

# DELL POWEREDGE C6220 AND FREEBSD 9.0: AN AMP REFERENCE ARCHITECTURE



A Principled Technologies Reference Architecture commissioned by Dell Inc.

## WHAT YOU WILL LEARN

- The features and advantages of the Dell PowerEdge C6220
- How to install the FreeBSD operating system on the Dell PowerEdge C6220
- How to install the AMP Web-application stack on FreeBSD
- How to configure the LSI SAS2008 storage controller

## TABLE OF CONTENTS

<b>Executive summary</b> .....	<b>3</b>
The Dell PowerEdge C6220 server .....	3
About FreeBSD .....	5
<b>Installing FreeBSD on the Dell PowerEdge C6220</b> .....	<b>6</b>
Prerequisites .....	6
Deployment options .....	6
Storage configuration .....	6
Installation procedure for the operating system .....	7
<b>Installing the AMP stack on FreeBSD and the Dell PowerEdge C6220</b> .....	<b>16</b>
The AMP stack – An overview .....	16
Installation procedure .....	17
<b>Summing it all up</b> .....	<b>19</b>
<b>Appendix A – References</b> .....	<b>21</b>
<b>Appendix B – Dell PowerEdge C6220 system details</b> .....	<b>22</b>
<b>Appendix C – Preparing FreeBSD 9.0 Stable</b> .....	<b>24</b>
<b>Appendix D – LSI SAS2008 storage configuration</b> .....	<b>25</b>
<b>Appendix E – Configuration files for AMP on FreeBSD 9.0</b> .....	<b>28</b>
<b>About Principled Technologies</b> .....	<b>29</b>

## EXECUTIVE SUMMARY

With the dominance of cloud computing in today's marketplace, companies require a reliable and powerful platform on which to deliver their cloud and application services. The massive data centers designed to provide cloud computing services require a large number of servers that are efficient, powerful, flexible, and easy to maintain. Software must be low cost, feature laden, and easy to integrate. Using a low-cost operating system paired with the Dell PowerEdge C series servers can allow service providers and other companies to deliver high-quality and efficient applications to their customers.

Dell designed the Dell PowerEdge C series, which includes the Dell PowerEdge C6220, specifically to meet the needs of these organizations that need to deploy large-scale environments. In this reference architecture, we look at some of the many benefits that the Dell PowerEdge C6220 server can bring to large deployments and describe in detail the setup of a common configuration: FreeBSD running on the Dell PowerEdge C6220.

Organizations often use open-source operating systems, such as FreeBSD, in these hyper-scale environments due to their price point, flexibility, ease of management, and performance capabilities. These operating systems offer many built-in application stacks, hypervisors, and other features that allow organizations to offer their customers a comprehensive set of services. In this document, we walk you through the task of deploying one such operating system, FreeBSD, and the Apache/MySQL/PHP (AMP) application stack on one node of the PowerEdge C6220, from start to finish.

### The Dell PowerEdge C6220 server

The Dell PowerEdge C6220 server features up to four independent 1U hot-swappable, two-socket server nodes that each harness the power of the Intel® Xeon® processor E5-2600 series to maximize performance for hyper-scale environments. Designed for flexibility, the multiple independent server nodes allow you to mix and match workloads on different servers within the same chassis. If your requirements demand it, configurations are available that feature just two independent 2U nodes, with greater I/O capacity. The high performance levels it delivers, coupled with a simple, modular, and easy-to-maintain design, make the Dell PowerEdge C6220 an optimal choice for large software as a service (SaaS) and cloud deployments. Figure 1 presents a 1U server node of the Dell PowerEdge C6220.

The Dell PowerEdge C6220 is available with multiple storage controller options, such as onboard storage with the Intel C600 chipset, the LSISAS2008 6Gb SAS mezzanine

card, or the LSI MegaRAID SAS 9265-8i RAID controller. For this installation guide, we used the LSI SAS2008 6Gb SAS mezzanine card.



**Figure 1: 1U server node of the Dell PowerEdge C6220 with the LSI SAS2008 mezzanine card.**

The Dell PowerEdge C6220 can deliver many benefits to your large deployment, and lets you:

- Make better use of expensive data center space by increasing the rack density with four two-socket server nodes fitting into a standard 2U rack slot.
- Configure servers to better fit application and workload needs for increased performance without reconfiguring your chassis and rack layout. You can easily use 1U nodes in a four-node configuration or 2U nodes in a two-node configuration. Additionally, an optional expandable backplane allows for adjustable disk and assignment and storage configurations.

- Reuse or repurpose servers easily when workloads change with hot-swappable server nodes – you no longer need to experience downtime by replacing the entire server chassis.

Designed with power-efficiency in mind to help reduce energy costs, the Dell PowerEdge C6220 utilizes dynamic HDD allocation for better resource utilization, and maximizes operating efficiency with a shared-infrastructure design. The Dell PowerEdge C6220 also offers different drive options, so you can allocate storage to the workloads that need it. To learn more about the Dell PowerEdge C6220 and the entire Dell PowerEdge C Series, visit <http://www.dell.com/us/enterprise/p/poweredge-cloud-servers>.

## Storage and expansion specifications

The Dell PowerEdge C6220 features the following specifications:

- Hard disk
  - SATA, SAS, and SSD options
  - Maximum raw storage capacity of 24 TB across four nodes when using SATA drives
  - 2.5" or 3.5" drive form factor
- Available storage controllers
  - Intel C600 chipset for onboard storage options with SATA and SSD
  - LSI SAS2008 6Gb SAS mezzanine card, which we used for this guide
  - LSI MegaRAID SAS 9265-8i add-in RAID controller
- Expansion slots
  - The PowerEdge C6220 four-node configuration has one x8 expansion slot and one x16 expansion slot per node.
  - The PowerEdge C6220 two-node configuration has one x8 expansion slot and two x16 expansion slots per node.

## About FreeBSD

FreeBSD is a free-to-use Unix-based operating system that focuses on performance, network, and storage to fully support your large-scale data center. FreeBSD provides advanced OS features such as the ZFS file system, 10Gbps network optimization, IPv6 support, advanced memory management, and the Stream Control Transmission Protocol (SCTP). FreeBSD provides highly scalable multiple-processing performance while keeping your network and servers safe. For more information about FreeBSD, visit <http://www.freebsd.org/>.

# INSTALLING FREEBSD ON THE DELL POWEREDGE C6220

## Prerequisites

### BIOS requirements

When installing FreeBSD 9.0 STABLE, we used the default factory BIOS setting for the server. Based on your workload requirements, BIOS settings may require adjustment, but you should thoroughly test these changes prior to production implementation.

### Driver prerequisites

In our lab installation, we used a Dell PowerEdge C6220 with the LSI SAS2008 mezzanine card. With this controller, FreeBSD (STABLE trunk) installs and runs without extra hardware drivers or software modules on the Dell PowerEdge C6220, as of this writing. If using the RELEASE trunk, you must install with a JBOD configuration.

## Deployment options

We recognize in mass deployment situations there are various options for mass OS deployment including Preboot eXecution Environment (PXE) or orchestration tools such as Puppet. For this guide, however, we wish to prepare our “gold image” for FreeBSD on a single Dell PowerEdge C6220 server node. To do this, we used its embedded baseboard management controller (BMC) console and virtual installation media.

## Storage configuration

The Dell PowerEdge C6220 can use several storage controllers to guard against disk failures. For this guide, we assume that we wish to change the disk configuration from the factory installation. We created one RAID6 virtual disk using the LSI SAS2008 RAID controller and the six 900GB internal hard drives assigned to the server.

As of early April 2012, the RELEASE version of FreeBSD 9.0 did not have the necessary updated LSI SAS2008 drivers. Therefore, it was necessary to use the STABLE trunk of FreeBSD 9.0, which involved downloading the source code, recompiling, and producing installable media. These driver updates should be in a future RELEASE version, but until that time, you may find it necessary to use FreeBSD 9.0 STABLE to avoid errors with the LSI SAS2008 controller. We provide details of the STABLE source download, recompile, and media creation in [Appendix C](#).

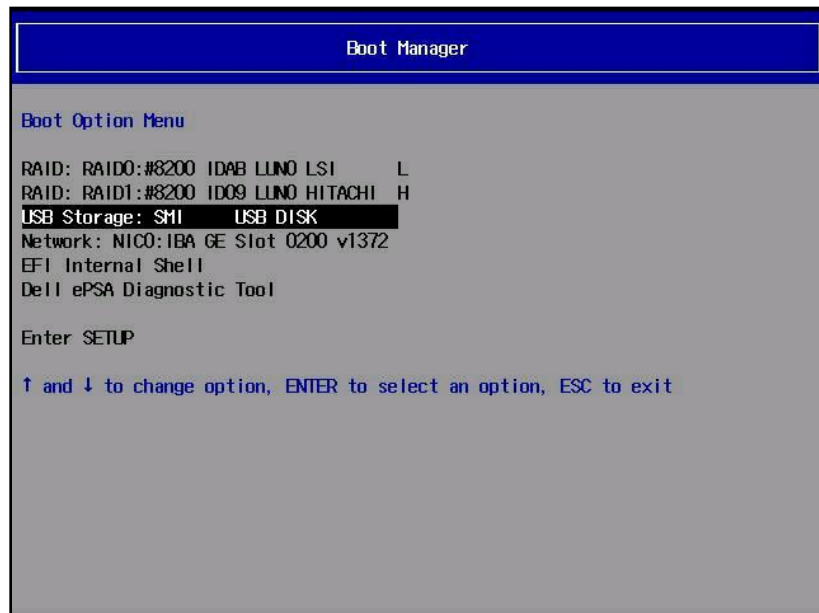
We partitioned the virtual disk for both OS and application data. Detailed instructions on how to configure the storage controller are in [Appendix D](#).

## Installation procedure for the operating system

1. Insert the USB flash drive containing a bootable FreeBSD 9.0 image into the server and start it.
2. On the C6220 Start Up screen, press F11 to select the boot device.



3. On the Boot Manager screen, select the USB Storage device, and press Enter.



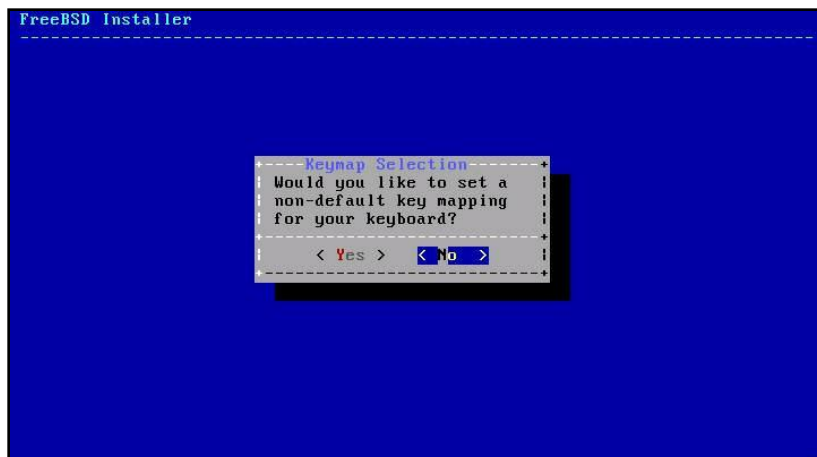
4. On the Welcome to FreeBSD boot screen, press Enter.



5. On the FreeBSD installer screen, select Install, and press Enter.

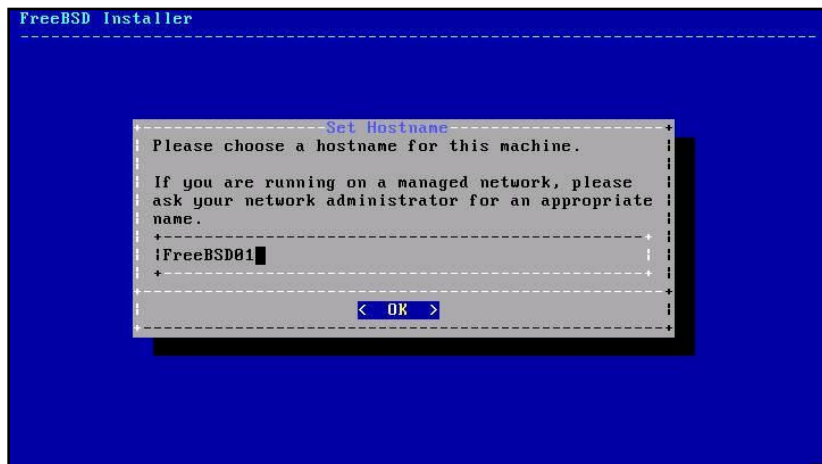


6. On the Keymap Selection screen, select No, and press Enter.

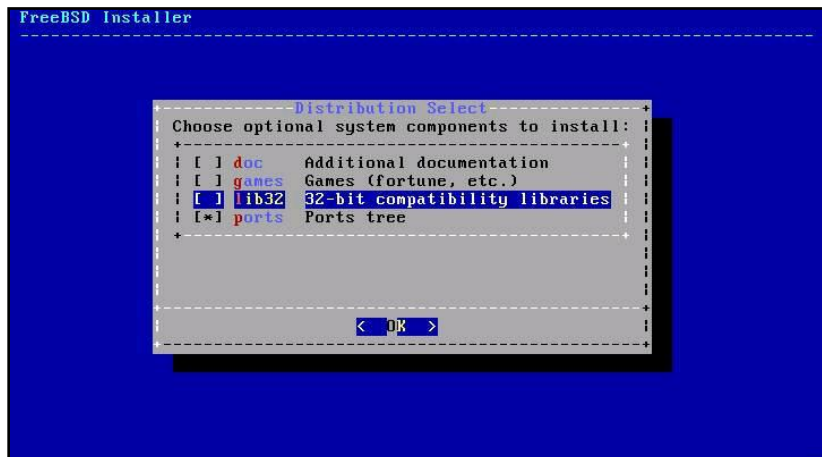




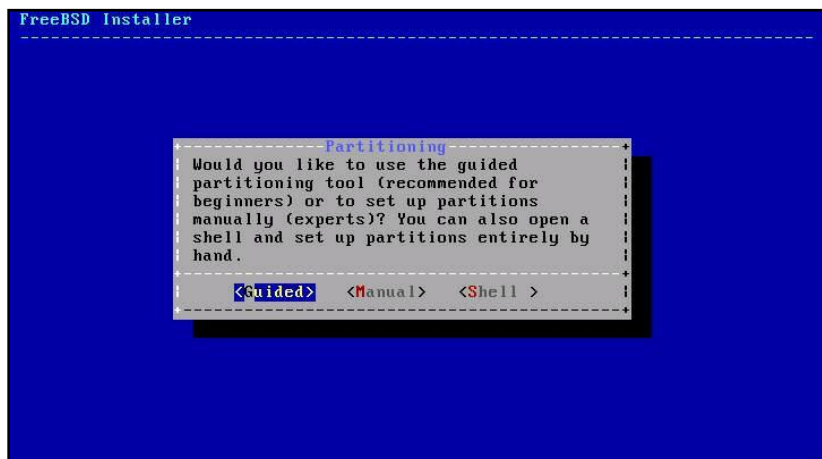
7. On the set Hostname screen, enter the name of the server, and press Enter.



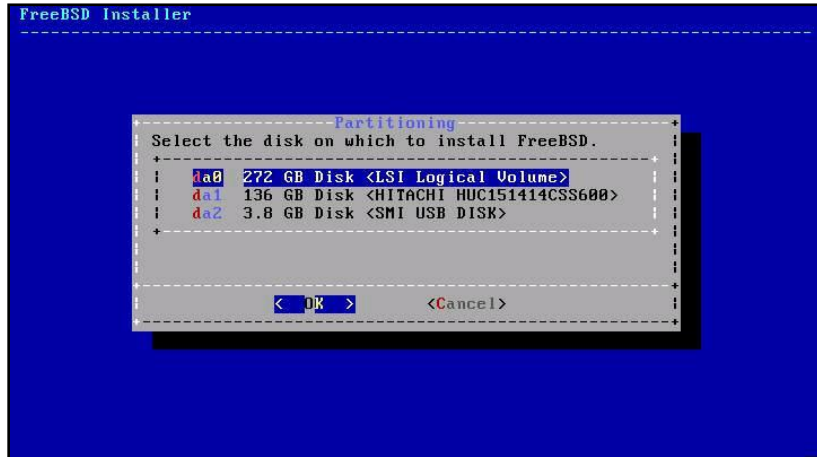
8. On the Distribution Select screen, use the space bar to unselect every component except ports, and press Enter.



9. On the Partitioning screen, select Guided, and press Enter.



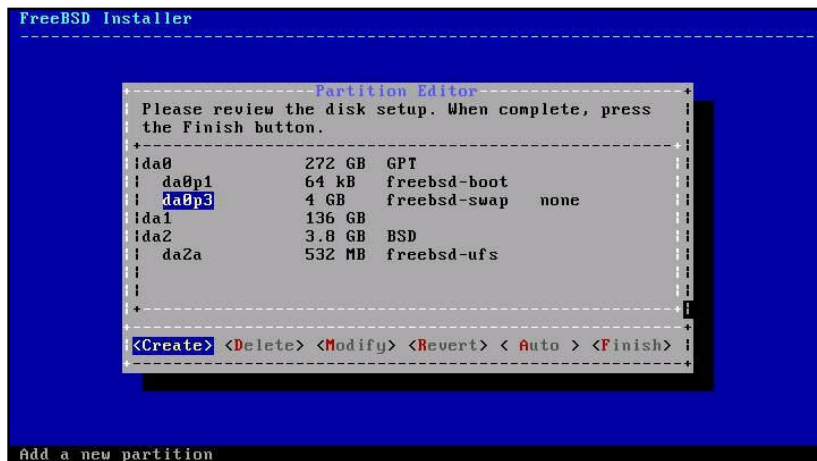
10. On the next Partitioning screen, select the disk corresponding to the LSI Logical Volume, da0, and press Enter.



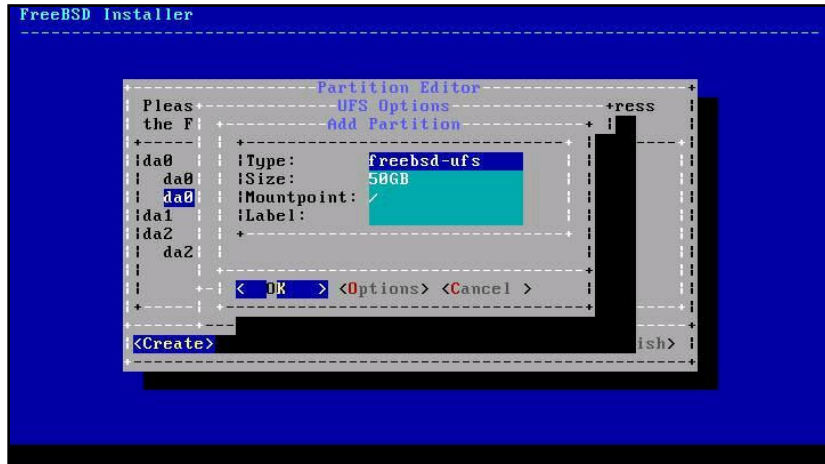
11. On the Partition screen, select Partition, and press Enter.



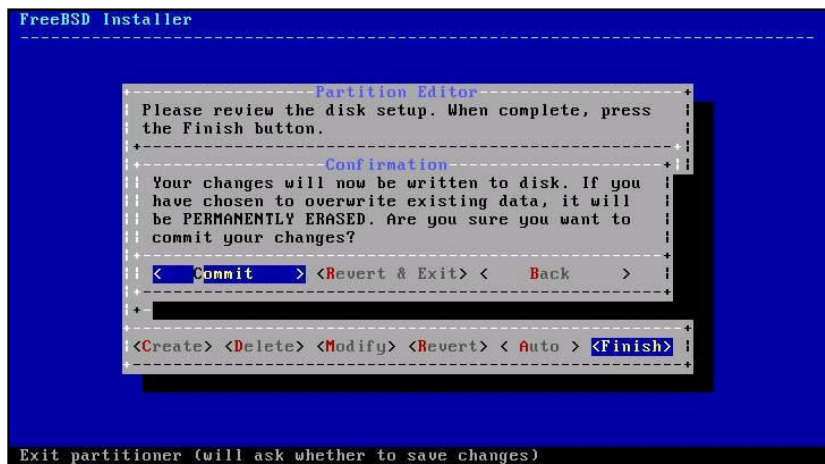
12. On the Partition Editor screen, select the root partition (da0p2), then Alt-D to delete it.



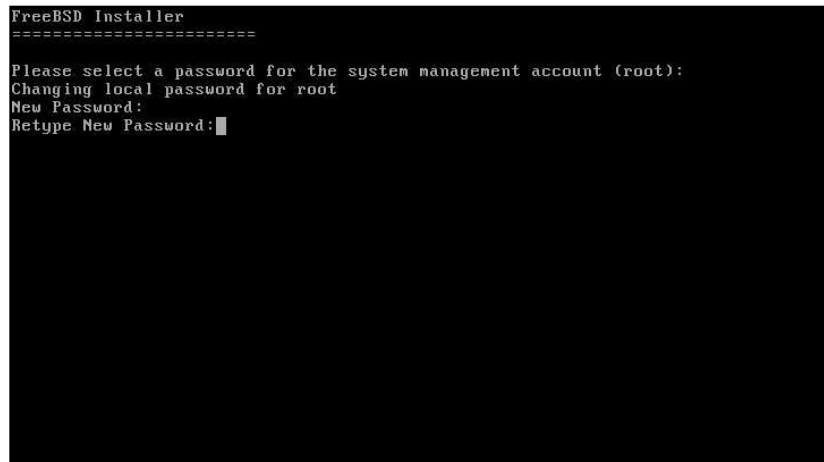
13. On the same screen, press Alt-C to add a partition. Set the Type to freebsd-ufs, if necessary; Size to 50GB; and the Mountpoint to /. Select OK, and press Enter.



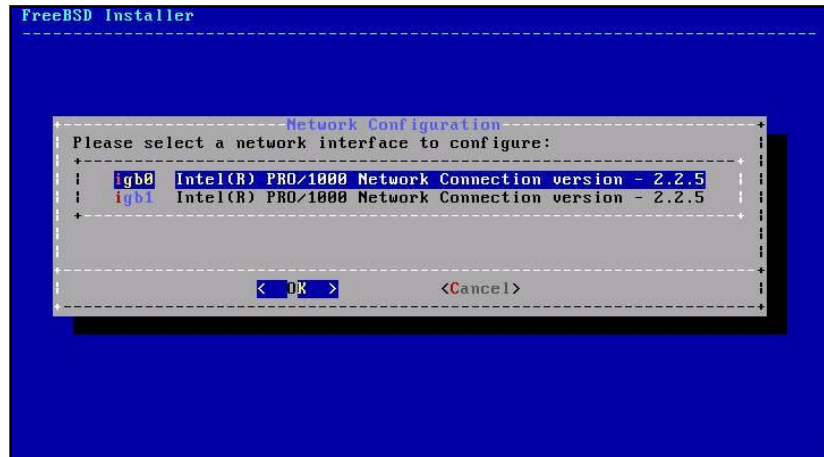
14. On the same screen, press Alt-F to exit the partitioning editor.
15. On the Confirmation screen, select Commit, and press Enter to format the disk and begin the operating system installation.



16. On the Root Password screen, enter a root password (twice).

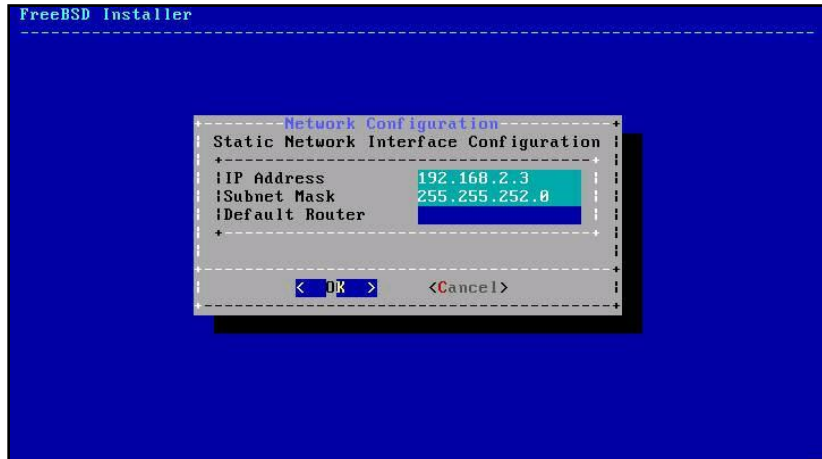


17. On the Network Configuration screen, select the first interface (igb0), and press Enter.

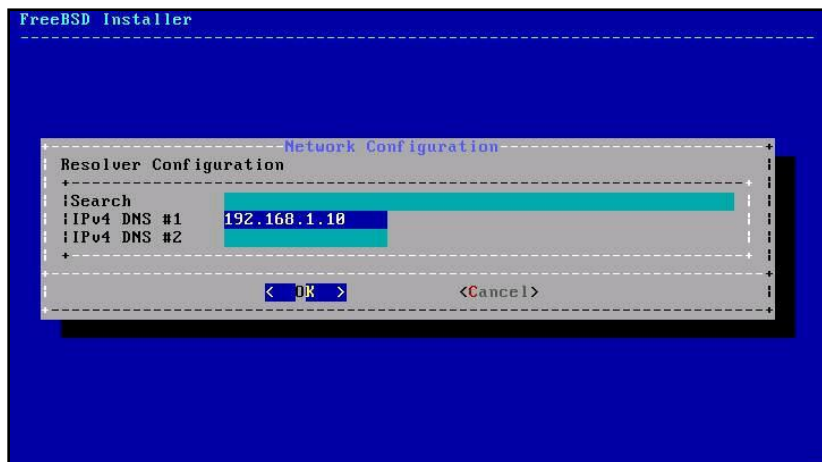


18. On the next two Network Configuration screens, select Yes to configure IPV4, and No to skip DHCP.

19. On the Static Network Interface Configuration screen, enter the IP Address, Subnet Mask, and Default Router for this NIC's network. Select OK, and press Enter.



20. On the next Network Configuration screen, select No to skip IPv6.
21. On the Resolver Configuration screen, enter one or more IP addresses for the server's DNS server(s).



22. On the local or UTC clock screen, select Yes, and press Enter.

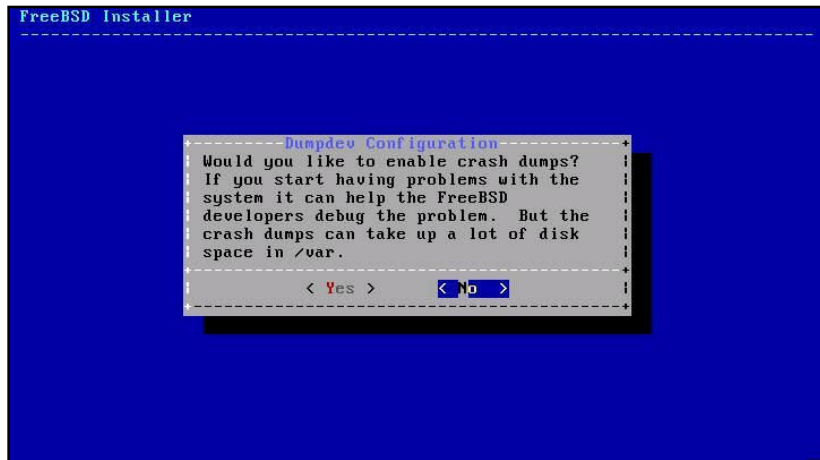


23. On the Time Zone Selector, use the arrow keys to choose your region, country or sub-region, and then the time zone for your locality.

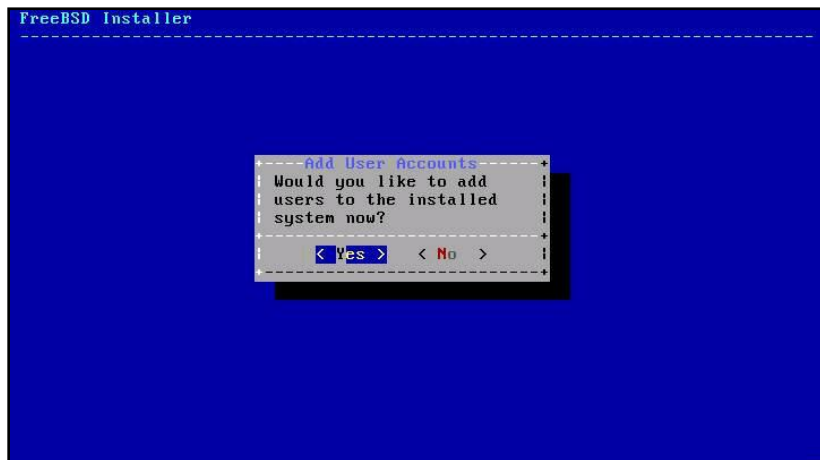


24. On the System Configuration screen, select the service to use, e.g., the SSH, NTP, and CPU Power daemons. Select OK, and press Enter.

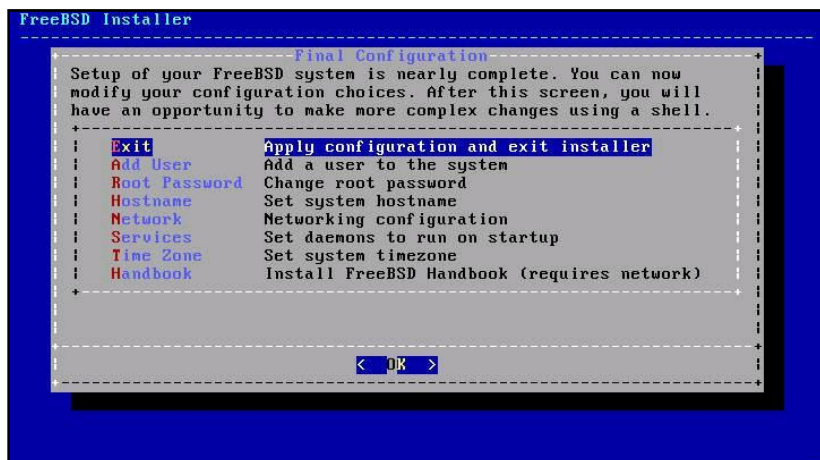
25. On the Dumpdev Configuration screen, select No, and press Enter.



26. On the Add User Accounts screen, select No, and press Enter.



27. On the Final Configuration, select Exit, and press Enter.



28. On the Manual Configuration screen, select No, and press Enter.



29. On the Complete screen, select Reboot, and press Enter.

30. After the server reboots, log onto the system as root.

31. Check for operating-system updates with `freebsd-update`. For this step, the server should be connected to the Internet directly or via an HTTP or FTP proxy. For the latter case, set the environment variables `http_proxy` and `FTP_PROXY` to the proxy server's URL. For example,

```
setenv http_proxy http://192.168.1.10:3128/  
setenv FTP_PROXY http://192.168.1.10:3128/  
freebsd-update fetch  
freebsd-update install
```

32. Reboot the server if kernel patches have been installed.

## INSTALLING THE AMP STACK ON FREEBSD AND THE DELL POWEREDGE C6220

### The AMP stack – An overview

AMP describes the components of a multi-tier software stack that an infrastructure may run: the Apache Web server, MySQL database, and PHP scripting language. This application stack has been used for years by service providers to provide powerful and flexible multi-tier environments for customers. Below, we briefly describe each component and then review the specific methods for setting up a single-server AMP stack on the Dell PowerEdge C6220.

#### Apache

Apache HTTP Server is an open-source Web server application that includes such features as Secure Sockets Layer and Transport Layer Security support, filtering





support, and custom log files. For more information, visit <http://www.apache.org/>.

## MySQL

MySQL is an open-source database that delivers high performance, high reliability, and is easy to use. Running on more than 20 operating system platforms and providing a range of database tools, MySQL delivers flexibility and performance to large-scale deployments. For more information about MySQL, visit <http://www.mysql.com/>.

## PHP

PHP is a Web scripting language that can be embedded into HTML source documents instead of using an external file to process data. The Web server interprets the PHP code to generate a Web page. For more information about PHP, visit <http://www.php.net/>.

## Installation procedure

### Preparation

1. Log onto the server as root.
2. Update the FreeBSD ports index:

```
portsnap fetch
```

### Installing Apache Web Server

1. Install the Apache Web Server application packages and their dependencies from FreeBSD ports:

```
cd /usr/ports/www/apache22  
make install clean
```

2. Accept defaults for apache, perl, m4, libconv, apr-ipv6-devrandom-gdbm-db42, python, gdbm, sqlite, tcl, and pcre.

3. Add the following line to `/etc/rc.conf`:

```
apache22_enable="YES"
```

4. Add the following two lines to `/usr/local/etc/apache22/httpd.conf`:

```
AddType application/x-httpd-php .php  
AddType application/x-httpd-php-source .phps
```

5. Start the Apache service:

```
service apache22 start
```

## Installing MySQL Database

1. Log in as root.
2. Install the MySQL application packages and their dependencies:

```
cd /usr/ports/databases/mysql55-server
make install clean
```
3. Start the mysql service:

```
service mysql-server start
```
4. Invoke the mysql\_secure\_installation utility:

```
mysql_secure_installation
```

  - a. Set a new mysql root password.
  - b. Enter Y to remove the ability for users to anonymously connect.
  - c. Enter Y to disallow root login remotely.
  - d. Enter Y to remove the test database and access to it.
  - e. Enter Y to reload the privileges table.

## Installing PHP scripting language

1. Install the application packages and their dependencies:

```
cd /usr/ports/lang/php5
make install clean
```

  - a. Enable APACHE module for php5 by selecting APACHE and pressing the space bar
2. Modify additional PHP configuration:

```
cd /usr/ports/lang/php5-extensions
make install clean
```

  - a. Enable MYSQL and MYSQLI support by selecting them and pressing space bar.
  - b. Accept default settings for php-mysql, php-mysqli, php-sqlite.
3. Copy the PHP ini file to its final location:

```
cp /usr/local/etc/php.ini-production
/usr/local/etc/php.ini
```

## Testing with a sample AMP application

To complete the AMP deployment, we created a sample AMP application consisting of a test database with test data and a PHP script that creates a dynamic Web page that prints the contents of a SQL query from the database. In this case, we demonstrate using the well-known “Hello World” example.

1. Log into the server as root.
2. Using the mysql client, create a test database, a test application user, and set privileges:

```
mysql --user root -password=RootPassword
mysql> USE mysql;
mysql> CREATE DATABASE helloworlddb;
mysql> CREATE USER testappuser@localhost IDENTIFIED BY
'Password1';
mysql> GRANT ALL ON helloworlddb.* TO
testappuser@localhost;
mysql> FLUSH PRIVILEGES;
```

3. Exit the mysql client utility.
4. Using the mysql client, login as the test application user to the newly created database and create a sample schema definition. In our case, this is just one table with one column.

```
mysql --user testappuser --password=Password1
mysql> USE helloworlddb;
mysql> CREATE TABLE tbl_hello_world (testcol CHAR(100));
mysql> INSERT INTO tbl_hello_world (testcol) VALUES
("Hello World");
```

5. Exit the mysql client utility.
6. In the Apache Web data directory, located by default on FreeBSD at `/usr/local/www/apache22/data/`, create a new file named `helloworld.php` that will query the database and print the results. See [Appendix E](#) for this sample PHP file contents.
7. From another machine, verify the page is operational by visiting [http://server\\_ip\\_address/helloworld.php](http://server_ip_address/helloworld.php)

## SUMMING IT ALL UP

The Dell PowerEdge C6220 server and the Unix-based FreeBSD operating system provide the power and features you need to deploy multiple, enterprise-class workloads in a large-scale cloud services environment. By increasing rack density, eliminating downtime with hot-swappable server nodes, and removing the cost of OS licenses and upgrade fees, running FreeBSD on the Dell PowerEdge C6220 can have a positive effect on your organization's bottom line, all while delivering top-of-the-line workload

performance for your cloud and SaaS users. As we have shown in this guide, deploying the Dell PowerEdge C6220 with FreeBSD is a simple, straightforward task that can bring many benefits to your cloud environment.

## APPENDIX A – REFERENCES

1. FreeBSD base documentation: <http://www.freebsd.org/docs.html>
2. Dell Support page: <http://support.dell.com>

## APPENDIX B – DELL POWEREDGE C6220 SYSTEM DETAILS

Figure 2 shows the detailed configuration information for the server we tested.

System	Dell PowerEdge C6220
<b>Power supplies (per chassis)</b>	
Total number	2
Vendor and model number	Dell Model : D1200E-S1
Wattage of each (W)	1400
<b>Cooling fans (per chassis)</b>	
Total number	4
Vendor and model number	Dell FHXY-A00
Dimensions (h x w) of each	2.5" x 2.5"
Volts	12
Amps	3.30
<b>General</b>	
Number of processor packages	2
Number of cores per processor	6
Number of hardware threads per core	2
System power management policy	Balanced
<b>CPU</b>	
Vendor	Intel
Name	Xeon
Model number	E5-2630
Stepping	7
Socket type	LGA2011
Core frequency (GHz)	2.30
Bus frequency	7.2 GT/s
L1 cache	32 KB + 32 KB (per core)
L2 cache	256 KB (per core)
L3 cache	15 MB
<b>Platform</b>	
Vendor and model number	Dell PowerEdge C6220
Motherboard model number	E145483
BIOS name and version	Dell 1.0.14
BIOS settings	Defaults
<b>Memory module(s)</b>	
Total RAM in system (GB)	32
Vendor and model number	Hynix HMT351R7BFR8A-H9
Type	PC3-10600R
Speed (MHz)	1,333
Speed running in the system (MHz)	1,333
Timing/Latency(tCL-tRCD-tRP-tRASmin)	9-9-9-36
Size (GB)	4

<b>System</b>	<b>Dell PowerEdge C6220</b>
Number of RAM module(s)	8
Chip organization	Double-sided
Rank	Dual
<b>Operating system</b>	
Name	FreeBSD 9.0-STABLE
File system	ext4
Kernel	9.0-STABLE amd64
Language	English
Updates	None
<b>Graphics</b>	
Vendor and model number	ASPEED VGA Controller
Graphics memory (MB)	8
<b>RAID controller</b>	
Vendor and model number	LSI MPT SAS2
Firmware version	11.00.00.00-IR
Cache size	None
<b>Internal hard drive</b>	
Vendor and model number	Seagate ST9900805SS
Number of disks in system	6
Size (GB)	900
Buffer size (MB)	64
RPM	10K
Type	6GB SAS
<b>Ethernet adapters</b>	
Vendor and model number	I350 Gigabit Network Connection
Type	Integrated
<b>USB ports</b>	
Number	2 external, 1 internal
Type	2.0

Figure 2: Detailed configuration information for the test server.

## APPENDIX C – PREPARING FREEBSD 9.0 STABLE

Below we provide instructions on preparing the STABLE trunk of FreeBSD 9.0, if you should find that the updated drivers for the LSISAS2008 mezzanine card included in that branch are necessary.

1. Check out the source code.

- a. Create a CVS update file for the 9.0 STABLE branch:

```
cp /usr/share/examples/cvsup/standard-supfile /root/supfile
sed -i -e 's/host=CHANGE_THIS/host=cvsup1.us/' \
    -e 's /tag=RELENG_9_0/tag=RELENG_9/' supfile
```

- b. Get the source code for the STABLE branch:

```
cvsup supfile
```

2. Compile the build tools and kernel:

```
cd /usr/src
make -j 8 buildworld
make -j 8 buildkernel
```

3. Make a flash-disk boot image, which will use approximately 660MB:

```
cd /usr/src/release
make memstick
```

4. Copy the boot image onto a flash disk. Be aware the contents of the flash disk will be overwritten.

- a. Insert a 1GB or larger flash disk into the machine.

- b. Determine its device name, e.g., 'sde', by examining the results of the following command.

```
dmesg | tail
```

- c. Copy the image to /dev/sde:

```
dd if=/usr/obj/FreeBSD-9.0-STABLE-amd64-memstick.img of=/dev/sde bs=1M
```

- d. Eject the flash drive:

```
eject /dev/sde
```



## APPENDIX D – LSI SAS2008 STORAGE CONFIGURATION

Below we provide the detailed instructions for creating one RAID6 virtual disk using the LSI SAS2008 RAID controller and four 900GB internal hard drives assigned to the server.

1. Connect to the server console. Boot the server and press Ctrl-H on the controller screen to enter the device's graphical interface:
2. On the Adapter Selection screen, select the SAS 2008 adapter, and press Enter.

```
LSI Corp Config Utility v7.21.00.00 (2011.08.11)
Adapter List Global Properties
Adapter PCI PCI PCI PCI FW Revision Status Boot
        Bus Dev Fnc Slot          Order
SAS 2008 FW v0.2 82 00 00 00 11.00.00.00-IR Enabled 0
Esc = Exit Menu F1/Shift+1 = Help
Alt+N = Global Properties -/+ = Alter Boot Order Ins/Del = Alter Boot List
```

3. On the Adapter Properties screen, select RAID Properties, and press Enter.

```
LSI Corp Config Utility v7.21.00.00 (2011.08.11)
Adapter Properties -- SAS2008
Adapter SAS 2008 FW v0.2
PCI Slot 00
PCI Address(Bus/Dev) 82:00
MPT Firmware Revision 11.00.00.00-IR
SAS Address 500A0D10:00123455
NVDATA Version 0A.03
Status Enabled
Boot Order 0
Boot Support Enabled BIOS & OS
RAID Properties
SAS Topology
Advanced Adapter Properties
Esc = Exit Menu F1/Shift+1 = Help
Enter = Select Item -/+ / Enter = Change Item
```

- On the Select New Volume Type screen, select Create RAID 1E/10 Volume, and press Enter.

```

LSI Corp Config Utility      v7.21.00.00 (2011.08.11)
Select New Volume Type -- SAS2008

  Create RAID 1 Volume      Create a RAID 1 volume
                             consisting of 2 disks plus up to 2
                             optional hot spares. ALL DATA on
                             volume disks will be DELETED!

  Create RAID 1E/10 Volume  Create a RAID 1E or RAID 10 volume
                             consisting of 3 to 10 disks including up
                             to 2 optional hot spares. ALL DATA on
                             volume disks will be DELETED!

  Create RAID 0 Volume      Create a RAID 0 volume consisting of
                             2 to 10 disks. ALL DATA on
                             volume disks will be DELETED!

Esc = Exit Menu      F1/Shift+1 = Help
Enter = Choose volume type to create

```

- On the Create New Volume screen, select four disks to be RAID10 disks, and press C to create the volume.

```

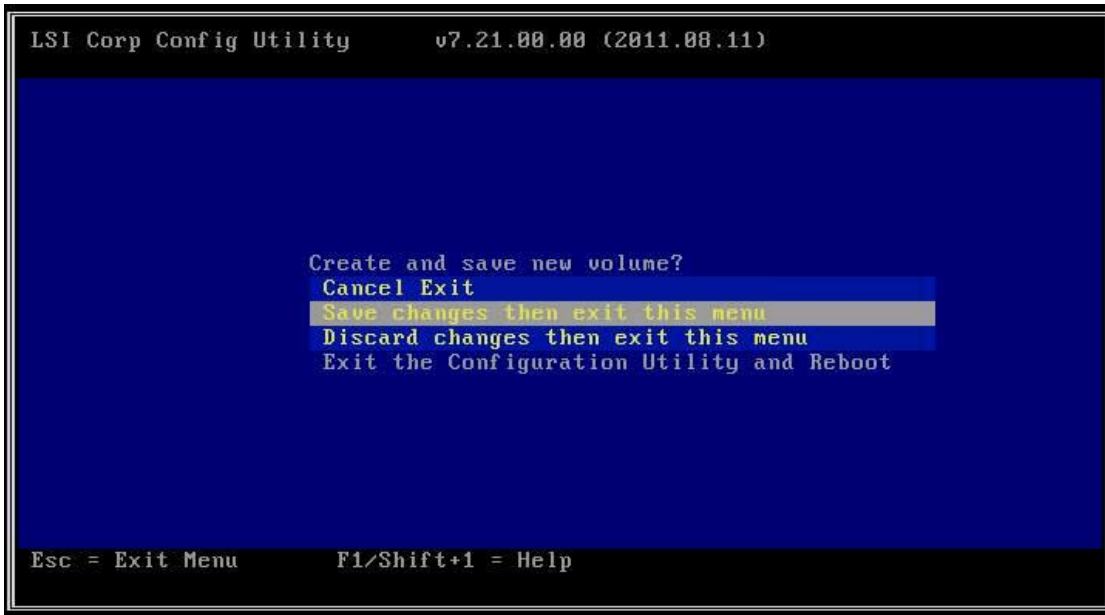
LSI Corp Config Utility      v7.21.00.00 (2011.08.11)
Create New Volume -- SAS2008
Volume Type:                RAID 10
Volume Size(GB):            271

Slot  Device Identifier      RAID  Drive   Pred   Size
Num   Num                    Disk   Status  Fail   (GB)
0     HITACHI HUC151414CSS600 K516  [No]   ----- No     136
2     HITACHI HUC151414CSS600 K516  [Yes]  ----- No     136
3     HITACHI HUC151414CSS600 K516  [Yes]  ----- No     136
4     HITACHI HUC151414CSS600 K516  [Yes]  ----- No     136
5     HITACHI HUC151414CSS600 K516  [Yes]  ----- No     136

Esc = Exit Menu      F1/Shift+1 = Help
Space/+/- = Select disk for volume      C = Create volume

```

6. On the Create and save new volume? screen, select Save changes the exit this menu, and press Enter.



7. On the Are you sure you want to exit screen, select Exit the Configuration Utility and Reboot, and press Enter.



## APPENDIX E – CONFIGURATION FILES FOR AMP ON FREEBSD 9.0

Figure 3 presents the sample PHP file to use for testing the AMP stack.

---

```
<?php
$db_username="testappuser";
$db_password="Password1";
$db_host="localhost";
$db_name="helloworlddb";
$link = mysql_connect($db_host, $db_username, $db_password);
mysql_select_db($db_name, $link);
$result = mysql_query("SELECT testcol FROM tbl_hello_world", $link);
$row = mysql_fetch_assoc($result);
print_r($row);
mysql_close($link);
?>
```

---

**Figure 3: Sample php file to query the test database: </usr/local/www/apache22/data/helloworld.php>**

## ABOUT PRINCIPLED TECHNOLOGIES



Principled Technologies, Inc.  
1007 Slater Road, Suite 300  
Durham, NC, 27703  
[www.principledtechnologies.com](http://www.principledtechnologies.com)

We provide industry-leading technology assessment and fact-based marketing services. We bring to every assignment extensive experience with and expertise in all aspects of technology testing and analysis, from researching new technologies, to developing new methodologies, to testing with existing and new tools.

When the assessment is complete, we know how to present the results to a broad range of target audiences. We provide our clients with the materials they need, from market-focused data to use in their own collateral to custom sales aids, such as test reports, performance assessments, and white papers. Every document reflects the results of our trusted independent analysis.

We provide customized services that focus on our clients' individual requirements. Whether the technology involves hardware, software, Web sites, or services, we offer the experience, expertise, and tools to help our clients assess how it will fare against its competition, its performance, its market readiness, and its quality and reliability.

Our founders, Mark L. Van Name and Bill Catchings, have worked together in technology assessment for over 20 years. As journalists, they published over a thousand articles on a wide array of technology subjects. They created and led the Ziff-Davis Benchmark Operation, which developed such industry-standard benchmarks as Ziff Davis Media's Winstone and WebBench. They founded and led eTesting Labs, and after the acquisition of that company by Lionbridge Technologies were the head and CTO of VeriTest.

---

Principled Technologies is a registered trademark of Principled Technologies, Inc.  
All other product names are the trademarks of their respective owners.

---

**Disclaimer of Warranties; Limitation of Liability:**

PRINCIPLED TECHNOLOGIES, INC. HAS MADE REASONABLE EFFORTS TO ENSURE THE ACCURACY AND VALIDITY OF ITS TESTING, HOWEVER, PRINCIPLED TECHNOLOGIES, INC. SPECIFICALLY DISCLAIMS ANY WARRANTY, EXPRESSED OR IMPLIED, RELATING TO THE TEST RESULTS AND ANALYSIS, THEIR ACCURACY, COMPLETENESS OR QUALITY, INCLUDING ANY IMPLIED WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE. ALL PERSONS OR ENTITIES RELYING ON THE RESULTS OF ANY TESTING DO SO AT THEIR OWN RISK, AND AGREE THAT PRINCIPLED TECHNOLOGIES, INC., ITS EMPLOYEES AND ITS SUBCONTRACTORS SHALL HAVE NO LIABILITY WHATSOEVER FROM ANY CLAIM OF LOSS OR DAMAGE ON ACCOUNT OF ANY ALLEGED ERROR OR DEFECT IN ANY TESTING PROCEDURE OR RESULT.

IN NO EVENT SHALL PRINCIPLED TECHNOLOGIES, INC. BE LIABLE FOR INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES IN CONNECTION WITH ITS TESTING, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. IN NO EVENT SHALL PRINCIPLED TECHNOLOGIES, INC.'S LIABILITY, INCLUDING FOR DIRECT DAMAGES, EXCEED THE AMOUNTS PAID IN CONNECTION WITH PRINCIPLED TECHNOLOGIES, INC.'S TESTING. CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES ARE AS SET FORTH HEREIN.

---