

Dell Cloud Solution for
OpenStack™ Solutions
Crowbar Deployment Guide

Version 1.2

Updated Dec 17th 2011

Notes, Cautions, and Warnings



NOTE: A NOTE indicates important information that helps you make better use of your system.



CAUTION: A CAUTION indicates potential damage to hardware or loss of data if instructions are not followed.



WARNING: A WARNING indicates a potential for property damage, personal injury, or death.

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1 Introduction

This guide is specific to the Dell OpenStack™ Powered Cloud Solution. It is included in the Crowbar installation to provide a reference for general Crowbar deployments. Crowbar use is not restricted to Dell hardware or the OpenStack solution. For additional details, please consult the Crowbar wiki at <http://github.com/dellcloudedge/crowbar/wiki>.

2 Simple environment setup

This section describes the required steps to achieve the default setup.

2.1 Hardware setup

This guide assumes the minimal hardware footprint described below. Please see the Reference Architecture for more details.

Role	Count	Usage	Notes
Bootstrap system	1	Runs the VMPlayer image needed to bootstrap	- Has VMPlayer and the proper VMPlayer image
Admin node	1	Runs Crowbar and infrastructure services	- Console access (KVM)* - 2 NICs
Compute node	3-5	Runs cloud components	- For Swift storage, should have at least 2 disks - Ideally, 2 NICs

*In the current release, console access to the admin node is required. In future versions, all configuration tasks will be performed without the need for console access.

The hardware on the admin node should be configured as follows:

- **Boot sequence:** BIOS is set to boot from local disk. Note that this is the “normal” operating setting, but for its initial setup boot, the admin node will need to boot from network in order to bootstrap the installation from the VMPlayer image.
- **RAID controller:** All disks should be in a RAID 10 configuration.

BMC and networking settings are configured using Crowbar, and manual steps are not required.

2.1.1 Recommended setup

The minimum or starter configuration for the solution is six nodes 1 Admin node, 1 Nova and/or Swift Controller and either two two-sled PowerEdge C6100/C6105 servers or 4 PowerEdge C2100 servers. While this configuration can be easily expanded to 15 chassis without any changes to the networking infrastructure, we recommend using more optimized hardware configurations for larger sites. Configurations beyond the 15 chassis are easily accomplished by adding additional building blocks of servers and networking.

2.2 Solution Bundling and Delivery

In this release of the solution, hardware options are given to meet the customer needs. The option is for a Nova and/or Swift deployment using the Dell™ PowerEdge™ C6100/C6105 server (two-sled configuration) or a combination of 1 the Dell™ PowerEdge™ C6100/C6105 server (two-sled configuration) and 4 Dell™ PowerEdge™ C2100 server to create a Swift deployment.

The PowerEdge C610X is a multi-node shared infrastructure platform delivered in a 2U chassis. There are two or four (in C610X) compute nodes (servers) that install in the chassis. The PowerEdge C610X configuration for this release is the two-node configuration. The PowerEdge C6100 compute node is a dual-socket Intel® Xeon® server while the PowerEdge C6105 is a dual-socket AMD Opteron™ 4000 series processor server. The only difference is the form factor and number of PCIe slots. Each compute node in the PowerEdge C6100 chassis has access to 12 hot-swappable 2.5-inch drives.

The C2100 maximizes space, energy and cost efficiency in a traditional 2U form factor. PowerEdge C2100 features include the performance of two six- or quad-core Intel® Xeon® 5500/5600 series processors with 18 DDR3 memory slots. It is purpose-built server for the Cloud where the software stack provides primary platform availability and resiliency while both large memory footprints AND high disk counts are required, without sacrificing one for another. For applications where the highest performance is required, the C2100 has a backplane configuration that allows you to control all 12 drives via 12 SAS/SATA ports, rather than requiring an expander chip where performance may be limited.

For the Nova or Swift deployment it is recommended that you use the following configuration:

- 1 Dell™ PowerEdge™ C6100/C6105 server (two-sled configuration) for Admin and Controller nodes
- 2 Dell™ PowerEdge™ C6100/C6105 server (two-sled configuration)
- 2 Dell™ PowerConnect™ 6248 switch

For a Swift only deployment it is recommended that you use the following configuration:

- 1 Dell™ PowerEdge™ C6100/C6105 server (two-sled configuration) for Admin and Controller nodes
- 4 Dell™ PowerEdge™ C2100 server for Storage nodes
- 2 Dell™ PowerConnect™ 6224 switch

Table 1: Deployment Platforms

Compute Node	PowerEdge C6100(5) 2-sled	PowerEdge C2100
Platform	PowerEdge C6100 12 2.5-inch Drive, 2-node BP per node	PowerEdge C2100 12 3.5-inch Drives
CPU	Intel Xeon E5620/AMD Opteron™ 4000 series processor	Intel Xeon X5650

RAM	96GB (1333 MHz) per node	48GB (1333 MHz) per node
Additional Network Controller	None	None
RAID Controller	LSI 2008	LSI 2008
DISK	12 x 1TB 2.5-inch SAS 10K per node	12 X 1TB 3.5-inch SATA 7.2K
RAID	(see Deployment Guide)	(see Deployment Guide)
Cluster Switch	PowerConnect 6248	PowerConnect 6248

Table 2 Admin and Controller System

Compute Node	PowerEdge C6100(5) 2-sled
Platform	PowerEdge C6100
	3 2.5-inch Drive, 2-node BP per node
CPU	Intel Xeon E5620/AMD Opteron™ 4000 series processor
RAM	96GB (1333 MHz) per node
Additional Network Controller	None
RAID Controller	LSI 2008
DISK	3 x 1TB 2.5-inch SAS 10K per node
RAID	(see Deployment Guide)
Cluster Switch	PowerConnect 6248

The tables below highlight the 4 configurations using the 6 node configuration and how each node/sled is allocated.

Role	Node Type	Raid Config	Bios Config
Admin	C6100(5)	RAID 10	Storage
Swift-Proxy	C6100(5)	RAID 10	Storage
Swift-Storage	C6100(5)	JBOD	Storage
Swift-Storage	C6100(5)	JBOD	Storage
Swift-Storage	C6100(5)	JBOD	Storage
Swift-Storage	C6100(5)	JBOD	Storage

Table 3 C6100 (5) Object Store

Role	Node Type	Raid Config	Bios Config
Admin	C6100(5)	RAID 10	Storage
Swift-Proxy	C6100(5)	RAID 10	Storage
Swift-Storage	C2100	JBOD	Storage

Swift-Storage	C2100	JBOD	Storage
Swift-Storage	C2100	JBOD	Storage
Swift-Storage	C2100	JBOD	Storage

Table 4 C2100 Object Store

Role	Node Type	Raid Config	Bios Config
Admin	C6100(5)	RAID 10	Storage
Controller	C6100(5)	RAID 10	Virtualization
Nova-Compute	C6100(5)	JBOD	Virtualization
Nova-Compute	C6100(5)	JBOD	Virtualization
Nova-Compute	C6100(5)	JBOD	Virtualization
Nova-Compute	C6100(5)	JBOD	Virtualization

Table 5 C6100 (5) Compute

Role	Node Type	Raid Config	Bios Config
Admin	C6100(5)	RAID 10	Storage
Controller	C6100(5)	RAID 10	Virtualization
Nova-Compute	C6100(5)	RAID 10	Virtualization
Nova-Compute	C6100(5)	RAID 10	Virtualization
Swift-Storage	C6100(5)	JBOD	Storage
Swift-Storage	C6100(5)	JBOD	Storage

Table 6 C6100 (5) Hybrid - Compute/Object Store

2.3 Expanding the Solution beyond the 6 node solution

Expanding the 6 node configuration to a full rack is the logical growth path. Then by scaling in rack increments one can scale the up to 60 C6100 or 44 C2100 nodes. This scale system can be accommodated without major changes in the networking infrastructure.

The first add-on to the six-node Nova/Swift configuration increases the compute nodes and can add dedicated storage to the cluster. This is done by adding 12 two-sled PowerEdge C6100 servers. Other options are to add PowerEdge C6100 four-node compute nodes. The table below provides some preliminary hardware recommendations.

For the PowerEdge C2100, the growth steps are from the 6 node cluster to a 16 node cluster. This is accomplished by adding 10 more C2100's per the below table.

To size your solution, please discuss your specific needs with your sales representative. These configurations are adjusted to meet individual needs

Table 7: Additional and Optional Hardware Recommendations

Compute Node	(optional)PowerEdge C6100 (4-node)	PowerEdge C2100
--------------	------------------------------------	-----------------

Platform	PowerEdge C6100	PowerEdge C2100
	6 2.5-inch Drive, 4-node BP per node	12 3.5-inch Drives
CPU	Intel Xeon E5620	Intel Xeon X5650
RAM	96GB (1333 MHz) per node	48GB (1333 MHz) per node
Additional Network Controller	None	None
RAID Controller	LSI 2008	LSI 2008
DISK	6 x 600GB 2.5-inch SAS 10K per node	12 X 1TB 3.5-inch SATA 7.2K
RAID	(see Deployment Guide)	(see Deployment Guide)
Cluster Switch	PowerConnect 6248	PowerConnect 6248

2.4 Site Preparation Needed for the Deployment

Solution deployment needs some preliminary preparation. The solution does not supply any firewalls or load-balancers. You may want to use firewalls or load-balancing to access and use portions of the solution. Indirectly, a bastion host, installed behind appropriate site-specific security systems, can be used to access the solution and the VMs remotely. This means that direct access to local/internal/external networks should not be done.

For the setup of the admin node, connect a keyboard, video, and monitor. In addition, all that is required is a laptop or another machine that can run a VM-Player and connect to the admin node via a crossover network cable.

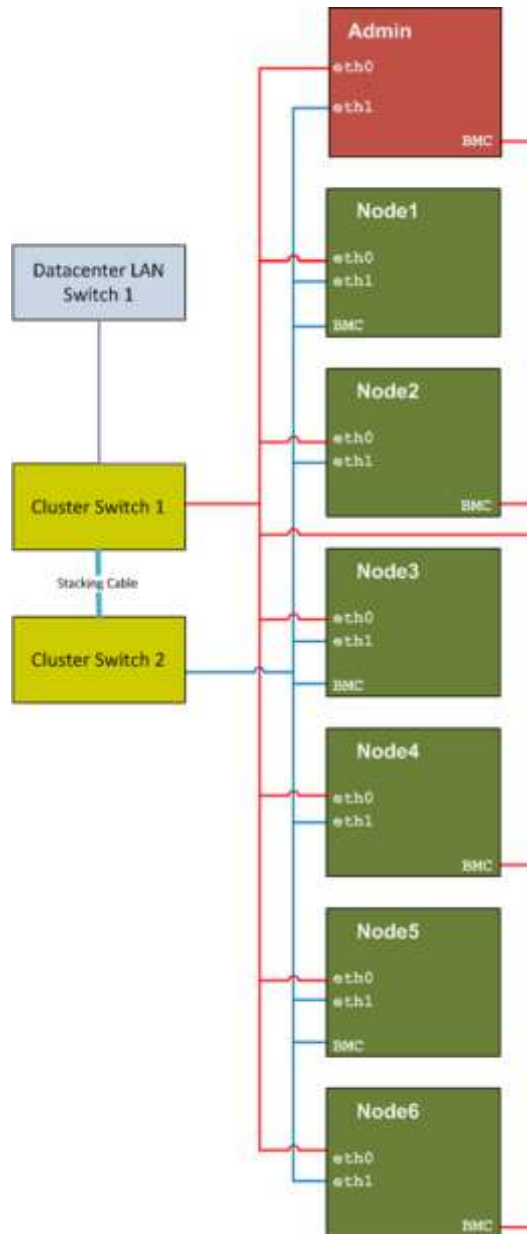
Estimate the electrical power and cooling usage using the Dell Energy Smart Solution Advisor: http://www.dell.com/content/topics/topic.aspx/global/products/pedge/topics/en/config_calculator?c=us&cs=555&l=en&s=biz

You can use this tool to plan the appropriate PDU and make sure the cooling is adequate.

3 Network Overview

Due to the nature of the different software used, the network is set up as flat as possible using a dedicated BMC port and bonded LOMs. Crowbar manages all networks, and comes out of the box preconfigured to allow the initial configuration to come up quickly by predefining the storage, admin, public, and BMC networks.

The Crowbar network configuration can be customized to better map to site specific networking needs and conventions. These changes include adding additional vLANs, changing vLAN mappings, and teaming NICs.



3.1 High-level Description

All servers in an OpenStack Cluster are tied together using TCP/IP networks. These networks form a data interconnect across which individual servers pass data back and forth, return query results, and load/unload data. These networks are also used for management.

The admin node manages all the cluster compute and storage nodes. It assigns the other nodes IP addresses; PXE boots them, configures them, and provides them the necessary software for their roles. To provide these services, the admin node runs Crowbar, Chef, DHCP, TFTP, NTP, and other servservices, and this must be the only DHCP server visible to the compute and storage nodes. Details follow:

- **Crowbar Server**—manages all nodes, supplying configuration of hardware and software.
- **Chef Server**—manages many of the software packages and allows the easy changing of nodes.

- **DHCP server**—assigns and manages IPs for the compute and storage nodes.
 - **NTP server** (Network Time Protocol server)—makes sure all nodes are keeping the same clock.
 - **TFTP server**—PXE boots compute and storage nodes with a Linux kernel. The TFTP server services any PXE boot request it receives with its default options.
- DNS server**—manages the name resolution for the nodes and can be configured to provide external name forwarding.

3.2 Network Cabling and Redundancy

Figure 10 shows an example of network connectivity inside the cluster with 1GbE links. As previously stated, the network in the pilot is not configured for redundancy.

3.2.1 Network Connectivity

All nodes have two 1Gb NICs. The admin node configures the BMC and the OS is configured to bond the two LOMs. Each NIC and BMC is cabled to the Dell PowerConnect 6248 switch per the cabling setup found in Table 4: Solution Starter Configuration Node Cabling.

3.3 Logical Network Configuration

The solution has been architected for minimal configuration tasks, but still maintains a logical segregation of traffic. There are many networks (admin/internal, storage, and external networks). Each is segmented into separate VLANs:

Admin/Internal VLAN	Used for administrative functions such as Crowbar node installation, TFTP booting, DHCP assignments, KVM, system logs, backups, and other monitoring. There is only one VLAN set up for this function and it is spanned across the entire network.
BMC VLAN	Used for connecting to the BMC of each node.
Storage VLAN	Used by the Swift storage system for replication of data between machines, monitoring of data integrity, and other storage-specific functions. (802.1q tagged)
External VLANs	Used for connections to devices that are external to the OpenStack cloud infrastructure. These include externally visible services, such as load balancers and web servers. Use one or many of these networks depending on the need to segregate traffic among groups of servers. (802.1q tagged)

Note: Unlike the external and internal VLANs, the administrative VLAN does not use 802.1q VLAN tagging.

3.4 Stacked Top-of-Rack Switches

When deployed, the top-of-rack (ToR) switches are physically stacked together. Stacking the switches offers some significant benefits.

3.4.1 Benefits

Improved Manageability	All switches in the stack are managed as a single switch.
Efficient Spanning Tree	The stack is viewed as a single switch by the Spanning Tree Protocol.
Link Aggregation	Stacking multiple switches in a chassis allows a link aggregation group (LAG) across ports on different switches in the stack.
Reduced Network Traffic	Traffic between the individual switches in a stack is passed across

	the stacking cable, reducing the amount of traffic passed upstream to network distribution switches.
Higher Speed	The stacking module supports a higher data rate than the 10GbE uplink module (supports 12Gb per stack port offering 24Gb between switches).
Lower Cost	Uplink ports are shared by all switches in the stack, reducing the number of distribution switch ports necessary to connect modular servers to the network.
Simplified Updates	The basic firmware management commands propagate new firmware versions and boot image settings to all switch stack members.

3.4.2 Drawbacks

- Stacking cables are proprietary and only come in 1m and 3m lengths. This requires that the switches be in close proximity to each other.
- Stacking requires a ring topology for redundancy. This makes the distance limitation on the distance of the stacking cables more of an issue.
- Errors in configuration propagate throughout the stack immediately.

3.5 Physical Configuration

3.5.1 Four Compute/Storage and One Admin

Using the PowerEdge C6100, the physical setup of the solution gives you 28TB (9.6TB usable with a replication factor of 3) of storage and 32 CPU cores. This is done by:

- One 42U rack
- Two Dell PowerConnect 6248 switches
- 1U horizontal cable management
- 1 Admin/Controller Dell PowerEdge C6100/C6105
- 2 Dell PowerEdge C6100/C6105 two-sled nodes
- Two PDUs

Using the PowerEdge C2100, the physical setup of the solution gives you 48TB (16TB usable with a replication factor of 3) of storage and 16 CPU Cores. This is done:

- One 42U Rack
- Two Dell PowerConnect 6224 switches
- 1U Horizontal cable management
- 1 Dell PowerEdge C6100/C6105 two-sled Admin Configuration
- 4 Dell PowerEdge C2100 nodes
- Two PDU's

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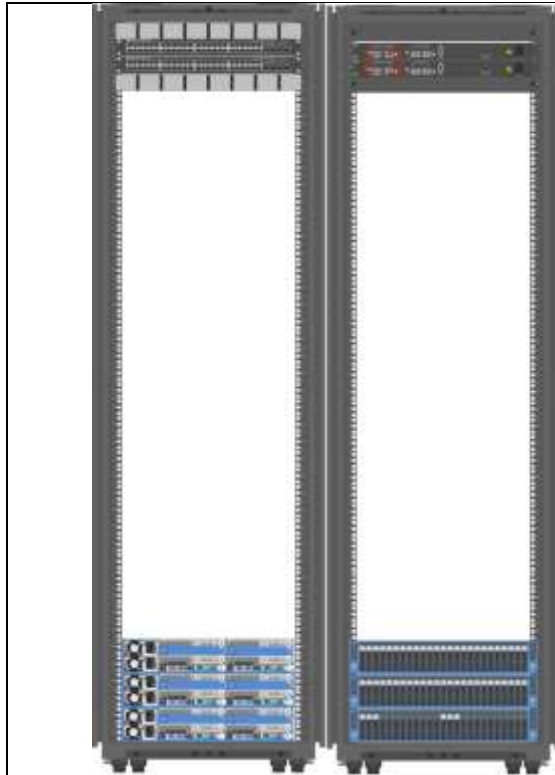


Figure 13 6-Node C6100(5)

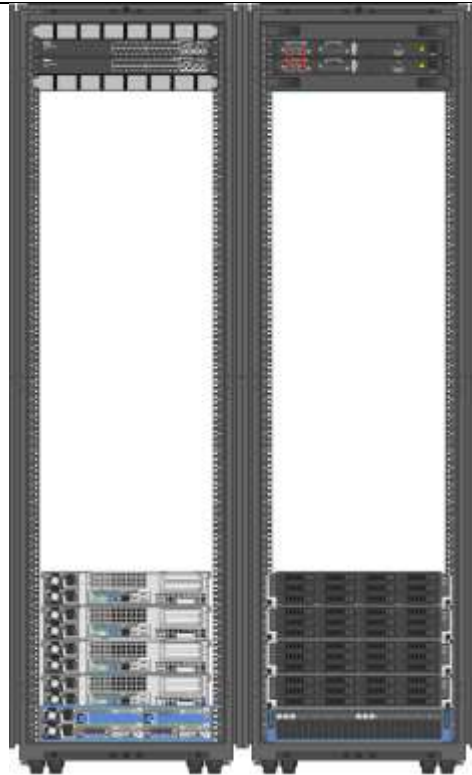


Figure 14 C2100 6 Node

Figures 13 and 14 show a typical 6 node install. The cabling should be done as explained above in figure 10 and per the tables 4 – 8.

3.6 Single Rack Expansion from Starter Configuration

You can build the solutions to a full rack of nodes. For the C6100(5) solution, you can reach a total storage capacity of 336TB (112TB usable with a replication factor of 3) across 336 Spindles and 224 CPU cores. This configuration gives you 28 Nova and/or Swift nodes, one controller node and one Admin Node. You would add to 6 node solution:

- 12 PowerEdge C6100(5) two-sled nodes
- Additional cable management

You can also increase the Swift only solution to a full rack for a per rack capacity of 168TB (56TB usable with a replication factor of 3) across 168 spindles and 56 CPU cores. This configuration will give you 12 Swift Nodes, one Controller and one Admin node.

Additional Equipment to the 6 node solution:

- 10 PowerEdge C2100 nodes

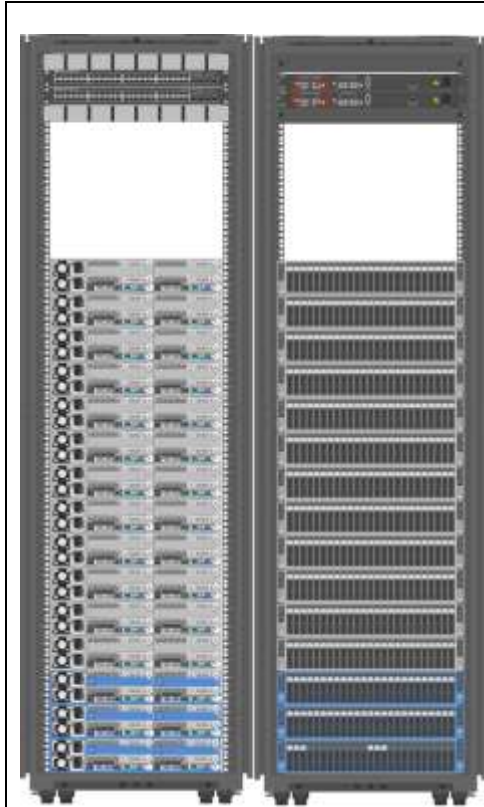


Figure 2 Full Rack C6100(5)

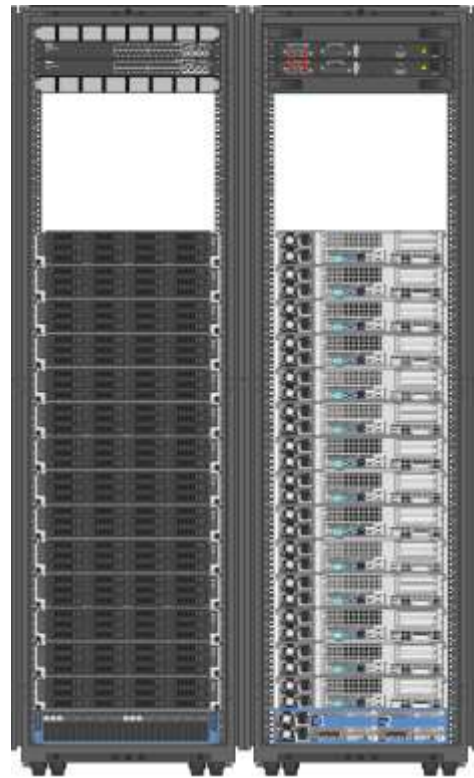


Figure 3 Full Rack C2100

3.6.1 Multi Rack Expansion

Expand the solution further by adding end-of-row (EoR) 10GbE switches and additional racks or equipment. The networking needs to use one the various hyperscale networking deployments using multiple 10GB LAGs between each of the racks. This is not part of this reference architecture.



Figure 4 C6100(5) 60-node deployment

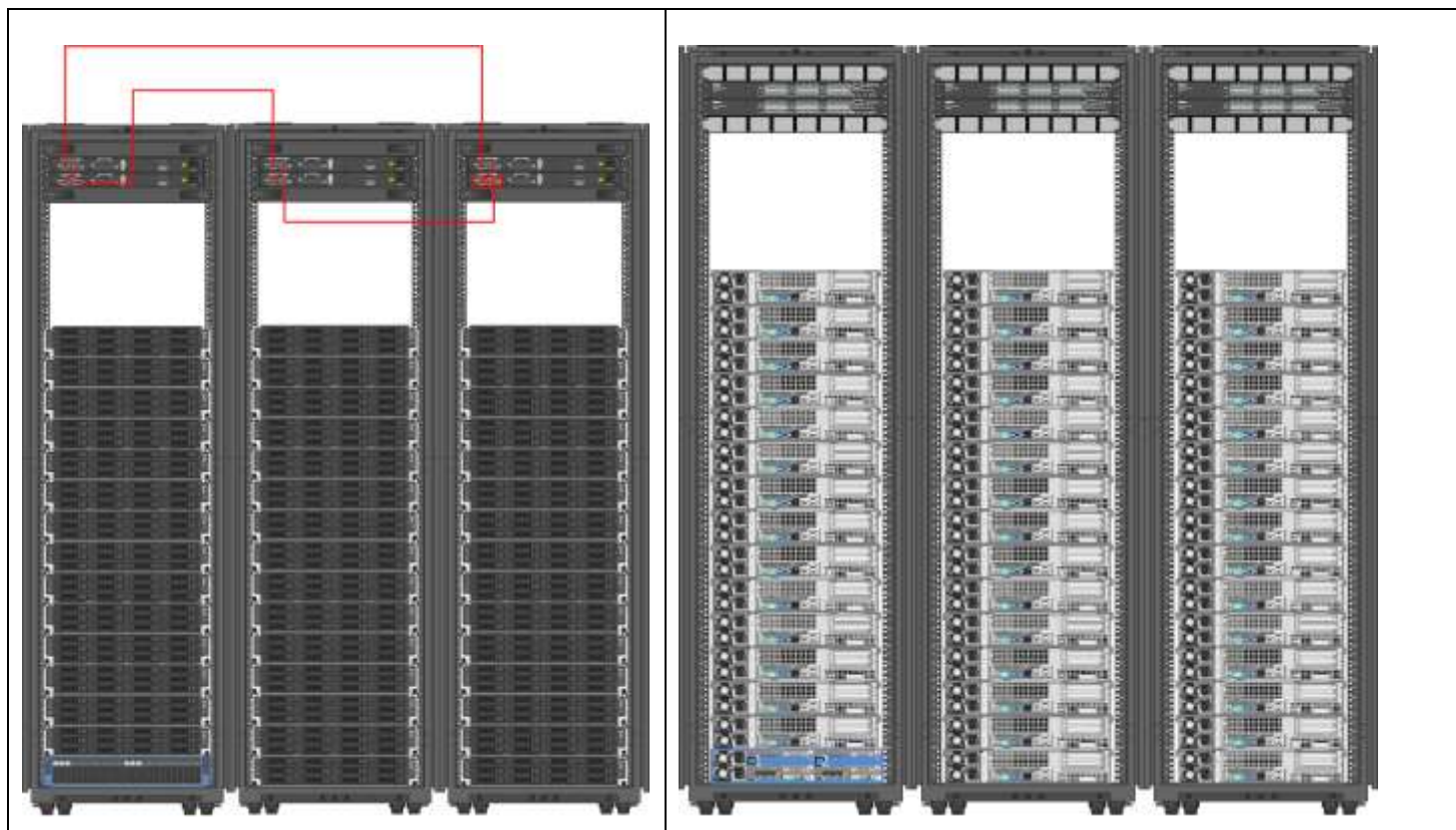


Figure 18 – C2100 Swift Only Storage of 46 Nodes

3.7 Network Port Assignments

Table 8: Nova/Swift Solution Configuration Node Cabling – PowerEdge C6100

(Items in italics are for 10-node.)

Component	LOM0	LOM1	BMC
CH1SL1(Admin)	SW1-1	SW2-1	SW1-31
CH1SL2(Controller)	SW1-2	SW2-2	SW2-31
CH2SL1	SW1-3	SW2-3	SW1-32
CH2SL2	SW1-4	SW2-4	SW2-32
CH3SL1	SW1-5	SW2-5	SW1-33
CH3SL2	SW1-6	SW2-6	SW2-33
<i>CH4SL1</i>	<i>SW1-7</i>	<i>SW2-7</i>	<i>SW1-34</i>
<i>CH4SL2</i>	<i>SW1-8</i>	<i>SW2-8</i>	<i>SW2-34</i>
<i>CH5SL1</i>	<i>SW1-9</i>	<i>SW2-9</i>	<i>SW1-35</i>
<i>CH5SL2</i>	<i>SW1-10</i>	<i>SW2-10</i>	<i>SW2-35</i>

Table 9: Nova/Swift Full Rack Network Cabling – PowerEdge C6100

Component	LOM0	LOM1	BMC
CH1SL1(Admin)	SW1-1	SW2-1	SW1-31
CH1SL2(Controller)	SW1-2	SW2-2	SW1-31
CH2SL1	SW1-3	SW2-3	SW1-32
CH2SL2	SW1-4	SW2-4	SW1-32
CH3SL1	SW1-5	SW2-5	SW1-33
CH3SL2	SW1-6	SW2-6	SW1-33
CH4SL1	SW1-7	SW2-7	SW1-34
CH4SL2	SW1-8	SW2-8	SW1-34
CH5SL1	SW1-9	SW2-9	SW1-35
CH5SL2	SW1-10	SW2-10	SW1-35
CH6SL1	SW1-11	SW2-11	SW1-36
CH6SL2	SW1-12	SW2-12	SW1-36
CH7SL1	SW1-13	SW2-13	SW1-37
CH7SL2	SW1-14	SW2-14	SW1-37
CH8SL1	SW1-15	SW2-15	SW1-38
CH8SL2	SW1-16	SW2-16	SW1-38
CH9SL1	SW1-17	SW2-17	SW1-39
CH9SL2	SW1-18	SW2-18	SW1-39
CH10SL1	SW1-19	SW2-19	SW1-40
CH10SL2	SW1-20	SW2-20	SW1-40
CH11SL1	SW1-21	SW2-21	SW1-41
CH11SL2	SW1-22	SW2-22	SW1-41
CH12SL1	SW1-23	SW2-23	SW1-42
CH12SL2	SW1-24	SW2-24	SW1-42
CH13SL1	SW1-25	SW2-25	SW1-43
CH13SL2	SW1-26	SW2-26	SW1-43
CH14SL1	SW1-27	SW2-27	SW1-44

CH14SL2	SW1-28	SW2-28	SW1-44
CH15SL1	SW1-29	SW2-29	SW1-45
CH15SL2	SW1-30	SW2-30	SW1-45

Table 6: Swift Only Configuration Node Cabling – PowerEdge C2100

(Items in *italics* are for 11-node.)

Component	LOM0	LOM1	BMC
CH1SL1(Admin)	SW1-1	SW2-1	SW1-16
CH1SL2(Controller)	SW1-2	SW2-2	SW2-16
CH2	SW1-3	SW2-3	SW1-17
CH3	SW1-4	SW2-4	SW2-17
CH4	SW1-5	SW2-5	SW1-18
CH5	SW1-6	SW2-6	SW2-18
CH6	SW1-7	SW2-7	SW1-19
CH7	SW1-8	SW2-8	SW1-19
CH8	SW1-9	SW2-9	SW2-20
CH9	SW1-10	SW2-10	SW1-20
CH10	SW1-11	SW2-11	SW2-20

Table 7: Swift Only Full Rack Storage Starter Configuration Node Cabling – PowerEdge C2100

Component	LOM0	LOM1	BMC
CH1SL1(Admin)	SW1-1	SW2-1	SW1-16
CH1SL2(Controller)	SW1-2	SW2-2	SW2-16
CH2	SW1-3	SW2-3	SW1-17
CH3	SW1-4	SW2-4	SW2-17
CH4	SW1-5	SW2-5	SW1-18
CH5	SW1-6	SW2-6	SW2-18
CH6	SW1-7	SW2-7	SW1-19
CH7	SW1-8	SW2-8	SW1-19
CH8	SW1-9	SW2-9	SW2-20
CH9	SW1-10	SW2-10	SW1-20
CH10	SW1-11	SW2-11	SW2-21
CH11	SW1-12	SW2-12	SW1-21
CH12	SW1-13	SW2-13	SW2-22
CH13	SW1-14	SW2-14	SW1-22
CH14	SW1-15	SW2-15	SW2-23
CH15	SW1-16	SW2-16	SW1-23

4 Installing the Admin Node OS

To use Crowbar, you must first install an admin node. Installing the admin node involves installing the base operating system, optionally customizing the Crowbar configuration, and installing Crowbar itself.

The first step is to bootstrap the admin node by PXE booting:

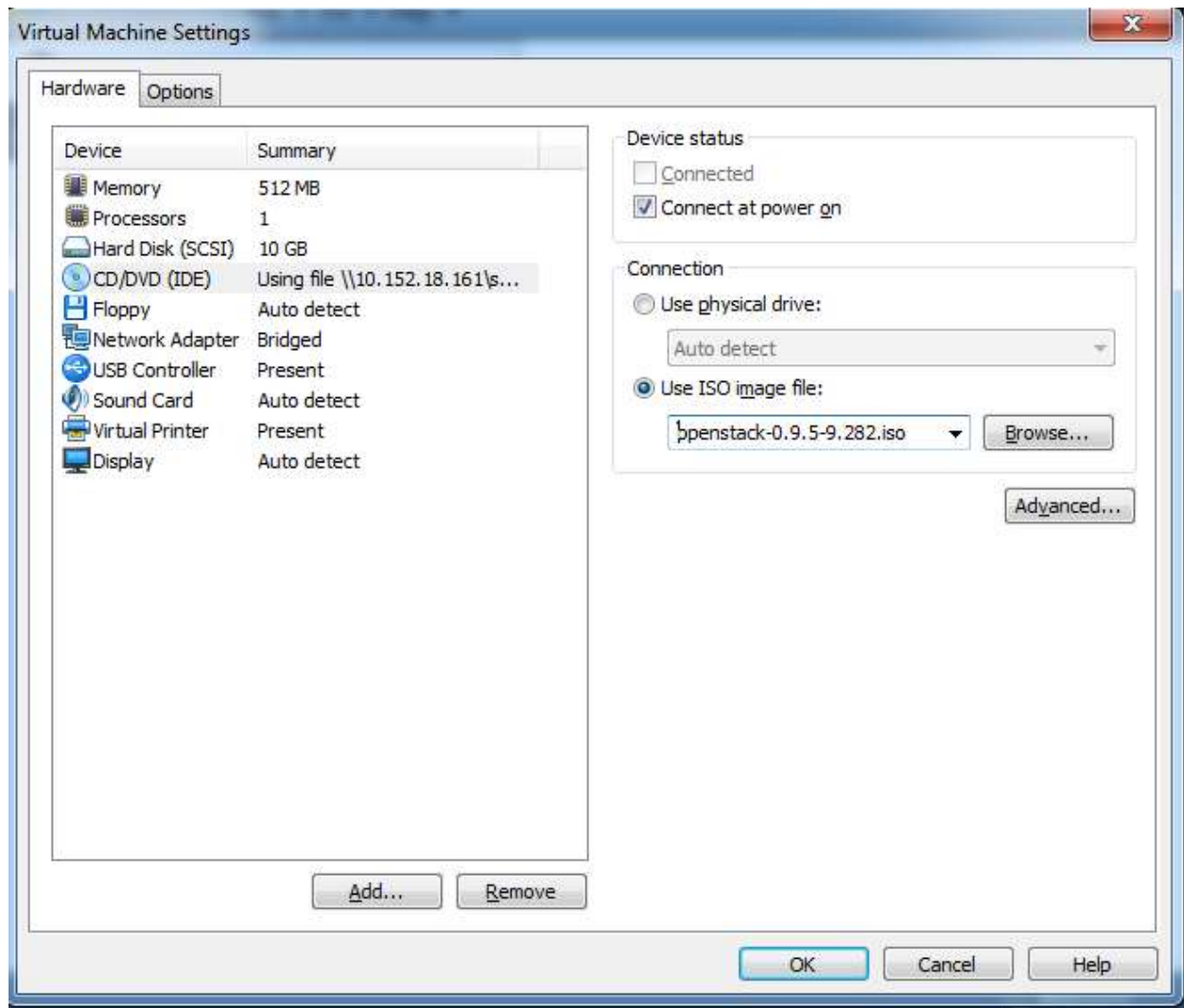
1. The user is expected to make the physical arrangements to connect this VM to the network such that the machine to be used as the admin node can PXE boot from it. A network crossover cable might be required.
2. A VM image with an initial TFTP/DHCP/boot-server is provided. VMware Player is required to execute it. VMware Player may be freely downloaded from VMware's website.

When prepared, install the admin node. (The following steps assume use of a laptop to run VMware Player.)

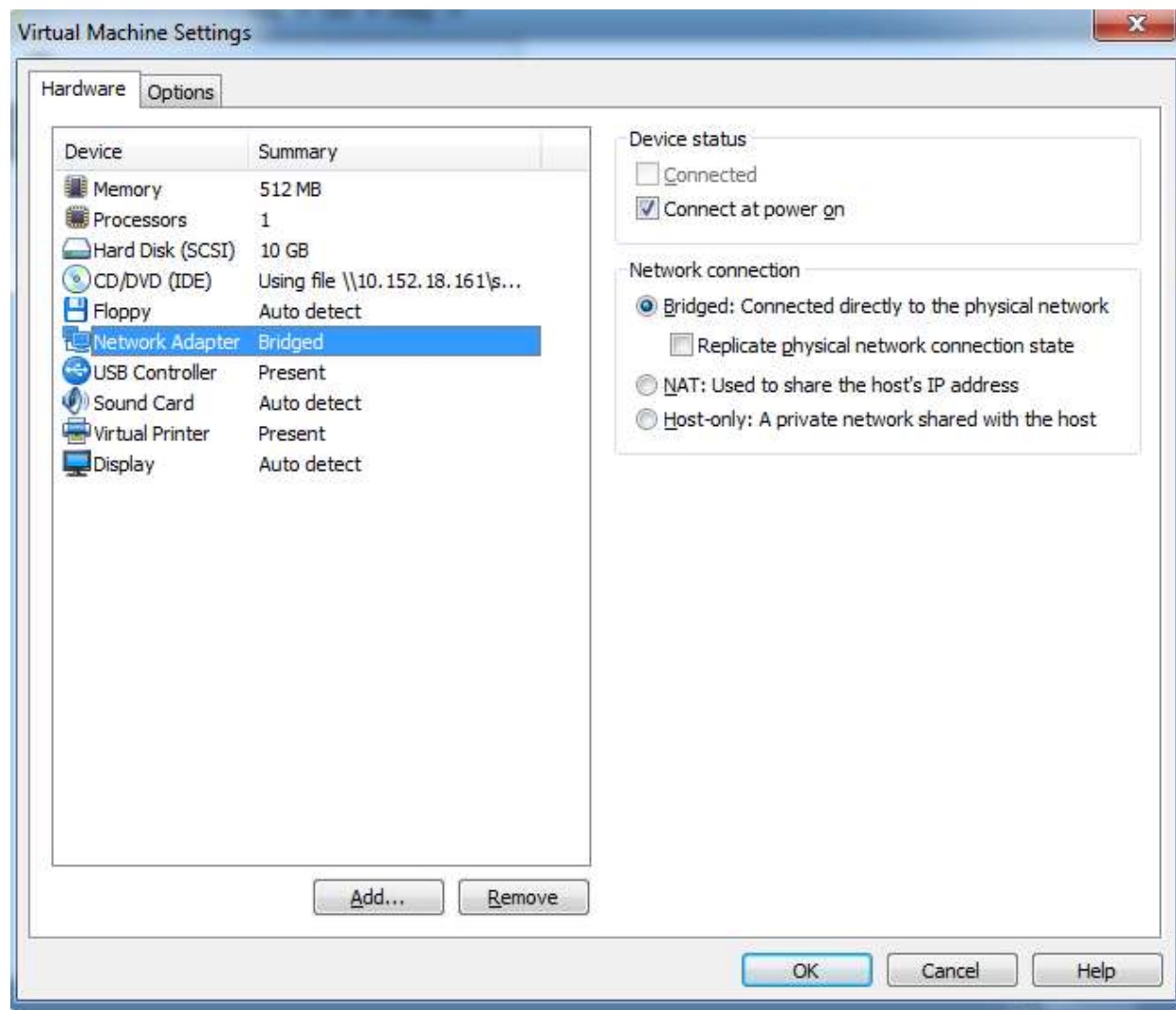
1. Make sure you have VMware Player installed on the laptop.
2. Open the VMware machine configuration distributed with Crowbar (this will be a .vmx file).
3. Edit the machine settings within Player and ensure that the network adapter is configured to use Bridged Networking (see images below).
4. Obtain the ISO distribution of Crowbar and configure Player to mount it as a DVD in the VM.
5. Plug the Crossover Cable into eth0 of the server and connect it to the network port of the laptop.
6. Start the VM – it should present a login prompt in under a minute.
7. Power on the admin node, and ensure that:
 - a. It is set up to boot from the hard disk for subsequent boots
 - b. This first boot (and only this first boot) is a network boot
8. Once the installation is complete power down the installer VM.

The machine should obtain its image from the VM and start the installation process.

VMware Player configuration for DVD:



VMware Player configuration for network adapter:



4.1 Installing Crowbar

The image installed in the previous steps includes all the required Crowbar components. Before actually installing Crowbar, the user may customize the installation to fit their deployment environment (see accompanying documentation). The steps below assume use of the default configuration.

1. Log onto the admin node. The default username is `crowbar`, password: `crowbar`.
2. If necessary edit the file `/opt/dell/chef/data_bags/crowbar/bc-template-network.json` to customize the network information for the deployment.



The networks cannot be reconfigured once the system is installed.

3. `sudo -i`

4. `cd /tftpboot/ubuntu_dvd/extra`
5. `./install systemname.yourdomain.com`

The rest of the installation is automated and will take a little while to complete.

4.2 Editing the Network JSON

The json is located at `/opt/dell/chef/data_bags/crowbar/bc-template-network.json`. The file should be edited before the install command is run to create your admin node.

The information you will need:

1. Vlan ID for each of the VLAN's used by crowbar.
2. Network subnet for each vlan
3. Netmask for each vlan
4. Gateway for the public network and possibly the BMC ranges
5. This is a section from the json

4.2.1 Example network (admin)

```
"admin": {
  "vlan": 100,
  "use_vlan": false,
  "add_bridge": false,
  "subnet": "192.168.124.0",
  "netmask": "255.255.255.0",
  "broadcast": "192.168.124.255",
  "ranges": {
    "admin"
      { "start": "192.168.124.10", "end": "192.168.124.11" },
    "dhcp"
      { "start": "192.168.124.21", "end": "192.168.124.80" },
    "host"
      { "start": "192.168.124.81", "end": "192.168.124.160" },
    "switch"
      { "start": "192.168.124.241", "end": "192.168.124.250" }
  }
}
```

The biggest issue that many users hit is putting a comma at the end of the section. Other networks are specified in the same manner. The default file contains a public network, a nova-fixed network, an admin network, and a storage network. These are used by the various barclamps when addresses are needed.

Network configuration options are:

Name	Default	Description
mode	single	A string value of either single, dual, or team. This specifies the default network interface construction model.
teaming	map	A map of values specific to teaming

networks	map	A map of networks that this barclamp should manage
-----------------	-----	--

The teaming sub-parameters are:

Name	Default	Description
mode	5	The teaming algorithm to use for the bonding driver in Linux used on all Nova Compute Nodes.
mode	6	The default teaming algorithm to use for the bonding driver in Linux used on all nodes except Nova Compute Nodes.

The system provides the following default networks.

Name	Usage	Notes
admin	Private network for node to node communication	A router, if wanted, is external to the system. This network must be owned by the crowbar system to run DHCP on.
bmc	Private network for bmc communication	This can be the same as the admin network by using the ranges to limit what IP goes where. A router, if wanted, is external to the system.
bmc_vlan	Private network for admin nodes on the bmc network	This must be the same as the bmc network and have the same vlan. This will be used to generate a vlan tagged interface on the admin nodes that can access the bmc lan.
storage	Private network for storage traffic	A router, if wanted, is external to the system
public	Public network for crowbar and other components	A router, if wanted, is external to the system.
nova_fixed	Public network for nova Virtual Machines	The nova-network node acts as a router. This must be completely owned by the nova system.
nova_floating	Broken	deprecated - most likely to be replaced by nova config.

Each network has the following parameters:

Name	Default	Description
vlan	Integer	The vlan to use on the switch and interfaces for this network
use_vlan	true	A value of true indicates that the vlan should applied to the interface. A value of false assumes that the node will receive untagged traffic for this network.
add_bridge	false	indicates if the network should have a bridge built on top of it. The bridge will be br. This is mostly for Nova compute.
subnet	IP Address	The subnet for this network
netmask	Netmask	The netmask for this network
router	IP Address	The default router for this network
broadcast	IP	The default broadcast address for this network

	Address	
ranges	map	This contains a map of strings to start and stop values for network. This allows for sub-ranges with the network for specific uses. e.g. dhcp, admin, bmc, hosts.

The range map has a string key that is the name and map defining the range.

Name	Type	Description
start	IP Address	First address in the range, inclusive
end	IP Address	Last address in the range, inclusive

4.2.2 JSON Configuration by Section

1. Attributes
 1. start up delay set to 30 seconds to allow Spanning tree to settle down
 2. Mode - This sets weather to build up single nics or bonded nics options are single, teamed
 3. teaming - sets the mode of the teaming in this case 6
2. Interface Maps - Setup the interface map for figuring out and defining eth0, eth1, eth2 on particular hardware models.
 1. Pattern - Pattern of the hardware model/type
 2. Bus order - order to start enumerating, enumeration begins at eth0, eth1, eth2, eth3, ... if a bus is not defined, then it will be enumerated at the end in order of how presented.
3. Conduit Maps - Determines what network, gets mapped to which interface based on what role
 1. Pattern this matched to the attribute variable, the nic type and role
 1. mode (single, team)
 2. nic typ 1g or 10g
 3. role - mastername, crowbar-config-default
4. Conduit or Network Lists to use
 1. conduit name (prod, mgmt, admin)
 1. if_list - what interfaces to use
 2. team_mode - how to team when needed
 2. repeat for other conduits
5. Networks - Define the network, IP ranges, available scopes, etc...
 1. Name of Network (admin, mgmt, prod...)
 2. Conduit - Name of conduit used in step 4
 3. vLan - vlan to use
 4. add_bridge - whether to use bridging protocol or vlan tagging

5. subnet - the IP subnet
6. netmask - subnet netmask
7. broadcast - broadcast IP
8. ranges - the ip ranges in the subnet broken down by usage
 1. admin, host, dhcp, are all possible examples.

Special Note: The following Networks are required: bmc, bmc_lan, storage and admin. Admin must have ranges set to the dhcp, admin and host.

4.2.3 JSON Example

```
"admin": {
"conduit": "prod",
"vlan": 100,
"use_vlan": false,
"add_bridge": false,
"subnet": "172.16.2.0",
"netmask": "255.255.254.0",
"broadcast": "172.16.3.255",
"ranges": {
"host": { "start": "172.16.2.21", "end": "172.16.2.254" },
"dhcp": { "start": "172.16.3.1", "end": "172.16.3.240" },
"admin": { "start": "172.16.2.18", "end": "172.16.2.20" }
```

Below is trimmed down version of the json

```
{
"id": "bc-template-network",
"description": "Instantiates network interfaces on the crowbar managed systems. Also manages the
address pool",
"attributes": {
"network": {
"start_up_delay": 30,
"mode": "team",
"teaming": {
"mode": 6
},
"interface_map": [
{
"pattern": "PowerEdge R610",
"bus_order": [
```

```
"/0/100/1",
"/0/100/3"
]
{
  "pattern": "product",
  "bus_order": [
    "/0/100/1",
    "/0/100/2"
  ]
}
],
"conduit_map": [
{
  "pattern": "team/.*/crowbar-config-default",
  "conduit_list": {
    "prod": {
      "if_list": [ "1g1", "1g2", "1g3" ],
      "team_mode": 6
    },
    "mgmt": {
      "if_list": [ "1g4" ]
    }
  }
},
{
  "pattern": ".*/.*/.*",
  "conduit_list": {
    "prod": {
      "if_list": [ "1g1" ]
    },
    "admin": {
      "if_list": [ "1g1" ]
    },
    "external": {
      "if_list": [ "1g1" ]
    }
  }
}
],
"networks": {
  "bmc": {
```

```
"conduit": "bmc",
"vlan": 300,
"use_vlan": true,
"add_bridge": true,
"subnet": "172.16.0.0",
"netmask": "255.255.255.0",
"broadcast": "172.16.0.255",
"router": "172.16.0.1",
"ranges": {
  "router": { "start": "172.16.0.1", "end": "172.16.0.10" },
  "host": { "start": "172.16.0.50", "end": "172.16.2.254" }
},
"storage": {
  "conduit": "intf1",
  "vlan": 200,
  "use_vlan": true,
  "add_bridge": false,
  "subnet": "192.168.125.0",
  "netmask": "255.255.255.0",
  "broadcast": "192.168.125.255",
  "ranges": {
    "host": { "start": "192.168.125.10", "end": "192.168.125.239" }
  },
  "bmc_vlan": {
    "conduit": "mgmt",
    "vlan": 300,
    "use_vlan": true,
    "add_bridge": true,
    "subnet": "172.16.0.0",
    "netmask": "255.255.255.0",
    "broadcast": "172.16.0.255",
    "router": "172.16.0.1",
    "ranges": {
      "host": { "start": "172.16.0.21", "end": "172.16.2.50" }
    },
    "admin": {
      "conduit": "prod",
      "vlan": 100,
      "use_vlan": false,
```

```

"add_bridge": false,
"subnet": "172.16.2.0",
"netmask": "255.255.254.0",
"broadcast": "172.16.3.255",
"ranges": {
  "host": { "start": "172.16.2.21", "end": "172.16.2.254" },
  "dhcp": { "start": "172.16.3.1", "end": "172.16.3.240" },
  "admin" : { "start": "172.16.2.18", "end": "172.16.2.20" }
}
}
}
}
},
"deployment": {
  "network": {
    "crowbar-revision": 0,
    "elements": {},
    "element_order": [
      [ "network" ]
    ],
    "config": {
      "environment": "network-base-config",
      "mode": "full",
      "transitions": true,
      "transition_list": [ "discovered" ]
    }
  }
}
}
}
}

```

4.3 How to add a public IP to a node

From a command prompt on the Admin node, you can execute the following:

- `crowbar network allocate_ip default <machine name> public host`

To validate address, you can run:

- `crowbar machines show <machine name>`

You should then have your system setup with a public IP. From the admin section above, you could do "admin switch" instead of "public host", and the IP allocated will be from the switch range of the admin network.

To edit the DNS or NTP time server, please modify the DNS and NTP Barclamps.

4.4 How to add an external interface for access to the admin node

You will need to do two things prior to installing the admin node.

First, you will need to add a new network stanza that defines your external network. We will assume for this example that you have one address that you want to assign to the admin node and you are going to run this as a native (non-tagged) interface.

You make up a **vlan** number since we aren't going to use it, make sure that **use_vlan** and **add_bridge** are false, and the rest of the parameters are correct for your network. The admin range will be used to assign the address to the admin node from this pool. Place the assigned address in the start and end fields. The final field is the **conduit** field. We make up an unused value to use in the conduit map in step 2. This example uses "bastion1".

Something like this for example.

```
"bastion": {
  "conduit": "bastion1",
  "vlan": 50,
  "use_vlan": false,
  "add_bridge": false,
  "subnet": "192.168.235.0",
  "netmask": "255.255.255.0",
  "broadcast": "192.168.235.255",
  "ranges": {
    "admin": { "start": "192.168.235.10", "end": "192.168.235.10" }
  }
}
```

Second, you will need to update the conduit map for you mode. For this example, we will assume that you are in single mode and have a second interface to use.

The normal conduit map for single mode, any role, and any interface (which is what the admin uses by default), looks like this:

```
{
  "pattern": "single/././.*",
  "conduit_list": {
    "intf0": {
      "if_list": [ "lg1" ]
    },
    "intf1": {
      "if_list": [ "lg1" ]
    },
    "intf2": {
      "if_list": [ "lg1" ]
    }
  }
},
```

You will need to add a new entry in this stanza. It looks like this:

```
"bastion1": {
  "if_list": [ "lg2" ]
},
```

Add it before the **intf0** definition. This will ensure commas match and fun JSON stuff.

This tells the node to make a conduit logically called **bastion1** on the second physical interface.

Save the network json file and install the admin node. Once the admin node is installed, exit out & log back in.

You will need to do two commands to make sure the node gets this new IP address.

```
# crowbar network allocate_ip default <admin name> bastion admin
# chef-client
```

Once the chef-client has finished, you should have access to the admin node through the new interface.

4.5 Configuring the network for external connectivity

1. Chose the json that matches your environment best,
 1. /opt/dell/barclamps/network/chef/data_bags/crowbar
 1. bc-network-template.json b. /tftpboot/redhat_dvd/extra/config/network-hadoop-noteam-admin.json ii. network-hadoop-team-admin.json
2. Backup the old file
 1. opt/dell/barclamps/network/chef/data_bags/crowbar/bc-network-template.json
3. Copy the file you want to use to
 1. opt/dell/barclamps/network/chef/data_bags/crowbar/bc-network-template.json (this will overwrite the existing one.)
4. Using your favorite editor edit that file
 1. Change the section of the public IP ranges to match your network

```
"public": {
"conduit"
"public",
"vlan"
500,
"use_vlan"
```

```

false,

"add_bridge"

false,

"subnet"

"192.168.1.0",

"netmask"

"255.255.255.0",

"broadcast"

"192.168.1.255",

"router"

"192.168.1.1",

"ranges"

{

"host"

{ "start": "192.168.1.10", "end": "192.168.1.25" } } }, b. Change the netmask,broadcast,
router and ranges c. Verify the file and save it.

```

1. Run the Install command
2. If you need to deploy the external network to the admin node continue or go to step 12
3. Before starting any slave nodes
4. Connect to the admin node at 172.16.2.18(unless you change the IP ranges of the Admin net) via ssh
5. Execute from the root command prompt
 1. "crowbar network allocate_ip default "admin node FQDN" public host b. "chef-client" c. /etc/init.d/chef-server-webui restart
6. From the Crowbar gui Modify the DNS and NTP barclamps to use the external server and apply them
7. From a command line you can do an ntpq -p
 1. [root@admin config]# ntpq -p
 2. remote refid st t when poll reach delay offset jitter
 3. =====
 4. *172.26.1.50 132.163.4.103 2 u 40 64 377 0.287 -0.433 0.169
8. When the "*" shows up the ntp server is now synced with your server and your server is now ready for the slaves to come online

4.6 Verifying admin node state

When the admin node finishes installation, it will remain at a shell prompt. At this point, all Crowbar services have started. Consult the table below to access these services.

Service	URL	Credentials
SSH	crowbar@192.168.124.10	crowbar
Crowbar UI	http://192.168.124.10:3000/	crowbar / crowbar
Nagios	http://192.168.124.10/nagios3	nagiosadmin / password
Ganglia	http://192.168.124.10/ganglia	nagiosadmin / password
Chef UI	http://192.168.124.10:4040/	admin / password

Logging into the UI requires acceptance of the EULA. It can be found on the Dashboard under EULA, in Appendix B of this document or at this web page:

<http://www.dell.com/content/topics/global.aspx/policy/en/policy?c=us&l=en&s=gen&~section=015#dsla>

4.7 Installing nodes

Nodes are installed automatically when they are first powered up. The machine will be PXE booted by the admin node. It will then proceed to go through several installation phases (involving several automatic reboots) culminating in the deployment of a minimal OS image installed on its local drive. Part of the basic installation includes “hooking” the nodes into the infrastructure services: NTP, DNS, Nagios, and Ganglia.

After the installation process, the node should be listed in the Crowbar UI. From the UI, a node can be powered on and off, rebooted, and reconfigured (see accompanying documentation for details).

Functional components are installed on nodes by including them in one or more proposals. For example, when a node is listed as a storage node in a proposal for Swift, the relevant packages, services and settings are deployed to that node upon committing the proposal within Crowbar.

5 Installing components

The general workflow to install any component (e.g. Nova, Swift) is the same:

- Obtain a default proposal which includes the parameters for the component and a mapping of nodes to the roles they are assigned
- If desired, edit the proposal for a custom configuration
- Save the proposal to Crowbar
- Commit the proposal

This may be done through the use of the Crowbar command line tool RESTful API or the web based UI. The sections that follow use the command line tool: `/opt/dell/bin/crowbar` (for details on using the UI, see the Crowbar Users Guide).



When using the crowbar tool on the admin node, the user may first have to set the following environment variable:

```
export CROWBAR_KEY=`cat /etc/crowbar.install.key`
```

If on a non-admin node, one may also use:

```
export CROWBAR_KEY=crowbar:crowbar (the default username/password)
```

5.1 Example: Implementing a Proposal via Cmd. Line



You must be root in order to run the crowbar command

5.1.1 Obtain a proposal

Crowbar will inspect the current known nodes and provide a proposal that it believes will best utilize available systems for the component being installed. To obtain and inspect this proposed configuration:

```
/opt/dell/bin/crowbar <component> proposal create <name>
```

```
/opt/dell/bin/crowbar <component> proposal show <name> > <local_file_name>
```

Where:

- `<component>` - is the component for which the proposal is made; e.g. swift, nova, glance
- `<name>` - is the name assigned to this proposal. This name should be unique for the component; i.e. if 2 swift clusters are being installed, the proposals for each should have unique names. They need not be unique between components of different types
- `<local_file_name>` - is a file into which the proposal will be written

5.1.2 Update a proposal

The local file created above can be inspected and modified. Common changes include:

- Changing default passwords and other Barclamp parameters (e.g. Swift replica count)
- Changing the assignment of machines to roles

Once edits are completed, crowbar must be updated. To update Crowbar with a modified proposal:

```
/opt/dell/bin/crowbar <component> proposal --file=<local_file_name> edit <name>
```

where the parameters in this command are the same as mentioned above. Crowbar will validate the proposal for syntax and make some basic sanity checks as part of this process.

5.1.3 Committing proposal

Once the proposal content is satisfactory, the Barclamp instance can be activated:

```
/opt/dell/bin/crowbar <component> proposal commit <name>
```

This might take a few moments, as Crowbar is deploying the required software to the machines mentioned in the proposal.

5.1.4 Modifying an active configuration

When committing a proposal which was previously committed, Crowbar compares the new configuration to the currently active state and applies the deltas.

To force crowbar to reapply a proposal, the active state needs to be deleted via:

```
/opt/dell/bin/crowbar <component> delete <name>
```

Then commit the proposal again as described above.

6 Appendix A: Default Switch Configuration

When deploying the switches the following configuration should be used to appropriately setup the VLANs. The following commands are to be used with a Dell PowerConnect 6248 switch. Modifications will be required depending on the network configuration of the environment. Items in red are optional.

```
#
#
vlan database
vlan 2,100,200,300,400,500
interface vlan 2
name mgmt
exit
switch 1 priority 10
switch 2 priority 9
interface vlan 100
name Admin_Net
ip address 192.168.124.1 255.255.255.0
routing
exit
interface vlan 200
name Storage_Net
exit
interface vlan 300
name External_Net
exit
interface vlan 400
name Nova_Floating
exit
interface vlan 500
name Nova_Fixed
exit
#
```

```
#  
  
interface range ethernet 1/g1-1/g48,2/g1-2/g48  
  
shutdown  
  
spanning-tree portfast  
  
switchport mode general  
  
switchport general pvid 100  
  
switchport general allowed vlan add 100  
  
switchport general allowed vlan add 200,300,400,500 tagged  
  
switchport general allowed vlan remove 1  
  
no switchport general acceptable-frame-type tagged-only  
  
lldp transmit-tlv port-desc sys-name sys-desc sys-cap  
  
lldp transmit-mgmt  
  
lldp notification  
  
no shutdown  
  
exit  
  
#  
  
#  
  
ip address 192.168.254.250 255.255.255.0  
  
ip address vlan 2  
  
ip ssh server  
  
#  
  
#  
  
UPLINK Port  
  
interface ethernet 1/gxxx  
  
shutdown  
  
switchport general pvid 300  
  
no switchport general acceptable-frame-type tagged-only  
  
switchport general allowed vlan add 300  
  
switchport general allowed vlan remove 1,2  
  
lldp transmit-tlv port-desc sys-name sys-desc sys-cap  
  
lldp transmit-mgmt
```

```
lldp notification

no shutdown

exit

switchport general allowed vlan add xxxx

switchport general allowed vlan add 300 tagged

switchport general allowed vlan remove 1

lldp transmit-tlv port-desc sys-name sys-desc sys-cap

lldp transmit-mgmt

lldp notification

exit
```

7 Appendix B: End User License Agreement

This end user license agreement (EULA) is provided as a reference for Dell solution customers. It is not applicable for users of the Crowbar Apache 2 Licensed open source components.

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Rev. 110109

DELL EQUALLOGIC PS SERIES ARRAY END USER LICENSE AGREEMENT

This License Agreement ("Agreement") is made as of the date of shipment of the Products to the Customer (the "Effective Date") by and between Dell, Inc, its subsidiaries and affiliates, with offices at 300 Innovative Way, Suite 301, Nashua, NH 03062 ("collectively "the Company"), and the Customer. In consideration of the mutual obligations set forth below the parties, intending to be legally bound, agree as follows:

1. Definitions

"Customer" means the end user of the Products.

"Hardware" means the Dell EqualLogic PS Series branded array hardware along with any end user manuals supplied by the Company.

"Maintenance Releases" means any update, upgrade, revision, patch, bug fix or an improved, upgraded or enhanced version of the Products released by the Company to which Customer is rightfully entitled by way of a valid maintenance agreement, warranty, or other Company offering. Third Party Products are excluded and subject to their own terms and conditions.

"Object Code" means computer programs assembled, compiled, or converted to magnetic or electronic binary form on software or hardware media, which are readable and usable by computer equipment, but not generally readable by humans without reverse assembly, reverse compiling, reverse conversion, reverse engineering and/or any other disassembly or decompilation.

"Product(s)" means, collectively, the Hardware and Software which may be supplied to Customer.

"Software" means all components of the Company's storage management software and related documentation made generally available by the Company from time to time not accompanied by its own license agreement. The term

"Software" shall include any and all software, scripts, firmware, and microcode running on Hardware or any computer system, including all Maintenance Releases supplied in accordance with this Agreement. The Software shall be provided in Object Code form only. No source code will be provided.

"Third Party Products" means any hardware or software licensed or distributed by the Company to Customer that is not owned by the Company.

2. Grant of License

The Company hereby grants to Customer a nonexclusive, nontransferable license to install and use the Software solely for Customer's ordinary internal business purposes and solely for Software's intended use in conjunction with Product. The Software is in use if it is loaded on the Product or any computer's permanent or temporary memory. Customer may make one copy of the Software for archive and security backup purposes only. You must include on any backup copy all copyright and other notices included on the Software as supplied by the Company. Installation on a network server for the sole purpose of your internal distribution of the Software is permitted so long as all arrays are properly licensed Products to which the Software is distributed. All rights not expressly granted to Customer in this Agreement are reserved by the Company. There are no implied rights. Unless otherwise indicated on the sales quotation, this License is perpetual (subject to termination pursuant to Section 6 below).

3. Payments

If Customer has purchased the Product through a value added reseller ("VAR") of the Company, the payment obligations of the customer are agreed upon between the VAR and the customer. If the Customer is buying the product directly from the Company, the Customer's payment obligations are set forth on the sales quotation. Customer agrees to pay all fees due pursuant to this Agreement in U.S. dollars, and unless the sales quotation expressly provides otherwise all fees are due net thirty (30) days from the date of invoice. Any amount not paid when due shall bear a late payment charge, until paid, in an amount equal to 1.5% per month or, if lower, the maximum rate allowed by law. In addition, Customer shall reimburse the Company for all reasonable costs (including court costs and attorneys' fees and expenses) incurred in collecting amounts owed under this Agreement. Customer shall be responsible for all sales, use, property, excise, and other similar taxes resulting from the transactions contemplated by this Agreement, excluding taxes on the net income of the Company.

4. Term of Agreement; Termination.

This Agreement shall commence upon the Effective Date and, unless terminated in accordance with this Section 4, or terminated by transfer with written approval by the Company according to Section 15, shall be perpetual. Either party may terminate this Agreement in the event of a material breach of this Agreement by the other party that is not cured within thirty (30) days of written notice thereof from the other party; provided, however, that this Agreement shall immediately terminate upon breach by Customer of Section 6.

5. Effect of Termination.

Upon termination of this Agreement, all licenses granted hereunder shall automatically terminate except as expressly stated in this Agreement. Each party shall promptly pay to the other any amounts due and owing hereunder. No termination of this Agreement shall release Customer from any obligation to pay the Company any amount that has accrued or will accrue or become payable prior to, at, or after the date of termination of this Agreement. Each party shall immediately cease using and return all property in its possession belonging to the other party, including without limitation all Products and tangible embodiments of Confidential Information (as defined below). Customer shall not be entitled to a refund, in whole or in part, of any amounts paid hereunder, other than in accordance with Section 8(a). Sections 3, 5-10 and 12- 15 hereof will survive termination of this Agreement.

6. Representations, and Covenants of Customer.

(a) Except as expressly permitted in this Agreement, Customer shall not, and shall not permit others to, (i) use, modify, copy (except for one copy of the Software for archive and security back-up purposes), or otherwise reproduce the Product in whole or in part, (ii) reverse engineer, decompile, disassemble, or otherwise attempt to derive the source code form, algorithms, processes, state machines or structure of the Software or the proprietary network protocols implemented by the Software, higher algorithms or state machines, (iii) transmit the Software over a

network by telephone or electronically using any means (iv) distribute, sublicense, assign, share, timeshare, sell, grant a security interest in, use for service bureau purposes, or otherwise transfer the Software or Customer's right to use the Products without the prior written consent of the Company and then only upon a permanent transfer of the Products purchased and provided all Software is included in such transfer and Customer does not retain a copy of the Software, (v) remove any proprietary notices or labels on the Products. Without limiting the foregoing, copying or reproduction of the software to any other server or location for further reproduction or redistribution is expressly prohibited.

(b) Customer hereby covenants and agrees to (i) limit access to the Products to its employees and consultants who require access in connection with Customer's use of the Products and who are bound by a duty of confidentiality no less protective than this Agreement, (ii) take all reasonable precautions to prevent unauthorized or improper use or disclosure of the Products, (iii) ensure that its use of the Products is in compliance with all foreign, federal, state, and local laws and regulations, including without limitation all laws and regulations relating to export and import control, privacy rights, and data protection and (iv) for any utilization of the Products for or on behalf of the United States of America, its agencies and/or instrumentalities ("U.S. Government"), ensure use, duplication, or disclosure of the Software by the U.S. government is subject to the restrictions set forth in FAR 12.212 for civilian agencies and DFAR 227.7202 for military agencies. If the licensee hereunder is the U.S. Government, the Software is licensed hereunder (i) only as a commercial item and (ii) only with those rights as are granted to all other end users pursuant to the terms and conditions of this Agreement.

Customer agrees to indemnify the Company for all claims or alleged claims for a breach of any of the foregoing covenants. Customer will obtain any export and/or re-export authorization required under the Export Administration Regulations of the United States Department of Commerce and other relevant regulations controlling the export of Product or related technical data.

7. Proprietary Rights and Confidentiality.

(a) Customer acknowledges and agrees that (i) as between the Company and Customer, all rights, title and interest in and to the Product and all derivatives thereof (including any and all patents, copyrights, trade secret rights, trademarks, trade names and other proprietary rights embodied therein or associated therewith) are and shall remain with the Company, their suppliers or licensors', and this Agreement in no way conveys any right or interest in the Product other than a limited license to use them in accordance herewith, and (ii) the Products are works protected by copyright, trade secret, and other proprietary rights and laws.

(b) Each party acknowledges that by reason of its relationship to the other party under this Agreement it may have access to Confidential Information. Each party agrees to maintain in confidence and use only as expressly permitted in this Agreement all Confidential Information received from the other, both orally and in writing. For the purposes of this Agreement, the term "Confidential Information" means the Products, the terms of this Agreement, and any other non-public information or materials; provided, that Confidential Information shall not include information the receiving party can demonstrate (i) is or becomes a matter of public knowledge through no fault of the receiving party, (ii) was rightfully in the receiving party's possession prior to disclosure by the disclosing party, as evidenced by written records of the receiving party, (iii) subsequent to disclosure, is rightfully obtained by the receiving party from a third party in lawful possession of such Confidential Information, as evidenced by written records of the receiving party, (iv) is independently developed by the receiving party without reference to Confidential Information, or (v) is required to be disclosed by law.

(c) The above limitations include but are not limited to the disclosure of information relating to the performance, functionality, reliability or any benchmarking tests or results of the Products. Under no circumstances are the above listed items to be placed into the public domain by the Customer without the prior written consent of the Company.

8. Indemnification Obligations.

(a) the Company shall defend and indemnify Customer against any action or proceeding brought against Customer which alleges that the Products infringe any United States patent, copyright, or trademark, and the Company shall pay damages finally awarded or agreed in settlement against Customer (including, without limitation, court costs and reasonable attorneys' fees and expenses); provided, that (i) Customer notifies the Company promptly in writing of the claim in question, (ii) the Company has sole control of the defense and all related settlement negotiations, and (iii) Customer provides the Company with all commercially reasonable assistance, information and authority to perform the above at the Company's expense. In the event that Customer's use of the Products are enjoined by a court of competent authority, the Company shall, at its sole option and at its expense, (I) procure for Customer the right to continue to use the Products in question, (II) modify the Products to avoid infringement without material impairment of

its functionality or (III) replace the Products with functionally equivalent non-infringing products. If none of the foregoing remedies can be obtained upon commercially reasonable terms, Customer shall remove and return to the Company the Products in question and the Company shall refund to Customer the unamortized portion, if any, of the fees paid by Customer to the Company for the Products in question (based on a three (3) year amortization of such fees commencing on the Effective Date). The foregoing indemnity shall not apply if the alleged infringement is attributable to the combination of the Products with products not provided by the Company, or if the Product is modified or altered by any person or entity other than the Company (or an authorized agent of the Company), or if the Products are used outside the scope of this Agreement (each a "Customer Modification"). THIS SECTION STATES THE COMPANY'S SOLE LIABILITY HEREUNDER WITH RESPECT TO INFRINGEMENT OF ANY INTELLECTUAL PROPERTY AND PROPRIETARY RIGHTS.

(b) Customer, at its expense, shall defend and indemnify the Company and any of its subsidiaries or affiliates against any action or proceeding brought against the Company or any of its subsidiaries or affiliates and Customer shall pay damages finally awarded or agreed in settlement which arises from or in any manner is connected with a Customer Modification or any of Customer's actions or omissions in using the Products (excluding claims for which the Company is obligated to defend Customer under Section 8(a) hereof); provided, that (i) the Company notifies Customer promptly in writing of the claim in question, (ii) Customer has sole control of the defense and all related settlement negotiations, and (iii) the Company provides Customer with all commercially reasonable assistance, information and authority to perform the above at Customer's expense.

9. Limitation of the Company's Liability.

CUSTOMER'S SOLE REMEDY AND THE COMPANY'S SOLE OBLIGATION WITH RESPECT TO ANY CLAIMS, WHETHER IN CONTRACT, TORT OR OTHERWISE, ARISING OUT OF, CONNECTED WITH, OR RESULTING FROM THIS AGREEMENT SHALL BE GOVERNED BY THIS AGREEMENT, AND IN ALL CASES CUSTOMER'S REMEDY SHALL BE EXPRESSLY LIMITED TO MONETARY DAMAGES NOT TO EXCEED THE LESSER OF THE FEES PAID FOR THE SPECIFIC PRODUCT WHICH CAUSED THE DAMAGE OR THE COST OF REPAIR OR REPLACEMENT OF ANY HARDWARE COMPONENTS THAT MALFUNCTION IN CONDITIONS OF NORMAL USE. WITHOUT LIMITING THE FOREGOING, IT IS EXPRESSLY AGREED THAT IN NO EVENT SHALL THE COMPANY OR THEIR SUPPLIERS OR ANYONE ELSE WHO HAS BEEN INVOLVED IN THE PERFORMANCE OF THIS AGREEMENT ON BEHALF OF THE COMPANY, INCLUDING ITS EMPLOYEES, SUBCONTRACTORS OR AGENTS, BE LIABLE FOR ANY DAMAGES CAUSED BY THE PRODUCT OR THE FAILURE OF THE PRODUCT TO PERFORM, INCLUDING ANY LOST PROFITS OR SAVINGS OR SPECIAL, INDIRECT, PUNITIVE, INCIDENTAL OR CONSEQUENTIAL DAMAGES. THE COMPANY IS NOT LIABLE FOR ANY CLAIM MADE BY A THIRD PARTY OR MADE BY YOU FOR A THIRD PARTY. THIS LIMITATION OF LIABILITY CANNOT BE WAIVED OR AMENDED BY ANY PERSON. THIS LIMITATION OF LIABILITY WILL BE EFFECTIVE EVEN IF YOU HAVE ADVISED THE COMPANY OR AN AUTHORIZED REPRESENTATIVE OF THE COMPANY OF THE POSSIBILITY OF ANY SUCH DAMAGES. THIS LIMITATION OF LIABILITY, HOWEVER, WILL NOT APPLY TO CLAIMS FOR PERSONAL INJURY. NOTWITHSTANDING THE FOREGOING, THE COMPANY SPECIFICALLY DISCLAIMS, TO THE EXTENT PERMITTED BY APPLICABLE LAW, LIABILITY FOR ANY PERSONAL INJURY RESULTING FROM FAILURE TO READ AND FOLLOW INSTRUCTIONS AND SAFETY PRECAUTIONS CONTAINED IN THE DOCUMENTATION SUPPLIED WITH THE PRODUCT.

10. Use of Customer's Name.

Customer consents to being listed as a customer of the Company in any standard customer listing (or partial customer listing) published by the Company and in press releases or other publications, provided that such release or publication relates to new customers or to customers generally and does not supply detail regarding Customer or this Agreement beyond the name of the Products licensed without the prior consent of Customer.

11. Third Party Products.

Any third party products are provided solely as a convenience to Customer, and are provided and/or licensed under the terms of said products' manufacturer. The Company assumes no responsibility for said products including but not limited to any warranties or indemnification rights contained in Sections 9 and 10 hereof.

12. Injunctive Relief; Cumulative Remedies.

The parties hereto agree that money damages would be an inadequate remedy for the Company in the event of a breach or threatened breach by Customer of the provisions set forth in Sections 7, 8 or 15 hereof; therefore, in the event of a breach or threatened breach by Customer of any such provisions, the Company may, either with or without pursuing any other remedies afforded to it by law, immediately obtain and enforce an injunction from any court of law or equity prohibiting the Customer from breaching such provisions. All rights and remedies afforded the Company by law shall be cumulative and not exclusive.

13. General.

Customer may not sublicense, assign (by operation of law or otherwise) or transfer this Agreement or any license or any right, duty or obligation under this Agreement without the Company's prior written consent, and any attempt to do so shall be null and void. Any transfer approved by the Company shall immediately terminate this agreement. Subject to the foregoing limitations, this Agreement will mutually benefit and be binding upon the parties, their successors and assigns. Nothing in this Agreement shall be construed to imply a joint venture, partnership or agency relationship between the parties and the Company shall be considered an independent contractor when performing any services in connection with this Agreement.

Any notice required to be provided pursuant to this Agreement shall be in writing and shall be deemed given if sent to the addresses stated on the sales quotation and such notices shall be effective upon receipt. A failure or delay by either party to enforce any right under this Agreement shall not at any time constitute a waiver of such right or any other right, and shall not modify the rights or obligations of either party under this Agreement. To the extent that any provision of this Agreement is found to be void or unenforceable, such provision shall be without effect and the remainder of the Agreement shall be enforced to the full extent of the law.

In no event shall either party be liable for any delay or failure to perform under this Agreement which is due to causes beyond the reasonable control of such part including but not limited to any act of God, act of any government or other authority or statutory undertaking, industrial dispute, fire, explosion, accident, power failure, flood, riot or war (declared or undeclared).

This Agreement shall be governed by and construed under the laws of the State of New Hampshire, without regard to principles of conflicts of laws. Application of the U.N. Convention on Contracts for the International Sale of Goods is expressly excluded. Any action brought pursuant to or in connection with this Agreement shall be brought only in the state or federal courts within the State of New Hampshire without regard to its conflict of law's provisions. In any such action, the parties shall submit to the personal jurisdiction of the courts of the State of New Hampshire and waive any objections to venue in such courts.

Pre-printed terms and conditions set forth on any purchase order submitted by Customer, or on any quotation, purchase order acceptance or invoice submitted by Customer, shall have no force and effect and are expressly superseded by the terms of this Agreement. In the event of a conflict between the terms of this Agreement and the terms of the Warranty and Support Information documentation supplied with the Product, the terms of the Warranty and Support Information shall control. The Company may make Product updates and enhancements available to Customer from time to time accompanied by a revision or amendment to this Agreement. Installation or use by Customer of the Products or any such updates or enhancements shall constitute acceptance by Customer of this Agreement and/or any such revised agreement. Except as expressly provided herein, no amendment or modification of this Agreement shall be effective unless made in writing and signed by the Company and Customer.

This Agreement is the entire agreement of the parties, and supersedes all prior agreements and communications, whether oral or in writing, between the parties with respect to the subject matter of this Agreement.

(Rev. 030109)

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Standard Appliance JumpStart	2 sessions
Standard Bundle JumpStart	4 sessions
Enterprise Appliance JumpStart	6 sessions
Enterprise Bundle JumpStart	12 sessions

These sessions must be completed within 60 days of the initial KACE Appliance shipment. Sessions not completed within that time period can be purchased separately at the then current price levels. All services delivered by or on behalf of Dell, including technical support services for Software and training including the KACE JumpStart Programs

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CONFIDENTIALITY

You agree to: (a) refrain from using Confidential Information (defined below) except as necessary to exercise the rights herein and (b) to use best efforts to preserve and protect the confidentiality of the Confidential Information. "Confidential Information" means any oral, written, graphic or machine-readable information disclosed by Dell that is (i) identified herein as confidential; (ii) designated in writing to be confidential or proprietary; or (iii) should be reasonably understood to be confidential. Notwithstanding the foregoing, Confidential Information shall not include information: (i) already publicly known through no fault of you; (ii) otherwise known to you by no wrongful conduct; or (iii) to the extent required to be disclosed by law or court order. You acknowledge that the Software and Dell products embody and contain valuable trade secrets and Confidential Information owned by Dell, including but not limited to source code, the development status of Software and Dell products, the appearance, content and flow of the user interface of the Software and Dell product, and the content and documentation of the Software or Dell product.

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