



Operating System Practice– Lab 1: Developing Embedded Systems

Che-Wei Chang

chewei@mail.cgu.edu.tw

Department of Computer Science and Information
Engineering, Chang Gung University



Preparation

Notices

- ▶ No food, no drink
- ▶ The evaluation boards are quite expensive
- ▶ Do not do anything else to crash the PC
- ▶ Do not update the OS nor tools to keep the consistency
- ▶ Remember the number of your evaluation board
 - Check the items before you use them
 - Check the items before you return them
- ▶ No rubbish



What are We Going to Do?

- ▶ Build Cross Development Toolchain
- ▶ Build Linux Kernel
 - ➔ Check Point 1: uImage
- ▶ Setup tftp Server
- ▶ Setup NFS Server
 - ➔ Check Point 2: Test the Services
- ▶ Setup Target Board
- ▶ Download Linux Kernel
 - ➔ Check Point 3: Try the Linux Kernel



Fedora Linux

- ▶ The Fedora Project was created in late 2003
- ▶ We are using the version 38
- ▶ Package manager: RPM
- ▶ Update method: Yum
 - Password: csie123456
 - Select the language: Taiwan
 - WindowsKey+Space to change the input language
 - Activities → Search: terminal → to get the terminal
 - Edit → Profile Preferences → Colors → Uncheck “use colors from system theme”
 - Click the icon at the right-top corner for network setting



Setting Network

The image shows a sequence of macOS System Settings windows for configuring a network profile. A red speech bubble labeled "Your IP" points to the IP address field in the "New Profile" window. Another red speech bubble labeled "Add Profile" points to the "Add Profile..." button in the "Network" window.

All Settings

- Personal: Background, Notifications, Online Accounts, Privacy, Region & Language, Search
- Hardware: Bluetooth, Color, Displays, Keyboard, Mouse & Touchpad, **Network**
- System: Date & Time, Storage, Sharing, Users & Groups

Network

- Wired (Connected - 100 Mb/s)
- Network proxy
- Profile 1 ✓
 - IP Address: 192.168.68.179
 - Hardware Address: BC:EE:7B:DD:3B:B8
 - Default Route: 192.168.68.254
 - DNS: 163.25.114.1
- p6p1
- Add Profile...**

New Profile

IPv4 ☒ ON

Addresses

Address: 192.168.68.179

Netmask: 255.255.255.0

Gateway: 192.168.68.254

DNS Automatic ☒ ON

Server: 163.25.114.1

Cancel Add



vi— A Screen-Oriented Text Editor

- ▶ vi is widely supported by Unix-like operating system
- ▶ Normal mode
 - Move, search, copy, paste, delete,...
 - Press i, I, a, A, o, O,... to change to the insert mode
 - Press : for the command mode
- ▶ Command mode
 - Save, quit, load, split,...
 - After enter the command, it will be back to the normal mode
- ▶ Insert mode
 - Move and input anything
 - Press ESC to go back to the normal mode



vi Commands

- ▶ Press 'i' to get the insert mode
- ▶ Key-in anything
- ▶ Press 'ESC' to go back the normal mode
- ▶ Press ':→w→q→ENTER" to save and quit
- ▶ Please search for some tutorial of vi and study by yourself

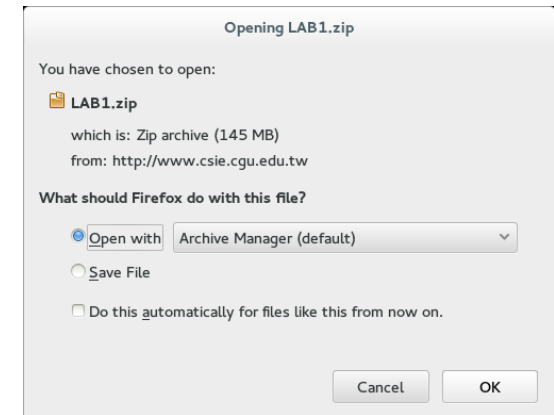




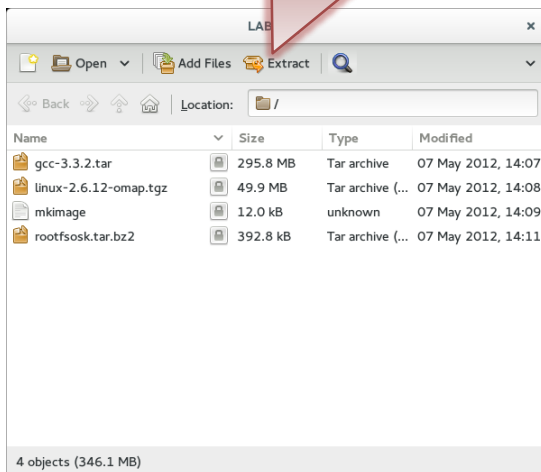
Lab1: Build the Linux Kernel for TI OMAP 5912

Download Files

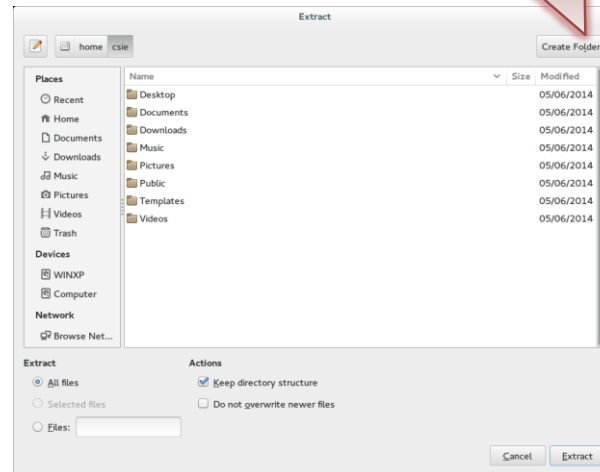
- Download the tools from the course website and extract the files



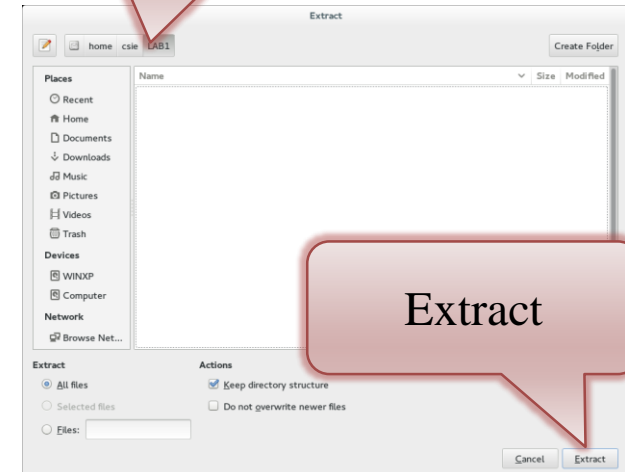
Extract



Create Folder



/home/csie/LAB1



Extract

Download Files

- ▶ You will need the following files
 - linux-2.6.12-omap.tgz → the kernel source code
 - gcc-3.3.2.tar → some gcc extension for this lab
 - mkimage → some script which is used when compiling kernel
 - rootfsosk.tar.bz2 → the content of the root filesystem
- ▶ You need the root privilege for the following actions
 - *sudo passwd root*
 - *su* (the password is root123456) → change to root
 - *cd /home/csie/LAB1*
 - *cp linux-2.6.12-omap.tgz /opt/linux-2.6.12-omap.tgz*
 - *cp gcc-3.3.2.tar /opt/gcc-3.3.2.tar*
 - *chmod +x mkimage*
 - *cd /opt*
 - *tar xvf gcc-3.3.2.tar*
 - *tar zxvf linux-2.6.12-omap.tgz*
 - *cp /home/csie/LAB1/mkimage /opt/usr/local/arm/3.3.2/bin/mkimage*



Prepare the Compiling Environment

► Set Path

- *export PATH=\$PATH:/opt/usr/local/arm/3.3.2/bin* → for every terminal session, before you compile the kernel
- *export LANG=en*

► Install Tools

- *yum -y install gcc* → compiler tools
- *yum -y install glibc.i686* → library for 32bit Linux kernel
- *yum -y install minicom* → minicom is the utility for the serial port connection



Build the Linux Kernel

- ▶ Go to the kernel source directory (be the root)
 - *cd /opt/linux-2.6.12*
- ▶ Set the kernel configuration
 - *make omap_osk_5912_defconfig*
- ▶ Compile the kernel
 - *make ulmage*
- ▶ Prepare the root filesystem
 - *cp /home/csie/LAB1/rootfsosk.tar.bz2 /tmp/rootfsosk.tar.bz2*
 - *cd /tmp*
 - *tar jxvf rootfsosk.tar.bz2*



Check Point 1

- ▶ Now, you should have the compiled kernel
- ▶ The kernel image is at:
`/opt/linux-2.6.12/arch/arm/boot/uImage`
- ▶ The root filesystem for the evaluation board is at:
`/tmp/rootfs2.6`



Set the Network Services (1 / 2)

- ▶ Disable the Firewall (it is not a good idea, only for this lab exercise)
 - *systemctl stop firewalld*
 - *systemctl disable firewalld*
- ▶ Set the TFTP Service
 - ~~*yum -y install tftp-server tftp*~~ → tftp is used to download kernel image
 - ~~*vi /etc/xinetd.d/tftp*~~
 - ✦ Find ~~*disable = yes*~~
 - ✦ Change it to ~~*disable = no*~~
 - ~~*systemctl start tftp.socket*~~
 - ~~*systemctl enable tftp.socket*~~
 - *dnf install tftp-server tftp -y*
 - *cp /usr/lib/systemd/system/tftp.service /etc/systemd/system/tftp-server.service*
 - *cp /usr/lib/systemd/system/tftp.socket /etc/systemd/system/tftp-server.socket*
 - *vi /etc/systemd/system/tftp-server.service*
 - *systemctl daemon-reload*
 - *systemctl enable --now tftp-server*
 - *chmod 777 /var/lib/tftpboot*

```
[Unit]
Description=Tftp Server
Requires=tftp-server.socket
Documentation=man:in.tftpd

[Service]
ExecStart=/usr/sbin/in.tftpd -c -p -s /var/lib/tftpboot
StandardInput=socket

[Install]
WantedBy=multi-user.target
Also=tftp-server.socket
```



Set the Network Services (2 / 2)

► Set the NFS Service

- *yum -y install nfs-utils* ➔ nfs for the root filesystem
- *vi /etc/exports*
 - Add the line */tmp/rootfs2.6 *(rw,fsid=1,no_root_squash)*
- *vi /etc/nfs.conf*
 - Add the line *udp=y*
- *exportfs -rv*
- *systemctl start rpcbind.service*
- *systemctl start nfs-mountd.service*



Test the Network Services

- ▶ You need a friend for the following test
 - One be the server and the other be the client
 - Switch the roles and do it again
- ▶ Test TFTP
 - Server side:
 - `vi /var/lib/tftpboot/testfile` → and then key something
 - Client side:
 - `tftp 192.168.68.xxx` (xxx is for the server IP)
 - `get testfile`
 - `quit`
 - `cat testfile`
- ▶ Test NFS
 - Server side:
 - Client side:
 - `mkdir /home/csie/nfstest`
 - `mount -t nfs 192.168.68.xxx:/tmp/rootfs2.6 /home/csie/nfstest`
 - `cd /home/csie/nfstest`
 - `ls`
 - `cd /`
 - `umount /home/csie/nfstest`



Check Point 2

- ▶ Now, you have enabled the TFTP and NFS services on your PC
- ▶ TFTP and NFS are properly working now



Set the Minicom (1 / 3)

- ▶ Enter the setting menu

- *minicom -s*

```
+-----[configuration]-----+
| Filenames and paths          |
| File transfer protocols      |
| Serial port setup            |
| Modem and dialing            |
| Screen and keyboard          |
| Save setup as dfl             |
| Save setup as..              |
| Exit                         |
| Exit from Minicom            |
+-----+
```

- ▶ Serial port setup ➔ press the letter to change it

```
+-----+
| A -   Serial Device          : /dev/ttyS0 |
| C -   Callin Program         :           |
| D -   Callout Program        :           |
| E -   Bps/Par/Bits           : 115200 8N1 |
| F -   Hardware Flow Control  : No        |
| G -   Software Flow Control  : No        |
|                               |
| Change which setting? █       |
+-----+
```



Set the Minicom (2/3)

► Modem and dialing

```
+-----[Modem and dialing parameter setup]-----+
| A - Init string .....
| B - Reset string .....
| C - Dialing prefix #1....
| D - Dialing suffix #1....
| E - Dialing prefix #2.... ATDP
| F - Dialing suffix #2.... ^M
| G - Dialing prefix #3.... ATX1DT
| H - Dialing suffix #3.... ;X4D^M
| I - Connect string ..... CONNECT
| J - No connect strings .. NO CARRIER      BUSY
|                               NO DIALTONE    VOICE
| K - Hang-up string ..... ~~+++~ATH^M
| L - Dial cancel string .. ^M
|
| M - Dial time ..... 45      Q - Auto bps detect ..... No
| N - Delay before redial . 2  R - Modem has DCD line .. Yes
| O - Number of tries ..... 10 S - Status line shows ... DTE speed
| P - DTR drop time (0=no). 1  T - Multi-line untag .... No
|
| Change which setting? ☐ Return or Esc to exit. Edit A+B to get defaults.
+-----+
```

```
+-----[configuration]-----+
| Filenames and paths
| File transfer protocols
| Serial port setup
| Modem and dialing
| Screen and keyboard
| Save setup as dfl
| Save setup as..
| Exit
| Exit from Minicom
+-----+
```



Set the Minicom (3 / 3)

- ▶ Save and leave the setting interface

```
+-----[configuration]-----+
| Filenames and paths          |
| File transfer protocols      |
| Serial port setup           |
| Modem and dialing            |
| Screen and keyboard         |
| Save setup as dfl            |
| Save setup as..             |
| Exit                         |
| Exit from Minicom           |
+-----+-----+-----+-----+
|                               |
+-----+-----+-----+-----+
```

```
+-----[configuration]-----+
| Filenames and paths          |
| File transfer protocols      |
| Serial port setup           |
| Modem and dialing            |
| Screen and keyboard         |
| Save setup as dfl            |
| Save setup as..             |
| Exit                         |
| Exit from Minicom           |
+-----+-----+-----+-----+
|                               |
+-----+-----+-----+-----+
```

- ▶ Start and quit minicom
 - Start *minicom*
 - Quit *CTRL+A → Q*

```
Welcome to minicom 2.6.2

OPTIONS: I18n
Compiled on Aug  7 2013, 13:32:48.
Port /dev/ttyS0, 21:18:16

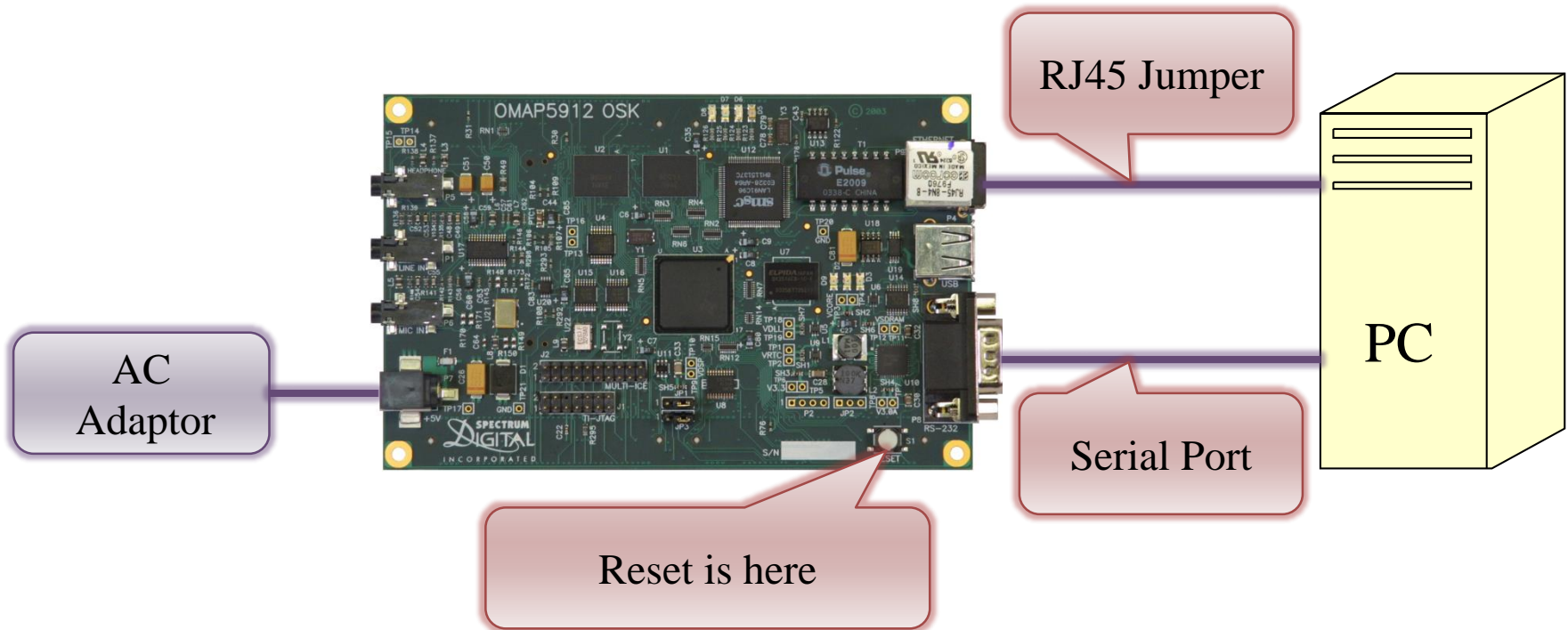
Press CTRL-A Z for help on special keys

█
```



Prepare for the Booting

- ▶ Copy the boot image for TFTP booting
 - `cp /opt/linux-2.6.12/arch/arm/boot/uImage /var/lib/tftpboot/uImage`
- ▶ Set the evaluation board as follows



Boot the Evaluation Board

- ▶ Start mimicom
 - *minicom*
- ▶ Press the reset button on the board
 - After the reset, immediately press any key on minicom terminal
 - You will get the following prompt

```
OMAP5912 OSK #
```



Download the New Kernel

► Set the boot configuration

- *set ipaddr 192.168.68.yy* (evaluation board IP)
- *set serverip 192.168.68.zz* (PC IP)
- *set netmask 255.255.255.0*
- *set gatewayip 192.168.68.254*
- *set ethaddr 00-0e-99-xx-xx-xx*
- *set bootargs console=ttyS0,115200n8 rw ip=192.168.68.yy root=/dev/nfs nfsroot=192.168.68.zz:/tmp/rootfs2.6,v3*
- *printenv* → double check the setting

```
OMAP5912 OSK # printenv
bootdelay=3
baudrate=115200
bootfile="uImage"
bootcmd=bootm 0x100000
ipaddr=192.168.68.123
serverip=192.168.68.186
netmask=255.255.255.0
gatewayip=192.168.68.254
ethaddr=00-0e-99-02-0d-0b
stdin=serial
stdout=serial
stderr=serial
bootargs=console=ttyS0,115200n8 rw ip=192.168.68.123 root=/dev/nfs nfsroot=192.168.68.186:/tmp/rootfs2.6,v3
Environment size: 337/131068 bytes
OMAP5912 OSK #
```

- *saveenv* → if everything is correct → be careful, do not crash the entire system



Boot the New Kernel and Mount the NFS Root Filesystem

- ▶ Download the kernel: *tftpboot 0x10000000 uImage*

```
OMAP5912 OSK # tftpboot 0x10000000 uImage
TFTP from server 192.168.68.186; our IP address is 192.168.68.123
Filename 'uImage'.
Load address: 0x10000000
Loading: #####
#####
#####
#####
done
Bytes transferred = 1110712 (10f2b8 hex)
OMAP5912 OSK # █
```

- ▶ Boot the OS: *bootm 0x10000000*

```
Looking up port of RPC 100003/3 on 192.168.68.186
Looking up port of RPC 100005/3 on 192.168.68.186
VFS: Mounted root (nfs filesystem).
Freeing init memory: 112K
init started: BusyBox v1.00-pre8 (2004.03.05-22:18+0000) multi-call binary

*****
Starting System Init for OMAP5912OSK
*****

Please press Enter to activate this console. █
```





Done!
Or Bugs!?

Common Mistakes

- ▶ *su* and *export* should be used whenever a new terminal is created
 - If you extract the root file system by the user csie, there will be an error when you boot the board to mount the NFS root file system
 - Reboot the computer and do everything again
 - If you do not export the path of the tools, you will get some error when you compile the kernel module
- ▶ Please read the error message if you type something wrong
- ▶ UART: it should be connected to the bottom port
- ▶ Ethernet: do check the IP is correct
- ▶ Some evaluation boards were tested to be good: 1(no usb cable), 7, 9, 10, 11, 15, 19, 20



Grading this Exercise

- ▶ Attend and understand this exercise: 10%
- ▶ Check point 1: 10%
- ▶ Check point 2: 10%
- ▶ Final results: 20%
- ▶ Report before the exercise: 25%
- ▶ Report after the exercise: 25%



Report Requirements

- ▶ Report before the exercise:
 - Only two pages, 12-pt font size
 - Deadline is 20:00, 2023/05/17
 - File name: OSP-Lab1-Study-StudentID
 - File type: PDF or Word
 - Upload to the e-learning system
- ▶ Report after the exercise:
 - Only two pages, 12-pt font size
 - Deadline is 20:00, 2023/05/26
 - File name: OSP-Lab1-Report-GroupID
 - File type: PDF or Word
 - Upload to the e-learning system
 - Remember to list all student IDs of your group

