CE5045
Embedded System Design

Embedded Operating System Introduction

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Computer Science & Information Engineering

Schema

- What is an Embedded Operating System?
  - ✓ The Requirements of Embedded O.S.
- O.S. for Embedded System
  - ✓ Windows Embedded
  - ✓ Embedded Linux
  - ✓ Other Embedded O.S.
- How to Get Started with Embedded System

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What is an Embedded O.S.?

- A generic operating system
  - ✓ Process management
  - ✓ Memory management
  - ✓ I/O device management
  - ✓ Network management
  - ✓ Secondary storage management
  - ✓ Security

Characteristics of Embedded O.S.

- An embedded operating system usually has…
  - ✓ Real-time operation
  - ✓ Reactive operation (event driven)
  - ✓ Configurability
  - ✓ I/O device flexibility
  - ✓ Streamlined protection mechanisms
  - ✓ Direct use of interrupts

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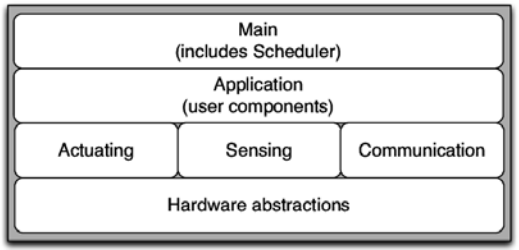
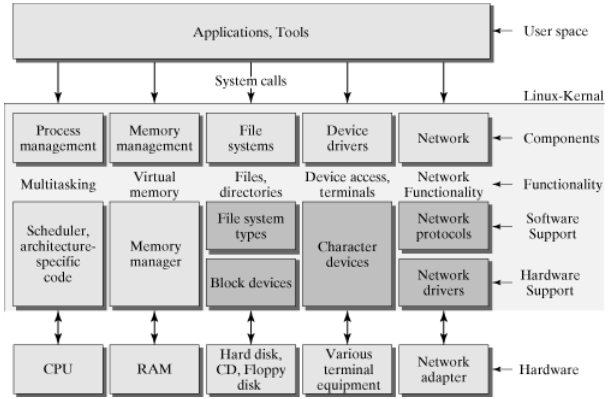
Embedded Operating System is

- Definition of Embedded O.S.
  - ✓ A simple operating system designed for embedded systems

Tiny O.S. architecture



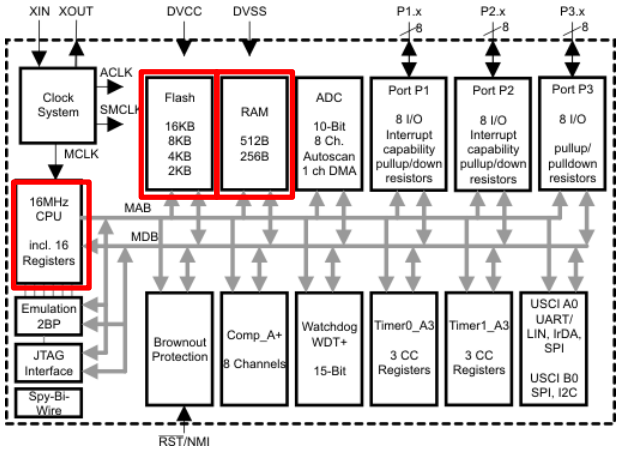
GP Linux architecture



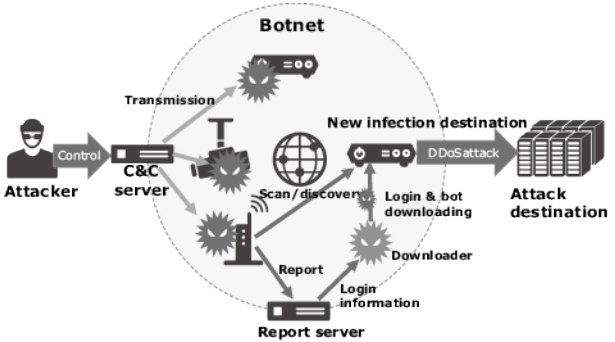
Embedded Operating System is

- Definition of Embedded O.S.
  - ✓ A simple operating system designed for embedded systems
  - ✓ Resource efficiency and reliability

TI MSP430 Specification



Embedded System Security



Embedded Operating System is

- Definition of Embedded O.S.
  - ✓ A simple operating system designed for embedded systems
  - ✓ Resource efficiency and reliability
  - ✓ Time constraint

Hard real-time embedded system

Soft real-time embedded system

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Difference: Penalty

Embedded Operating System is

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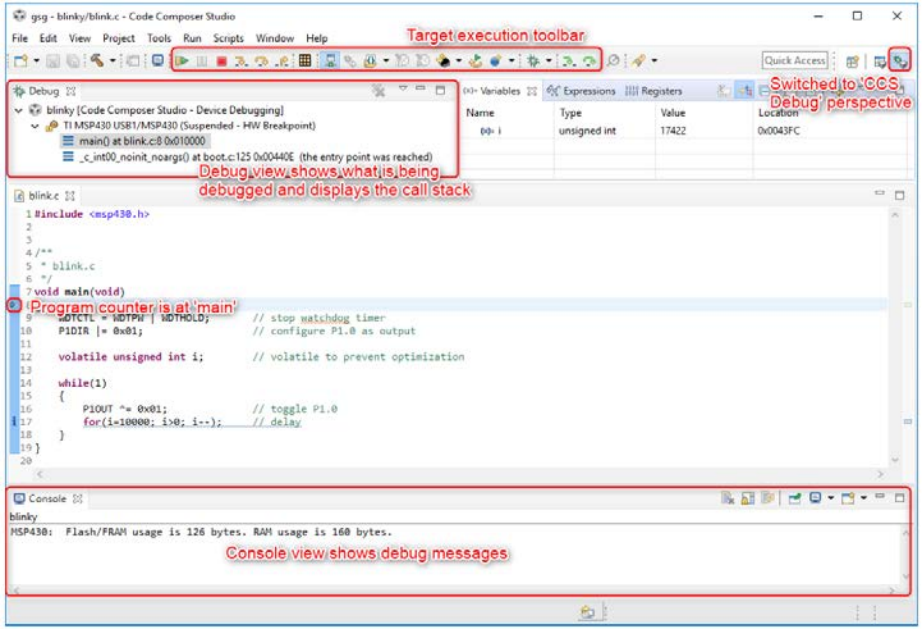
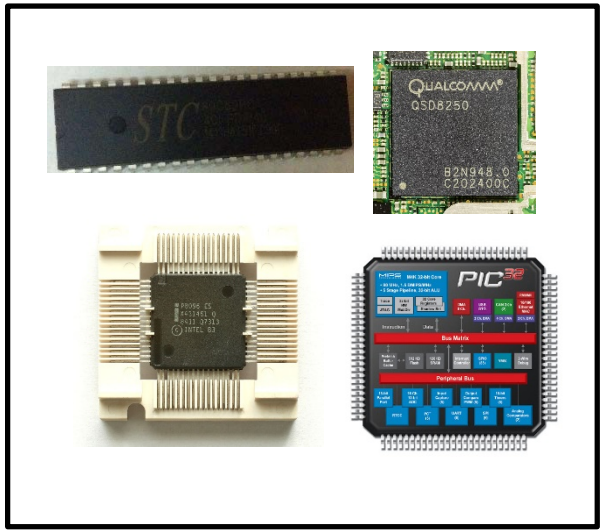
  - ✓ Resource efficiency and reliability
  - ✓ Time constraint
  - ✓ Generally written in the C language



Types of Embedded System

- Embedded systems can be classified based on
  - ✓ Performance and functional requirement
  - ✓ Performance of microcontroller



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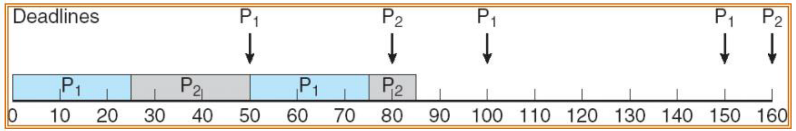
    - **Real-time embedded systems: Hard real-time and soft real-time**
    - Stand alone embedded systems
    - Networked embedded systems
    - Mobile embedded systems
  - ✓ Performance of microcontroller

Rate-monotonic scheduling: misses deadlines

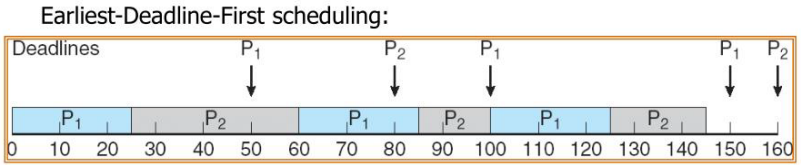


$T = \{S, D, P, E\}$

$T_1 = \{0, 50, 50, 25\}$

$T_2 = \{0, 80, 80, 35\}$

Earliest-Deadline-First scheduling:



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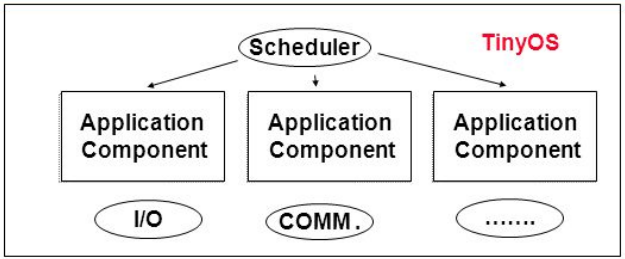

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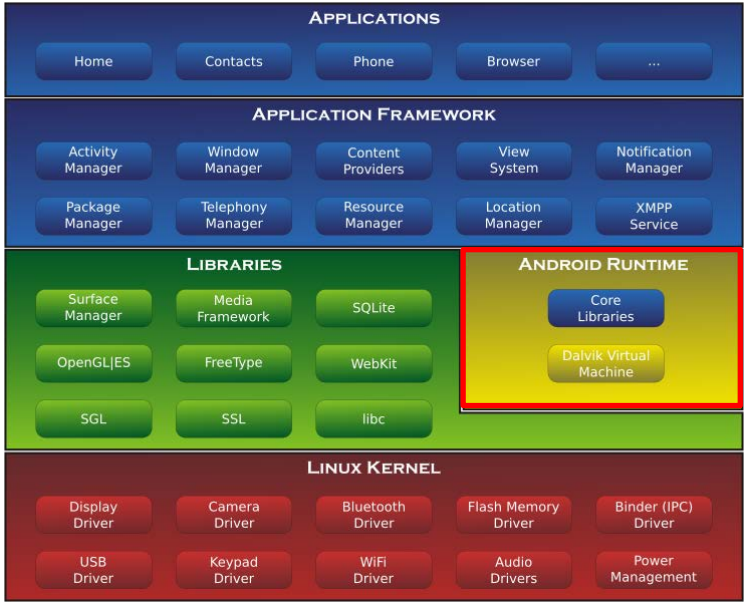

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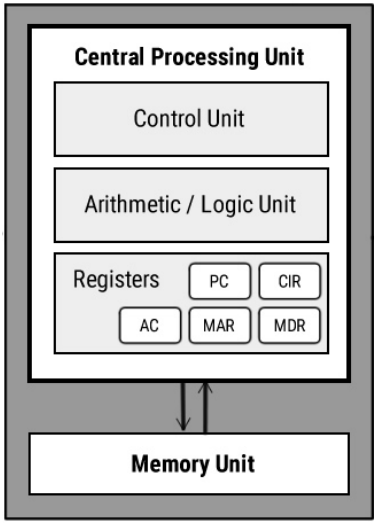
    - 16-bit controller: Intel 8096 and PIC 24
    - 32-bit controller: ARM and PIC 32
    - Heterogeneous SoC



Von Neumann

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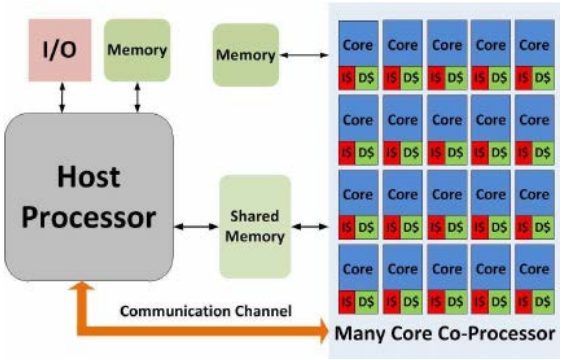

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Developing an Embedded O.S.

- How to build an embedded operating system?
  - ✓ Take an existing O.S. and adapt it for the embedded application.
  - ✓ Design and implement an O.S. intended solely for embedded use

Adapting an Existing O.S.

- An existing commercial OS can be used for an embedded system by adding:
  - ✓ Real time capability
  - ✓ Streamlining operation
  - ✓ Adding necessary functionality

Advantage:

- Familiar interface

Disadvantage:

- Not optimized for real-time and embedded applications

Embedded Windows

- Common version – Windows 10
  - ✓ Easy of use: Friendly graphic user interface
  - ✓ Available software
  - ✓ Support for new hardware
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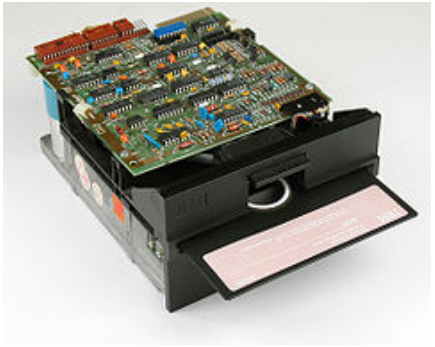
- But for embedded system?
  - ✓ High resource requirements

Embedded Windows

- Long time ago…
  - ✓ DOS
    - The most famous one: MS-DOS by created by Tim Paterson
    - 16 bits O.S.
    - Single user and single task
    - Application: LED billboard and industry control



Embedded Windows

- Embedded Windows Family
  - ✓ Products:
    - Windows Embedded Standard, Windows Embedded Compact, Windows Embedded Enterprise, Windows Embedded POSReady
  - ✓ Support CPU: x86, ARM, MIPS, …etc
  - ✓ Development tool: Visual studio and windows IoT emulator [link]

What’s Linux

- Definition of Linux
  - ✓ Linux is the kernel developed and maintained by Linus Torvalds
  - ✓ Based on the Linux kernel, there are many different distributions
  - ✓ Linux Kernel includes
    - Controls all hardware
    - Provides core system facilities
    - Manages system through its lifecycle (next reboot)
    - Provides higherlevel abstractions to software

What’s Embedded Linux

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- Embedded Linux doesn't exist

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  - ✓ There is no specific kernel for embedded systems
  - ✓ There are, nevertheless, customized kernels specially configured / customized for specific embedded hardware configurations.

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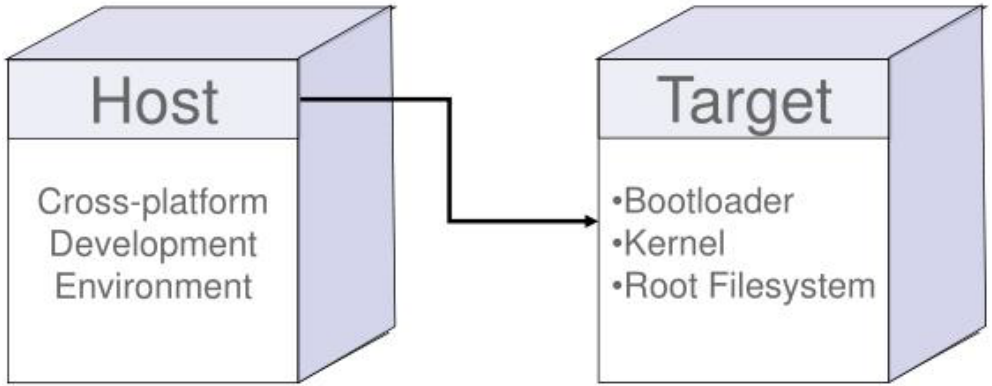
- What does exist:
  - ✓ Embedded Linux system
    - An embedded system running the Linux kernel
    - Userspace tools & configuration likely to be very different from desktop (uClibc instead of glibc, BusyBox instead of coreutils, etc.)

Cross Compiler

- A key differentiator between desktop/server and embedded Linux distributions is that desktop and server software is typically compiled on the platform where it will execute
- Embedded Linux distributions are usually compiled on one platform but are intended to be executed on another
  - ✓ The software used for this purpose is referred to as a cross-compiler

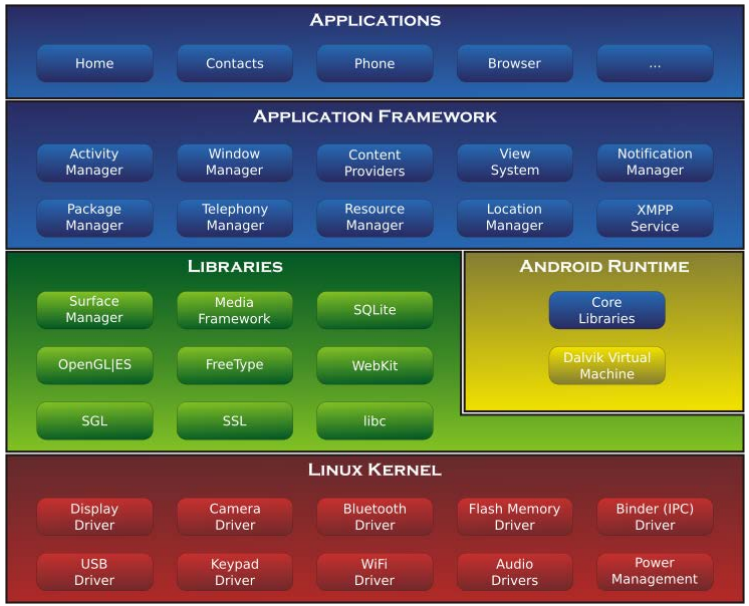


Advantages of Embedded Linux System

- The strengths of an embedded Linux system include
  - ✓ Vendor independence
  - ✓ Varied hardware support
  - ✓ Low cost
  - ✓ Open source

Based on Linux Kernel

- Android mobile system
  - ✓ Focus of Android lies in the vertical integration of the Linux kernel and the Android user-space components.



Purpose-Built Embedded O.S.

- Typical characteristics include:
  - ✓ Fast and lightweight process or thread switch
  - ✓ Scheduling policy is real time and dispatcher module is part of scheduler
  - ✓ Small size
  - ✓ Responds to external interrupts quickly
  - ✓ Provides fixed or variable-sized partitions for memory management
  - ✓ Provides special sequential files that can accumulate data at a fast rate

Other Embedded O.S.

- VxWorks
  - ✓ Created by WindRiver
  - ✓ Support CPU: x86, i960, MIPS, PowerPC
  - ✓ Popularly use in embedded systems
  - ✓ GNU compiler and debugger
  - ✓ Hard real-time