Android Porting

移植 Android 至 PXA270

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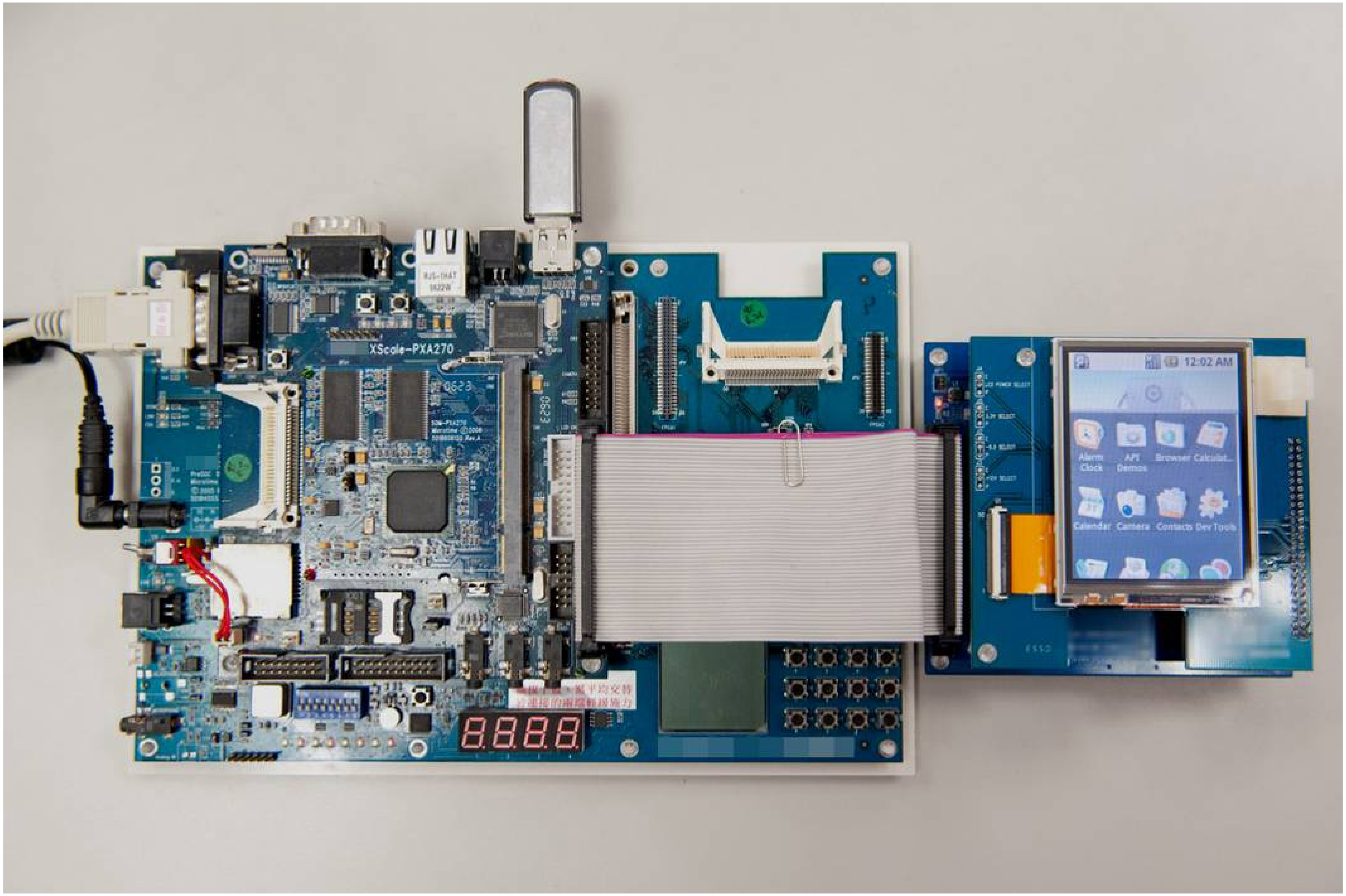
- **數年 Linux 及 Embedded Linux 相關開發經驗，開發產品包含 Set-Top-Box、手機及快速開機軟體等相關產品，接觸過 x86、MIPS 及 ARM platform，對 Linux kernel、Linux device driver、Shared Library、Application 等皆有所涉獵。**
- **在 IC 廠完全沒有支援 Android 的情況下，獨立移植 Android 至 PXA270、OMAP3530 等硬體平台。**
- **豐富的 Android Porting 授課經驗。**

Android 1.0 on PXA270



Outline

- Introduction
- Motivation
- Porting Procedure
- Building Environment
- Conclusion

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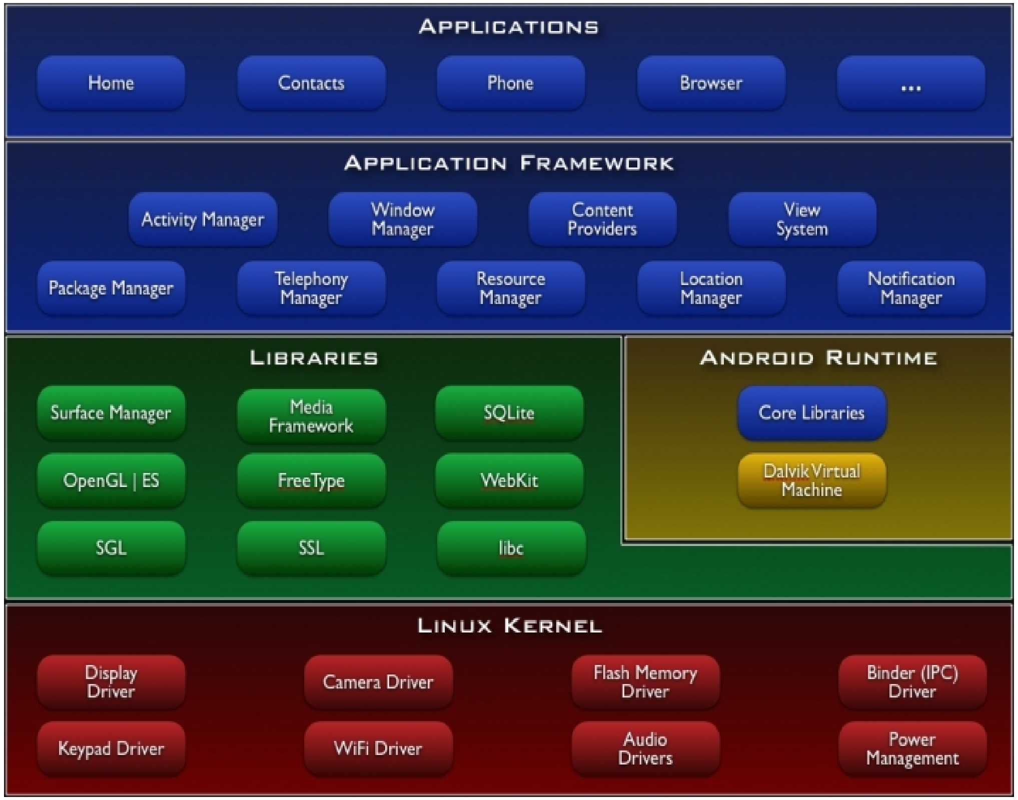
What Is Android

- Android is a software stack for mobile devices that includes an operating system, middleware and key applications



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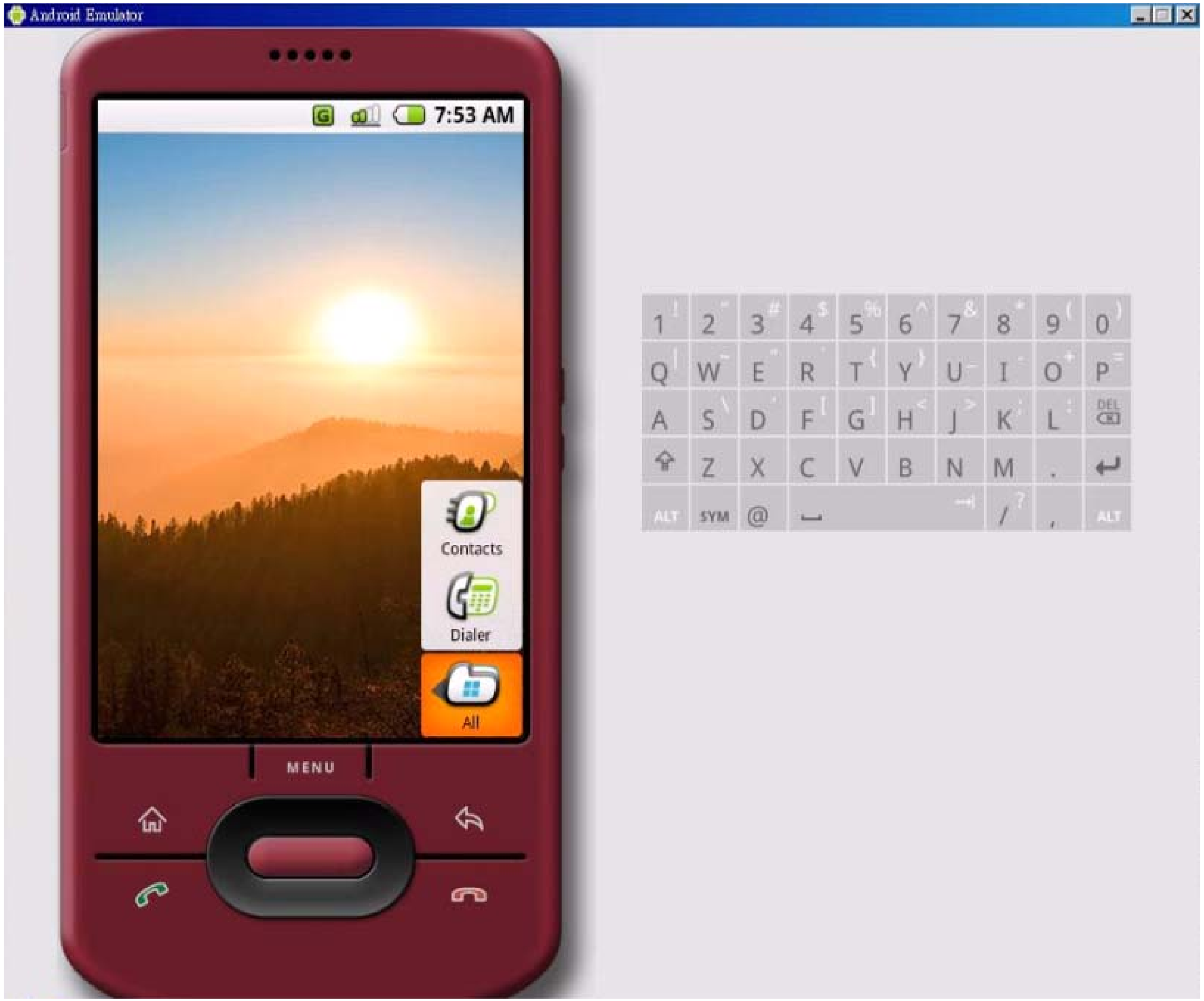
Android Features

- Bionic libc
- Multimedia
- 2D, 3D graphics
- FreeType
- SQLite
- Application framework
- Dalvik virtual machine
- Network
- Rich development environment

Android Emulator



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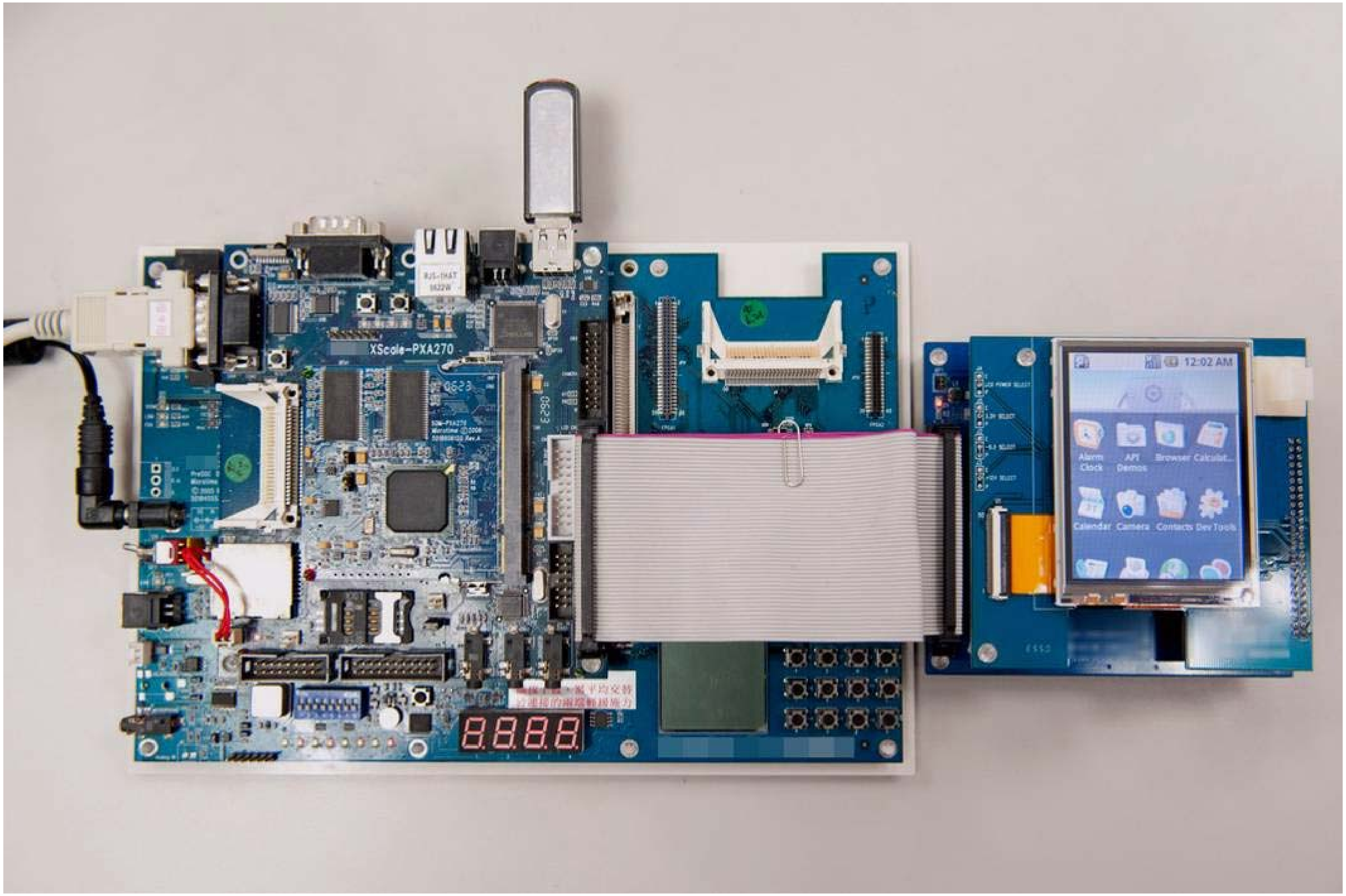
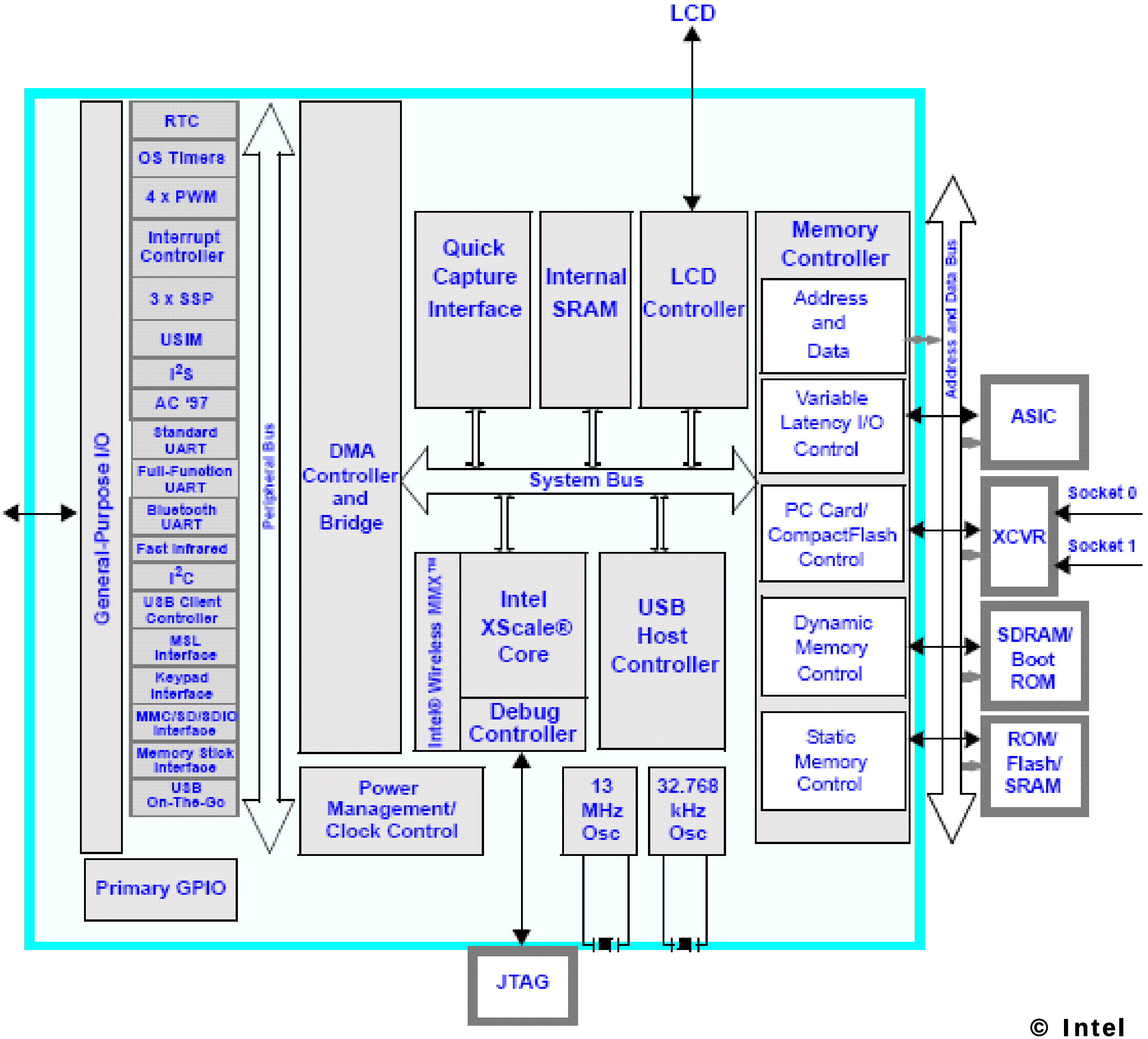
Experimental Android



Recommended Minimum Device Requirements on ARM Platform

	Official	Our
CPU	ARM-based	●ARM9 at least (Goldfish use ARM926) ●ARMv5
RAM	128MB	128MB up
Flash	256MB	128MB up

PXA27x Processor Block Diagram



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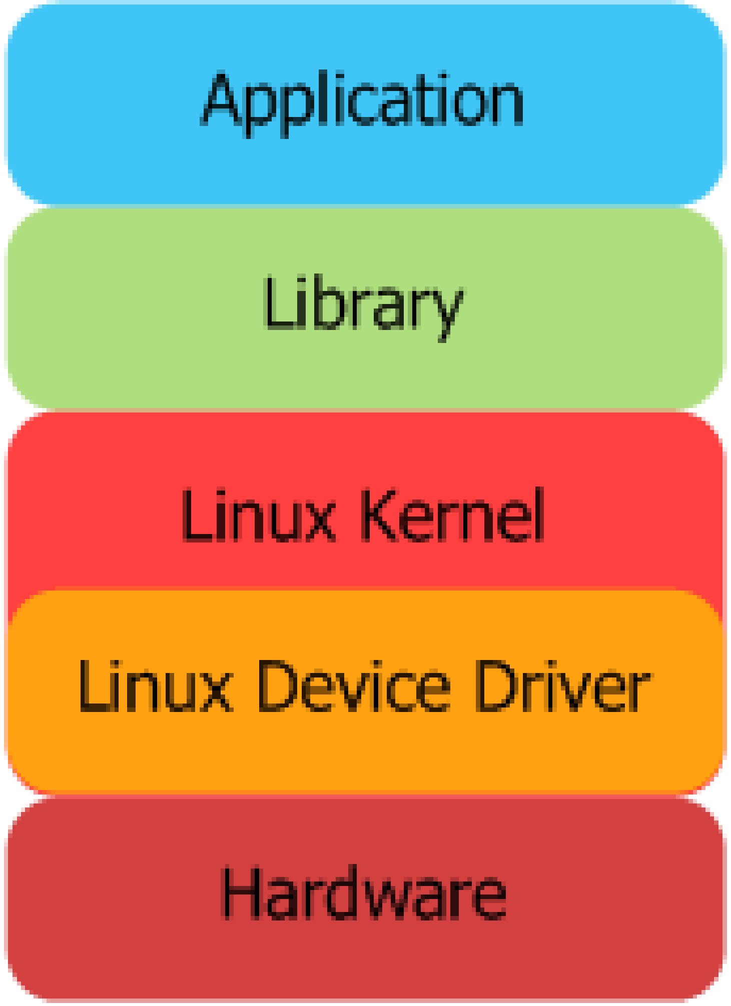
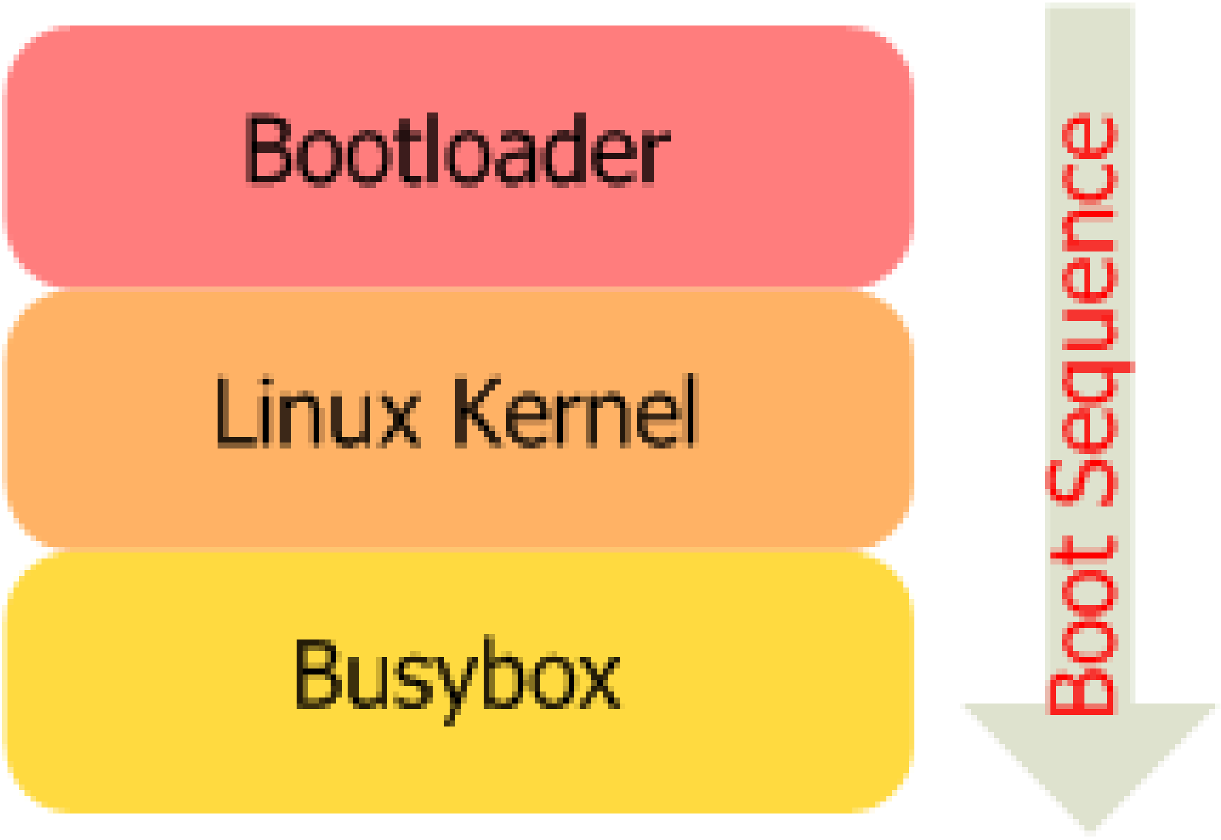
Our PXA270 Hardware Brief

CPU	Intel XScale PXA270 520MHz	
Flash ROM	32M Bytes	
SDRAM	64M Bytes	
Keypad	4x4 matrix	
Touch	UCB1400	
LCD Module(LCM)	LCD Panel	TOPPOLY TD035STEB1
	Display Area	53.64mm(H) x 71.52mm(V)
	Drive System	TFT active matrix
	Display Colors	262144 colors
	Number of Pixels	240 x RGB(H) x 320(V)
	Pixel Arrangement	RGB Vertical stripe
	Signal System	6-bit digital signals for each RGB
UART		
Ethernet	10/100 Mbps	
USB		
Audio	UCB1400	

Embedded Linux System Architecture



Embedded Linux System Boot Sequence



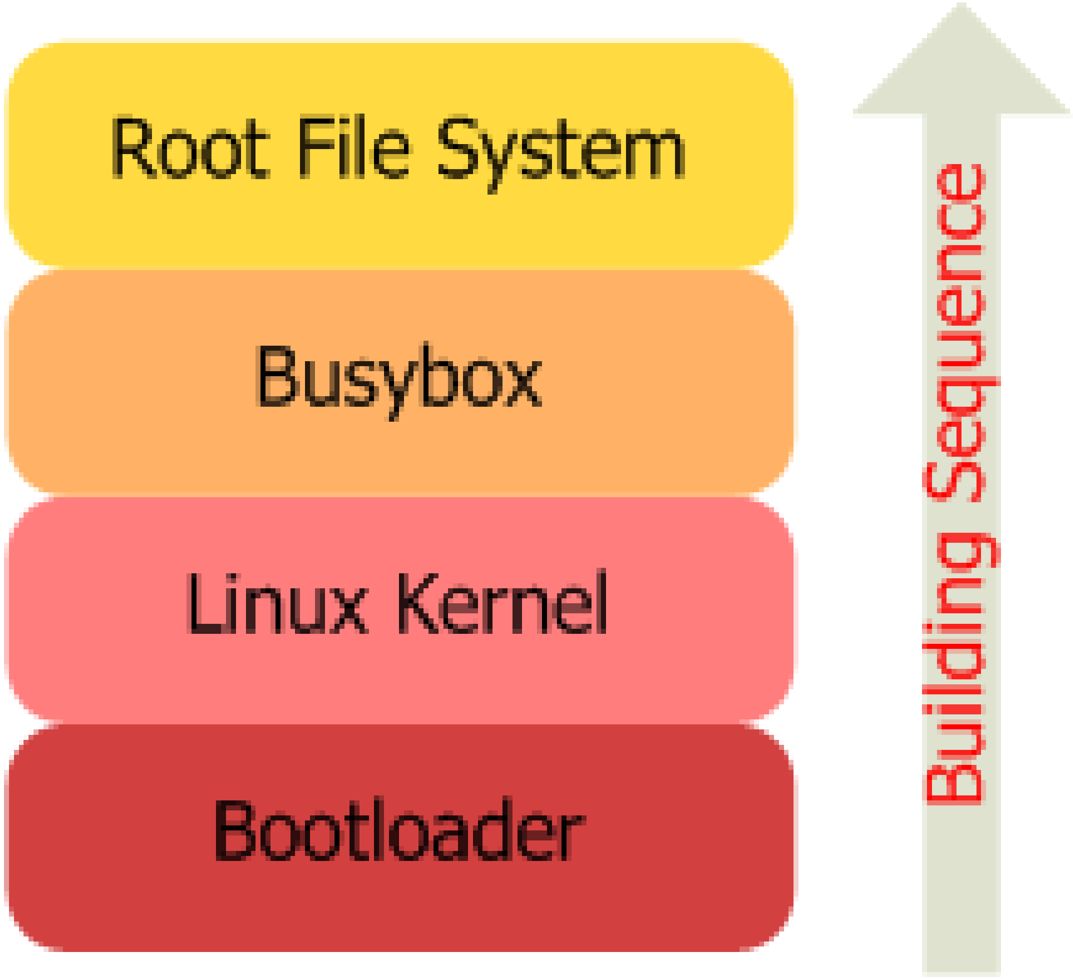
Bootloader

Linux Kernel

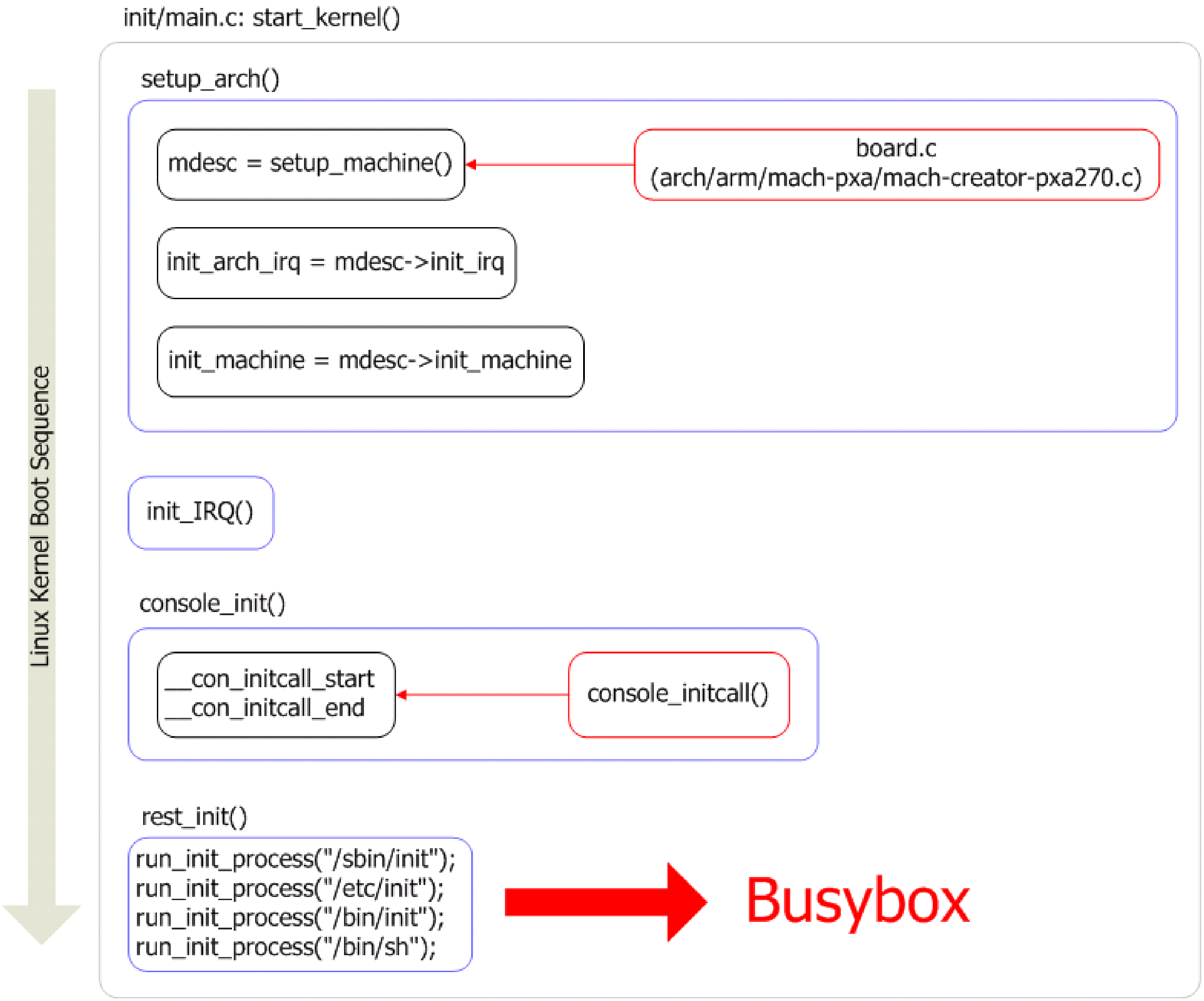
Busybox

Boot Sequence

How to Build An Embedded Linux System



Linux Kernel Boot Sequence



init/main.c: start_kernel()

setup_arch()

mdesc = setup_machine()

board.c
(arch/arm/mach-pxa/mach-creator-pxa270.c)

init_arch_irq = mdesc->init_irq

init_machine = mdesc->init_machine

init_IRQ()

console_init()

__con_initcall_start
__con_initcall_end

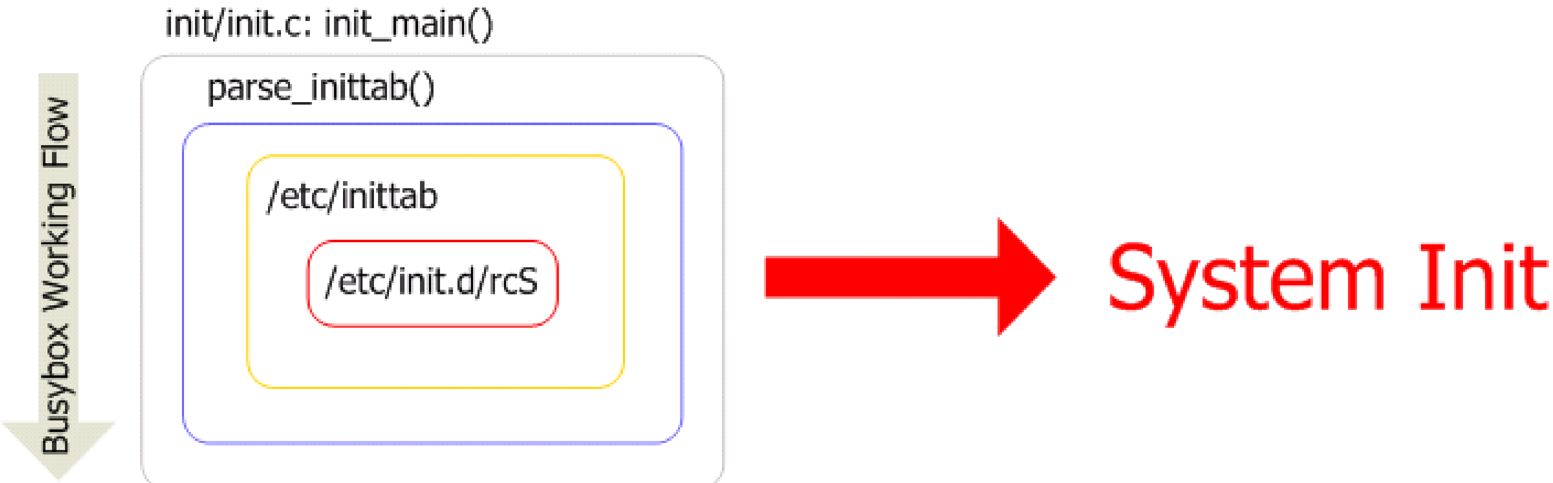
console_initcall()

rest_init()

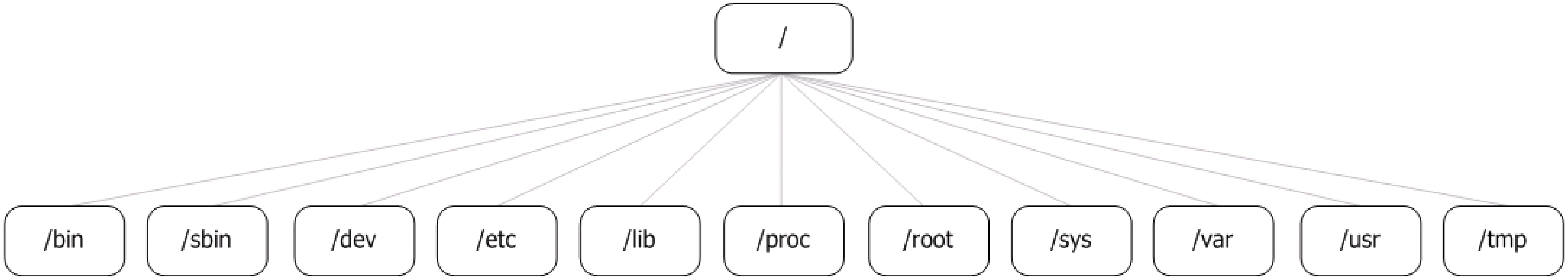
```
run_init_process("/sbin/init");
run_init_process("/etc/init");
run_init_process("/bin/init");
run_init_process("/bin/sh");
```

Busybox

Busybox Working Flow



Embedded Linux System Directories



Embedded Linux System Directories (cont)

- /bin, /sbin
  - Utilities
- /dev
  - Device nodes
- /etc
  - Configurations
  - Init scripts
- /lib
  - Kernel modules (device driver)
- /proc
  - Process information

Embedded Linux System Directories (cont)

- /root
  - Specific utilities
- /sys
  - An interface for user accessing kernel information
  - Representation of hardware architecture
- /var
  - Logs
- /tmp
  - Memory space

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Motivation

- Build a new experimental Android platform
- Study how Linux device drivers cooperate with Android applications
- Open Source
- Share Android Porting experience
- Prove Android could run on PXA270

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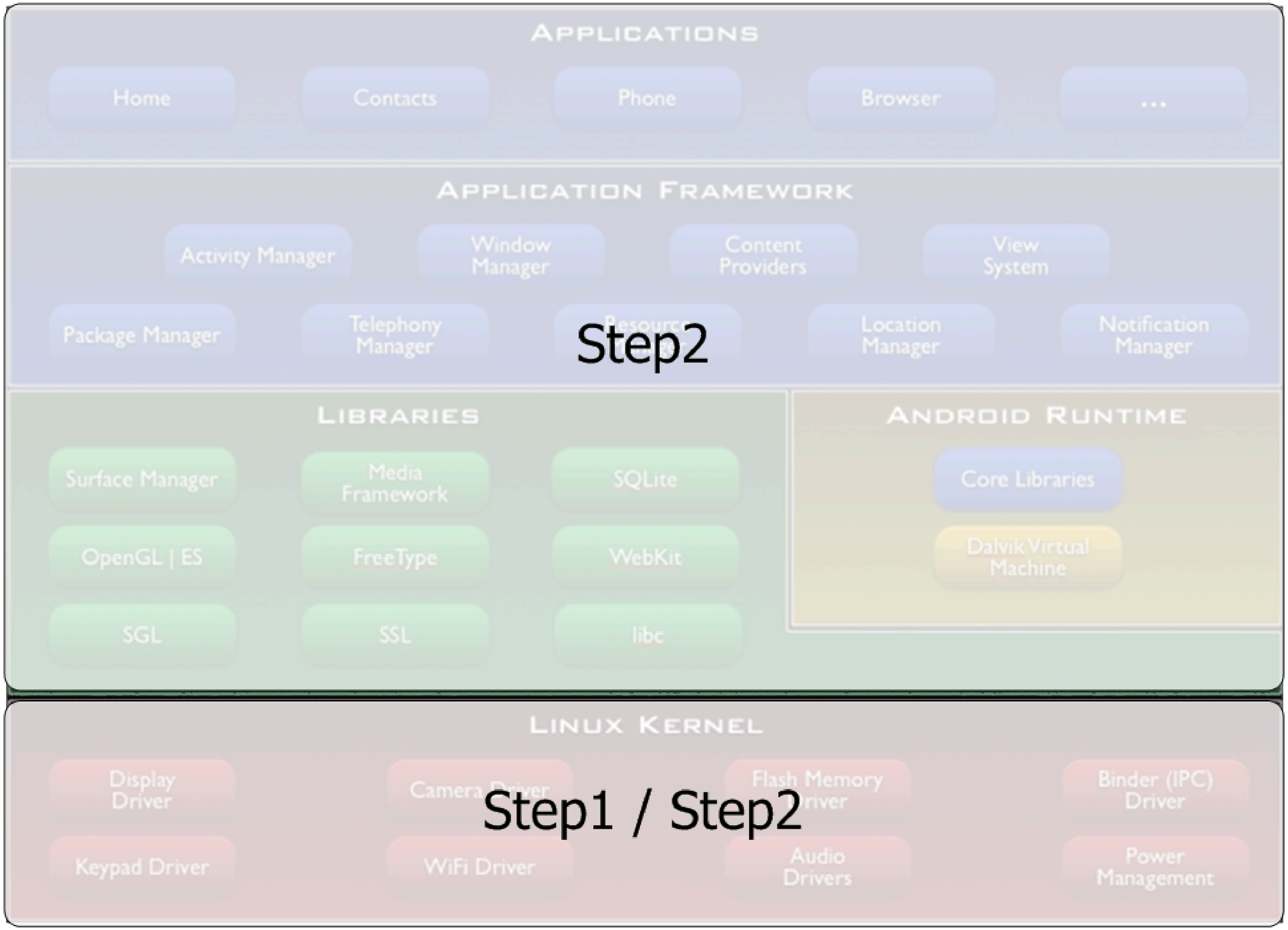
Key Points of Building An Android Run-time System

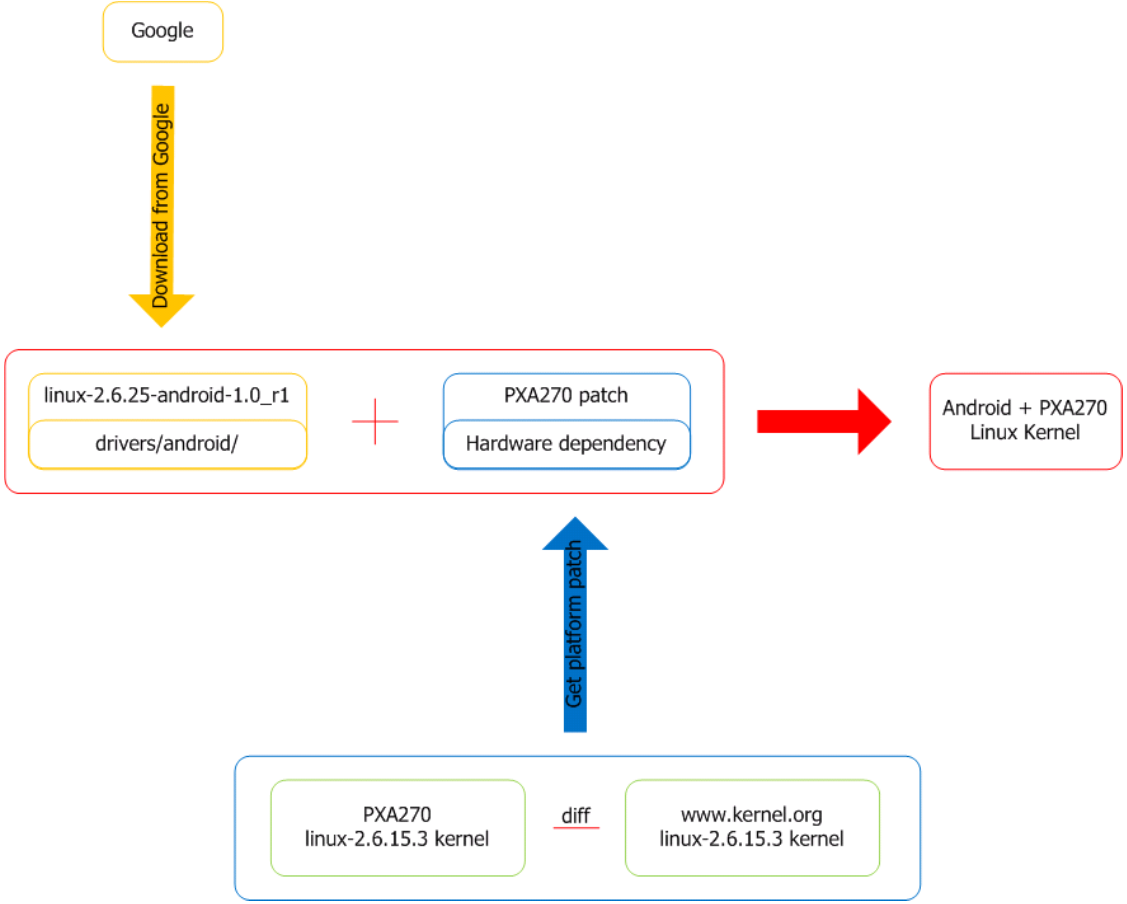
- Carefulness
- Luckiness
- Experience

Porting Steps



How to Construct Linux Kernel with Android Patch

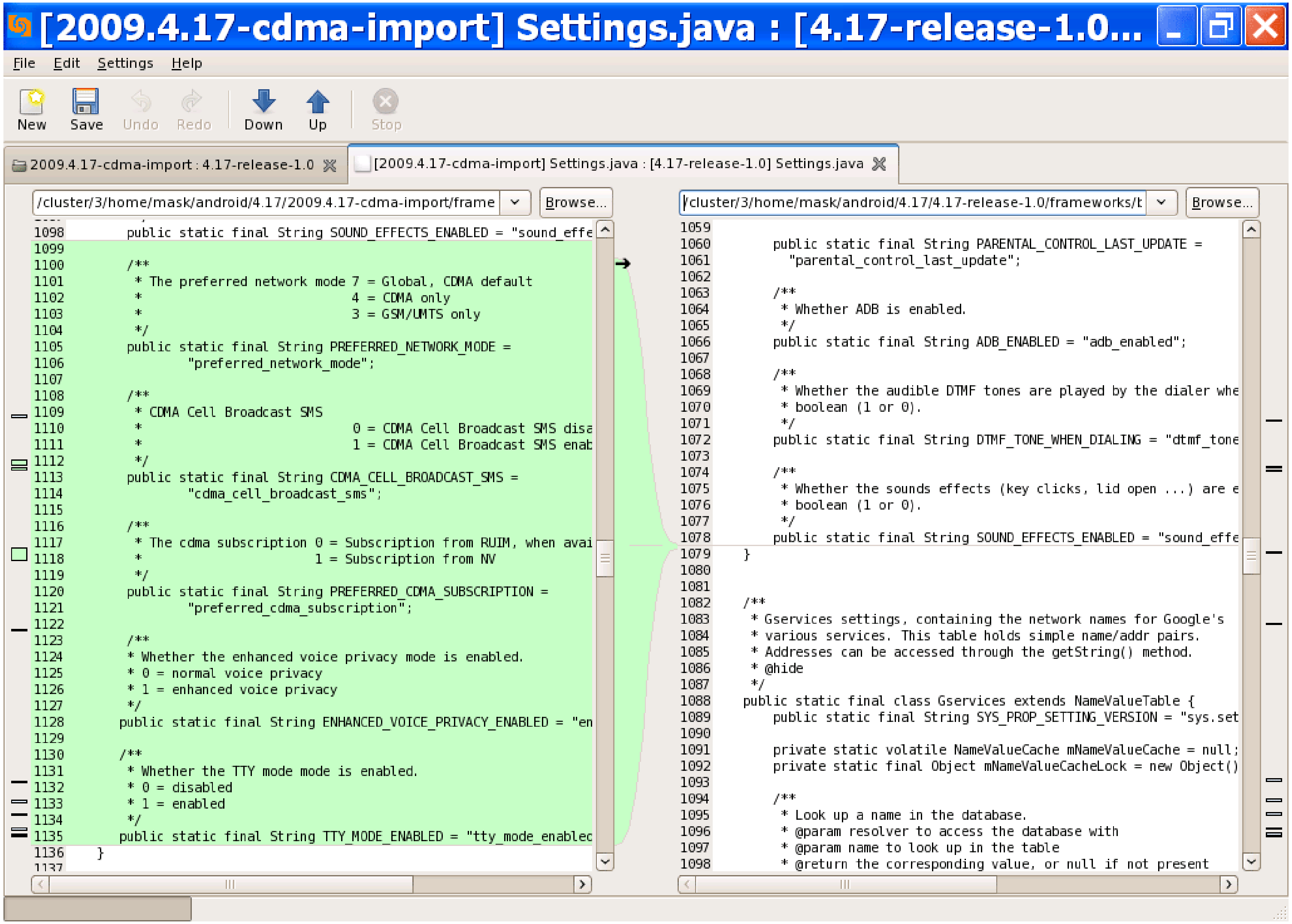
- There are different ways to patch Linux kernel depending on different situations


Google
Download from Google
linux-2.6.25-android-1.0_r1
drivers/android/
+
PXA270 patch
Hardware dependency
Android + PXA270 Linux Kernel
Get platform patch
PXA270 linux-2.6.15.3 kernel
diff
www.kernel.org linux-2.6.15.3 kernel

Use Which Tools to Patch Linux Kernel

- Linux platform
  - Meld
- Windows platform
  - WinMerge

Meld


[2009.4.17-cdma-import] Settings.java : [4.17-release-1.0...
File
Edit
Settings
Help
New
Save
Undo
Redo
Down
Up
Stop
2009.4.17-cdma-import : 4.17-release-1.0
[2009.4.17-cdma-import] Settings.java : [4.17-release-1.0] Settings.java
Browse...
Browse...

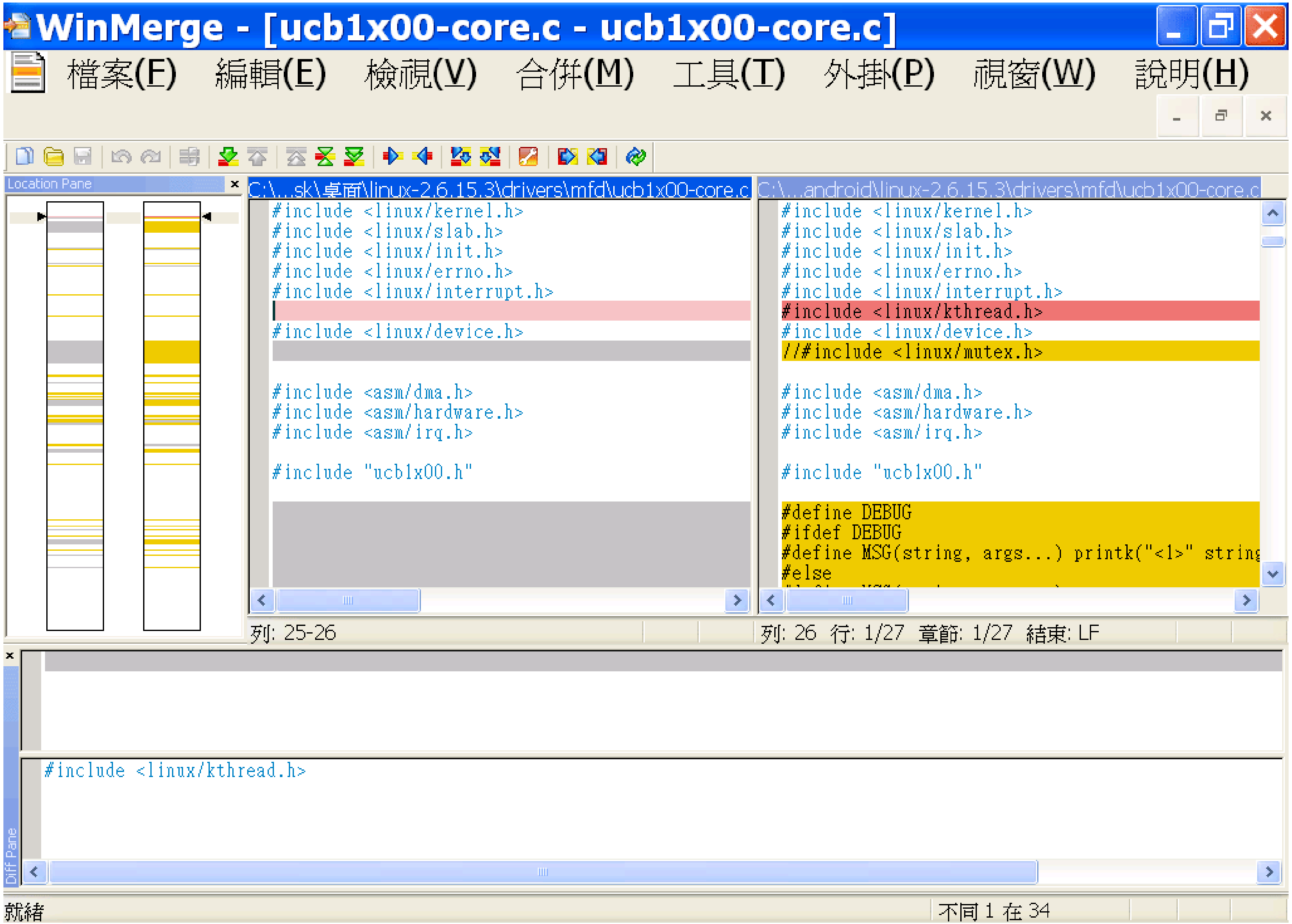
/cluster/3/home/mask/android/4.17/2009.4.17-cdma-import/frame

```
        public static final String SOUND_EFFECTS_ENABLED = "sound_effe

        /**
         * The preferred network mode 7 = Global, CDMA default
         *                            4 = CDMA only
         *                            3 = GSM/UMTS only
         */
        public static final String PREFERRED_NETWORK_MODE =
                "preferred_network_mode";

        /**
         * CDMA Cell Broadcast SMS
         *                            0 = CDMA Cell Broadcast SMS disa
         *                            1 = CDMA Cell Broadcast SMS enab
         */
        public static final String CDMA_CELL_BROADCAST_SMS =
                "cdma_cell_broadcast_sms";

        /**
         * The cdma subscription 0 = Subscription from RUIM, when avai
         *                       1 = Subscription from NV
         */
        public static final String PREFERRED_CDMA_SUBSCRIPTION =
                "preferred_cdma_subscription";

        /**
        * Whether the enhanced voice privacy mode is enabled.
        * 0 = normal voice privacy
        * 1 = enhanced voice privacy
        */
       public static final String ENHANCED_VOICE_PRIVACY_ENABLED = "en

       /**
        * Whether the TTY mode mode is enabled.
        * 0 = disabled
        * 1 = enabled
        */
       public static final String TTY_MODE_ENABLED = "tty_mode_enablec
    }
```

/cluster/3/home/mask/android/4.17/4.17-release-1.0/frameworks/t

```

        public static final String PARENTAL_CONTROL_LAST_UPDATE =
          "parental_control_last_update";

        /**
         * Whether ADB is enabled.
         */
        public static final String ADB_ENABLED = "adb_enabled";

        /**
         * Whether the audible DTMF tones are played by the dialer whe
         * boolean (1 or 0).
         */
        public static final String DTMF_TONE_WHEN_DIALING = "dtmf_tone

        /**
         * Whether the sounds effects (key clicks, lid open ...) are e
         * boolean (1 or 0).
         */
        public static final String SOUND_EFFECTS_ENABLED = "sound_effe
    }


    /**
     * Gservices settings, containing the network names for Google's
     * various services. This table holds simple name/addr pairs.
     * Addresses can be accessed through the getString() method.
     * @hide
     */
    public static final class Gservices extends NameValueTable {
        public static final String SYS_PROP_SETTING_VERSION = "sys.set

        private static volatile NameValueCache mNameValueCache = null;
        private static final Object mNameValueCacheLock = new Object()

        /**
         * Look up a name in the database.
         * @param resolver to access the database with
         * @param name to look up in the table
         * @return the corresponding value, or null if not present
```

WinMerge



C:\...sk\桌面\linux-2.6.15.3\drivers\mfd\ucb1x00-core.c

```
#include <linux/kernel.h>
#include <linux/slab.h>
#include <linux/init.h>
#include <linux/errno.h>
#include <linux/interrupt.h>

#include <linux/device.h>



#include <asm/dma.h>
#include <asm/hardware.h>
#include <asm/irq.h>

#include "ucb1x00.h"
```

C:\...android\linux-2.6.15.3\drivers\mfd\ucb1x00-core.c

```
#include <linux/kernel.h>
#include <linux/slab.h>
#include <linux/init.h>
#include <linux/errno.h>
#include <linux/interrupt.h>
#include <linux/kthread.h>
#include <linux/device.h>
//#include <linux/mutex.h>

#include <asm/dma.h>
#include <asm/hardware.h>
#include <asm/irq.h>

#include "ucb1x00.h"

#define DEBUG
#ifdef DEBUG
#define MSG(string, args...) printk("<1>" string
#else
```

列: 25-26

列: 26 行: 1/27 章節: 1/27 結束: LF

```
#include <linux/kthread.h>
```

就緒

不同 1 在 34

Potential Problems on Patching Linux Kernel

- Data structure
  - Reference similar platforms
- Init section
  - Reference successfully compiled drivers
- Source dispersed
  - Only consider the BSP changed from the official Linux Kernel
- File name changed
  - Same as the previous item
- Kernel configuration
  - 1st stage
    - make oldconfig
    - make platform_old_defconfig
  - 2nd stage
    - Depend on your requirements to adjust

How to Fix Compiling Problems

- Refer to kernel source of similar platforms
  - Mainstone (PXA270)
- Refer to the workable BSP from vendor
  - 2.6.15.3 from vendor

Use Easy Ways to Debug Linux Kernel

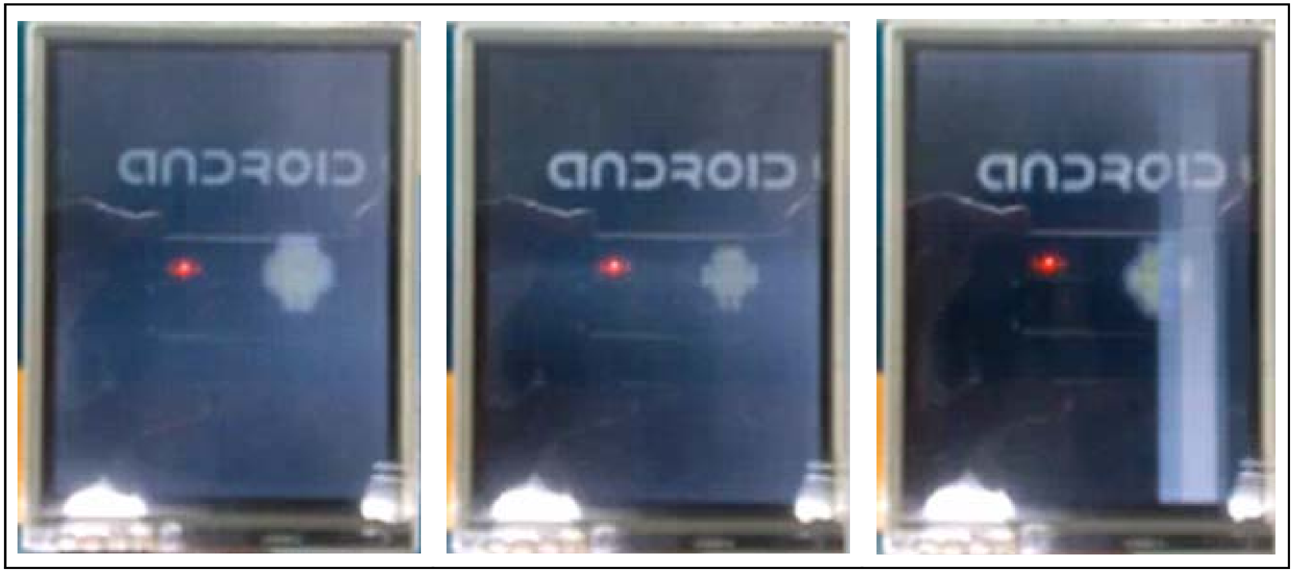
- Enable options in the kernel configuration
  - CONFIG_DEBUG_KERNEL
- If you want to get more debug informations
  - CONFIG_DEBUG_DRIVER
  - CONFIG_DEBUG_DEVRES
- make V=1
  - Get detail information during compiling process

Which Drivers May Need to Modify

- Serial
- NIC
- Framebuffer
- USB
- Touch
- Keypad
- Etc.

LCD Flickering Problem (linux/drivers/video/pxafb.c)

- Problem
  - LCD Screen Flicker



LCD Flickering Problem (cont)

- Cause
  - LCD controller is enabled and then disabled repeatedly
  - It’s cause by the register LCCR0 is not properly synchronized in pxafb.c, which then falsely switches the status of LCD
- Solution
  - Add fb_pan_display() to change LCD states accordingly

Keypad Driver (linux/drivers/input/keyboard/android_keypad.c)

- Problem
  - Only 16 keys
  - The keypad device doesn’t use IRQ
- Solution
  - Composed key
    - KEY_MENU
    - KEY_BACK
    - …
  - kthread
  - Polling
  - Idle algorithm
    - Incrementally double the idle time until reaching the maximum idle time

Touch Panel Driver (linux/drivers/input/touchscreen/ucb1400_ts.c)

- Modification
  - Assign IRQ number to 161
  - Connected to input subsystem
  - Calibrate (x,y) position
  - Adjust touch sensitive

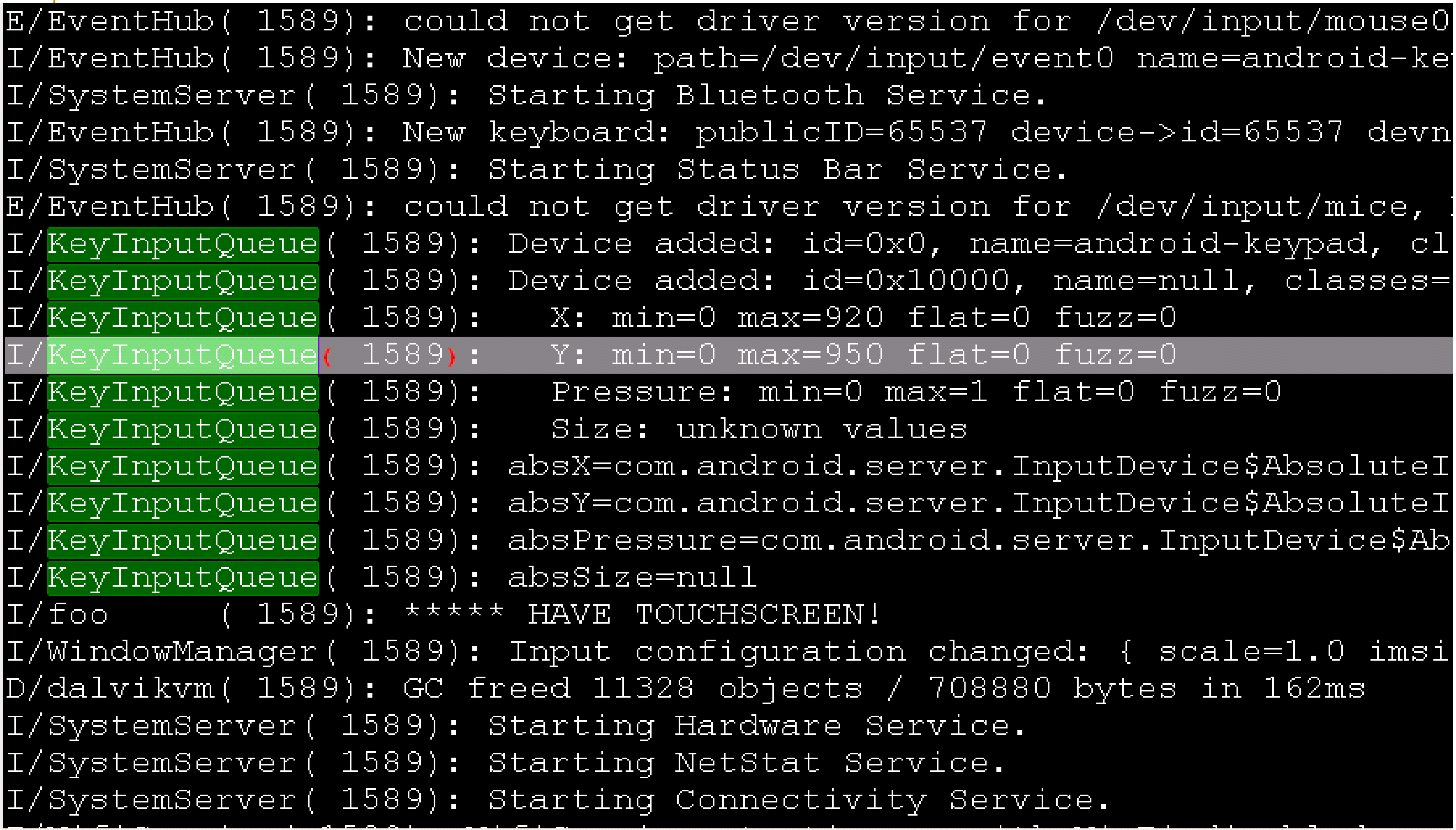
How to Trace Android Source Code

- ctags --C++-kinds=+p -R

It Seems Android Gets Wrong (x,y) Positions from Touch Driver

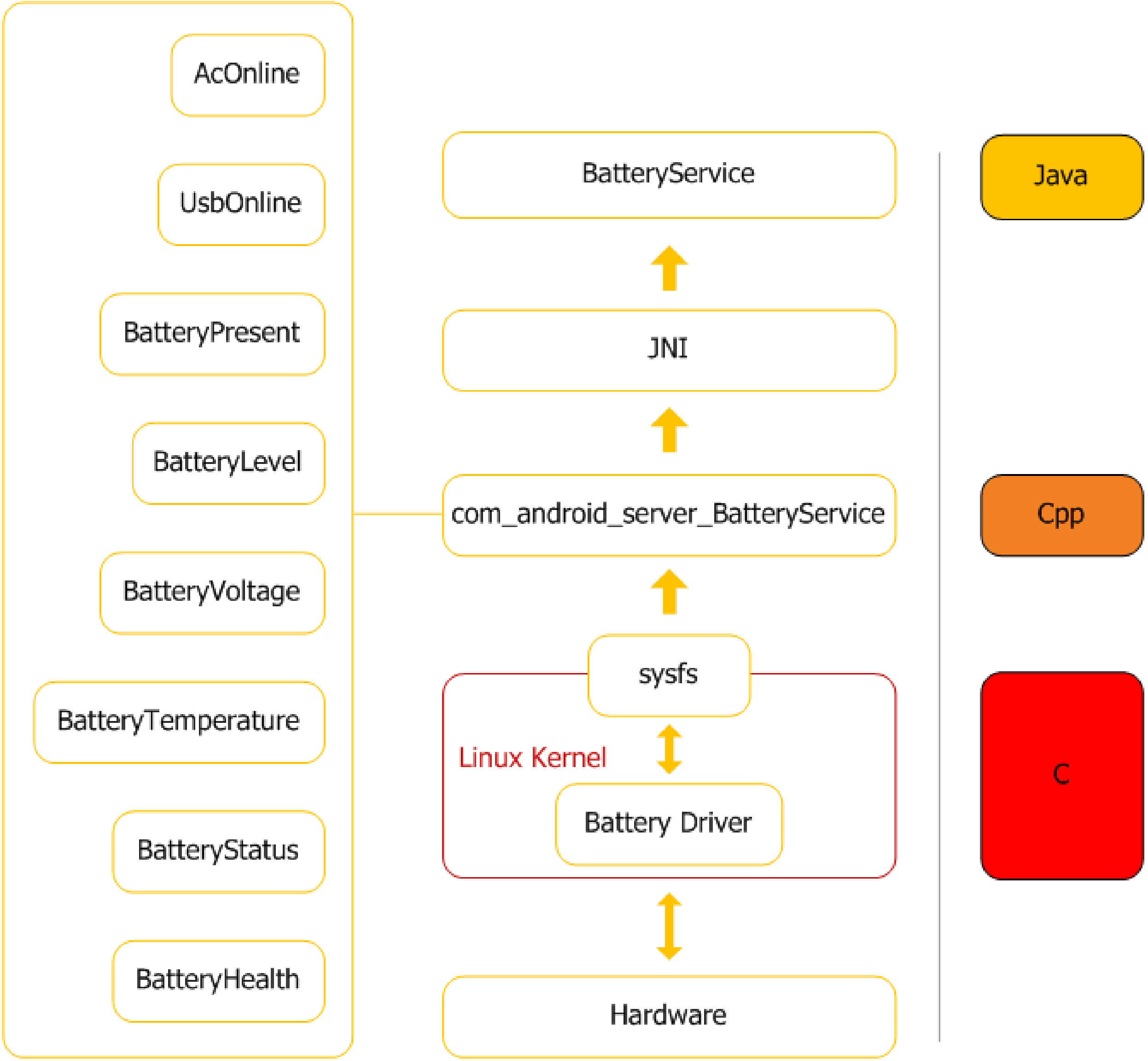
- Problem
  - The touch driver gets the (x,y) position successfully but Android always reports the (0,0) to applications
- Analysis
  - Did (x,y) report to the user space correctly?
  - Did Android get the correct (x,y)?
  - Did Android modify the (x,y) somewhere?
  - Why Android modify the (x,y)?
- Cause
  - The reporting (x,y) relates to the LCD status
  - The LCD status relates to the power status

Android Gets The Touch Device



```
E/EventHub( 1589): could not get driver version for /dev/input/mouse0
I/EventHub( 1589): New device: path=/dev/input/event0 name=android-ke
I/SystemServer( 1589): Starting Bluetooth Service.
I/EventHub( 1589): New keyboard: publicID=65537 device->id=65537 devn
I/SystemServer( 1589): Starting Status Bar Service.
E/EventHub( 1589): could not get driver version for /dev/input/mice,
I/KeyInputQueue( 1589): Device added: id=0x0, name=android-keypad, cl
I/KeyInputQueue( 1589): Device added: id=0x10000, name=null, classes=
I/KeyInputQueue( 1589):   X: min=0 max=920 flat=0 fuzz=0
I/KeyInputQueue( 1589):   Y: min=0 max=950 flat=0 fuzz=0
I/KeyInputQueue( 1589):   Pressure: min=0 max=1 flat=0 fuzz=0
I/KeyInputQueue( 1589):   Size: unknown values
I/KeyInputQueue( 1589): absX=com.android.server.InputDevice$AbsoluteI
I/KeyInputQueue( 1589): absY=com.android.server.InputDevice$AbsoluteI
I/KeyInputQueue( 1589): absPressure=com.android.server.InputDevice$Ab
I/KeyInputQueue( 1589): absSize=null
I/foo      ( 1589): ***** HAVE TOUCHSCREEN!
I/WindowManager( 1589): Input configuration changed: { scale=1.0 imsi
D/dalvikvm( 1589): GC freed 11328 objects / 708880 bytes in 162ms
I/SystemServer( 1589): Starting Hardware Service.
I/SystemServer( 1589): Starting NetStat Service.
I/SystemServer( 1589): Starting Connectivity Service.
```

Android BatteryService Workflow



AcOnline

UsbOnline

BatteryPresent

BatteryLevel

BatteryVoltage

BatteryTemperature

BatteryStatus

BatteryHealth

BatteryService

JNI

com_android_server_BatteryService

sysfs

Linux Kernel

Battery Driver

Hardware

Java

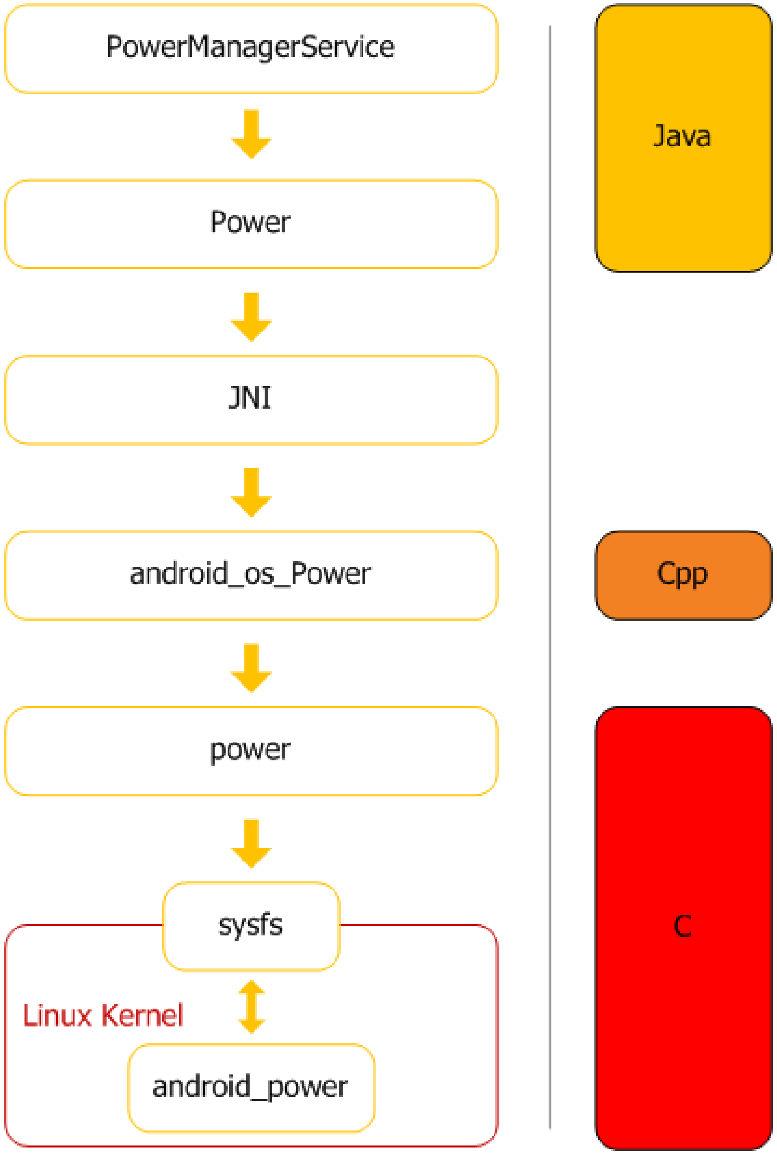
Cpp

C

Battery Driver

- Battery Driver creates the following sysfs entries
  - /sys/class/power_supply/ac/online
  - /sys/class/power_supply/usb/online
  - /sys/class/power_supply/battery/status
  - /sys/class/power_supply/battery/health
  - /sys/class/power_supply/battery/present
  - /sys/class/power_supply/battery/capacity
  - /sys/class/power_supply/battery/batt_vol
  - /sys/class/power_supply/battery/batt_temp
  - /sys/class/power_supply/battery/technology

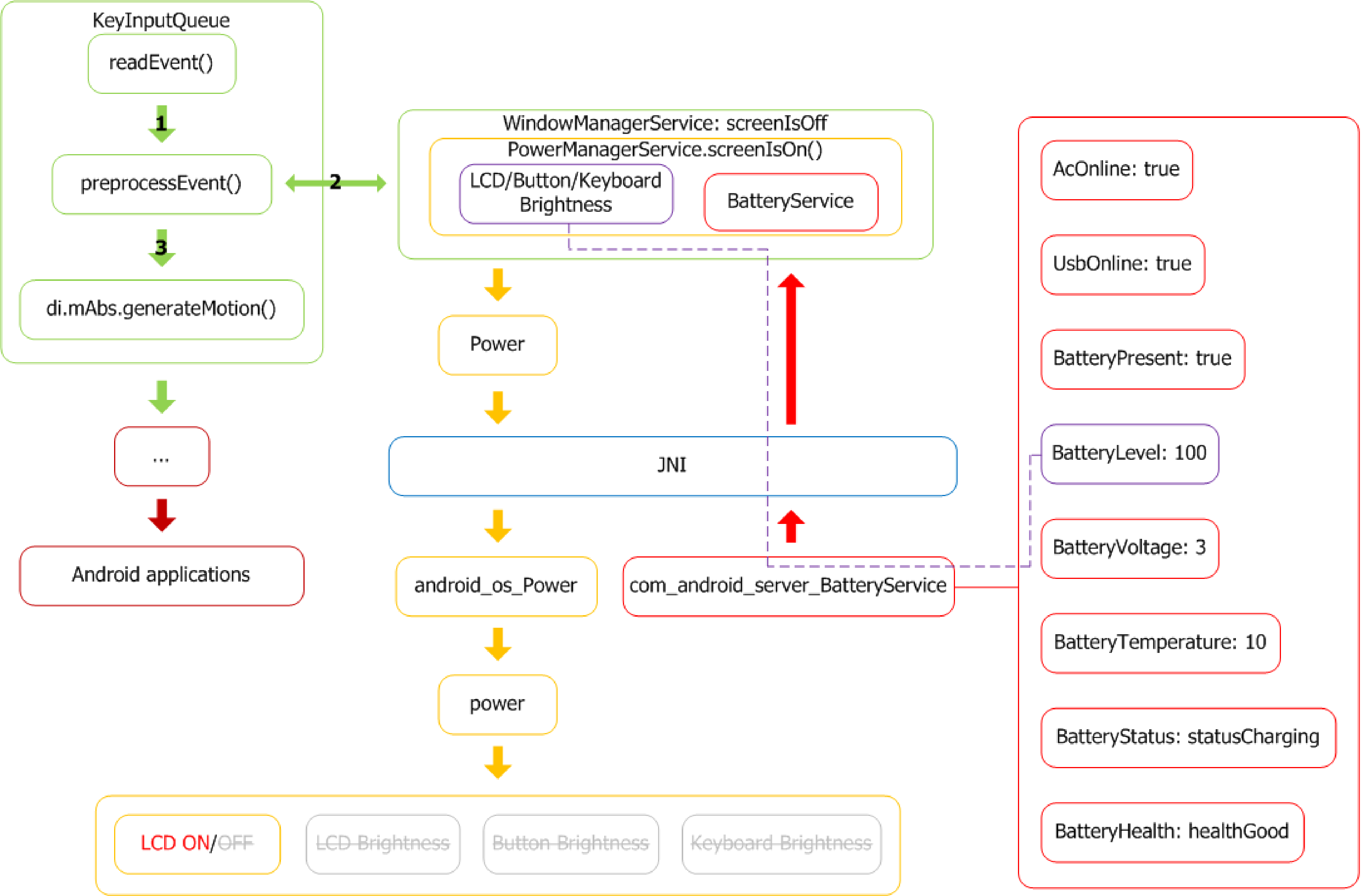
Android PowerManagerService Workflow



Android Power Driver

- Android Power Driver creates the following sysfs entries
  - /sys/android_power/acquire_partial_wake_lock
  - /sys/android_power/acquire_full_wake_lock
  - /sys/android_power/release_wake_lock
  - /sys/android_power/request_state
  - /sys/android_power/auto_off_timeout
- Currently, we only use:
  - /sys/android_power/request_state
    - Turn on LCD

Relationship between Input Keys and Android Services



KeyInputQueue

readEvent()

1

preprocessEvent()

3

di.mAbs.generateMotion()

...

Android applications

2

WindowManagerService: screenIsOff

PowerManagerService.screenIsOn()

LCD/Button/Keyboard Brightness

BatteryService

Power

JNI

android_os_Power

com_android_server_BatteryService

power

LCD ON/~~OFF~~

~~LCD Brightness~~

~~Button Brightness~~

~~Keyboard Brightness~~

AcOnline: true

UsbOnline: true

BatteryPresent: true

BatteryLevel: 100

BatteryVoltage: 3

BatteryTemperature: 10

BatteryStatus: statusCharging

BatteryHealth: healthGood

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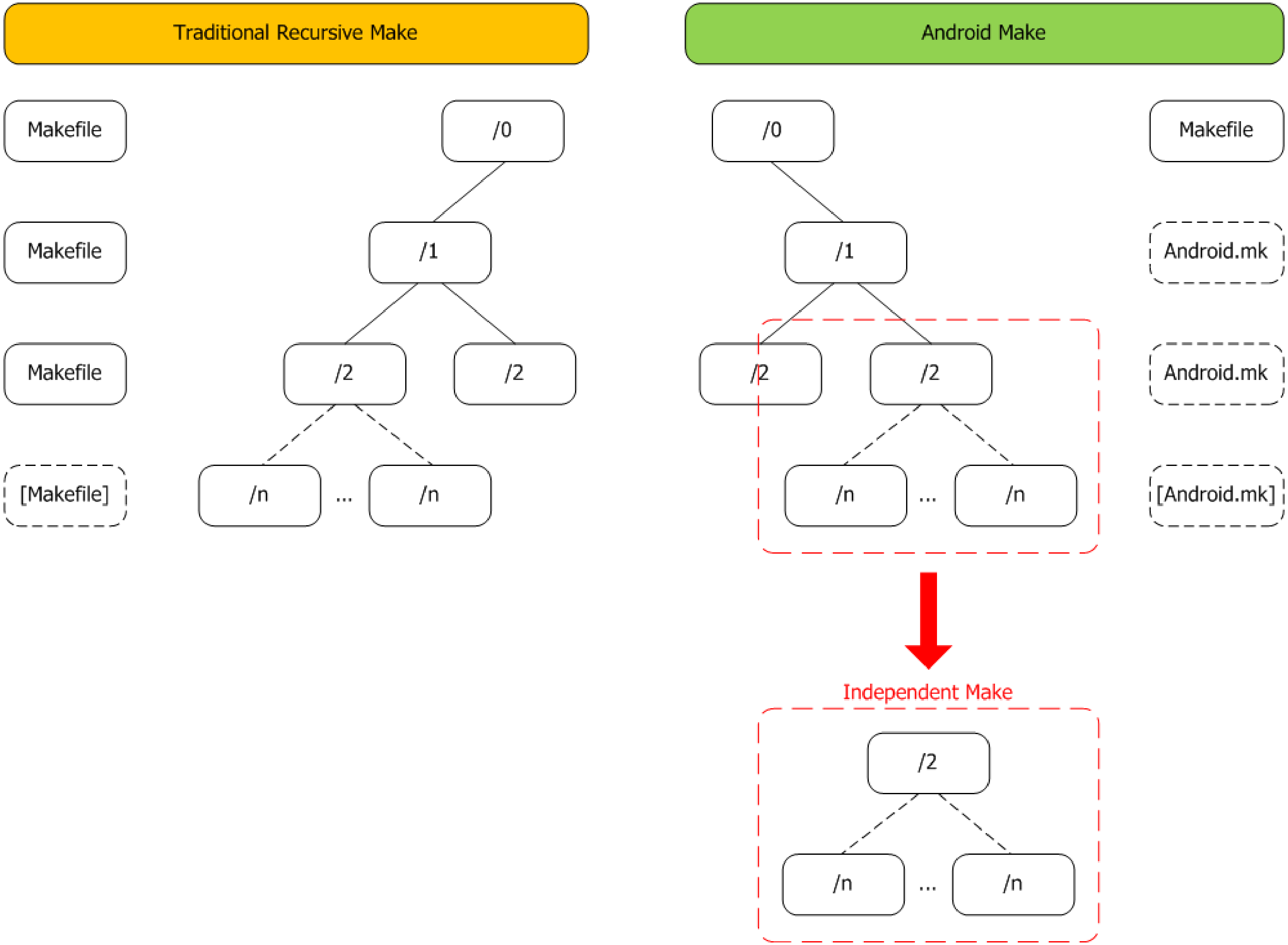
Why We Need A Building Environment

- Just type "make" to build a whole Android run-time system
- Speeding up development
- Complete system integration

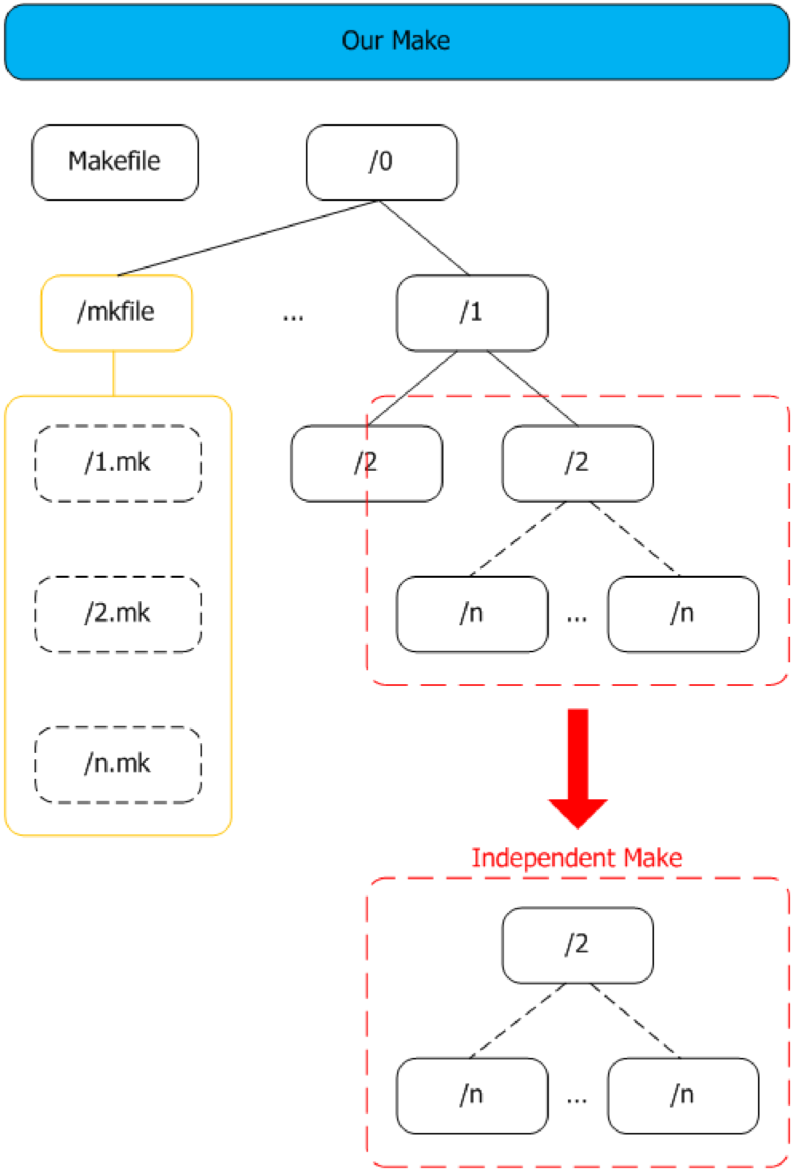
Our Building Environment

- A new building environment
- Avoid recursive make
- Reduce variable declaration in Makefile
- Structural building system
  - Component based building
  - Easy to add components through adding new Makefile in the mkfile directory
- Support parallel make as much as we could
  - Reduce dependency
  - Distributed make process

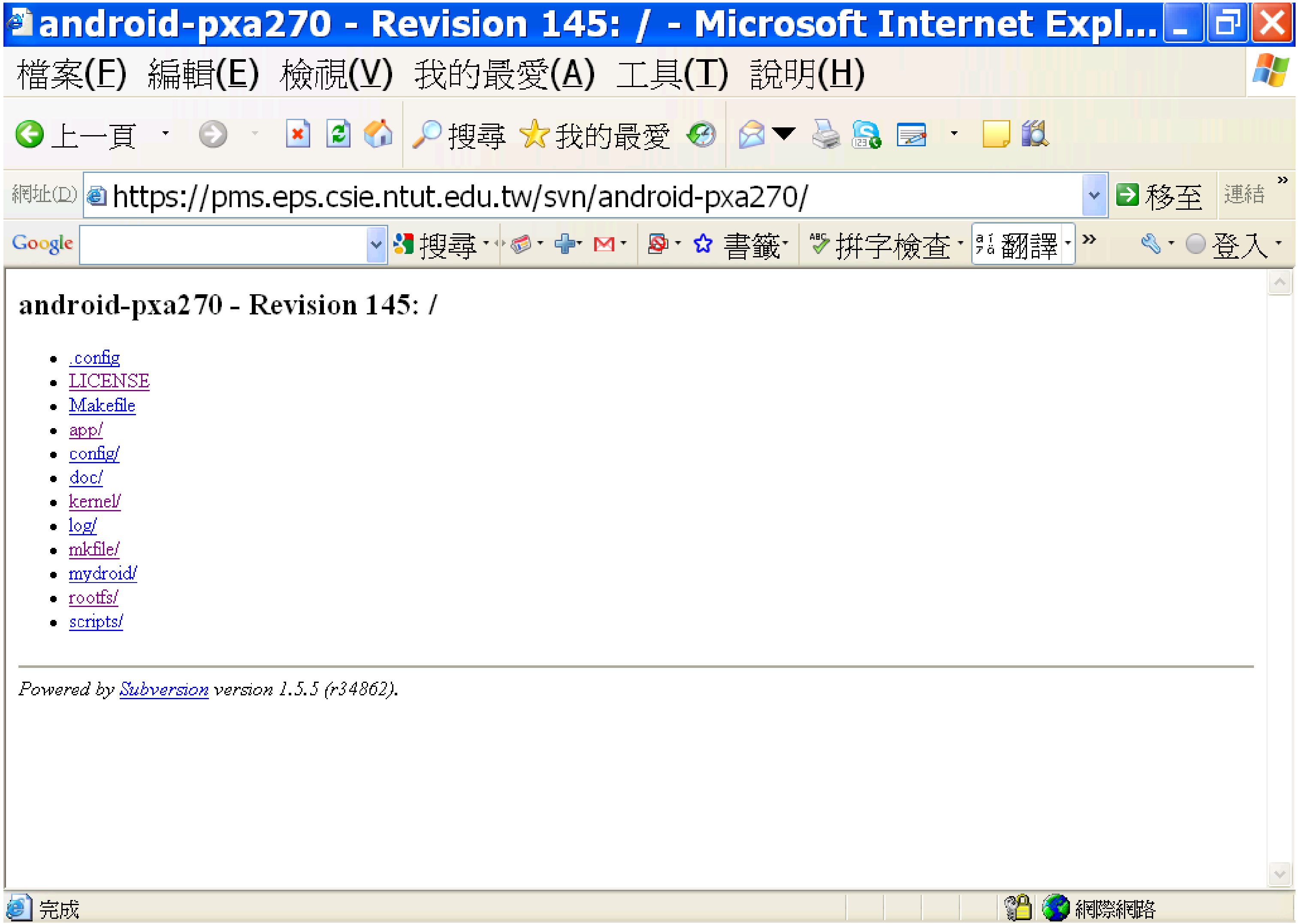
Recursive Make vs. Independent Make



Our Building Environment



How to Use Our Building Environment



android-pxa270 - Revision 145: / - Microsoft Internet Expl...
檔案(F) 編輯(E) 檢視(V) 我的最愛(A) 工具(T) 說明(H)
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連結
Google
搜尋
書籤
拼字檢查
翻譯
登入
完成
網際網路

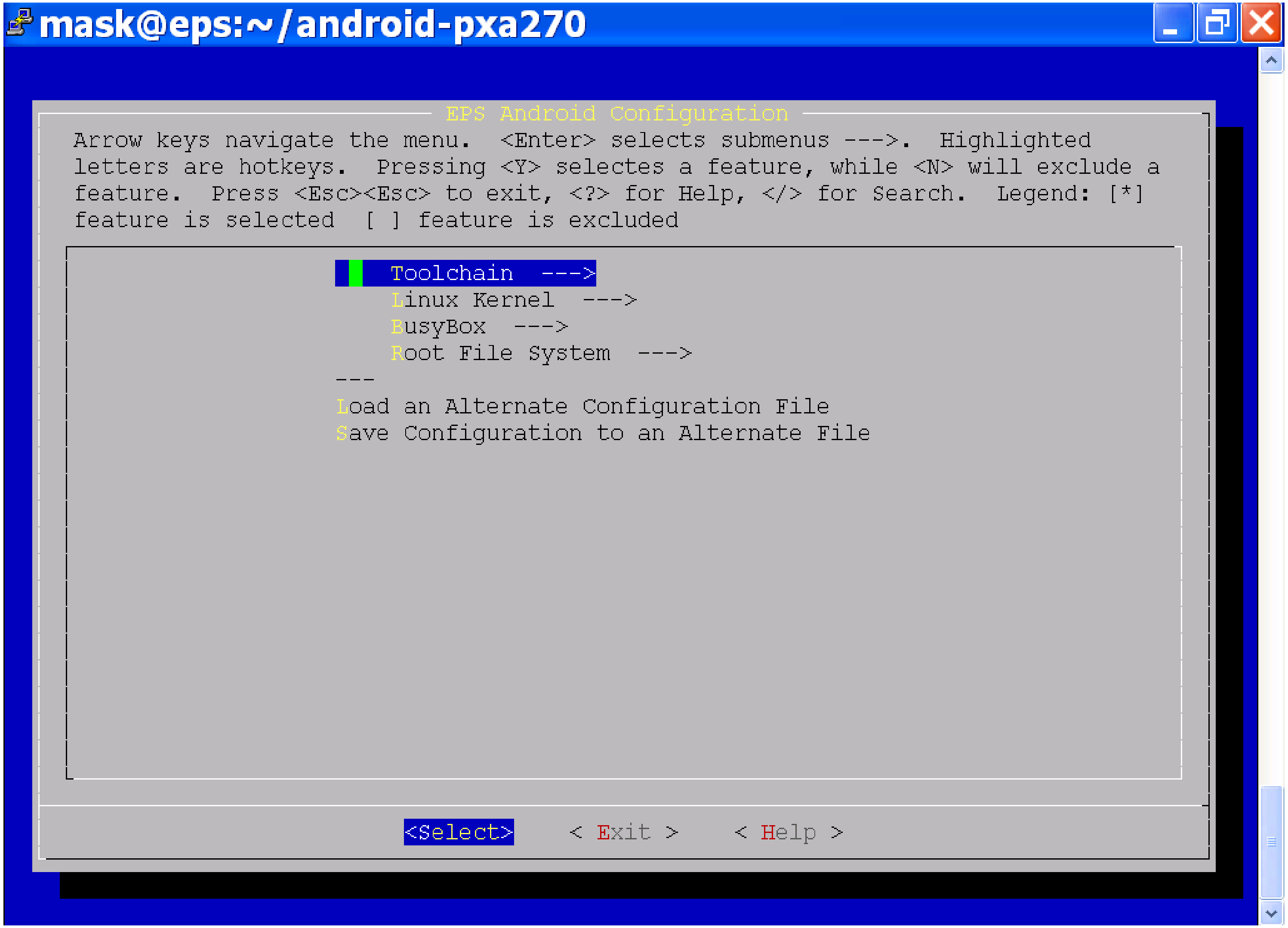
https://pms.eps.csie.ntut.edu.tw/svn/android-pxa270/

android-pxa270 - Revision 145: /

- .config
- LICENSE
- Makefile
- app/
- config/
- doc/
- kernel/
- log/
- mkfile/
- mydroid/
- rootfs/
- scripts/

Powered by Subversion version 1.5.5 (r34862).

make menuconfig

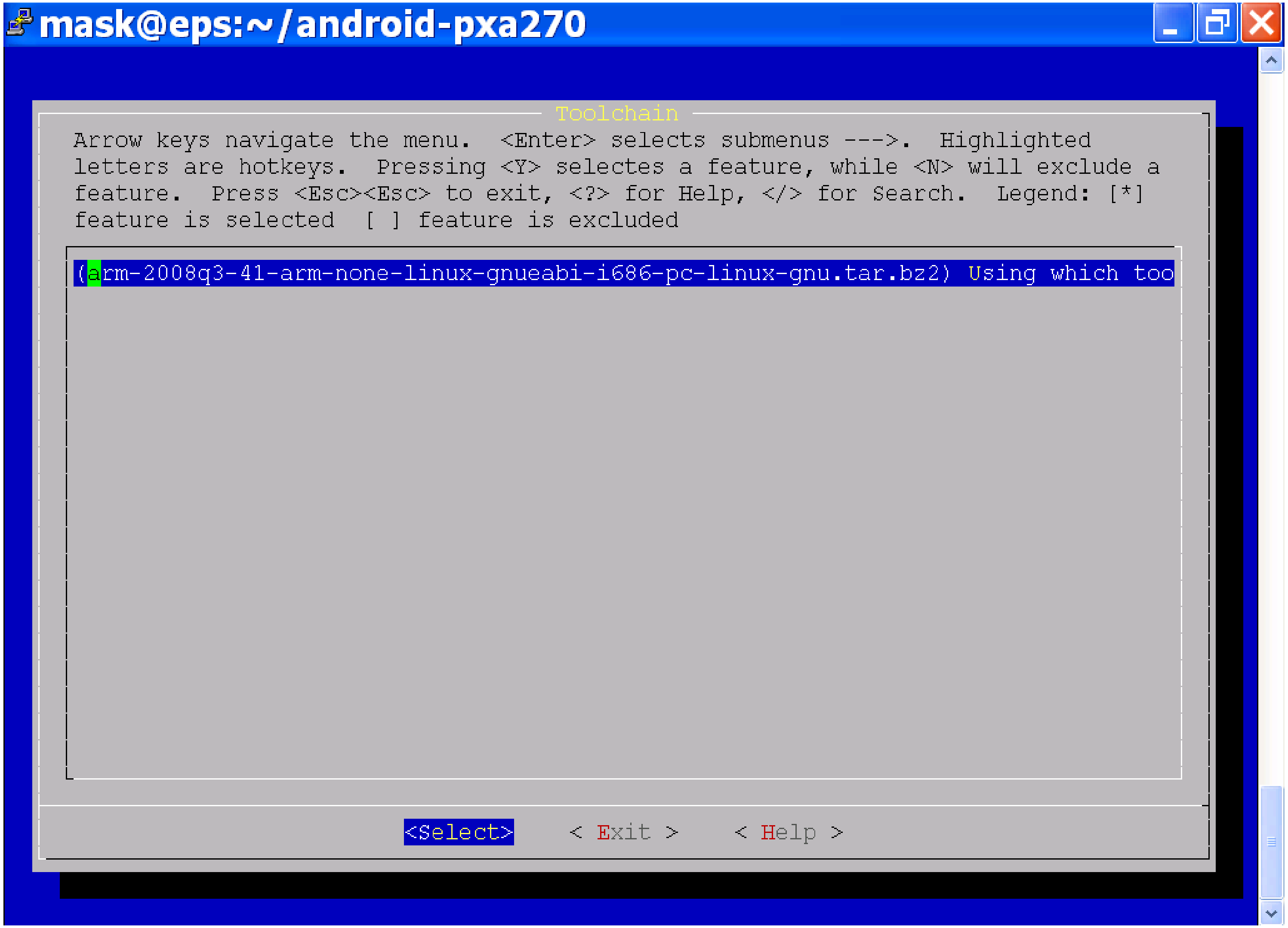


```
                        EPS Android Configuration
  Arrow keys navigate the menu.  <Enter> selects submenus --->.  Highlighted
  letters are hotkeys.  Pressing <Y> selectes a feature, while <N> will exclude a
  feature.  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*]
  feature is selected  [ ] feature is excluded

                     Toolchain  --->
                     Linux Kernel  --->
                     BusyBox  --->
                     Root File System  --->
                 ---
                 Load an Alternate Configuration File
                 Save Configuration to an Alternate File

                 <Select>    < Exit >    < Help >
```

Choose Toolchain

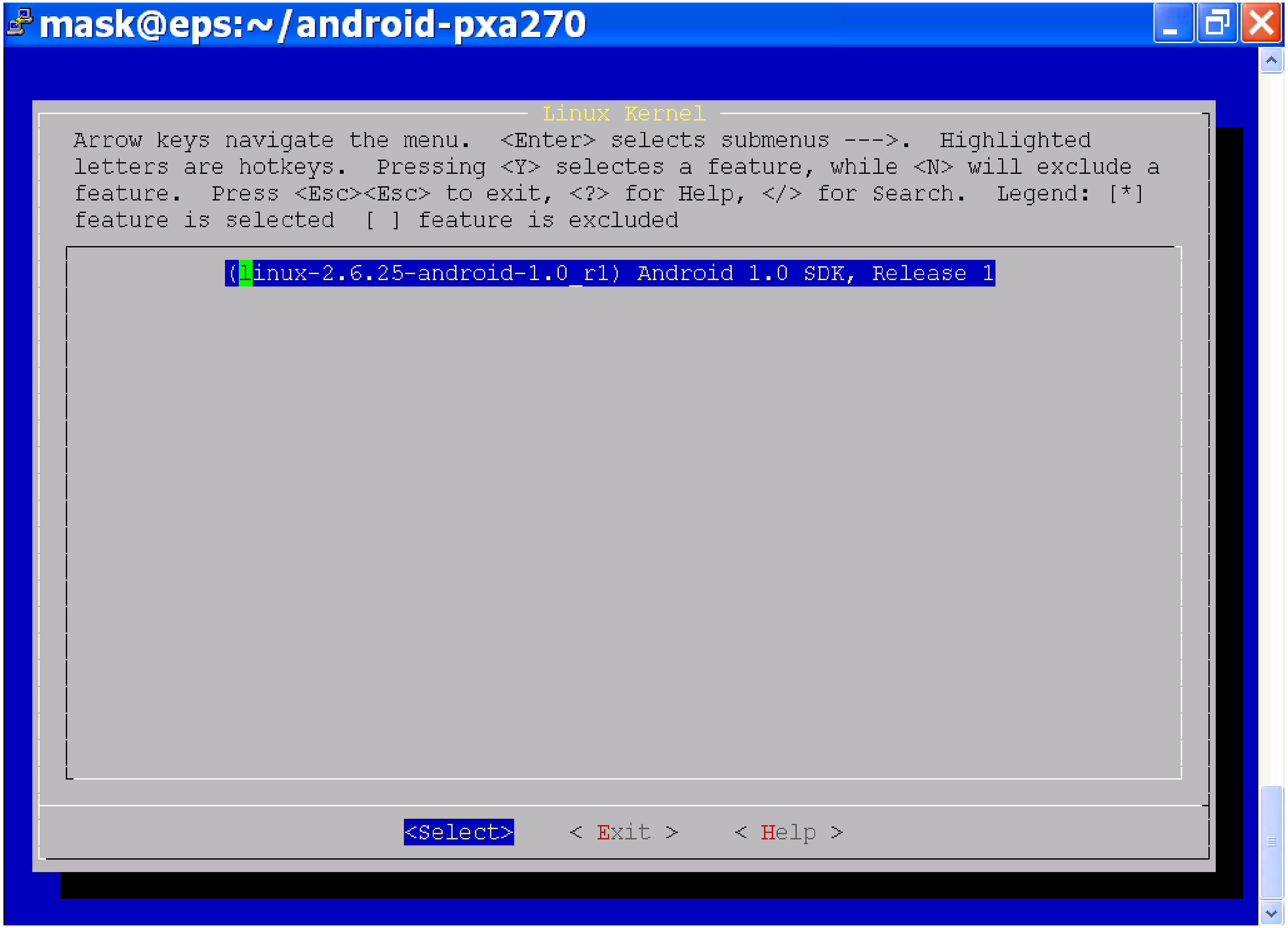


```
Toolchain
Arrow keys navigate the menu.  <Enter> selects submenus --->.  Highlighted
letters are hotkeys.  Pressing <Y> selectes a feature, while <N> will exclude a
feature.  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*]
feature is selected  [ ] feature is excluded

(arm-2008q3-41-arm-none-linux-gnueabi-i686-pc-linux-gnu.tar.bz2) Using which too

<Select>    < Exit >    < Help >
```

Choose Linux Kernel



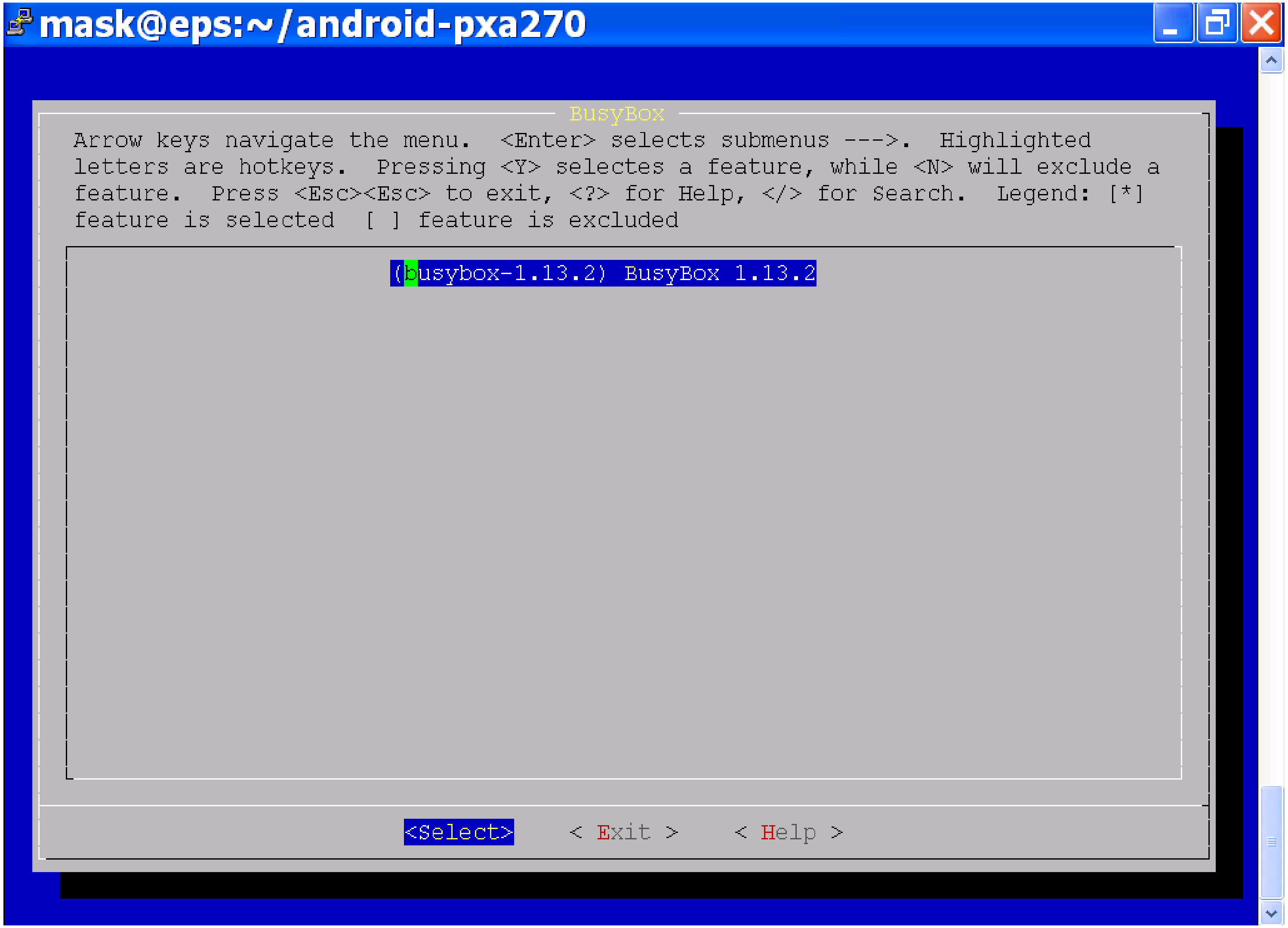
mask@eps:~/android-pxa270

```
                           Linux Kernel
  Arrow keys navigate the menu.  <Enter> selects submenus --->.  Highlighted
  letters are hotkeys.  Pressing <Y> selectes a feature, while <N> will exclude a
  feature.  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*]
  feature is selected  [ ] feature is excluded

             (linux-2.6.25-android-1.0_r1) Android 1.0 SDK, Release 1

                    <Select>    < Exit >    < Help >
```

Choose Busybox

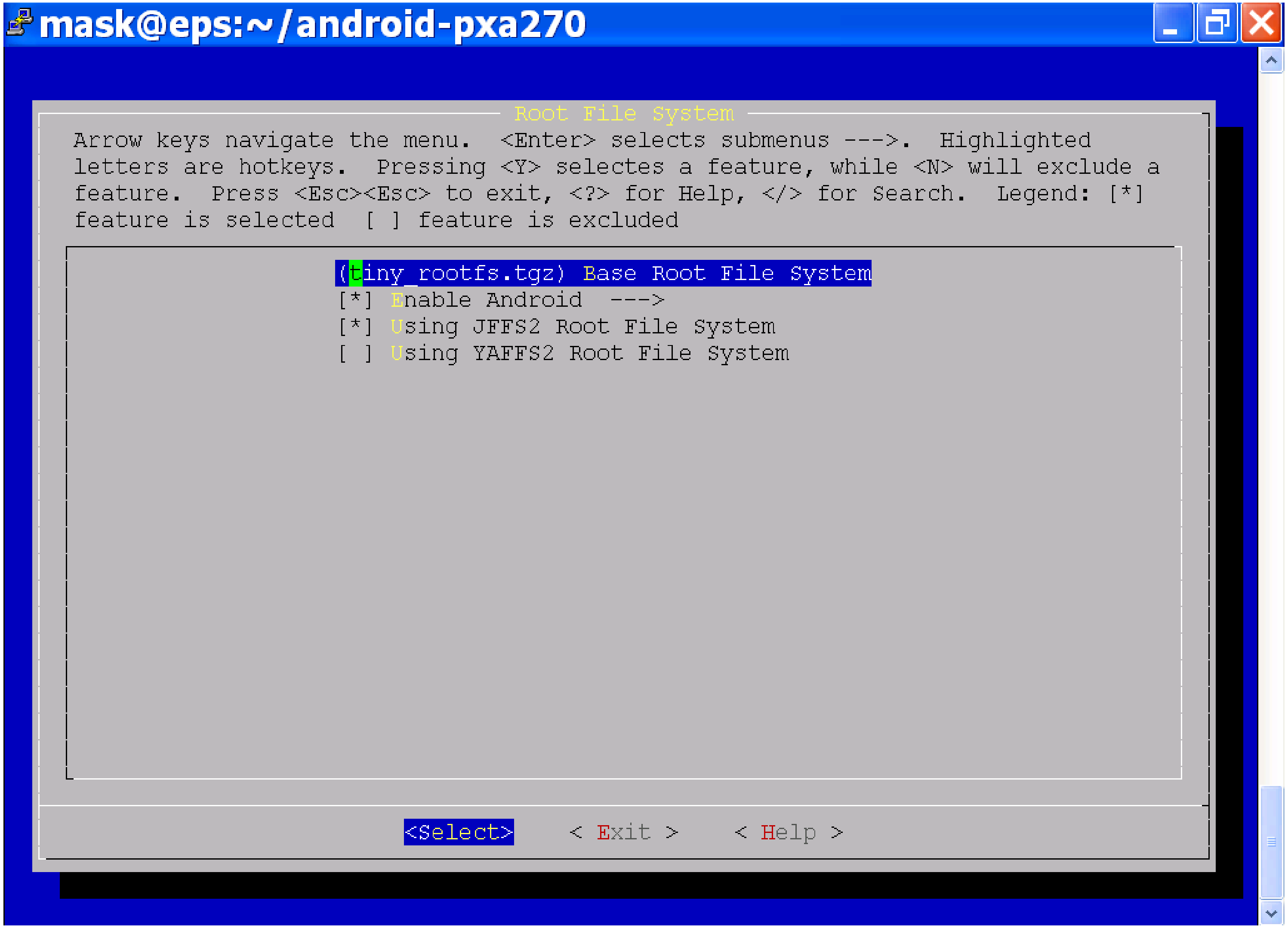


```
                              BusyBox
 Arrow keys navigate the menu.  <Enter> selects submenus --->.  Highlighted
 letters are hotkeys.  Pressing <Y> selectes a feature, while <N> will exclude a
 feature.  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*]
 feature is selected  [ ] feature is excluded

                  (busybox-1.13.2) BusyBox 1.13.2

                  <Select>    < Exit >    < Help >
```

Choose Root File System



```
                         Root File System
  Arrow keys navigate the menu.  <Enter> selects submenus --->.  Highlighted
  letters are hotkeys.  Pressing <Y> selectes a feature, while <N> will exclude a
  feature.  Press <Esc><Esc> to exit, <?> for Help, </> for Search.  Legend: [*]
  feature is selected  [ ] feature is excluded

                   (tiny_rootfs.tgz) Base Root File System
                   [*] Enable Android  --->
                   [*] Using JFFS2 Root File System
                   [ ] Using YAFFS2 Root File System

                      <Select>    < Exit >    < Help >
```

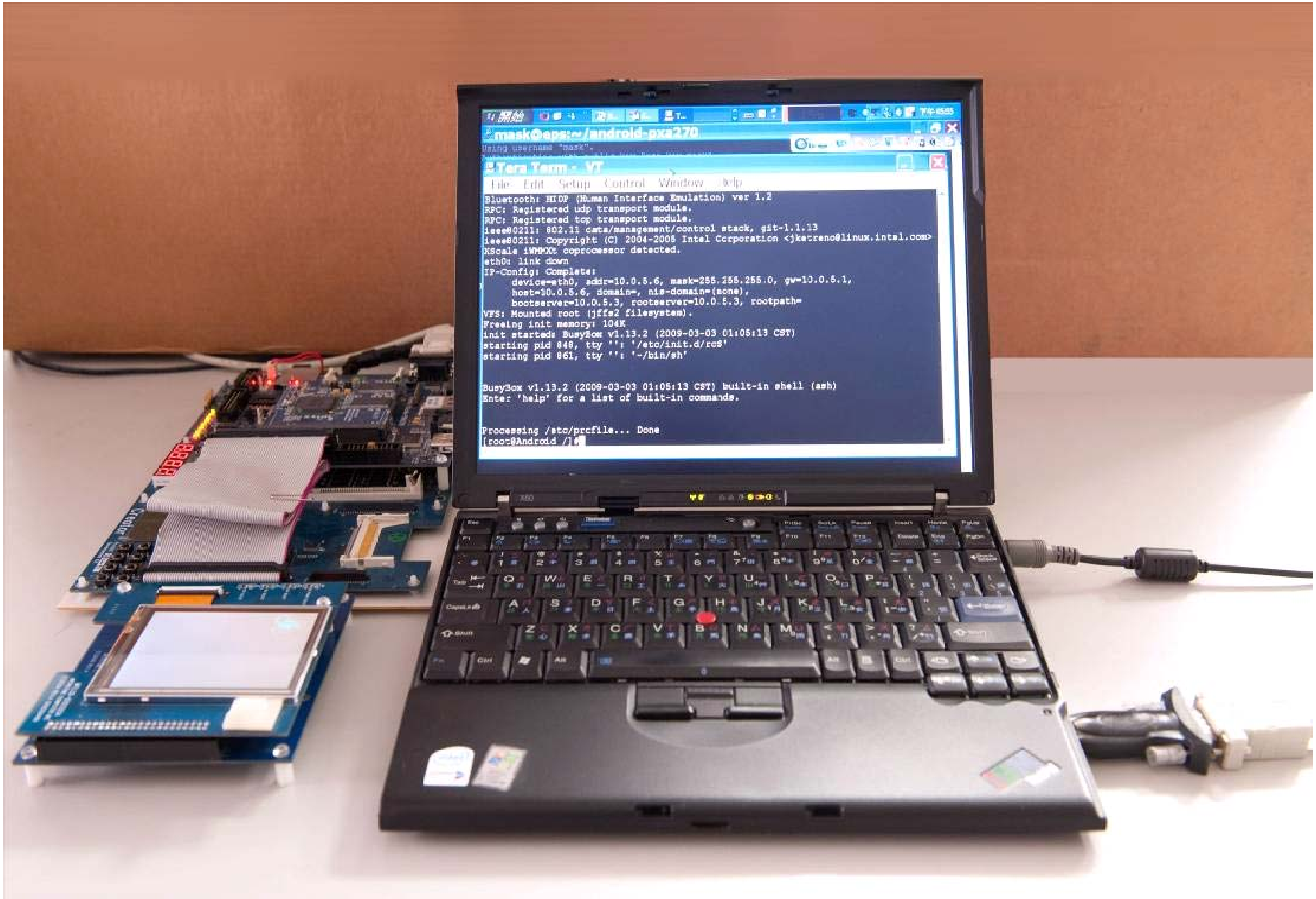
We Need More Powerful Developing Environment

- SVN
- SVN backup
- More powerful CPU
  - May need more than 1~2 hours to build our whole android run-time system at first time
- More large disk space
  - More than 6GB disk space

Statistics of Compiling Time

	CentOS release 5.3 (Final) / Red Hat Enterprise Linux Server release 5 (Tikanga)	Fedora release 7 (Moonshine)	Ubuntu 8.04.2
Kernel	2.6.18-128.1.10.el5，x86_64	2.6.23.17-88.fc7	2.6.24-23-generic
CPU	4x Intel(R) Xeon(TM) MP CPU 3.16GHz	2x Intel(R) Core(TM)2 CPU 6320 @ 1.86GHz	AMD Athlon(tm) 64 Processor 3000+
DRAM	4GB	1GB	2GB
make	1：28：39	1：47：01	1：18：57
make -j	53：48	FAIL	1：28：14
make –j4	47：37	N/A	N/A

Our Developing Environment



mask@eps:~/android-pxa270
Using username "mask".
Tera Term - VT
File Edit Setup Control Window Help

```
Bluetooth: HIDP (Human Interface Emulation) ver 1.2
RPC: Registered udp transport module.
RPC: Registered tcp transport module.
ieee80211: 802.11 data/management/control stack, git-1.1.13
ieee80211: Copyright (C) 2004-2005 Intel Corporation <jketreno@linux.intel.com>
XScale iWMMXt coprocessor detected.
eth0: link down
IP-Config: Complete:
      device=eth0, addr=10.0.5.6, mask=255.255.255.0, gw=10.0.5.1,
      host=10.0.5.6, domain=, nis-domain=(none),
      bootserver=10.0.5.3, rootserver=10.0.5.3, rootpath=
VFS: Mounted root (jffs2 filesystem).
Freeing init memory: 104K
init started: BusyBox v1.13.2 (2009-03-03 01:05:13 CST)
starting pid 848, tty '': '/etc/init.d/rcS'
starting pid 861, tty '': '-/bin/sh'


BusyBox v1.13.2 (2009-03-03 01:05:13 CST) built-in shell (ash)
Enter 'help' for a list of built-in commands.


Processing /etc/profile... Done
[root@Android /]#
```

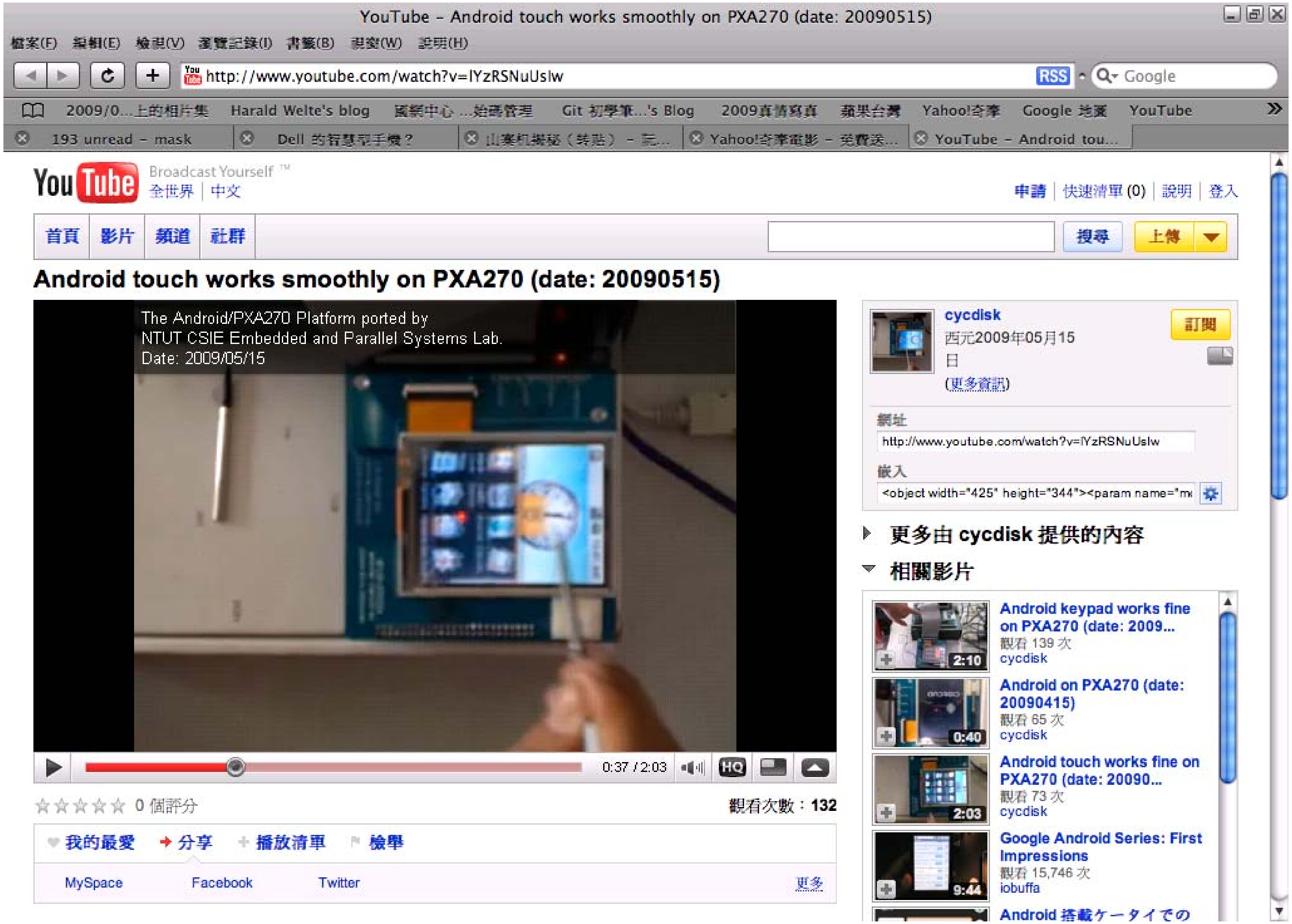
Outline

- Introduction
- Motivation
- Porting Procedure
- Building Environment
- Conclusion

Contributions

- Port Android to a real PXA270 target
- Open porting procedure
- Modify device drivers and whole Android system to make them cooperate with each other
- Open Source
- Build a new, simple, smart, component based building environment for developers co-work to each other

Contributions (cont)



YouTube - Android touch works smoothly on PXA270 (date: 20090515)

http://www.youtube.com/watch?v=lYzRSNuUslw

Android touch works smoothly on PXA270 (date: 20090515)

The Android/PXA270 Platform ported by
NTUT CSIE Embedded and Parallel Systems Lab.
Date: 2009/05/15

cycdisk
西元2009年05月15日
(更多資訊)

網址
http://www.youtube.com/watch?v=lYzRSNuUslw

嵌入
<object width="425" height="344"><param name="m

更多由 cycdisk 提供的內容

相關影片

2:10	Android keypad works fine on PXA270 (date: 2009... 觀看 139 次 cycdisk
0:40	Android on PXA270 (date: 20090415) 觀看 65 次 cycdisk
2:03	Android touch works fine on PXA270 (date: 20090... 觀看 73 次 cycdisk
9:44	Google Android Series: First Impressions 觀看 15,746 次 iobuffa
	Android 搭載ケータイでの

Future Works

- Enable peripherals
  - Audio
  - Wireless
  - …
- Low power
- Benchmarks
- Android applications

Q & A