Operating System Practice

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An Real-Time OS: µC/OS-II Quick Overview

Introduction of μC/OS–II (1/2)

- 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
- Preemptible priority-driven real-time scheduling
  - 64 priority levels (max 64 tasks)
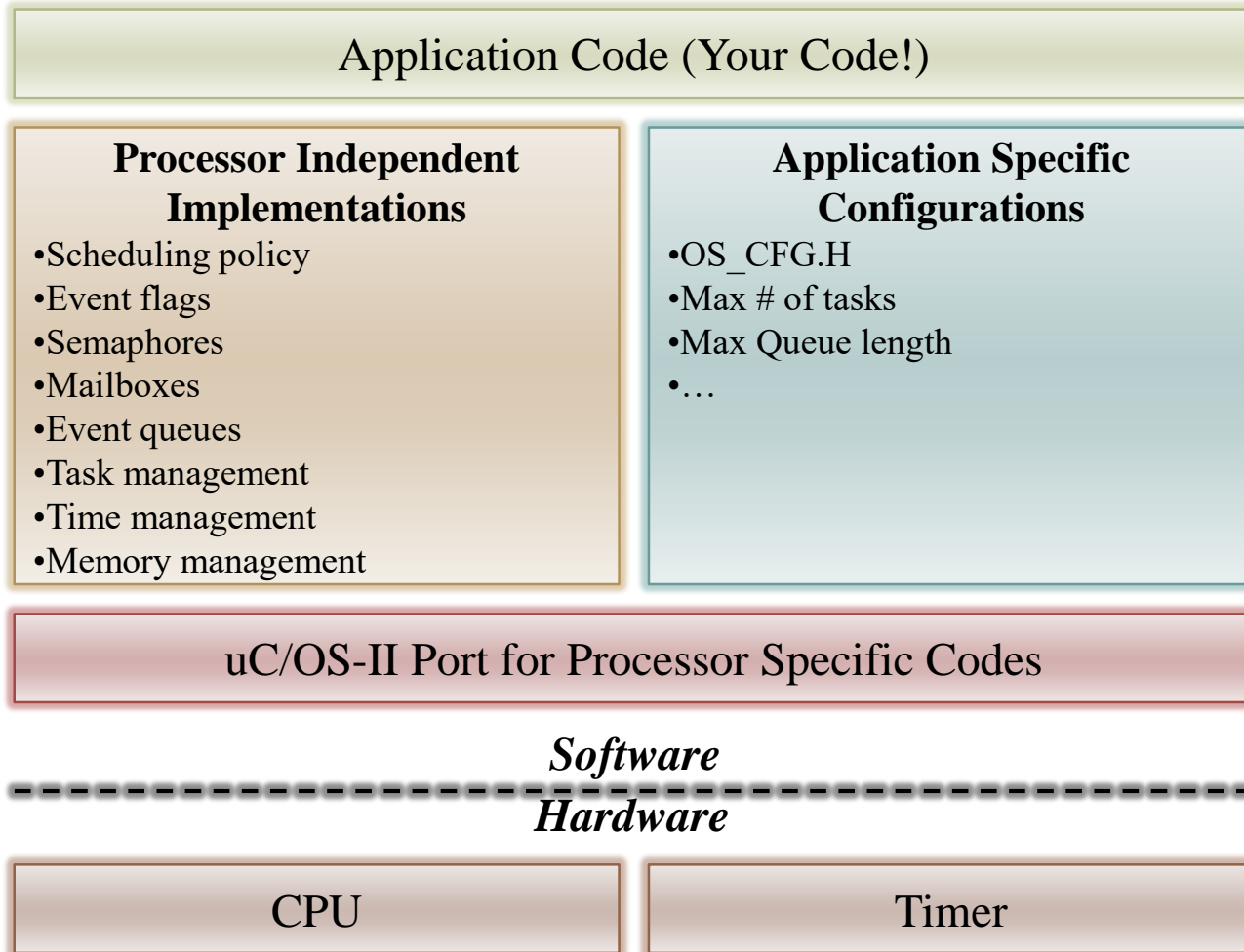 - 8 reserved for μC/OS-II
  - Each task is an infinite loop

Introduction of μC/OS-II (2/2)

- Deterministic execution times for most μC/OS-II functions and services

- Nested interrupts could go up to 256 levels

- Supports of various 8-bit to 64-bit platforms: x86, ARM, MIPS, 8051, etc.

- Easy for development: Borland C++ compiler and DOS (optional)

- However, uC/OS-II still lacks of the following features:
  - Resource synchronization protocol
  - Soft-real-time support

The µC/OS−II File Structure

Application Code (Your Code!)	

Processor Independent Implementations	**Application Specific Configurations**
•Scheduling policy •Event flags •Semaphores •Mailboxes •Event queues •Task management •Time management •Memory management	•OS_CFG.H •Max # of tasks •Max Queue length •…

uC/OS-II Port for Processor Specific Codes

Software

- -

Hardware

CPU	Timer

Requirements of μC/OS-II Emulator

- Operating System
  - Windows XP 32bits
  - Use virtual machine to install the OS
  - Install "Guest Additions" for Virtualbox
- Tools
  - Borland C++ compiler (V4.5)
    - BC45 is the compiler
  - Turbo Assembler
    - The assembler is in tasm
  - The source code and the emulation environment of μC/OS-II
    - SOFTWARE is the package
- Full Package
  - Download it from the course website with password: csie2020
  - https://www.csie.cgu.edu.tw/~chewei/files/ucOSII_ProjectPackage.zip
  - https://www.csie.cgu.edu.tw/~chewei/files/Files.zip

Borland C++ Compiler

- Download Borland C++ and install it on your windows XP environment
  - Double click the "INSTALL.EXE"
- Add ";C:\BC45\BIN" to your system Path
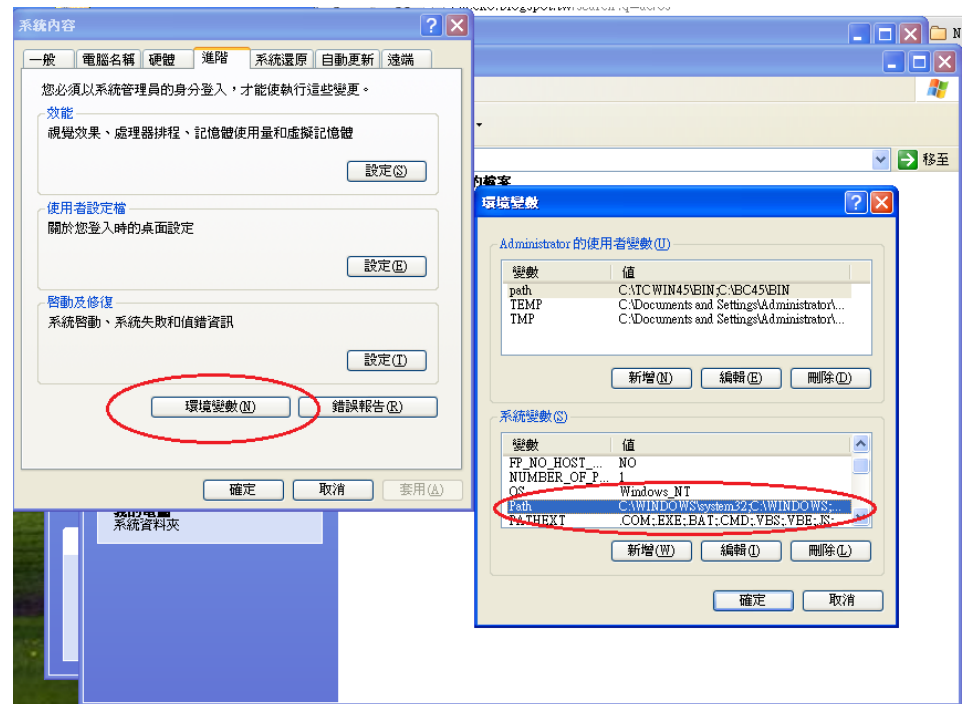
Turbo Assembler

- Download Turbo assembler and unzip the file
- Copy "\tasm\BIN\TASM.EXE" to your "C:\BC45\BIN"
  - Include the missing assembler which is going to be used during we compile the source code of μC/OS-II

Compile µC/OS-II Example Code

▸ Download the source code and emulator µC/OS-II
  ◦ It is recommended to put the source code package "SOFTWARE" directly in C:\

▸ Test the first example
  ◦ Execute C:\SOFTWARE\uCOS-II\EX1_x86L\BC45\TEST\TEST.EXE
  ◦ Press ESC to leave

▸ Rename or remove the executable file
  ◦ Rename TEST.EXE

▸ Compile the µC/OS-II and the source code of the first example
  ◦ Run C:\SOFTWARE\uCOS-II\EX1_x86L\BC45\TEST\ MAKETEST.BAT
  ◦ A new "TEST.EXE" will be created if we compile it successfully

OSTimeDly() and OSTimeDlyHMSM()

▸ Study the two function by yourself and use them for the homework implementation

▸ Requirements
1. Print out "This is OPS 2025 homework!"
2. Delay for 5 seconds
3. Print out YOUR STUDENT ID
4. Delay for 2 seconds
5. Print out 1 2 3 4 5 6 7 8 9 10 one by one, call delay for 1 second after the printing of each number
6. Clean all numbers printed in Step 5, and call delay for 5 seconds
7. Goto Step 5

Common Mistakes

▸ Did you directly put the package "SOFTWARE" in C:\ ?

▸ Have you copied the correct file "TASM.EXE" to your "C:\BC45\BIN" directory?

▸ Did you set the Path correctly?

◦ See the picture in Page 7

◦ There is no space

Reading Exercise

▸ Read the e-book of µC/OS-II

  ◦ Try to read and understand the first chapter

▸ Read the source code to understand the application

  ◦ The application source code is in C:\SOFTWARE\uCOS-II\EX1_x86L\BC45\SOURCE

▸ Browse the source code of µC/OS-II

  ◦ The source code of µC/OS-II is in C:\SOFTWARE\uCOS-II\SOURCE

Report

▸ Each student should write a report

▸ Upload it to our E-learning system

▸ Only two A4 pages

▸ 內文12 pt font

▸ Deadline is 23:00 2022/05/21

▸ File name: OSP-Homework-StudentID

▸ File type: PDF

Grading Rules

▸ No demonstration!

▸ Grading
  ◦ Reports 80% ± 20

▸ No late submission will be accepted

An Example on μC/OS-II: Multitasking

▸ Three system tasks

▸ Ten application tasks randomly prints its number

Multitasking: Workflow

Header File

Include

Starting Point

Main() Function

Invoke

TaskStartCreateTasks()
Function

Create

TaskStart() task

Task() task

...
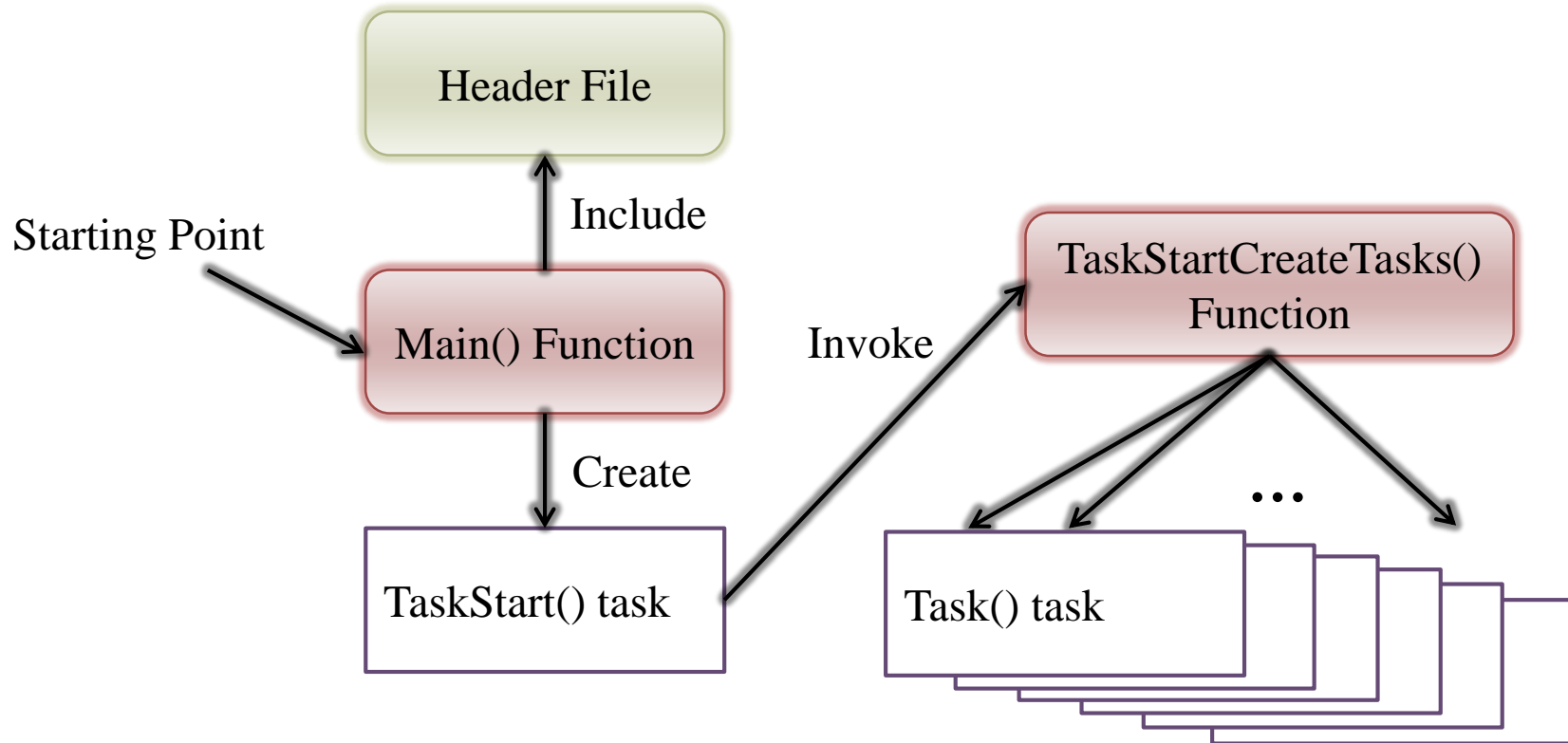
Multitasking: TEST.C
(\SOFTWARE\uCOS-II\EX1_x86L\BC45\SOURCE\TEST.C)

```c
#include "includes.h"
/*
*********************************************************************
CONSTANTS
*********************************************************************
*/
#define TASK_STK_SIZE 512
#define N_TASKS 10
/*
*********************************************************************
VARIABLES
*********************************************************************
*/
OS_STK TaskStk[N_TASKS][TASK_STK_SIZE];
OS_STK TaskStartStk[TASK_STK_SIZE];
char TaskData[N_TASKS];
OS_EVENT *RandomSem;
```

Multitasking: Main()

```
void main (void)
{
        PC_DispClrScr(DISP_FGND_WHITE + ISP_BGND_BLACK);
        OSInit();
        PC_DOSSaveReturn();
        PC_VectSet(uCOS, OSCtxSw);
        RandomSem = OSSemCreate(1);
        OSTaskCreate( TaskStart,
                      (void *)0,
                      (void *)&TaskStartStk[TASK_STK_SIZE-1],
                      0);
        OSStart();
}
```

Entry point of the task (a pointer to a function)

User-specified data

Top of stack

Priority (0=hightest)

Multitasking: TaskStart()

```
void TaskStart (void *pdata)
{
        /*skip the details of setting*/
        OSStatInit();
        TaskStartCreateTasks();
        for (;;)
        {
                if (PC_GetKey(&key) == TRUE)
                {
                        if (key == 0x1B) { PC_DOSReturn(); }
                }
                OSTimeDlyHMSM(0, 0, 1, 0);
        }
}
```

Call the function to create the other tasks

See if the ESCAPE key has been pressed

Wait one second

Multitasking: TaskStartCreateTasks()

```
static void TaskStartCreateTasks (void)
{
        INT8U i;
        for (i = 0; i < N_TASKS; i++)
        {
                TaskData[i] = '0' + i;
                OSTaskCreate(
                        Task,
                        (void *)&TaskData[i],
                        &TaskStk[i][TASK_STK_SIZE - 1],
                        i + 1 );
        }
}
```

Entry point of the task (a pointer to function)

Argument: character to print

Top of stack

Priority

Multitasking: Task()

```
void Task (void *pdata)
{
          INT8U x;
          INT8U y;
          INT8U err;
          for (;;)
          {
                     OSSemPend(RandomSem, 0, &err);
                     /* Acquire semaphore to perform random numbers */
                     x = random(80);
                     /* Find X position where task number will appear */
                     y = random(16);
                     /* Find Y position where task number will appear */
                     OSSemPost(RandomSem);
                     /* Release semaphore */
                     PC_DispChar(x, y + 5, *(char *)pdata, DISP_FGND_BLACK +DISP_BGND_LIGHT_GRAY);
                     /* Display the task number on the screen */
                     OSTimeDly(1);
                     /* Delay 1 clock tick */
          }
}
```

Randomly pick up the position to print its data

Print & delay

OSinit()
(\SOFTWARE\uCOS-II\SOURCE\OS_CORE.C)

- Initialize the internal structures of μC/OS-II and MUST be called before any services
- Internal structures of μC/OS-2
  - Task ready list
  - Priority table
  - Task control blocks (TCB)
  - Free pool
- Create housekeeping tasks
  - The idle task
  - The statistics task

PC_DOSSaveReturn()
(\SOFTWARE\BLOCKS\PC\BC45\PC.C)

▸ Save the current status of DOS for the future restoration

◦ Interrupt vectors and the RTC tick rate

▸ Set a global returning point by calling setjump()

◦ µC/OS-II can come back here when it terminates.

◦ PC_DOSReturn()

PC_VectSet(uCOS,OSCtxSw)
(\SOFTWARE\BLOCKS\PC\BC45\PC.C)

- Install the context switch handler
- Interrupt 0x08 (timer) under 80x86 family
  - Invoked by INT instruction

OSStart()
(SOFTWARE\uCOS-II\EX1_x86L\BC45\SOURCE\CORE.C)

- Start multitasking of µC/OS-II
- It never returns to main()
- µC/OS-II is terminated if PC_DOSReturn() is called