

# CS 460

# Operating Systems

## Linux Boot Process

## Arch Linux

# Questions

- Kernel vs Root vs User
- makefile
- ???

# Resources

[https://wiki.archlinux.org/index.php/Arch\\_boot\\_process](https://wiki.archlinux.org/index.php/Arch_boot_process)

<https://doc.opensuse.org/documentation/leap/reference/html/book.opensuse.reference/cha.boot.html>

<https://doc.opensuse.org/documentation/leap/reference/html/book.opensuse.reference/cha.systemd.html>

<http://www.thegeekstuff.com/2011/02/linux-boot-process> (a bit dated)

<https://www.freedesktop.org/wiki/Software/systemd/>

<https://wiki.archlinux.org/index.php/systemd>

<https://opensource.com/article/18/1/analyzing-linux-boot-process>

<https://0xax.gitbooks.io/linux-insides/content/> <https://0xax.github.io>

# Process - Linux

- POST
- BIOS/UEFI
  - disk partitions
  - file hierarchy standard
- Boot Loader
- Kernel
- initramfs
- init process
- Display Manager / Getty

# POST

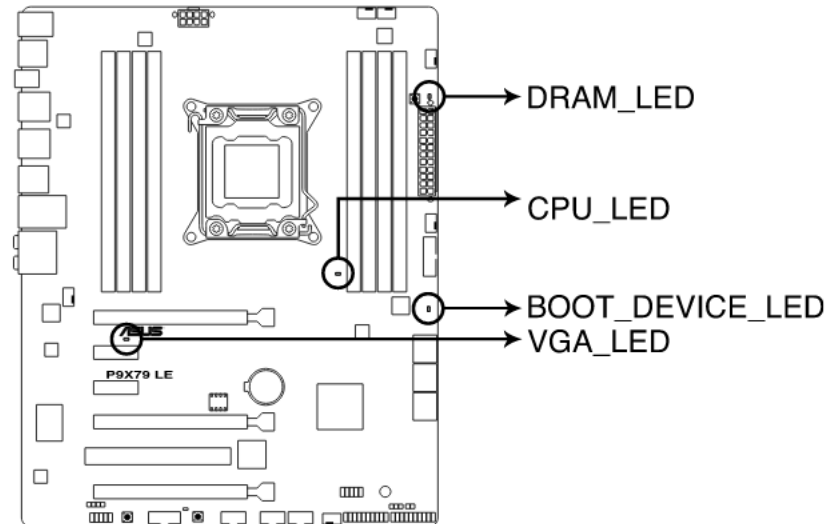
- Power On Self Test
  - firmware on motherboard does check of the hardware
  
- Common failures

# Zeus Motherboard Manual

- [http://dlcdnet.asus.com/pub/ASUS/mb/LGA2011/P9X79-LE/E8039\\_P9X79\\_LE.pdf](http://dlcdnet.asus.com/pub/ASUS/mb/LGA2011/P9X79-LE/E8039_P9X79_LE.pdf)

## Q-LEDs

These ID LEDs of CPU, DRAM, VGA card, and HDD indicate key component status during POST (Power-on Self Test), providing an elegant embellishment to the motherboard design. The LED lights will flash sequentially during system bootup. If an error is found, the LED next to the error device will continue lighting until the problem is solved. This user-friendly design provides an intuitional way to locate the root problem within a second.



**P9X79 LE CPU/ DRAM/  
BOOT\_DEVICE/ VGA LED**

BIOS Beep	Description
One short beep	VGA detected Quick boot set to disabled No keyboard detected
One continuous beep followed by two short beeps then a pause (repeated)	No memory detected
One continuous beep followed by three short beeps	No VGA detected
One continuous beep followed by four short beeps	Hardware component failure

# BIOS/UEFI

- Main job: launch the boot loader
- BIOS
  - basic input/output system
- UEFI
  - Unified Extensible Firmware Interface
  - can handle larger boot disks
  - 32bit or 64 bit mode (larger address space)
  - **Secure boot (don't panic)**
  - can have network capabilities
  - shell

# Master Boot Record

- First 512 bytes of a device
- Boot loader
- Partition Table
- Used by BIOS
- Partition Types
  - Primary: Bootable (max of 4, max of 3 if extended partition exists)
  - Extended: contains logical partitions (max of 1 extended partition)
    - Logical: the actual partition (not bootable)
    - unlimited number










<http://thestarman.pcministry.com/asm/mbr/GRUB.htm>



# GUID Partition Table

- Used by UEFI
- Replaces MBR
- Bigger disks
- “Unlimited” number of partitions (128 easily)
- Better recover options
- Used GUID
  - Globally Unique ID or UUIDs to define partition types
- Backwards compatible with MBR-based software

# Zeus

Device	Size	F	Enc	Type	FS Type	Label	Mount Point
/dev/sda	3.64 TB			 WDC-WD4001FAEX-0			
/dev/sda1	156.00 MB			 EFI boot	FAT		/boot/efi
/dev/sda2	4.00 GB			 Linux swap	Swap		swap
/dev/sda3	500.00 GB			 Linux native	Ext4		/
/dev/sda4	250.00 GB			 Linux native	Ext4		/tmp
/dev/sda5	1.00 TB			 Linux native	Ext4		/var
/dev/sda6	1.90 TB			 Linux native	Ext4		/data
/dev/sdb	1.36 TB			 WDC-WD1502FAEX-0			
/dev/sdb1	1.36 TB			 Linux native	Ext4		/home

Same information can be obtained with: `df -h`

# zeus /etc/fstab

```
/dev/sda2 swap          swap          defaults          0 0
/dev/sda3 /                    ext4          acl,user_xattr    1 1
/dev/sda1 /boot/efi            vfat          umask=0002,utf8=true 0 0
/dev/sda6 /data              ext4          acl,user_xattr    1 2
/dev/sdb1 /home              ext4          acl,user_xattr    1 2
/dev/sda4 /tmp              ext4          rw,noexec,nosuid,nodev,acl,user_xattr 1 2
/dev/sda5 /var              ext4          acl,user_xattr    1 2
```

# Filesystem Hierarchy Standard

- /
- /bin
- /sbin
- /usr
  - /bin
  - /include
- /lib
- /dev
- /etc
- /home
- /var
- /tmp

Symbolic Link

In -s src dest

[https://wiki.archlinux.org/index.php/Frequently\\_asked\\_questions](https://wiki.archlinux.org/index.php/Frequently_asked_questions) FHS

<https://jlk.fjfi.cvut.cz/arch/manpages/man/file-hierarchy.7>

[https://refspecs.linuxfoundation.org/FHS\\_3.0/fhs-3.0.pdf](https://refspecs.linuxfoundation.org/FHS_3.0/fhs-3.0.pdf)

# Zeus /boot/efi

<http://blog.learningtree.com/how-does-linux-boot-part-3-uefi-to-shim-to-the-next-link-in-the-chain/>  
<http://www.rodsbooks.com/efi-bootloaders/secureboot.html>

```
chadd@zeus:/boot/efi/EFI/opensuse> ls
total 3524
drwxrwxr-x 2 root root 4096 Feb 9 2015 .
drwxrwxr-x 4 root root 4096 Feb 9 2015 ..
-rwxrwxr-x 1 root root 1283752 Oct 31 2016 MokManager.efi
-rwxrwxr-x 1 root root 58 Oct 31 2016 boot.csv
-rwxrwxr-x 1 root root 125 Oct 31 2016 grub.cfg
-rwxrwxr-x 1 root root 887416 Oct 31 2016 grub.efi
-rwxrwxr-x 1 root root 121344 Oct 31 2016 grubx64.efi
-rwxrwxr-x 1 root root 1294048 Oct 31 2016 shim.efi
```

- UEFI→shim.efi→grubx64.efi
  - shim.efi is signed
- read grub.cfg (points to /boot/grub2/grub.cfg)
- Machine Owner Key: Mok
  - use to sign your own kernels

# Boot loader

- Load the OS Kernel into memory and go
  - provide parameters to the kernel
  - initial RAM disk: initramfs or initrd
- Windows has its own boot loader
  - can be invoked via the Linux boot loader on a dual boot machine
- Linux has many boot loader options
  - **GRUB**, LILO, Syslinux

```
grub-install /dev/sda
```

```
grub-mkconfig -o /boot/grub/grub.cfg
```

# Kernel

- /boot/vmlinuz
  - kernel space
- mounts initial filesystem
- runs init

# initramfs / initrd

- Initial RAM file system
  - Previously initrd (Still is in OpenSUSE)
  - initial RAM disk
- contains device drivers to mount actual root file system
  - /dev/sda1
    - `lsinitcpio /boot/initramfs-linux.img`
    - `lsinitrd /boot/initrd`

<https://www.kernel.org/doc/Documentation/filesystems/ramfs-rootfs-initramfs.txt>



- Early user space
  - mount root file system
  - Kernel runs /init from initramfs
  - kernel swaps initramfs out for real root file system
- Replace /init with /sbin/init
  - from hard drive

<https://web.archive.org/web/20150430223035/http://archlinux.me/brain0/2010/02/13/early-userspace-in-arch-linux/>

# systemd

- /sbin/init
- bring the rest of the system up
  - starts various packages in parallel
  - long running daemons (sshd, httpd, submit (cs300))
- SysV init
  - old style
- systemd
  - new style

<https://freedesktop.org/wiki/Software/systemd/>

Rationale:

<https://bbs.archlinux.org/viewtopic.php?pid=1149530#p1149530>

# systemd

- `systemctl [enable|disable|start|stop] sshd`
- `journalctl`
  - k show only kernel messages
  - b show only messages from the most recent boot
  - u *sshd* show only sshd messages

# unit files

```
chadd@zeus:~> systemctl status  
chadd@zeus:~> cat /lib/systemd/system/submitServer.service
```

```
[Unit]  
Description=Submit Server  
  
[Service]  
Type=simple  
ExecStart=/usr/local/bin/submitServer  
  
[Install]  
WantedBy=multi-user.target
```

Task:  
In Arch Linux, find the atd.service file

# dmesg

- Get kernel messages

# dbus (D-Bus)

- Desktop Bus
  - just a standard
  - many implementations
- daemon
- interprocess communication and remote procedure call
- allows software to provide services to other software
  - sound, networking, ...
  - privilege separation
- One system bus
- Many session bus(es) (1 per user logged in)

# getty

- virtual terminals
  - generally 6
- Alt-F#
  - at console
- Control-Alt-F#
  - within the window manager
- Alt-F7
  - GUI/Window Manager
- console login prompt

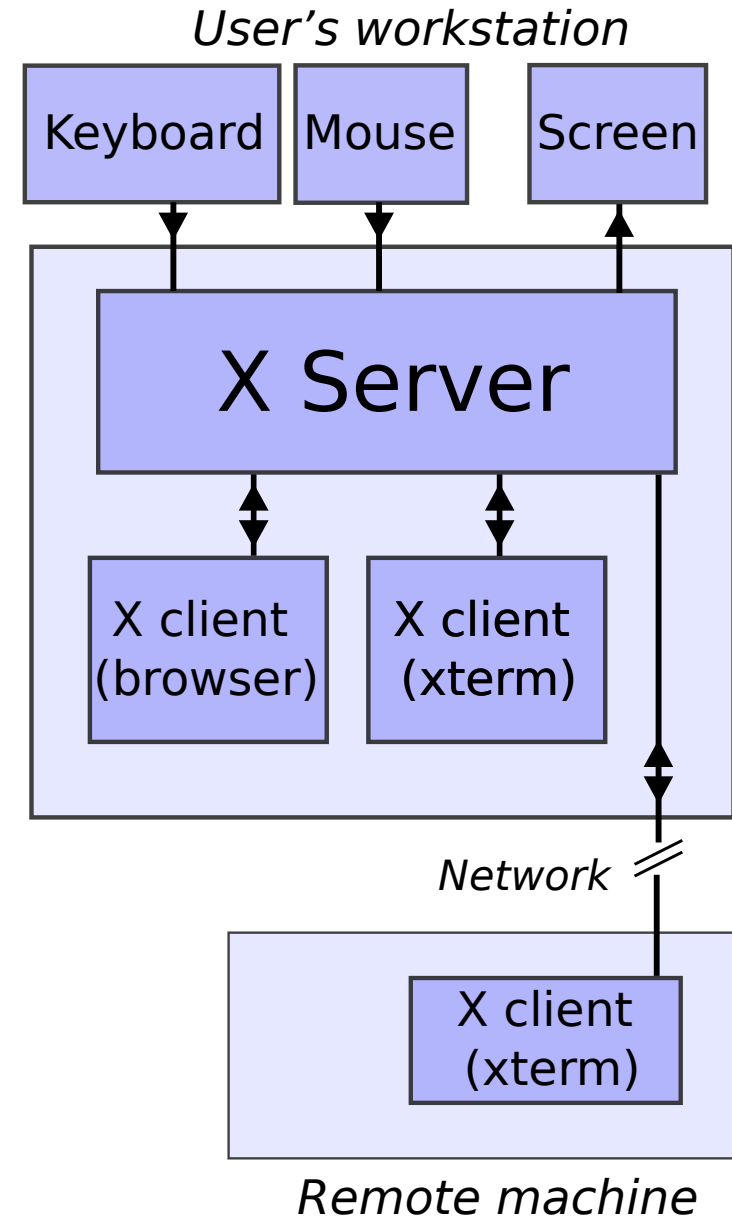
# Display Manager

- GUI Login manager
  - lightdm
  - lxdm
  - sddm
  - gdm
  - xdm
- Logs you into a shell
  - command line interface
- Shell can optionally start a window manager
  - xinit or startx or *startxfce4*



# X Server / Wayland

- X Protocol
  - version 11
  - X11
- Wayland
  - not strictly a replacement for X11



[http://www.linfo.org/x\\_server.html](http://www.linfo.org/x_server.html)

[https://en.wikipedia.org/wiki/File:X\\_client\\_server\\_example.svg](https://en.wikipedia.org/wiki/File:X_client_server_example.svg)



# Other servers

- sshd
- ntpd
- dhcpd
- atd

# Shell

- command line interface
- Many to choose from, all with different features
- bash
- zsh
- csh
- korn
- Powershell
  - originally for Windows

<https://www.ibm.com/developerworks/linux/library/l-linux-shells/index.html>

# Commands

- sudo
- lspci
- ping
- lsmod
- ip link
- ip addr

# Shell Programming

- Unix Philosophy (via Peter H. Salus):
  - Write programs that **do one thing and do it well.**
  - Write programs to work together.
  - Write programs to handle text streams, because that is a universal interface.
- 

Criticism:

[http://www.bradleymonk.com/File:The\\_truth\\_about\\_Unix\\_Don\\_Norman.pdf](http://www.bradleymonk.com/File:The_truth_about_Unix_Don_Norman.pdf)