The Embedded Linux Quick Start Guide

# Kernel and user space

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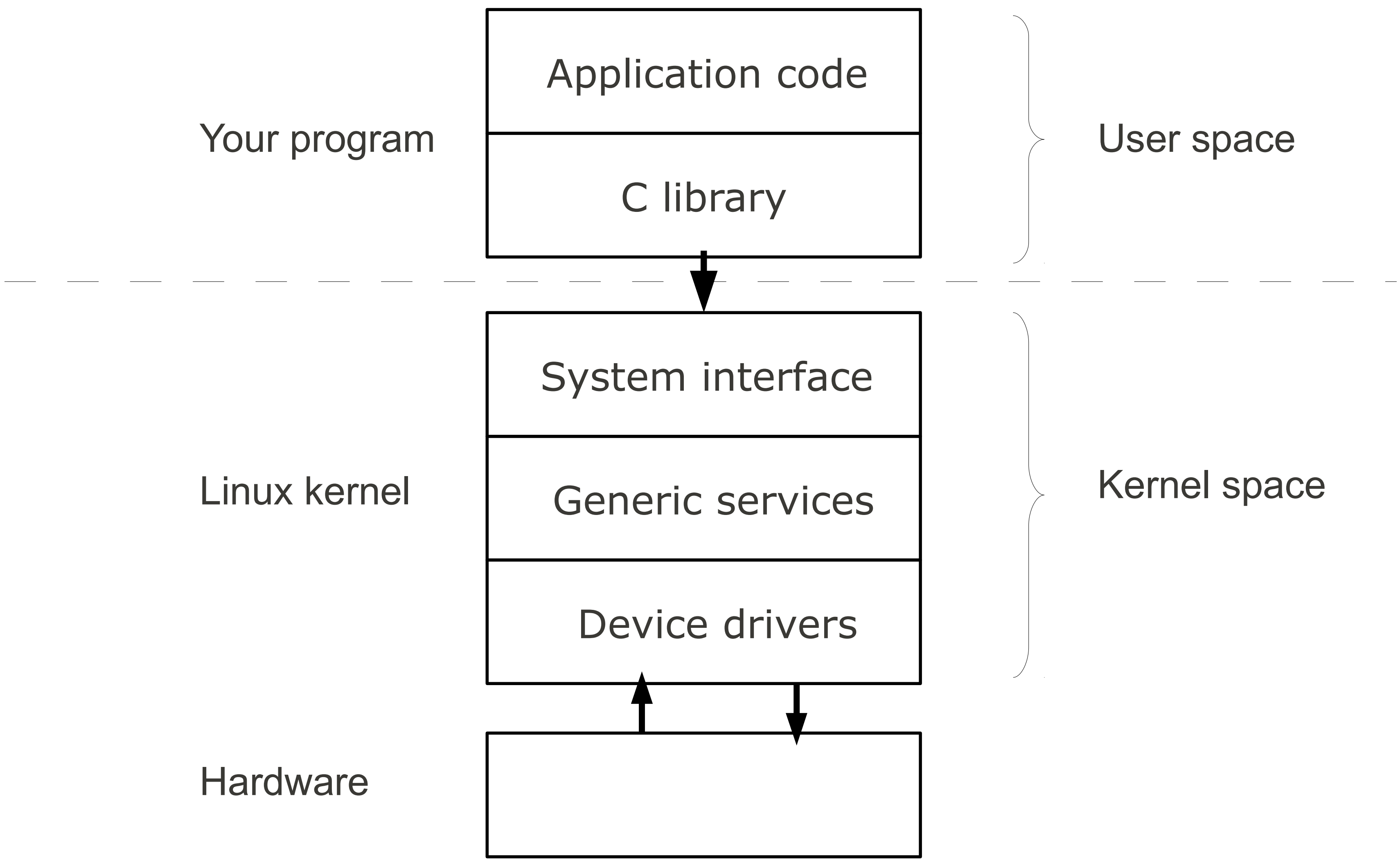
# Third element: kernel

- Version numbers
- About “BSPs”
- Configuring and cross compiling
- Booting

# Kernel vs user space



# Kernel version numbers

Example: 2.6.35.1

2: very unlikely to change

6: unlikely to change
2.6.0 released in December 2003

35: changes with each release,
every 12 weeks or so

1: bug fix number: changes every time
a bug is fixed, sometimes several times
per week

# Bug fix releases

- Maintained by Greg Kroah-Hartman
- Serious bugs are fixed in the current stable version immediately
- Sometimes older versions are fixed as well
- Special note: the 2.6.27 and 2.6.32 stable kernels maintained by Adrian Bunk
  - Current releases (October 2010)
    - 2.6.27.54
    - 2.6.32.24

# Board Support Packages

- Mainline kernel works out-of-the-box for a number of development boards
  - e.g. Beagleboard
- But in most cases you will need a BSP from the board or chip vendor
  - Lags mainline by a few versions
  - Levels of support vary between vendors
- For custom boards you will have to write your own BSP

# Levels of board support

- Architecture
  - arm,mips, powerpc, x86,...
- Chip (also known as System on Chip, SoC)
  - Atmel 91sam9, Freescale i.MX, TI OMAP, ...
- Board
  - SoC manufacturer evaluation boards
    - Freescale Babbage, TI EVM, ...
  - COTS boards
    - Digi, Eurotech, ...

# Levels of board support (cont.)

- Chip level support mostly done by manufacturer
  - often in own kernel tree: e.g. Freescale
- Board level support done by board manufacturer
  - based on SoC kernel

# Board support

- Usually a kernel patch and a configuration file
- Typical procedure is

```
tar xjf linux-2.6.34.tar.bz2
cd linux-2.6.34
patch -p 1 < ../linux-2.6.34-some_bsp.patch
cp ../some_bsp-kernel.config .config
make oldconfig
```

# Kernel modules

- Kernel code that is loaded after the kernel has booted
- Advantages
  - Load drivers on demand (e.g. for USB devices)
  - Load drivers later – speed up initial boot
- Disadvantages
  - Adds kernel version dependency to root file system
  - More files to manage

# Kernel configuration

- Typical kernel has >> 1000 configuration options
- Default configuration part of the BSP
- Tweak configuration using
  - make menuconfig (ncurses text menu)
  - make xconfig (graphical menus using Qt)
  - make gconfig (graphical menus using Gtk+)
- Files generated
  - .config
  - include/linux/autoconf.h

# Building the kernel

- Set CROSS_COMPILE and ARCH

```
export ARCH=arm
export CROSS_COMPILE=arm-angstrom-linux-gnueabi-
```

- Make targets
  - zImage - compressed kernel image
  - uImage - zImage plus U-Boot header
- Files generated
  - vmlinux
  - arch/arm/boot/zImage
  - arch/arm/boot/uImage

# Kernel command line

- Kernel behaviour set by “command line”
  - see Documentation/kernel-parameters.txt
- Some examples

console: device to send kernel messages to, e.g.

```
console=ttyS0,115200
```

root: set device to load root file system from, e.g.

```
root=/dev/sda1
```

quiet: output fewer console messages

debug: output all console messages

# Fourth element: user space

- What is user space?
- Obtaining a root file system
- Busybox
- Two types of init: Busybox and System V
- Managing device nodes: udev
- Mounting a root file system over the network and from flash memory

# What is user space?

- A sane (POSIX) environment for applications (unlike the kernel)
- The main components are
  - Programs – e.g. init and a shell
  - Libraries - e.g. libc
  - Configuration files in /etc
  - Device nodes in /dev
  - User data in /home

# The root file system

- Mounted by the kernel during boot
  - requires a `root=...` kernel command line
- Loaded from:
  - ram disk (initramfs)
  - storage device: flash, SD, hard disk
  - network: nfs

# “I got a rootfs with my board”

- As with the toolchain, this is usually a trap!
- Board vendors usually over-configure to show off the board
  - bloated root file system
  - slow boot
- … yet, they only offer a limited set of packages
- and limited or no update service

# Other options for a root file system

- Roll-Your-Own (RYO)
- Use an integrated build tool
  - Buildroot
  - OpenEmbedded
- Use a binary distro
  - Ångström
  - Ubuntu or Debian

# Busybox

- Web - http://www.busybox.net
- Very common in embedded systems
- Single binary that masquerades as many Linux utilities, including
  - init
  - ash (a Bourne shell)
  - file system utilities: mount, umount,...
  - network utilities: ifconfig, route,...
  - and of course, the vi editor

# Busybox example

```
# ls -l /bin
lrwxrwxrwx 1 root  root       7 2008-08-06 11:44 addgroup -> busybox
lrwxrwxrwx 1 root  root       7 2008-08-06 11:44 adduser -> busybox
lrwxrwxrwx 1 root  root       7 2008-08-06 11:44 ash -> busybox
-rwxr-xr-x 1 root  root  744480 2008-05-16 15:46 busybox
lrwxrwxrwx 1 root  root       7 2008-08-06 11:44 cat -> busybox
...
```

So when you type (for example)

`cat /etc/inittab`

... launches /bin/busybox with `argv [0] = “/bin/cat”`

Busybox main() parses argv[0] and jumps to cat applet

# init

- /sbin/init is the first program to be run
  - change by setting kernel parameter “init=...”
- Two common versions of init
  - Busybox init
    - e.g. by buildroot
  - System V init
    - e.g. by Angstrom

# Busybox init

- Begins by reading /etc/inittab, for example:

/etc/inittab

```
::sysinit:/etc/init.d/rcS
::respawn:-/sbin/getty -L ttyS0 115200 vt100
::ctrlaltdel:/sbin/reboot
::shutdown:/bin/umount -a -r
::restart:/sbin/init
```

/etc/init.d/rcS

```
#! /bin/sh
echo "Starting rcS"
mount -t proc proc /proc
mount -t sysfs sysfs /sys
ifconfig lo 127.0.0.1
ifconfig eth0 192.168.1.101
```

# System V init

- Also begins by reading /etc/inittab
  - More complex format than Busybox
- System V runlevels
  - A runlevel defines a system state
    - 0 is halt
    - 1 is single user
    - 2-5 are multi-user
    - 6 is reboot

# System V inittab

Format:
`id:runlevels:action:process`

```
id:5:initdefault:

si::sysinit:/etc/init.d/rcS

~~:S:wait:/sbin/sulogin

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

z6:6:respawn:/sbin/sulogin
S:2345:respawn:/sbin/getty 38400 ttyS1
```

Default runlevel = 5

Boot script = /etc/init.d/rcS

Single-user mode: add 'S' to kernel command line

Scripts for each runlevel

Launch a login on the console

# Initialisation scripts

- Each service is controlled by a script in /etc/init.d:

```
# ls /etc/init.d
alignment.sh          modutils.sh              sendsigs
banner                mountall.sh              single
bootmisc.sh           mountnfs.sh              sysfs.sh
checkroot             networking               syslog
devpts.sh             populate-volatile.sh     syslog.busybox
dropbear              ramdisk                  udev
finish.sh             rc                       udev-cache
functions             rcS                      umountfs
halt                  reboot                   umountnfs.sh
hostname.sh           rmnologin                urandom
hwclock.sh            save-rtc.sh
```

- Most take parameters *start* and *stop*, e.g.

```
/etc/init.d/syslog stop
```

# /dev: device nodes

- Most hardware appears as nodes in /dev
- Create by hand:

```
mknod /dev/ttyS0 c 4 64
```

- Or, use a dynamic device manager (udev)
- udev pros
  - less hassle; handles removable devices (e.g. USB)
- udev cons
  - slow

# The rootfs during development

- Advantages of mounting rootfs over NFS
  - easy to access and modify the rootfs
  - No limit on size

Step 1. Export a directory on the development host with a line like this in /etc/exports

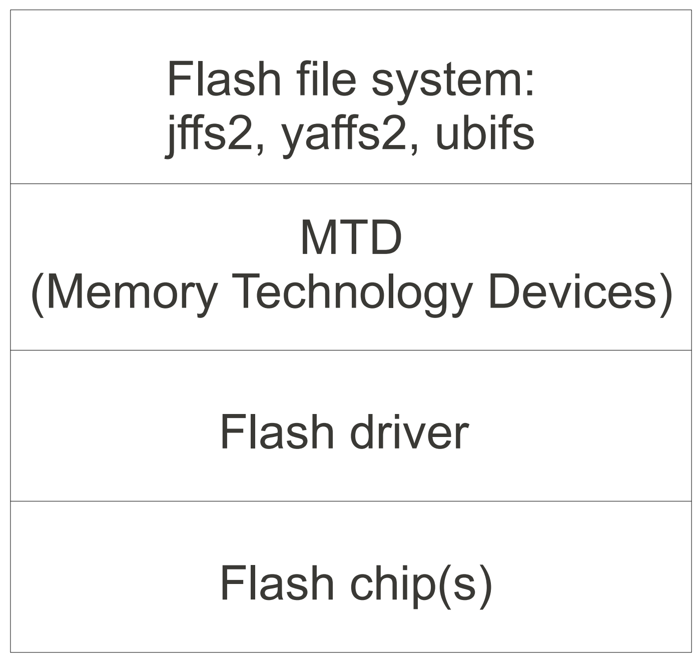
```
/home/chris/rootdir *(rw,sync,no_subtree_check,no_root_squash)
```

Step 2. Set kernel parameters

```
root=/dev/nfs rw nfsroot=192.168.1.1:/home/chris/rootdir ip=192.168.1.101
```

# The rootfs in production

- Usually stored in a partition of flash memory




Typical kernel parameters:

```
root=/dev/mtdblock1 rootfstype=jffs2
```

# Flash file systems

- jffs2 (Journalling Flash File System 2)
  - This is the most common Linux flash fs
  - Robust, but slow (especially mount time)
- yaffs2 (Yet Another Flash File System 2)
  - Optimised for NAND flash memory
  - Not part of main-line kernel
- ubifs (Unsorted Block Image File System)
  - Fast and robust

# Summary

- Kernel
  - Your choice of kernel is limited by BSP
  - Many build-time kernel configuration options
  - Boot-time configuration via command line
- User space
  - Starts when kernel mounts rootfs
  - First program to run is (default) /sbin/init
  - Both Busybox init and System V init are common