University of Zurich[UZH]

S3IT: Service and Support for Science IT

Cloud middleware

Part2: Let's pick one cloud IaaS middleware: OpenStack

Sergio Maffioletti

S3IT: Service and Support for Science IT,
University of Zurich
http://www.s3it.uzh.ch/

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Part2: content

1. Understand the OpenStack ecosystem
2. Understand OpenStack architecture

What is OpenStack ?

OpenStack Foundation: “Open source software for building private and public clouds”

- Open source project (Apache 2.0).
- Up to 1’128 contributors, including commercial companies.
- Biggest contributor is **Rackspace**.
- Releases every 6 months. (check releases).
- Currently the only real alternative to proprietary clouds.

OpenStack capabilities

VMs on demand

Volumes

Network

Object storage

Multi-tenancy

OpenStack capabilities

VMs on demand

- provisioning.
- snapshotting.

Volumes

Network

Object storage

Multi-tenancy

OpenStack capabilities

VMs on demand

Volumes

- block storage devices.
- allow persistent storage.
- R/W to single instance.
- provisioned via API.

Network

Object storage

Multi-tenancy

OpenStack capabilities

VMs on demand

Volumes

Networks

- define network connectivity and IP addressing.
- L3 forwarding and NAT to load balancing
- virtual network, subnet, and port abstractions to describe networking resources.

Object storage

Multi-tenancy

OpenStack capabilities

VMs on demand

Volumes

Network

Object storage

- redundant, scalable.
- global API access.
- no POSIX interface (only objects).

Multi-tenancy

OpenStack capabilities

VMs on demand

Volumes

Network

Object storage

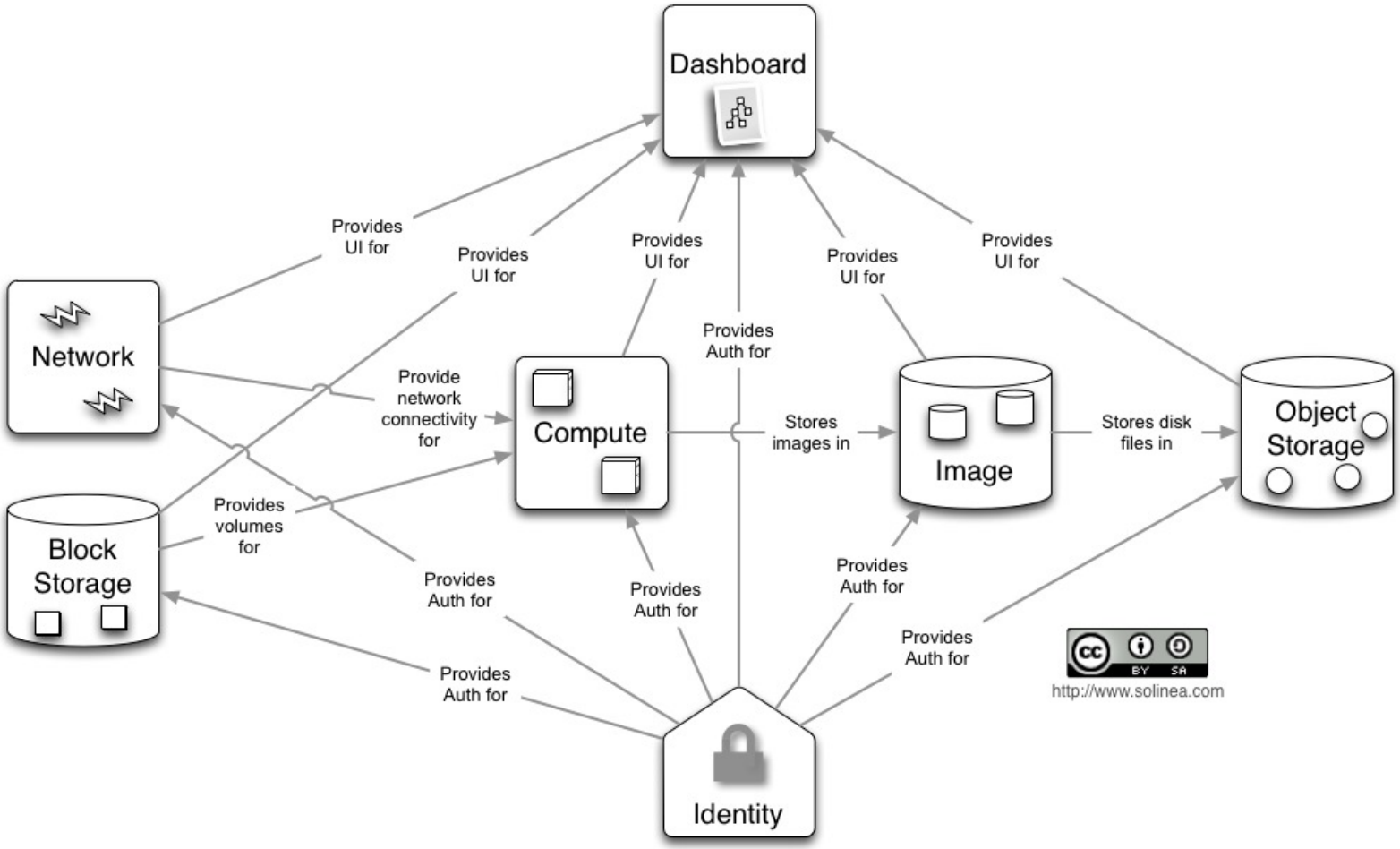
Multi-tenancy

- quotas for different tenants.
- user can be associated with multiple tenants.

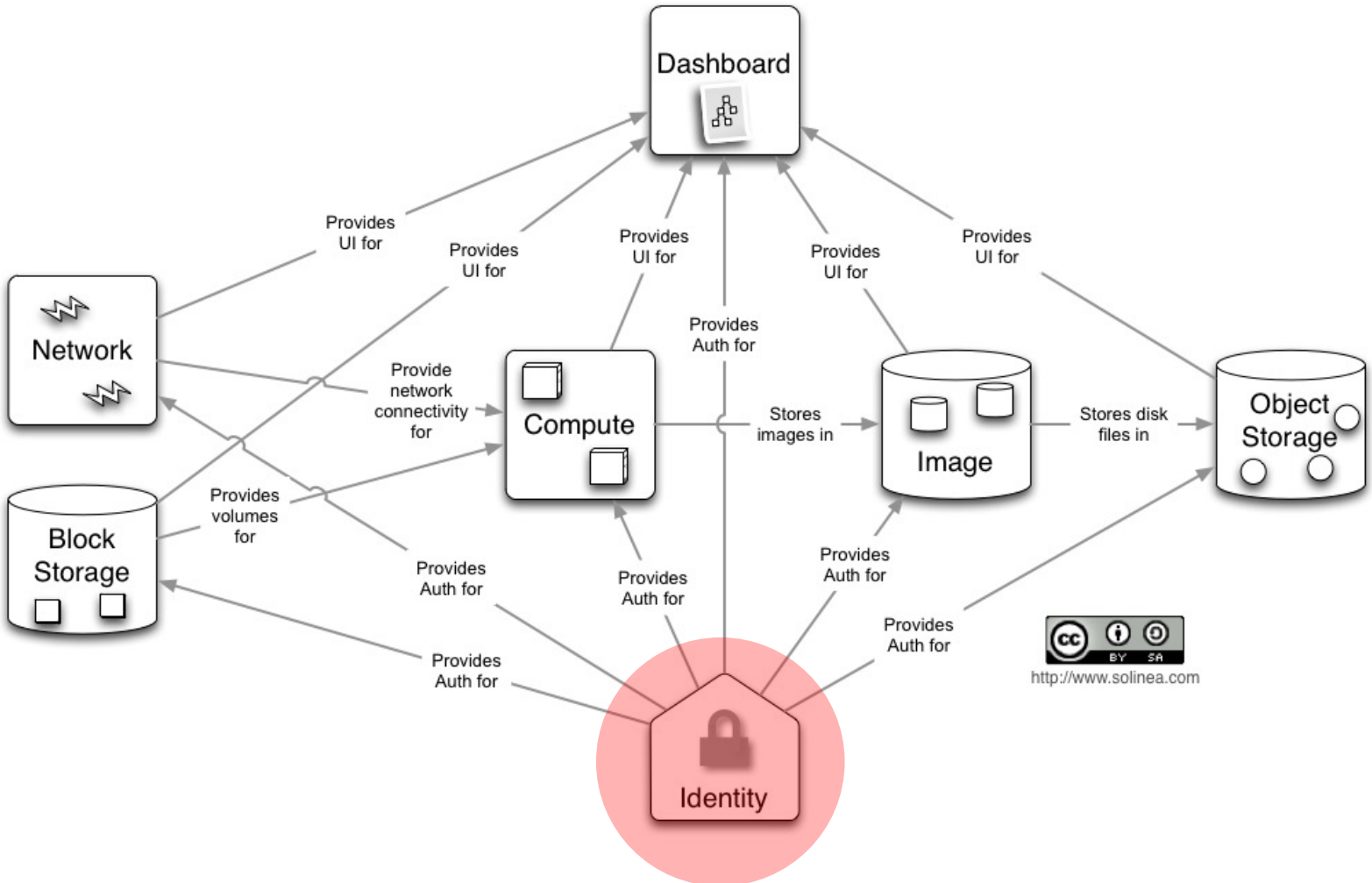
OpenStack Architecture

- Everything is in Python (plus auxiliary shell scripts)
- Build around **independent components**
- **Highly distributed** architecture
- **Intrinsic HA** for OpenStack services (MySQL and RabbitMQ have to be properly configured)
- ***SQL** database used to store persistent data
- **RabbitMQ** used for inter-service communication and notification
- **Web API** services (mostly Django)

OpenStack logical view

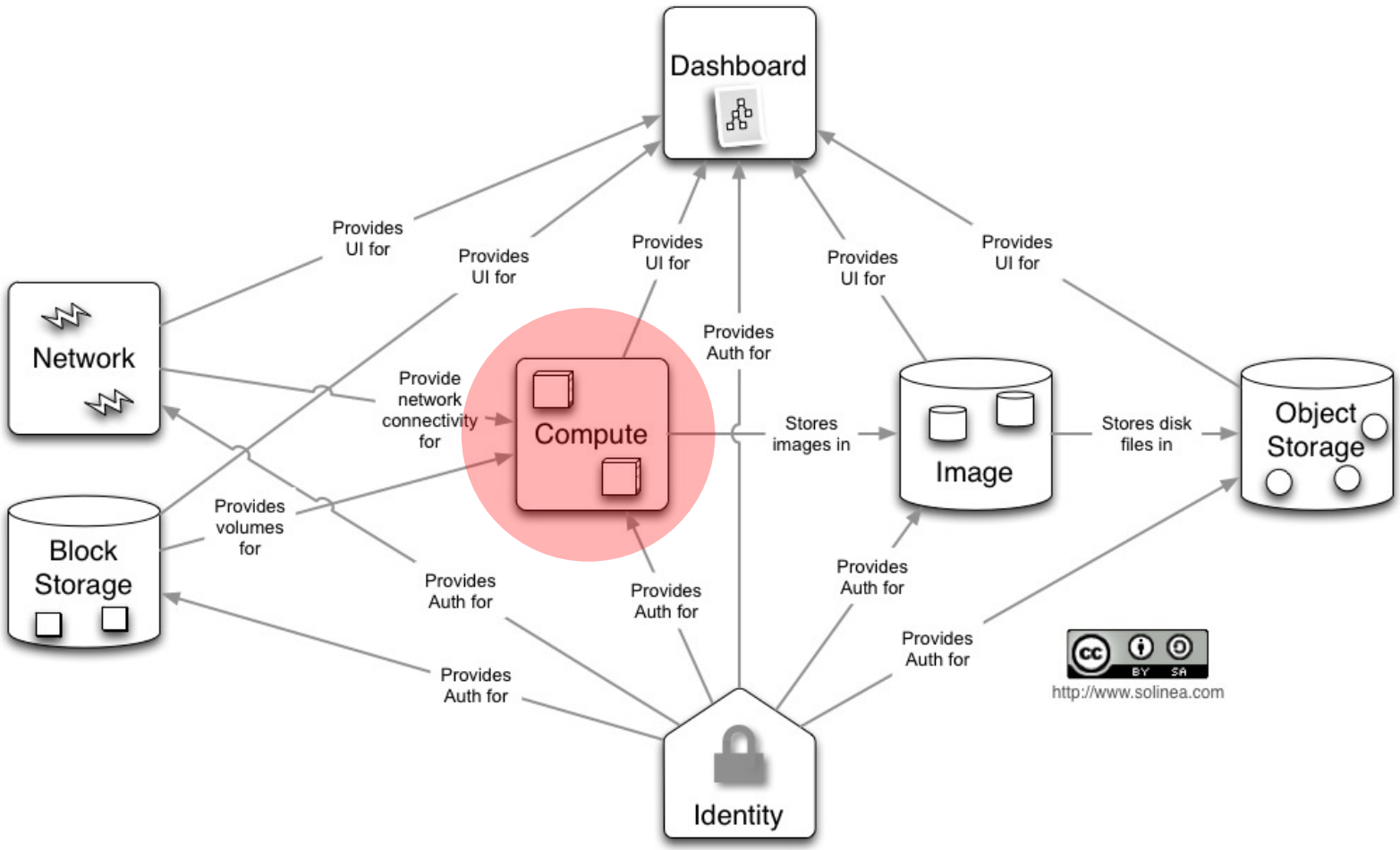


OpenStack logical view



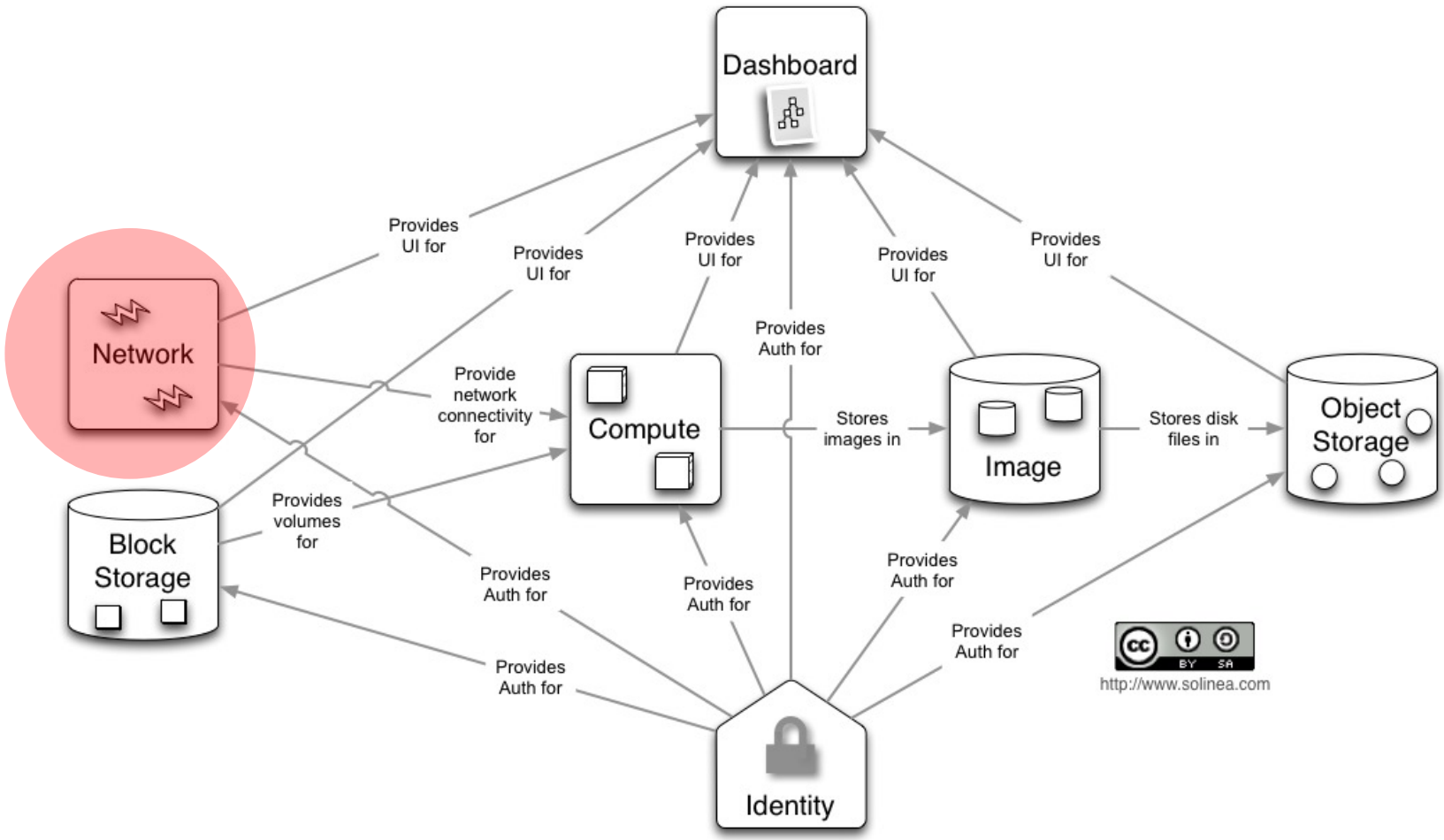
keystone provides the authentication service

OpenStack logical view



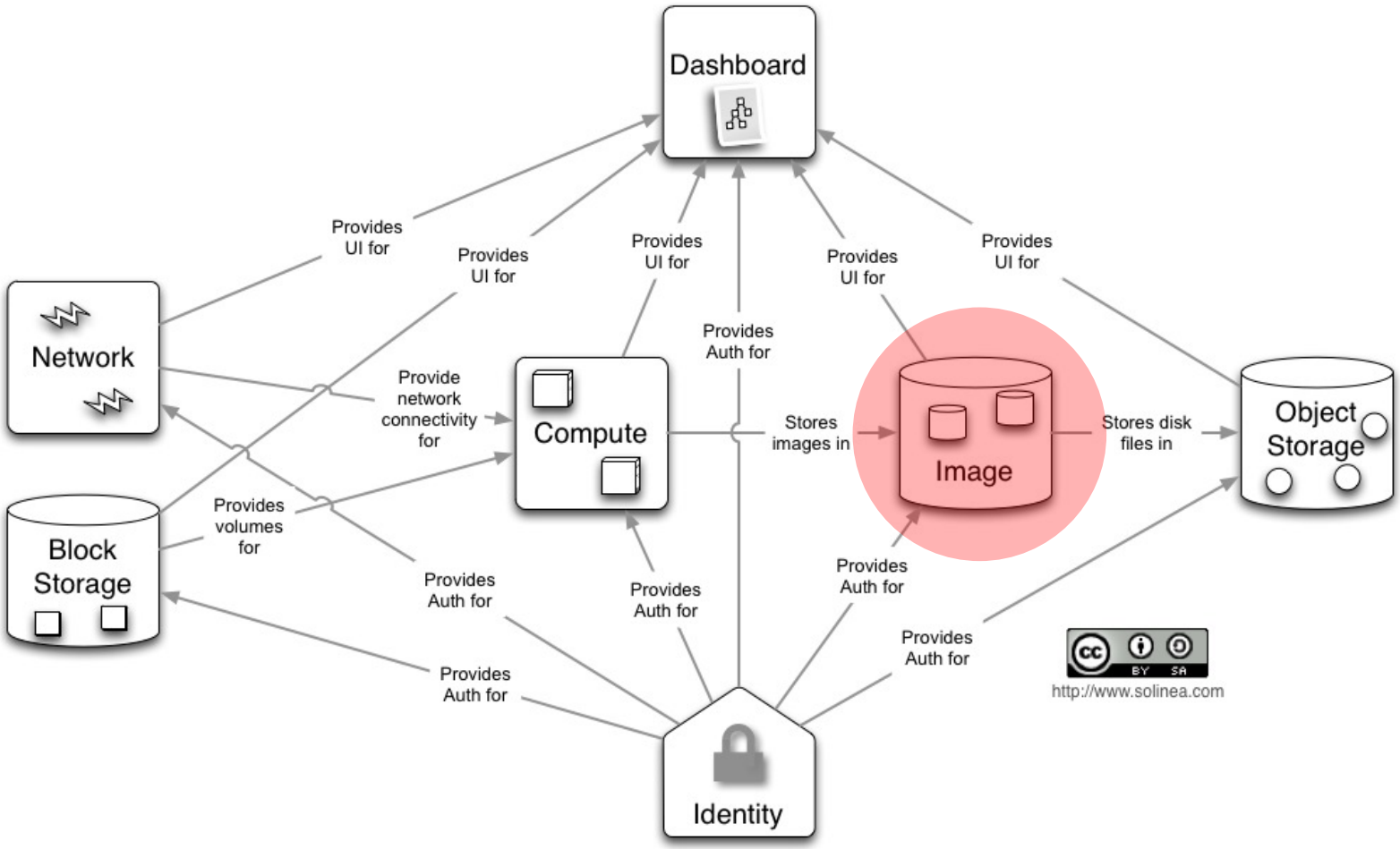
nova provides computational services

OpenStack logical view



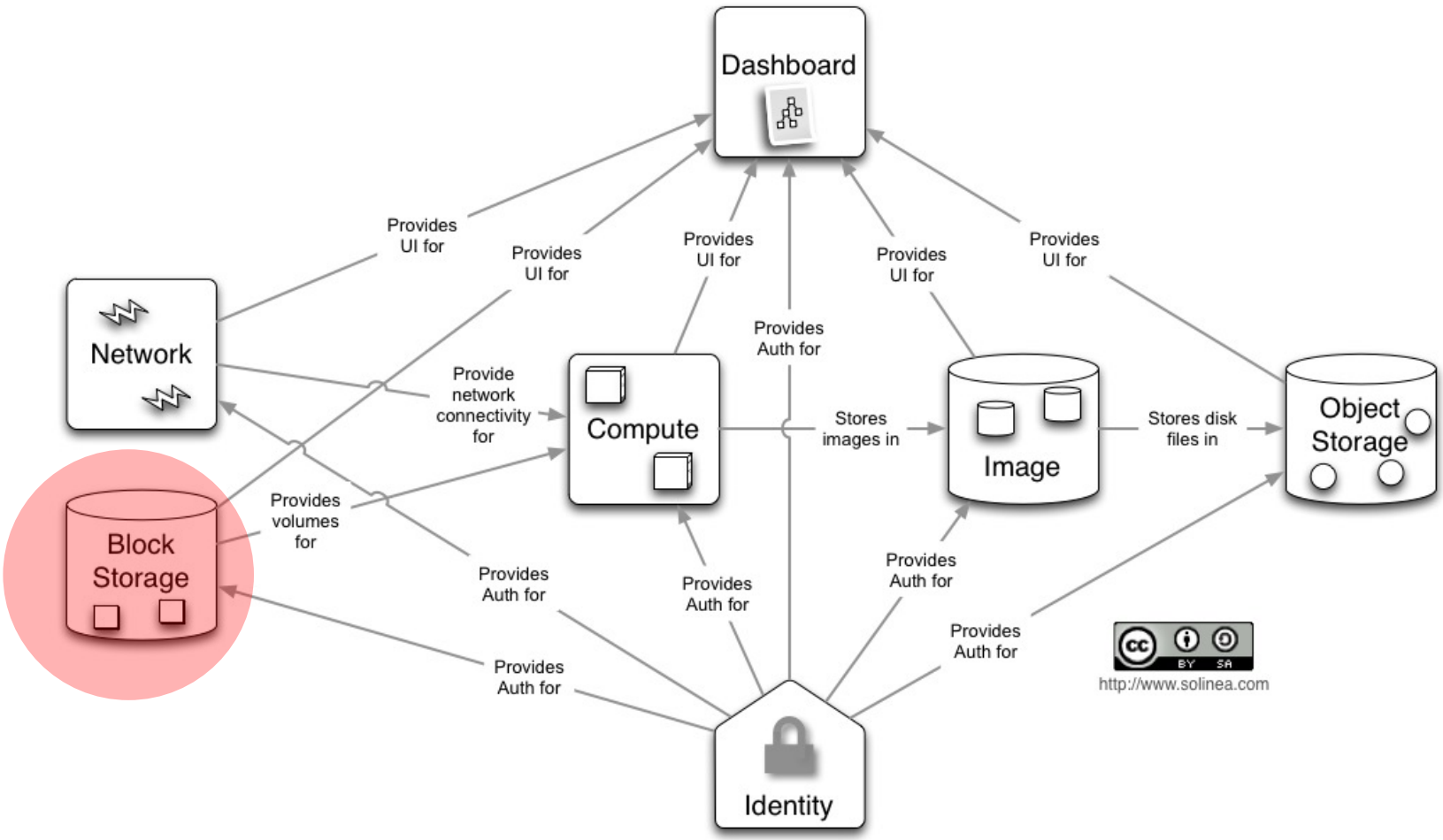
neutron provides network services

OpenStack logical view



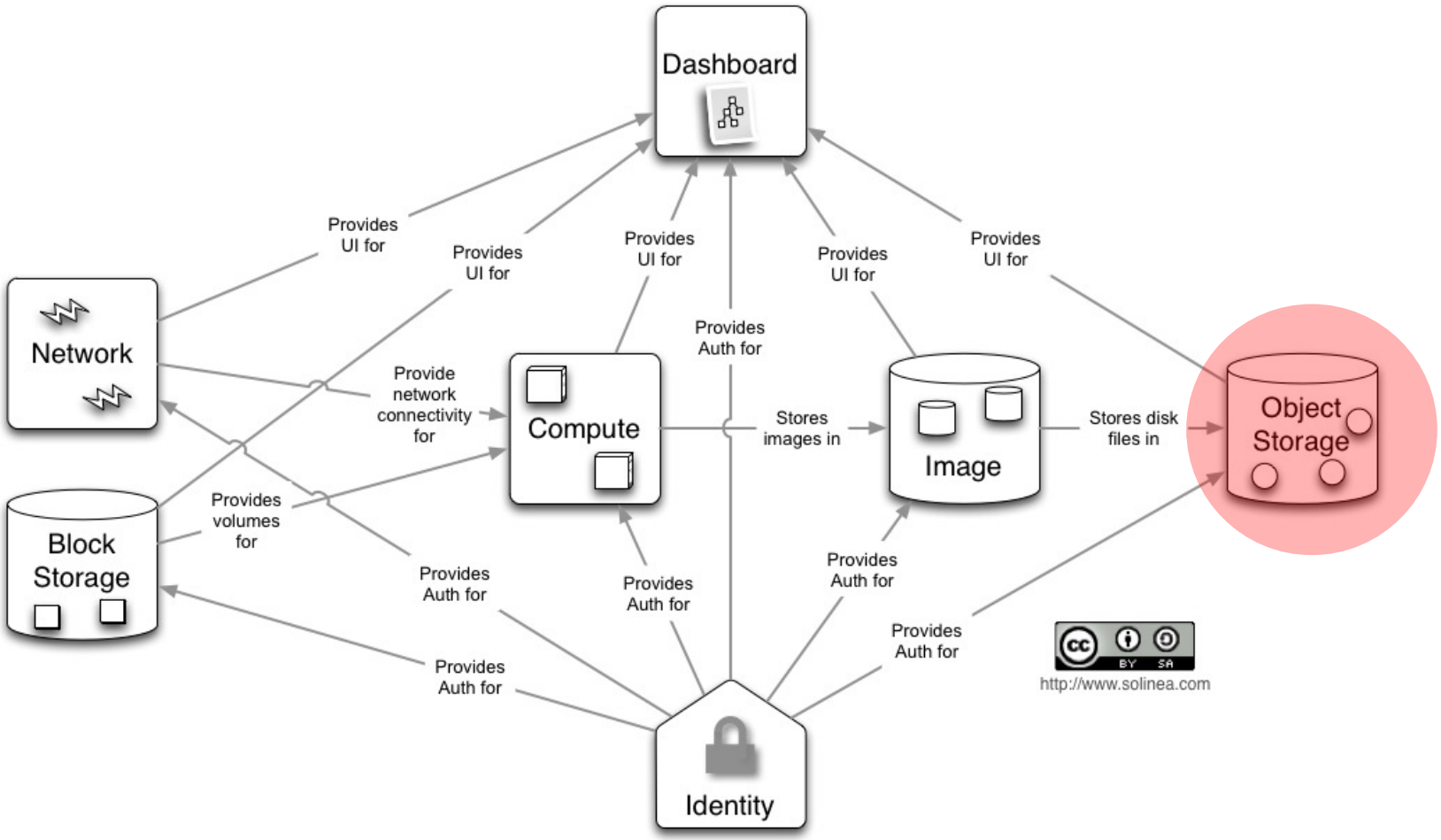
glance provides image store

OpenStack logical view



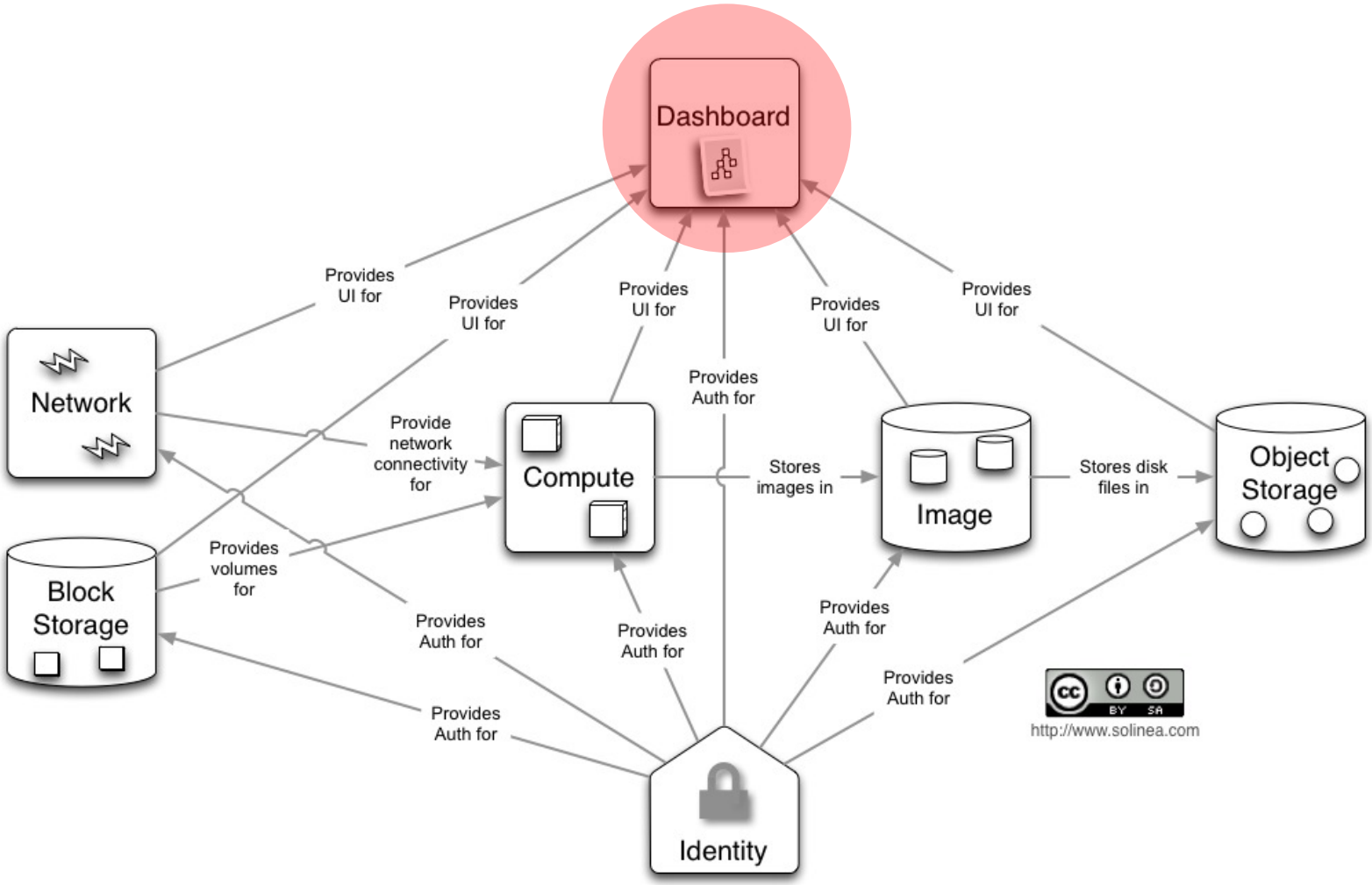
cinder provides block persistent store

OpenStack logical view



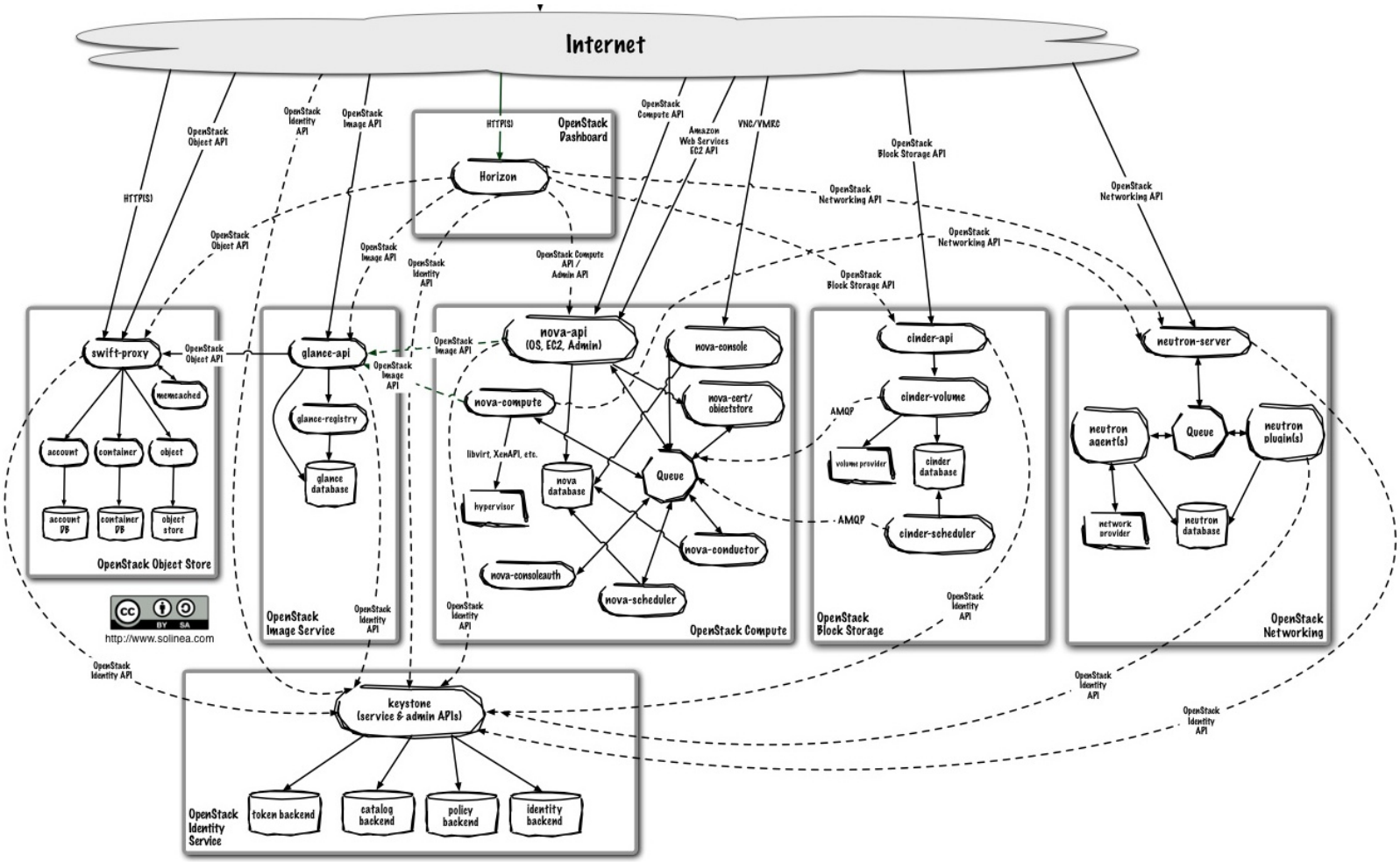
swift provides object persistent store

OpenStack logical view

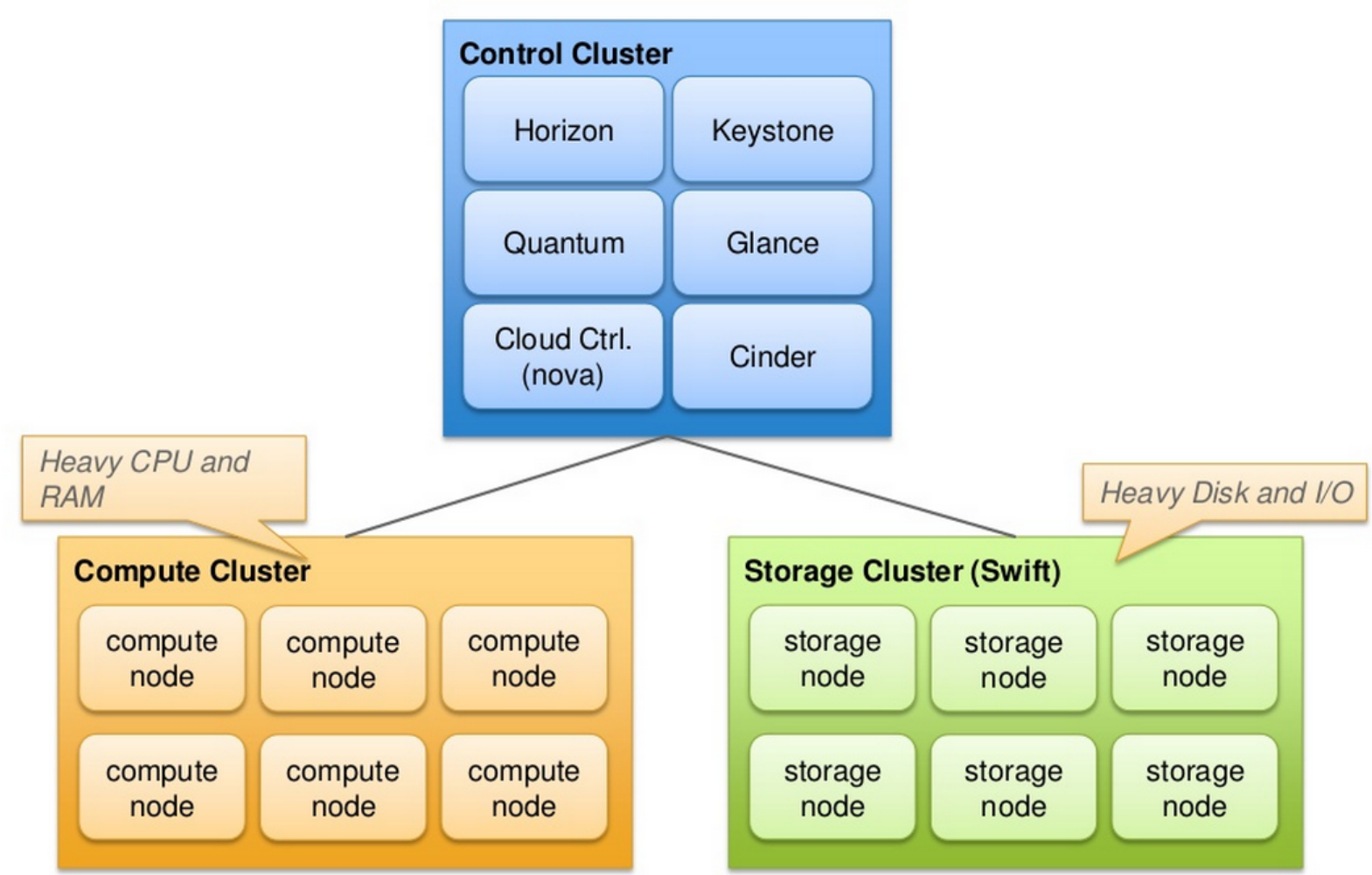


horizon provides web user interface

OpenStack software overview



Typical deployment scenario



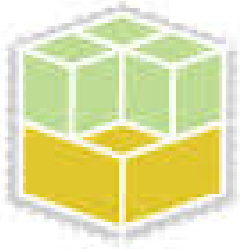
keystone - authentication service

- Stores authentication information (*users*, *passwords*, *tokens*, *projects*, *roles*).
- Holds a catalog of available services and their endpoints.
- Can use different backends (SQL database, LDAP).
- It's the entry point for OpenStack API.

keystone Data Model

- User: has account credentials, is associated with one or more tenants.
- Tenant: unit of ownership in OpenStack, contains one or more users.
- Role: a first-class piece of metadata associated with many user-tenant pairs.
- Token: identifying credential associated with a user or user and tenant .

nova service

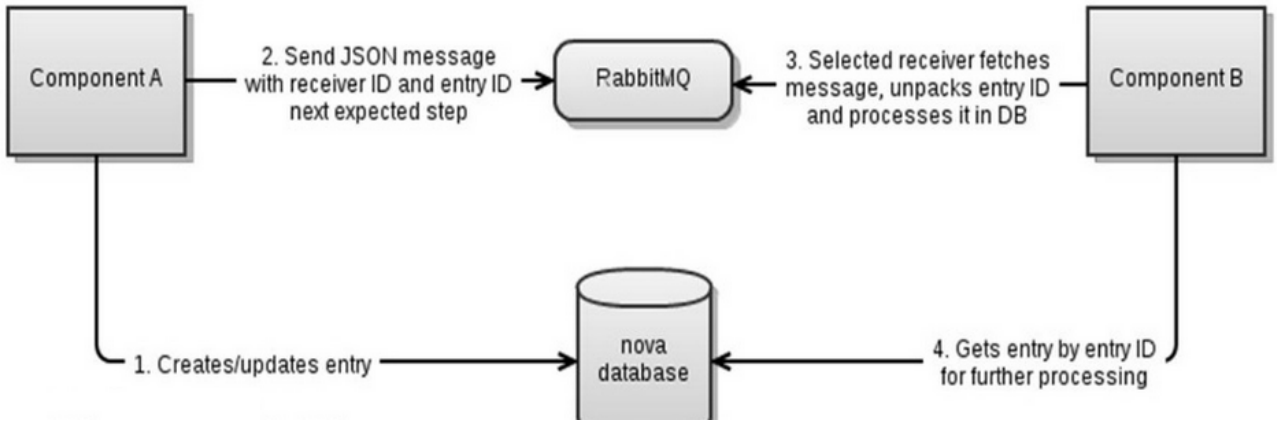


Service responsible of managing virtual instances.

nova-api Web API frontend, accepts requests, validates them and contact other services if needed. Supports OpenStack Compute API, Amazon's EC2 API and a special Admin API.

nova-scheduler it takes a virtual machine instance request from the **message-queue** an determines where it should run.

Message Queue



Message Queue is a unified way for collaboration between components.

Use multiple queues within single MQ instance.

Usually RabbitMQ.

nova-scheduler

nova-scheduler determines which compute host the request should run.

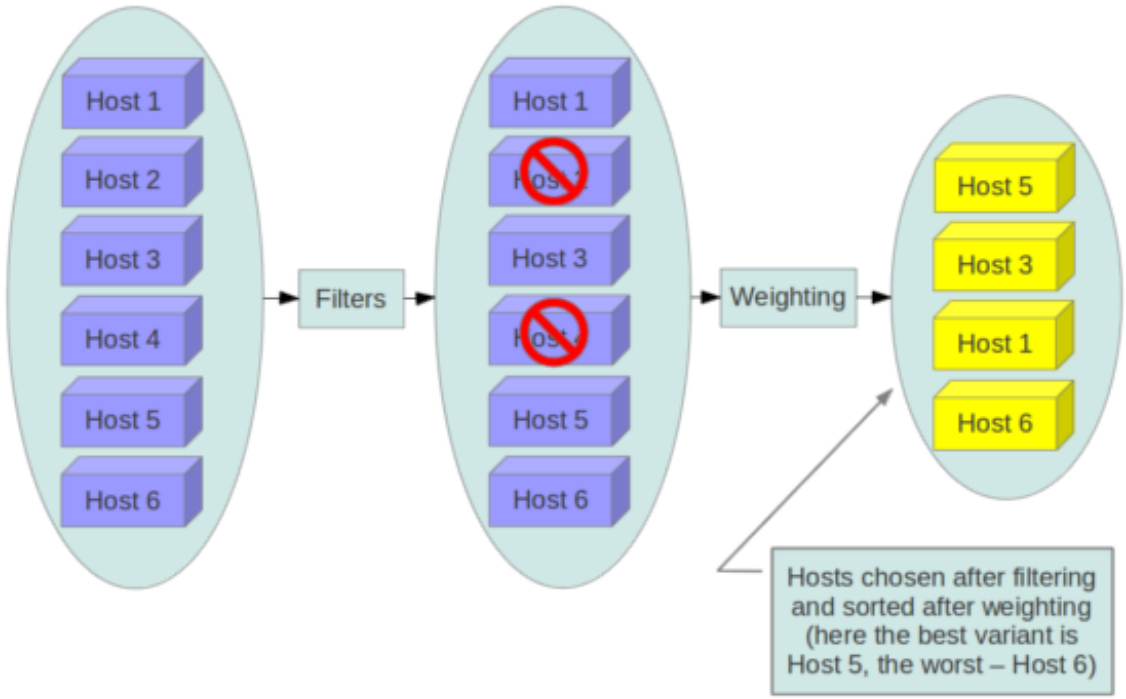
nova-scheduler : provision VM to particular host.

provision VMs of the particular tenant to isolated hosts.

provision all VMs on different hosts.

provision VMs to "higher density" hosts.

nova-scheduler filters



- Filters statically configured.
- Multiple filters can be specified (Affinity, anti-affinity, . . .).

nova - compute service

Running on each compute node, interacts with the hypervisor and actually controls the VM.

nova-compute Drivers

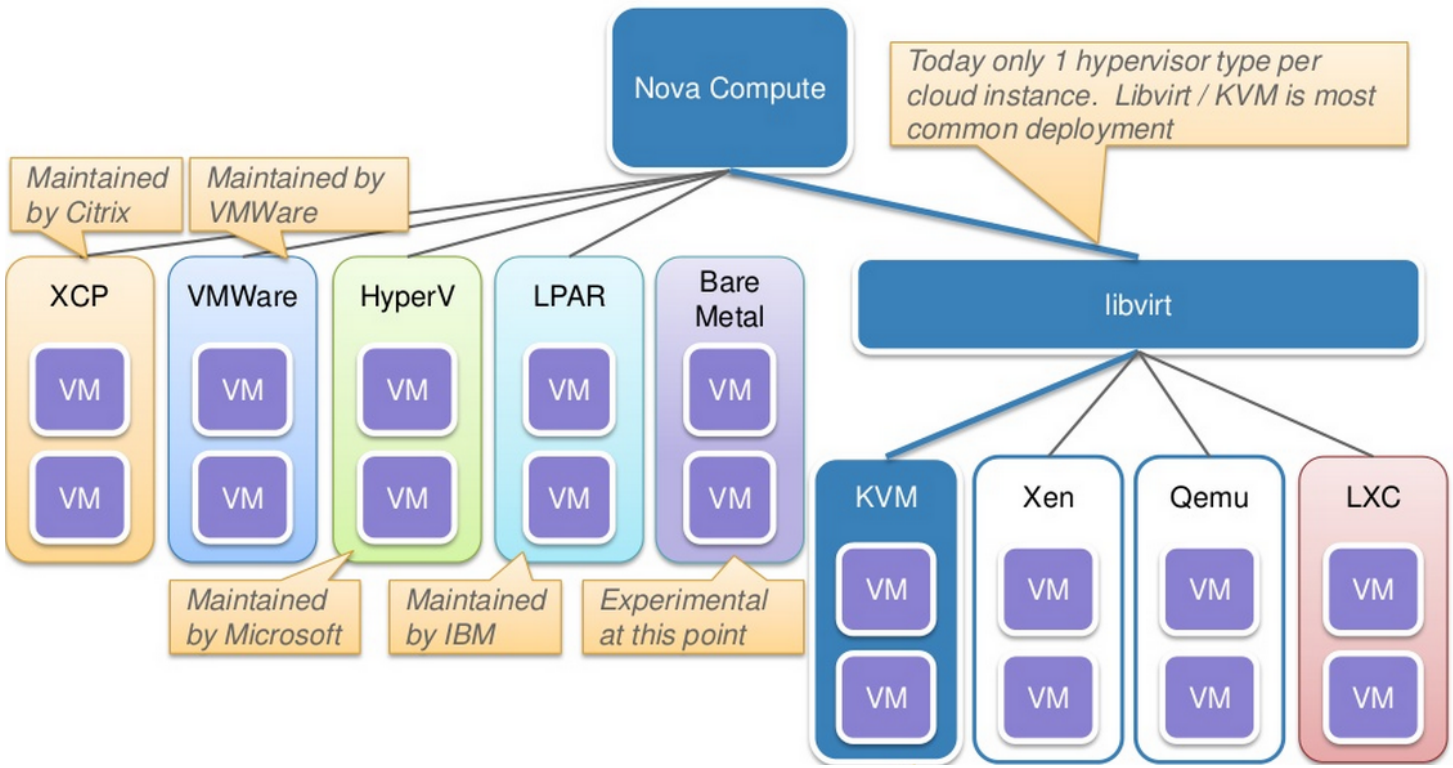


Image courtesy of Mirantis

neutron - network service

Service responsible of creating and managing networks. It is supposed to replace **nova-network**.

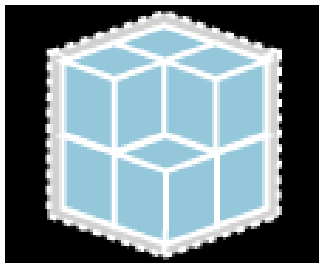
Still not widely used, but very feature rich.

- L2 and L3 networks.
- Allow creation of multiple networks and subnets.
- Plugin architecture.
- Supports Load Balancer As a Service.
- Integrates with network devices (Cisco, NEC).

Network configuration flow

1. Allocate MAC addresses.
2. Allocate IPs (for each network).
3. Associate IP and MAC with VM (DB).
4. Setup network - L2.
5. Setup network - L3.
   - update DHCP config
   - initialize gateway

cinder - block storage



- Creates and export Volumes via iSCSI to the compute node.
- Volumes are mounted **transparently** from the virtual machines.
- Supports **multiple storage backends** (NFS, LVM, Ceph, GlusterFS but also SAN/NAS devices from IBM, NetApp etc. . .).

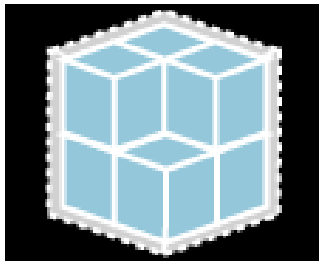
composed of **multiple services**:

cinder-api Web API frontend.

cinder-volume Manages block storage devices. You can have many of these.

cinder-scheduler Decides which **cinder-volume** has to provide the Volume for an instance.

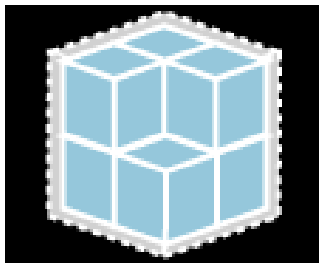
glance - image service



Service responsible of storing image Information and, optionally, image files.

- Holds information about available images.
- Optionally allow to download and upload images.
- Images can be stored on **different backends** (RDB, S3, swift, filesystem).
- Multiple image formats supported (raw, vhd, vdi, qcow2, ami, . . .).

swift - object storage



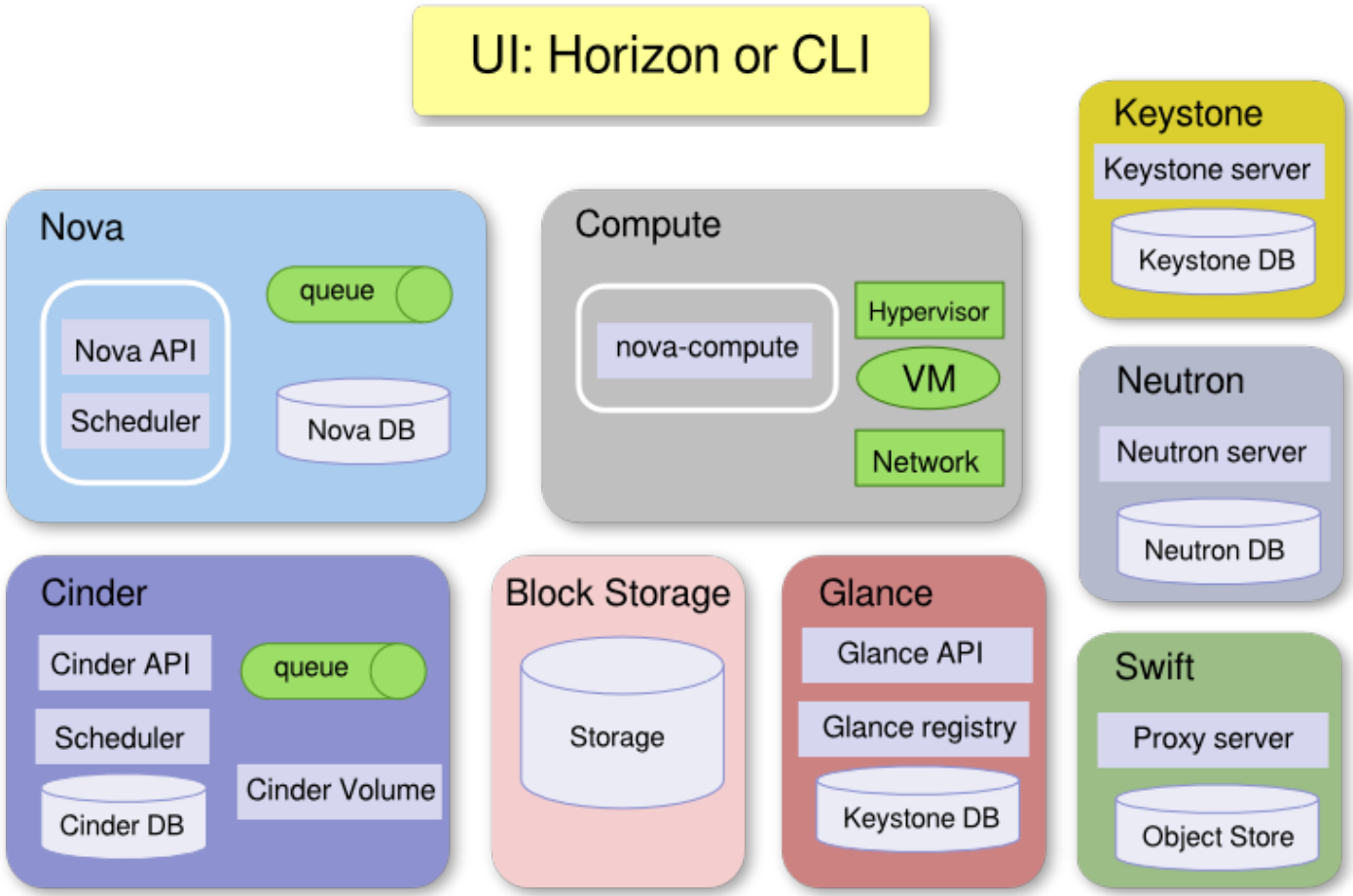
Object storage distributed service.

- Redundant, scalable object storage on commodity hardware.
- Not a POSIX filesystem.
- Scales horizontally simply by adding new servers.
- Supports AWS S3 APIs.

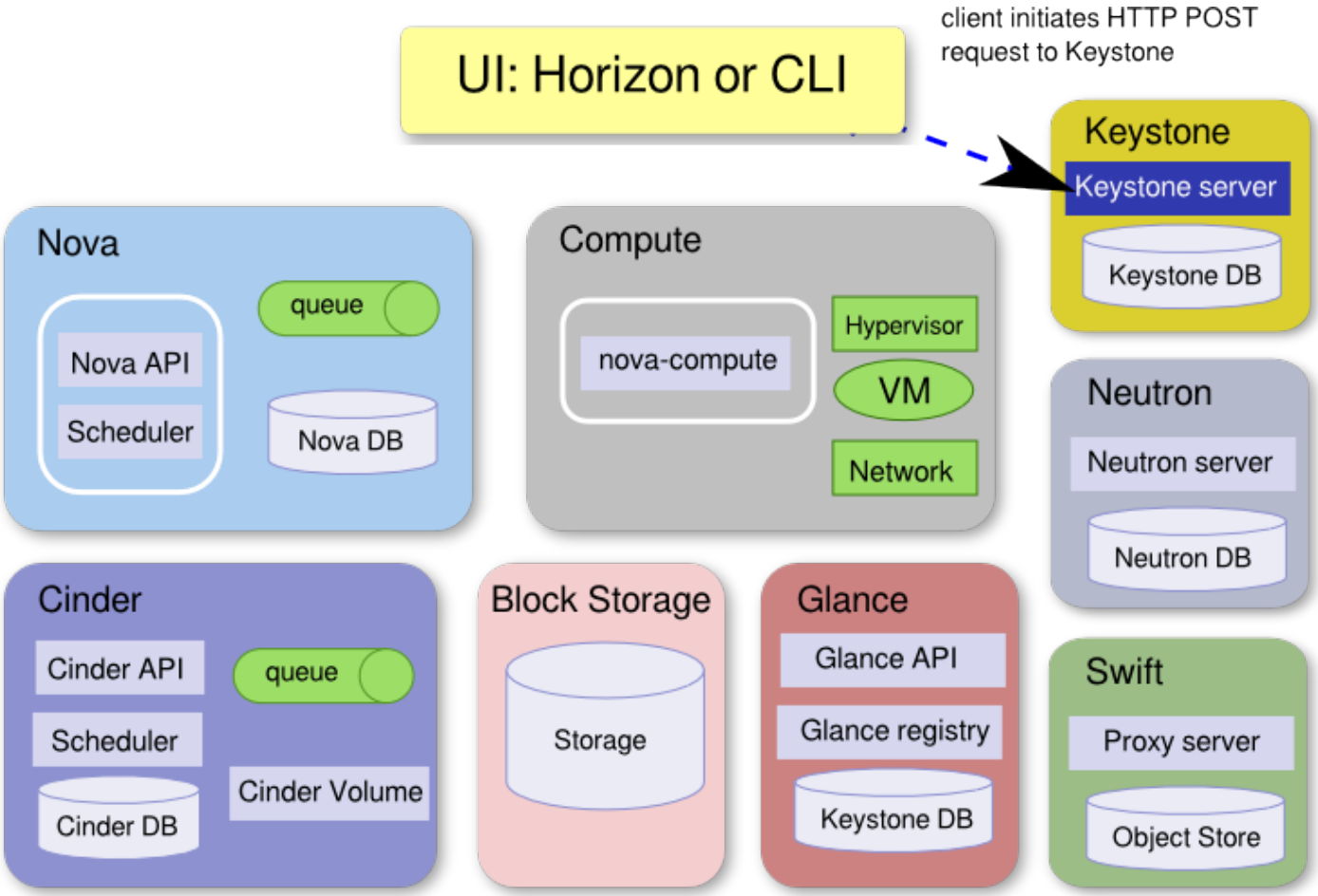
Life of a virtual machine

1. Authentication is performed either by the web interface **horizon** or **nova** command line tool.
2. **nova-api** is contacted and a new request is created.
3. **nova-scheduler** find an appropriate host.
4. **nova-compute** reads the request and start an instance.
5. **neutron/nova-network** configure the network.
6. **nova-compute** contacts **cinder** to provision the Volume.
7. **nova-compute** fetches VM image from **glance**.
8. **nova-compute** starts the virtual machine.
9. **horizon/nova** poll **nova-api** until the VM is ready.

Initial state



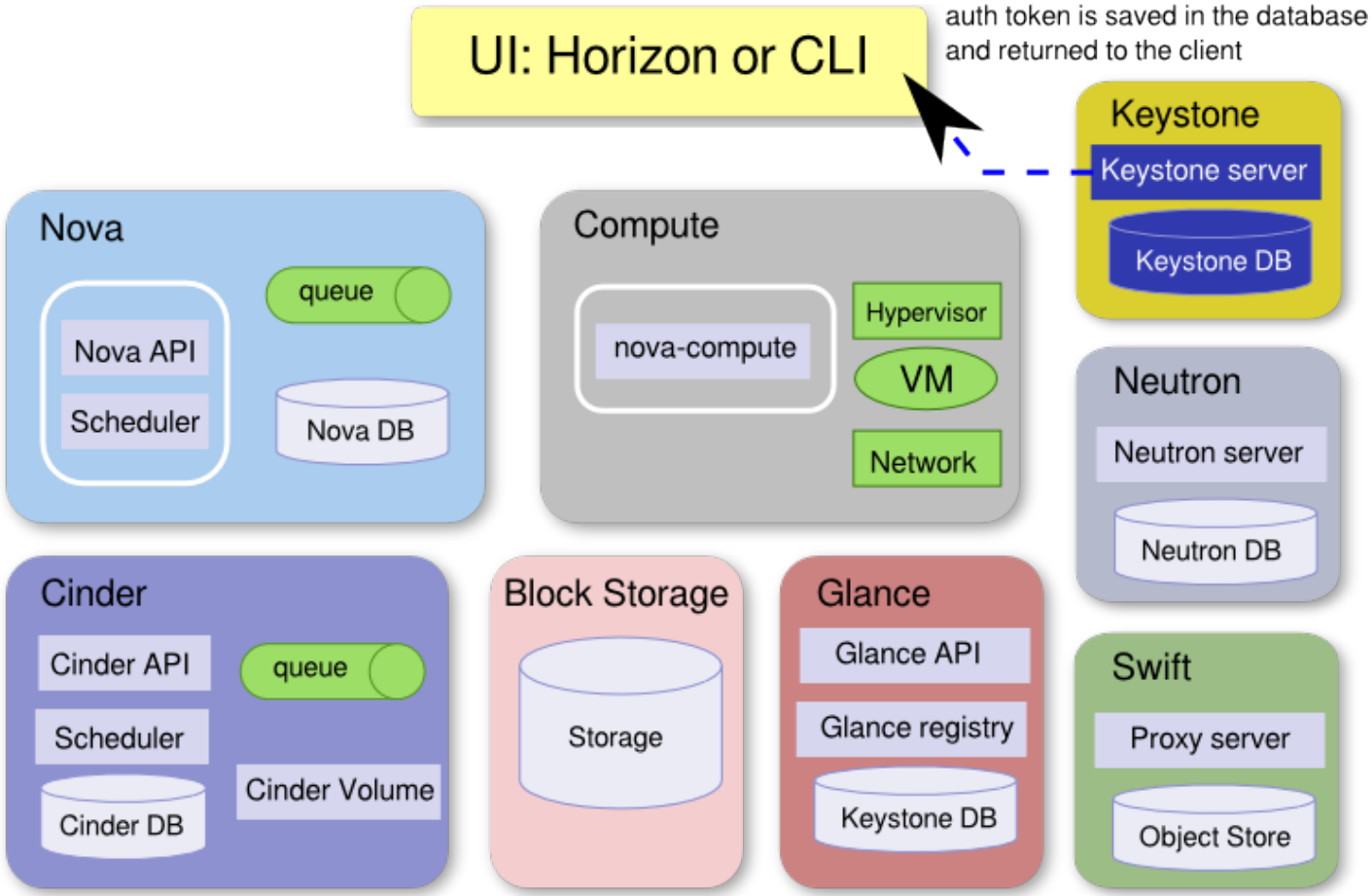
Step 1: Authentication and Authorization



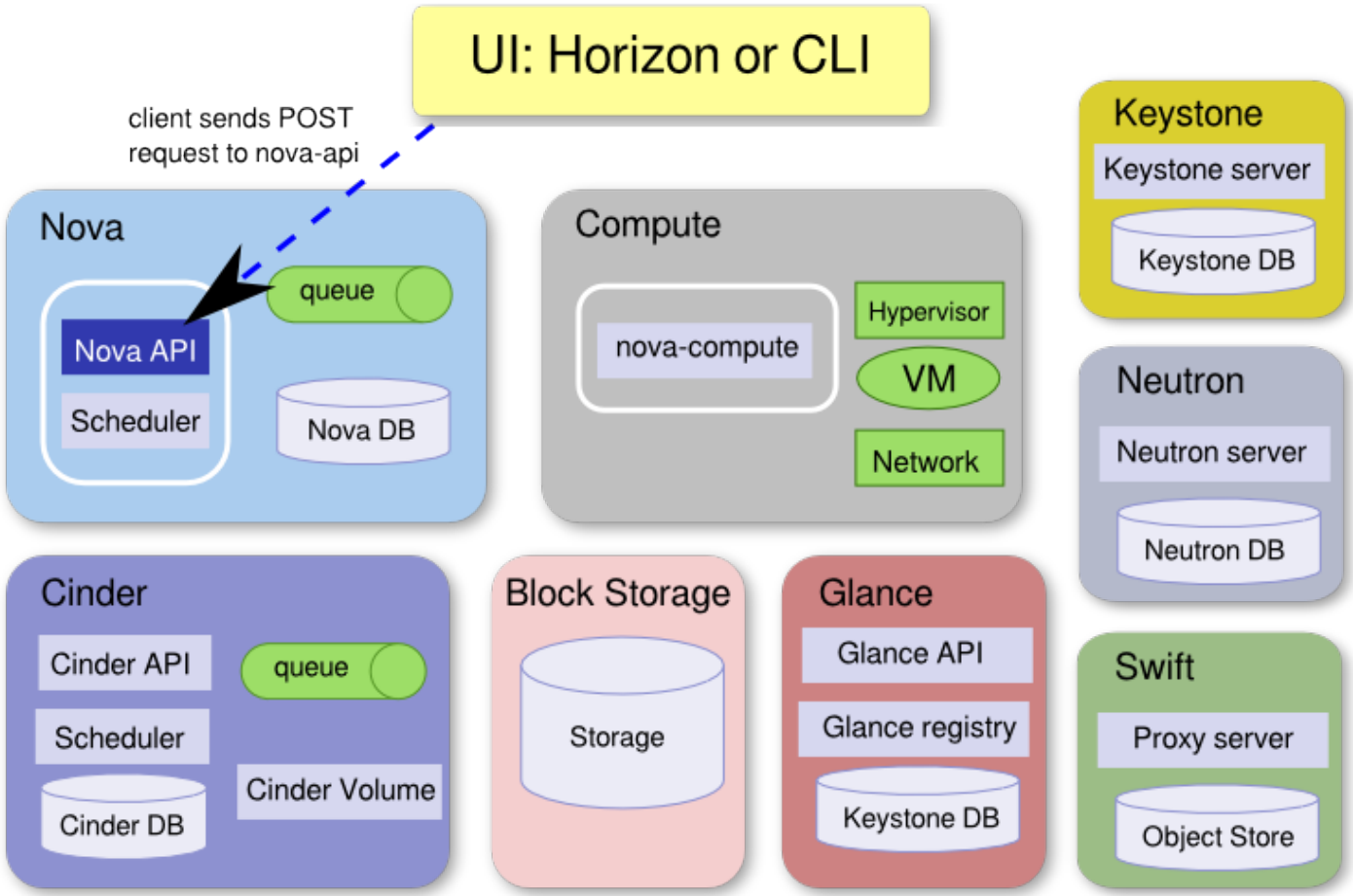
Validate Auth Data

1. Client initiates HTTP POST request to keystone
2. keystone parses HTTP requests and verifies
   - Authentication
   - Access Control
   - Authorization
3. a token is saved in the **keystone-db** and returned to the client to be used with later interactions with OpenStack services for this request.

Step 1: Authentication and Authorization



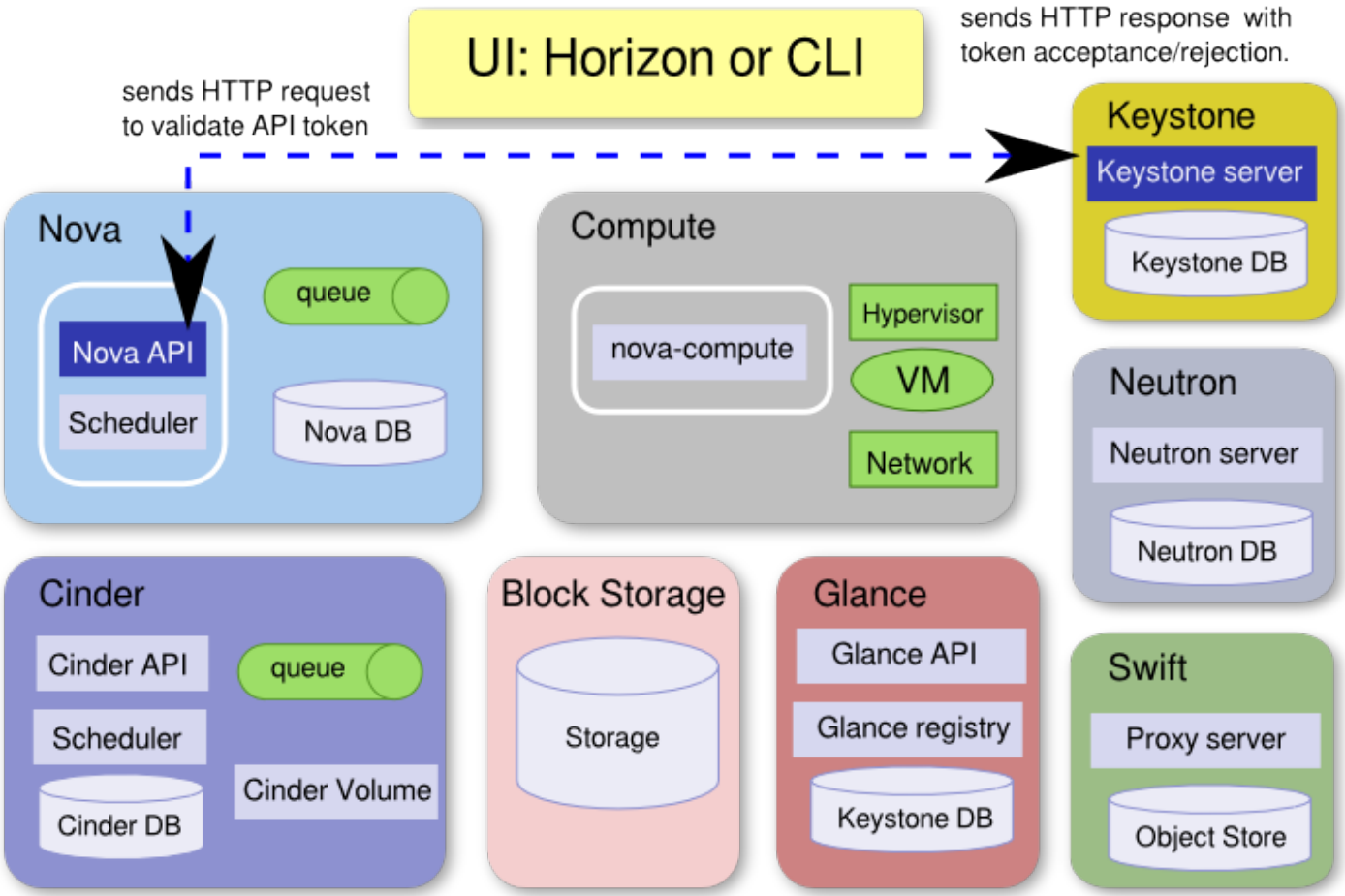
Step 2: Send API request to nova-API



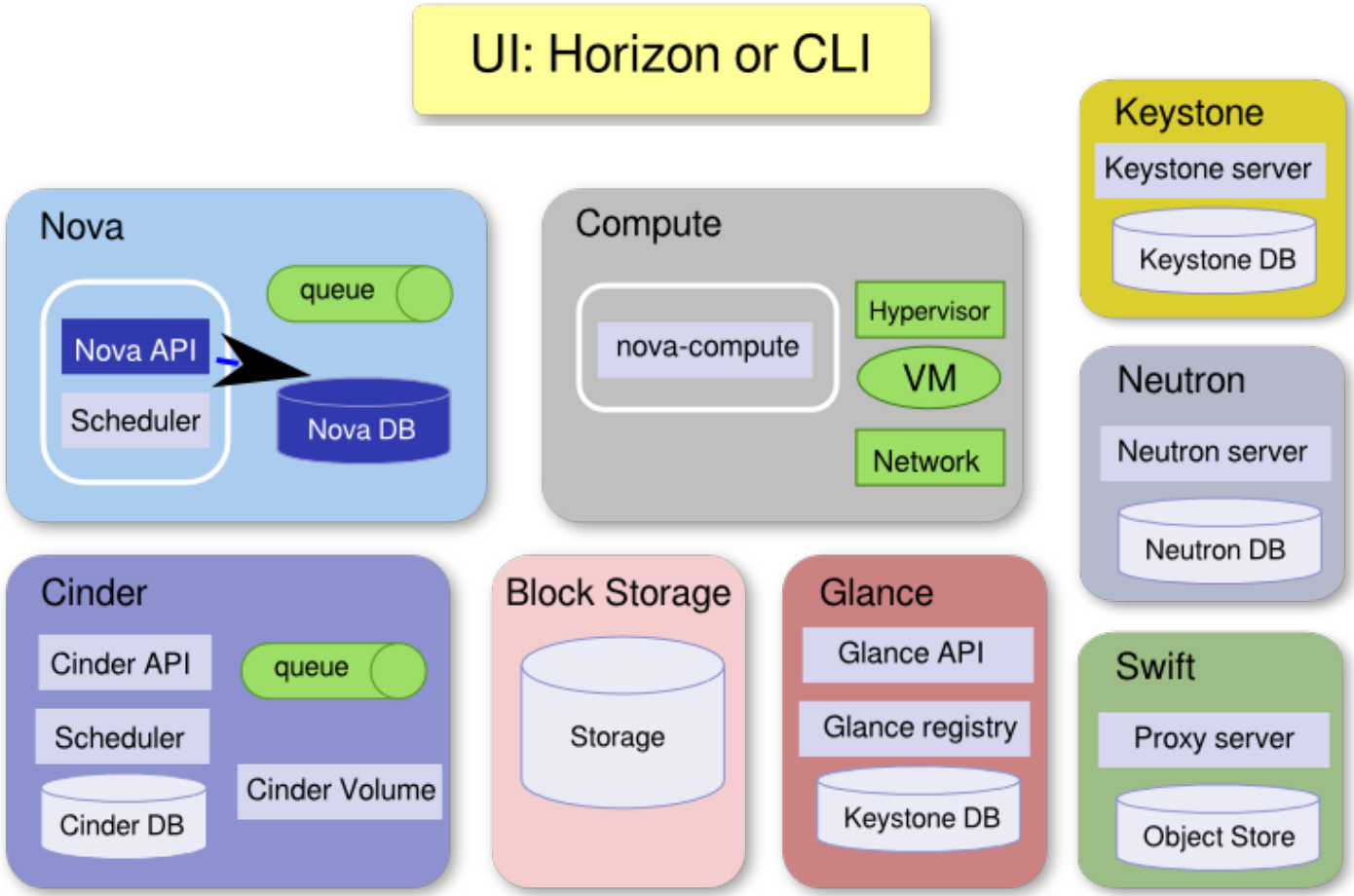
nova-API validate request process

1. checks via **keystone** the validity of the token
2. validates parameters and create a new request in the **nova-db**
3. calls the **nova-scheduler** via **message-queue**

Step 2.1: checks via keystone the validity of the token

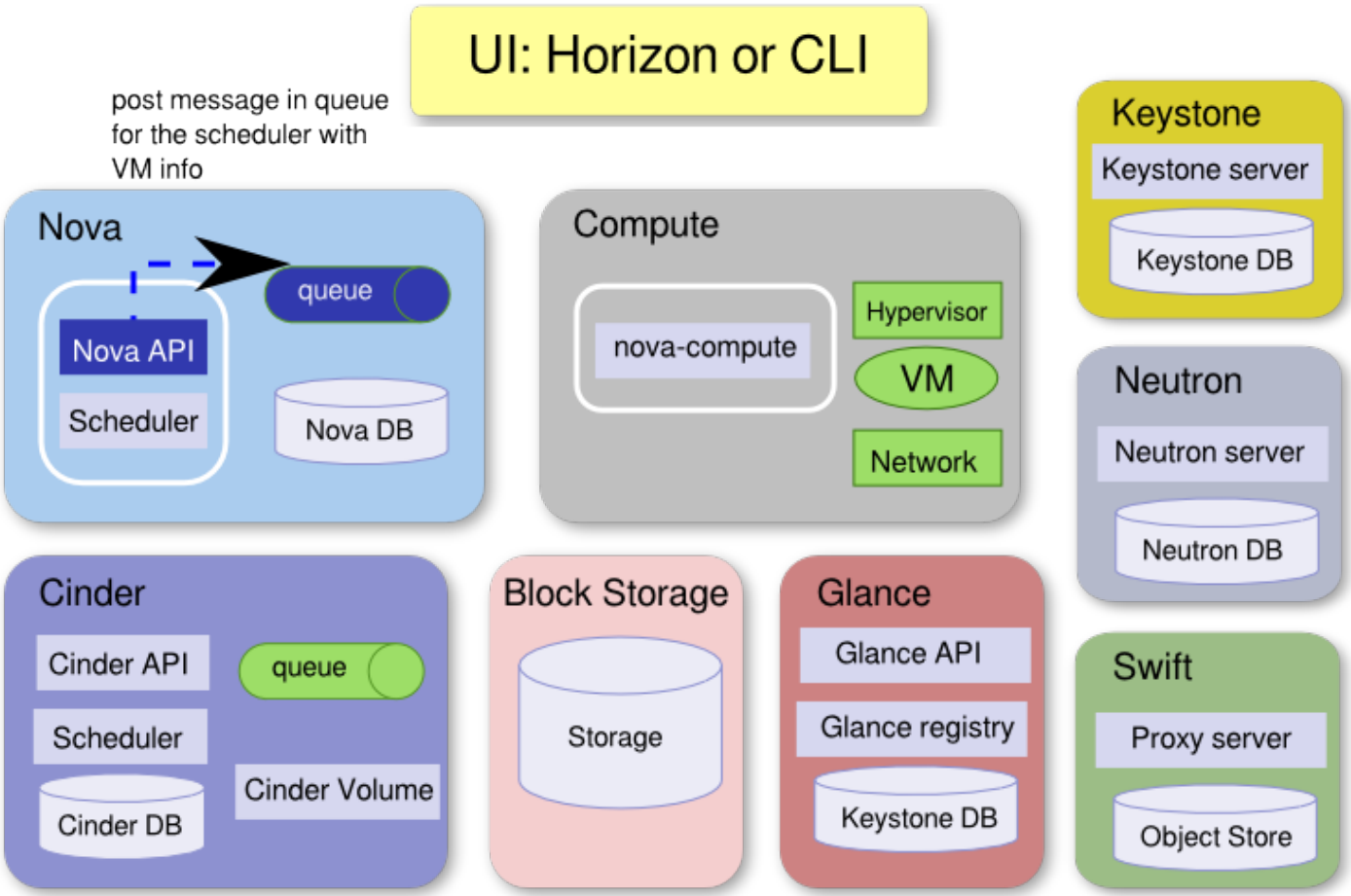


Step 2.2: Validates parameters and create a new request in the nova-db



nova-db stores current state of all objects in the compute cluster.

Step 2.3: calls the nova-scheduler via message-queue

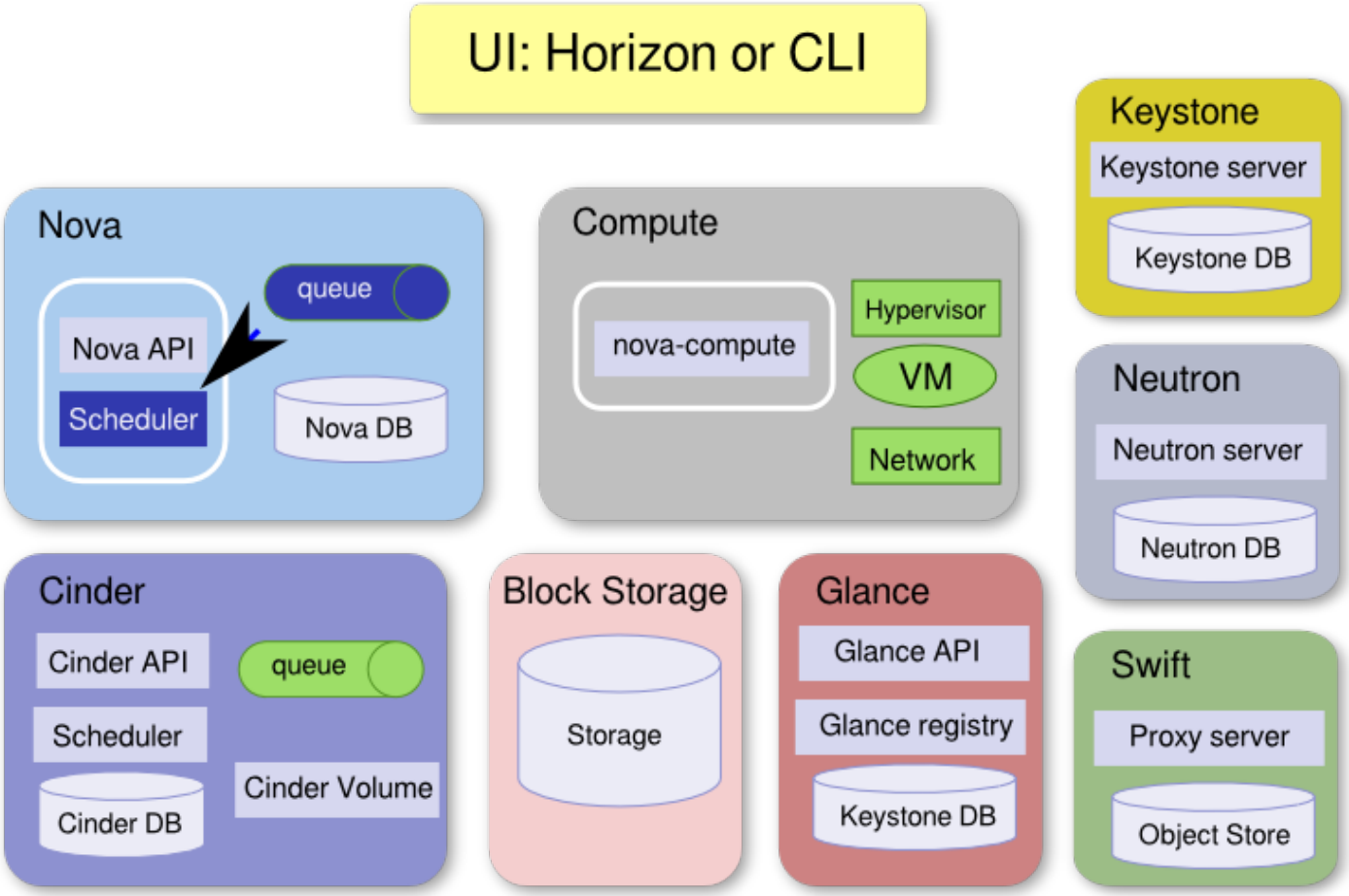


Request has been validated but not actions have been taken yet.

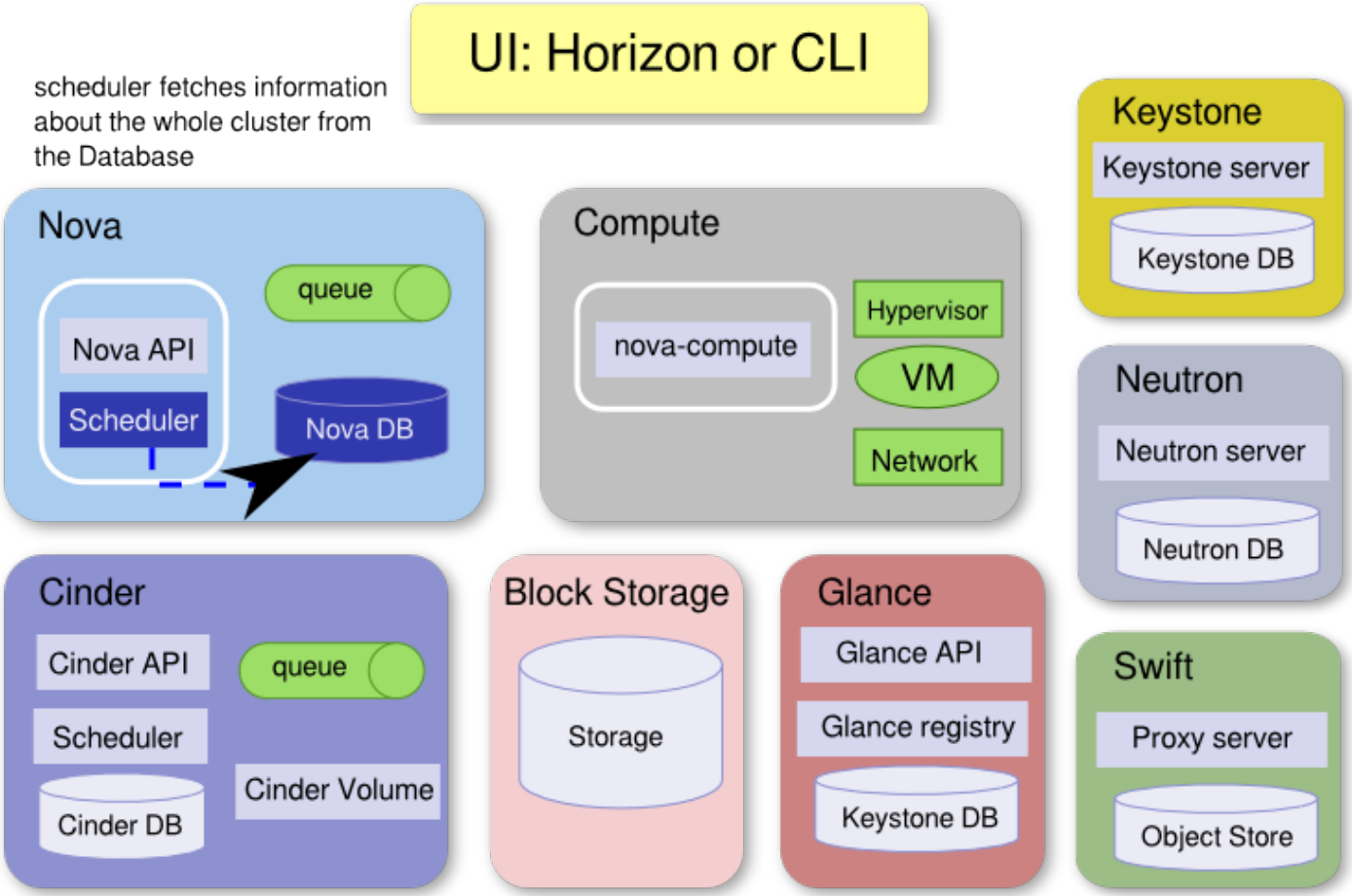
Step 3: nova-scheduler request process

1. reads the request from **message-queue**
2. fetches information about the whole cluster from **nova-db**
3. finds an appropriate host via filtering and weighting
4. calls the chosen **nova-compute** host via **message-queue**

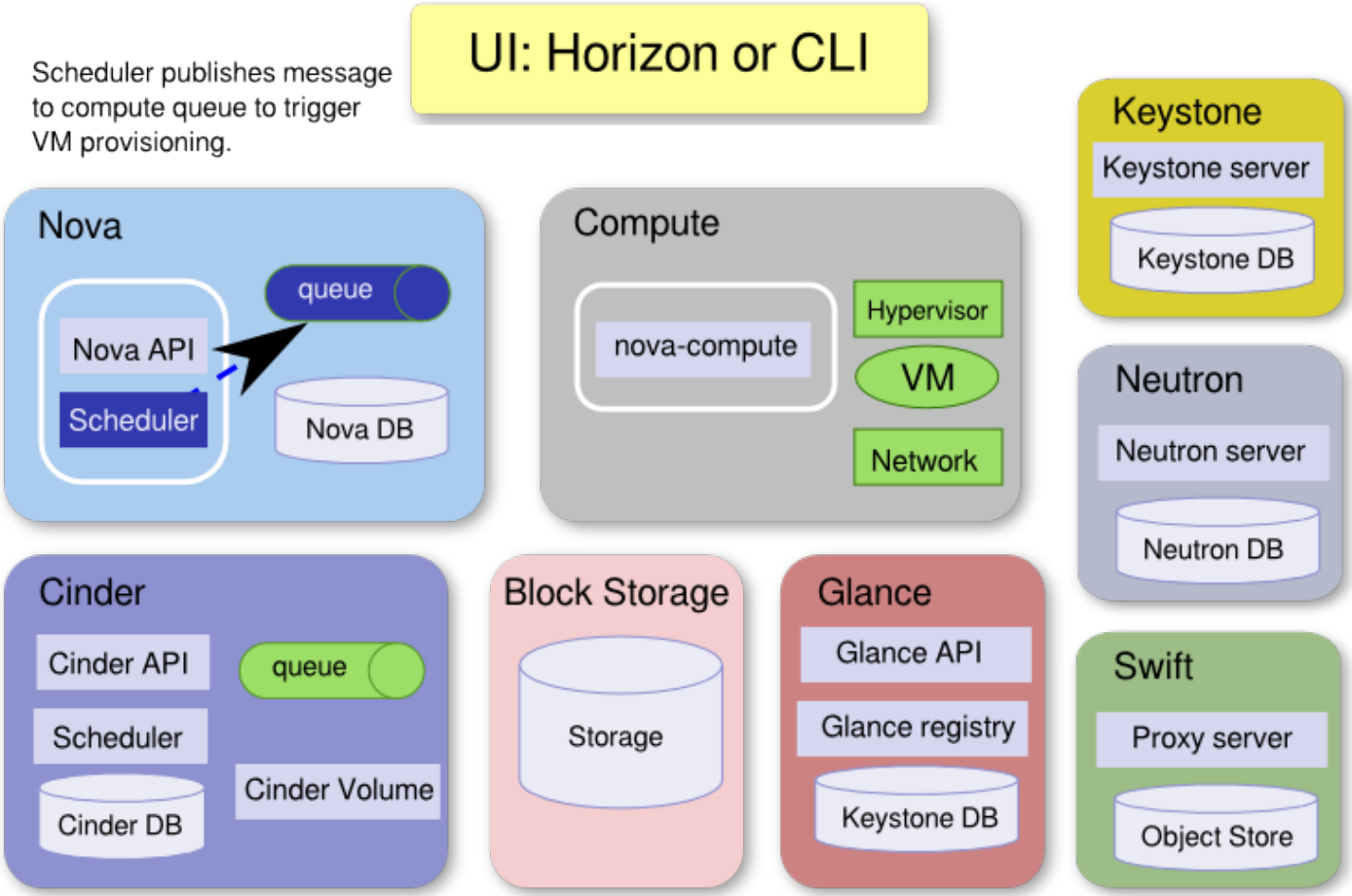
Step 3.1: nova-scheduler reads message from message-queue



Step 3.1: nova-scheduler fetched information from nova-db



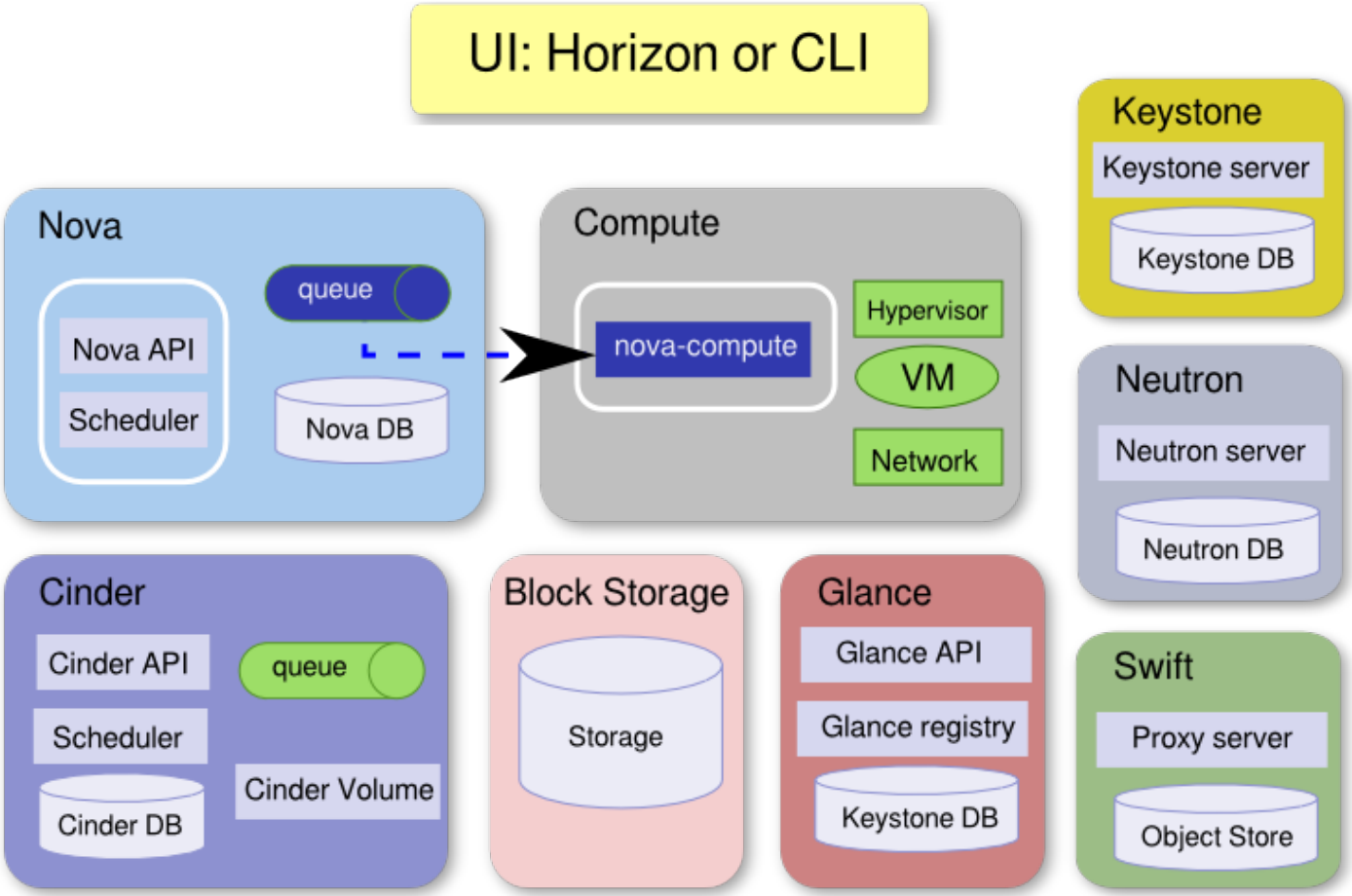
Step 3.2: nova-scheduler calls the chosen nova-compute host via message-queue



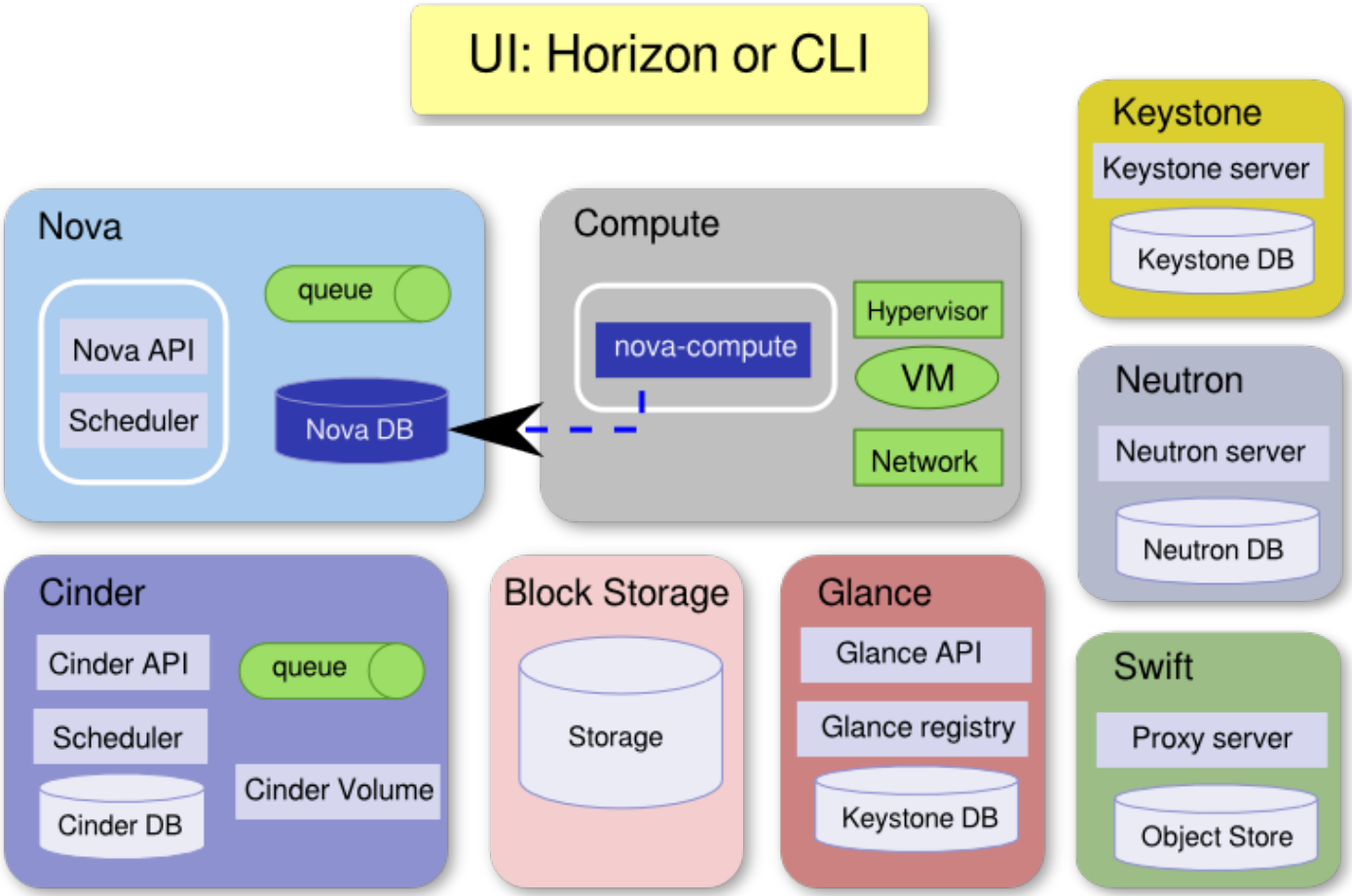
Step 4: nova-compute reads the request and starts the instance

1. reads the request from **message-queue**
2. reads VM information from **nova-db**

Step 4.1: nova-compute reads message from message-queue



Step 4.2: nova-compute reads VM information from nova-db

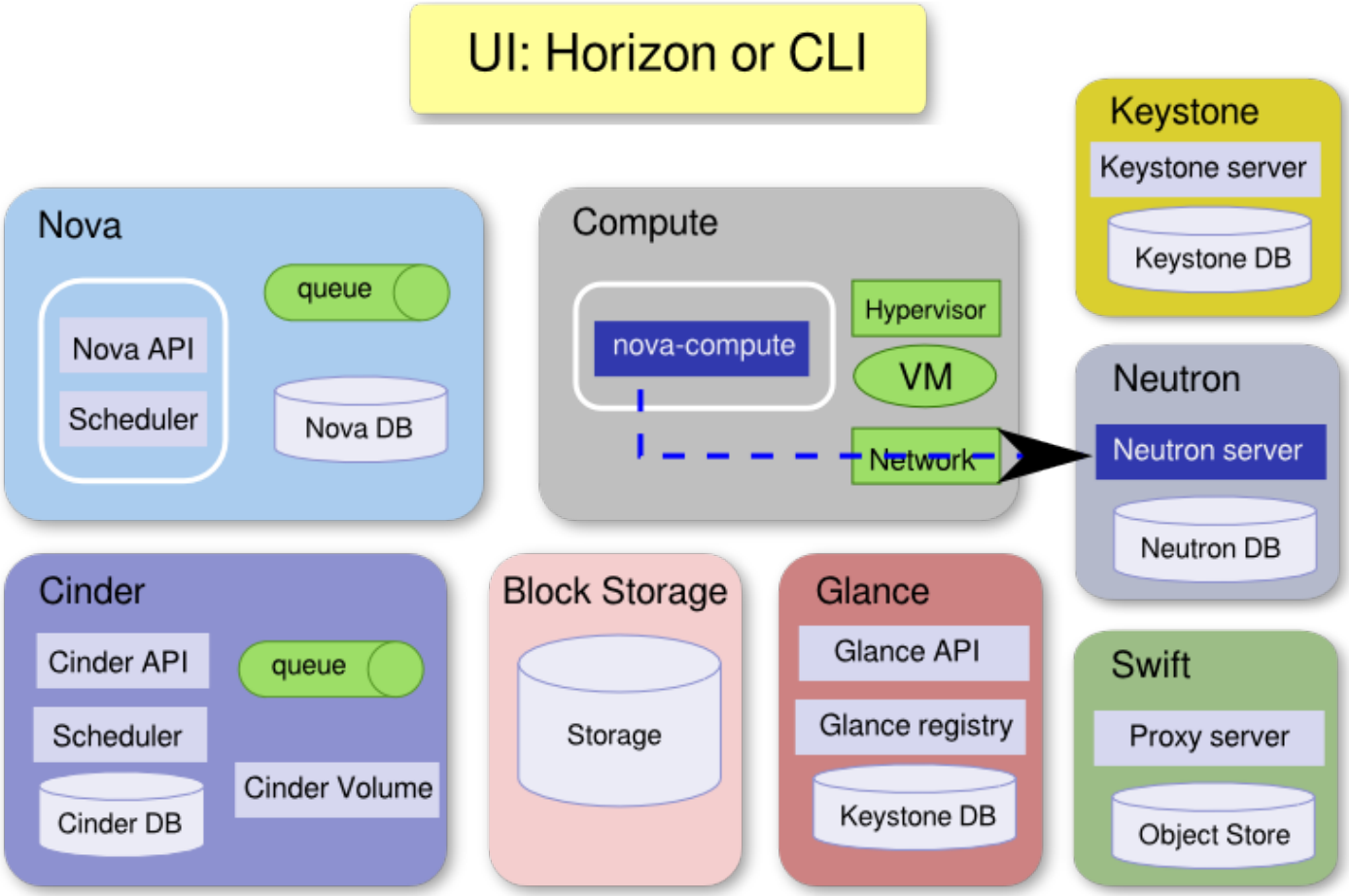


From *Grizzly* release *nova-conductor* has been introduced to address remote-DB access.

Step 5: neutron configures Network

1. **nova-compute** queries **neutron** for Network service
2. **neutron** Associate IP and MAC with VM (DB)
   - setup network - L2
   - setup network - L3

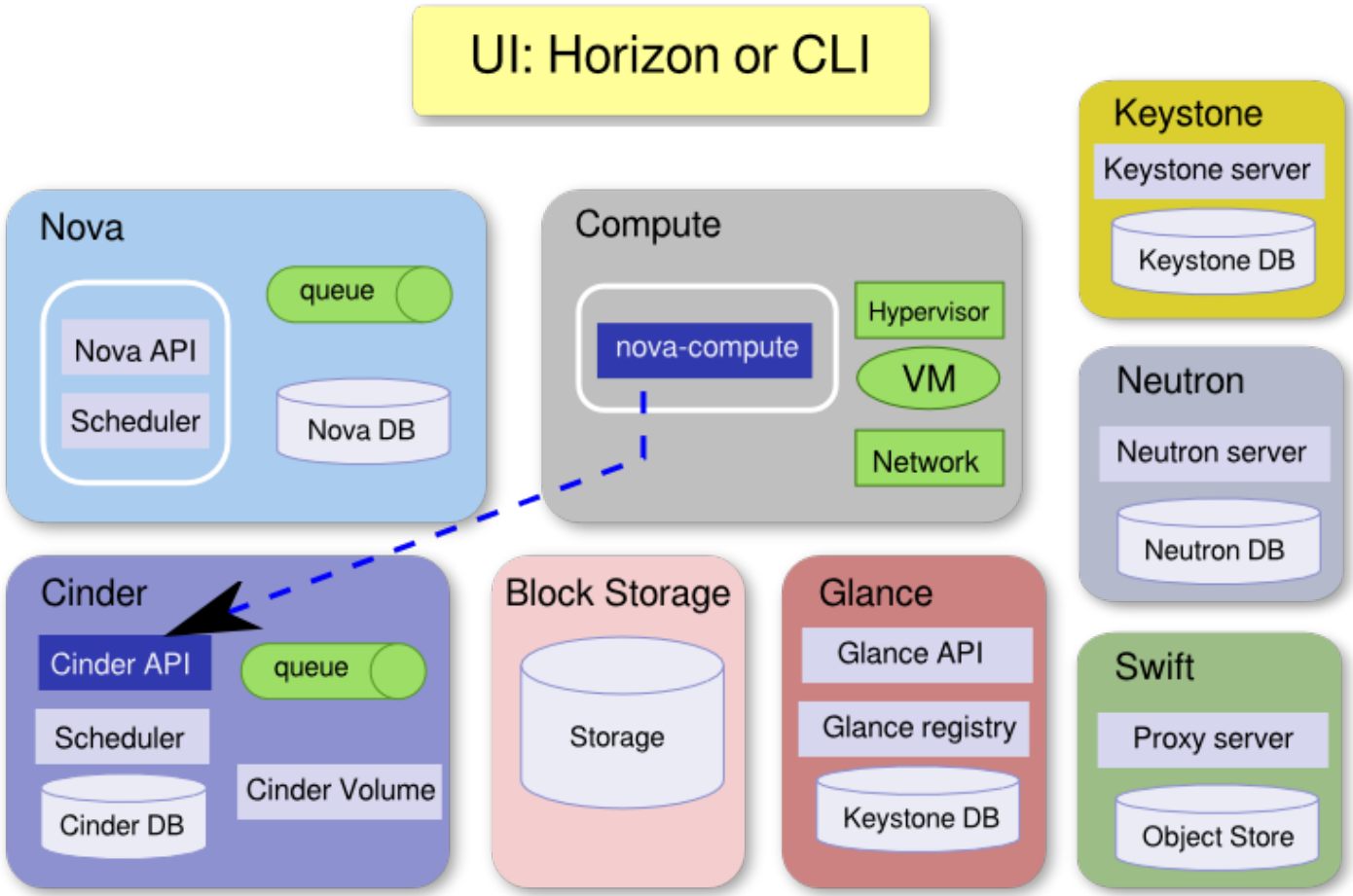
Step 5: nova-compute queries neutron for Network service



Step 6: nova-compute contacts cinder to provision Volumes

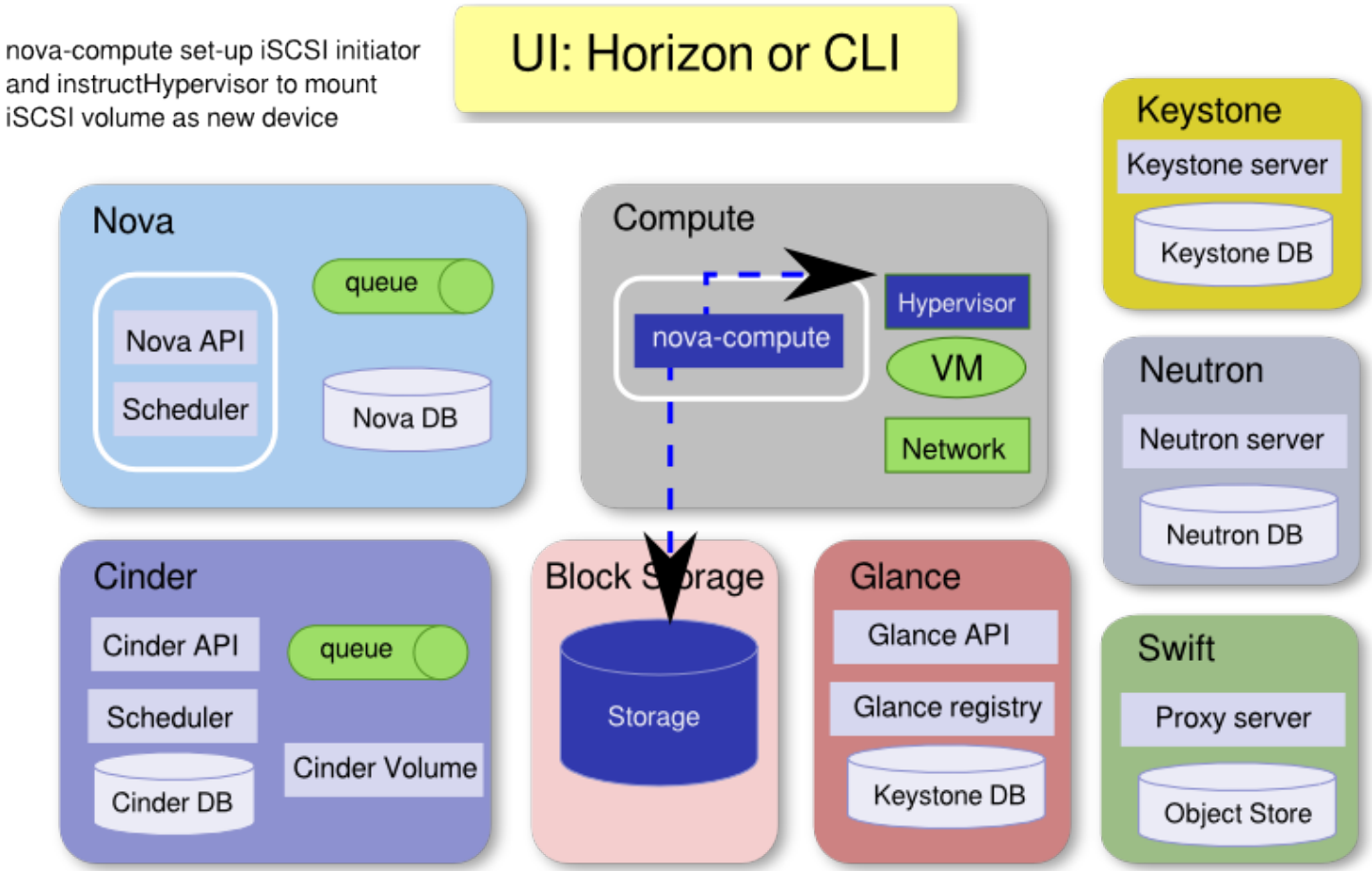
1. **nova-compute** gets Volume data from **cinder**
2. **nova-compute** initiate iSCSI connector
3. **nova-compute** instructs Hypervisor to mount the iSCSI Volume as a new block device.

Step 6.1: nova-compute contacts cinder to provision the Volume



cinder provides Volume information (optional step for persistent data).

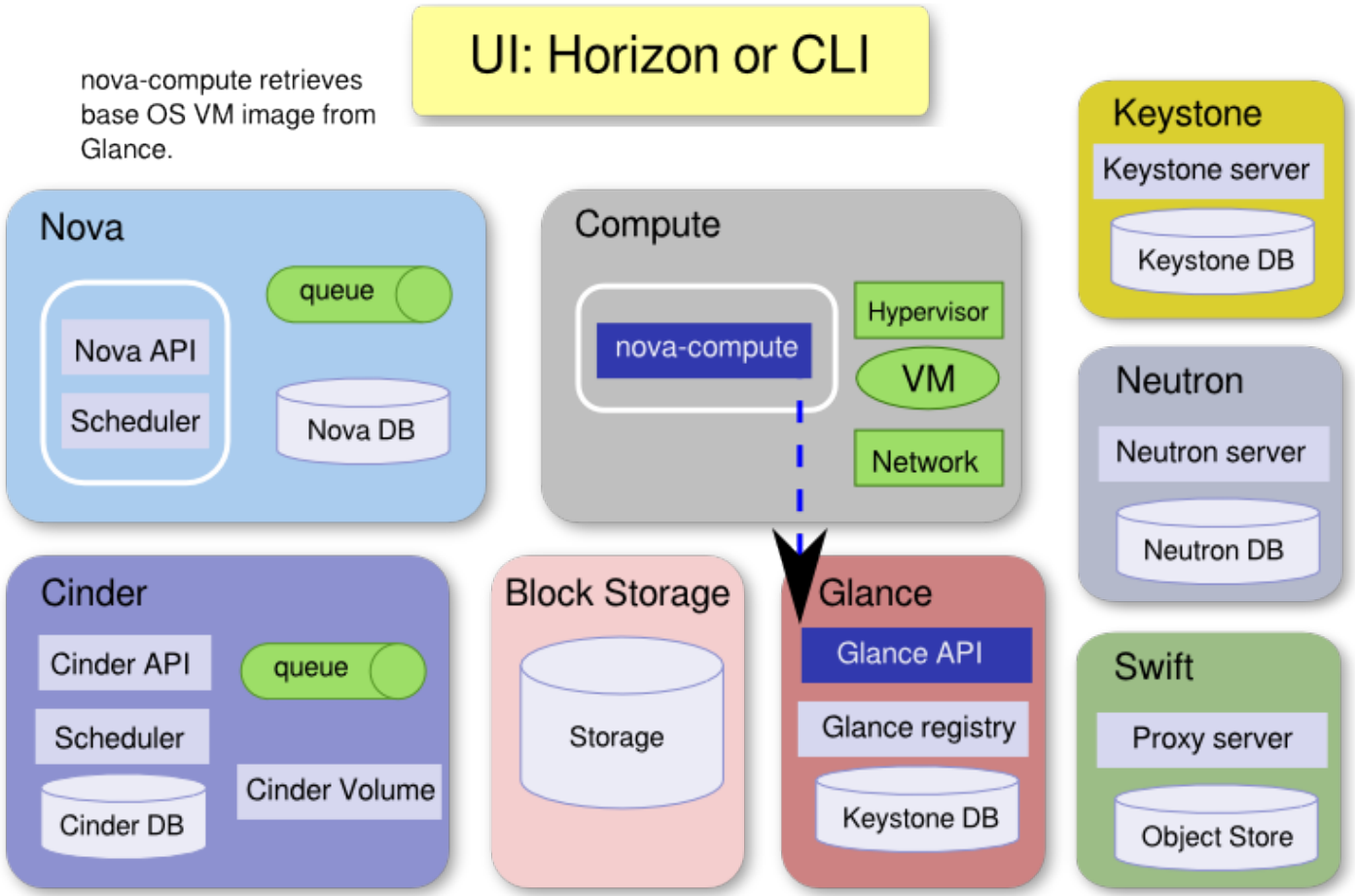
Step 6.2: nova-compute requests Volume



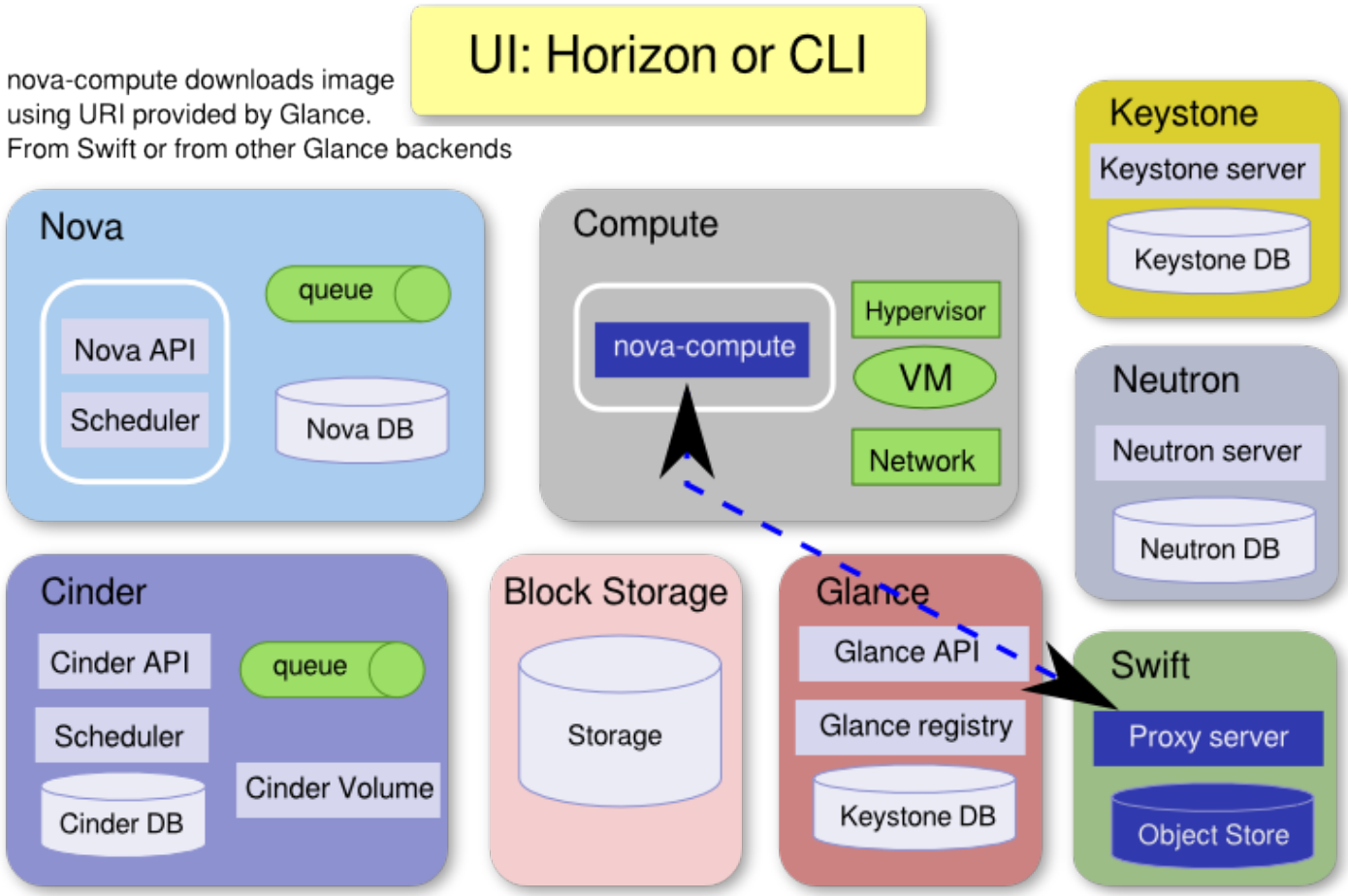
Step 7: nova-compute fetches VM image

1. **nova-compute** requests image from **glance** via Image ID
2. **glance** returns an URI if image ID is valid
3. **nova-compute** downloads image using URI.

7.1: nova-compute requests image from glance



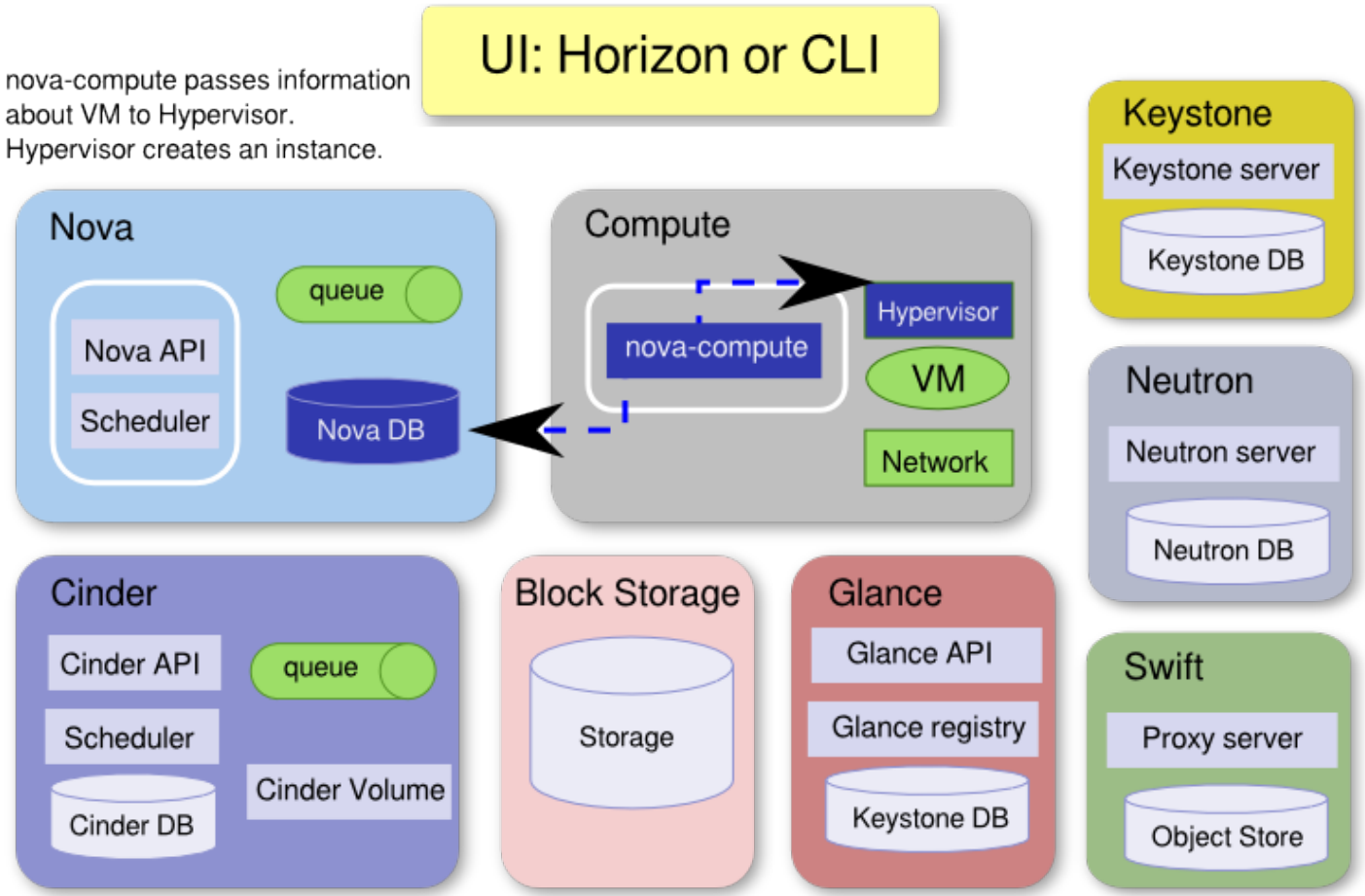
Step 7.2: nova-compute downloads image from swift



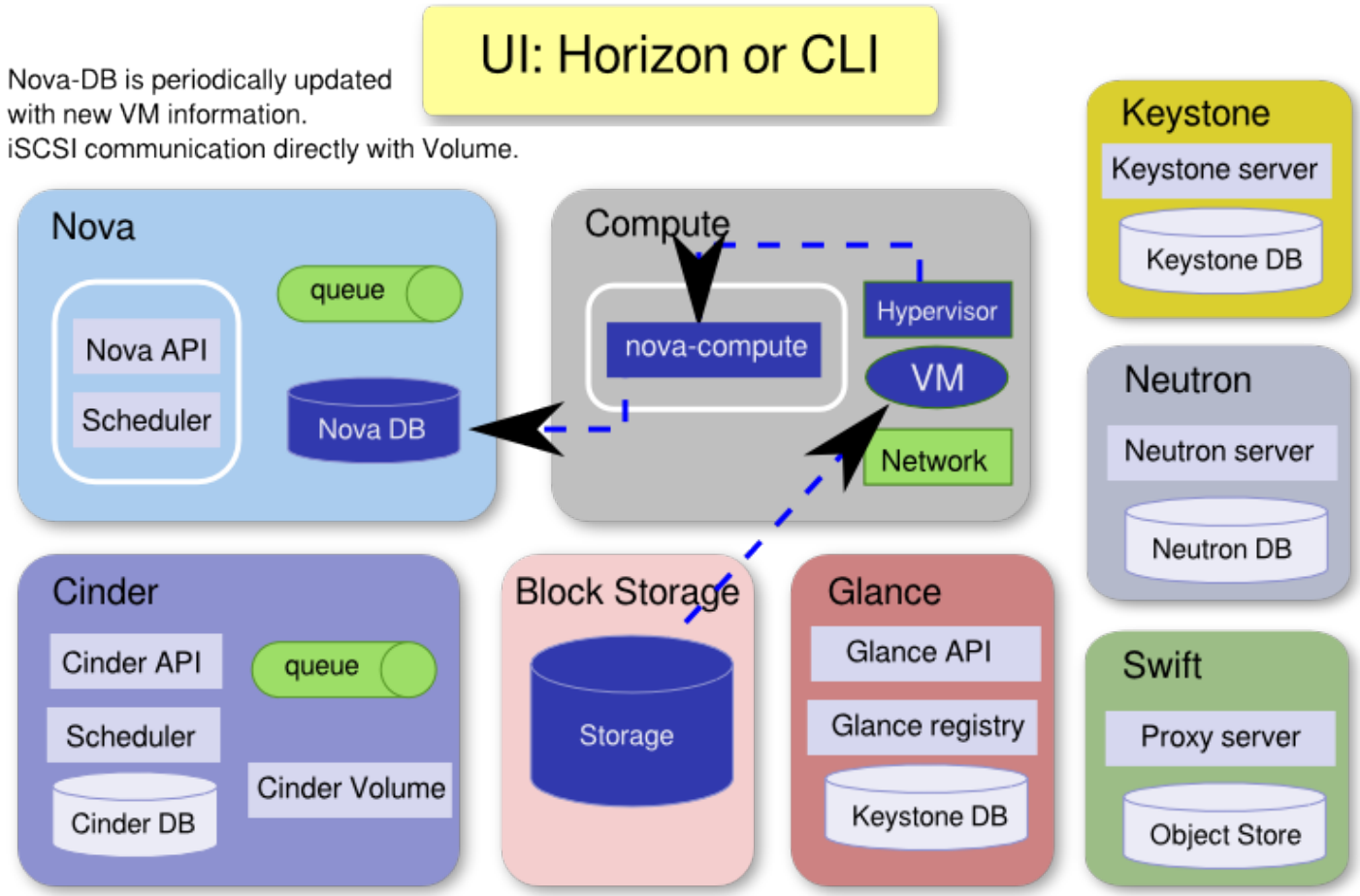
Step 8: nova-compute starts VM

1. **nova-compute** fetches information about VM from **nova-db**
2. creates a command to Hypervisor
   - in case of KVM/libvirt this is a single VM XML config file.
3. delegates to Hypervisor the activation of VM
4. Periodically polls VM status from Hypervisor and updates **nova-db**

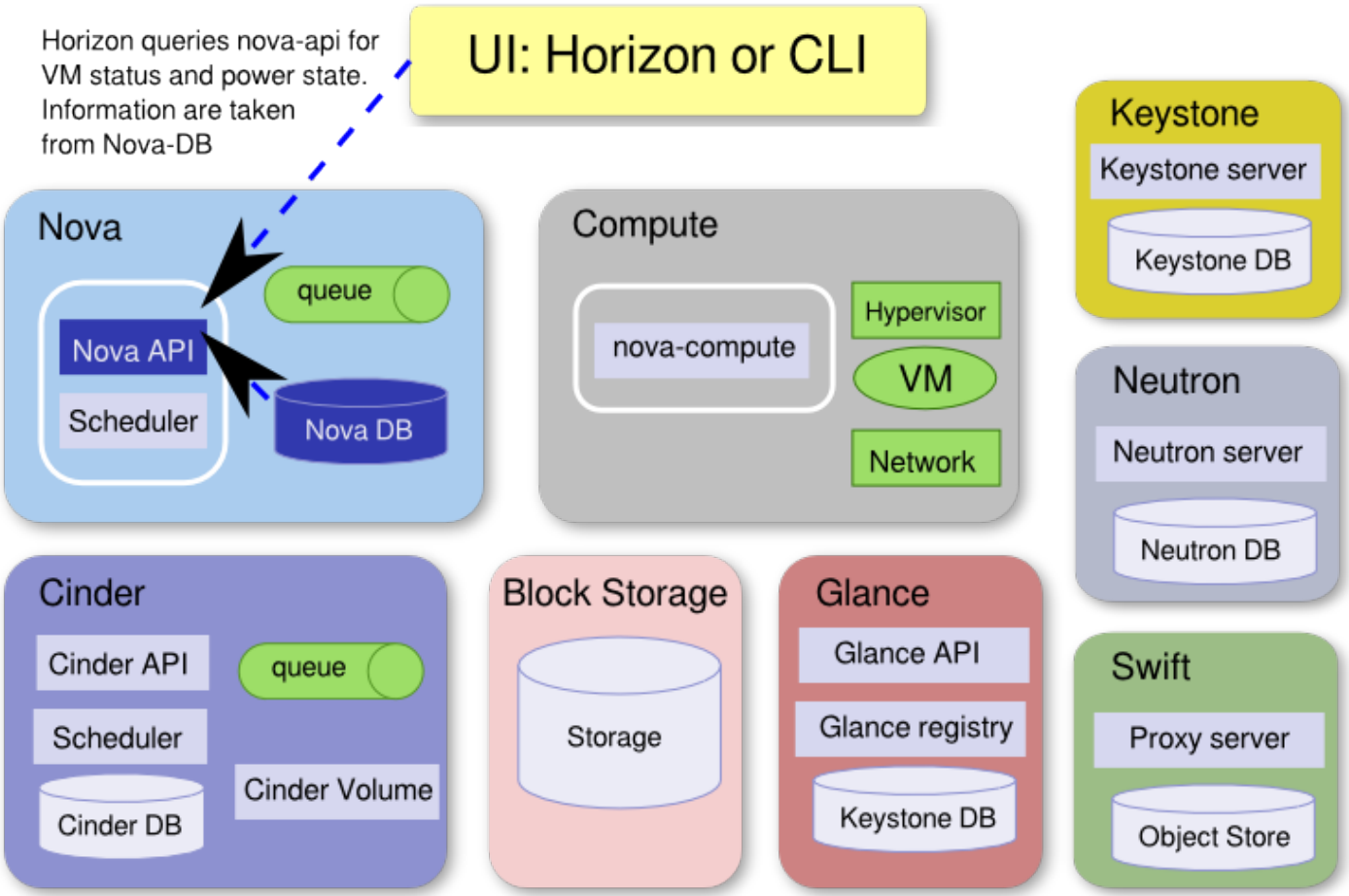
Step 8.1: VM can be started



Step 8.2: nova-compute polls VM status and updates nova-db



Step 9: horizon/nova CLI poll nova-api for updated VM status



Recap

- User logs into **horizon** and initiates a VM create request,
- **keystone** authorizes,
- **nova** initiates provisioning and saves state to **nova-db**,
- **nova-scheduler** finds appropriate host,
- **neutron** configures networking,
- **cinder** provides block device,
- image URI is looked up through **glance**,
- image is retrieved via **swift**,
- VM is rendered.