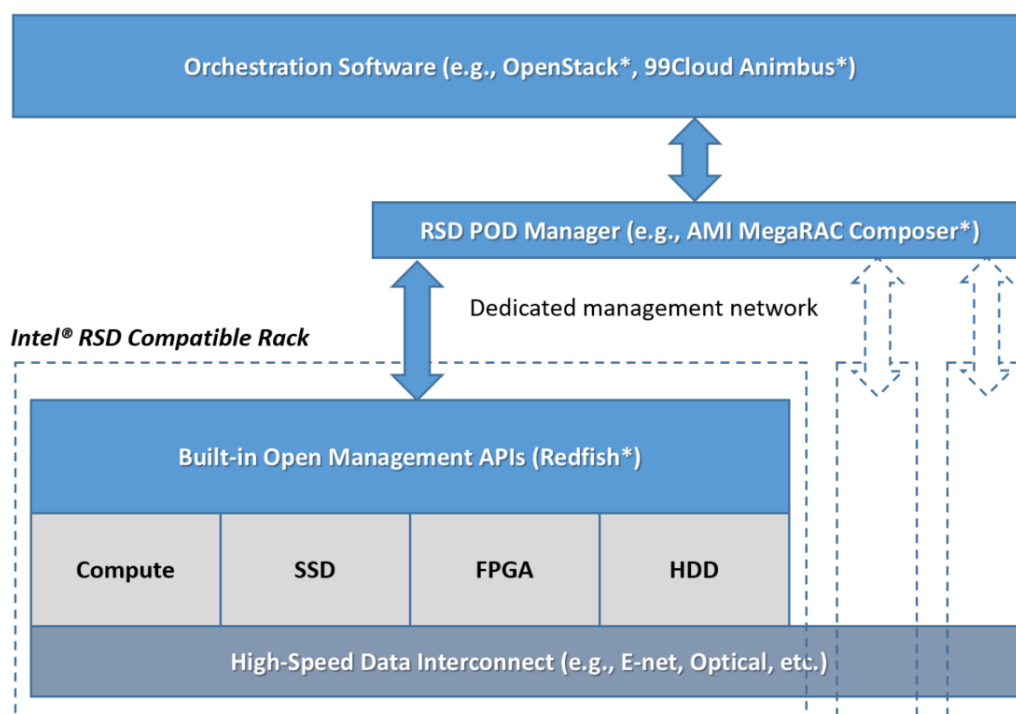


## Provisioning Intel® Rack Scale Design Bare Metal Resources in the OpenStack Environment

*NOTE: If you are familiar with Intel® Rack Scale Design and OpenStack\* and just want to know how to install components to enable OpenStack composition and bare metal provisioning, please skip to “[Installing the Intel® RSD OpenStack Components](#)” below.*

### Introduction

Intel® Rack Scale Design (Intel® RSD) is an open source Data Center architecture that enables dynamic composition of logical systems, or “nodes” from disaggregated pools of compute, storage, and (in an upcoming release) accelerator resources. It is based on open, scalable and secure infrastructure management APIs that support a software defined infrastructure with interoperability across hardware and software vendors. Intel® RSD makes the Data Center more economical, flexible, simpler to manage, and easier to scale out on demand.



**Figure 1.** Intel® Rack Scale Design is an industry-aligned specification for composable disaggregated infrastructure.

Today, Data Center managers using cloud-oriented virtualized environments like OpenStack\* are asking how they can employ Intel® RSD in their existing public, private and hybrid clouds. In this paper we describe how to deploy Intel® RSD-based equipment in an existing OpenStack environment, using OpenStack's Ironic\* service for logical node composition and bare metal provisioning. Readers should keep in mind that as the Intel® RSD specification continues to evolve it will address more use models, technologies and products, and there are many integration efforts currently under way to support Intel® RSD systems as native platforms in a wide range of virtual and cloud environments.

### Traditional vs. Intel® RSD Bare Metal Provisioning

Even in cloud environments like OpenStack, operators still need to provision bare metal servers for specific purposes:

- High-performance computing clusters
- Applications that require access to hardware devices that can't be virtualized
- Database hosting (some databases run poorly on a hypervisor)
- Single tenant, dedicated hardware to meet performance, security, dependability or regulatory requirements
- Or simply to rapidly deploy an OpenStack cloud infrastructure

The OpenStack environment provides a component called Ironic that supports operators with a set of services to provision servers, either for incorporation into the virtual cloud environment, or to run dedicated applications directly on bare metal. To provision a traditional bare metal server, operators physically install and make physical power and network connections to the target servers. Then they "enroll" these servers in the Ironic database, i.e., they provide a description of the assets, including such things as the CPU type, number of sockets and cores, size of DRAM and attached SSDs or hard disk storage, accelerator resources, port address, and so on, either manually or using an in-band script. When a new server is needed to support a workload, the Nova service in OpenStack will search the Ironic database for a server that matches the workload requirements, provision it, and deploy the workload.

To understand how Ironic works with Intel® RSD based equipment, we need to keep in mind that Intel® RSD provides a degree of flexibility that is not available in traditional fixed-configuration servers. Intel® RSD is a disaggregated architecture, so rather than fixed configuration servers, equipment is visualized as pools of resources by type, e.g., compute, storage, and (in the future) accelerator resources. When fully deployed Intel® RSD will allow operators to define or "compose" logical nodes in real time with any mix of resources available in the resource pools. Rather than choosing a "best fit" existing server, Intel® RSD allows operators to create logical nodes with the exact resource requirements "on-the-fly" and then enroll the node in the Ironic database for future consumption. The current version of Intel® RSD (2.2) enables storage pooling and composition over PCIe interconnects. Upcoming versions will support NVMe over Fabric\*, FPGA pooling, network function virtualization (NFV) management and additional features.

Composing a logical node from pooled compute and storage resources and making it available to Nova\* requires one extra step compared to provisioning traditional bare metal servers. This is the composition step, which is accomplished by a simple operation using a modified OpenStack Client (OSC) command line interface (CLI) to define the new node with the desired resources (compute, DRAM, storage, etc.). Once this is accomplished, the operator enrolls the new node as usual, and then provisions it with a call to Nova, which invokes Ironic "under the covers."

### Intel® and Redfish

At this point we should clarify the relationship between Intel® RSD and Redfish. Redfish is an open standard for Data Center management created by the Distributed Management Task Force (DMTF)\*. Essentially, Redfish is the successor to IPMI\* (Intelligent Platform Management Interface), which is about 20 years old. In addition to being more scalable and secure than IPMI due to its web-friendly, RESTful APIs, Redfish also introduces significant new functionality, including the ability to control the composition of logical servers from disaggregated resources.

Intel is a longstanding member of DMTF, and a major contributor to Redfish. In general, new functionality and APIs needed to implement the Intel® RSD vision are prototyped and tested by Intel and our partners, and then submitted to Redfish committees as candidates for inclusion into the Redfish standard. As with any industry standard effort, Redfish submissions require review, discussion and approval by the governing committees, so there is always a time lag between Intel® RSD APIs and reference code, and the official Redfish APIs. In addition, there may be some changes to the management interface (i.e., the URIs) as a result of this process. For this reason, some functionality, such as the functionality described in the paper, is not supported by the officially released Redfish APIs at this time. **The following discussion assumes that the target Intel® RSD equipment implements Intel® RSD version 2.2 APIs, although over time, we expect this capability to be fully supported by any Redfish compliant equipment.**



**Figure 2.** Intel® RSD is a collaborative initiative by which pathfinding activities with Intel’s ecosystem partners and definitional customers result in proposed functions and APIs submitted to the DMTF Redfish working group.

### Discovery, Composition, Provisioning and Deployment of Workloads on Intel® RSD Resources with OpenStack

To enable Intel® RSD in the OpenStack environment, Intel created a python library called “rsd-lib” and an OpenStack Client (OSC) plugin called “python-rsdclient” and upstreamed them to the OpenStack project. The rsd-lib library extends the standard Ironi Redfish Sushy driver, enabling it to make composition calls to the POD Manager (PODM) software component of Intel® RSD. PODM then carries out node composition requests by communicating with hardware resources through Intel® RSD APIs exposed by PSME software components running on hardware modules within the rack. The python-rsdclient plugin provides the user commands for node composition and Ironi enrollment. The diagram below shows the Intel® RSD bare metal provisioning process:

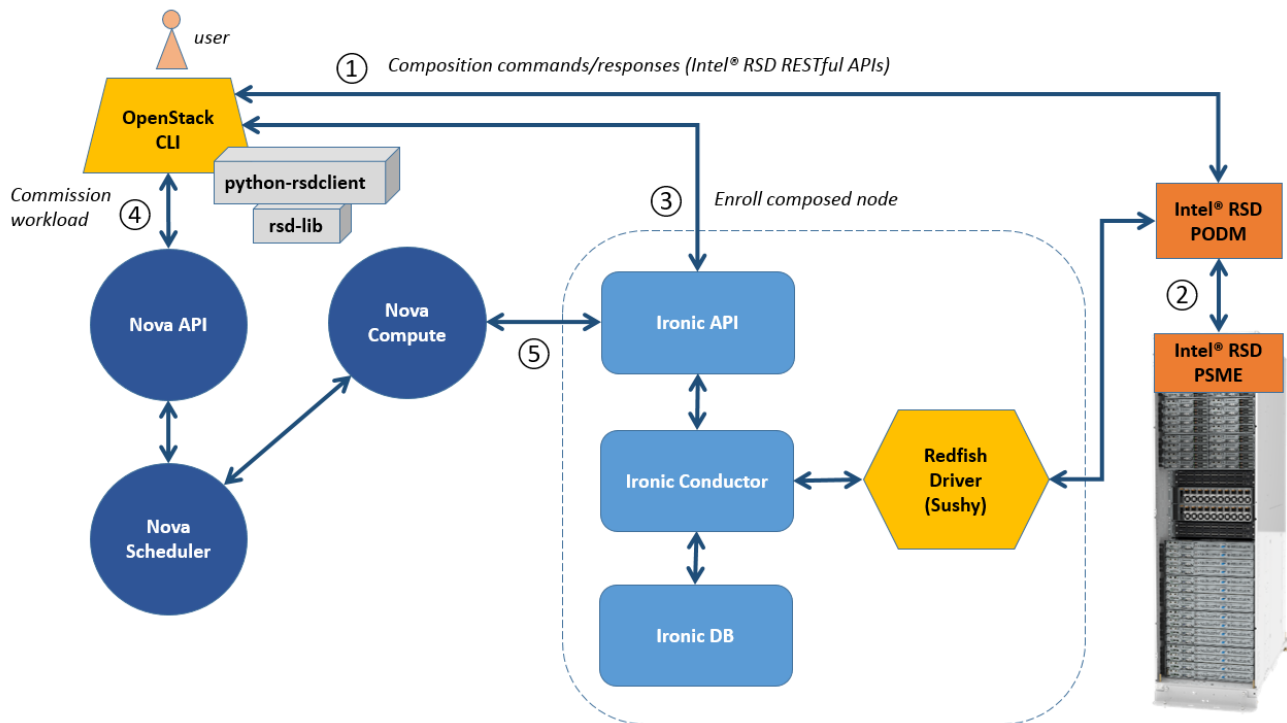
1. User requests a new composed node with specific parameters (CPU, DRAM, storage, etc.) using the OSC RSD CLI, which sends requests to PODM.
2. PODM composes the node and returns node status to the user.
3. The user enrolls the new node into the Ironi database using the OSC Ironi CLI.
4. The user commissions a workload on the new node using Nova, like any other server.
5. Nova invokes Ironi to provision the node and then deploys the workload.

### Installing the Intel® RSD OpenStack Components

*Note: The changes to enable Intel® RSD bare metal provisioning have been upstreamed to the OpenStack community. As of release of this application note, the Intel® RSD modified OpenStack client and Ironi Sushy extensions are in the OpenStack review process. This situation may change as these submissions are promoted to official plug-in status. You may have to search Github\* to find the current location of this package. We expect these changes to be incorporated into the “Queens” release of OpenStack.*

The Python\* library for Intel® Rack Scale Design, rsd-lib, extends the existing Redfish Sushy driver to include functionality for Intel® RSD PODM APIs. Capabilities include logical node composition and decomposition, remote storage discovery and composition, and attaching and detaching NVMe drives over PCIe to logical nodes. The rsd-lib library is located at <https://github.com/openstack/rsd-lib> and is made available to OSC automatically through the RSD OSC plugin—no additional user actions are required.

Users interact with Intel® Rack Scale Design compatible hardware through the RSD plugin for OSC, which provides the extended RSD command line interface (CLI). To use OpenStack RSD commands, install the normal `python-openstackclient` and the `python-rsdclient` RSD plugin on any node that has a network connection to OpenStack:



**Figure 3.** Python libraries upstreamed by Intel to the OpenStack project provide the ability to dynamically compose, enroll and provision logical nodes using OSC.

```
# pip install python-openstackclient
# pip install python-rsdclient
```

Next, initiate your user session by logging in to the RSD OpenStack client. First, provide your OpenStack username, password, project, and auth endpoint. You can use configuration options `--os-username`, `--os-password`, `--os-project-id` (or `--os-project-name`), and `--os-auth-url`, or set the corresponding environment variables:

```
$ export OS_USERNAME=user
$ export OS_PASSWORD=password
$ export OS_PROJECT_NAME=project # or OS_PROJECT_ID
$ export OS_PROJECT_DOMAIN_ID=default
$ export OS_USER_DOMAIN_ID=default
$ export OS_IDENTITY_API_VERSION=3
$ export OS_AUTH_URL=http://auth.example.com:5000/identity
```

Then, you have to provide Intel PODM username, password, SSL certificate with admin privilege, and PODM URL. You can use configuration options `--rsd-username`, `--rsd-password`, `--rsd-verify`, and `--rsd-url`, or set the corresponding environment variables:

```
$ export RSD_USERNAME=admin
$ export RSD_PASSWORD=password
$ export RSD_VERIFY=False # or RSD_VERIFY=<path to SSL certificate>
$ export RSD_URL=https://localhost:8443/
```

Once logged in to the CLI, users can issue commands to compose logical nodes and enroll them to the Ironi database (see examples below). The PODM access endpoint (URL) can be specified in a Linux environment variable, or it can be entered as a CLI parameter when composition is initiated in the OSC CLI.

### Enrolling Composed Nodes

Once a new node is composed, it must be enrolled in the Ironic database prior to provisioning, just like any new server resource. However, there is one difference users must be aware of—the `/redfish/v1/Nodes/<node ID>` endpoint for the composed node returned by PODM cannot be used directly, since it is specific to Intel RSD, and the Ironic driver for Redfish uses standard Redfish only (see “Intel® and Redfish” section above).

However, users can determine the correct Redfish URIs by displaying the system UUIDs for composed nodes using the OSC RSD CLI. The URIs can then be used to retrieve the Redfish system IDs (e.g. `/redfish/v1/Systems/<system ID>`), which can be used to enroll the new nodes with Ironic. For example:

Get the list of nodes that have been composed:

```
$ openstack rsd node list
```

| Identity | Name | UUID                                 | Description |
|----------|------|--------------------------------------|-------------|
| 2        | Test | fd011520-86a2-11e7-b4d4-5d323196a3e4 | None        |

Use the UUIDs of the composed nodes you want to enroll to retrieve the correct Redfish system IDs

```
$ openstack node show fd011520-86a2-11e7-b4d4-5d323196a3e4 | grep -i "system"
```

Here we’re using `grep` to isolate just the systems URI from the large amount of information potentially returned for each node, so the response should contain a string representing the systems URI. For example:

```
/redfish/v1/Systems/<system ID>
```

Then enroll the composed nodes using the Redfish systems URIs:

```
$ openstack baremetal node create --driver redfish --driver-info \
  redfish_address=https://example.com --driver-info \
  redfish_system_id=/redfish/v1/Systems/<system ID> --driver-info \
  redfish_username=admin --driver-info redfish_password=password
```

General enrollment documentation can be found at <https://docs.openstack.org/project-install-guide/baremetal/draft/enrollment.html>.

### OpenStack RSD CLI Examples

Compose node command allows the user to issue node composition command through OpenStackClient(OSC):

```
$ openstack rsd node compose [--name <name>]
                                [--description <description>]
                                [--processor <processor requirements>]
                                [--memory <memory requirements>]
                                [--remote-drives <remote drives requirements>]
                                [--local-drives <local drives requirements>]
                                [--ethernet <ethernet requirements>]
```

Attach specific resource to existing composed node:

```
$ openstack rsd node attach [--resource <resource uri>]
                             [--capacity <size>]
                             <node>
```

Detach specific resource from existing composed node:

```
$ openstack rsd node detach [--resource <resource uri>]
                             <node>
```

Delete composed node allows the user to delete composed node(s) by specifying `<node_uuid>`:

```
$ openstack rsd node delete <node> [<node> ...]
```

Show composed node detail command allows the user to get composed node details by specifying <node\_uuid>:

```
$ openstack rsd node show <node>
```

List composed node command allows the user to list all composed node with brief info:

```
$ openstack rsd node list
```

| Identity | Name | UUID                                 | Description |
|----------|------|--------------------------------------|-------------|
| 2        | Test | fd011520-86a2-11e7-b4d4-5d323196a3e4 | None        |

List storage services command allows the user to list all storage services brief info like below shows:

```
$ openstack rsd storage list
```

| Identity | Name            | Description                 |
|----------|-----------------|-----------------------------|
| 1        | Storage Service | Storage Service for Testing |

Show storage detail command allows the user to display the storage service details:

```
$ openstack rsd storage show <storage service>
```

List fabric command allows the user to list all fabrics with brief info:

```
$ openstack rsd fabric list
```

Show fabric detail command allows the user to display the fabric details:

```
$ openstack rsd fabric show <fabric>
```

To get a list of available sub-commands and options, run:

```
$ openstack help rsd
```

To get usage and options of a command, run:

```
$ openstack help rsd <sub-command>
```

### Limitations and Future Developments

The current version of Intel® RSD (version 2.2) provides a core set of network management functions, but they are not yet robust. There are plans to provide full FPGA pooling and a Yang-based set of APIs within the Redfish RESTful framework in the future. For now, network settings will be controlled by Neutron\* as usual, using the plugins available in the user's OpenStack environment.

Full storage management capabilities, such as partial SSD drive allocation to a volume, are included in the Redfish extension called Swordfish\* from the SNIA\*. These will be incorporated into Intel® RSD version 2.3 in 2018. This update will also include the ability to pool and compose FPGA resources.

Intel® RSD compatible products are available now from major vendors including Dell EMC\*, Ericsson\*, HPE\*, Huawei\*, Inspur\*, Quanta\*, Radisys\*, Supermicro\*, Wiwynn\* and others. Learn more about how Intel® RSD can accelerate your transition to an open, modular, software-defined Data Center at: <https://www.intel.com/intelrdsd>. Or contact your local Intel representative to discuss how Intel® can help you to meet the demands of the Digital Transformation.



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