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Using HTTP IPv6 Boot to Install a Linux OS on Lenovo ThinkSystem Severs

Introduces the use of HTTP IPv6 Boot as a way to deploy servers over the network

Compares HTTP IPv6 Boot with the existing PXE Boot functionality

Demonstrates how to set up HTTP IPv6 Boot on Lenovo ThinkSystem servers

Provides instructions for use with SLES 12 & 15 and RHEL 7 & 8

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Abstract

HTTP Boot is an application based on client-server communication. It combines the DHCP, DNS, and HTTP protocols to provide the ability to installl an operating system over the network. This new capability can be utilized as a higher-performance replacement for TFTP-based on PXE Boot methods of network deployment.

This paper provides a brief introduction to the HTTP Boot mechanism, instructions on setting up the HTTP Boot server on SUSE Linux Enterprise Server 15 SP2, and step-by-step instructions on how to install an operating system on a Lenovo® ThinkSystem™ server using HTTP Boot.

This paper is intended for IT administrators. Readers are expected to have the basic knowledge of network deployment.

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Introduction

UEFI Specification V2.5 includes protocols that are related to he HTTP Boot in network stack. HTTP Boot is one method of booting a server from a Uniform Resource Identifier (URI), using HTTP technology. Users can boot a Network Boot Program (NBP) with HTTP Boot technology.

Internet Protocol version 6 (IPv6), the successor to Internet Protocol version 4 (IPv4), expands the addressing capability by increasing from a 32-bit IP address size to a 128-bit IP address, thereby solving the problem of IPv4 address exhaustion.

The European Telecommunications Standards Institute (ETSI) white paper *IPv6 Best Practices, Benefits, Transition Challenges and the Way Forward*[1], reveals that 1.2 billion Internet users are using IPv6 today, the majority of which are from India (358 million), China (200 million) and US (143 million). It also shows the percentage of web sites with IPv6 support is increasing from 5% (Jan. 2015) to 15% (Jan. 2020). The trend of using IPv6 will keep increasing in the future.

This paper describes how to enable HTTP Boot using IPv6 (HTTP IPv6 Boot) on a ThinkSystem server running SUSE Linux Enterprise Server 15 SP2. HTTP Boot is also supported on RHEL 7.9, RHEL 8.2, RHEL 8.3, SLES 12 SP5 and SLES 15.x.

Key benefits of HTTP Boot and IPv6

HTTP Boot with IPv6 is recommended if you want to deploy an operating system in a faster and more stable way.

Key benefits of HTTP Boot include:

- HTTP Boot can handle much larger files than TFTP, and scale to much larger distances.
- More stable than TFTP & UDP
- More safer than TFTP & UDP

Key benefits of IPv6 include:

- No more NAT (Network Address Translation)
- No more private address collisions
- Better multicast routing
- Simpler header format
- Simplified, more efficient routing
- True quality of service (QoS), also called “flow labeling”
- IPSec (Internet Protocol Security) is built into the IPv6 protocol, usable with a proper key infrastructure.
- Flexible options and extensions
- Easier administration

[1] IPv6 Best Practices, Benefits, Transition Challenges and the Way Forward, https://www.etsi.org/images/files/ETSIWhitePapers/etsi_WP35_IPv6_Best_Practices_Benefits_Transition_Challenges_and_the_Way_Forward.pdf

Setting up the HTTP IPv6 Boot server

In this section, we demonstrate how HTTP IPv6 Boot is applied to Lenovo ThinkSystem servers. We also show how to deploy an HTTP IPv6 Boot server in SLES 15 SP2.

In our lab, we have configured two servers: One serves as the HTTP IPv6 Boot server, and the other as the HTTP Boot client. The network interfaces for the HTTP IPv6 Boot server are as follows:

- IPv6 address: `2001:db8:f00f:cafe:1/64`
- Domain name: `www.httpboot.local`

Configuring the HTTP Boot server

This section introduces how to set up the following services on one physical server:

- HTTP service
- DNS service
- DHCP service
- RADVD service

The detailed network interface information is shown in Figure 1:

```
eth1: <BROADCAST,MULTICAST,UP,LOWER_UP> mtu 1500 qdisc mq state UP group default qlen 1000
 link/ether 6c:0b:84:fl:fl:7d brd ff.ff:ff:ff:ff:ff
 inet6 2001:db8:f00f:cafe::1/64 scope global
    valid_lft forever preferred_lft forever
 inet6 fe80::6e0b:84ff:fefl:fl7d/64 scope link
    valid_lft forever preferred_lft forever
```

Figure 1 Network Interface Information

Configuring the HTTP service

Configure the HTTP service as follows:

1. Install the following packages on the machine that you plan to use as a HTTP IPv6 Boot server:
   - dhcp6-server
   - radvd
   - apache2 (or lighttpd)
   - dnsmasq

   The default directory is /var/www/htdocs however you can change it in the /etc/apache2/default-server.conf configuration file.
2. Launch the HTTP service and make it start automatically at boot time, run the following command as root:

```
localhost:~# systemctl start apache2.service
localhost:~# systemctl enable apache2.service
localhost:~#
```

Figure 2 Starting the HTTP service

Configuring the DNS service

Configuring the DNS service is optional but it's nice to configure your server a well-known name. To set up the DNS server:

1. Add the following lines to /etc/dnsmasq.conf

```
localhost:~ # cat /etc/dnsmasq.conf | tail -n2
interface=ethl
addn-hosts=/etc/dnsmasq.d/hosts
localhost:~ #
```

Figure 3 Adding lines to dnsmasq.conf

2. Add the following lines to /etc/dnsmasq.d/hosts:

```
localhost:~ # cat /etc/dnsmasq.d/hosts
2001:db8:f00f: cafe::1 www.httpboot.local
localhost:~ #
```

Figure 4 Adding lines to dnsmasq.d/hosts:

3. Run the following command to start the DNS service.

```
localhost:~ # systemctl start dnsmasq
```

Figure 5 Starting the DNS service

Configuring the DHCP service

Configure DHCP Service as follows:

1. Before setting up the DHCP servers, specify the network interface for them in /etc/sysconfig/dhcpd. For example, we added the line `DHCPD6_INTERFACE="eth1"` on our server:

```
localhost:~ # cat /etc/sysconfig/dhcpd | grep "DHCPD6_INTERFACE"
# Examples: DHCPD6_lNTERFACE="eth0 ethl eth2
#           DHCPD6_INTERFACE="ANY"
DHCPD6_INTERFACE="eth1"
localhost:~ #
```

Figure 6 Adding the network interface to dhcpd config

2. Mount OS image and copy all the files of EFI directory to the “/var/www/htdocs”

```
localhost:~ # mkdir sles15sp2
localhost:~ # mount -o loop ./SLE-15-SP2-Full-x86_64-GM-Media1.iso sles15sp2/
mount: /root/sles15sp2: WARNING: device write-protected, mounted read-only.
localhost:~ # cp -rf sles15sp2/EFI/* /var/www/htdocs /
localhost:~ # umount sles15sp2
```

Figure 7 Mount the image and copy files

3. Edit the /etc/dhcpd6.conf file as shown in Figure 8:

```
localhost:~ # cat /etc/dhcpd6.conf | tail -n11
option dhcp6.bootfile-url code 59 = string;
option dhcp6.vendor-class code 16 = {integer 32, integer 16, string};
subnet6 2001 :db8:f00f:cafe::/64 {
        authoritative;
        range6 2001:db8:f00f:cafe::42:10 2001:db8:f00f:cafe::42:99;
        default-lease-time 14400;
        option dhcp6. domain-search "httpboot.local";
        option dhcp6.bootfile-url "http://www.httpboot.local/BOOT/bootx64.efi";
        option dhcp6. name-servers 2001:db8:f00f:cafe::1 ;
        option dhcp6.vendor-class 0 10 "httpcIient";
}
```

Figure 8 Add lines to the dhcpd6.conf file

4. Start the DHCP service and make it start automatically at boot time, use the following commands:

```
localhost:~ # systemctl start dhcpd6
localhost:~ #
localhost:~ # systemctl enable dhcpd6
```

Figure 9 Starting the DHCP services

Configuring RADVD service

The Router Advertisement Daemon (radvd) is an open-source software product that implements link-local advertisements of IPv6 router addresses and IPv6 routing prefixes using the Neighbor Discovery Protocol (NDP) as specified in RFC 2461.

1. Enable IPv6 forwarding using the following commands:

```
localhost:~ # echo "net.ipv6.conf.al1.forwarding = 1" > /etc/sysctl.d/50-ipv6-router.conf
localhost:~ # sysctl -p /etc/sysctl.d/50-ipv6-router.conf
net.ipv6.conf.all.forwarding = 1
```

Figure 10 Enable IPv6 forwarding

2. Edit the configuration file:

```
localhost:~ # cat /usr/lib/systemd/system/radvd.service
[Unit]
Description=lPv6 Router Advertisement Daemon
After=syslog.target

[Service]
EnvironmentFi1e=-/etc/sysconfig/radvd
Execstart=/usr/sbin/radvd --noaaemon $RADVD_OPTIONS
ExecReload=/bin/kill -HUP $MAINPID

[install]
wantedBy=multi-user.target
localhost:~ #
localhost:~ # cat /etc/radvd.conf
interface ethl
{
        IgnoreIfMissing on;
        AdvSendAdvert on;

        AdvManagedFlag on;         ## == DHCLlENT6_MODE=managed
        #AdvOtherConfigFlag on;    ## == DHCLlENT6_MODE=info if AdvManagedFlag off

        AdvDefaultLifetime 0;      ## lifetime of the default route, 0 -> none
        #AdvDefaultLifetime 3600;  ## to set a default route valid for 1h

        prefix 2001:db8:f00f:cafe::/64 {
                           ## ^^
                                ## DHCLIENT6_ADDRESS_LENGTH=64
                AdvonLink on;      ## /64 in prefix is on-link
                AdvAutonomous off; ## disable slaac ip address assignment
                AdvPreferredLifetime 2400;  ## preferred for 40min
                AdwalidLifetime      3600;  ## valid for 1h
         };
};
localhost:~ #
```

Figure 11 Edit the radvd.service file

3. Start the radvd service and make it start automatically at boot time, use the following command:

```
localhost:~ # systemctl start radvd
localhost:~ # systemctl enable radvd
created symlink /etc/systemd/system/multi-user.target.wants/radvd.service
/usr/1ib/systemd/system/radvd.service.
localhost:~ #
```

Figure 12 Starting the radvd service

OS installation demonstration via UEFI IPv6

In this section, we demonstrate the GRUB configuration for various Linux operating systems. You will need to edit /srv/www/htdocs/BOOT/grub.cfg on the HTTP Boot server to fit your needs.

1. Create a folder under the /srv/www/htdocs directory as the OS image mounting point, for example:

```
localhost:~ # mkdir /srv/www/htdocs/slesl5sp2
localhost:~ # mount -o loop /home/SLE-15-SP2-Full-x86_64-GM-Medial.iso /srv/www/htdocs/slesl5sp2
mount: /srv/www/htdocs/slesl5sp2: warning: device write-protected, mounted read-only.
localhost:~ #
```

Figure 13 Mounting the OS image

2. Modify the grub.cfg file under the /srv/www/htdocs/BOOT/ directory as follows:

   For SLES 12 SP5, make the changes to grup.cfg as shown in Figure 14.

```
menuentry 'SLES12.5 HttpBootIPv6 Installation' --class opensuse --class gnu-linux --class gnu
--class os {
    set gfxpayload=keep
    echo 'Loading kernel ...'
    linuxefi /slesl2sp5/boot/x86_64/loader/linux install=http://www.httpboot.local/sles12sp5
ipv6only=1 ifcfg=*=dhcp6
    echo 'Loading initial ramdisk ...'
    initrdefi /sles!2sp5/boot/x86_64/loader/initrd
}
```

Figure 14 grub.cfg file for SLES 12 SP5

For SLES 15 SP2, make the changes to grup.cfg as shown in Figure 15.

```
menuentry 'SLES15 SP2 http Boot IPv6' --class opensuse --class gnu-linux --class gnu --class
os {
    set gfxpayload=keep
    echo 'Loading kernel ...'
    linuxefi /slesl5sp2/boot/x86_64/loader/linux install=http://www.httpboot.local/sles15sp2
ipv6only=1 ifcfg=*=dhcp6
    echo 'Loading initial ramdisk ...'
    initrdefi /sles15sp2/boot/x86_64/loader/initrd
}
```

Figure 15 grub.cfg file for SLES 15 SP2

For RHEL 7.9, make the changes to grup.cfg as shown in Figure 16.

Notes:

- For all RHEL versions, the value of the `inst.repo` parameter in linuxefi command should be the IP address of the server, not the domain name.
- For RHEL 7.x, the value of the ip parameter is *`network-interface`*`:dhcp6` (highlighted in red), where *`network-interface`* is name of the Ethernet interface on the target server. You may need to manually install Linux on the target server to get this value ahead of time.

```
menuentry 'RHEL7.9 HTTP Boot IPv6' --class opensuse --class gnu-1inux --class gnu --class os {
    set gfxpayload=keep
    echo 'Loading kernel ...'
    1inuxefi /rhel79/images/pxeboot/vmlinuz inst.repo=http://[2001:db8:f00f:cafe::1]/rhel79/
ip=eno1:dhcp6
    echo 'Loading initial ramdisk ...'
    initrdefi /rnel79/images/pxeboot/initrd.img
}
```

Figure 16 grub.cfg file for RHEL 7.9

For RHEL 8.2, make the changes to grup.cfg as shown in Figure 17.

Notes:

- For all RHEL versions, the value of the `inst.repo` parameter in linuxefi command should be the IP address of the server, not the domain name.
- For RHEL 8.2, the value of the ip parameter is `ip=dhcp6` as highlighted in red.

```
menuentry 'RHEL8.2 HTTP Boot IPv6' --class opensuse --class gnu-1inux --class gnu --class os {
    set gfxpayload=keep
    echo 'Loading kernel ...'
    linuxefi /rhel82/images/pxeboot/vmlinuz inst.repo=http://[2001:db8:f00f:cafe::1]/rhel82/
ip=dhcp6
    echo 'Loading initial ramdisk ...'
    initrdefi /rhel82//images/pxeboot/initrd.img
}
```

Figure 17 grub.cfg file for RHEL 8.2

For RHEL 8.3, make the changes to grup.cfg as shown in Figure 18.

Notes:

- For all RHEL versions, the value of the `inst.repo` parameter in linuxefi command should be the IP address of the server, not the domain name.
- For RHEL 8.3, the value of the ip parameter is `ip=auto6` as highlighted in red.

```
menuentry RHEL8.3 HTTP Boot IPv6 --class opensuse --class gnu-linux --class gnu --class os {
    set gfxpayload=keep
    echo 'Loading kernel ...'
    linuxefi /rhel83/images/pxeboot/vmlinuz inst.repo=http://[2001:db8:f00f:cafe::1]/rhel83/
ip=auto6
    echo 'Loading initial ramdisk ...'
    initrdefi /rhel83//images/pxeboot/initrd.img
}
```

Figure 18 grub.cfg file for RHEL 8.3

3. Power on the target server (HTTP Boot Client) and press F12 when prompted to select a One Time Boot Device, as shown in Figure 19.

Figure 19 Press F12 to select One Time Boot Device

4. Choose the network interface with `HTTP IP6` in the name, as shown in Figure 20 and press Enter. If there is more than one, select one that matches a network port that is cabled and active.

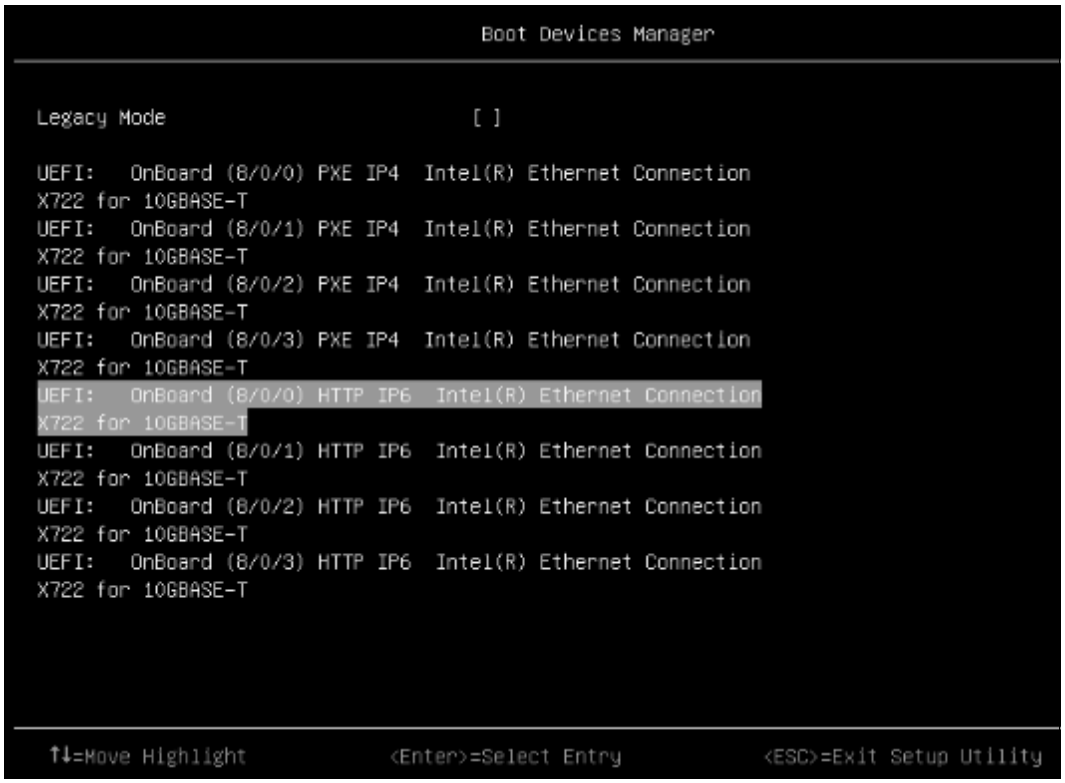

Figure 20 Boot Devices Manager in UEFI

5. Choose which OS to install on the GRUB menu as shown in Figure 21, and begin the installation process.

Figure 21 GRUB menu

The operating system will now be installed over the IPv6 network.

Acronyms

BDS	Boot Device Selection
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
HTTP	Hypertext Transfer Protocol
NBP	Network Boot Program
NIC	Network interface card
OS	Operating system
RADVD	Router Advertisement Daemon
PXE	Preboot Execution Environment
RAM	Random-access memory
TFTP	Trivial File Transfer Protocol
TLS	Transport Layer Security
URI	Uniform Resource Identifier

References

Review the following resources for more information:

- Lenovo Press paper, Using HTTP Boot to Install an Operating System on Lenovo ThinkSystem servers

  https://lenovopress.com/lp0736

- SUSE web page for Setting up a UEFI HTTP Boot Server:

  https://documentation.suse.com/sles/15-SP2/html/SLES-all/cha-deployment-prep-uefi-httpboot.html

- European Telecommunications Standards Institute (ETSI) white paper, IPv6 Best Practices, Benefits, Transition Challenges and the Way Forward

  https://www.etsi.org/images/files/ETSIWhitePapers/etsi_WP35_IPv6_Best_Practices_Benefits_Transition_Challenges_and_the_Way_Forward.pdf

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