ARM PROGRAMMING

Bùi Quốc Bảo

What's A Task?

- A Taskis an active flow of control within a computation
  - Associated with a program counter value and set of register values
  - Multiple tasks can be active concurrently
  - Tasks are not supposed to interfere with other task's register values
  - Tasks share memory space and, in particular, can interfere with memory values

Preemptive vs. Non-Preemptive Tasks

- Non-preemptive task
  - Task runs to completion, even if other tasks want service
  - Example: the ISR routines
- Preemptive task
  - Task is suspended if some other task wants service, then restarted at a later time
  - Example: main program loop (preempted by ISRs)

Preemptive vs. Non-Preemptive Tasks

- Most real systems are a combination of both
  - ISRs pre-empt non-ISR tasks, but are not preemptable themselves
- Main tasks are preemptable

Purely Non-Preemptive Tasking

- Sometimes called “cooperative” tasking
  - Cyclic executive is a degenerate case
  - In general, want a pool of tasks that are executed by a scheduler
  - Only one task runs at a time
  - No preemption, so no need for executive to save state:
    - 1. Task saves its own state before yielding control to scheduler
    - 2. Task runs to completion

Example

- Starting point – cyclic executive:
  - // main program

```
loopfor(;;)
{       poll_uart();
        do_task1();
        do_task2();
}
```

Round Robin Cooperative Tasking Latency

- "Round Robin" = everyone takes one turn in some defined order
- For Round Robin, response time for N tasks is:
- (assume task reads inputs at start, processes, does outputs at end)•
- The task has just started, and will need to run again for new inputs•
- All other tasks will need to run•
- This same task will need to run again•
- Same time for all tasks ... "i" doesn't appear on right hand side of equation

$$R_i = \sum_{j=0}^{j=N-1} C_j$$

$$R_i = \sum_{j=0}^{j=N-1} C_j$$

Task Scheduling Policies

- Scheduler needs to have a task selection policy –answer to question “which task runs next?” varies:
  - Round-Robin
  - Earliest Deadline
  - Highest Priority
- Latency depends on scheduling policy!

Why Preemptive Tasks?

- Preemptive task
  - Executing task is suspended if some other task wants service
  - Suspended task is restarted at a later time
  - Example: an ISR preempts the main program loop
- Without preemption, latency is bounded by longest single task execution
  - Might even be lowest priority task that keeps everything else blocked

General Idea Of Preemption

- Interrupts are the simplest types of preemption
  - Save main program state on stack
  - Execute interrupt
  - Restore main program state from stack
  - Return to main program

General Idea Of Preemption

- General preemptive scheduling approach
  - N tasks are running concurrently
  - Have a place to store N copies of program state
    - NOT on the stack – that limits order of execution
  - Have a scheduler that saves and restores state:
    - Stop task K
    - Save state in the “task K save area”
    - Restore state from the “task J save area”
    - Restart task J from wherever it left off
  - Simplest approach is to have K stacks
    - one per task – and save states there

How Do You Know When To Preempt?

- Hardware approach
  - Hardware determines something of higher priority needs to execute
  - Works OK for ISRs preempting ordinary code
  - But, tricky for ISRs preempting other ISRs!

How Do You Know When To Preempt?

- Software approach
  - Software sees which task is highest priority, and starts it running
- You need a context swap to make this work
  - “Context” = all data required to define the state of the current task
  - Simplest example: all register values
  - Might include other things in more complex computing enviroments(for example, file I/O status)

Should You Build Your Own Scheduler

- Or, put another way, should you build your own RTOS
  - Short answer: probably not.
- It is really difficult to get an RTOS to be correct
- Even if you are an expert, and you do write your own...
  - What happens when you leave the company?
    - Win the lottery; Get a better job; Get run over by a beer truck;
  - What happens when there is a bug found?

Should You Build Your Own Scheduler

- "Make/buy" decision advice:
  - Real time operating systems should be bought, not made
  - Unless you are in a company that sells an RTOS as a product
  - In management speak, only build an RTOS if that is a critical core competency
  - If you are an embedded system company, RTOS is probably not a core competency (unless you actually sell an RTOS!)

FreeRTOS

- A Real Time Operating System
- Written by Richard Barry & FreeRTOS Team
- Owned by Real Time Engineers Ltd but free to use
- Huge number of users all over the world
  - 6000 Download per month
- Simple but very powerful

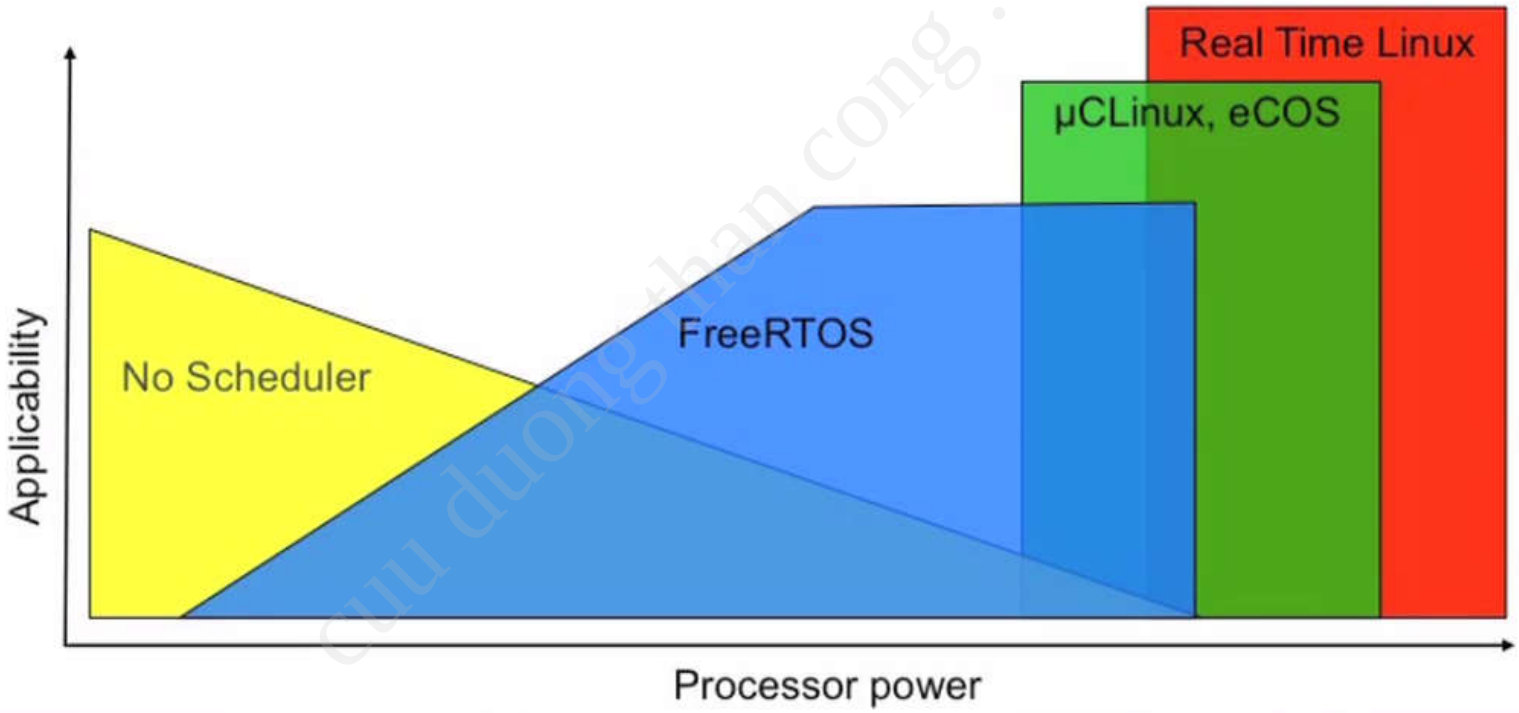
Real-Time Operating System ?

- A type of an operating system
- It's all about scheduler :
  - multi user operating system(UNIX)— fair amount of the processing time
  - desk top operating system(Windows)— remain responsive to its user
  - ……
- RTOS scheduler focuses on predictable execution pattern

Why using FreeRTOS

- Abstract out timing information
- Maintainability/Extensibility
- Modularity
- Cleaner interfaces
- Easier testing (in some cases)
- Code reuse
- Improved efficiency?
- Idle time

When to use FreeRTOS

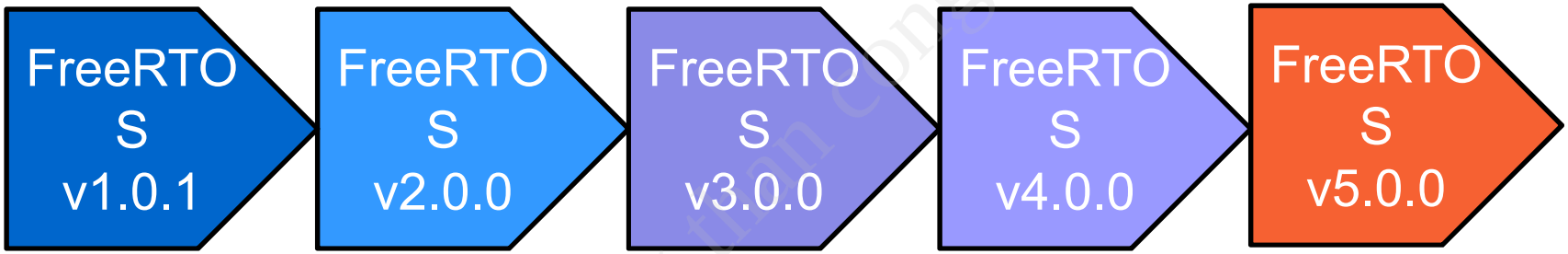


License of FreeRTOS

- Modified GPL

History of FreeRTOS

- Newest version: 10.1.1



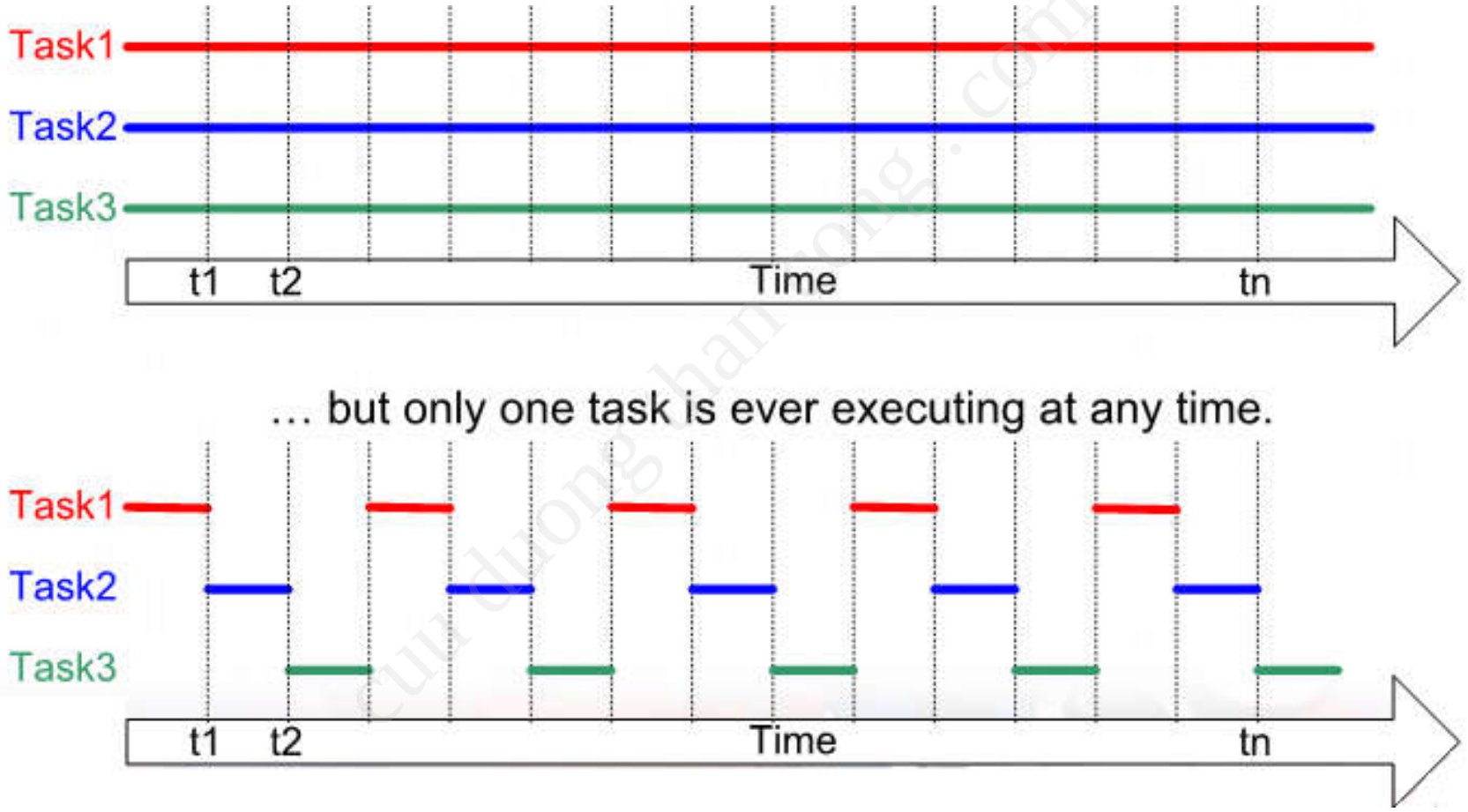
+Scalability
+New Task API

+API Changes
+Directory Names Changed
+Changes in Kernel

+Co-routines

+API Changes

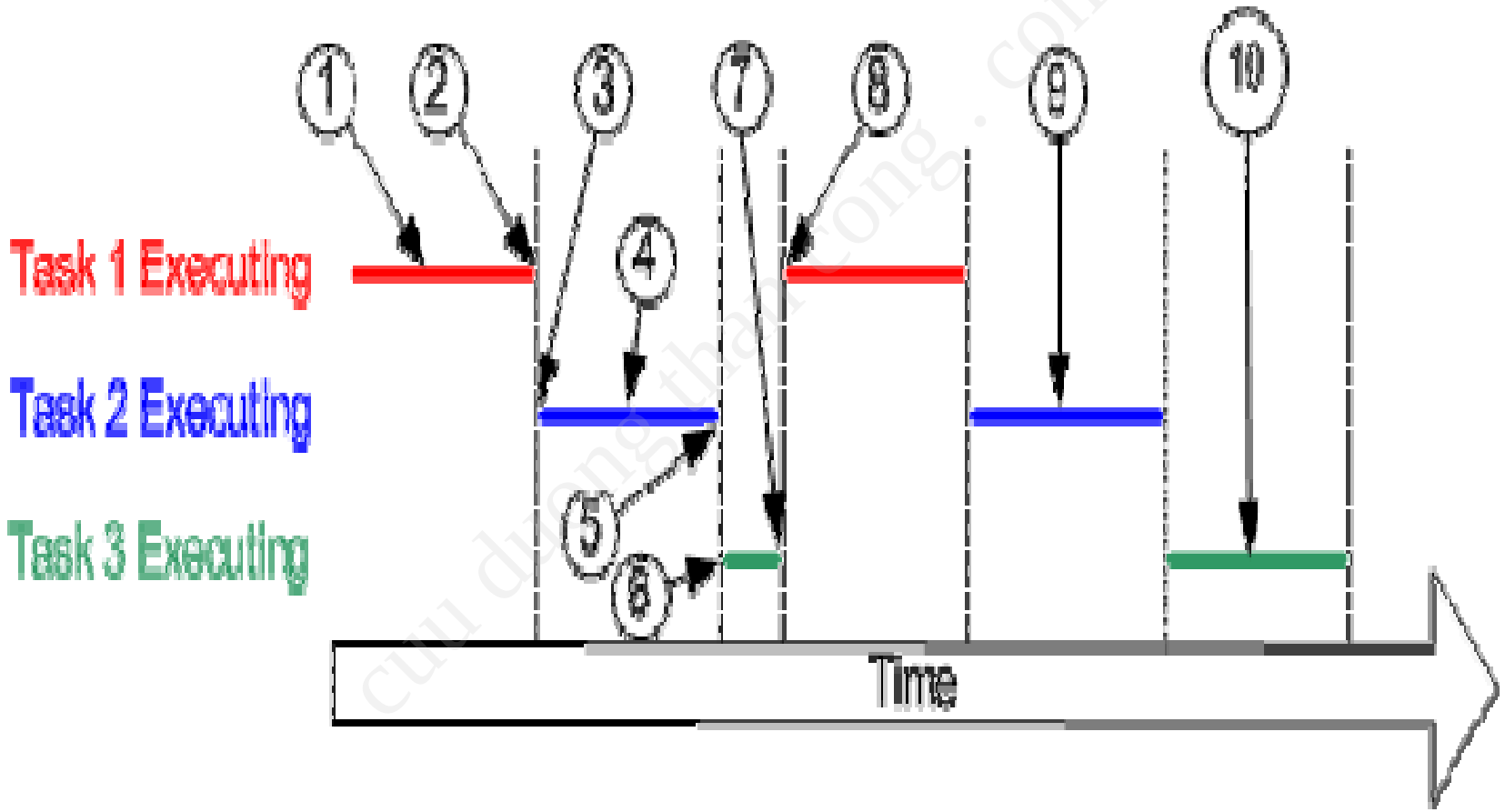
Concurrent processing



Scheduler

- Scheduler là 1 phần của kernel dùng để quyết định tác vụ nào được chạy tại mỗi thời điểm.
- Kernel có thể dừng và phục hồi hoạt động của 1 tác vụ trong khi tác vụ đang chạy.
- Một tác vụ có thể dừng chính nó bằng cách **delay** (**sleep**) một khoảng thời gian, hoặc **chờ** (**block**) để đợi một sự kiện (vd: keypressed) hay 1 tài nguyên (vd: serialport)

Scheduler



Scheduler

- At (1) task 1 is executing.
- At (2) the kernel suspends task 1 ...
- and at (3) resumes task 2.
- While task 2 is executing (4), it locks a processor peripheral for it's own exclusive access.
- At (5) the kernel suspends task 2 ...
- ... and at (6) resumes task 3.

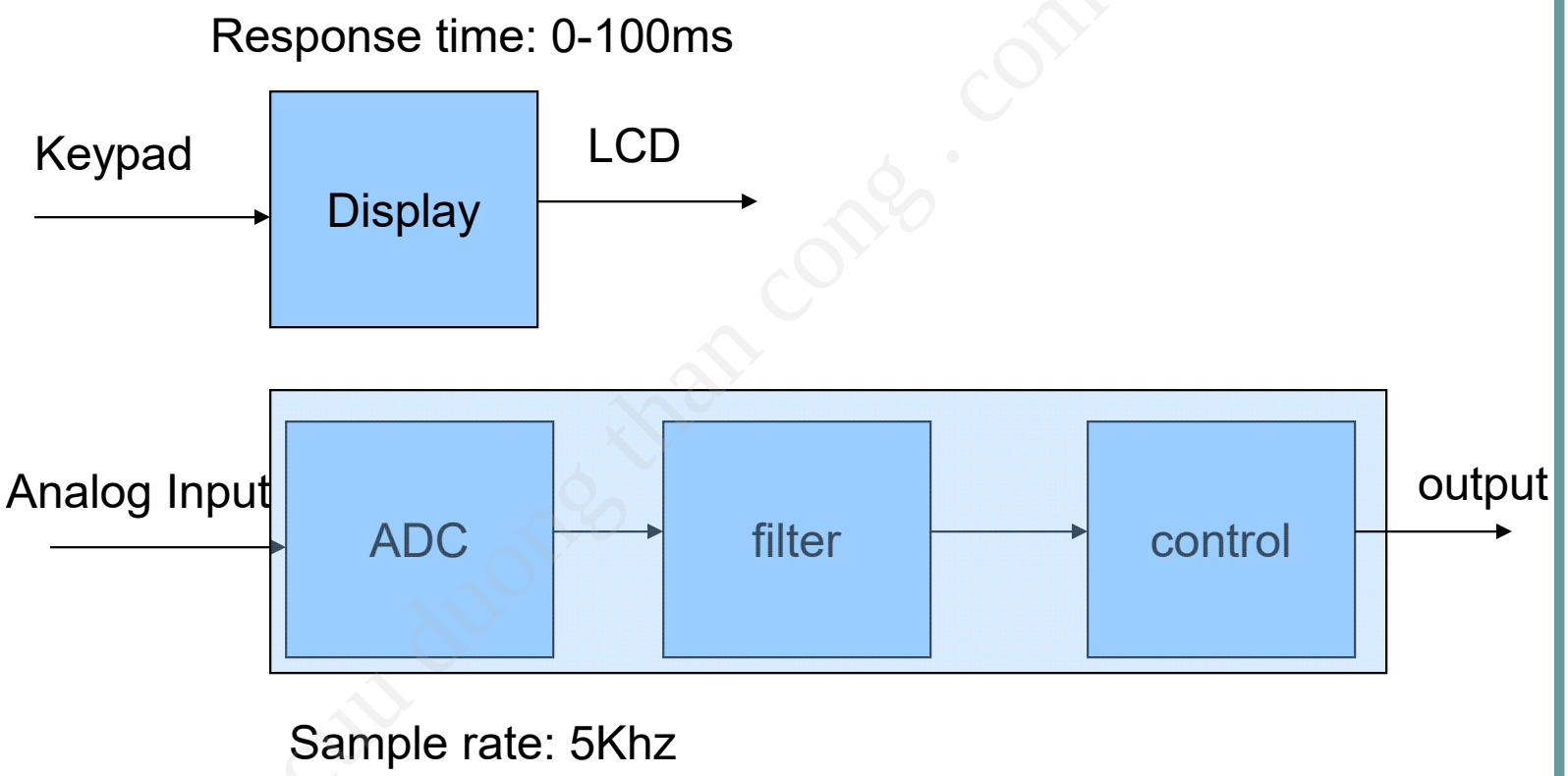
Scheduler

- Task 3 tries to access the same processor peripheral, finding it locked, task 3 cannot continue so suspends itself at (7).
- At (8) the kernel resumes task 1.
- Etc.
- The next time task 2 is executing (9) it finishes with the processor peripheral and unlocks it.
- The next time task 3 is executing (10) it finds it can now access the
- processor peripheral and this time executes until suspended by the kernel.

Realtime scheduler

- Mỗi tác vụ phải đáp ứng (response) trong thời gian qui định (deadline).
- Mỗi tác vụ có 1 mức ưu tiên riêng
- Scheduler sẽ đảm bảo tác vụ có quyền ưu tiên cao luôn được thực thi bằng cách tạm dừng tác vụ có quyền ưu tiên thấp.

Realtime OS



Keypad handler

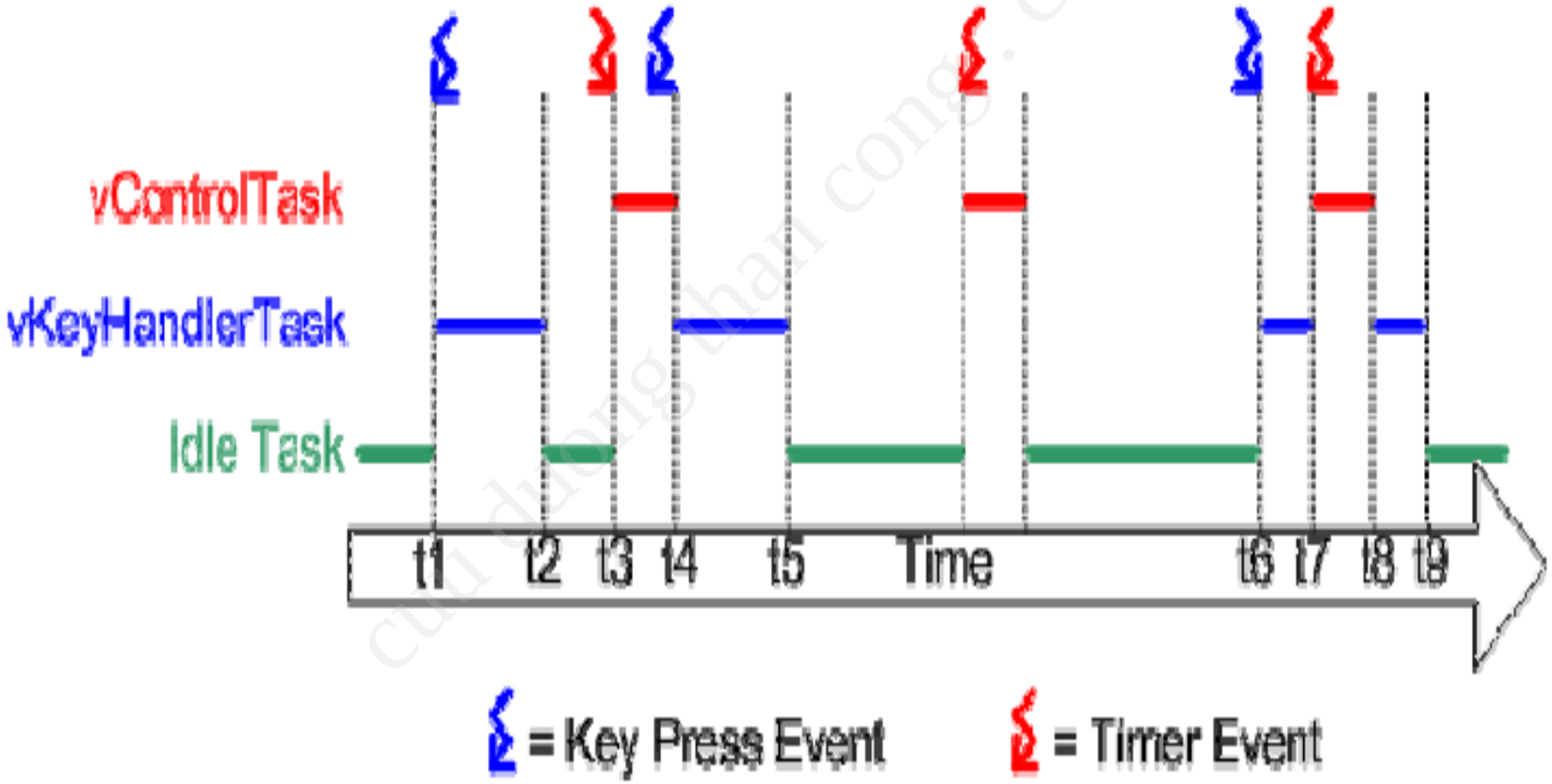
```
void vKeyHandlerTask( void *pvParameters )
{
    // Key handling is a continuous process and as such the task
    // is implemented using an infinite loop (as most real time
    // tasks are).
    for( ;; )
    {
        [Suspend waiting for a key press]
        [Process the key press]
    }
}
```

control

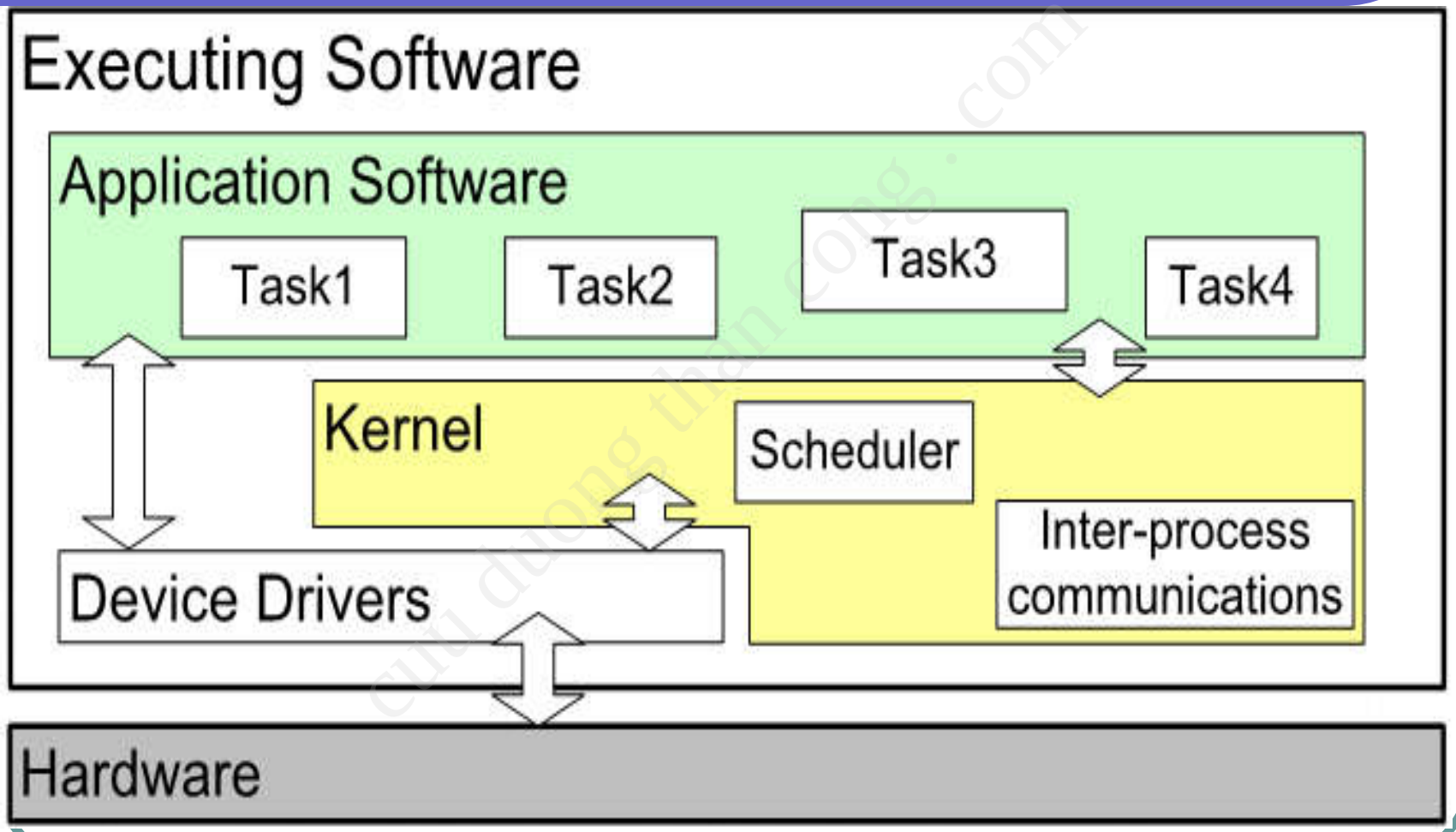
```
void vControlTask( void *pvParameters )
{
    for( ;; )
    {
        [Suspend waiting for 0.5ms since the start of the previous
        cycle]
        [Sample the input]
        [Filter the sampled input]
        [Perform control algorithm]
        [Output result]
    }
}
```

Mức ưu tiên

- Deadline của tác vụ control thì nghiêm ngặt hơn của tác vụ keypad.
- Hậu quả của việc trễ deadline của tác vụ control thì lớn hơn so với keypad



FreeRTOS realtime kernel



Example using FreeRTOS

```
int main( void ){
/* Create the 2 task in exactly the same way. */
    xTaskCreate( vTask1, "Task 1", 1000, NULL, 1, NULL );
    xTaskCreate( vTask2, "Task 2", 1000, NULL, 1, NULL );
    /* Start the scheduler so our tasks start executing.
   */
    vTaskStartScheduler();
    /* If all is well we will never reach here as the
      scheduler will now be running.  If we do reach
      here then it is likely that there was insufficient
   heap available for the idle task to be created. */
    for( ;; );
    return 0;
}
```

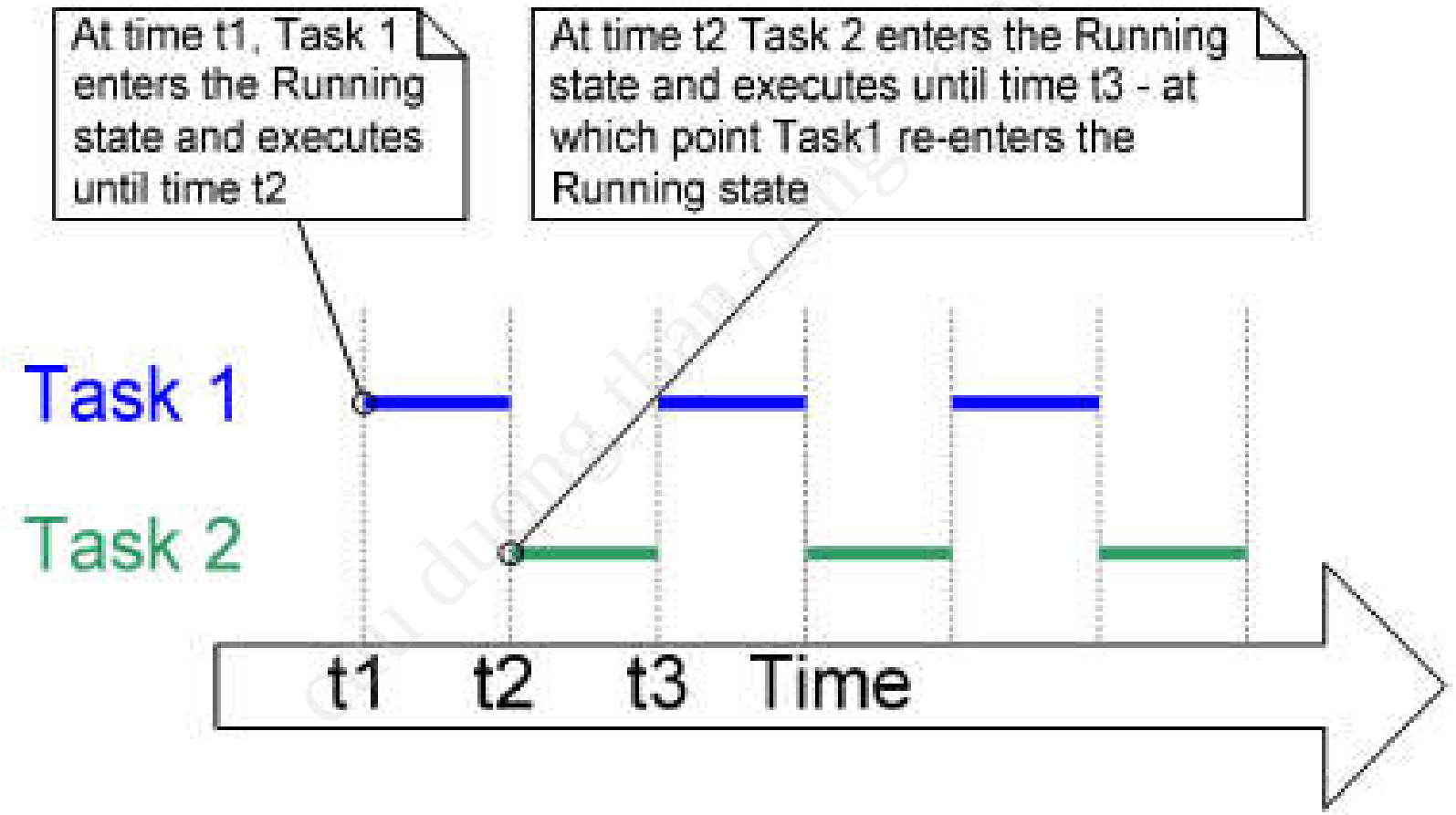
Example using FreeRTOS

```
void vTask1( void *pvParameters )
{
const char *pcTaskName = "Task 1 is running\r\n";
volatile unsigned long ul;

    /* As per most tasks, this task is implemented in an infinite
   loop. */
    for( ;; )
    {
        /* Print out the name of this task. */
        vPrintString( pcTaskName );
        /* Delay for a period. */
        for( ul = 0; ul < mainDELAY_LOOP_COUNT; ul++ )
        {
            }
    }
}
```

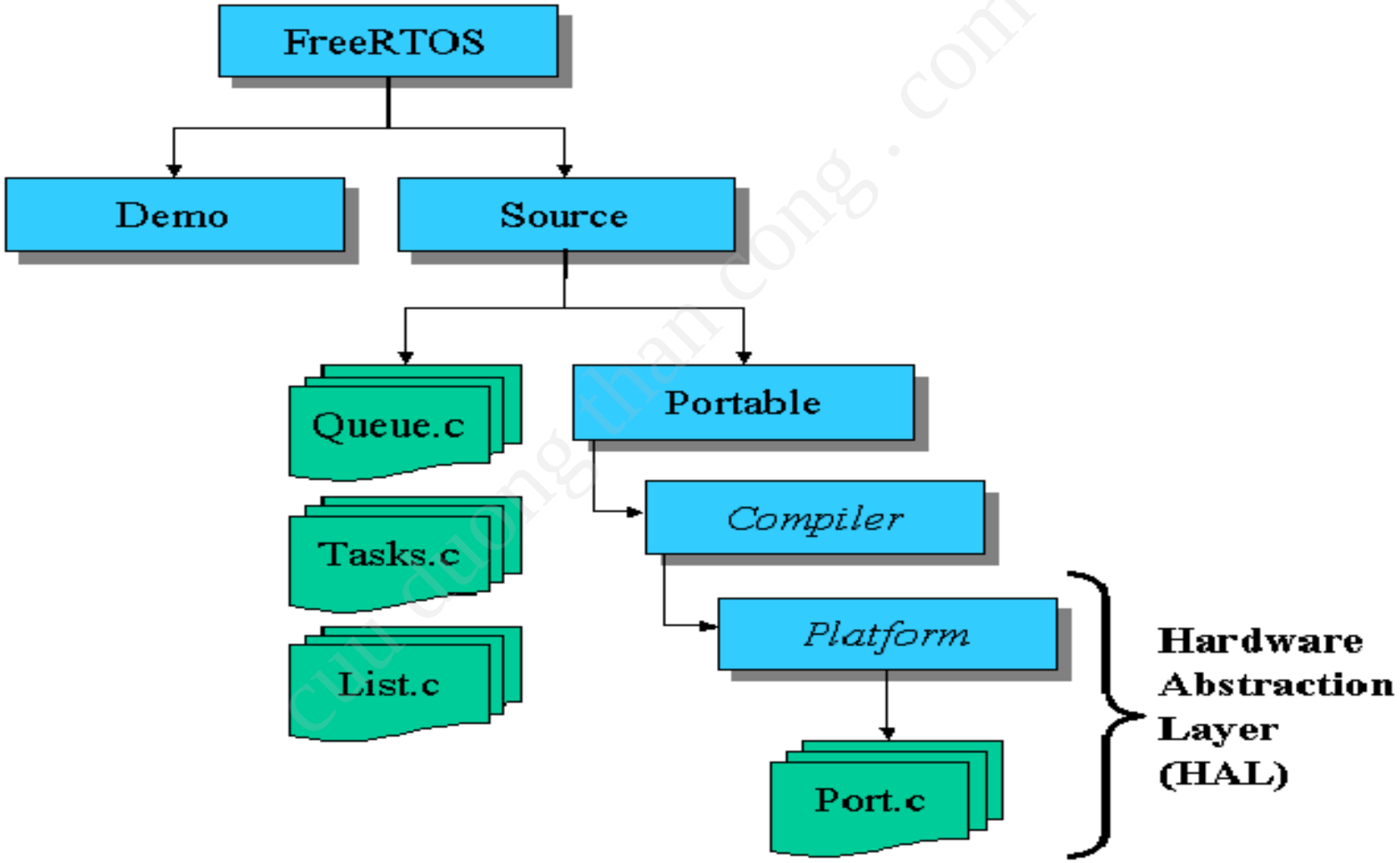
Example using FreeRTOS

```
void vTask2( void *pvParameters )
{
const char *pcTaskName = "Task 2 is running\r\n";
volatile unsigned long ul;

    /* As per most tasks, this task is implemented in an infinite
   loop. */
    for( ;; )
    {
        /* Print out the name of this task. */
        vPrintString( pcTaskName );
        /* Delay for a period. */
        for( ul = 0; ul < mainDELAY_LOOP_COUNT; ul++ )
        {
            }
    }
}
```

The actual execution pattern of the two tasks



FreeRTOS source code structure



freeRTOSconfig.h

```
#define  configUSE_PREEMPTION                    1
#define  configUSE_IDLE_HOOK                     0
#define  configUSE_TICK_HOOK                     1
#define  configCPU_CLOCK_HZ          ( ( unsigned long ) 50000000 )
#define  configTICK_RATE_HZ          ( ( portTickType ) 1000 )
#define  configMINIMAL_STACK_SIZE    ( ( unsigned short ) 70 )
#define  configTOTAL_HEAP_SIZE       ( ( size_t ) ( 24000 ) )
#define  configMAX_TASK_NAME_LEN             ( 12 )
#define  configUSE_TRACE_FACILITY            1
#define  configUSE_16_BIT_TICKS              0
#define  configIDLE_SHOULD_YIELD             0
#define  configUSE_CO_ROUTINES               0
#define  configUSE_MUTEXES           1
#define  configUSE_RECURSIVE_MUTEXES         1
#define  configCHECK_FOR_STACK_OVERFLOW 2
```

freeRTOSconfig.h

```
#define configMAX_PRIORITIES    ( ( unsigned portBASE_TYPE ) 5 )
#define configMAX_CO_ROUTINE_PRIORITIES ( 2 )
#define configQUEUE_REGISTRY_SIZE                       10

/* Set the following definitions to 1 to include the API function, or zero
to exclude the API function. */

#define INCLUDE_vTaskPrioritySet                        1
#define INCLUDE_uxTaskPriorityGet                       1
#define INCLUDE_vTaskDelete                             1
#define INCLUDE_vTaskCleanUpResources                   0
#define INCLUDE_vTaskSuspend                            1
#define INCLUDE_vTaskDelayUntil                         1
#define INCLUDE_vTaskDelay                              1
#define INCLUDE_uxTaskGetStackHighWaterMark             1
```

Task management

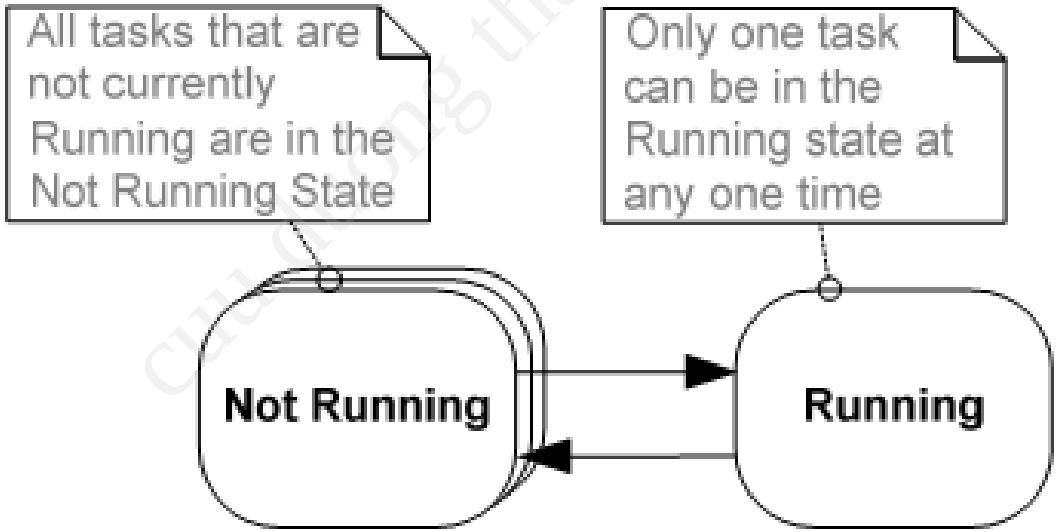
Tác vụ là 1 hàm với một vòng lặp vô tận.

```
void ATaskFunction( void *pvParameters )
{
int iVariableExample = 0;

   /* A task will normally be implemented as in infinite loop. */
   for( ;; )
   {
         [suspend waiting for a key press]
          [process the key]
   }

vTaskDelete( NULL );
}
```

Task state

Tác vụ chuyển từ trạng thái dừng sang chạy gọi là “swapped in”, “switched in”

Tác vụ chuyển từ trạng thái chạy sang dừng gọi là “swapped out”, “switched out”



Task management function

Creation
xTaskCreate
xTaskDelete

Control
vTaskDelay
vTaskDelayUntil
uxTaskPriorityGet
vTaskPrioritySet
vTaskSuspend
vTaskResume
xTaskResumeFromISR

Utilities
tskIDLE_PRIORITY
xTaskGetTickCount
uxTaskGetNumberOfTasks
vTaskList
vTaskGetRunTimeStats
vTaskStartTrace
ulTaskEndTrace
uxTaskGetStackHighWaterMark
vTaskSetApplicationTaskTag
xTaskSetApplicationTaskTag
xTaskCallApplicationTaskHook

Naming convention

FreeRTOS name	Equivalent C
portCHAR	char
portFLOAT	float
portDOUBLE	double
portLONG	int
portSHORT	short
portSTACK_TYPE	unsigned int
portBASE_TYPE	int
portTickType	unsigned int

Naming convention

- Variables of type char are prefixed c
- Variables of type short are prefixed s
- Variables of type long are prefixed l
- Variables of type float are prefixed f
- Variables of type double are prefixed d
- Enumerated variables are prefixed e
- Other types (e.g. structs) are prefixed x
- Pointers have an additional prefixed p , for example a pointer to a short will have prefix ps
- Unsigned variables have an additional prefixed u , for example an unsigned short will have prefix us

Naming convention

- File private functions are prefixed with prv
- API functions are prefixed with their return type, as per the convention defined for variables
- Function names start with the file in which they are defined. For example vTaskDelete is defined in Task. c
- x is used both for structures and for RTOS types such as portTickType (in the ARM port this is equivalent to unsigned int)

Creating a Task, xTaskCreate

```
portBASE_TYPE xTaskCreate(
pdTASK_CODE                     pvTaskCode,
const signed portCHAR           * const pcName,
unsigned portSHORT              usStackDepth,
void                            *pvParameters,
unsignedportBASE_TYPE           uxPriority,
xTaskHandle                     *pxCreatedTask
                    );
```

Creating a Task, xTaskCreate

- pvTaskCode: con trỏ chỉ đến tên tác vụ
- pcName: tên mô tả tác vụ (chiều dài lớn nhất mặc định là 16)
- usStackDepth: độ rộng stack của tác vụ.
- pvParameters: con trỏ chỉ đến tham số đưa vào tác vụ.

Creating a Task, xTaskCreate

- uxPriority: mức ưu tiên của tác vụ.
  - Có giá trị từ 0 đến (configMAX_PRIORITIES – 1)
  - 0 là mức ưu tiên thấp nhất
- pxCreatedTask: dùng để trả về handle của tác vụ

Creating a Task, xTaskCreate

- Giá trị trả về:
  - pdPass nếu thành công
  - errCOULD_NOT_ALLOCATE_REQUIRED_MEMORY nêú tác vụ không thể được khởi tạo

Creating a Task, xTaskCreate

```
xTaskCreate(    vTask1,
/* Pointer to the function that implements the task. */
                "Task 1",
/* Text name for the task.  This is to facilitate debugging
   only. */
                1000,
 /* Stack depth - most small microcontrollers will use much
   less stack than this. */
 NULL,          /* We are not using the task parameter. */
1,      /* This task will run at priority 1. */
 NULL );        /* We are not going to use the task handle. */
```

Using the task parametter

```
void vTaskFunction( void *pvParameters )
{
char *pcTaskName;
volatile unsigned long ul;
pcTaskName = ( char * ) pvParameters;

for( ;; )
   {
vPrintString( pcTaskName );

      /* Delay for a period. */
      for( ul = 0; ul < mainDELAY_LOOP_COUNT; ul++ ) ;
}
}
```

Using the task parametter

```
static const char *pcTextForTask1 = "Task 1 is running\r\n";
static const char *pcTextForTask2 = "Task 2 is running\t\n";
int main( void )
{
    /* Create one of the two tasks. */
    xTaskCreate(    vTaskFunction, "Task 1",   1000,
                (void*)pcTextForTask1,
/* Pass the text to be printed into the task
    using the task parameter. */
                1, NULL );
xTaskCreate( vTaskFunction, "Task 2", 1000,
                    (void*)pcTextForTask2, 1, NULL );
vTaskStartScheduler();
for( ;; );
}
```

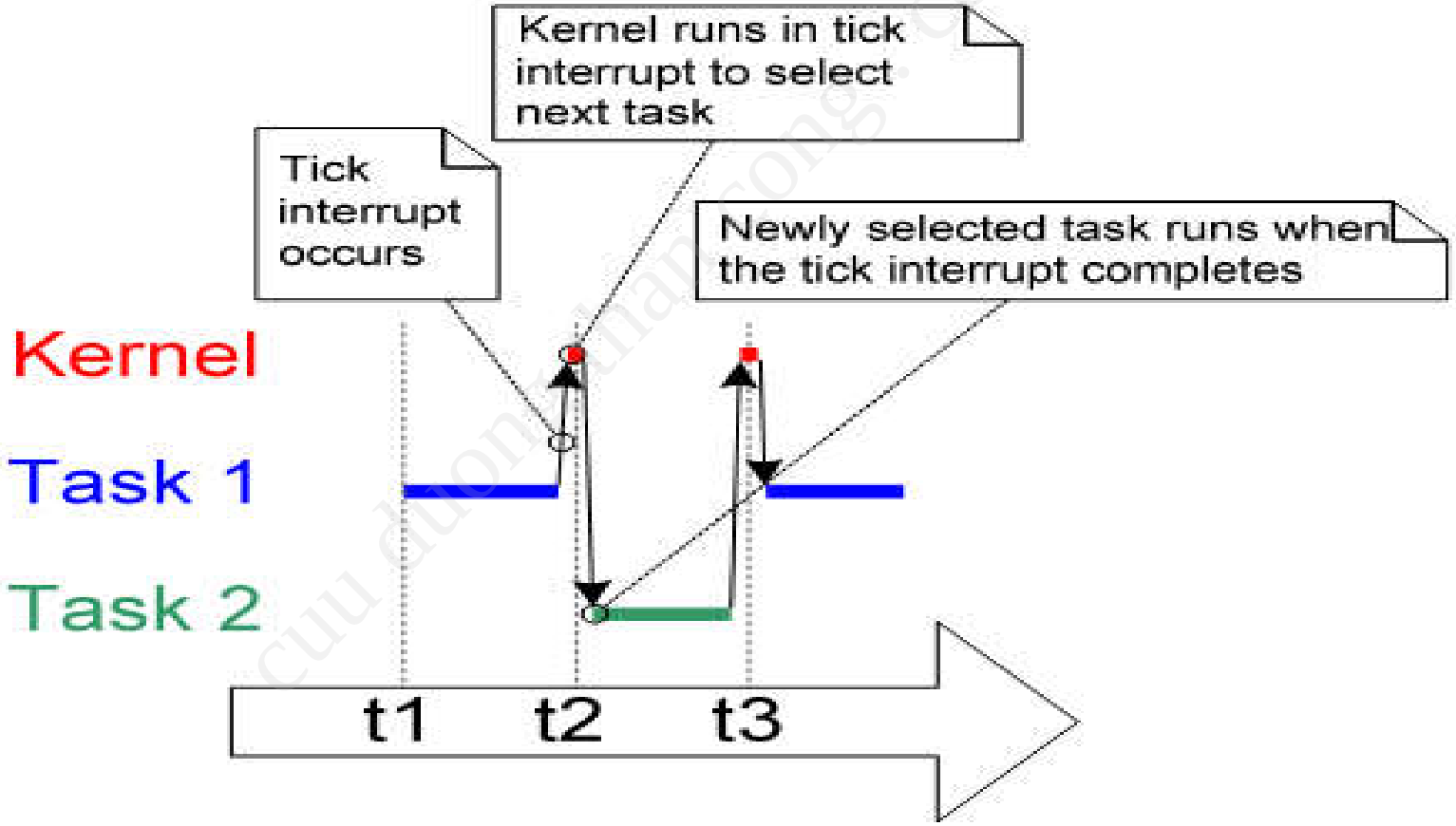
Task priorities

- Tham số configMAX_PRIORITIES qui định số mức ưu tiên có thể có.
- Nhiều tác vụ có thể có cùng mức ưu tiên
- Scheduler chạy sau mỗi khoảng thời gian xác định (system tick).
- Tham số configTICK_RATE_HZ qui định khoảng thời gian giữa 2 lần systemTick.

Task priorities

- Các API của FreeRTOS luôn dùng số lần systemTick xảy ra để đếm thời gian
- Tham số portTICK_RATE_MS dùng để chuyển đổi từ số lần sysTick sang thời gian ở ms.

Task priorities



Two task with different priorities

```
static const char *pcTextForTask1 = “Task 1 is running\r\n”;
static const char *pcTextForTask2 = “Task 2 is running\t\n”;
int main( void )
{
   /* Create one of the two tasks. */
   xTaskCreate(    vTaskFunction, "Task 1",   1000,
                (void*)pcTextForTask1,
/* Pass the text to be printed into the task
    using the task parameter. */
                1, NULL );
xTaskCreate( vTaskFunction, "Task 2", 1000,
                        (void*)pcTextForTask2, 2, NULL );
vTaskStartScheduler();
for( ;; );
}
```

Continous processing

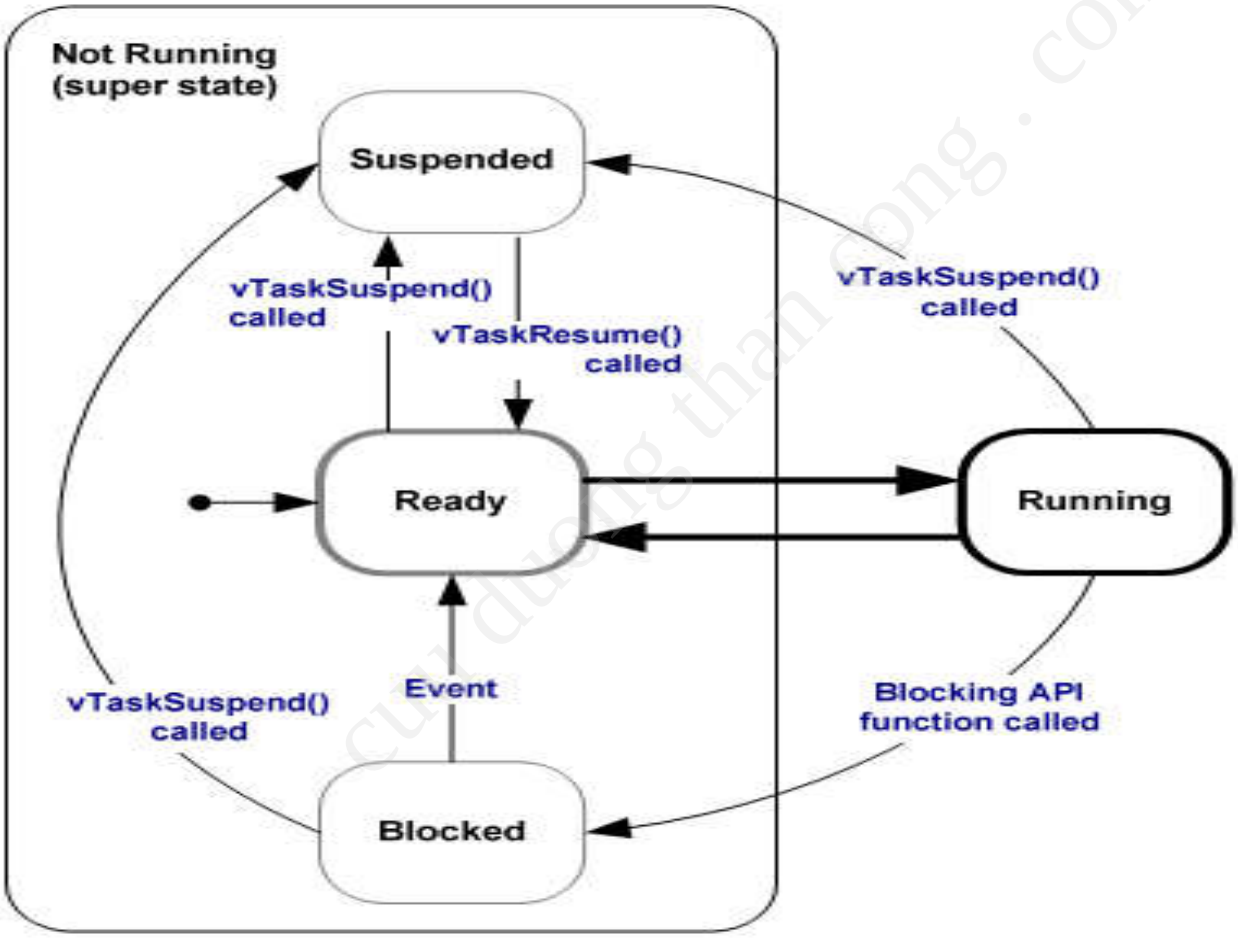
- Trong các ví dụ trên, các tác vụ luôn chạy mà không cần đợi bất kỳ sự kiện nào.
- Vì vậy, các tác vụ luôn ở trạng thái sẵn sàng chuyển sang Running

Chuyện gì xảy ra khi tác vụ dạng này có độ ưu tiên cao?

Event driven task

- Trong hệ thống nhúng, các tác vụ thường được thiết kế theo dạng “event-driven”
- Chúng phải chờ 1 sự kiện xảy ra để có thể đi vào trạng thái “Running”
- Scheduler sẽ chọn tác vụ có độ ưu tiên cao nhất mà có thể chuyển sang trạng thái Running.

Task state



The Blocked State

- Tác vụ đi vào trạng thái Block để chờ 2 dạng event sau:
- Thời gian:
  - một khoảng thời gian delay hoặc một thời điểm xác định kể từ khi scheduler bắt đầu chạy.
- Synchronization event: (sự kiện đồng bộ)
  - Khi sự kiện được tạo từ 1 tác vụ khác hay interrupt.
  - **FreeRTOS queues, binary semaphores, counting semaphores, recursive semaphores, mutexes** có thể dùng để tạo synchronization event.

The Suspended State

- Tác vụ bị trong trạng thái Suspended sẽ bị scheduler bỏ qua.
- Hàm vTaskSuspend() được gọi để đưa tác vụ vào trạng thái Suspended
- Hàm vTaskResume() hoặc xvTaskResumeFromISR dùng để đưa tác vụ ra khỏi trạng thái Suspended.

The Ready State

- Tác vụ sẵn sàng để chạy (vẫn nằm ở trạng thái NotRunning) thì ở trạng thái Ready

vTaskDelay()

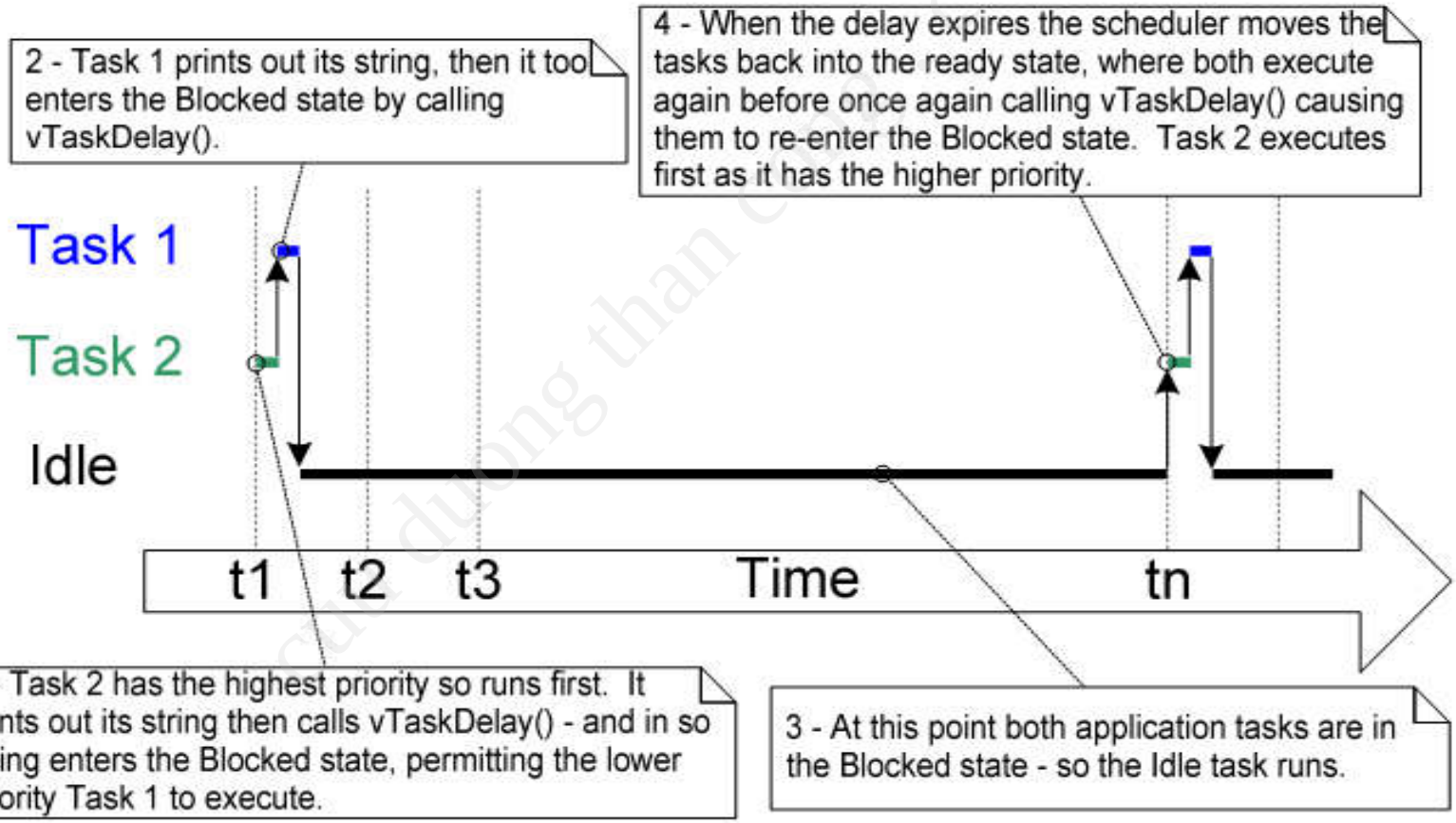
```
void vTaskDelay( portTickType
  xTicksToDelay );
```

- Hàm vTaskDelay() đưa tác vụ vào trạng thái Blocked.
- Tác vụ trở lại trạng thái Ready sau xTicksToDelay lần Systick.

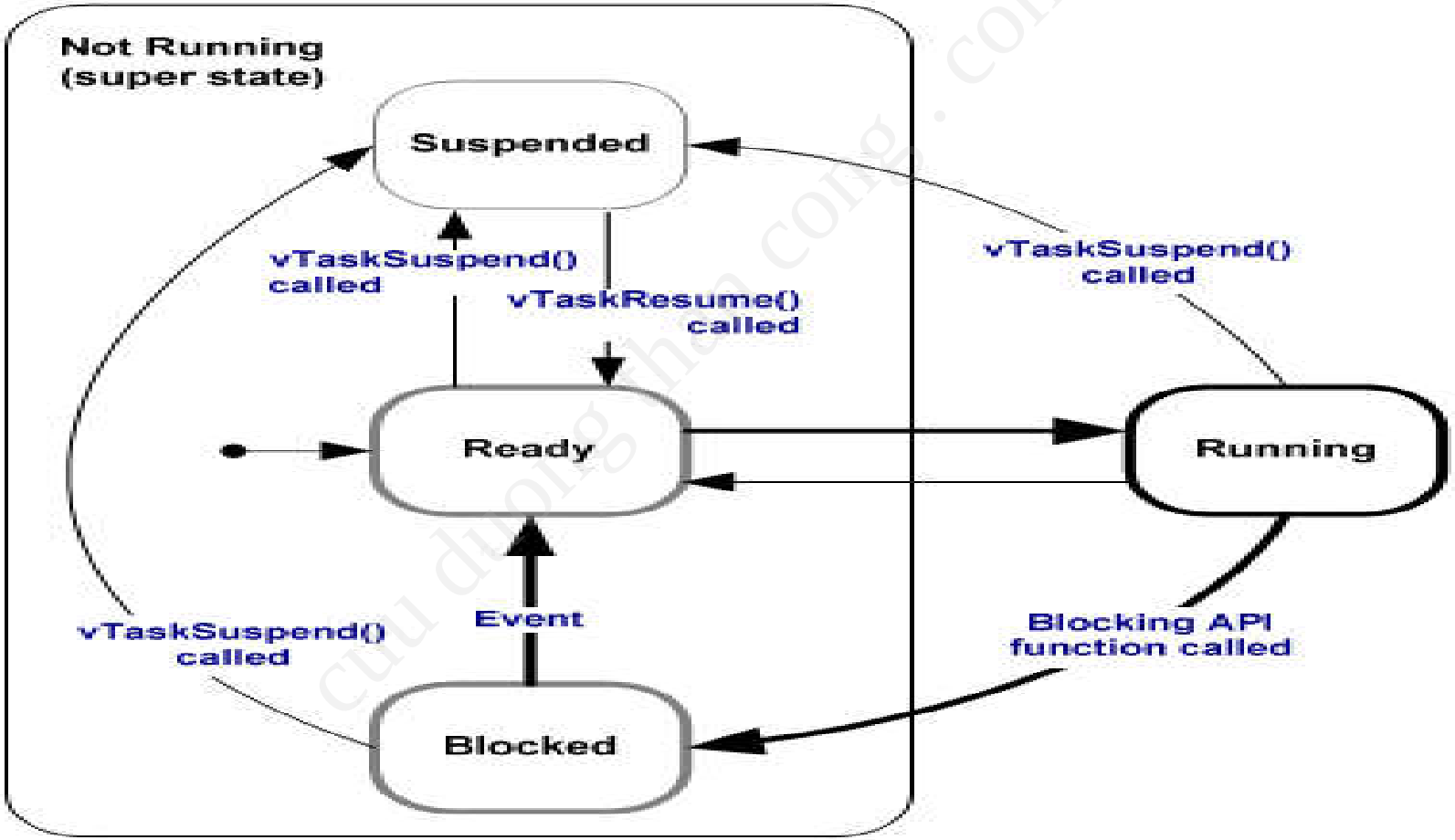
Example using vTaskDelay

```
void vTaskFunction( void *pvParameters )
{
char *pcTaskName;
pcTaskName = ( char * ) pvParameters;

    /* As per most tasks, this task is implemented in an infinite loop. */
    for( ;; )
    {
      vPrintString( pcTaskName );

/* In this case a period of 250 milliseconds is being specified. */
       vTaskDelay( 250 / portTICK_RATE_MS );
    }
}
```

```
static const char *pcTextForTask1 = “Task 1 is running\r\n”;
static const char *pcTextForTask2 = “Task 2 is running\t\n”;
int main( void )
{
   /* Create one of the two tasks. */
   xTaskCreate(    vTaskFunction, "Task 1",   1000,
                (void*)pcTextForTask1,
/* Pass the text to be printed into the task
    using the task parameter. */
                1, NULL );
xTaskCreate( vTaskFunction, "Task 2", 1000,
                        (void*)pcTextForTask2, 2, NULL );
vTaskStartScheduler();
for( ;; );
}
```



Task transition



vTaskDelayUntil() API function

- void vTaskDelayUntil(portTickType * pxPreviousWakeTime, portTickType xTimeIncrement);
  - vTaskDelayUntil chỉ chính xác số lần Systick kể từ khi tác vụ chuyển sang trạng thái Running trước đó đến lần chuyển sang trạng thái Running kế tiếp

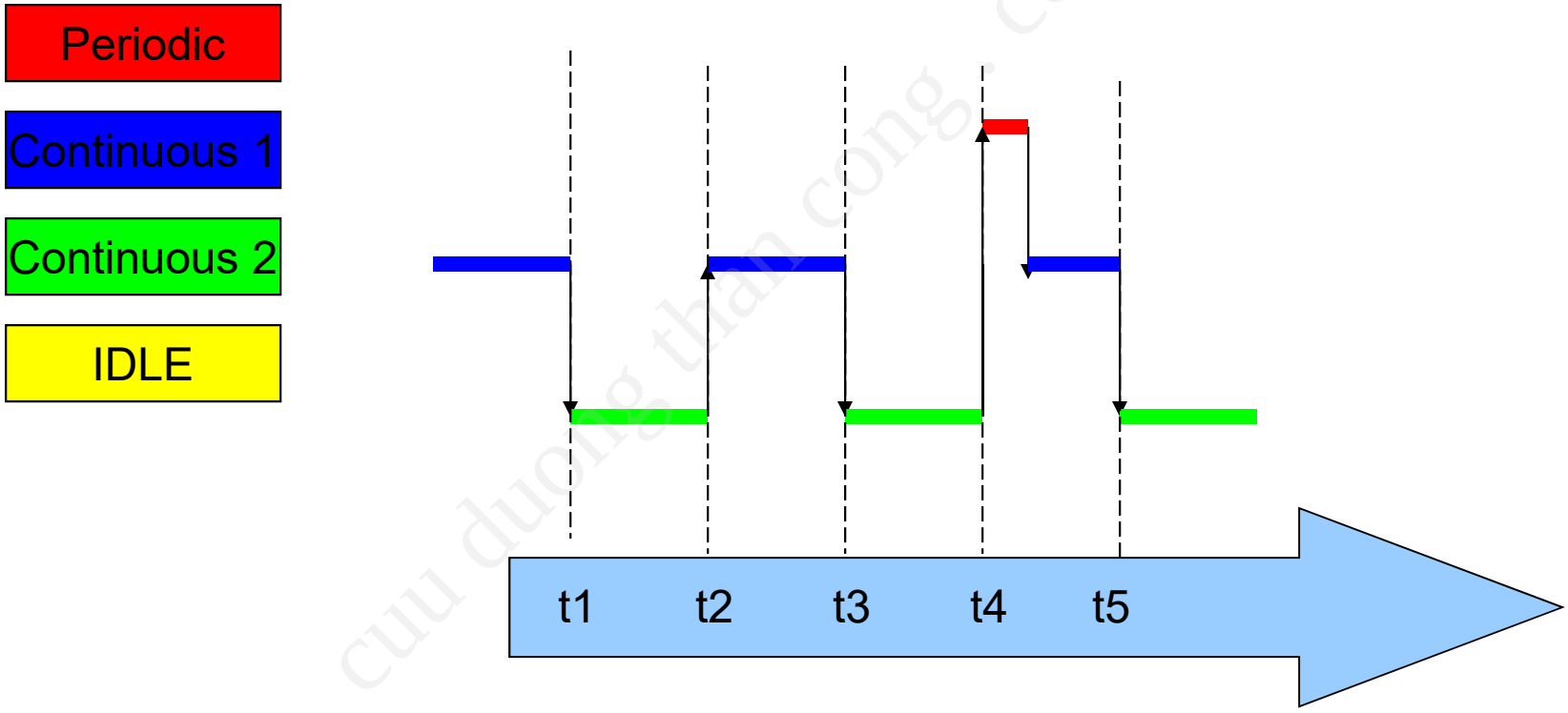
```
void vTaskFunction( void *pvParameters )
{
char      *pcTaskName;
portTickType      xLastWakeTime;
pcTaskName = ( char * ) pvParameters;

xLastWakeTime = xTaskGetTickCount();

    /* As per most tasks, this task is implemented in an infinite loop. */
    for( ;; )
    {
        /* Print out the name of this task. */
        vPrintString( pcTaskName );
     vTaskDelayUntil( &xLastWakeTime, ( 250 / portTICK_RATE_MS ) );
    }
}
```

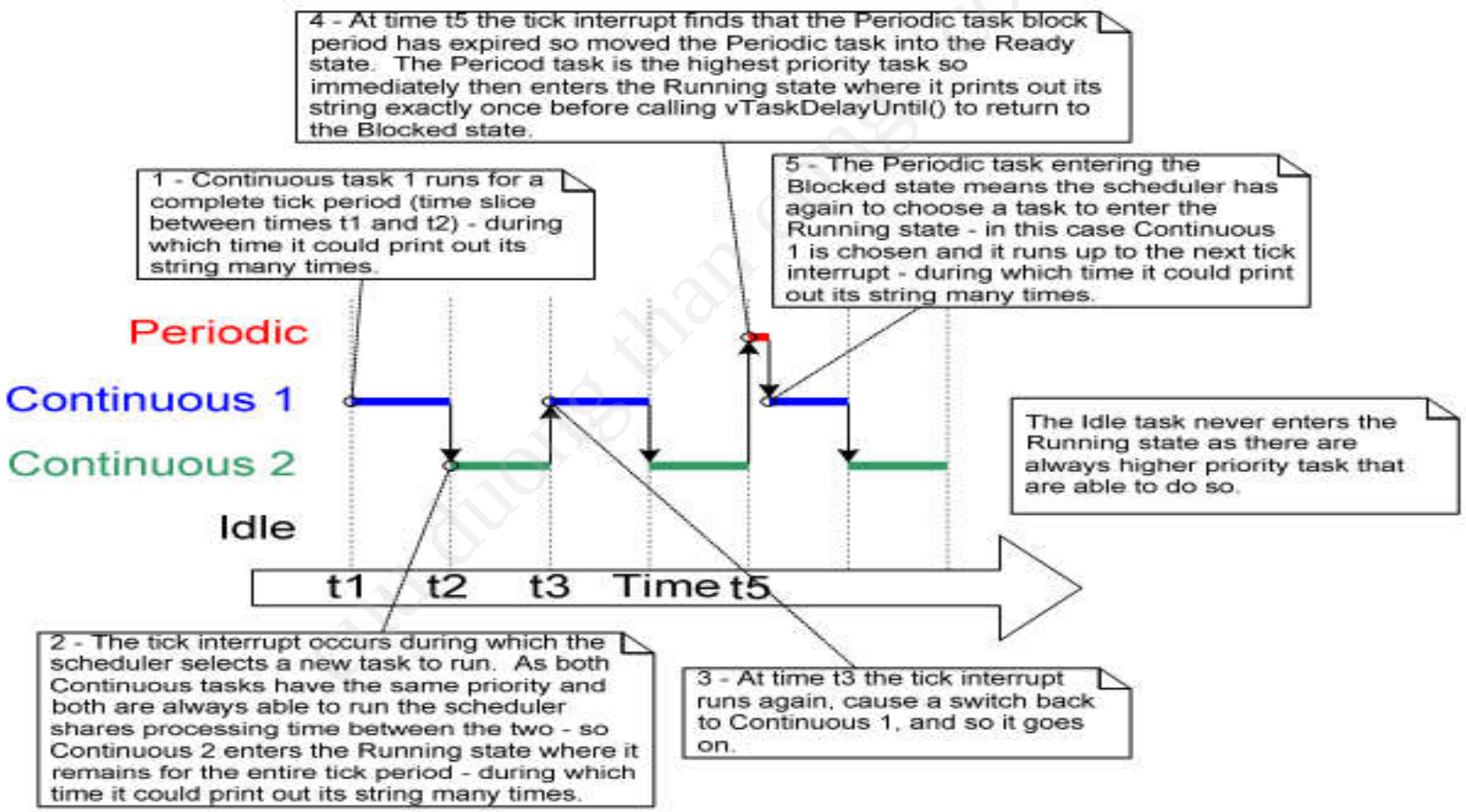
Blocking and unblocking task

```
void vContinuousProcessingTask( void *pvParameters )
{
    char *pcTaskName;

    pcTaskName = ( char * ) pvParameters;
    for( ;; )
    {
        vPrintString( pcTaskName );
    }
}
```

```
void vPeriodicTask( void *pvParameters )
{
portTickType xLastWakeTime;

xLastWakeTime = xTaskGetTickCount();

    /* As per most tasks, this task is implemented in an infinite loop. */
    for( ;; )
    {
        /* Print out the name of this task. */
        vPrintString( "Periodic task is running\r\n" );

        /* The task should execute every 10 milliseconds exactly. */
        vTaskDelayUntil( &xLastWakeTime, ( 10 / portTICK_RATE_MS ) );
    }
}
```

```
int main( void )
{
    xTaskCreate( vContinuousProcessingTask, "Task 1", 1000,
    (void*)pcTextForTask1, 1, NULL );
      xTaskCreate( vContinuousProcessingTask, "Task 2", 1000,
    (void*)pcTextForTask2, 1, NULL );

      /* Create one instance of the periodic task at priority 2. */
      xTaskCreate( vPeriodicTask, "Task 3", 1000,
    (void*)pcTextForPeriodicTask, 2, NULL );

      /* Start the scheduler so our tasks start executing. */
      vTaskStartScheduler();

      for( ;; );
      return 0;
}
```





IDLE task

- Idle task được tạo ra tự động, có độ ưu tiên 0.
- Nó được chạy khi không có bất kỳ tác vụ nào có mức ưu tiên cao hơn sẵn sàng chạy.

IDLE task hook

- Idle task hook là 1 hàm được idle task gọi trong mỗi vòng lặp của nó.
- Idle task hook thường dùng để:
  - Thực hiện các xử lý có ưu tiên thấp
  - Đo thời gian rảnh của hệ thống
  - Đưa CPU vào trạng thái công suất thấp

IDLE task hook

```
/* Declare a variable that will be incremented by the hook
   function. */
unsigned long ulIdleCycleCount = 0UL;

/* Idle hook functions MUST be called vApplicationIdleHook(),
   take no parameters,
and return void. */
void vApplicationIdleHook( void )
{
   /* This hook function does nothing but increment a counter.
   */
   ulIdleCycleCount++;
}
```

IDLE task hook

```
void vTaskFunction( void *pvParameters )
{
char *pcTaskName;

pcTaskName = ( char * ) pvParameters;

   /* As per most tasks, this task is implemented in an infinite loop. */
   for( ;; )
   {
vPrintStringAndNumber( pcTaskName, ulIdleCycleCount );

      /* Delay for a period for 250 milliseconds. */
      vTaskDelay( 250 / portTICK_RATE_MS );
   }
}
```

IDLE task hook

- IDLE task hook không được block hoặc suspend.
- Nếu có 1 tác vụ gọi hàm vTaskDelete(), IDLE task hook phải quay về idle task sau 1 khoảng thời gian vì idle task có nhiệm vụ tổ chức lại tài nguyên của kernel sau khi có 1 tác vụ bị xóa bỏ.

Change task priority

void vTaskPrioritySet(xTaskHandle pxTask, unsigned portBASE_TYPE uxNewPriority);

(Tham số INCLUDE_vTaskPrioritySet phải bằng 1 để có thể dùng được hàm này.)

- Parameters:
  - pxTask: Handle của tác vụ muốn được thay đổi mức ưu tiên. Nếu handle là NULL mức ưu tiên của chính tác vụ đang gọi hàm này sẽ được set.
  - uxNewPriority: Mức ưu tiên mới

Query the task's priority

```
unsigned portBASE_TYPE uxTaskPriorityGet(
    xTaskHandle       pxTask );
```

pxTask: task handle

Nếu pxTask là NULL, giá trị trả về sẽ là mức ưu tiên của chính tác vụ đang gọi hàm này.

```
void vTask1( void *pvParameters )
{
unsigned portBASE_TYPE uxPriority;
 uxPriority = uxTaskPriorityGet( NULL );

    for( ;; )
    {
        /* Print out the name of this task. */
        vPrintString( "Task1 is running\r\n" );

       vPrintString( "About to raise the Task2 priority\r\n" );
        vTaskPrioritySet( xTask2Handle, ( uxPriority + 1 ) );
}
}
```

```
void vTask2( void *pvParameters )
{
unsigned portBASE_TYPE uxPriority;

uxPriority = uxTaskPriorityGet( NULL );

    for( ;; )
    {
vPrintString( "Task2 is running\r\n" );


        vTaskPrioritySet( NULL, ( uxPriority - 2 ) );
    }
}
```

```
/* Declare a variable that is used to hold the handle of
   Task2. */
xTaskHandle xTask2Handle;

int main( void )
{
xTaskCreate( vTask1, "Task 1", 1000, NULL, 2, NULL );
xTaskCreate( vTask2, "Task 2", 1000, NULL, 1,
                     &xTask2Handle );
vTaskStartScheduler();

for( ;; );
}
```

Delete a task

void vTaskDelete(xTaskHandle pxTaskToDelete);

Tác vụ có thể xóa 1 tác vụ khác hay chính nó.

Ide task sẽ giải phóng vùng nhớ đã cấp phát cho tác vụ được xóa.

```
void vTask1( void *pvParameters )
{
const portTickType xDelay100ms = 100 / portTICK_RATE_MS;

    for( ;; )
    {
        /* Print out the name of this task. */
        vPrintString( "Task1 is running\r\n" );

xTaskCreate( vTask2, "Task 2", 1000, NULL, 2, &xTask2Handle );
vTaskDelay( xDelay100ms );
    }
}
```

```
void vTask2( void *pvParameters )
{
   vPrintString( "Task2 is running and about
   to delete itself\r\n" );
    vTaskDelete( xTask2Handle );
}
```

```
int main( void )
{
xTaskCreate( vTask1, "Task 1", 1000, NULL, 1, NULL );

    /* Start the scheduler so the tasks start executing. */
    vTaskStartScheduler();

    /* main() should never reach here as the scheduler
    has been started. */
    for( ;; );
}
```