



Embedded Systems

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Embedded Systems

- Definition of embedded system

- » Embedded system = H/W + S/W
 - ◆ H/W = CPU + Memory + I/O
 - ◆ S/W = Device driver + OS (or non OS) + Application program
- » Any electronic system that uses a CPU chip, but that is not a general-purpose workstation, desktop or laptop computer.
- » In embedded systems, the software typically resides in memory device, such as a flash memory or ROM chip. In contrast to a general-purpose computer that loads its programs into RAM each time.
- » Sometimes, single board and rack mounted general-purpose computers are called "embedded computers" if used to control.



Embedded Systems

- Computing systems using CPU are everywhere
 - » Most of us think of general purpose computers.
 - ◆ PC's, Laptops, Mainframes, Servers
 - » But there's another type of computing system.
 - ◆ Embedded computing systems : far more common
- Embedded computing systems
 - » Computing systems embedded within electronic devices.
 - » Nearly any computing system other than a general purpose computer.
 - » Performs pre-defined tasks, usually with very specific requirements.
 - » Since the system is dedicated to a specific task, design engineers can optimize it, reducing the size and cost of the product.
 - » Billions of units produced yearly, versus millions of desktop units.



Applications

- Appliances

- » Cell phones, Cell-phone base stations, Pagers, Answering machines, Teleconferencing systems, Video phones, Satellite phones, Cordless phones, Modems
- » PDAs, Digital cameras, GPS devices, Camcorders, Portable video games, Set top boxes, On-board navigation systems, MPEG decoders
- » Automatic teller machines, Logic analyzers, Digital storage oscilloscopes, Automatic toll systems, Electronic card readers, Electronic instruments
- » Air conditioners, Washing machines, Microwave ovens, Dish washers, Televisions, Refrigerators, VCRs, CD/DVD players, Video game consoles, Fax machines, Stereo systems, Music synthesizers
- » Floppy and hard disk drives, CD-RW and DVD-ROM drives, Printers, Scanners, Network cards, Network switches/routers



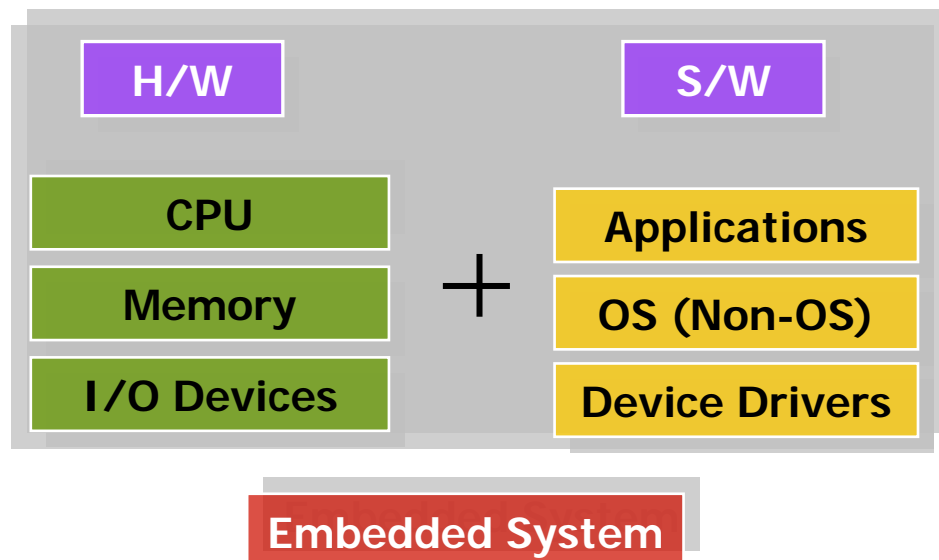
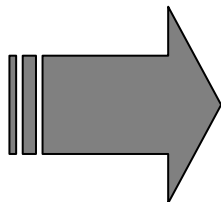
Applications

- » Electronic toys/games, Factory control, Fingerprint identifiers, Home security systems, Life-support systems, Medical testing systems, Photocopiers, Point-of-sale systems, Speech recognizers, Temperature controllers, Theft tracking systems
- » Avionic systems, Air planes, Spacecrafts, Boats
- The uses are endless, Most digital systems contain microprocessors.
- Billions of microprocessors are shipped every year for a myriad of applications.
- Cars may contain as many as 20 microprocessors
 - » controlling such tasks as antilock braking, climate control, engine control, audio system control, airbag deployment, automatic transmission, and cruise control.
- Perhaps 50 microprocessors per household

Applications



- Embedded System Design : H/W + S/W
 - » Application Software
 - » OS (porting or design)
 - » Device Driver
 - » Hardware (target platform)





Hardware in Embedded system

- **Hardware** : CPU + I/O + Memory

- » 1. CPU

- ◆ **embedded processor**

- an embedded processor (CPU) is a processor that is embedded in a system or device for some specific purpose.
- a processor (CPU) is to provide general purpose computing in computer system.

- ◆ **Microcontrollers, DSPs, Media Processors, Graphics Processors, Network and Communication Processors <-- 4, 8, 16, 32, 64 bits**

- The Intel 4004 was intended for an embedded application (calculator) in 1971.

- ◆ **CPU Classes (ISA) :** www.edn.com/microdirectory

- 4004, 4040, 8008, 8080, 8085, 8086/88, 80186/188, 80286, 386, 486, 586/Pentium/K5, 686/PentiumPro/II/III/IV/K6/K7, i860, i960, Z80, Z8000, eZ8, 650x, 680x, 68000, 68010, 68020, 68030, 68040, 68060, Alpha AXP, AVR, Clipper, DEC PDP, MCS48, MCS51, MCS96, MIPS Rx000, PA-RISC, PIC, PICmicro, PowerPC, SPARC, ARM, StrongARM, TMS9900, COP8, CoolRISC, H8, HC08, LatticeMico8, M8C, NEC K, ST7, TLCS, Ubicom, C166, CP3, HCS12, M16C, MSP430, S12X, Blackfin, Coldfire, FR, V850, Nios, SHARC, SuperH, Tricore



Hardware in Embedded system

- ◆ CPU Manufacturers : www.cpu-collection.de

- AMD, Altera, Analog Devices, AMI, ARM, Atmel, Broadcom, Chips and Technologies, Cirrus Logic, Cybernetic Micro Systems, Cypress, Cyrix, Dallas/Maxim, DEC, Fairchild, Freescale, Fujitsu, Harris, Hitachi, HP, IBM, IDT, IIT, Infineon, Intel, Intergraph, LSI Logic, Microchip, MIPS, Mitsubishi, MOS, Mostek, Motorola, National Semiconductor, NCR, NEC, NexGen, OKI, Philips, QED, Rabbit Semiconductor, Renesas, Rockwell, Samsung, SGS-Thomson, Sharp, Silicon Lab, Siemens, Signetics, Sony, SST, STM, Sun Microsystems, Texas Instruments, Toshiba, Transmeta, Ubicom, ULSI, UMC, VIA, VLSI Technology, WDC, Weitek, Xilinx, Zilog

- » 2. I/O Devices

- ◆ Digital IO (GPIO-LED, Relay, Switch,...) , ADC, DAC, U(S)ART, Timer/counter, WDT, I2C, SPI, PWM, Actuator, Sensor, Touch screen, IRDA, Network (Ethernet, X.25, Wireless...), USB, IEEE1394 (Firewire), Audio, Video Graphic, LCD, Keyboard, Mouse, DMAC

- » 3. Memory : *program + data*

- ◆ Volatile : RAM (SRAM, DRAM)
- ◆ Non-volatile : UVEPROM (Chip Level Erase), EEPROM (Byte Level Erase), Flash ROM (Block Level Erase), OTPROM, Mask ROM



Software in Embedded system

- **Software** : Device driver + OS + Application program
 - » 1. Device driver
 - ◆ Digital IO (GPIO-LED, Relay, Switch,...) , ADC, DAC, U(S)ART, Timer/counter, WDT, I2C, SPI, PWM, Actuator, Sensor, Touch screen, IRDA, Network (Ethernet, X.25, Wireless...), USB, IEEE1394 (Firewire), Audio, Video Graphic, LCD, Keyboard, Mouse, DMAC, Bluetooth
 - » 2. OS or non-OS
 - ◆ OS roles and missions
 - a. Process Management : Task scheduling, Context switching
 - b. Resource Management : CPU, Memory, Disk, I/O devices
 - c. Memory Management : MMU
 - d. File System : FAT, NTFS, EXT2/3, JFS, NFS
 - e. Device Driver : I/O, Network
 - f. GUI, Security, ...
 - ◆ Embedded system OS
 - Multi-tasking, Network, Multimedia, GUI, Portable, ROMable, Preemptive, Deterministic (**Hard Real-time**), Robust & Reliable



Software in Embedded System

◆ OS classes : Non-RTOS, RTOS

→ RTOS :

- » Soft Real-time : Computers, PDAs, Air conditioners, VCRs,
- » Hard Real-time (**deterministic**) : Air planes, Cars, Space crafts, Plant controls, ...

→ 1) non-RTOS

- » **Open source** : Linux, uClinux (www.uclinux.org), OpenSolaris (www.opensolaris.org), FreeBSD (www.freebsd.org), Minix (www.minix3.org)
- » **Proprietary** : Multics, Unix, AIX, VMS, SunOS, HP/UX, SCO Unix, Zenix, System V, NextStep, MVS, CP/M, DOS, OS/2, Windows, Symbian (www.symbian.com), Windows CE/Windows XP Embedded (www.microsoft.com), Qplus/NanoQplus (www.qplus.or.kr), BeOS/ZETA (www.yellowtab.com)

→ 2) RTOS

- » **Open source** : eCos (www.ecos.sourceware.org), FreeRTOS (www.freertos.org), Nut/OS (www.ethernut.de), RTLinux (www.rtlinuxfree.com), TRON (www.sakamura-lab.org/TRON), TinyOS (www.tinyos.net), LinuxWorks (www.linuxworks.com),
- » **Proprietary** : RTLinuxPro (www.fsmlabs.com), iTRON (www.ertl.jp/ITRON), LynxOS (www.linuxworks.com/rtos), uLinux (www.lineo.co.jp), uC/OS (www.ucos-ii.com), Nucleus/VRTX (www.mentor.com), OS-9 (www.radisys.com), VxWorks/pSOS (www.windriver.com), QNX (www.qnx.com), ThreadX (www.rtos.com), Neos (www.velos.co.kr), Montavista Linux (www.mvista.com)



Software in Embedded System

» 3. Application program

- ◆ Media player, Navigation, GIS, GUI,

- ◆ GUI : GUI + GUI toolkit

 - Graphical User Interface

 - » Window environments

 - » Graphics applications : not character oriented.

 - » Graphics application programming : toolkit (GUI Lib./API)

 - Embedded GUI architectures

 - » Nano-X : www.microwindows.org

 - » Qt/embedded : www.trolltech.com

 - » MiniGUI : www.minigui.com

 - » MatchBox : projects.o-hand.com/matchbox

 - » PicoGUI : www.picogui.org

 - » FLNX : www.fltk.org, toolkit

 - » DirectFB : www.directfb.org

 - » GTK+/FB : www.gtk.org, toolkit

 - » TinyX : XFree86 based

 - Kdrive : www.pps.jussieu.fr/~jch/software/kdrive.html

 - SmallX : www.superant.com/smalllinux/tinyX01.html

 - Integrated Tiny-X : www.x-oz.com/tinyx.html



Knowledges for Embedded System Design

- **Hardware Design**

- » Digital components, Microprocessor, Memory, I/O devices, Bus structure, DMA,... : Computer Architecture

- **Programming Tools**

- » Assembler : Target CPU (ARM, x86, PowerPC,...)
- » Programming Language & Compiler : C, C++, Java, perl, html, gcc Compiler
- » Utility : make utility

- **Real-Time and Embedded OS**

- » Device Driver, Kernel, File System, Network Protocols
- » Administration : Shell script, Network, H/W & S/W Installation and Maintenance

- **Applications**

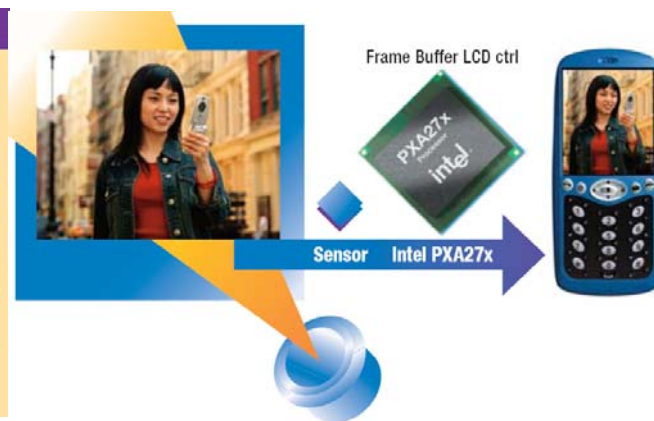
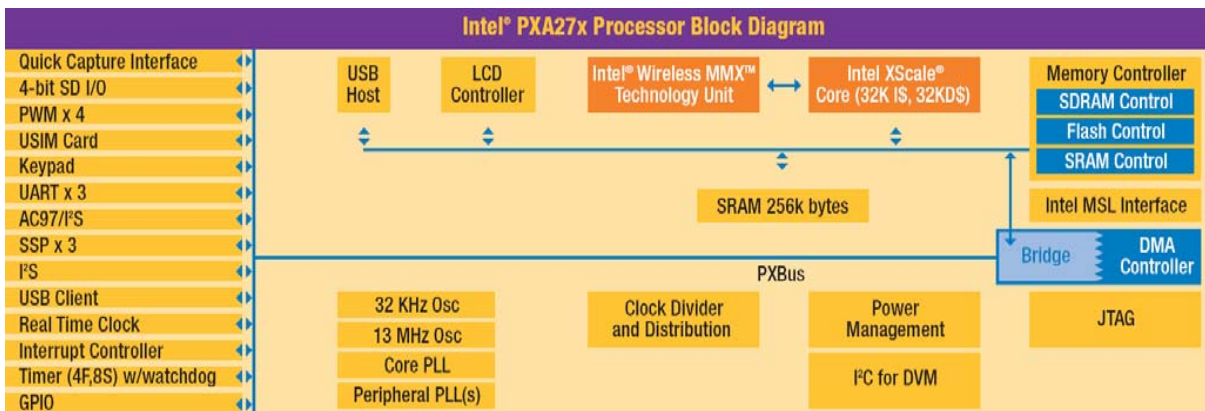
- » GUI : Xwindows, gnome, qtopia, match box, nano-x,....





Intel PXA270 Application Processor

- Our Class Target System
 - » 1. PXA270 Bulverde Embedded Controller
 - » 2. Linux Operating System
 - » 3. Applications : GUI(matchbox, Qt/Embedded), Device drivers
- 1. PXA270 Kit : Hybus
 - » Handheld & Handset Intel Application Processor
 - ◆ developer.intel.com/design/pca/applicationsprocessors/index.htm
 - ◆ mobile, handheld, wireless
 - ◆ Block Diagram & Quick capture





PXA270 Processor

- » Quick capture
 - ◆ 3 operation modes : Quick view/shot/video
 - Quick View mode : low-power, real-time previews
 - Quick Shot mode : high-resolution image capture up to 4+ mega pixels
 - Quick Video mode : full-motion, high-quality video capture
- » 4-bit SD I/O
 - ◆ 1-bit = 19.5 Mbps, 4-bit = 78 Mbps
- » USIM (Universal Subscriber Identity Module) interface
 - ◆ communications interface for a GSM mobile handset.
- » SSP (Synchronous Serial Protocol)
 - ◆ Texas Instruments (TI) Synchronous Serial Protocol
 - ◆ Motorola Serial Peripheral Interface (SPI) protocol
 - ◆ National Semiconductor Microwire
 - ◆ Programmable Serial Protocol (PSP)
- » I2S (Inter-IC sound)
 - ◆ the name of a protocol defined by Philips Semiconductor for transferring two-channel digital audio signals from one IC device to another.



Linux Operating System

• 2. Linux Operating System

» History

- ◆ First developed in 1991 by **Linus Torvalds**, with the major design goal of UNIX compatibility.
- ◆ Linux - **L**inux 's **N**ot **U**ni**X**
- ◆ Modern, free operating system based on UNIX standards.
- ◆ Collaboration by many users from all around the world.
- ◆ Designed to run efficiently and reliably on common PC hardware, but also runs on a variety of other platforms.
- ◆ Kernel version : www.kernel.org
 - Major version number
 - Minor version number
 - » Even indicates production release
 - » Odd indicates development release
 - Patch-level number
- ◆ Linux kernel ver. 0.01 (May 1991) had no networking, ran only on 80386-compatible Intel processors and on PC hardware, had extremely limited device-drive support.

2.6.17-9



Linux Operating System

- ◆ **Linux Kernel ver. 1.0 (March 1994) included these new features:**
 - Support for UNIX's standard TCP/IP networking protocols.
 - BSD-compatible socket interface for networking programming.
 - Enhanced file system & Support for SCSI controllers for high-performance disk access
 - The main Linux Vendors appear : RedHat, Caldera, SuSe
- ◆ **Linux kernel ver. 2.0 (June 1996) added major new capabilities:**
 - Support for multiple architectures, including a fully 64-bit Alpha processor, Motorola 68000 processor, Sun Sparc system, and PowerMac system.
 - Support for multiprocessor architectures (SMP).
 - Improved memory-management code and TCP/IP performance.
 - Standardized configuration interface.
- ◆ **2.4 and 2.6 increased SMP support, added journaling file system, preemptive kernel, 64-bit memory support.**
- ◆ **Linux uses many tools developed as part of Berkeley's BSD operating system, MIT's X Window System, and the Free Software Foundation's GNU project.**
- ◆ **GNU/Linux Distributions : Linux kernel + GNU Free software**
 - Commercial distributions : Ubuntu, Mandriva, Redhat, Suse
 - Free distributions : Debian, Gentoo, Fedora



Linus Benedict Torvalds

» Linus Benedict Torvalds

- ◆ Born on December 28, 1969 in Helsinki, Finland.
- ◆ Learned to write computer games for Commodore VIC 20 when he was twelve.
- ◆ In 1988, Linus began studying computer science at the University of Helsinki. He began learning the assembly language for Intel 386 processor. He coded a number of advanced software projects, including a floppy disk driver and software assembler.
- ◆ In 1991, when he was just 21, He found the existing DOS and UNIX too expensive and inadequate. Linus was inspired by Minix to develop a capable Unix-like operating system that could be run on a PC.
- ◆ From 1997 to 2003, Linus worked for Transmeta Corporation. He currently works for Open Source Development Labs in Beaverton, Oregon.





Linux Operating System

» License

- ◆ The Linux kernel is distributed under the GNU General Public License
- ◆ GNU GPL or simply GPL : GNU General Public License
 - The GPL was written by Richard Stallman for use with programs released as part of the GNU project, and GPL version 1 was released in January 1989.
 - You can redistribute and modify GNU/Linux by GPL.
 - <http://www.gnu.org/copyleft/copying-1.0.html>
- ◆ GNU LGPL : formerly the GNU **L**ibrary General Public License
 - The GNU **L**esser General Public License(LGPL) was written in 1991 (and updated in 1999) by Richard Stallman.
 - if a legal ruling states that they can only distribute the software in binary form, they cannot distribute it at all.
 - <http://www.gnu.org/copyleft/lesser.html>
- ◆ GNU : <http://www.gnu.org>
 - Project in Free Software Foundation (FSF)
 - » <http://www.gnu.org/fsf/fsf.html>
 - Organization that maintain and collect many free software
 - » <http://directory.fsf.org/> : 4960 packages (bash, gcc, binutil, make,...)
 - GNU = **G**nu is **N**ot **U**nix, Initiated by Richard Stallman since 1984



Linux Operating System

- ◆ The GPL grants the recipients of a computer program the following rights:
 - the right to run the program, for any desired purpose.
 - the right to study how the program works, and modify it. (Access to the source code is a precondition for this)
 - the right to redistribute copies.
 - the right to improve the program, and release the improvements to the public. (Access to the source code is a precondition for this)
- ◆ Copyleft License: GPL and LGPL
 - a general method for making a program free software and requiring all modified and extended versions of the program to be free software as well.
- ◆ FSF : Free Software Foundation
 - The FSF, established in 1985, is dedicated to promoting computer users' rights to use, study, copy, modify, and redistribute computer programs.
 - The FSF promotes the development and use of free software.



Richard Matthew Stallman

- » Richard Matthew Stallman = rms
 - ◆ President and founder of the Free Software Foundation and GNU project.
 - ◆ Born in Manhattan, New York on March 16, 1953.
 - ◆ Author of the GNU Compiler, the GNU symbolic debugger (gdb), and GNU Emacs.
 - ◆ At high school in 1969. Hired by the IBM New York Scientific Center.
 - ◆ Graduated from Harvard in 1974 with a BA in physics. During his college years, he also worked as a staff hacker at the MIT Artificial Intelligence Lab.
 - ◆ In January 1984 he resigned from MIT to start the GNU project.





Linux Operating System

» Linux Features

- ◆ Main design goals are speed, efficiency, and standardization
- ◆ Multiuser, multitasking system with a full set of UNIX-compatible tools.
- ◆ Fully implements the standard UNIX networking model.
- ◆ Designed to be compliant with the POSIX documents.
- ◆ Stability : system robustness in the standards of all the Unix systems
- ◆ Security : viruses, spywares
- ◆ No purchase cost, no registration, no obligations
- ◆ Open source OS : modify any part of the OS and adapt it to your needs, without any restriction
- ◆ User friendly : KDE and GNOME Window Managers

» Disadvantages compared with Windows

- ◆ Various application software cannot run on Linux
- ◆ Not as popular as Windows
- ◆ No one is responsible for Linux support
 - help is available in Internet only
- ◆ Relatively hard to install, learn and use



Linux Operating System

- » Linux is mainly used in commercial applications such as server implementation or embedded system.
- » Due to the relatively high reliability, more than 75% current network servers are based on Linux or Unix systems.
- » Linux Study
 - ◆ Linux Programmer
 - Linux GUI Programming
 - Linux Network & System Programming
 - Linux Kernel Programming
 - Linux Device Driver Programming
 - ◆ Linux Administrator
 - Linux System Administrator
 - Linux Network & Security Administrator
 - Linux Cluster
 - MySQL Administrator



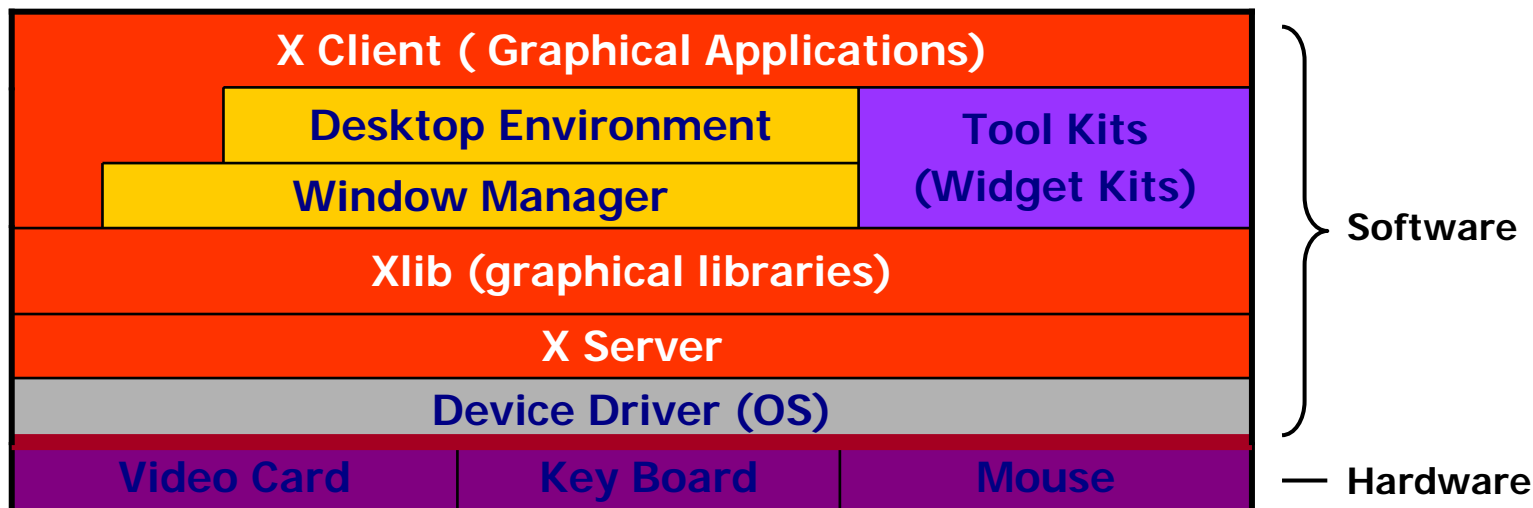
Target System Applications

- » Linux porting to the target board in this class
 - ◆ Menuconfig : Kernel configuration
 - ◆ Kernel compile
 - ◆ Device driver programming
- » Linux kernel version in this class
 - ◆ Host : 2.4.20-8 Target : 2.6.11-8
- 3. Applications : Device drivers + GUI applications
 - » Device drivers : LED, 7-Segment, LCD, GPIO, Network,...
 - ◆ Physical address directly
 - ◆ mmap, ioremap
 - ◆ device module
 - ◆ kernel inclusion
 - » GUI applications
 - ◆ Desktop GUI : X window
 - ◆ Embedded target system GUI: Qtopia (current target GUI : Match box)



X Window System

- » X Window System (commonly X11 or X)
 - ◆ X originated at MIT in 1984, and current protocol version X11R7.2
 - ◆ provides windowing for bitmap displays, and the standard toolkit and protocol to build graphical user interfaces(GUI).
 - ◆ client-server model: the terms "client" and "server" reversed, in that "server" refers to the user's local display ("display server")
 - ◆ The server accepts requests for graphical output (windows) and sends back user input (from keyboard, mouse, or touch screen).





X Window System

- ◆ XFree86 and X.org
 - In September 1998, X11R6.4 was released with non-free distribution terms.
 - The XFree86 group will not accept copylefted software and choose a "non free software compliant" license (contained an advertising clause).
- ◆ Why did the XFree86 modify their license?
 - David Dawes, the current President of the XFree86 Project, when he announced the revision on 29 January 2004, noted that the main reason was to ensure that the Project and its developers receive their full due for what they have given freely away these past 12 years.
- ◆ Why X.Org Foundation?
 - In a period between close to the end of 2003 and beginning of 2004, there were attempts from leading XFree86.org project members to apply a few restrictions on the existing 1.0 license of the upcoming XFree86 X4.4.0 release. Since not all (developers, distributors, hardware vendors) were able or willing to agree with and implement that new licensing policy in their code, their development process and their products, they consequently split up and rejoined in the form of the X.org Foundation.
- ◆ The X.Org Foundation leads the X project.



X Window System

» Window Manager

◆ Special X-client software

- defines the way windows are placed on the screen.
- Defines how the window borders look and act.

◆ Provides interactive components for windows

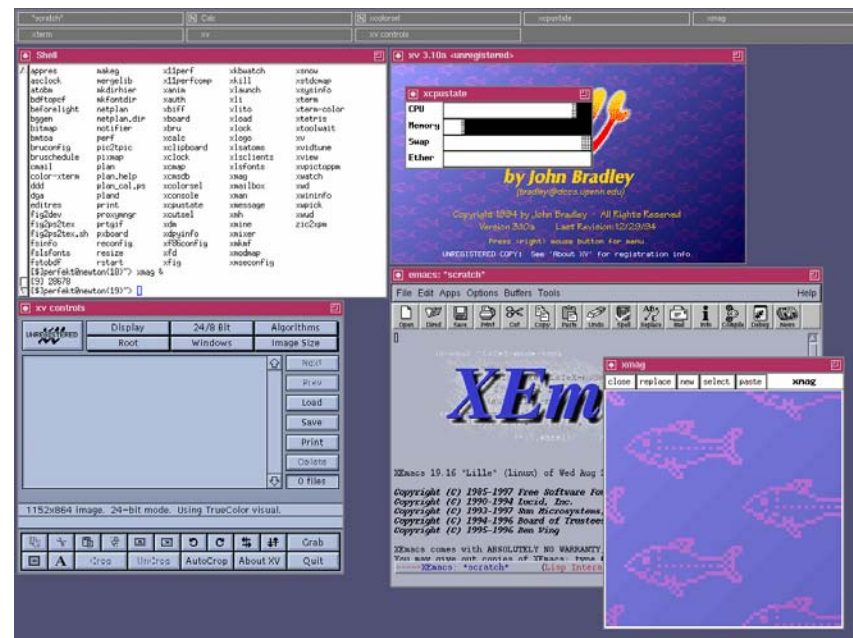
- menus, close box, resize, and start new application capabilities

◆ Much of the visible behavior of the window system

- such as whether windows are allowed to overlap or are tiled, and windows move

◆ Creates the look and feel of each window

◆ twm example





Desktop Environment

- » Window managers available for Linux
 - ◆ twm : Tom's or Tab Window Manager
 - default for the X Window System since version X11R4
 - Derivatives : fvwm (feeble virtual window manager), Window Maker and Afterstep
 - ◆ mwm : motif window manager
 - ◆ olwm : openlook window manager
 - ◆ Kwin : originally called KWM, default for KDE
 - ◆ Metacity : default for GNOME since version 2.2
 - ◆ Sawfish : past default for GNOME, originally called Sawmill
- » Desktop environment
 - ◆ Includes a window manager (such as Metacity or KWin), file manager (such as Konqueror or Nautilus), help system, task bar, desktop shortcuts, system utilities and configuration tools
 - ◆ Applications with common interface
 - ◆ Drag and drop, file associations
 - ◆ A set of themes



Desktop Environment

- » Linux/Unix Desktop Environments : Windows XP, Vista, Mac OS X
 - ◆ KDE : K Desktop Environment
 - Built with Trolltech's Qt toolkit
 - ◆ GNOME: GNU Network Object Model Environment
 - Official desktop of the GNU Project
 - Built with GNU GTK+ toolkit
 - ◆ CDE : Common Desktop Environment
 - De fact standard Unix desktop based on Motif widget toolkit
 - ◆ GNUStep : GNU version of OpenStep
 - ◆ OpenStep : cutting down version of NextStep for Sun Solaris
 - Collaboration between NeXT Computer and Sun Microsystems
 - Basis for Mac OS X (In 1997 Apple Computer acquired NeXT Computer)
 - Traces of the NextStep/OpenStep heritage can still be seen in Mac OS X.



GUI Toolkits

» GUI Toolkits (or Widget Toolkits) for The X Window System

◆ GUI Toolkit = Widget Toolkit

- 1) Integrated in the operating system : Windows API (MFC)
- 2) separate layer on top of the operating system : GTK+, Qt, Motif

◆ POSIX based Toolkits

- GTK+ : GNOME
- Trolltech Qt : KDE
- Fast, Light Tool Kit (FLTK)
- wxWindows
- FOX Toolkit
- OSF/Motif

◆ Why Do We Need Toolkits

Swing : java widget toolkit

- 1) Portability
- 2) Xlib API is hard to use
- 3) Look and Feel : skin, theme
 - » Look = design aspects : colors, shapes, layout, and typefaces.
 - » Feel = behavior of dynamic elements : button, box, and menu

◆ Widget (or Control)

- A user interface object in X graphical user interfaces
- button, value slider, text box, window, check box, radio button.

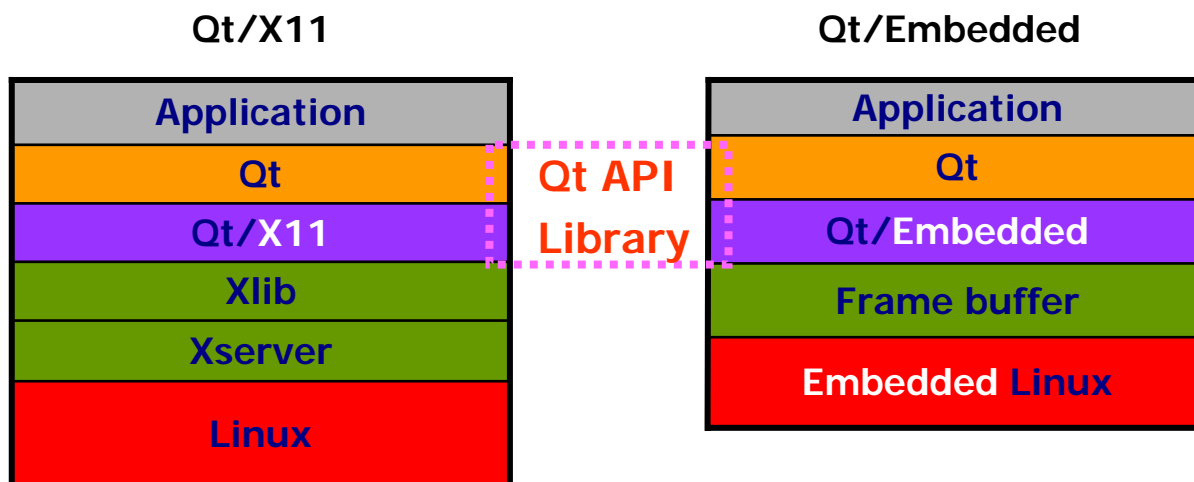


Embedded Target System GUI

◆ Embedded target system GUI :

- Nano-X, Qt/embedded, MiniGUI, MatchBox, PicoGUI, FLNX, DirectFB, GTK+/FB, TinyX
- Qtopia example ;
 - » A window environment and application suite designed for PDAs, palmtop computers, internet appliances, and similar devices.
 - » Includes a full set of Personal Information Management (PIM) applications, like calendar, address book, to do-list, e-mail client, games, configuration utilities, and more.
- Qt/Embedded : **Frame buffer is used**
 - » A version of Qt designed for resource-constrained embedded systems.
 - » Full GUI functionality without requiring X11 to reduce the memory and CPU demands of the embedded software.

◆ “Hello” program for Qt/Embedded in this class





Linux Installation

● Red Hat 9.0 Installation

- » Installation type : Workstation
 - ◆ Customize the set of packages to be installed
 - Server configuration tools
 - Windows file server : samba server
 - Kernel development : kernel source
- » Partition : Automatic / Manual
 - ◆ Remove all Linux Partitions (Keep Windows partitions) : Automatic
 - ◆ boot (100 MB), / (root) , swap (RAM size x 2 = 1 GB) : Manual
 - ◆ Keep vfat for sharing with Windows
- » No firewall
- » Language support : English and Korean
- » grub.conf 수정 : up kernel (default 1)
 - ◆ Not smp kernel : some driver problem
 - Kernel 확인 : `uname -a`, `cat /proc/cpuinfo`

After Installation



Linux Installation

- » File share with Windows : 50 GB (Linux), 30 GB (Windows)
 - ◆ `mount -t vfat /dev/hda? /mnt/share` or
 - ◆ `/etc/fstab : /dev/hda? /mnt/share vfat defaults 0 0`
 - 32 GB limit, FAT32 file format
 - `fdisk -l` 에서 Win95 FAT32 device 확인
- » Intel Ethernet Driver
 - ◆ `tar xzvf e100-3.5.14.tar.gz`
 - ◆ Module install
 - `make clean, make install`
 - `modprobe e100`
 - `ifconfig eth0 192.168.1.xxx (100)`
 - » Target default IP : 192.168.1.128
 - » Target default G/W : 192.168.1.1
 - service network restart
- » Next lectures
 - ◆ 1) Linux command
 - ◆ 2) 개발환경 구축
 - Cross-compiler, Minicom, tftp, NFS, samba server



❖ Note : /etc/fstab

man mount

- » 1. The name of the device such as "/dev/hda1"
- » 2. The mount point. Use "/" for root, "/dos" for DOS, "swap" or "none" for the swap partition
- » 3. The type of filesystem. mini, ext, ext2(linux native), msdos, hpfs, ntfs, fat32, iso9660(CD-ROM), NFS, **vfat**, swap.
- » 4. The mount options for use with the file system. **defaults**= rw, suid, dev, exec, auto, nouser, and async.
- » 5. The frequency the file system needs to be dumped (backed up) by the **dump** command. **0** or nothing means it is not dumped. If **1**, it is backed up during a system backup.
- » 6. the file systems should be checked at reboot time by the **fsck** program. Your root should be **1**, others are in ascending order or **0** to not be checked.