Operating System Practice– Final Project

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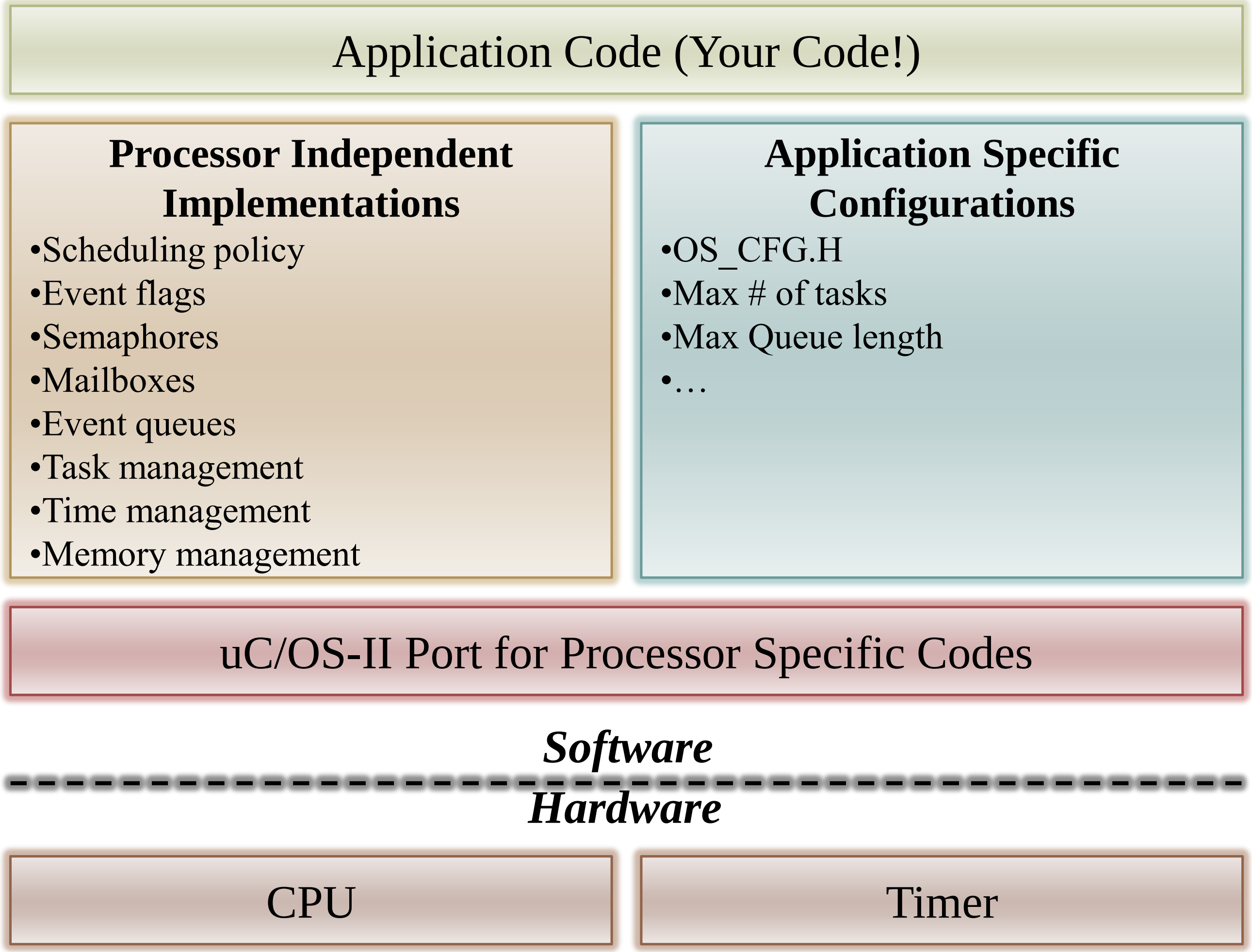
Report

- Only four A4 pages
- Two students in each group
- 12 pt words
- Deadline is 23:59 2022/06/15
- File name: OSP-Project-StudentID1-StudentID2.zip
- Required Files: The source code files and the report
- In the report, remember to provide your names, student IDs
- Upload to the e-learning system

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
  - You have 30 seconds to answer the 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

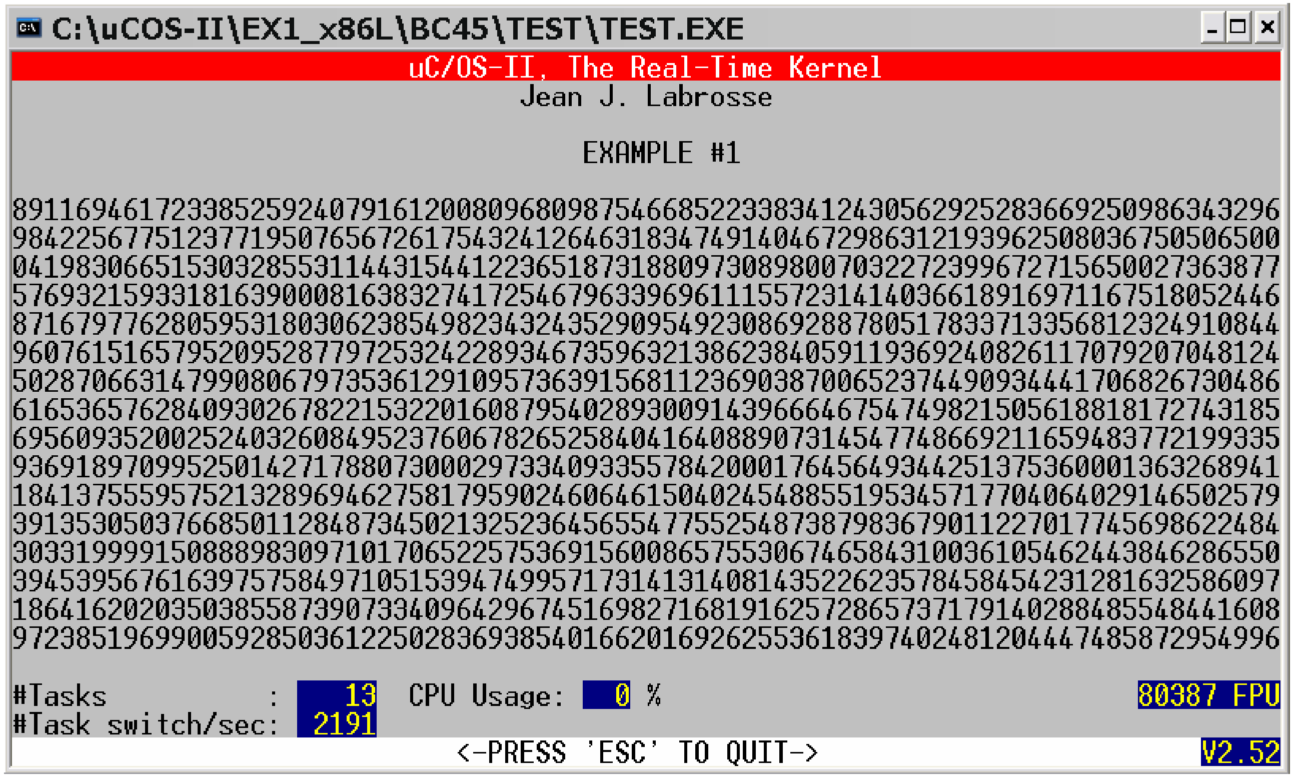
Software

Hardware

CPU

Timer

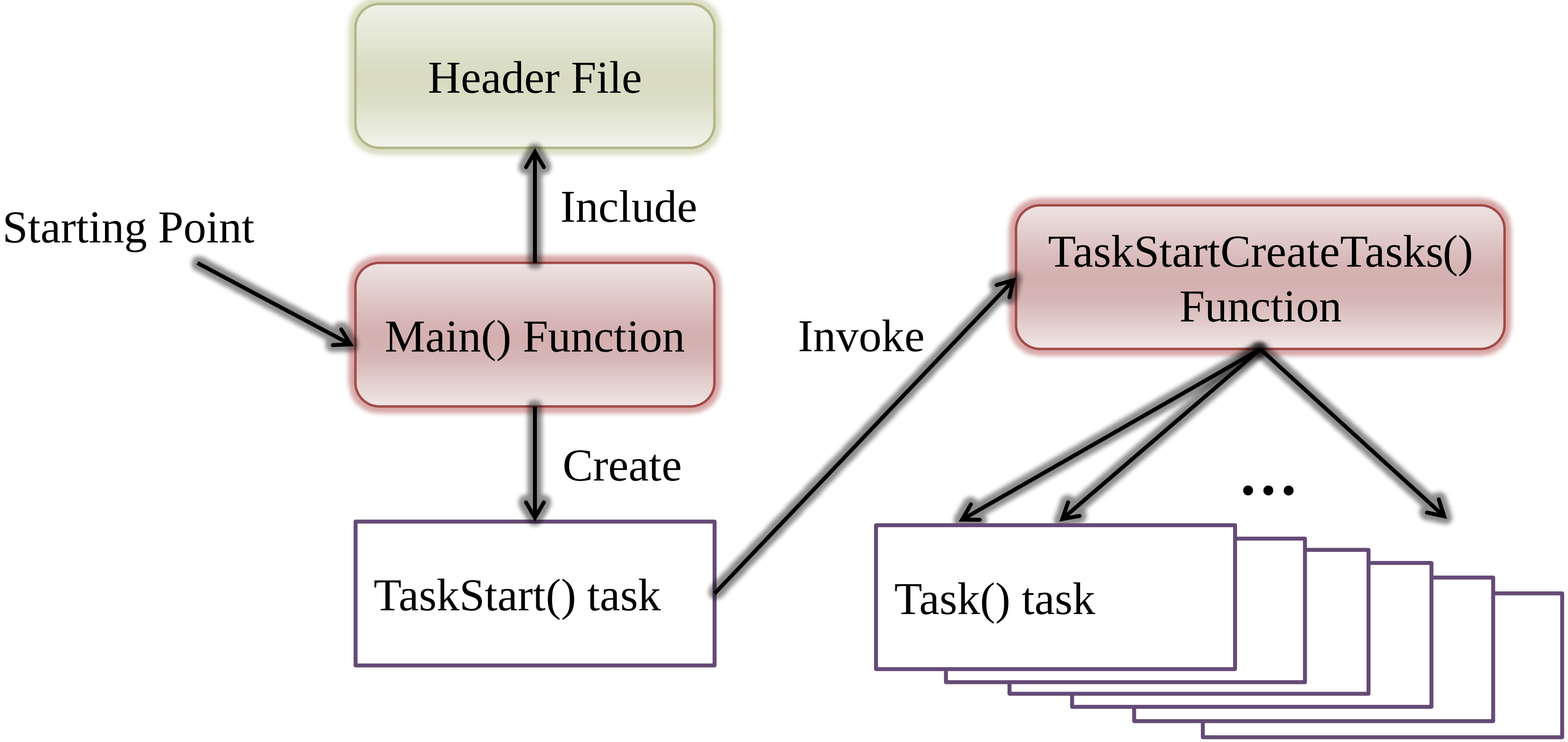
An Example on µC/OS-II: Multitasking



```
                          uC/OS-II, The Real-Time Kernel
                                Jean J. Labrosse

                                   EXAMPLE #1

89116946172338525924079161200809680987546685223383412430562925283669250986343296
98422567751237719507656726175432412646318347491404672986312193962508036750506500
04198306651530328553114431544122365187318809730898007032272399672715650027363877
57693215933181639000816383274172546796339696111557231414036618916971167518052446
87167977628059531803062385498234324352909549230869288780517833713356812324910844
96076151657952095287797253242289346735963213862384059119369240826117079207048124
50287066314799080679735361291095736391568112369038700652374490934441706826730486
616536576284093026782215322016087954028930091439666646754749821505618818172743185
69560935200252403260849523760678265258404164088907314547748669211659483772199335
93691897099525014271788073000297334093355784200017645649344251375360001363268941
18413755595752132896946275817959024606461504024548855195345717704064029146502579
391353050376685011284873450213252364565554775525487387983679011227017745698622484
30331999915088898309710170652257536915600865755306746584310036105462443846286550
39453956761639757584971051539474995717314131408143522623578458454231281632586097
18641620203503855873907334096429674516982716819162572865737179140288485548441608
97238519699005928503612250283693854016620169262553618397402481204447485872954996

#Tasks          :    13   CPU Usage:   0 %                            80387 FPU
#Task switch/sec:  2191
                           <-PRESS 'ESC' TO QUIT->                          V2.52
```

- 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

Requirements

- Task Scheduling
  - Adopt priority-driven scheduling
  - The scheduler always schedules the highest priority ready task to run
  - Modify the priority of each task
  - Related code in uC/OS II
    - See OS_Sched( ) for scheduling policy
    - See OSTimeTick() for time management
    - See OSIntExit( ) for the interrupt management
- Provide the RM/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 total utilization is no more than 65%
- The number of tasks is no more than 7

Input Example (1/2)

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

Input Example (2/2)

```
5
1 18
1 17
2 16
1 20
1 6
```

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

Hints (1/2)

- You can read three other example in the document and refer to the source code.
- In order to implement a new scheduler, we might have to modify the os_tcb data structure to include some new attributes.
- The function OSTaskCreateExt() is used to create tasks, and we can modify this function to input the execution time and the period to each task.
- Each task executes an infinite loop and uses OSTimeGet() to get the execution time, where OS_TICKS_PER_SEC is the number of ticks for a second.
    - Note that a task might be preempted during its execution.
- Use OSTimeDly() when the task finish its execution.

Hints (2/2)

- Modify the deadline of a task before it call OSTimeDly() (ex: OSTCBCur->deadline= OSTCBCur->deadline+TaskPeriod)
- When the delay of a task is completed, the function OSTaskResume() is called to put the task back to ready queue and reschedule.
- Modify the function OS_Sched() to pick the task with the shortest period or the earliest deadline.
- OSStart() is used to start the execution of tasks.

Bonuses

- Implementation and discussion of both RM and EDF: 15%

- Implementation and discussion of PIP: 20%

  or

- Implementation and discussion of PCP: 30%

- Implementation and discussion of Deferrable Server: 30%

  or

- Implementation and discussion of Sporadic Server: 40%