4     "endpoint": "http://.../data/",
5     "protocol": "mongo"
6   }
7 }

```

### 3.8. Stream

A stream provides a stream of data while providing information about 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.

Listing 3.8: stream

```

1 {
2   "stream": {
3     "name": "name of the variable",
4     "format": "the format of the data
↪   exchanged in the stream",
5     "attributes": {
6       "rate": 10,
7       "limit": 1000
8     }
9   }
10 }

```

Examples for streams could be a stream of random numbers but could also include more complex formats such as the retrieval of data records.

Services can subscribe, unsubscribe from a stream, while also applying filters to the subscribed stream.

Listing 3.9: filter

```

1 {
2   "filter": {
3     "name": "name of the filter",
4     "function": "the function of the data
↪   exchanged in the stream"
5   }
6 }

```

Filter needs to be refined

## 4. IAAS

In this section we are defining resources related to Infrastructure as a Service frameworks. This includes specific objects useful for OpenStack, Azure, and AWS, as well as others.

### 4.1. Openstack

#### 4.1.1. Openstack Flavor

Listing 4.1: openstack flavor

```
{
  "openstack_flavor": {
    "os_flv_disabled": "string",
    "uuid": "string",
    "os_flv_ext_data": "string",
    "ram": "string",
    "os_flavor_access": "string",
    "vcpus": "string",
    "swap": "string",
    "rxtx_factor": "string",
    "disk": "string"
  }
}
```

#### 4.1.2. Openstack Image

Listing 4.2: openstack image

```
{
  "openstack_image": {
    "status": "string",
    "username": "string",
    "updated": "string",
    "uuid": "string",
    "created": "string",
    "minDisk": "string",
    "progress": "string",
    "minRam": "string",
    "os_image_size": "string",
    "metadata": {
      "image_location": "string",
      "image_state": "string",
      "description": "string",
      "kernel_id": "string",
      "instance_type_id": "string",
      "ramdisk_id": "string",
      "instance_type_name": "string",
      "instance_type_rxtx_factor": "string",
      "instance_type_vcpus": "string",
      "user_id": "string",
      "base_image_ref": "string",
      "instance_uuid": "string",
      "instance_type_memory_mb": "string",
      "instance_type_swap": "string",
      "image_type": "string",
      "instance_type_ephemeral_gb": "string",
      "instance_type_root_gb": "string",
      "network_allocated": "string",
      "instance_type_flavorid": "string",
      "owner_id": "string"
    }
  }
}
```

```
}
```

#### 4.1.3. Openstack Vm

Listing 4.3: openstack vm

```
{
  "openstack_vm": {
    "username": "string",
    "vm_state": "string",
    "updated": "string",
    "hostId": "string",
    "availability_zone": "string",
    "terminated_at": "string",
    "image": "string",
    "floating_ip": "string",
    "diskConfig": "string",
    "key": "string",
    "flavor__id": "string",
    "user_id": "string",
    "flavor": "string",
    "static_ip": "string",
    "security_groups": "string",
    "volumes_attached": "string",
    "task_state": "string",
    "group": "string",
    "uuid": "string",
    "created": "string",
    "tenant_id": "string",
    "accessIPv4": "string",
    "accessIPv6": "string",
    "status": "string",
    "power_state": "string",
    "progress": "string",
    "image_id": "string",
    "launched_at": "string",
    "config_drive": "string"
  }
}
```

## 4.2. Azure

### 4.2.1. Azure Size

The size description of an azure vm

Listing 4.4: azure-size

```
{
  "azure-size": {
    "_uuid": "None",
    "name": "D14 Faster Compute Instance",
    "extra": {
      "cores": 16,
      "max_data_disks": 32
    },
    "price": 1.6261,
    "ram": 114688,
    "driver": "libcloud",
    "bandwidth": "None",
    "disk": 127,
    "id": "Standard_D14"
  }
}
```



```
16 }
329
```

#### 4.2.2. Azure Image

Listing 4.5: azure-image

```
1 {
2   "azure_image": {
3     "_uuid": "None",
4     "driver": "libcloud",
5     "extra": {
6       "affinity_group": "",
7       "category": "Public",
8       "description": "Linux VM image with
9         ↪ coreclr-x64-beta5-11624 installed to
10        ↪ /opt/dnx. This image is based on Ubuntu
11        ↪ 14.04 LTS, with prerequisites of CoreCLR
12        ↪ installed. It also contains PartsUnlimited
13        ↪ demo app which runs on the installed
14        ↪ coreclr. The demo app is installed to
15        ↪ /opt/demo. To run the demo, please type
16        ↪ the command /opt/demo/Kestrel in a
17        ↪ terminal window. The website is listening
18        ↪ on port 5004. Please enable or map a
19        ↪ endpoint of HTTP port 5004 for your azure
20        ↪ VM.",
21       "location": "East Asia;Southeast
22        ↪ Asia;Australia East;Australia
23        ↪ Southeast;Brazil South;North Europe;West
24        ↪ Europe;Japan East;Japan West;Central
25        ↪ US;East US;East US 2; North Central
26        ↪ US;South Central US;West US",
27       "media_link": "",
28       "os": "Linux",
29       "vm_image": "False"
30     },
31     "id": "03f55de797f546a1b29d1...",
32     "name": "CoreCLR x64 Beta5 (11624) with
33     ↪ PartsUnlimited Demo App on Ubuntu Server
34     ↪ 14.04 LTS"
35   }
36 }
```

#### 4.2.3. Azure Vm

An Azure virtual machine

Listing 4.6: azure-vm

```
1 {
2   "azure-vm": {
3     "username": "string",
4     "status": "string",
5     "deployment_slot": "string",
6     "cloud_service": "string",
7     "image": "string",
8     "floating_ip": "string",
9     "image_name": "string",
10    "key": "string",
11    "flavor": "string",
12    "resource_location": "string",
13    "disk_name": "string",
14    "private_ips": "string",
334
```

```
15   "group": "string",
16   "uuid": "string",
17   "dns_name": "string",
18   "instance_size": "string",
19   "instance_name": "string",
20   "public_ips": "string",
21   "media_link": "string"
22 }
23 }
```

## 5. HPC

### 5.1. Batch Job

Listing 5.1: batchjob

```
1 {
2   "batchjob": {
3     "output_file": "string",
4     "group": "string",
5     "job_id": "string",
6     "script": "string, the batch job script",
7     "cmd": "string, executes the cmd, if None
8     ↪ path is used",
9     "queue": "string",
10    "cluster": "string",
11    "time": "string",
12    "path": "string, path of the batchjob, if
13    ↪ non cmd is used",
14    "nodes": "string",
15    "dir": "string"
16  }
17 }
```

## 6. VIRTUAL CLUSTER

### 6.1. Cluster

The cluster object has name, label, endpoint and provider. The *endpoint* defines.... The *provider* defines the nature of the cluster, e.g., its a virtual cluster on an openstack cloud, or from AWS, or a bare-metal cluster.

Listing 6.1: cluster

```
1 {
2   "cluster": {
3     "label": "c0",
4     "endpoint": {
5       "passwd": "secret",
6       "url": "https"
7     },
8     "name": "myCLuster",
9     "provider": [
10      "openstack",
11      "aws",
12      "azure",
13      "eucalyptus"
14    ]
15  }
16 }
```

## 6.2. Compute Resource

An important concept for big data analysis is the representation of a compute resource on which we execute the analysis. We define a compute resource by name and by endpoint. A compute resource is an abstract concept and can be instantiated through virtual machines, containers, or bare metal resources. This is defined by the “kind” of the compute resource.

**compute\_resource** object has attribute *endpoint* which specifies ... The *kind* could be *baremetal* or *VC*.

Listing 6.2: compute resource

```
{
  "compute_resource": {
    "name": "Compute1",
    "endpoint": "http://.../cluster/",
    "kind": "baremetal"
  }
}
```

## 6.3. Computer

This defines a **computer** object. A computer has name, label, IP address. It also listed the relevant specs such as memory, disk size, etc.

Listing 6.3: computer

```
{
  "computer": {
    "ip": "127.0.0.1",
    "name": "myComputer",
    "memoryGB": 16,
    "label": "server-001"
  }
}
```

## 6.4. Compute Node

A node is composed of multiple components:

1. Metadata such as the *name* or *owner*.
2. Physical properties such as *cores* or *memory*.
3. Configuration guidance such as *create\_external\_ip*, *security\_groups*, or *users*.

The metadata is associated with the node on the provider end (if supported) as well as in the database. Certain parts of the metadata (such as *owner*) can be used to implement access control. Physical properties are relevant for the initial allocation of the node. Other configuration parameters control and further provisioning.

In the above, after allocation, the node is configured with a user called *hello* who is part of the *wheel* group whose account can be accessed with several SSH identities whose public keys are provided (in *authorized\_keys*).

Additionally, three ssh keys are generated on the node for the *hello* user. The first uses the *ed25519* cryptographic method with a password read in from a GPG-encrypted file on the Command and Control node. The second is a 4098-bit RSA key also password-protected from the GPG-encrypted

file. The third key is copied to the remote node from an encrypted file on the Command and Control node.

This definition also provides a security group to control access to the node from the wide-area-network. In this case all ingress and egress TCP and UDP traffic is allowed provided they are to ports 22 (SSH), 443 (SSL), and 80 and 8080 (web).

Listing 6.4: node

```
{
  "node_new": {
    "authorized_keys": [
      "ssh-rsa AAAA...",
      "ssh-ed25519 AAAA...",
      "...etc"
    ],
    "name": "example-001",
    "external_ip": "",
    "loginuser": "root",
    "create_external_ip": true,
    "internal_ip": "",
    "memory": 2048,
    "owner": "",
    "cores": 2,
    "users": {
      "name": "hello",
      "groups": [
        "wheel"
      ]
    },
    "disk": 80,
    "security_groups": [
      {
        "ingress": "0.0.0.0/32",
        "egress": "0.0.0.0/32",
        "ports": [
          22,
          443,
          80,
          8080
        ],
        "protocols": [
          "tcp",
          "udp"
        ]
      }
    ],
    "ssh_keys": [
      {
        "to": ".ssh/id_rsa",
        "password": {
          "decrypt": "gpg",
          "from": "yaml",
          "file": "secrets.yml.gpg",
          "key": "users.hello.ssh[0]"
        },
        "method": "ed25519",
        "ssh_keygen": true
      },
      {
        "to": ".ssh/testing",
        "password": {
```



```

54     "decrypt": "gpg",
55     "from": "yaml",
56     "file": "secrets.yml.gpg",
57     "key": "users.hello.ssh[i]"
58   },
59   "bits": 4098,
60   "method": "rsa",
61   "ssh_keygen": true
62 },
63 {
64   "decrypt": "gpg",
65   "from":
↪ "secrets/ssh/hello/copied.gpg",
66   "ssh_keygen": false,
67   "to": ".ssh/copied"
68 }
69 ]
70 }
71 }

```

### 6.5. Virtual Cluster

A virtual cluster is an agglomeration of virtual compute nodes that constitute the cluster. Nodes can be assembled to be baremetal, virtual machines, and containers. A virtual cluster contains a number of virtual compute nodes.

Listing 6.5: virtual cluster

```

1 {
2   "virtual_cluster": {
3     "name": "myvc",
4     "frontend": "objectid:virtual_machine",
5     "nodes": [
6       "objectid:virtual_machine"
7     ]
8   }
9 }

```

### 6.6. Virtual Compute node

Listing 6.6: virtual compute node

```

1 {
2   "virtual_compute_node": {
3     "name": "data",
4     "endpoint": "http://.../cluster/",
5     "metadata": {
6       "experiment": "exp-001"
7     },
8     "image": "Ubuntu-16.04",
9     "ip": [
10      "TBD"
11    ],
12     "flavor": "TBD",
13     "status": "TBD"
14   }
15 }

```

### 6.7. Virtual Machine

Virtual Machine Virtual machines are an emulation of a computer system. We are maintaining a very basic set of infor-

mation. It is expected that through the endpoint the virtual machine can be introspected and more detailed information can be retrieved.

Listing 6.7: virtual machine

```

1 {
2   "virtual_machine" :{
3     "name": "vm1",
4     "ncpu": 2,
5     "RAM": "4G",
6     "disk": "40G",
7     "nics": ["objectid:nic"
8   ],
9     "OS": "Ubuntu-16.04",
10    "loginuser": "ubuntu",
11    "status": "active",
12    "metadata":{
13    },
14    "authorized_keys": [
15      "objectid:sshkey"
16    ]
17  }
18 }

```

### 6.8. Mesos

Refine

Listing 6.8: mesos

```

1 {
2   "mesos-docker": {
3     "instances": 1,
4     "container": {
5       "docker": {
6         "credential": {
7           "secret": "my-secret",
8           "principal": "my-principal"
9         },
10        "image": "mesosphere/inky"
11      },
12      "type": "MESOS"
13    },
14    "mem": 16.0,
15    "args": [
16      "argument"
17    ],
18    "cpus": 0.2,
19    "id": "mesos-docker"
20  }
21 }

```

## 7. CONTAINERS

### 7.1. Container

This defines container object.

Listing 7.1: container

```

1 {
2   "container": {
3     "name": "container1",

```

```

4      "endpoint": "http://.../container/",
5      "ip": "127.0.0.1",
6      "label": "server-001",
7      "memoryGB": 16
8  }
9  }

```

```

49  {
50      "name": "e2e",
51      "user": {
52          "username": "admin",
53          "password": "secret"
54      }
55  }
56  ]
57  }
58  }

```

## 7.2. Kubernetes

REFINE

Listing 7.2: kubernetes

```

1  {
2      "kubernetes": {
3          "kind": "List",
4          "items": [
5              {
6                  "kind": "None",
7                  "metadata": {
8                      "name": "127.0.0.1"
9                  },
10                 "status": {
11                     "capacity": {
12                         "cpu": "4"
13                     },
14                     "addresses": [
15                         {
16                             "type": "LegacyHostIP",
17                             "address": "127.0.0.1"
18                         }
19                     ]
20                 },
21             },
22             {
23                 "kind": "None",
24                 "metadata": {
25                     "name": "127.0.0.2"
26                 },
27                 "status": {
28                     "capacity": {
29                         "cpu": "8"
30                     },
31                     "addresses": [
32                         {
33                             "type": "LegacyHostIP",
34                             "address": "127.0.0.2"
35                         },
36                         {
37                             "type": "another",
38                             "address": "127.0.0.3"
39                         }
40                     ]
41                 },
42             }
43         ],
44         "users": [
45             {
46                 "name": "myself",
47                 "user": "gregor"
48             },

```

## 8. DEPLOYMENT

### 8.1. Deployment

A **deployment** consists of the resource *cluster*, the location *provider*, e.g., AWS, OpenStack, etc., and software *stack* to be deployed (e.g., hadoop, spark).

Listing 8.1: deployment

```

1  {
2      "deployment": {
3          "cluster": [{ "name": "myCluster"},
4                      { "id" : "cm-0001"}
5                  ],
6          "stack": {
7              "layers": [
8                  "zookeeper",
9                  "hadoop",
10                 "spark",
11                 "postgresql"
12             ],
13             "parameters": {
14                 "hadoop": {
15                     ↪ "zookeeper.quorum": [ "IP", "IP", "IP"]
16                 }
17             }
18         }
19     }

```

## 9. MAPREDUCE

### 9.1. Hadoop

A **hadoop** definition defines which *deployer* to be used, the *parameters* of the deployment, and the system packages as *requires*. For each requirement, it could have attributes such as the library origin, version, etc.

Listing 9.1: hadoop

```

1  {
2      "hadoop": {
3          "deployers": {
4              "ansible":
5              ↪ "git://github.com/cloudmesh_roles/hadoop"
6          },
7          "requires": {
8              "java": {
9                  "implementation": "OpenJDK",
10                 "version": "1.8",

```

```

10     "zookeeper": "TBD",
11     "supervisord": "TBD"
12   },
13 },
14 "parameters": {
15   "num_resourcemangers": 1,
16   "num_namenodes": 1,
17   "use_yarn": false,
18   "use_hdfs": true,
19   "num_datanodes": 1,
20   "num_historyservers": 1,
21   "num_journalnodes": 1
22 }
23 }
24 }

```

## 9.2. Mapreduce

This defines a **mapreduce** deployment with its layered components.

Listing 9.2: mapreduce

```

1 {
2   "mapreduce": {
3     "layers": [
4       "hadoop"
5     ],
6     "hdfs_datanode": "IP ADDRESS",
7     "java": {
8       "platform": "OpenJDK",
9       "version": "1.8"
10    },
11    "supervisord": "",
12    "hdfs_namenode": "IP ADDRESS",
13    "zookeeper": "IP ADDRESS",
14    "yarn_historyserver": "IP ADDRESS",
15    "hdfs_journalnode": "IP ADDRESS",
16    "yarn_resourcemanager": "IP ADDRESS"
17  }
18 }

```

## 10. SECURITY

### 10.1. Key

Listing 10.1: key

```

1 {
2   "sshkey": {
3     "comment": "string",
4     "source": "string",
5     "uri": "string",
6     "value": "ssh-rsa",
7     "fingerprint": "string, unique"
8   }
9 }

```

## 11. MICROSERVICE

### 11.1. Microservice

introduce registry we can register many things to it latency provide example on how to use each of them, not just the object definition example

necessity of local direct attached storage. Mimd model to storage Kubernetes, mesos can not spin up ? Takes time to spin them up and coordinate them. While setting up environment takes more thsn using the microservice, so we must make sure that the micorservices are used sufficiently to offset spinup cost.

limitation of resource capacity such as networking.

Benchmarking to find out thing about service level agreement to access the

A system could be composed of from various microservices, and this defines each of them.

Listing 11.1: microservice

```

1 {
2   "microservice" :{
3     "name": "ms1",
4     "endpoint": "http://.../ms/",
5     "function": "microservice spec"
6   }
7 }

```

### 11.2. Reservation

Listing 11.2: reservation

```

1 {
2   "reservation": {
3     "hosts": "string",
4     "description": "string",
5     "start_time": [
6       "date",
7       "time"
8     ],
9     "end_time": [
10      "date",
11      "time"
12    ]
13  }
14 }

```

## 12. NETWORK

We are looking for volunteers to contribute here.

## A. SCHEMA COMMAND

## B. SCHEMA

TBD

Listing B.1: schema

```

1  profile = {
2      'schema': {
3          'username': {
4              'type': 'string'
5          },
6          'context': {
7              'type': 'string'
8          },
9          'description': {
10             'type': 'string'
11         },
12         'firstname': {
13             'type': 'string'
14         },
15         'lastname': {
16             'type': 'string'
17         },
18         'email': {
19             'type': 'string'
20         },
21         'uuid': {
22             'type': 'string'
23         }
24     }
25 }
26
27 virtual_machine = {
28     'schema': {
29         'status': {
30             'type': 'string'
31         },
32         'authorized_keys': {
33             'type': 'list',
34             'schema': {
35                 'type': 'objectid',
36                 'data_relation': {
37                     'resource': 'sshkey',
38                     'field': '_id',
39                     'embeddable': True
40                 }
41             }
42         },
43         'name': {
44             'type': 'string'
45         },
46         'nics': {
47             'type': 'list',
48             'schema': {
49                 'type': 'objectid',
50                 'data_relation': {
51                     'resource': 'nic',
52                     'field': '_id',
53                     'embeddable': True
54                 }
55             }
56         }
57     }
58 }

```

```

56     },
57     'RAM': {
58         'type': 'string'
59     },
60     'ncpu': {
61         'type': 'integer'
62     },
63     'loginuser': {
64         'type': 'string'
65     },
66     'disk': {
67         'type': 'string'
68     },
69     'OS': {
70         'type': 'string'
71     },
72     'metadata': {
73         'type': 'dict',
74         'schema': {}
75     }
76 }
77
78 kubernetes = {
79     'schema': {
80         'items': {
81             'type': 'list',
82             'schema': {
83                 'type': 'dict',
84                 'schema': {
85                     'status': {
86                         'type': 'dict',
87                         'schema': {
88                             'capacity': {
89                                 'type':
90                                     'dict',
91                                     'schema': {
92                                         'cpu': {
93                                             'type':
94                                                 'dict',
95                                                 'schema': {
96                                                     'addresses': {
97                                                         'type':
98                                                             'list',
99                                                             'schema': {
100                                                                 'type':
101                                                                     'dict',
102                                                                     'schema':
103                                                                         {
104                                                                 'type': {
105                                                                    'type': 'string'
106                                                                },
107                                                                'address': {
108                                                                    'type': 'string'
109                                                                }
110                                                            }
111                                                        }
112                                                    }
113                                                }
114                                            }
115                                        }
116                                    }
117                                }
118                            }
119                        }
120                    }
121                }
122            }
123        }
124    }
125 }

```

```

108         }
109     }
110 }
111 }
112 },
113 'kind': {
114     'type': 'string'
115 },
116 'metadata': {
117     'type': 'dict',
118     'schema': {
119         'name': {
120             'type':
↪ 'string'
121         }
122     }
123 }
124 }
125 }
126 },
127 'kind': {
128     'type': 'string'
129 },
130 'users': {
131     'type': 'list',
132     'schema': {
133         'type': 'dict',
134         'schema': {
135             'name': {
136                 'type': 'string'
137             },
138             'user': {
139                 'type': 'dict',
140                 'schema': {
141                     'username': {
142                         'type':
↪ 'string'
143                     },
144                     'password': {
145                         'type':
↪ 'string'
146                     }
147                 }
148             }
149         }
150     }
151 }
152 }
153 }
154 }
155 nic = {
156     'schema': {
157         'name': {
158             'type': 'string'
159         },
160         'ip': {
161             'type': 'string'
162         },
163         'mask': {
164             'type': 'string'
165         },

```

```

166         'bandwidth': {
167             'type': 'string'
168         },
169         'mtu': {
170             'type': 'integer'
171         },
172         'broadcast': {
173             'type': 'string'
174         },
175         'mac': {
176             'type': 'string'
177         },
178         'type': {
179             'type': 'string'
180         },
181         'gateway': {
182             'type': 'string'
183         }
184     }
185 }
186 }
187 virtual_compute_node = {
188     'schema': {
189         'status': {
190             'type': 'string'
191         },
192         'endpoint': {
193             'type': 'string'
194         },
195         'name': {
196             'type': 'string'
197         },
198         'ip': {
199             'type': 'list',
200             'schema': {
201                 'type': 'string'
202             }
203         },
204         'image': {
205             'type': 'string'
206         },
207         'flavor': {
208             'type': 'string'
209         },
210         'metadata': {
211             'type': 'dict',
212             'schema': {
213                 'experiment': {
214                     'type': 'string'
215                 }
216             }
217         }
218     }
219 }
220 }
221 openstack_flavor = {
222     'schema': {
223         'os_flv_disabled': {
224             'type': 'string'
225         },
226         'uuid': {

```

```

227         'type': 'string'
228     },
229     'os_flv_ext_data': {
230         'type': 'string'
231     },
232     'ram': {
233         'type': 'string'
234     },
235     'os_flavor_acces': {
236         'type': 'string'
237     },
238     'vcpus': {
239         'type': 'string'
240     },
241     'swap': {
242         'type': 'string'
243     },
244     'rxtx_factor': {
245         'type': 'string'
246     },
247     'disk': {
248         'type': 'string'
249     }
250 }
251 }

```

```

252
253 azure_vm = {
254     'schema': {
255         'username': {
256             'type': 'string'
257         },
258         'status': {
259             'type': 'string'
260         },
261         'deployment_slot': {
262             'type': 'string'
263         },
264         'group': {
265             'type': 'string'
266         },
267         'private_ips': {
268             'type': 'string'
269         },
270         'cloud_service': {
271             'type': 'string'
272         },
273         'dns_name': {
274             'type': 'string'
275         },
276         'image': {
277             'type': 'string'
278         },
279         'floating_ip': {
280             'type': 'string'
281         },
282         'image_name': {
283             'type': 'string'
284         },
285         'instance_name': {
286             'type': 'string'
287         },

```

```

288     'public_ips': {
289         'type': 'string'
290     },
291     'media_link': {
292         'type': 'string'
293     },
294     'key': {
295         'type': 'string'
296     },
297     'flavor': {
298         'type': 'string'
299     },
300     'resource_location': {
301         'type': 'string'
302     },
303     'instance_size': {
304         'type': 'string'
305     },
306     'disk_name': {
307         'type': 'string'
308     },
309     'uuid': {
310         'type': 'string'
311     }
312 }
313 }

```

```

314
315 azure_size = {
316     'schema': {
317         'ram': {
318             'type': 'integer'
319         },
320         'name': {
321             'type': 'string'
322         },
323         'extra': {
324             'type': 'dict',
325             'schema': {
326                 'cores': {
327                     'type': 'integer'
328                 },
329                 'max_data_disks': {
330                     'type': 'integer'
331                 }
332             }
333         },
334         'price': {
335             'type': 'float'
336         },
337         '_uuid': {
338             'type': 'string'
339         },
340         'driver': {
341             'type': 'string'
342         },
343         'bandwidth': {
344             'type': 'string'
345         },
346         'disk': {
347             'type': 'integer'
348         },

```



```

349         'id': {
350             'type': 'string'
351         }
352     }
353 }
354
355 openstack_vm = {
356     'schema': {
357         'vm_state': {
358             'type': 'string'
359         },
360         'availability_zone': {
361             'type': 'string'
362         },
363         'terminated_at': {
364             'type': 'string'
365         },
366         'image': {
367             'type': 'string'
368         },
369         'diskConfig': {
370             'type': 'string'
371         },
372         'flavor': {
373             'type': 'string'
374         },
375         'security_groups': {
376             'type': 'string'
377         },
378         'volumes_attached': {
379             'type': 'string'
380         },
381         'user_id': {
382             'type': 'string'
383         },
384         'uuid': {
385             'type': 'string'
386         },
387         'accessIPv4': {
388             'type': 'string'
389         },
390         'accessIPv6': {
391             'type': 'string'
392         },
393         'power_state': {
394             'type': 'string'
395         },
396         'progress': {
397             'type': 'string'
398         },
399         'image__id': {
400             'type': 'string'
401         },
402         'launched_at': {
403             'type': 'string'
404         },
405         'config_drive': {
406             'type': 'string'
407         },
408         'username': {
409             'type': 'string'

```

```

410     },
411     'updated': {
412         'type': 'string'
413     },
414     'hostId': {
415         'type': 'string'
416     },
417     'floating_ip': {
418         'type': 'string'
419     },
420     'static_ip': {
421         'type': 'string'
422     },
423     'key': {
424         'type': 'string'
425     },
426     'flavor__id': {
427         'type': 'string'
428     },
429     'group': {
430         'type': 'string'
431     },
432     'task_state': {
433         'type': 'string'
434     },
435     'created': {
436         'type': 'string'
437     },
438     'tenant_id': {
439         'type': 'string'
440     },
441     'status': {
442         'type': 'string'
443     }
444 }
445 }
446
447 cluster = {
448     'schema': {
449         'provider': {
450             'type': 'list',
451             'schema': {
452                 'type': 'string'
453             }
454         },
455         'endpoint': {
456             'type': 'dict',
457             'schema': {
458                 'passwd': {
459                     'type': 'string'
460                 },
461                 'url': {
462                     'type': 'string'
463                 }
464             }
465         },
466         'name': {
467             'type': 'string'
468         },
469         'label': {
470             'type': 'string'

```

```

471     }
472   }
473 }
474
475 computer = {
476   'schema': {
477     'ip': {
478       'type': 'string'
479     },
480     'name': {
481       'type': 'string'
482     },
483     'memoryGB': {
484       'type': 'integer'
485     },
486     'label': {
487       'type': 'string'
488     }
489   }
490 }
491
492 libcloud_image = {
493   'schema': {
494     'username': {
495       'type': 'string'
496     },
497     'status': {
498       'type': 'string'
499     },
500     'updated': {
501       'type': 'string'
502     },
503     'description': {
504       'type': 'string'
505     },
506     'owner_alias': {
507       'type': 'string'
508     },
509     'kernel_id': {
510       'type': 'string'
511     },
512     'hypervisor': {
513       'type': 'string'
514     },
515     'ramdisk_id': {
516       'type': 'string'
517     },
518     'state': {
519       'type': 'string'
520     },
521     'created': {
522       'type': 'string'
523     },
524     'image_id': {
525       'type': 'string'
526     },
527     'image_location': {
528       'type': 'string'
529     },
530     'platform': {
531       'type': 'string'

```

```

532   },
533   'image_type': {
534     'type': 'string'
535   },
536   'is_public': {
537     'type': 'string'
538   },
539   'owner_id': {
540     'type': 'string'
541   },
542   'architecture': {
543     'type': 'string'
544   },
545   'virtualization_type': {
546     'type': 'string'
547   },
548   'uuid': {
549     'type': 'string'
550   }
551 }
552
553
554 user = {
555   'schema': {
556     'username': {
557       'type': 'string'
558     },
559     'context': {
560       'type': 'string'
561     },
562     'uuid': {
563       'type': 'string'
564     },
565     'firstname': {
566       'type': 'string'
567     },
568     'lastname': {
569       'type': 'string'
570     },
571     'roles': {
572       'type': 'list',
573       'schema': {
574         'type': 'string'
575       }
576     },
577     'email': {
578       'type': 'string'
579     }
580   }
581 }
582
583 file = {
584   'schema': {
585     'endpoint': {
586       'type': 'string'
587     },
588     'name': {
589       'type': 'string'
590     },
591     'created': {
592       'type': 'string'

```

```

593     },
594     'checksum': {
595         'type': 'dict',
596         'schema': {
597             'md5': {
598                 'type': 'string'
599             }
600         }
601     },
602     'modified': {
603         'type': 'string'
604     },
605     'accessed': {
606         'type': 'string'
607     },
608     'size': {
609         'type': 'list',
610         'schema': {
611             'type': 'string'
612         }
613     }
614 }
615 }
616
617 deployment = {
618     'schema': {
619         'cluster': {
620             'type': 'list',
621             'schema': {
622                 'type': 'dict',
623                 'schema': {
624                     'id': {
625                         'type': 'string'
626                     }
627                 }
628             },
629         },
630         'stack': {
631             'type': 'dict',
632             'schema': {
633                 'layers': {
634                     'type': 'list',
635                     'schema': {
636                         'type': 'string'
637                     }
638                 },
639                 'parameters': {
640                     'type': 'dict',
641                     'schema': {
642                         'hadoop': {
643                             'type': 'dict',
644                             'schema': {
645
646             ↪ 'zookeeper.quorum': {
647
648             ↪ 'list',
649
650             ↪ {
651
652             ↪ 'type': 'string'
653
654             ↪ }
655         }
656     }
657 }

```

```

650     }
651     }
652     }
653     }
654     }
655     }
656     }
657     }
658 }
659
660 mapreduce = {
661     'schema': {
662         'layers': {
663             'type': 'list',
664             'schema': {
665                 'type': 'string'
666             }
667         },
668         'hdfs_datanode': {
669             'type': 'string'
670         },
671         'java': {
672             'type': 'dict',
673             'schema': {
674                 'platform': {
675                     'type': 'string'
676                 },
677                 'version': {
678                     'type': 'string'
679                 }
680             }
681         },
682         'supervisord': {
683             'type': 'string'
684         },
685         'yarn_historyserver': {
686             'type': 'string'
687         },
688         'zookeeper': {
689             'type': 'string'
690         },
691         'hdfs_namenode': {
692             'type': 'string'
693         },
694         'hdfs_journalnode': {
695             'type': 'string'
696         },
697         'yarn_resourcemanager': {
698             'type': 'string'
699         }
700     }
701 }
702
703 group = {
704     'schema': {
705         'users': {
706             'type': 'list',
707             'schema': {
708                 'type': 'objectid',
709                 'data_relation': {
710                     'resource': 'user',

```

```

711         'field': '_id',
712         'embeddable': True
713     }
714 }
715 },
716 'name': {
717     'type': 'string'
718 },
719 'description': {
720     'type': 'string'
721 }
722 }
723 }
724
725 role = {
726     'schema': {
727         'users': {
728             'type': 'list',
729             'schema': {
730                 'type': 'objectid',
731                 'data_relation': {
732                     'resource': 'user',
733                     'field': '_id',
734                     'embeddable': True
735                 }
736             }
737         },
738         'name': {
739             'type': 'string'
740         },
741         'description': {
742             'type': 'string'
743         }
744     }
745 }
746
747 virtual_directory = {
748     'schema': {
749         'endpoint': {
750             'type': 'string'
751         },
752         'protocol': {
753             'type': 'string'
754         },
755         'name': {
756             'type': 'string'
757         },
758         'collection': {
759             'type': 'list',
760             'schema': {
761                 'type': 'string'
762             }
763         }
764     }
765 }
766
767 file_alias = {
768     'schema': {
769         'alias': {
770             'type': 'string'
771         },

```

```

772         'name': {
773             'type': 'string'
774         }
775     }
776 }
777
778 virtual_cluster = {
779     'schema': {
780         'nodes': {
781             'type': 'list',
782             'schema': {
783                 'type': 'objectid',
784                 'data_relation': {
785                     'resource':
786                     ↪ 'virtual_machine',
787                     'field': '_id',
788                     'embeddable': True
789                 }
790             },
791             'frontend': {
792                 'type': 'objectid',
793                 'data_relation': {
794                     'resource': 'virtual_machine',
795                     'field': '_id',
796                     'embeddable': True
797                 }
798             },
799             'name': {
800                 'type': 'string'
801             }
802         }
803     }
804
805 libcloud_flavor = {
806     'schema': {
807         'uuid': {
808             'type': 'string'
809         },
810         'price': {
811             'type': 'string'
812         },
813         'ram': {
814             'type': 'string'
815         },
816         'bandwidth': {
817             'type': 'string'
818         },
819         'flavor_id': {
820             'type': 'string'
821         },
822         'disk': {
823             'type': 'string'
824         },
825         'cpu': {
826             'type': 'string'
827         }
828     }
829 }
830
831 batchjob = {

```

```

832     'schema': {
833         'output_file': {
834             'type': 'string'
835         },
836         'group': {
837             'type': 'string'
838         },
839         'job_id': {
840             'type': 'string'
841         },
842         'script': {
843             'type': 'string'
844         },
845         'cmd': {
846             'type': 'string'
847         },
848         'queue': {
849             'type': 'string'
850         },
851         'cluster': {
852             'type': 'string'
853         },
854         'time': {
855             'type': 'string'
856         },
857         'path': {
858             'type': 'string'
859         },
860         'nodes': {
861             'type': 'string'
862         },
863         'dir': {
864             'type': 'string'
865         }
866     }
867 }
868
869 organization = {
870     'schema': {
871         'users': {
872             'type': 'list',
873             'schema': {
874                 'type': 'objectid',
875                 'data_relation': {
876                     'resource': 'user',
877                     'field': '_id',
878                     'embeddable': True
879                 }
880             }
881         }
882     }
883 }
884
885 container = {
886     'schema': {
887         'ip': {
888             'type': 'string'
889         },
890         'endpoint': {
891             'type': 'string'
892         },

```

```

893         'name': {
894             'type': 'string'
895         },
896         'memoryGB': {
897             'type': 'integer'
898         },
899         'label': {
900             'type': 'string'
901         }
902     }
903 }
904
905 sshkey = {
906     'schema': {
907         'comment': {
908             'type': 'string'
909         },
910         'source': {
911             'type': 'string'
912         },
913         'uri': {
914             'type': 'string'
915         },
916         'value': {
917             'type': 'string'
918         },
919         'fingerprint': {
920             'type': 'string'
921         }
922     }
923 }
924
925 stream = {
926     'schema': {
927         'attributes': {
928             'type': 'dict',
929             'schema': {
930                 'rate': {
931                     'type': 'integer'
932                 },
933                 'limit': {
934                     'type': 'integer'
935                 }
936             }
937         },
938         'name': {
939             'type': 'string'
940         },
941         'format': {
942             'type': 'string'
943         }
944     }
945 }
946
947 database = {
948     'schema': {
949         'endpoint': {
950             'type': 'string'
951         },
952         'protocol': {
953             'type': 'string'

```

```

954     },
955     'name': {
956         'type': 'string'
957     }
958 }
959 }
960
961 default = {
962     'schema': {
963         'context': {
964             'type': 'string'
965         },
966         'name': {
967             'type': 'string'
968         },
969         'value': {
970             'type': 'string'
971         }
972     }
973 }
974
975 openstack_image = {
976     'schema': {
977         'status': {
978             'type': 'string'
979         },
980         'username': {
981             'type': 'string'
982         },
983         'updated': {
984             'type': 'string'
985         },
986         'uuid': {
987             'type': 'string'
988         },
989         'created': {
990             'type': 'string'
991         },
992         'minDisk': {
993             'type': 'string'
994         },
995         'progress': {
996             'type': 'string'
997         },
998         'minRam': {
999             'type': 'string'
1000         },
1001         'os_image_size': {
1002             'type': 'string'
1003         },
1004         'metadata': {
1005             'type': 'dict',
1006             'schema': {
1007                 'instance_uuid': {
1008                     'type': 'string'
1009                 },
1010                 'image_location': {
1011                     'type': 'string'
1012                 },
1013                 'image_state': {
1014                     'type': 'string'

```

```

1015     },
1016     'instance_type_memory_mb': {
1017         'type': 'string'
1018     },
1019     'user_id': {
1020         'type': 'string'
1021     },
1022     'description': {
1023         'type': 'string'
1024     },
1025     'kernel_id': {
1026         'type': 'string'
1027     },
1028     'instance_type_name': {
1029         'type': 'string'
1030     },
1031     'ramdisk_id': {
1032         'type': 'string'
1033     },
1034     'instance_type_id': {
1035         'type': 'string'
1036     },
1037     'instance_type_ephemeral_gb':
1038     {
1039         'type': 'string'
1040     },
1041     'instance_type_rxtx_factor': {
1042         'type': 'string'
1043     },
1044     'image_type': {
1045         'type': 'string'
1046     },
1047     'network_allocated': {
1048         'type': 'string'
1049     },
1050     'instance_type_flavorid': {
1051         'type': 'string'
1052     },
1053     'instance_type_vcpus': {
1054         'type': 'string'
1055     },
1056     'instance_type_root_gb': {
1057         'type': 'string'
1058     },
1059     'base_image_ref': {
1060         'type': 'string'
1061     },
1062     'instance_type_swap': {
1063         'type': 'string'
1064     },
1065     'owner_id': {
1066         'type': 'string'
1067     }
1068 }
1069 }
1070 }
1071
1072 azure_image = {
1073     'schema': {
1074         '_uuid': {

```



```

1075         'type': 'string'
1076     },
1077     'driver': {
1078         'type': 'string'
1079     },
1080     'id': {
1081         'type': 'string'
1082     },
1083     'name': {
1084         'type': 'string'
1085     },
1086     'extra': {
1087         'type': 'dict',
1088         'schema': {
1089             'category': {
1090                 'type': 'string'
1091             },
1092             'description': {
1093                 'type': 'string'
1094             },
1095             'vm_image': {
1096                 'type': 'string'
1097             },
1098             'location': {
1099                 'type': 'string'
1100             },
1101             'affinity_group': {
1102                 'type': 'string'
1103             },
1104             'os': {
1105                 'type': 'string'
1106             },
1107             'media_link': {
1108                 'type': 'string'
1109             }
1110         }
1111     }
1112 }
1113 }

```

```

1115 hadoop = {
1116     'schema': {
1117         'deployers': {
1118             'type': 'dict',
1119             'schema': {
1120                 'ansible': {
1121                     'type': 'string'
1122                 }
1123             }
1124         },
1125         'requires': {
1126             'type': 'dict',
1127             'schema': {
1128                 'java': {
1129                     'type': 'dict',
1130                     'schema': {
1131                         'implementation': {
1132                             'type': 'string'
1133                         },
1134                         'version': {
1135                             'type': 'string'

```

```

1136     },
1137     'zookeeper': {
1138         'type': 'string'
1139     },
1140     'supervisord': {
1141         'type': 'string'
1142     }
1143 }
1144 }
1145 }
1146 },
1147 'parameters': {
1148     'type': 'dict',
1149     'schema': {
1150         'num_resourcemanager': {
1151             'type': 'integer'
1152         },
1153         'num_namenodes': {
1154             'type': 'integer'
1155         },
1156         'use_yarn': {
1157             'type': 'boolean'
1158         },
1159         'num_datanodes': {
1160             'type': 'integer'
1161         },
1162         'use_hdfs': {
1163             'type': 'boolean'
1164         },
1165         'num_historyservers': {
1166             'type': 'integer'
1167         },
1168         'num_journalnodes': {
1169             'type': 'integer'
1170         }
1171     }
1172 }
1173 }
1174 }
1175 }

```

```

1176 compute_resource = {
1177     'schema': {
1178         'kind': {
1179             'type': 'string'
1180         },
1181         'endpoint': {
1182             'type': 'string'
1183         },
1184         'name': {
1185             'type': 'string'
1186         }
1187     }
1188 }
1189 }

```

```

1190 node_new = {
1191     'schema': {
1192         'authorized_keys': {
1193             'type': 'list',
1194             'schema': {
1195                 'type': 'string'
1196             }

```

```

1197     },
1198     'name': {
1199         'type': 'string'
1200     },
1201     'external_ip': {
1202         'type': 'string'
1203     },
1204     'memory': {
1205         'type': 'integer'
1206     },
1207     'create_external_ip': {
1208         'type': 'boolean'
1209     },
1210     'internal_ip': {
1211         'type': 'string'
1212     },
1213     'loginuser': {
1214         'type': 'string'
1215     },
1216     'owner': {
1217         'type': 'string'
1218     },
1219     'cores': {
1220         'type': 'integer'
1221     },
1222     'disk': {
1223         'type': 'integer'
1224     },
1225     'ssh_keys': {
1226         'type': 'list',
1227         'schema': {
1228             'type': 'dict',
1229             'schema': {
1230                 'from': {
1231                     'type': 'string'
1232                 },
1233                 'decrypt': {
1234                     'type': 'string'
1235                 },
1236                 'ssh_keygen': {
1237                     'type': 'boolean'
1238                 },
1239                 'to': {
1240                     'type': 'string'
1241                 }
1242             }
1243         },
1244     },
1245     'security_groups': {
1246         'type': 'list',
1247         'schema': {
1248             'type': 'dict',
1249             'schema': {
1250                 'ingress': {
1251                     'type': 'string'
1252                 },
1253                 'egress': {
1254                     'type': 'string'
1255                 },
1256                 'ports': {
1257                     'type': 'list',

```

```

1258         'schema': {
1259             'type': 'integer'
1260         }
1261     },
1262     'protocols': {
1263         'type': 'list',
1264         'schema': {
1265             'type': 'string'
1266         }
1267     }
1268 }
1269 },
1270 'users': {
1271     'type': 'dict',
1272     'schema': {
1273         'name': {
1274             'type': 'string'
1275         },
1276         'groups': {
1277             'type': 'list',
1278             'schema': {
1279                 'type': 'string'
1280             }
1281         }
1282     }
1283 }
1284 }
1285 }
1286 }
1287
1288 filter = {
1289     'schema': {
1290         'function': {
1291             'type': 'string'
1292         },
1293         'name': {
1294             'type': 'string'
1295         }
1296     }
1297 }
1298
1299 reservation = {
1300     'schema': {
1301         'start_time': {
1302             'type': 'list',
1303             'schema': {
1304                 'type': 'string'
1305             }
1306         },
1307         'hosts': {
1308             'type': 'string'
1309         },
1310         'description': {
1311             'type': 'string'
1312         },
1313         'end_time': {
1314             'type': 'list',
1315             'schema': {
1316                 'type': 'string'
1317             }
1318         }
1319     }

```

```

1319     }
1320 }
1321
1322 replica = {
1323     'schema': {
1324         'endpoint': {
1325             'type': 'string'
1326         },
1327         'name': {
1328             'type': 'string'
1329         },
1330         'checksum': {
1331             'type': 'dict',
1332             'schema': {
1333                 'md5': {
1334                     'type': 'string'
1335                 }
1336             },
1337         },
1338         'replica': {
1339             'type': 'string'
1340         },
1341         'accessed': {
1342             'type': 'string'
1343         },
1344         'size': {
1345             'type': 'list',
1346             'schema': {
1347                 'type': 'string'
1348             }
1349         }
1350     }
1351 }
1352
1353 microservice = {
1354     'schema': {
1355         'function': {
1356             'type': 'string'
1357         },
1358         'endpoint': {
1359             'type': 'string'
1360         },
1361         'name': {
1362             'type': 'string'
1363         }
1364     }
1365 }
1366
1367 var = {
1368     'schema': {
1369         'type': {
1370             'type': 'string'
1371         },
1372         'name': {
1373             'type': 'string'
1374         },
1375         'value': {
1376             'type': 'string'
1377         }
1378     }
1379 }

```

```

1380 mesos_docker = {
1381     'schema': {
1382         'container': {
1383             'type': 'dict',
1384             'schema': {
1385                 'docker': {
1386                     'type': 'dict',
1387                     'schema': {
1388                         'credential': {
1389                             'type': 'dict',
1390                             'schema': {
1391                                 'secret': {
1392                                     'type':
1393                                     ↪ 'string'
1394                                     },
1395                                     'principal': {
1396                                     ↪ 'string'
1397                                     }
1398                                 },
1399                                 'image': {
1400                                     'type': 'string'
1401                                 }
1402                             }
1403                         },
1404                         'type': {
1405                             'type': 'string'
1406                         }
1407                     }
1408                 },
1409                 'mem': {
1410                     'type': 'float'
1411                 },
1412                 'args': {
1413                     'type': 'list',
1414                     'schema': {
1415                         'type': 'string'
1416                     }
1417                 },
1418                 'cpus': {
1419                     'type': 'float'
1420                 },
1421                 'instances': {
1422                     'type': 'integer'
1423                 },
1424                 'id': {
1425                     'type': 'string'
1426                 }
1427             }
1428         }
1429     }
1430 }
1431
1432 libcloud_vm = {
1433     'schema': {
1434         'username': {
1435             'type': 'string'
1436         },
1437         'status': {
1438             'type': 'string'
1439         },

```

```

1439     'root_device_type': {
1440         'type': 'string'
1441     },
1442     'private_ips': {
1443         'type': 'string'
1444     },
1445     'instance_type': {
1446         'type': 'string'
1447     },
1448     'image': {
1449         'type': 'string'
1450     },
1451     'private_dns': {
1452         'type': 'string'
1453     },
1454     'image_name': {
1455         'type': 'string'
1456     },
1457     'instance_id': {
1458         'type': 'string'
1459     },
1460     'image_id': {
1461         'type': 'string'
1462     },
1463     'public_ips': {
1464         'type': 'string'
1465     },
1466     'state': {
1467         'type': 'string'
1468     },
1469     'root_device_name': {
1470         'type': 'string'
1471     },
1472     'key': {
1473         'type': 'string'
1474     },
1475     'group': {
1476         'type': 'string'
1477     },
1478     'flavor': {
1479         'type': 'string'
1480     },
1481     'availability': {
1482         'type': 'string'
1483     },
1484     'uuid': {
1485         'type': 'string'
1486     }
1487 }
1488 }

```

```

1491 eve_settings = {
1492     'MONGO_HOST': 'localhost',
1493     'MONGO_DBNAME': 'testing',
1494     'RESOURCE_METHODS': ['GET', 'POST',
1495 ↪ 'DELETE'],
1496     'BANDWIDTH_SAVER': False,
1497     'DOMAIN': {
1498         'profile': profile,

```

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```

1499     'virtual_machine': virtual_machine,
1500     'kubernetes': kubernetes,
1501     'nic': nic,
1502     'virtual_compute_node':
1503 ↪ virtual_compute_node,
1504     'openstack_flavor': openstack_flavor,
1505     'azure-vm': azure_vm,
1506     'azure-size': azure_size,
1507     'openstack_vm': openstack_vm,
1508     'cluster': cluster,
1509     'computer': computer,
1510     'libcloud_image': libcloud_image,
1511     'user': user,
1512     'file': file,
1513     'deployment': deployment,
1514     'mapreduce': mapreduce,
1515     'group': group,
1516     'role': role,
1517     'virtual_directory':
1518 ↪ virtual_directory,
1519     'file_alias': file_alias,
1520     'virtual_cluster': virtual_cluster,
1521     'libcloud_flavor': libcloud_flavor,
1522     'batchjob': batchjob,
1523     'organization': organization,
1524     'container': container,
1525     'sshkey': sshkey,
1526     'stream': stream,
1527     'database': database,
1528     'default': default,
1529     'openstack_image': openstack_image,
1530     'azure_image': azure_image,
1531     'hadoop': hadoop,
1532     'compute_resource': compute_resource,
1533     'node_new': node_new,
1534     'filter': filter,
1535     'reservation': reservation,
1536     'replica': replica,
1537     'microservice': microservice,
1538     'var': var,
1539     'mesos-docker': mesos_docker,
1540     'libcloud_vm': libcloud_vm,
1541 }
1542 }

```

489

## 490 C. CONTRIBUTING

491 We invite you to contribute to this paper and its discussion to  
492 improve it. Improvements can be done with pull requests. We  
493 suggest you do *small* individual changes to a single section  
494 and object rather than large changes as this allows us to  
495 integrate the changes individually and comment on your  
496 contribution via github.

497 Once contributed we will appropriately acknowledge you  
498 either as contributor or author. Please discuss with us how  
499 we best acknowledge you.

## 500 D. USING THE CLOUDMESH REST SERVICE

501 Components are written as YAML markup in files in the  
502 resources/samples directory.

For example:

Listing D.1: profile

```

1 {
2   "profile": {
3     "description": "The Profile of a user",
4     "uuid": "jshdjkdh...",
5     "context": "resource",
6     "email": "laszewski@gmail.com",
7     "firstname": "Gregor",
8     "lastname": "von Laszewski",
9     "username": "gregor"
10  }
11 }
```

## D.1. Element Definition

Each resource should have a description entry to act as documentation. The documentation should be formatted as reStructuredText. For example:

## D.2. Yaml

```

entry = yaml.read('''
profile:
  description: |
    A user profile that specifies general information
    about the user
  email: laszewski@gmail.com, required
  firtsname: Gregor, required
  lastname: von Laszewski, required
  height: 180
''')
```

## D.3. Cerberus

```

schema = {
'profile': {
  'description': {'type': 'string'}
  'email':       {'type': 'string', 'required': True}
  'firtsname':   {'type': 'string', 'required': True}
  'lastname':    {'type': 'string', 'required': True}
  'height':      {'type': 'float'}
}
```

## E. MONGOENGINE

```

class profile(Document):
    description = StringField()
    email = EmailField(required=True)
    firstname = StringField(required=True)
    lastname = StringField(required=True)
    height = FloatField(max_length=50)
```

## F. CLOUDMESH NOTATION

```

profile:
  description: string
  email: email, required
  firstname: string, required
  lastname: string, required
  height: flat, max=10
```

proposed command

```

cms schema FILENAME --format=mongo -o OUTPUT
cms schema FILENAME --format=cerberus -o OUTPUT
cms schema FILENAME --format=yaml -o OUTPUT
```

reads FILENAME in cloudmesh notation and returns format

```

cms schema FILENAME --input=evegenie -o OUTPUT
reads eavegene example and create settings for eve
```

## F.1. Defining Elements for the REST Service

To manage a large number of elements defined in our REST service easily, we manage them through definitions in yaml files. To generate the appropriate settings file for the rest service, we can use teh following command:

```
cms admin elements <directory> <out.json>
```

where

- <directory>: directory where the YAML definitions reside
- <out.json>: path to the combined definition

For example, to generate a file called all.json that integrates all yml objects defined in the directory resources/samples you can use the following command:

```
cms elements resources/samples all.json
```

## F.2. DOIT

```
cms schema spec2tex resources/specification resources/tex
```

## F.3. Generating service

With evegenie installed, the generated JSON file from the above step is processed to create the stub REST service definitions.

## G. ABC

README.rst

## H. CLOUDMESH REST

### H.1. Prerequistis

- mongo instalation
- eve instalation
- cloudmesh cmd5
- cloudmesh rest

#### H.1.1. Install Mongo on OSX

```

brew update
brew install mongodb
# brew install mongodb --with-openssl
```

#### H.1.2. Install Mongo on OSX

ASSIGNMET TO STUDENTS, PROVIDE PULL REQUEST WITH INSTRUCTIONS

## H.2. Introduction

With the cloudmesh REST framework it is easy to create REST services while defining the resources in the service easily with examples. The service is based on eve and the examples are defined in yml to be converted to json and from json with evegenie into a valid eve settings file.

Thus you can either write your examples in yml or in json. The resources are individually specified in a directory. The directory can contain multiple resource files. We recommend that for each resource you define your own file. Conversion of the specifications can be achieved with the schema command.

## H.3. Yaml Specification

Let us first introduce you to a yaml specification. Let us assume that your yaml file is called profile.yaml and located in a directory called 'example':

```
profile:
  description: The Profile of a user
  email: laszewski@gmail.com
  firstname: Gregor
  lastname: von Laszewski
  username: gregor
```

As eve takes json objects as default we need to convert it first to json. This is achieved with:

```
cd example
cms schema convert profile.yml profile.json
```

This will provide the json file profile.json as Listed in the next section

## H.4. Json Specification

A valid json resource specification looks like this:

```
{
  "profile": {
    "description": "The Profile of a user",
    "email": "laszewski@gmail.com",
    "firstname": "Gregor",
    "lastname": "von Laszewski",
    "username": "gregor"
  }
}
```

## H.5. Conversion to Eve Settings

The json files in the ~/sample directory need now to be converted to a valid eve schema. This is achieved with two commands. First, we must concatenate all json specified resource examples into a single json file. We do this with:

```
cms schema cat . all.json
```

As we assume you are in the samples directory, we use a . for the current location of the directory that contains the samples. Next, we need to convert it to the settings file. This can be achieved with the convert program when you specify a json file:

```
cms schema convert all.json
```

The result will be a eve configuration file that you can use to start an eve service. The file is called all.settings.py

## H.5.1. Managing Mongo

Next you need to start the mongo service with

```
cms admin mongo start
```

You can look at the status and information about the service with :

```
cms admin mongo info
cms admin mongo status
```

If you need to stop the service you can use:

```
cms admin mongo stop
```

## H.5.2. Managing Eve

Now it is time to start the REST service. This is done in a separate window with the following commands:

```
cms admin settings all.settings.json
cms admin rest start
```

The first command copies the settings file to

```
~/cloudmesh/eve/settings.py
```

This file is then used by the start action to start the eve service. Please make sure that you execute this command in a separate window, as for debugging purposes you will be able to monitor this way interactions with this service

Testing - OLD ~~~~~:

```
make setup      # install mongo and eve
make install    # installs the code and integrates it into cmd5
make deploy
make test
```

```
classes lessons rest.rst
```

## I. REST WITH EVE

### I.1. Overview of REST

REST stands for REpresentational State Transfer. REST is an architecture style for designing networked applications. It is based on stateless, client-server, cacheable communications protocol. Although not based on http, in most cases, the HTTP protocol is used. In contrast to what some others write or say, REST is not a *standard*.

RESTful applications use HTTP requests to:

- post data: while creating and/or updating it,
- read data: while making queries, and
- delete data.

Hence REST uses HTTP for the four CRUD operations:

- Create
- Read
- Update
- Delete

As part of the HTTP protocol we have methods such as GET, PUT, POST, and DELETE. These methods can then be used to implement a REST service. As REST introduces collections and items we need to implement the CRUD functions for them. The semantics is explained in the Table illustrating how to implement them with HTTP methods.

Source: [https://en.wikipedia.org/wiki/Representational\\_state\\_transfer](https://en.wikipedia.org/wiki/Representational_state_transfer)



## I.2. REST and eve

Now that we have outlined the basic functionality that we need, we like to introduce you to Eve that makes this process rather trivial. We will provide you with an implementation example that showcases that we can create REST services without writing a single line of code. The code for this is located at <https://github.com/cloudmesh/rest>

This code will have a master branch but will also have a dev branch in which we will add gradually more objects. Objects in the dev branch will include:

- virtual directories
- virtual clusters
- job sequences
- inventories

You may want to check our active development work in the dev branch. However for the purpose of this class the master branch will be sufficient.

### I.2.1. Installation

First we have to install mongodb. The installation will depend on your operating system. For the use of the rest service it is not important to integrate mongodb into the system upon reboot, which is focus of many online documents. However, for us it is better if we can start and stop the services explicitly for now.

On ubuntu, you need to do the following steps:

TO BE CONTRIBUTED BY THE STUDENTS OF THE CLASS as homework

On windows 10, you need to do the following steps:

TO BE CONTRIBUTED BY THE STUDENTS OF THE CLASS as homework  
select Windows 10. You could be using the online documentation provided by starting it on Windows, or running it in a docker container.

On OSX you can use homebrew and install it with:

```
brew update
brew install mongodb
```

In future we may want to add ssl authentication in which case you may need to install it as follows:

```
brew install mongodb --with-openssl
```

### I.2.2. Starting the service

We have provided a convenient Makefile that currently only works for OSX. It will be easy for you to adapt it to Linux. Certainly you can look at the targets in the makefile and replicate them one by one. Important targets are deploy and test.

When using the makefile you can start the services with:

```
make deploy
```

It will start two terminals. In one you will see the mongo service, in the other you will see the eve service. The eve service will take a file called sample.settings.py that is based on sample.json for the start of the eve service. The mongo service is configured in such a way that it only accepts incoming connections from the local host which will be sufficient for our case. The mongo data is written into the \$USER/.cloudmesh directory, so make sure it exists.

To test the services you can say:

```
make test
```

You will see a number of json text been written to the screen.

## I.3. Creating your own objects

The example demonstrated how easy it is to create a mongodb and an eve rest service. Now let's use this example to create your own. For this we have modified a tool called evegenie to install it onto your system.

The original documentation for evegenie is located at:

- <http://evegenie.readthedocs.io/en/latest/>

However, we have improved evegenie while providing a commandline tool based on it. The improved code is located at:

- <https://github.com/cloudmesh/evegenie>

You clone it and install on your system as follows:

```
cd ~/github
git clone https://github.com/cloudmesh/evegenie
cd evegenie
python setup.py install
pip install .
```

This should install in your system evegenie. You can verify this by typing:

```
which evegenie
```

If you see the path evegenie is installed. With evegenie installed its usage is simple:

```
$ evegenie
Usage: evegenie [options]
Options:
  -h, --help            show this help message and exit
  -f FILENAME, --file=FILENAME
                        read settings from FILENAME
```

It takes a json file as input and writes out a settings file for the use in eve. Let's assume the file is called sample.json, then the settings file will be called sample.settings.py. Having the evegenie program will allow us to generate the settings files easily. You can include them into your project and leverage the Makefile targets to start the services in your project. In case you generate new objects, make sure you rerun evegenie, kill all previous windows in which you run eve and mongo and restart. In case of changes to objects that you have designed and run previously, you need to also delete the mongo database.

## I.4. Towards cmd5 extensions to manage eve and mongo

Naturally it is of advantage to have in cms administration commands to manage mongo and eve from cmd instead of targets in the Makefile. Hence, we propose that the class develops such an extension. We will create in the repository the extension called admin and hope that students through collaborative work and pull requests complete such an admin command.

The proposed command is located at:

- <https://github.com/cloudmesh/rest/blob/master/cloudmesh/ext/command/admin.py>



```

860 @command
861 def do_bar(self, args, arguments):
862     """
863     ::
864         Usage:
865             command -f FILE
866             command FILE
867             command list
868         This command does some useful things.
869         Arguments:
870             FILE    a file name
871         Options:
872             -f      specify the file
873     """
874     print(arguments)

```

875 An important difference to other CMD solutions is that  
876 our commands can leverage (besides the standard definition),  
877 docopts as a way to define the manual page. This allows  
878 us to use arguments as dict and use simple if conditions to  
879 interpret the command. Using docopts has the advantage  
880 that contributors are forced to think about the command and  
881 its options and document them from the start. Previously we  
882 used not to use docopts and argparse was used. However  
883 we noticed that for some contributions the lead to commands  
884 that were either not properly documented or the developers  
885 delivered ambiguous commands that resulted in confusion  
886 and wrong usage by the users. Hence, we do recommend  
887 that you use docopts.

888 The transformation is enabled by the @command decora-  
889 tor that takes also the manual page and creates a proper help  
890 message for the shell automatically. Thus there is no need  
891 to introduce a separate help method as would normally be  
892 needed in CMD.

#### 893 J.4. Excercise

894 **CMD5.1:** Install cmd5 on your computer.

895 **CMD5.2:** Write a new command with your firstname as the  
896 command name.

897 **CMD5.3:** Write a new command and experiment with do-  
898 copt syntax and argument interpretation of the dict with  
899 if conditions.

900 **CMD5.4:** If you have useful extensions that you like us to  
901 add by default, please work with us.