



**RIPE NCC**  
RIPE NETWORK COORDINATION CENTER

# Introduction to Network Boot

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macOS, RPi & PXE

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# Why should you care?



- Install computers without
  - USB sticks
  - CD/DVDs
- No more
  - flashing new images
  - dying USB sticks
  - out of date images
- Use **the network** instead



# Network Boot: the easy way (1)



OSXDaily

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## How to Re-Install OS X with Internet Recovery on a Mac

Dec 14, 2014 114 Comments



In some rare situations, reinstalling OS X on a Mac may be required. This is made fairly easy as all modern Macs include the OS X Internet Recovery feature, which lets you reinstall OS X through a netboot type of mode that is accessed from the internet rather than a local drive. This is helpful in the event you need to reinstall Mac OS X whether for fun, because something has gone truly haywire, or because you need to replace the system software for whatever other reason.

# Network Boot: the easy way (1)



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 [Fix Your Stuff](#) [Community](#) [Store](#) [EUR](#)

### Step 2



- Once the computer is completely shut down, press the power button, then immediately press and hold the key combination **cmd + option + R**.

# Network Boot: the easy way (1)



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## How to Re-Install OS X with Internet Recovery on a Mac


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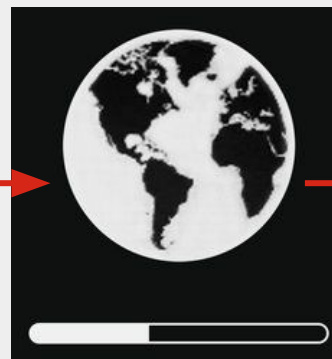
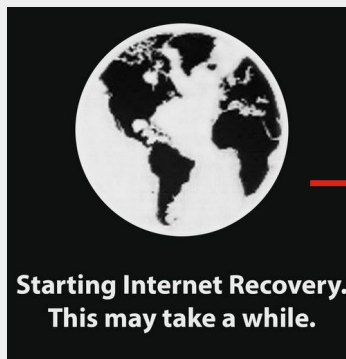
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### Step 2



- Once the computer is completely shut down, press the power button, then immediately press and hold the key combination **cmd + option + R**.



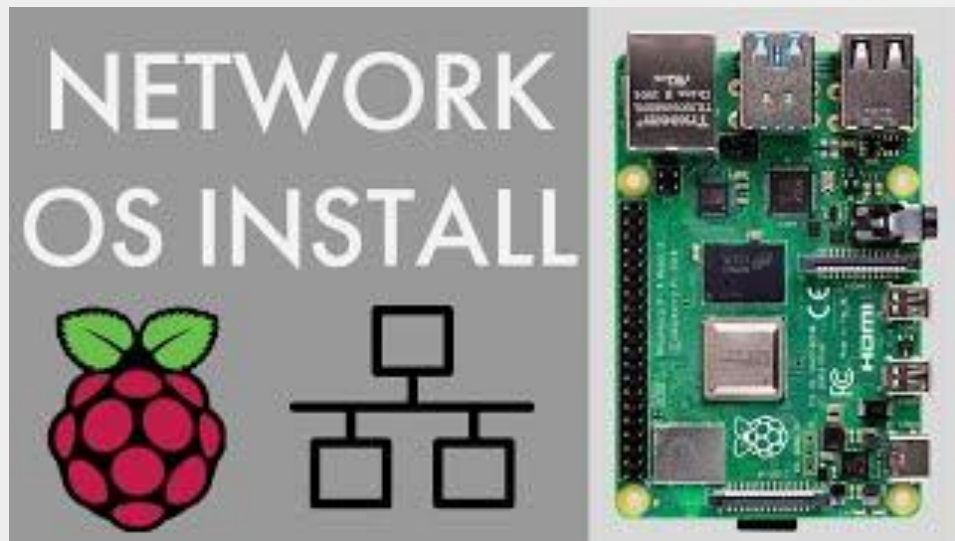
# Network Boot: the easy way (2)



## Install over the network

Network Install enables a Raspberry Pi to install an operating system on a storage device using a version of Raspberry Pi Imager downloaded over the network. With Network Install, you can get an operating system installed on your Raspberry Pi with no separate SD card reader and no computer other than your Raspberry Pi. You can run Network Install on any compatible storage device, including SD cards and USB storage.

Network Install only runs on Raspberry Pi 4, 400, and 5. If your Raspberry Pi runs an older bootloader, you may need to update the bootloader to use Network Install.



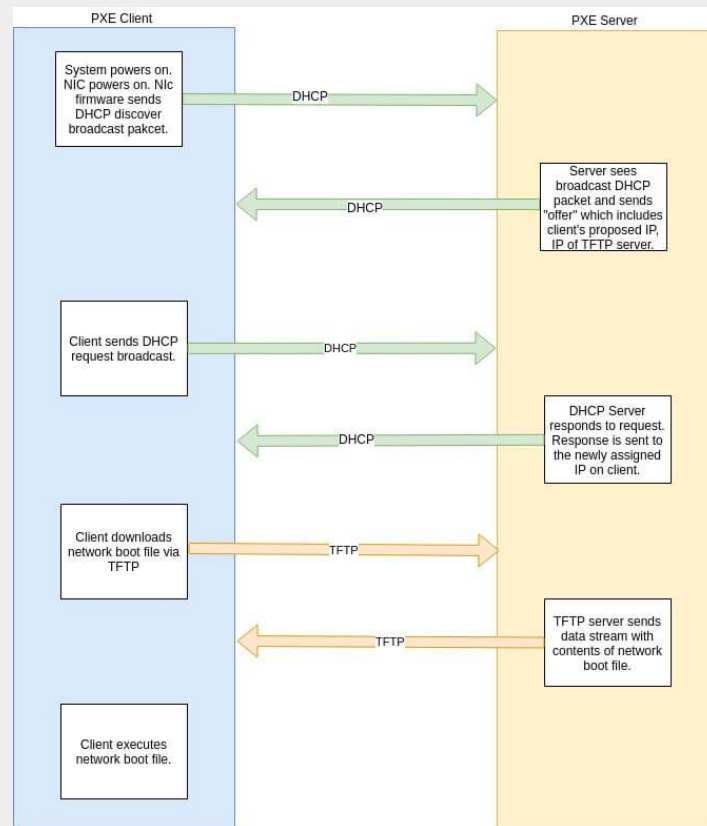


# What is PXE? (simplified)

1. Computer **boots up**
2. Computer **asks for DHCP**
3. **DHCP gives** IP + PXE information
4. Computer **gets PXE file**
5. Computer **boots PXE file**

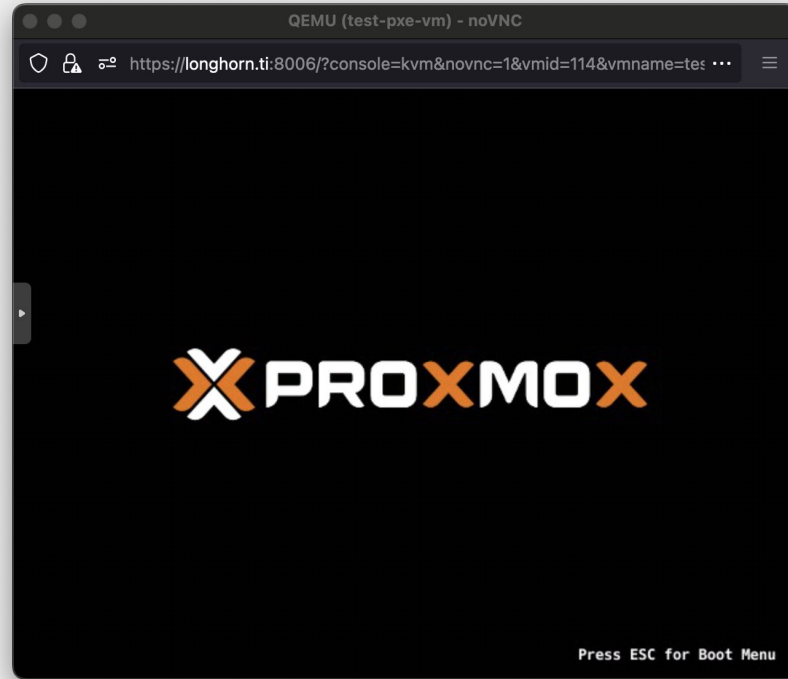
## Why?

Unlike previously seen solutions,  
**PXE** is relatively **standard**





# Network Boot: the difficult way (PXE)



# Network Boot: the difficult way (PXE)

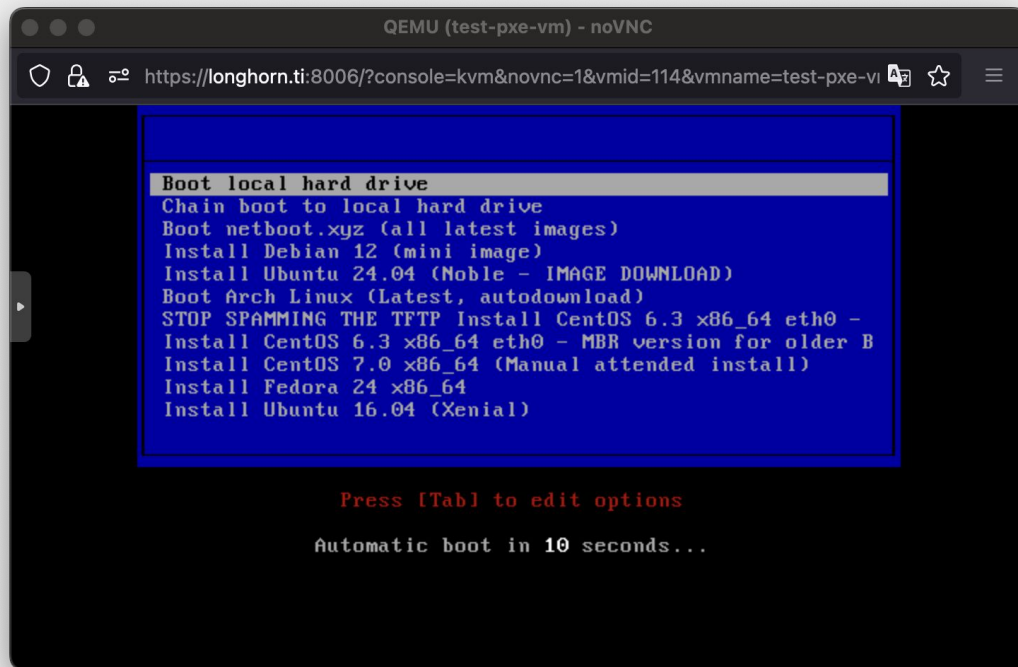


```
QEMU (test-pxe-vm) - noVNC
https://longhorn.ti:8006/?console=kvm&novnc=1&vmid=114&vmname=test-pxe-vm
SeaBIOS (version rel-1.16.2-0-gea1b7a073390-prebuilt.qemu.org)
Machine UUID 7c9140f4-c8e9-4c08-8b38-310ed0e81b16
Booting from ROM...
iPXE (PCI 00:12.0) starting execution...ok
iPXE initialising devices...ok

iPXE 1.20.1+ (g4bd0) -- Open Source Network Boot Firmware -- http://ipxe.org
Features: DNS HTTP iSCSI TFTP AoE ELF MBOOT PXE bzImage Menu PXEXT

net0: bc:24:11:19:f5:1a using virtio-net on 0000:00:12.0 (open)
[Link:up, TX:0 TXE:0 RX:0 RXE:0]
Configuring (net0 bc:24:11:19:f5:1a)...
```

# Network Boot: the difficult way (PXE)



# Network Boot: the difficult way (PXE)



QEMU (test-pxe-vm) - noVNC

https://longhorn.ti:8006/?console=kvm&novnc=1&vmid=114&vmname=test-pxe-vi

```
Boot local hard drive
Chain boot to local hard drive
Boot netboot.xyz (all latest images)
Install Debian 12 (mini image)
Install Ubuntu 24.04 (Noble - IMAGE DOWNLOAD)
Boot Arch Linux (Latest, autodownload)
STOP SPAMMING THE TFTP Install CentOS 6.3 x86_64 eth0 -
Install CentOS 6.3 x86_64 eth0 - MBR version for older B
Install CentOS 7.0 x86_64 (Manual attended install)
Install Fedora 24 x86_64
Install Ubuntu 16.04 (Xenial)
```

Press [Tab] to edit options

Automatic boot in 10 seconds...

# Network Boot: the difficult way (PXE)



The image shows a QEMU virtual machine window titled "QEMU (test-pxe-vm) - noVNC". The browser address bar shows "https://longhorn.ti:8006/?console=kvm&novnc=1&vmid=1148". The main console area displays a blue boot menu with the following options:

- Boot local hard drive
- Chain boot to local hard drive
- Boot netboot.xyz (all latest images)
- Install Debian 12 (mini image)
- Install Ubuntu 24.04 (Noble - IMAGE DOWNLOADED)
- Boot Arch Linux (Latest, autodownload)
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- Install CentOS 7.0 x86\_64 (Manual attended install)
- Install Fedora 24 x86\_64
- Install Ubuntu 16.04 (Xenial)

Below the menu, it says "Press [Tab] to edit options" and "Automatic boot in 10 seconds.".

Overlaid on the right is a terminal window titled "ttaiclet - ssh root@10.209.60.14 - 79x24". The terminal shows the following commands and output:

```
root@techinc-pxeboot:~/tftpboot# head pxelinux.cfg/default -n 22
default menu.c32
prompt 0
timeout 100
ONTIMEOUT chainlocal

LABEL local
    MENU LABEL Boot local hard drive
    LOCALBOOT 0

LABEL chainlocal
    MENU LABEL Chain boot to local hard drive
    KERNEL chain.c32
    APPEND hd0

LABEL netbootxyz
    MENU LABEL Boot netboot.xyz (all latest images)
    KERNEL images/netbootxyz/netboot.xyz.lkrn

LABEL Debian-12
    MENU LABEL Install Debian 12 (mini image)
    KERNEL images/debian/bookworm/debian-installer/amd64/linux
    INITRD images/debian/bookworm/debian-installer/amd64/initrd
root@techinc-pxeboot:~/tftpboot#
```

# Network Boot: the difficult way (PXE)



QEMU (test-pxe-vm) - noVNC

<https://longhorn.ti:8006/?console=kvm&novnc=1&vmid=1148>

Boot local hard drive  
Chain boot to local hard drive  
Boot netboot.xyz (all latest images)  
Install Debian 12 (mini image)  
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Install Fedora 24 x86\_64  
Install Ubuntu 16.04 (Xenial)

Press [Tab] to edit options

Automatic boot in 10 seconds.

root@techinc-pxeboot:~/tftpboot# head pxelinux.cfg/default -n 22  
default menu.c32  
prompt 0  
timeout 100  
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LABEL local  
MENU LABEL Boot local hard drive  
LOCALBOOT 0

LABEL chainlocal  
MENU LABEL Chain boot to local hard drive  
KERNEL chain.c32  
APPEND hd0

LABEL netbootxyz  
MENU LABEL Boot netboot.xyz (all latest images)  
KERNEL images/netbootxyz/netboot.xyz.lkrn

LABEL Debian-12  
MENU LABEL Install Debian 12 (mini image)  
KERNEL images/debian/bookworm/debian-installer/amd64/linux  
INITRD images/debian/bookworm/debian-installer/amd64/initrd

root@techinc-pxeboot:~/tftpboot#

# PXE: Setup (1)



## Set up DHCP server

On the Server, we need to set up a DHCP server.

Current best practice seems to be to use the package  [isc-dhcp-server](#), which provides a daemon

Its configuration file is `/etc/dhcp/dhcpd.conf`. Modify this file so that it contains about the following; a

```
default-lease-time 600;
max-lease-time 7200;

allow booting;

# in this example, we serve DHCP requests from 192.168.0.(3 to 253)
# and we have a router at 192.168.0.1
subnet 192.168.0.0 netmask 255.255.255.0 {
    range 192.168.0.3 192.168.0.253;
    option broadcast-address 192.168.0.255;
    option routers 192.168.0.1; # our router
    option domain-name-servers 192.168.0.1; # our router has DNS functionality
    next-server 192.168.0.2; # our Server
    filename "pxelinux.0"; # setting a default, might be wrong for "non defaults"
}
```

## Set up TFTP server

Next, we need to set up a TFTP server on the Server.

Again, there are several packages that provide TFTP (trivial FTP, unsafe, to be used in LAN's only). It seems best practice to use the `atftpd-hpa` package. The response to these questions goes into a configuration file, `/etc/default/tftpd-hpa`. There should be no need to modify the following default

```
TFTP_USERNAME="tftp"
TFTP_DIRECTORY="/srv/tftp"
TFTP_ADDRESS="0.0.0.0:69"
TFTP_OPTIONS="--secure"
```

Ignore older Web sites that instruct you to insert something like `'RUN_DAEMON="yes"'`.

After each modification of the above configuration file, restart the TFTP server with

```
# /etc/init.d/tftpd-hpa restart
```

or

```
# systemctl restart tftpd-hpa
```

On Jessie, the directory `/srv/tftp` will be automatically created. This means the next two steps are not necessary if you use Jessie.

Initially, on pre-Jessie versions, restarting the TFTP server might fail with a message like

## PXE: Setup (2)



“Simply put **these files** in your TFTP server, including all the **pxelinux** files”

OK, but I want to have **more control** over it

### Index of /debian/dists/bookworm/main/installer-amd64/current/images/netboot/debian-installer/amd64

<u>Name</u>	<u>Last modified</u>	<u>Size</u>
<a href="#">Parent Directory</a>	-	-
<a href="#">boot-screens/</a>	2024-08-27 22:35	-
<a href="#">bootnetx64.efi</a>	2024-08-27 22:35	938K
<a href="#">grub/</a>	2024-08-27 22:35	-
<a href="#">grubx64.efi</a>	2024-08-27 22:35	3.7M
<a href="#">initrd.gz</a>	2024-08-27 22:35	39M
<a href="#">linux</a>	2024-08-27 22:35	7.8M
<a href="#">pxelinux.0</a>	2024-08-27 22:35	41K
<a href="#">pxelinux.cfg/</a>	2024-08-27 22:35	-

Apache Server at ftp.debian.org Port 80

-> **Do it yourself**



## PXE: Setup (3)



```
pxelinux/oldstable,now 3:6.04~git20190206.bf6db5b4+dfsg1-3 all [installed]
collection of bootloaders (PXE network bootloader)

syslinux/oldstable,now 3:6.04~git20190206.bf6db5b4+dfsg1-3+b1 amd64 [installed]
collection of bootloaders (DOS FAT and NTFS bootloader)

syslinux-common/oldstable,now 3:6.04~git20190206.bf6db5b4+dfsg1-3 all [installed,automatic]
collection of bootloaders (common)
```

```
cp /usr/lib/PXELINUX/pxelinux.0 ./
cp /usr/lib/syslinux/modules/bios/chain.c32 ./
cp /usr/lib/syslinux/modules/bios/menu.c32 ./
cp /usr/lib/syslinux/modules/bios/mboot.c32 ./
cp /usr/lib/syslinux/modules/bios/pxechn.c32 ./
399,1 80%
```



Return a **different file**,  
depending on the  
**architecture option**  
(DHCP option)

## 4 Setting Up DHCP Services



Go into YaST and select **DHCP Server** from network services. Configure the IP range you want to use. After that, it is your choice on whether you use YaST or edit the configuration file ( `/etc/dhcpd.conf` ) manually. As with the other services, be sure to open the ports in the firewall. The end result needs to be a file that looks like the below:

```
option domain-name "my.lab";
option domain-name-servers 172.16.253.5;
option routers 192.168.124.1;
option ntp-servers 192.168.124.3;
option arch code 93 = unsigned integer 16; # RFC4578
default-lease-time 3600;
ddns-update-style none;
subnet 192.168.124.0 netmask 255.255.255.0 {
    range 192.168.124.100 192.168.124.199;
    next-server 192.168.124.3;
    default-lease-time 3600;
    max-lease-time 3600;
    if option arch = 00:07 or option arch = 00:09 {
        filename "/EFI/x86/bootx64.efi";
    } else if option arch = 00:0b {
        filename "/EFI/armv8/bootaa64.efi";
    } else {
        filename "/bios/x86/pxelinux.0";
    }
}
```



**Note:** if option arch

The `if option arch` sections allow the DHCP server to make the correct decision on which file to use for booting.



Image you boot into

- **all the OSeS** you might want
- Linux **installers**
  - Linux **Live CDs**
  - **BSDs** (FreeBSD, OpenBSD)
  - **Windows** (needs setup, see docs)
    - uses Windows PE
    - needs SMB

- allows you to boot **latest version**
- can be put on **USB stick**

```
netboot.xyz v2.x - next-server: 10.209.60.14

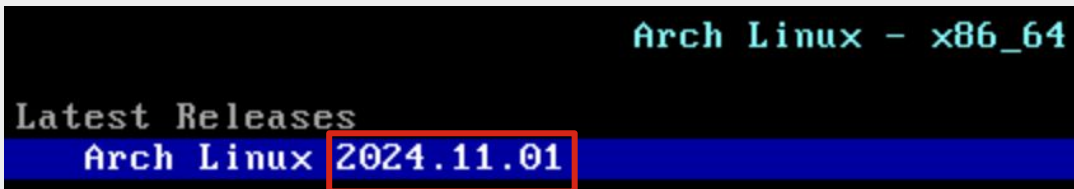
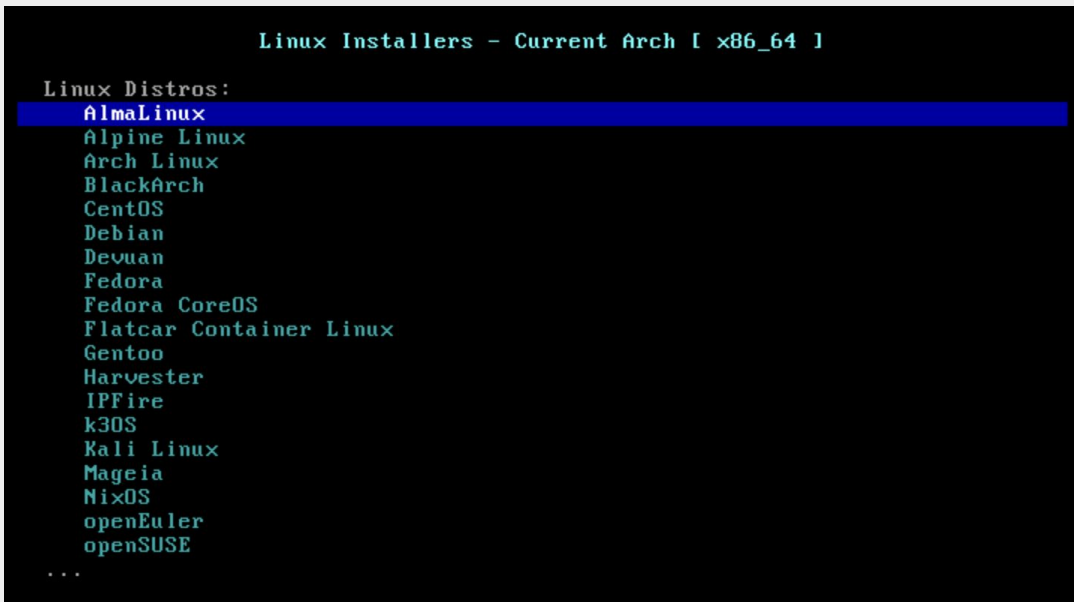
Default:
  Boot from local hdd
Distributions:
  Linux Network Installs (64-bit)
  Live CDs
  BSD Installs
  Unix Network Installs
  FreeDOS
  Windows
Tools:
  Utilities (64-bit)
  Architecture: x86_64
  iPXE shell
  Network card info
  PCI Device List
  About netboot.xyz
Signature Checks:
  netboot.xyz [ enabled: true ]
```



Image you boot into

- **all the OSeS** you might want
- Linux **installers**
  - Linux **Live CDs**
  - **BSDs** (FreeBSD, OpenBSD)
  - **Windows** (needs setup, see docs)
    - uses Windows PE
    - needs SMB

- allows you to boot **latest version**
- can be put on **USB stick**





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# Live demo ?



# Questions & Comments



[trix@c3l.lu](mailto:trix@c3l.lu)



“And the result follows, **the intermediary steps** are **trivial** and **obvious** and as such, **are left as an exercise to the reader.**”



The simple (and dirty) steps to setup PXE are as follows:

1. Setup a TFTP server (slide 15)
2. Configure the DHCP server to return the TFTP server and pxelinux.0 path. (slide 15)
3. Install packages and copy over files to TFTP root (slide 17)
4. Create configuration file "pxelinux.cfg/default" at the root of the TFTP server. A full example at slide 13, basic example:

```
default menu.c32
prompt 0
timeout 100
```

```
LABEL local
    MENU LABEL Boot local hard drive
    LOCALBOOT 0
```