Operating System Practice— Introduction

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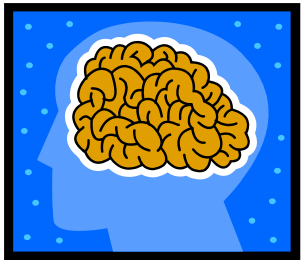
Course Roadmap

Advanced Operating System Concepts

- Concepts and Implementation of File System
- Storage Management and I/O Devices
- System Protection and Security



Exercises on PC and Emulators

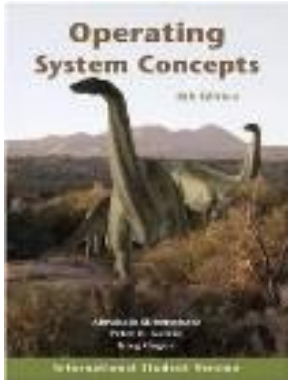
- Concepts of the Linux Kernel
- Real-Time System Knowledge
- Android Programing on Android Emulator

Embedded System Exercises

- Introduction to Embedded System
- Tools and Techniques to Build Embedded System
- Implementation on Embedded System Evaluation Boards

Advanced Operating System Concepts

- Cover some contents of the textbook
- Show you some advanced OS techniques
- Have some quizzes
- Use midterm and final exam to evaluate your study



Exercises on PC and Emulators

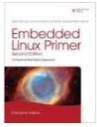
- Provide some basic knowledge for the Linux kernel
- Conduct some implementation on virtual machines
- Understand the Android framework with the Android emulator
- Have a real case study of real-time embedded systems

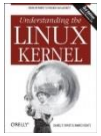
Embedded System Exercises

- Let you use an evaluation board
- Let you know the common issues and bugs of using embedded systems
- Let you use tools for developing an embedded system
- You should provide two reports for each exercise
- You can test your ideas on the evaluation board

Syllabus

- Instructor: **Che-Wei Chang 張哲維**
- Classroom: **CSIE Seminar Room (4)**
  資工系研討室 (4)
- Class Time: **Thursday 9:10-12:00**
- TA: 鍾岳蓉 <nasa91011@gmail.com>
- Reference Books:
  - Silberschatz, Galvin, and Gagne, “Operating System Principles,” 10th Edition, John Wiley & Sons, 2018.
  - Christopher Hallinan, “Embedded Linux Primer,” 2nd Edition, Prentice Hall, 2011.
  - Daniel P. Bovet and Marco Cesati, “Understanding the Linux Kernel”, 3rd Edition, O’Reilly, 2005.





Grading and Resources

- Midterm: 20%
- Lab Exercises: 20%
- Quizzes and Attendance: 20%
- Final Exam: 20%
- Final Project: 20%

- Office Hours: **Wednesday 17:30-20:30**
- Course Website:
- https://icechewei.github.io/webpage/teaching.html

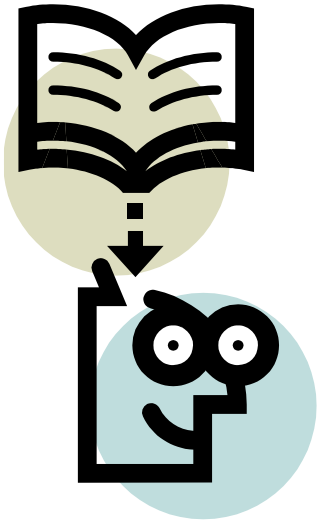
Rules and Requirements

- It is better to complete the course “Operating System” before you take this course
- We have closed-book midterm and final exams
- Teamwork is required for lab exercises and a final project
- No adjustment for the final grading results
- We will give the grading results after 18 weeks

Course Overview

Advanced Operating System Concepts

- Chapter 10: File System
- Chapter 11: Implementing File-Systems
- Chapter 12: Mass-Storage Structure
- Chapter 13: I/O Systems
- Chapter 14: System Protection
- Chapter 15: System Security



File System

- The Basic Concepts of File System
  - File Concept and Access Methods
  - Disk and Directory Structure
  - File-System Mounting
  - File Sharing and Protection
- Implementing File Systems
  - File-System Structure
  - Directory Implementation
  - Allocation Methods
  - Free-Space Management
  - Efficiency and Performance

Storage and I/O Systems

- Mass-Storage Systems
  - Disk Structure
  - Disk Scheduling
  - Disk Management
  - Swap-Space Management
  - RAID Structure
- I/O Systems
  - I/O Hardware
  - Application I/O Interface
  - Kernel I/O Subsystem
  - Transforming I/O Requests to Hardware Operations

System Protection and Security

- System Protection
  - Principles of Protection
  - Domain of Protection
  - Access Control
- System Security
  - Security Problems
  - System and Network Threats
  - Cryptography as a Security Tool
  - User Authentication
  - Implementing Security Defenses
  - Firewalling to Protect Systems and Networks
  - Computer-Security Classifications

Flexible Embedded Systems

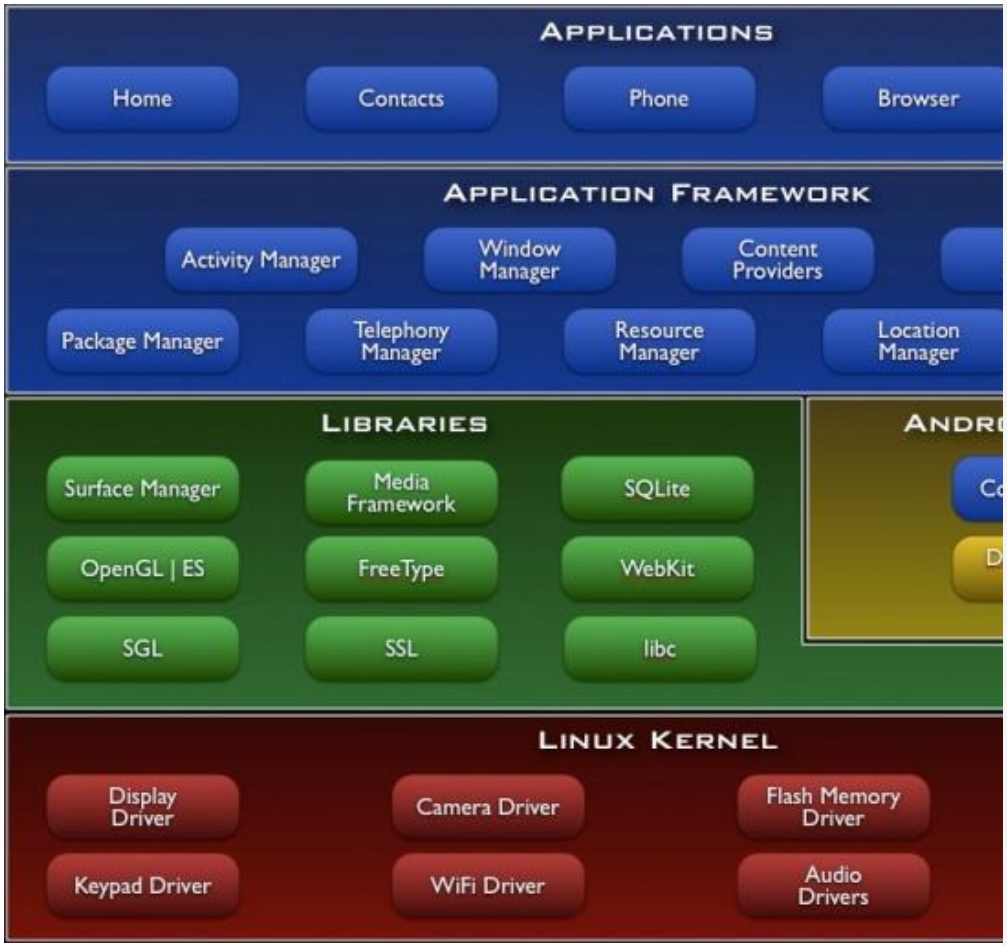
- Features of Embedded Systems
  - Customized hardware with high scalability
  - Heterogeneous devices with unified interface
  - Application-aware designs for energy saving

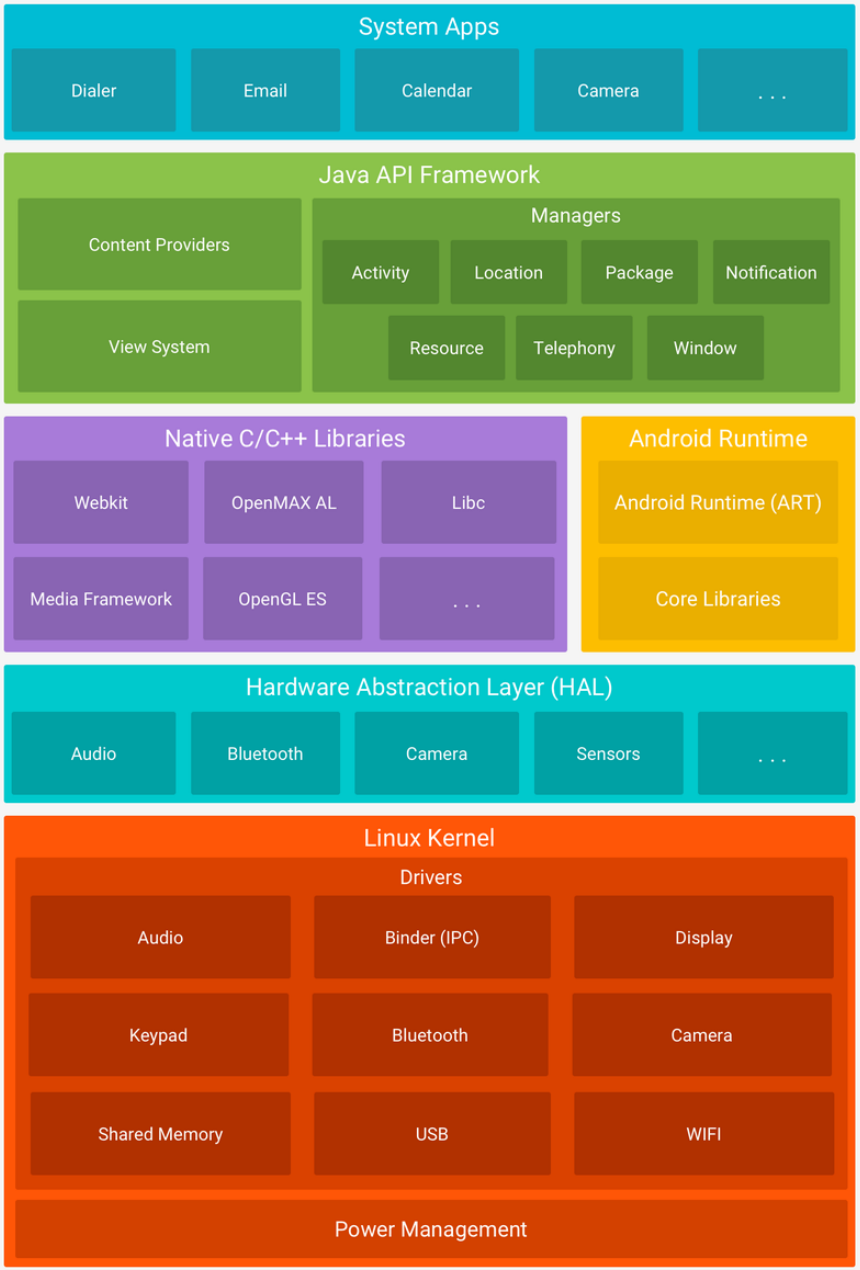
Integrated Hardware and System Software

Linux Kernel

- Open Source: GPL
- Preemptive Multitasking
- Virtual Memory System
- Shared Libraries
- Demand Paging
- Dynamic Kernel Modules
- Shared Copy-on-Write Executables
- TCP/IP networking
- SMP Support

Android OS

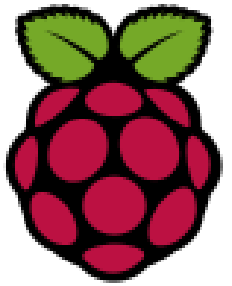




Prototyping Platforms

- Arduino
  - Is a single-board microcontroller
  - Has pre-programmed boot loader
  - Is defined as do-it-yourself kits
  - Is from Italy: Arduino (*Ar Du Wee No*)

- Raspberry Pi
  - Is a credit-card-sized single-board computer
  - Is promoted for teaching
  - Is based on the Linux kernel
  - Is from UK



Exercises on Evaluation Boards

- Link Setup
  - RS-232 on UART for debugging and control interface
  - Ethernet for TFTP and NFS
  - JTAG interface for debugging information
- System Startup
  - Bootloader
  - Kernel
  - Init process
- Development with Cross-Platform Toolchains
  - Binary utilities, gcc, glibc
  - Kernel headers setup
  - Binary utility setup

Design Challenge—Optimizing Performance Metrics

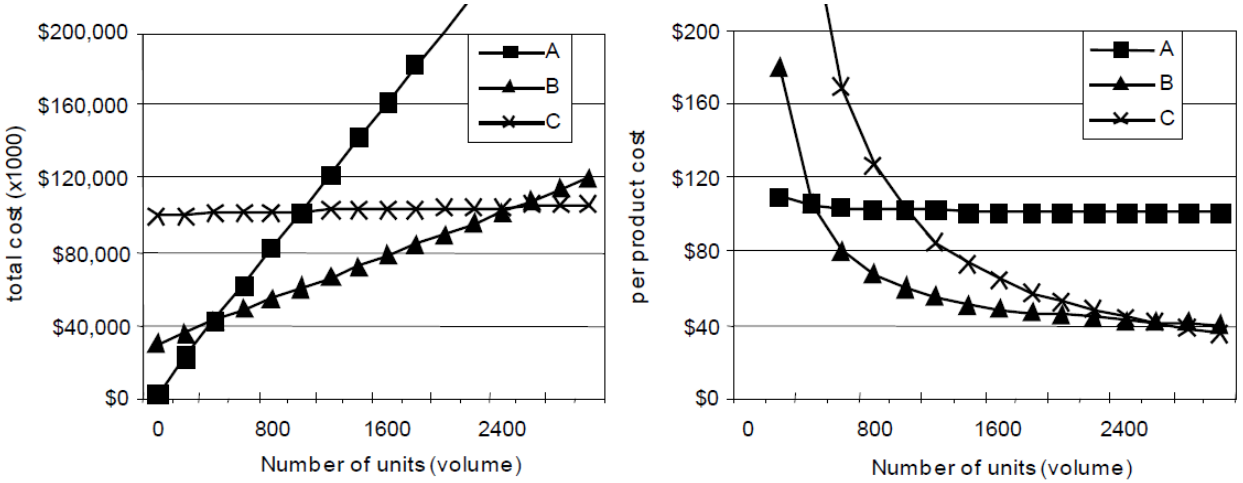
- Obvious Design Goal
  - Construct an implementation with desired functionality
- Performance Metrics
  - Performance metrics are the measurable features of a system's implementation
  - Simultaneously optimizing numerous design metrics is a challenging issue

Common Performance Metrics

- Unit Cost: the monetary cost of manufacturing each copy of the system
- NRE Cost (Non-Recurring Engineering cost): the one-time monetary cost of designing the system
- Size: the physical space required by the system
- Performance: the execution time or throughput of the system
- Power: the amount of power consumed by the system
- Flexibility: the ability to change the functionality of the system without incurring heavy NRE cost
- Time-to-Market: the time required to develop a system to the point that it can be released and sold to customers
- Maintainability: the ability to modify the system after its initial release

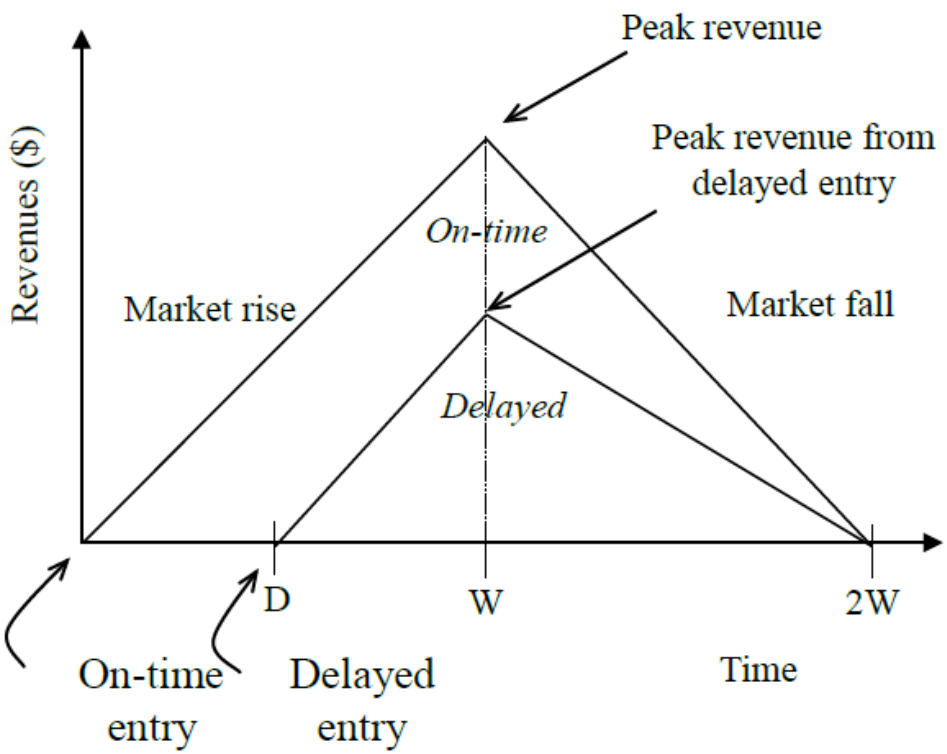
NRE and Unit Cost

- Compare Technologies by Costs— the best solution depends on quantity of the product
  - Technology A: NRE=$2,000, unit=$100
  - Technology B: NRE=$30,000, unit=$30
  - Technology C: NRE=$100,000, unit=$2



  - We must also consider time-to-market

Delayed Market Entry



- A Simplified Revenue Model
  - Product life = 2W, peak at W
  - The time of market entry defines a triangle, representing the market penetration
  - The triangle area represents the revenue
- Loss
  - The difference between the on-time and delayed triangle areas

A Case Study: µC/OS-II

- The name is from micro-controller operating system, version 2
- µC/OS-II is certified in an avionics product by FAA in July 2000 and is also used in the Mars Curiosity Rover
- It is a very small real-time kernel
  - Memory footprint is about 20KB for a fully functional kernel
  - Source code is about 5,500 lines, mostly in ANSI C
  - It's source is open but not free for commercial usages
- Preemptive priority-driven real-time scheduling
  - 64 priority levels (max 64 tasks)
  - 8 reserved for µC/OS-II
  - Each task is an infinite loop

Any Question?