06-3 Userspace Initialization

Chapter 6

Initialization

- Chapter 5 – Kernel Initialization
- Chapter 6 – Userspace Initialization

Chapter 6 - Userspace Initialization

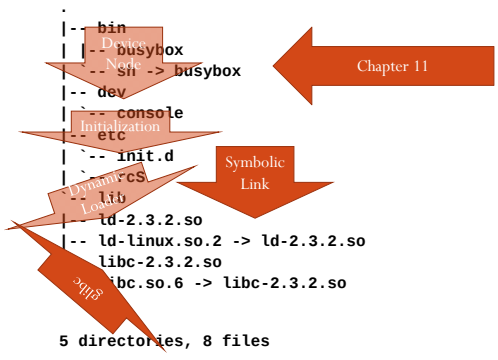
- At startup
  - Kernel initializes
  - Mounts a root file system
  - Executes set of initialization routines
- We'll start with a minimal filesystem and build on it

Root File System: Top-Level Directories

```
host$ tree
/
|-- bin
|-- dev
|-- etc
|-- home
|-- lib
|-- sbin
|-- usr
|-- var
`-- tmp
```

Directory	Contents
bin	Binary executables, usable by all users on the system
dev	Device nodes (see Chapter 8, "Device Driver Basics")
etc	Local system configuration files
home	User account files
lib	System libraries, such as the standard C library and many others
sbin	Binary executables usually reserved for superuser accounts on the system
usr	A secondary file system hierarchy for application programs, usually read-only
var	Contains variable files, such as system logs and temporary configuration files
tmp	Temporary files

Minimal File System (Listing 6-1)




```
.
|-- bin
|   |-- busybox
|   `-- sh -> busybox
|-- dev
|   `-- console
|-- etc
|   `-- init.d
|       `-- rcS
|-- lib
|   |-- ld-2.3.2.so
|   |-- ld-linux.so.2 -> ld-2.3.2.so
|   |-- libc-2.3.2.so
|   `-- libc.so.6 -> libc-2.3.2.so
|-- sbin
`-- usr

5 directories, 8 files
```

The Embedded Root FS Challenge

- Don't have large hard drive or flash storage
- Hard to tell what depends on what
- Two approaches
  - Trial-and-Error
  - Automated
    - **bitbake** (www.openembedded.org)
    - Buildroot (http://buildroot.uclibc.org/)

Kernel's Last Boot Steps (.../init/main.c)

```
   if (execute_command) {
         run_init_process(execute_command);
         printk(KERN_WARNING "Failed to execute %s.  Attempting "
                                  "defaults...\n", execute_command);
   }
   run_init_process("/sbin/init");
   run_init_process("/etc/init");
   run_init_process("/bin/init");
   run_init_process("/bin/sh");

   panic("No init found.  Try passing init= option to kernel.");
}

// 2.6.32
```

Kernel's Last Boot Steps (.../init/main.c)

```
         /*
         * We try each of these until one succeeds.
         *
         * The Bourne shell can be used instead of init if we are
         * trying to recover a really broken machine.
         */
        if (execute_command) {
               run_init_process(execute_command);
               printk(KERN_WARNING "Failed to execute %s.  Attempting "
                                        "defaults...\n", execute_command);
        }
        run_init_process("/sbin/init");
        run_init_process("/etc/init");
        run_init_process("/bin/init");
        run_init_process("/bin/sh");

        panic("No init found.  Try passing init= option to kernel. "
              "See Linux Documentation/init.txt for guidance.");

// 3.2.18
```

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- Final sequence of events for the kernel thread called **`kernel_init`** spawned by the kernel during the final stages of boot
- **`run_init_process()`** is a small wrapper around the **`execve()`** function, which is a kernel system call
- **`execve()`** function *never returns* if no error conditions
- Memory space in which the calling thread is executing from is overwritten by the called program's memory image
- In effect, the called program directly replaces the calling thread, including inheriting its Process ID (PID)

Kernel's Last Boot Steps

```
   if (execute_command) {
         run_init_process(execute_command);
         printk(KERN_WARNING "Failed to execute %s.  Attempting "
                                  "defaults...\n", execute_command);
   }
   run_init_process("/sbin/init");
   run_init_process("/etc/init");
   run_init_process("/bin/init");
   run_init_process("/bin/sh");

   panic("No init found.  Try passing init= option to kernel.");
}
```

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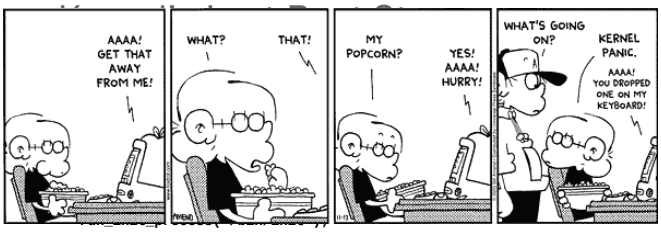
- This is the start of user space processing
- Unless the kernel is successful in executing one of these processes, the kernel will halt, displaying the message passed in the **`panic()`** system call
- If you have been working with embedded systems for any length of time, and especially if you have experience working on root file systems, you are more than familiar with this kernel **`panic()`** and its message!
- If you search on Google for this **`panic()`** error message, you will find page after page of hits for this FAQ.
- When you complete this chapter, you will be an expert at troubleshooting this common failure.




```
   run_init_process("/bin/sh");

   panic("No init found.  Try passing init= option to kernel.");
}
```

First User Space Program

- Most systems: **`/sbin/init`** is spawned.

```
|-- bin
| |-- busybox
| '-- sh -> busybox
|-- dev
| '-- console
|-- etc
| '-- init.d
| '-- rcS
'-- lib
|-- ld-2.3.2.so
|-- ld-linux.so.2 -> ld-2.3.2.so
|-- libc-2.3.2.so
'-- libc.so.6 -> libc-2.3.2.so
```

```
run_init_process("/sbin/init");
run_init_process("/etc/init");
run_init_process("/bin/init");
run_init_process("/bin/sh");
```

Busybox is run as the initial process

Resolving Dependencies

- You can't put just any program as **`init`**
- There may be dependencies

```
host$ ldd a.out
linux-gate.so.1 =>  (0x002df000)
libc.so.6 => /lib/tls/i686/cmov/libc.so.6 (0x00da8000)
/lib/ld-linux.so.2 (0x00a92000)
```

- To do: find cross version of ldd.

Customized Initial Process

```
console=ttyS0,115200 ip=bootp
  root=/dev/nfs init=/sbin/myinit
```

The `init` process

- Use standard **`init`**
- Reads **`/etc/inittab`**

```
# /etc/inittab: init(8) configuration.
# $Id: inittab,v 1.91 2002/01/25 13:35:21 miquels Exp $

# The default runlevel.
id:5:initdefault:

# Boot-time system configuration/initialization script.
# This is run first except when booting in emergency (-b) mode.
si::sysinit:/etc/init.d/rcS
```

The `init` process

```
# What to do in single-user mode.
~~:S:wait:/sbin/sulogin

# /etc/init.d executes the S and K scripts upon change
# of runlevel.
#

l0:0:wait:/etc/init.d/rc 0
l1:1:wait:/etc/init.d/rc 1
l2:2:wait:/etc/init.d/rc 2
l3:3:wait:/etc/init.d/rc 3
l4:4:wait:/etc/init.d/rc 4
l5:5:wait:/etc/init.d/rc 5
l6:6:wait:/etc/init.d/rc 6
```

The `init` process

```
# Normally not reached, but fallthrough in case of emergency.
z6:6:respawn:/sbin/sulogin
S:2345:respawn:/sbin/getty 115200 ttyS2
# /sbin/getty invocations for the runlevels.
#
# The "id" field MUST be the same as the last
# characters of the device (after "tty").
#
# Format:
#  <id>:<runlevels>:<action>:<process>
#

1:2345:respawn:/sbin/getty 38400 tty1
```

Runlevels

Runlevel	Purpose
0	System shutdown (halt)
1	Single-user system configuration for maintenance
2	User defined
3	General purpose multiuser configuration
4	User defined
5	Multiuser with graphical user interface on startup
6	System restart (reboot)

- Runlevel scripts are found in **`/etc/rc.d/init.d/`**
- or **`/etc/init.d/`**

NFS Restart

```
$ /etc/rc.d/init.d/nfs restart
Shutting down NFS mountd: [ OK ]
Shutting down NFS daemon: [ OK ]
Shutting down NFS quotas: [ OK ]
Shutting down NFS services: [ OK ]
Starting NFS services: [ OK ]
Starting NFS quotas: [ OK ]
Starting NFS daemon: [ OK ]
Starting NFS mountd: [ OK ]
```

Runlevel Directory Structure on Beagle

```
beagle$ ls -dl /etc/rc*
drwxr-xr-x 2 root root 4096 Mar 13 20:18 /etc/rc0.d
drwxr-xr-x 2 root root 4096 Mar 13 20:18 /etc/rc1.d
drwxr-xr-x 2 root root 4096 Mar 13 20:18 /etc/rc2.d
drwxr-xr-x 2 root root 4096 Mar 13 20:18 /etc/rc3.d
drwxr-xr-x 2 root root 4096 Mar 13 20:18 /etc/rc4.d
drwxr-xr-x 2 root root 4096 Mar 13 20:18 /etc/rc5.d
drwxr-xr-x 2 root root 4096 Mar 13 20:18 /etc/rc6.d
drwxr-xr-x 2 root root 4096 Mar 13 20:18 /etc/rcS.d
```

Example Runlevel Directory on Beagle

```
beagle$ ls -ls rc5.d/
total 0
0 lrwxrwxrwx 1 root root 20 Mar 13 20:18 S05led-config -> ../init.d/led-config
0 lrwxrwxrwx 1 root root 18 Mar 13 20:18 S10dropbear -> ../init.d/dropbear
0 lrwxrwxrwx 1 root root 14 Mar 13 20:18 S20apmd -> ../init.d/apmd
0 lrwxrwxrwx 1 root root 16 Mar 13 20:18 S20dbus-1 -> ../init.d/dbus-1
0 lrwxrwxrwx 1 root root 16 Mar 13 20:18 S20syslog -> ../init.d/syslog
0 lrwxrwxrwx 1 root root 22 Mar 13 20:18 S21avahi-daemon -> ../init.d/avahi-daen
0 lrwxrwxrwx 1 root root 17 Mar 13 20:18 S22connman -> ../init.d/connman
0 lrwxrwxrwx 1 root root 17 Mar 13 20:18 S30ntpdate -> ../init.d/ntpdate
0 lrwxrwxrwx 1 root root 20 Mar 13 20:18 S50usb-gadget -> ../init.d/usb-gadget
0 lrwxrwxrwx 1 root root 16 Mar 13 20:18 S99gpe-dm -> ../init.d/gpe-dm
0 lrwxrwxrwx 1 root root 19 Mar 13 20:18 S99rmnologin -> ../init.d/rmnologin
0 lrwxrwxrwx 1 root root 20 Mar  4 22:09 S99zzapsplash -> ../init.d/zzapsplash
```

Runlevel 5

```
beagle$ ls /etc/rc5.d | cat
K36cups
S02dbus-1
S05led-config
S10dropbear
S20apmd
```

```
INIT: Entering runlevel: 5
Starting system message bus: dbus.
Starting Hardware abstraction layer hald
Configuring leds:
  beagleboard::pmu_stat: none
  beagleboard::usr0: heartbeat
  beagleboard::usr1: mmc0
Starting Dropbear SSH server: dropbear.
Starting advanced power management
daemon: No APM support in kernel
(failed.)
```

Runlevel 5

```
S20cron
S20samba
S20syslog
S20xinetd
S21avahi-daemon
S28NetworkManager
S30pvr-init
S50system-tools-backends
S50usb-gadget
S81cups
S99gdm
S99rmnologin
```

```
Starting Vixie-cron.
Starting Samba: smbd nmbd.
Starting syslog-ng:.
Starting internet superserver:
xinetd.
 * Starting Avahi mDNS/DNS-SD
Daemon: avahi-daemon
[ ok ]
Starting Network connection
manager daemon: NetworkManager.
Starting PVR
cups: started scheduler.
Starting GNOME Display Manager
gdm
```

systemd

- init.d is not used on the bone
- systemd is used for user space initialization
- http://www.freedesktop.org/wiki/Software/systemd/
- Faster boot time by allowing initialization in parallel

systemctl

```
beagle $ systemctl
UNIT                        LOAD   ACTIVE SUB       JOB DESCRIPTION
proc-sys...misc.automount loaded active running       Arbitrary
Executable File Formats File System Automount Point
sys-devi...et-eth0.device loaded active plugged
/sys/devices/platform/cpsw.0/net/eth0
sys-devi...et-usb0.device loaded active plugged
/sys/devices/platform/omap/musb-ti81xx/musb-hdrc.0/gadget/net/usb0
sys-devi...cblk0p1.device loaded active plugged
/sys/devices/platform/omap/omap_hsmmc.0/mmc_host/mmc0/mmc0:1234/bl
ock/mmcblk0/mmcblk0p
sys-devi...cblk0p2.device loaded active plugged
/sys/devices/platform/omap/omap_hsmmc.0/mmc_host/mmc0/mmc0:1234/bl
ock/mmcblk0/mmcblk0p
sys-devi...mmcblk0.device loaded active plugged
/sys/devices/platform/omap/omap_hsmmc.0/mmc_host/mmc0/mmc0:1234/bl
ock/mmcblk0
```

systemctl

```
beagle $ systemctl
UNIT                        LOAD   ACTIVE SUB     JOB DESCRIPTION
sys-devi...y-ttyO0.device loaded active plugged   /sys/devices/platform/omap/omap_uart.0/tty/ttyO0
sys-devi...y-ttyO1.device loaded active plugged   /sys/devices/platform/omap/omap_uart.1/tty/ttyO1
sys-devi...y-ttyO2.device loaded active plugged   /sys/devices/platform/omap/omap_uart.2/tty/ttyO2
sys-devi...y-ttyO3.device loaded active plugged   /sys/devices/platform/omap/omap_uart.3/tty/ttyO3
sys-devi...y-ttyO4.device loaded active plugged   /sys/devices/platform/omap/omap_uart.4/tty/ttyO4
sys-devi...y-ttyO5.device loaded active plugged   /sys/devices/platform/omap/omap_uart.5/tty/ttyO5
sys-devi...y-ttyS0.device loaded active plugged   /sys/devices/platform/serial8250/tty/ttyS0
sys-devi...y-ttyS1.device loaded active plugged   /sys/devices/platform/serial8250/tty/ttyS1
sys-devi...y-ttyS2.device loaded active plugged   /sys/devices/platform/serial8250/tty/ttyS2
sys-devi...y-ttyS3.device loaded active plugged   /sys/devices/platform/serial8250/tty/ttyS3
sys-devi...et-sit0.device loaded active plugged   /sys/devices/virtual/net/sit0
sys-devi...ty-tty0.device loaded active plugged   /sys/devices/virtual/tty/tty0
sys-devi...y-tty1.device loaded active plugged   /sys/devices/virtual/tty/tty1
sys-devi...y-tty10.device loaded active plugged   /sys/devices/virtual/tty/tty10
sys-devi...y-tty11.device loaded active plugged   /sys/devices/virtual/tty/tty11
sys-devi...y-tty12.device loaded active plugged   /sys/devices/virtual/tty/tty12
sys-devi...ty-tty2.device loaded active plugged   /sys/devices/virtual/tty/tty2
sys-devi...ty-tty3.device loaded active plugged   /sys/devices/virtual/tty/tty3
sys-devi...ty-tty4.device loaded active plugged   /sys/devices/virtual/tty/tty4
sys-devi...ty-tty5.device loaded active plugged   /sys/devices/virtual/tty/tty5
sys-devi...ty-tty6.device loaded active plugged   /sys/devices/virtual/tty/tty6
sys-devi...ty-tty7.device loaded active plugged   /sys/devices/virtual/tty/tty7
sys-devi...ty-tty8.device loaded active plugged   /sys/devices/virtual/tty/tty8
sys-devi...ty-tty9.device loaded active plugged   /sys/devices/virtual/tty/tty9
-.mount                     loaded active mounted   /
dev-mqueue.mount            loaded active mounted   POSIX Message Queue File System
etc-machine\x2did.mount     loaded active mounted   /etc/machine-id
proc-sys...fmt_misc.mount loaded active mounted   Arbitrary Executable File Formats File System
sys-kernel-debug.mount      loaded active mounted   Debug File System
tmp.mount                   loaded active mounted   Temporary Directory
systemd-...d-console.path loaded active waiting   Dispatch Password Requests to Console Directory Watch
systemd-...word-wall.path loaded active waiting   Forward Password Requests to Wall Directory Watch
avahi-daemon.service        loaded active running   Avahi mDNS/DNS-SD Stack
bone101.service             loaded active running   Beaglebone 101 presentation
cape.service                loaded active exited    Beaglebone cape support
cloud9.service              loaded active running   Cloud9 IDE
connman.service             loaded active running   Connection service
console-...-start.service loaded active exited    Console System Startup Logging
crond.service               loaded active running   Periodic Command Scheduler
```

systemctl

```
beagle $ systemctl
UNIT                        LOAD   ACTIVE SUB       JOB DESCRIPTION
dbus.service                loaded active running       D-Bus System Message Bus
dropbear...:59238.service loaded active running       SSH Per-Connection Server
gateone.service             loaded active running       GateOne daemon
gdm.service                 loaded active running       Gnome Display Manager
getty@tty1.service          loaded active running       Getty on tty1
leds.service                loaded active exited        Angstrom LED config
network-...t-init.service loaded active exited        Start USB Ethernet gadget
pvr-init.service            loaded active exited        pvr-init.service
remount-rootfs.service      loaded active exited        Remount Root FS
serial-g...@ttyO0.service loaded active running       Serial Getty on ttyO0
systemd-journald.service    loaded active running       Journal Service
systemd-logind.service      loaded active running       Login Service
systemd-...s-load.service loaded active exited        Load Kernel Modules
systemd-...pi-vfs.service loaded active exited        Remount API VFS
```

systemctl

```
beagle $ systemctl
UNIT                        LOAD   ACTIVE SUB       JOB DESCRIPTION
systemd-sysctl.service      loaded active exited        Apply Kernel Variables
systemd-...-setup.service loaded active exited        Recreate Volatile Files and
Directories
systemd-...ssions.service loaded active exited        Permit User Sessions
timestamp.service           loaded active exited        Timestamping service
udev-trigger.service        loaded active exited        udev Coldplug all Devices
udev.service                loaded active running       udev Kernel Device Manager
udhcpd.service              loaded active running       DHCP server for USB0 network
gadget
xinetd.service              loaded active exited        xinetd.service
avahi-daemon.socket         loaded active listening     Avahi mDNS/DNS-SD Stack
Activation Socket
dbus.socket                 loaded active running       D-Bus System Message Bus
Socket
dropbear.socket             loaded active listening     dropbear.socket
systemd-initctl.socket      loaded active listening     /dev/initctl Compatibility
Named Pipe
systemd-journald.socket     loaded active running       Journal Socket
systemd-shutdownd.socket    loaded active listening     Delayed Shutdown Socket
```

systemctl

```
beagle $ systemctl
UNIT                      LOAD   ACTIVE SUB       JOB DESCRIPTION
udev-control.socket       loaded active listening     udev Control Socket
udev-kernel.socket        loaded active running       udev Kernel Socket
basic.target              loaded active active        Basic System
getty.target              loaded active active        Login Prompts
graphical.target          loaded active active        Graphical Interface
local-fs-pre.target       loaded active active        Local File Systems (Pre)
local-fs.target           loaded active active        Local File Systems
multi-user.target         loaded active active        Multi-User
remote-fs.target          loaded active active        Remote File Systems
sockets.target            loaded active active        Sockets
swap.target               loaded active active        Swap
sysinit.target            loaded active active        System Initialization
systemd-...es-clean.timer loaded active waiting       Daily Cleanup of Temporary Directories

LOAD   = Reflects whether the unit definition was properly loaded.
ACTIVE = The high-level unit activation state, i.e. generalization of SUB.
SUB    = The low-level unit activation state, values depend on unit type.
JOB    = Pending job for the unit.

86 units listed. Pass --all to see inactive units, too.
```