Embedded Operating Systems- Final Project

Che-Wei Chang

chewei@mail.cgu.edu.tw

Department of Computer Science and Information Engineering, Chang Gung University

Report

- Only four A4 pages
- 12 pt words
- Deadline is 23:59 2020/01/10
- File name: EOS-Project-StudentID
- Required Files: only the report
- In the report, remember to provide your names, student IDs, and group ID.
- Send it to my email: chewei@mail.cgu.edu.tw
- Email title: EOS Project StudentID

- Source Code: create an BitBucket account and create a git repository, and add icechewei@gmail.com to your repository before 2020/12/22

The Requirements of Final Presentation

- Presentation is only for 10 minutes
  - Quickly go through the implementation
  - Talk more about the problems you solved
  - Highlight your extra exercise
- Live demo is required
  - Bring your source code
- I will ask each of you a question

The μC/OS-II File Structure

Application Code (Your Code!)

Processor Independent Implementations

- Scheduling policy
- Event flags
- Semaphores
- Mailboxes
- Event queues
- Task management
- Time management
- Memory management

Application Specific Configurations

- OS_CFG.H
- Max # of tasks
- Max Queue length
- …

uC/OS-II Port for Processor Specific Codes

Software

Hardware

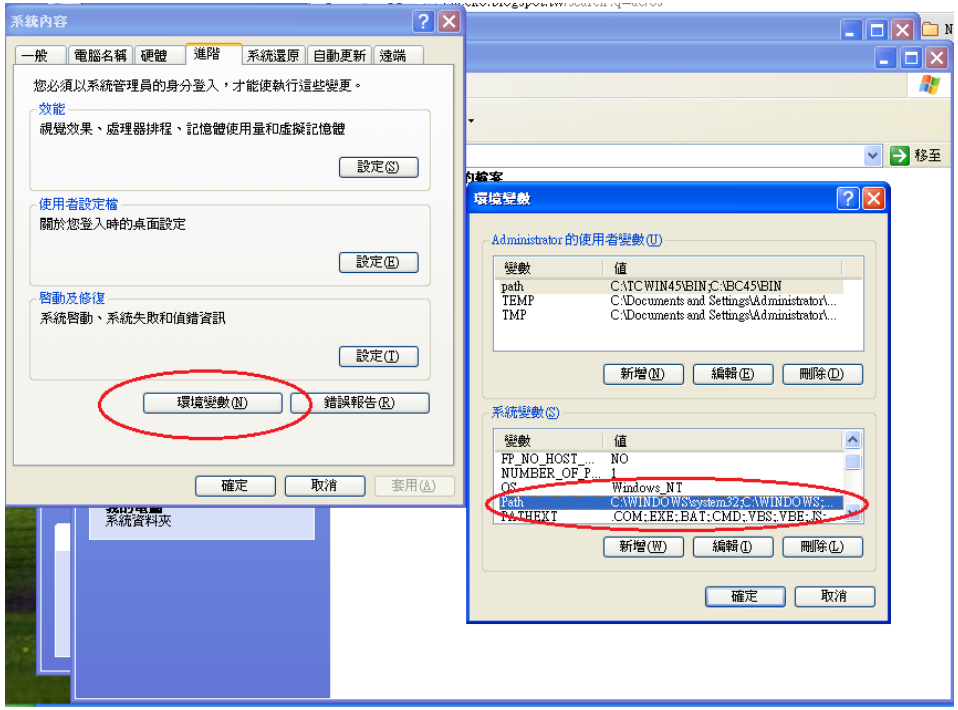
CPU | Timer

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: csie2018

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

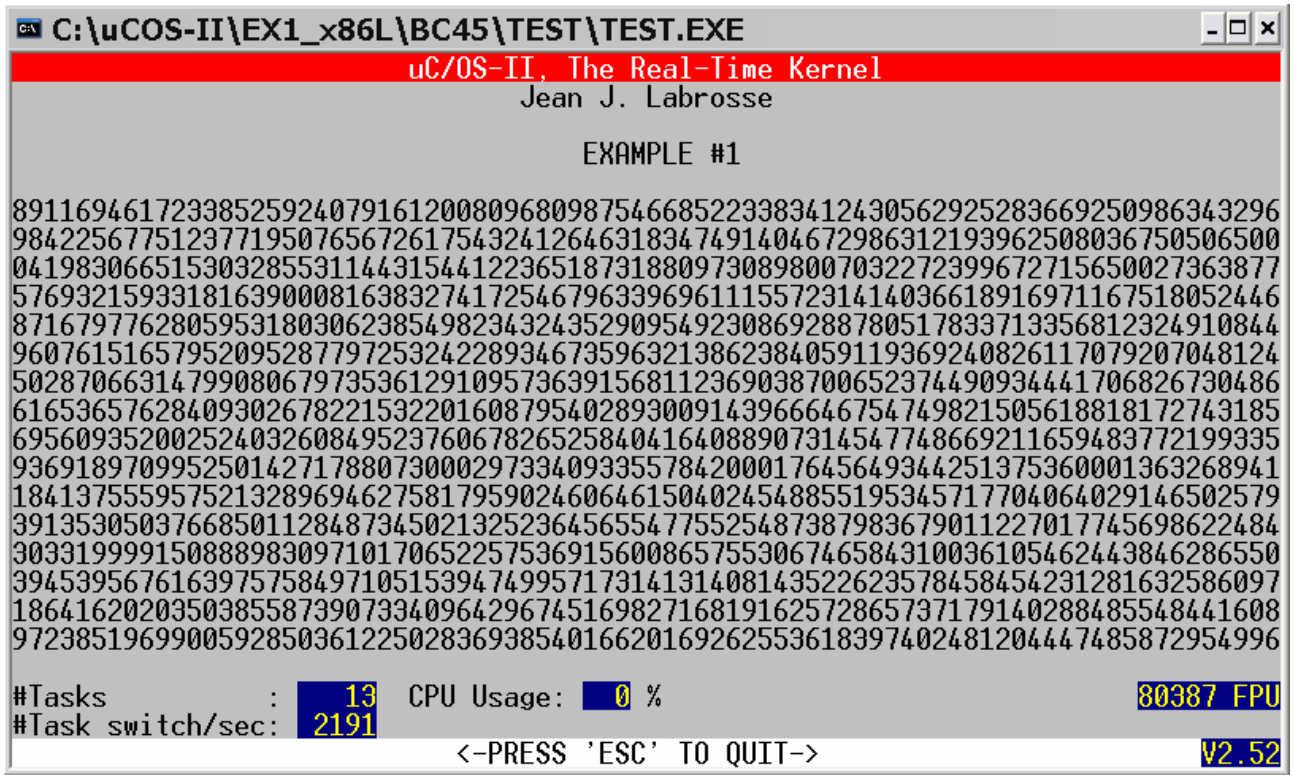
Compile µC/OS-II Example Code

- 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 ECS 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

Common Mistakes

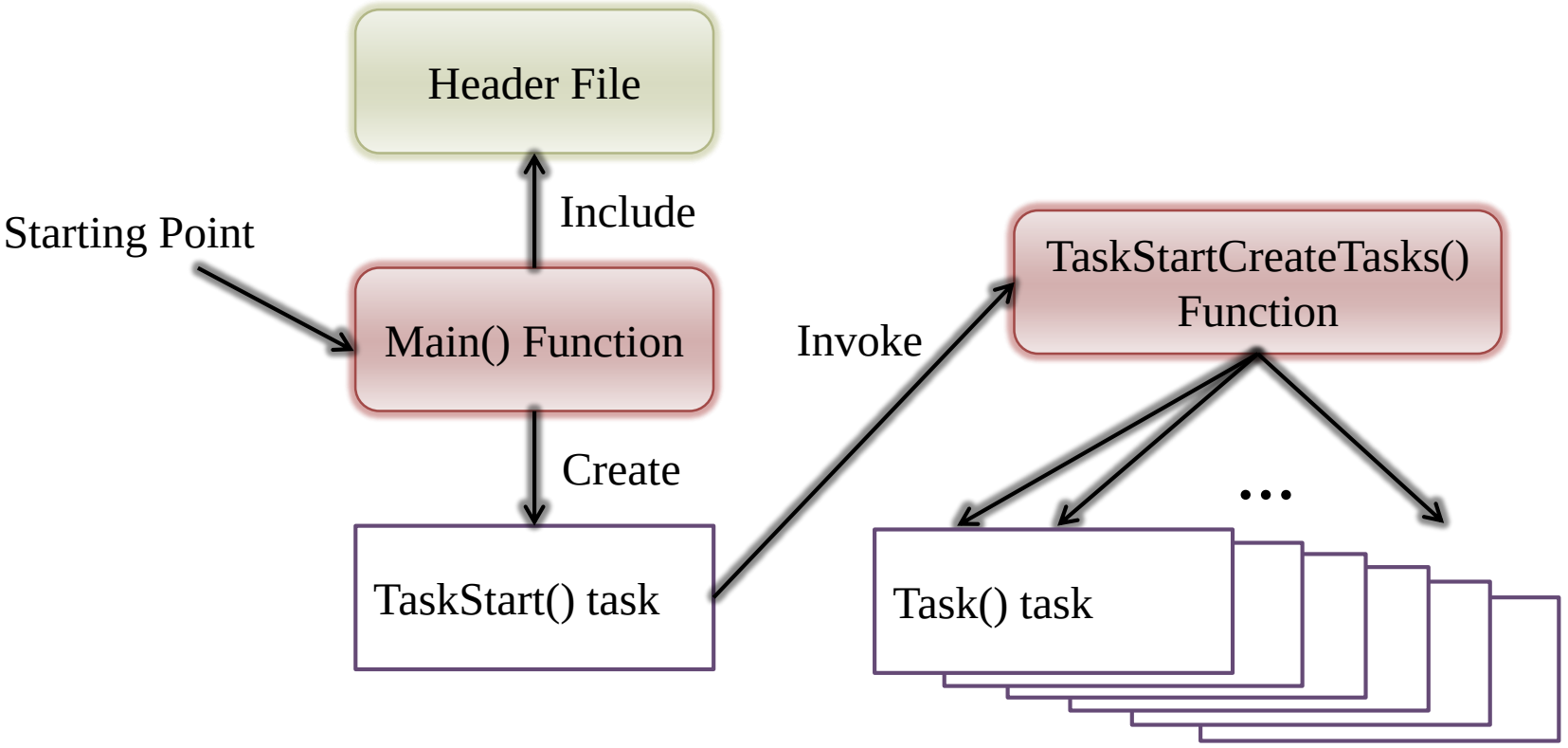
- Did you directly put the package “SOFTWARE” in C:\ ?
- Have you copied the correct file “TASM.EXE” to your “C:\BC45\BIN” directory?
- Did you set the Path correctly?
  - See the picture in Page 6
  - There is no space

An Example on µC/OS-II: Multitasking



- Three system tasks
- Ten application tasks randomly prints its number

Multitasking: Workflow



Multitasking: TEST.C

(\SOFTWARE\uCOS-II\EX1_x86L\BC45\SOURCE\TEST.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

Final Project: Basic Part

Implement RM or EDF Scheduling

- Task Scheduling
  - See OS_Sched( ) for scheduling policy
  - See OSTimeTick() for time management
  - See OSIntExit( ) for the interrupt management
  - See OSTaskChangePrio() for changing the priority of a task

- Provide the RM or EDF Scheduler
  - Input: A task set, each task is with its execution time and period
  - Output: The printed result of each task

Input

- The input format should be as follows
  - Your program should have the capability to create the assigned number of tasks and their corresponding period and execution time.
  - Example: taskset.txt

    3 //number of task

    1 3 // task 1: (execution time 1, period 1)

    2 9 // task 2: (execution time 2, period 2)

    4 12 // task 3: (execution time 3, period 3)
- The number of tasks is no more than 7

Input Example

```
4
1 12
1 7
2 19
3 20
```

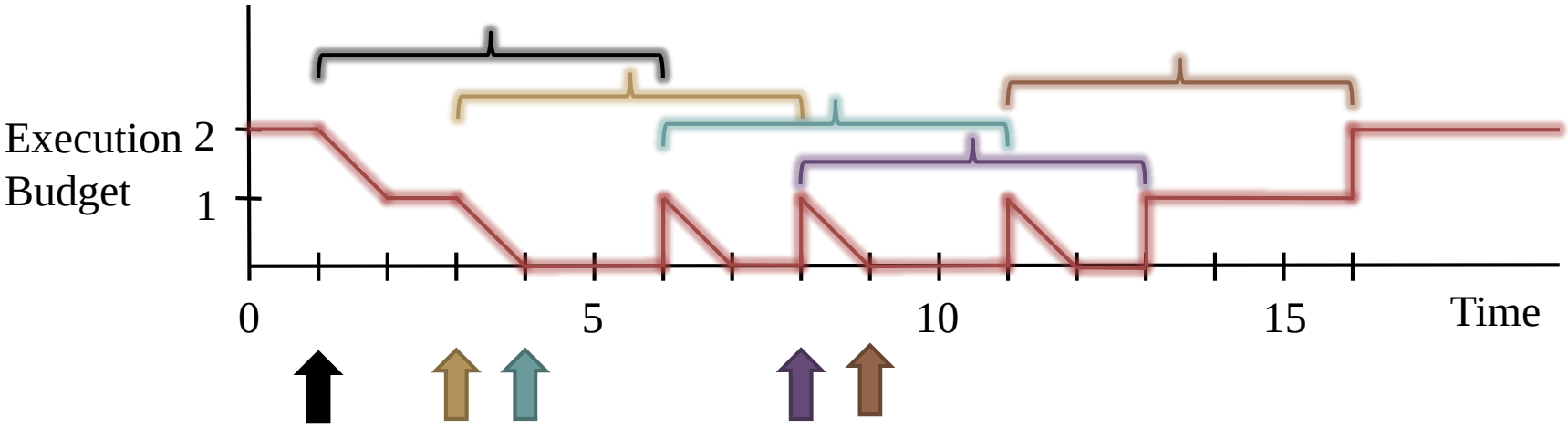

Output

- Your program output must show the following information
  - A sequence of the running task over time
  - The time when context switch occurred
- A report to describe your implementation
  - Relationship of each function
  - Implementation flow chart
  - Implementation details

Final Project: Sporadic Server

Implement Sporadic Server

- A sporadic server has a replenishment period 5 and an execution budget 2
- Each event consumes the execution 1
- Events arrive at 1, 3, 4, 8, 9



Input

- The input format should be as follows
  - Your program should have the capability to create the assigned number of tasks and their corresponding period and execution time
  - Assume that at starting time 0, the system has full execution budget
  - Example: taskset.txt

    2 6 5// execution budget: 2 replenishment period: 6 number of events: 5

    4 5 10 14 15 /* event arrival times */
- The number of events is no more than 20
- The arrival time of the last even is no late than 100
- The execution budget is no more than 4
- The replenishment period is no longer than 10

Input Example

```
4
1 12
1 7
2 19
2 20
2 10 5
1  3  4  18  19
```


Output

- Your program output must show the following information
  - A sequence of the running task over time
  - You can not just draw the results, there should be some tasks running
- A report to describe your implementation
  - Relationship of each function
  - Implementation flow chart
  - Implementation details

Implantation of a Sporadic Server: TEST.C – Data Structure

- The Extract Data Structure of a Sporadic Server:
  - The number of events: N
  - The arrival time of the last evens: A[N]
  - The execution budget: B
  - The execution start time: S[B]
  - The replenishment period: P
  - The total execution time: T
- The global information:
  - The system startup time: Z
  - The system current time: C

Implantation of a Sporadic Server: TEST.c – the Sporadic Server TASK

- Print out some information of the sporadic server execution

- Should we run some job of the sporadic server?
  - Check Z, C, A[N], T
  - Yes, go ahead within the infinite loop
  - No, break the infinite loop and go sleep until the next arrival time

Implantation of a Sporadic Server: OS_CORE.C – OSTimeTick(void)

- Does the sporadic server have execution budget to run some jobs?
  - Check P, S[0], C
  - Yes, increase T
    - If it is a starting point of a job, update S[B]:
    - S[0]=S[1]; S[1]=S[2]; … S[B-2]=S[B-1];
    - S[B-1] =C;
  - No, sleep for time P – (C - S[0])