06-3 Userspace Initialization

Chapter 6

Initialization

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

Chapter 6 - Userspace Initialization

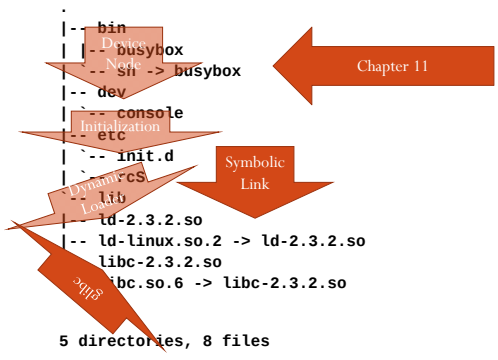
- At startup
  - Kernel initializes
  - Mounts a root file system
  - Executes set of initialization routines
- We'll start with a minimal filesystem and build on it

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 (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.");
}
```

Page 138

- 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)

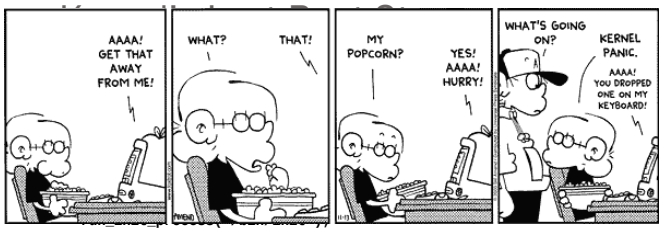
Kernel's Last Boot Steps

```
  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.");
}
```

Page 138 (cont.)

- 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 | 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
```