Embedded Systems

CS 397

TRIMESTER 3, AY 2021/22

Hands-On 6-1: Ethernet – LwIP HTTP Server Netconn RTOS

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Hands-On LwIP HTTP Server Netconn RTOS

Objectives

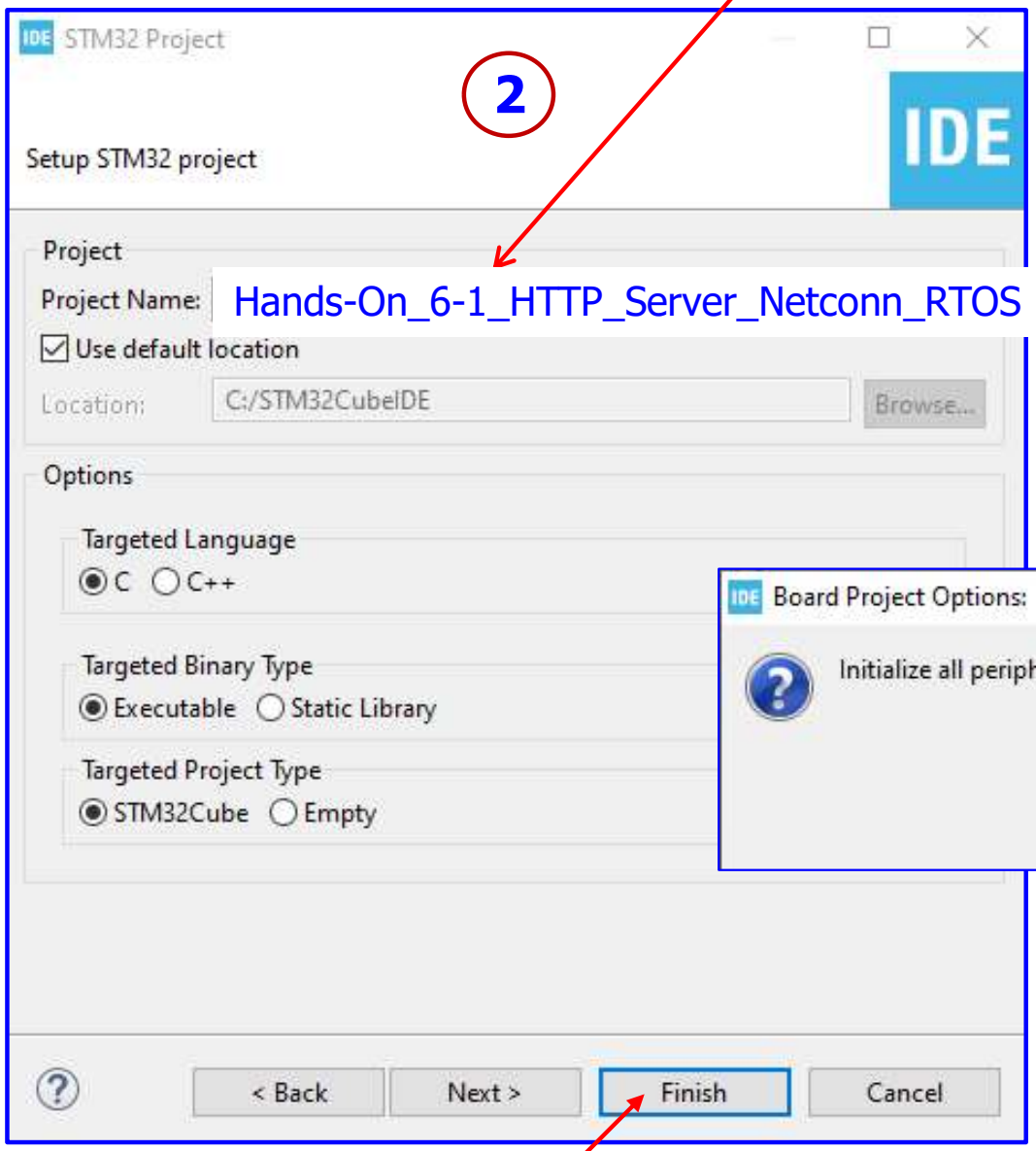
The aims of this hands-on session are to

- develop a STM32 (STM32CubeIDE) project
- Implement a web (HTTP) server application based on Netconn RTOS using STM32F767 microcontroller
- configure and program the Ethernet peripheral to make the microcontroller operating as a HTTP server and connecting web clients for loading of HTML pages
- develop program using the htmlgen.exe software to generate the web pages
- test the developed application by opening a web client on a remote PC to interact with the web server
- build up the knowledge of Ethernet application development

Note that, this web server contains two HTML pages. The first one gives general information about STM32F7xx microcontrollers and the LwIP stack. The second one lists the running tasks and their status. This page is automatically updated every second.

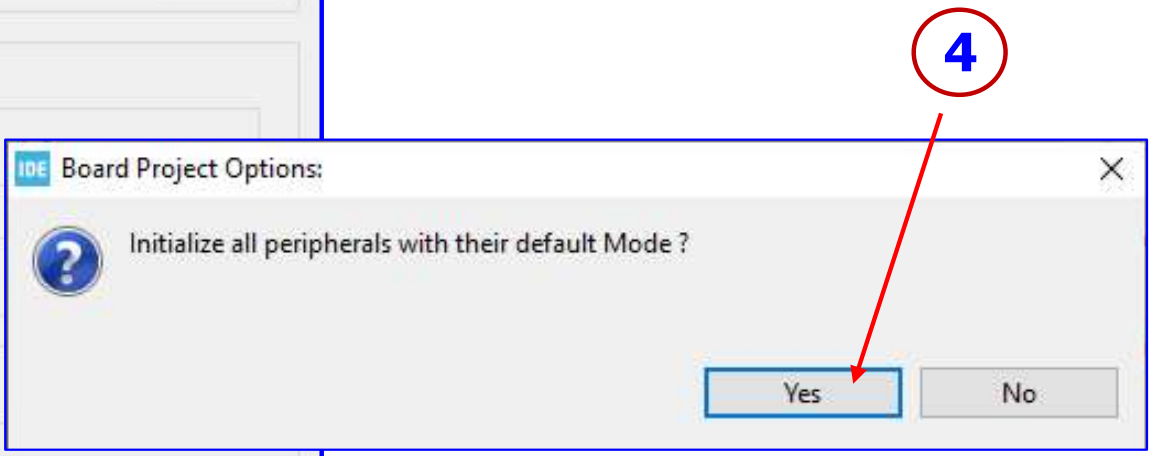
Hands-On LwIP HTTP Server Netconn RTOS

Create the STM32 Project: **Hands-On_6-1_HTTP_Server_Netconn_RTOS**



3

- Run STM32CubeIDE (1)
- Select workspace: C:\STM32_CS397
- File -> Close All Editors
- Start a New STM32 Project
- Select the Nucleo-F767ZI Board



Follow all the setup steps in (5)

Hands-on_4-1_TCP_Echo_Client

(Pages 4-18)

Hands-On LwIP HTTP Server Netconn RTOS

Configure LwIP – HTTPD:

Pinout & Configuration | Clock Configuration | Project Manager | Tools

Additional Software | Pinout

Categories | A->Z

System Core
Analog
Timers
Connectivity
Multimedia
Security
Computing
Middleware

FATFS
FREERTOS
LIBJPEG
LWIP
MBEDTLS
PDM2PCM
USB_DEVICE
USB_HOST

LWIP Mode and Configuration

Mode

Enabled

Configuration

Reset Configuration

MDNS/TFTP | Perf/Checks | Statistics | Checksum | Debug | User Constants
General Settings | Key Options | PPP | IPv6 | HTTPD | SNMP | SNTP/SMTP

Configure the below parameters :

Search (Crtl+F) | Show Advanced Parameters

HTTPD Options

LWIP_HTTPD (LwIP HTTPD Support ** CubeMX specific **)	Enabled
LWIP_HTTPD_CGI (HTTP CGI Old Style)	Enabled
LWIP_HTTPD_CGI_SSI (HTTP CGI New Style)	Disabled
LWIP_HTTPD_SSI (HTTP Server Side Includes)	Enabled
LWIP_HTTPD_SSI_RAW (HTTP SSI Tag Handler Callback)	Disabled
LWIP_HTTPD_SSI_BY_FILE_EXTENSION (HTTP SSI By File Extension)	Enabled
LWIP_HTTPD_SUPPORT_POST (HTTP POST)	Disabled
LWIP_HTTPD_MAX_CGI_PARAMETERS (Max Sent Parameters Number for CGI)	16
LWIP_HTTPD_SSI_MULTIPART (Server-Side-Includes Multipart)	Disabled
LWIP_HTTPD_MAX_TAG_NAME_LEN (Max Tag Name String Length)	16
LWIP_HTTPD_MAX_TAG_INSERT_LEN (Max Tag Inserted String Length)	192
LWIP_HTTPD_POST_MANUAL_WND (HTTP POST Manual WND)	Disabled
HTTPD_SERVER_AGENT (HTTP Server)	"lwIP/2.0.0 (http://sa...
LWIP_HTTPD_DYNAMIC_HEADERS (HTTP Dynamic Headers Creation)	Disabled
HTTPD_USE_MEM_POOL (HTTP Use Memory Pool)	Disabled
HTTPD_SERVER_PORT (HTTP Server Port)	80
HTTPD_SERVER_PORT_HTTPS (HTTPS Server Port)	443

Use default settings for other options

Hands-On LwIP HTTP Server Netconn RTOS

Enable **FREERTOS** by selecting the interface "**CMSIS_V1**".

Pinout & Configuration | Clock Configuration | Project Manager

Software Packs | Pinout

Categories | A->Z

System Core
Analog
Timers
Connectivity
Multimedia
Security
Computing
Middleware

FATFS
FREERTOS
LIBJPEG
LWIP
MBEDTLS
PDM2PCM
USB_DEVICE
USB_HOST

FREERTOS Mode and Configuration

Mode

Interface CMSIS_V1

Configuration

Reset Configuration

Tasks and Queues | Timers and Semaphores | Mutexes | Events | FreeRTOS Heap Usage

Config parameters | Include parameters | Advanced settings | User Constants

Configure the below parameters :

Search (Ctrl+F)

API	
FreeRTOS API	CMSIS v1
Versions	
FreeRTOS version	10.2.1
CMSIS-RTOS version	1.02
MPU/FPU	
ENABLE_MPU	Disabled
ENABLE_FPU	Disabled
Kernel settings	
USE_PREEMPTION	Enabled
CPU_CLOCK_HZ	SystemCoreClock
TICK_RATE_HZ	1000
MAX_PRIORITIES	7
MINIMAL_STACK_SIZE	1024 Words
MAX_TASK_NAME_LEN	16
USE_16_BIT_TICKS	Disabled

Set Minimal Stack Size: 1024

Hands-On LwIP HTTP Server Netconn RTOS

Increase **TOTAL_HEAP_SIZE**, enable **USE_TRACE_FACILTY** and **USE_STATS_FORMATTING_FUNCTIONS**

Pinout & Configuration | Clock Configuration | Project Manager

Software Packs | Pinout

Categories | A->Z

System Core
Analog
Timers
Connectivity
Multimedia
Security
Computing
Middleware

FATFS
FREERTOS
LIBJPEG
LWIP
MBEDTLS
PDM2PCM
USB_DEVICE
USB_HOST

FREERTOS Mode and Configuration

Mode

Interface CMSIS_V1

Configuration

Reset Configuration

Tasks and Queues | Timers and Semaphores | Mutexes | Events | FreeRTOS Heap Usage

Config parameters | Include parameters | Advanced settings | User Constants

Configure the below parameters :

Search (Ctrl+F)

Memory management settings	
Memory Allocation	Dynamic / Static
TOTAL_HEAP_SIZE	63488 Bytes
Memory Management scheme	heap_4
Hook function related definitions	
USE_IDLE_HOOK	Disabled
USE_TICK_HOOK	Disabled
USE_MALLOC_FAILED_HOOK	Disabled
USE_DAEMON_TASK_STARTUP_HOOK	Disabled
CHECK_FOR_STACK_OVERFLOW	Disabled
Run time and task stats gathering related definitions	
GENERATE_RUN_TIME_STATS	Disabled
USE_TRACE_FACILITY	Enabled
USE_STATS_FORMATTING_FUNCTIONS	Enabled

Set Total Heap Size: 63488

LwIP Settings

Hands-On LwIP HTTP Server Netconn RTOS

Pinout & Configuration | Clock Configuration | Project Manager

Software Packs | Pinout

Categories | A->Z

- System Core
- Analog
- Timers
- Connectivity
- Multimedia
- Security
- Computing
- Middleware

FATFS
FREERTOS
LIBJPEG
LWIP
MBEDTLS
PDM2PCM
USB_DEVICE
USB_HOST

LWIP Mode and Configuration

Mode

☑ Enabled

Configuration

Reset Configuration

Perf/Checks | Statistics | Checksum | Debug | User Constants | Platform S

General Settings | Key Options | PPP | IPv6 | HTTPD | SNMP | SNTP/SMTP | MDNS/TFTP

Configure the below parameters :

Search (Ctrl+F)

LwIP Version	
LwIP Version (Version of LwIP supported by CubeMX...	2.1.2
IPv4 - DHCP Options	
LWIP_DHCP (DHCP Module)	Disabled
IP Address Settings	
IP_ADDRESS (IP Address)	192.168.001.205
NETMASK_ADDRESS (Netmask Address)	255.255.255.000
GATEWAY_ADDRESS (Gateway Address)	192.168.001.001
RTOS Dependency	
WITH_RTOS (Use FREERTOS ** CubeMX specific **)	Enabled
CMSIS_VERSION (CMSIS API Version used)	CMSIS v1
RTOS_USE_NEWLIB_REENTRANT (RTOS used - 1)	Disabled
Platform Settings	
PHY Driver	Choose/LAN8742/DP83848
Protocols Options	
LWIP_ICMP (ICMP Module Activation)	Enabled
LWIP_IGMP (IGMP Module)	Disabled
LWIP_DNS (DNS Module)	Disabled
LWIP_UDP (UDP Module)	Enabled
MEMP_NUM_UDP_PCB (Number of UDP Connectio...	4
LWIP_TCP (TCP Module)	Enabled
MEMP_NUM_TCP_PCB (Number of TCP Connections)	5

For different router (gateway):

192.168.1.205
255.255.255.0
192.168.1.1

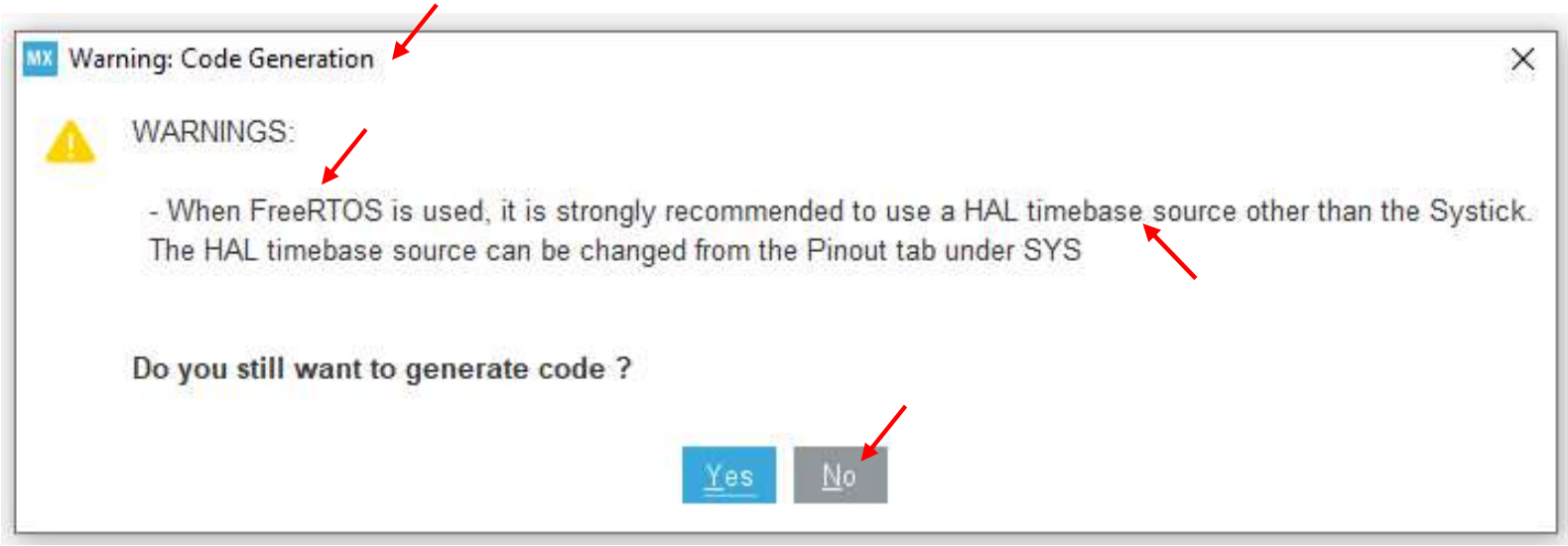
192.168.50.205
255.255.255.0
192.168.50.1

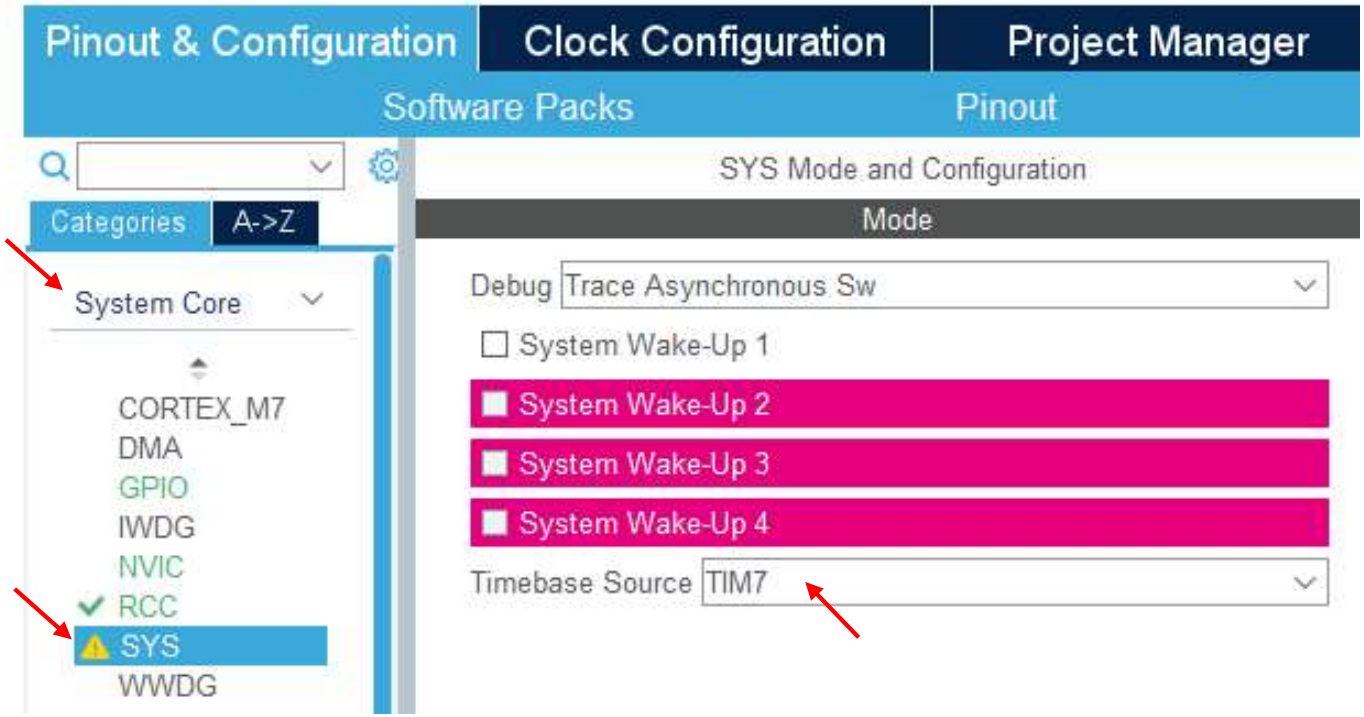
Need to enter:
- IP address
- Netmask address
- Gateway address

With **FREERTOS** selected

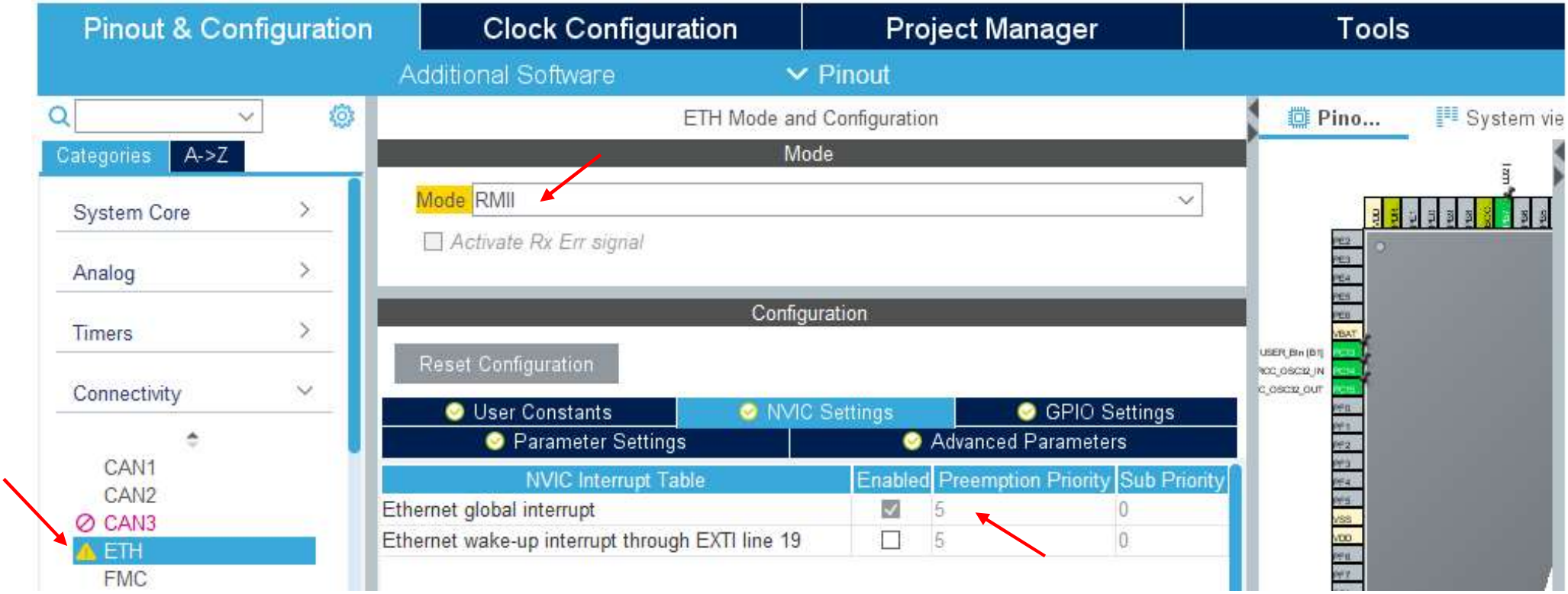
Hands-On LwIP HTTP Server Netconn RTOS

With **FREERTOS** selected, the **Timebase Source** is changed to **TIM7** manually.





With **FREERTOS** selected, **Ethernet Global Interrupt** is enabled and assigned with Preemption Priority.



Hands-On LwIP HTTP Server Netconn RTOS

With **FREERTOS** and **Time Base** selections, the NVIC settings are modified automatically

Pinout & Configuration | Clock Configuration | Project Manager | Tools

Software Packs | Pinout

Categories | A->Z

System Core

CORTEX_M7
DMA
GPIO
IWDG
NVIC
RCC
SYS
WWDG

Analog

Timers

Connectivity

CAN1
CAN2
CAN3
ETH
FMC
I2C1
I2C2

NVIC Mode and Configuration

Configuration

NVIC | Code generation

Priority Group: 4 bits for pre-emp... | Sort by Premption Priority and Sub Priority | Sort by interrupts names

Search: Search (C... | Show: available interrupts | Force DMA channels Interrupts

NVIC Interrupt Table	Enabled	Preemption Priority	Sub Priority	Uses FreeRTOS functions
Non maskable interrupt	☑	0	0	☐
Hard fault interrupt	☑	0	0	☐
Memory management fault	☑	0	0	☐
Pre-fetch fault, memory access fault	☑	0	0	☐
Undefined instruction or illegal state	☑	0	0	☐
System service call via SWI instruction	☑	0	0	☐
Debug monitor	☑	0	0	☐
Pendable request for system service	☑	15	0	☑
System tick timer	☑	15	0	☑
PVD interrupt through EXTI line 16	☐	5	0	☑
Flash global interrupt	☐	5	0	☑
RCC global interrupt	☐	5	0	☑
USART3 global interrupt	☐	5	0	☑
EXTI line[15:10] interrupts	☑	5	0	☑
Time base: TIM7 global interrupt	☑	15	0	☐
Ethernet global interrupt	☑	5	0	☑
Ethernet wake-up interrupt through EXTI line 19	☐	5	0	☑
FPU global interrupt	☐	5	0	☑

Hands-On LwIP HTTP Server Netconn RTOS

Information: Firmware Package Name and Version

Pinout & Configuration | Clock Configuration | Project Manager | Tools

Project | Code Generator | Advanced Settings

Project Settings

Project Name	Hands-On_6-1_HTTP_Server_Netconn_RTOS
Project Location	C:\STM32_CS397
Application Structure	Advanced ☐ Do
Toolchain Folder Location	C:\STM32_CS397\Hands-On_6-1_HTTP_Server_Netconn_RTOS\
Toolchain / IDE	STM32CubeIDE ☑ Generate Under Root

Linker Settings

Minimum Heap Size	0x200
Minimum Stack Size	0x400

Thread-safe Settings

Cortex-M7NS

☐ Enable multi-threaded support

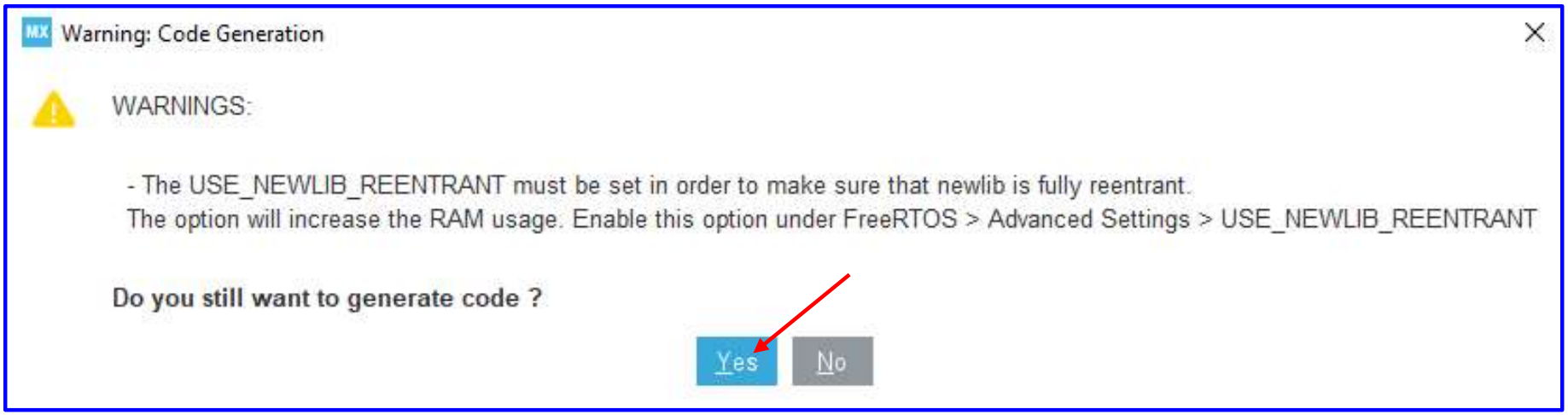
Thread-safe Locking Strategy	Default – Mapping suitable strategy depending on RTOS selection

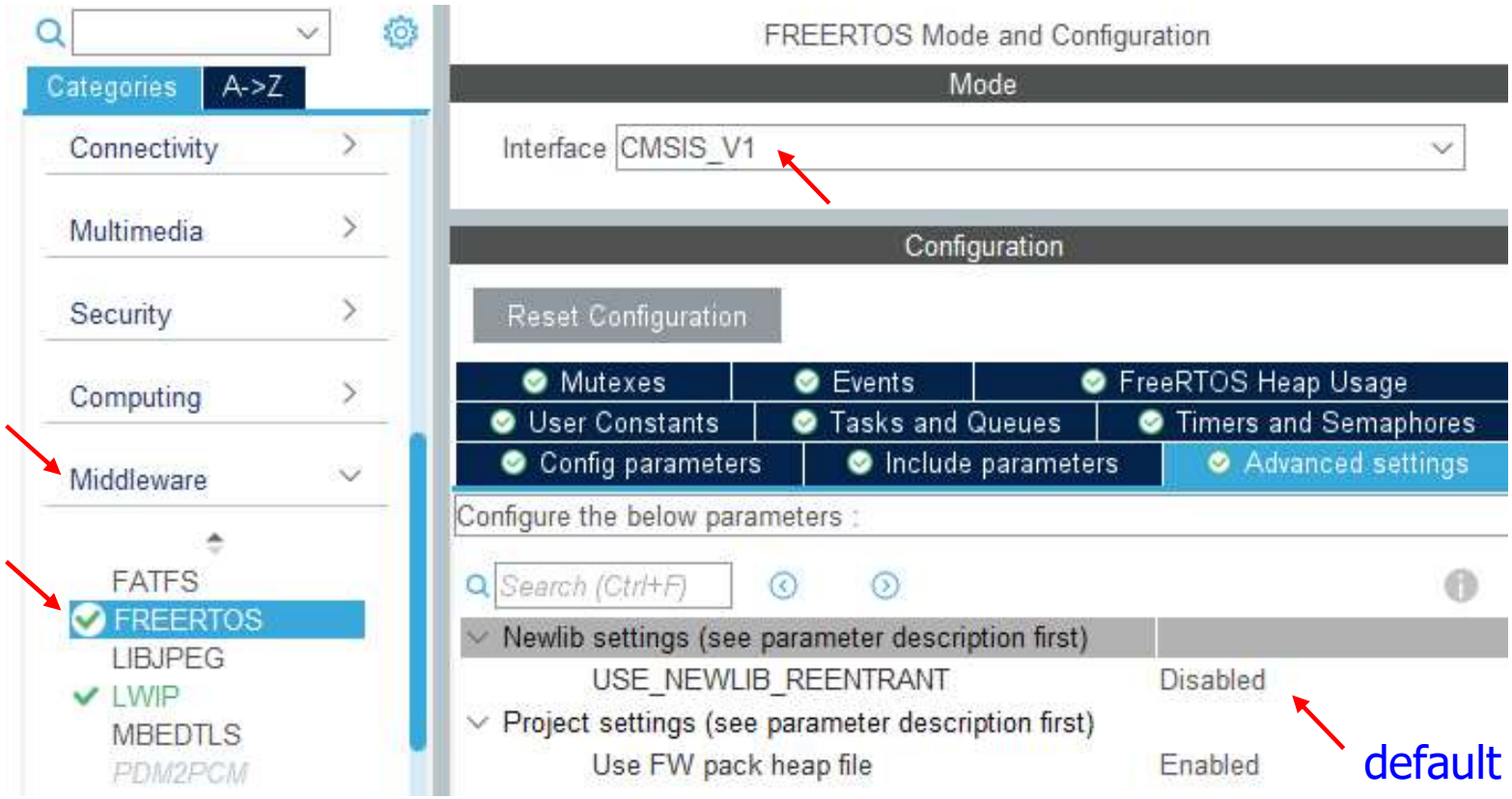
Mcu and Firmware Package

Mcu Reference	STM32F767ZITx
Firmware Package Name and Version	STM32Cube FW_F7 V1.17.0

Hands-On LwIP HTTP Server Netconn RTOS

Code Generation: Do not enable USE_NEWLIB_REENTRANT





default setting

Build warning: Hands-On LwIP HTTP Server Netconn RTOS

```
../LWIP/Target/ethernetif.h:36:13: warning: 'ethernetif_input' declared
'static' but never defined [-Wunused-function]
   36 | static void ethernetif_input(void const * argument);
```

Hands-On_5-1_UDP_TCP_Echo_Server_Netc
- Binaries
- Includes
- Core
  - Inc
  - Src
  - Startup
- Drivers
- LWIP
  - App
  - Target
    - ethernetif.c
    - ethernetif.h
    - lwipopts.h
- Middlewares
- Debug

```
23
24 #include "lwip/err.h"
25 #include "lwip/netif.h"
26 #include "cmsis_os.h"
27
28 /* Within 'USER CODE' section, code will be kept by default at each generation */
29 /* USER CODE BEGIN 0 */
30
31 /* USER CODE END 0 */
32
33 /* Exported functions ------------------------------------------------------- */
34 err_t ethernetif_init(struct netif *netif);
35
36 static void ethernetif_input(void const * argument);
37 void ethernet_link_thread(void const * argument);
38
39 void Error_Handler(void);
40 u32_t sys_jiffies(void);
41 u32_t sys_now(void);
```

insert "//"

```
35
36 // static void ethernetif_input(void const * argument);
37 void ethernet_link_thread(void const * argument);
```

App
- Target
  - ethernetif.c
  - ethernetif.h
  - lwipopts.h
- Middlewares

```
34 /* Within 'USER CODE' section, code will be kept by default at each generation */
35 /* USER CODE BEGIN 0 */
36 static void ethernetif_input(void const * argument);
37 /* USER CODE END 0 */
38
39 /* Private define ------------------------------------------------------------*/
40 /* The time to block waiting for input. */
```

add

Hands-On LwIP HTTP Server Netconn RTOS

Generate the **fsdata_custom.c** and **fsdata_StartPage.c**

Name	Date modified	Type	Size
fsdata_custom.c		C File	221 KB
fsdata_StartPage.c		C File	10 KB

4 Copy generated files to folder "Fs"

1 **Unzip 13_CS397_Hands-On_6-1_LwIP_HTTP_Server_Netconn_RTOS.zip**

Name	Date modified	Type	Size
Fs		File folder	
Fs_StartPage_HTTP_Server_Netconn_RTOS		File folder	
Fs_Webpages_HTTP_Server_Netconn_RTOS		File folder	
httpserver-netconn.c		C File	18 KB
httpserver-netconn.h		C/C++ Header	1 KB

2 Copy these folders to

C:\CS397>

5 Copy above folders and files to STM32 project

Fs_StartPage_HTTP_Server_Netconn_RTOS	File folder	
Fs_Webpages_HTTP_Server_Netconn_RTOS	File folder	
echotool.exe	Application	29 KB
fsdata_custom.c	C File	221 KB
fsdata_StartPage.c	C File	10 KB
htmlgen.exe	Application	106 KB

3 Run

```
C:\CS397>htmlgen Fs_StartPage_HTTP_Server_Netconn_RTOS  -f:fsdata_StartPage.c
C:\CS397>htmlgen Fs_Webpages_HTTP_Server_Netconn_RTOS   -f:fsdata_custom.c
```

Hands-On LwIP HTTP Server Netconn RTOS

- Hands-On_6-1_HTTP_Server_Netconn_RTOS
  - Includes
  - Core
    - Inc
    - Src
    - Startup
  - Drivers
  - LWIP
    - App
      - lwip.c
      - lwip.h
    - Target
      - ethernetif.c
      - ethernetif.h
      - lwipopts.h
  - Middlewares
    - Third_Party
      - FreeRTOS
      - LwIP
        - src
          - api
          - apps
            - http
              - fs.c
              - fsdata.h
              - httpd_structs.h
              - httpd.c
              - fsdata_custom.c
            - mqtt
          - core
          - include
          - netif
        - system
  - Debug
  - Fs
    - fsdata_custom.c
    - fsdata_StartPage.c
  - Fs_StartPage_HTTP_Server_Netconn_RTOS
    - STM32F767TASKS.html
  - Fs_Webpages_HTTP_Server_Netconn_RTOS
    - STM32F767_files
    - 404.html
    - STM32F767.html
  - Hands-On_6-1_HTTP_Server_Netconn_RTOS.ioc

12_CS397_Hands-On_5-2_LwIP_HTTP_Server_Raw_25Jul2022.pptx

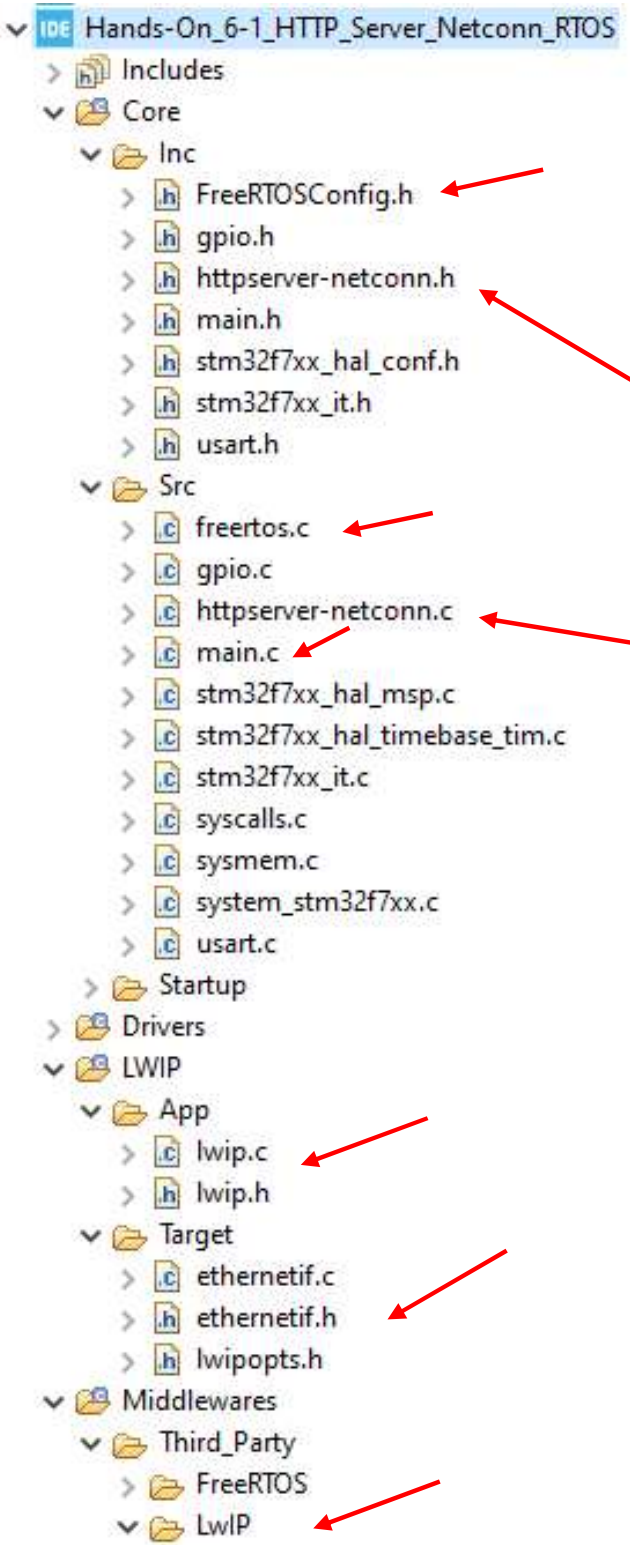
Refer to the previous example for setting up these files, pages 10 – 12, and pages 15 – 16.

standby for copying

This **STM32F767TASKS.html** file is converted to **fsdata_StartPage.c**

These files (webpages) are converted to **fsdata_custom.c**

Hands-On LwIP HTTP Server Netconn RTOS



Copy two files to this project:

`httpserver-netconn.h`

`httpserver-netconn.c`

Part of the **main.c**

```
/* Part of the main.c */
/* Includes */
#include "main.h"
#include "cmsis_os.h"
#include "lwip.h"
#include "usart.h"
#include "gpio.h"

/* Private function prototypes */
void SystemClock_Config(void);
void MX_FREERTOS_Init(void);
int main(void)
{
  /* Reset of all peripherals, Initializes the Flash interface and the Systick. */
  HAL_Init();
  /* Configure the system clock */
  SystemClock_Config();

  /* Initialize all configured peripherals */
  MX_GPIO_Init();
  MX_USART3_UART_Init();
  /* Call init function for freertos objects (in freertos.c) */
  MX_FREERTOS_Init();
  /* Start scheduler */
  osKernelStart();

  /* We should never get here as control is now taken by the scheduler */
  /* Infinite loop */
  while (1) { }
}
```

UM1713 User manual

Developing applications on STM32Cube with LwIP TCP/IP stack

Section 6 Using the LwIP applications

6.2.2 Web Server based on Netconn RTOS

Add to **main.c**

```
/* USER CODE BEGIN 4 */

void HAL_GPIO_EXTI_Callback(uint16_t GPIO_Pin)
{
    if(GPIO_Pin == GPIO_PIN_13)
    {
        HAL_GPIO_TogglePin(GPIOB, LD1_Pin);
    }
}

int __io_putchar(int ch)
{
    uint8_t c[1];
    c[0] = ch & 0x00FF;
    HAL_UART_Transmit(&huart3, &*c, 1, 10);
    return ch;
}

int _write(int file, char *ptr, int len)
{
    int DataIdx;
    for(DataIdx= 0; DataIdx< len; DataIdx++)
    {
        __io_putchar(*ptr++);
    }
    return len;
}

 /* USER CODE END 4 */
```

Add code (optional)

The freertos.c (1/2)

Add code

```
/* freertos.c */
/* Includes */
#include "FreeRTOS.h"
#include "task.h"
#include "main.h"
#include "cmsis_os.h"

/* Private includes */
/* USER CODE BEGIN Includes */
#include "httpserver-netconn.h"
/* USER CODE END Includes */

osThreadId defaultTaskHandle;
void StartDefaultTask(void const * argument);

extern void MX_LWIP_Init(void);
void MX_FREERTOS_Init(void); /* (MISRA C 2004 rule 8.1) */

/* GetIdleTaskMemory prototype (linked to static allocation support) */
void vApplicationGetIdleTaskMemory( StaticTask_t **ppxIdleTaskTCBBuffer, StackType_t
**ppxIdleTaskStackBuffer, uint32_t *pulIdleTaskStackSize );

/* USER CODE BEGIN GET_IDLE_TASK_MEMORY */
static StaticTask_t xIdleTaskTCBBuffer;
static StackType_t xIdleStack[configMINIMAL_STACK_SIZE];

void vApplicationGetIdleTaskMemory( StaticTask_t **ppxIdleTaskTCBBuffer, StackType_t
**ppxIdleTaskStackBuffer, uint32_t *pulIdleTaskStackSize )
{
    *ppxIdleTaskTCBBuffer = &xIdleTaskTCBBuffer;
    *ppxIdleTaskStackBuffer = &xIdleStack[0];
    *pulIdleTaskStackSize = configMINIMAL_STACK_SIZE;
}
/* USER CODE END GET_IDLE_TASK_MEMORY */
```

The freertos.c (2/2)

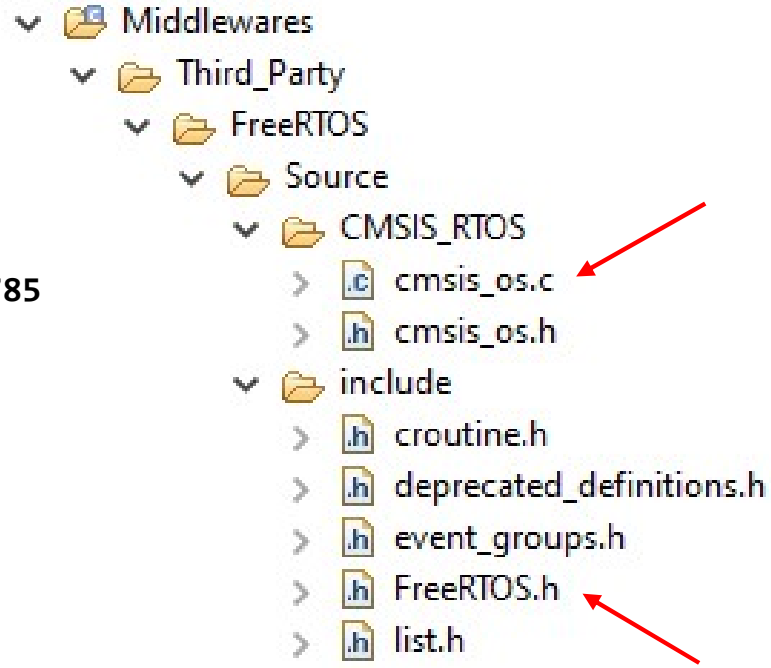
```
/* @brief  FreeRTOS initialization */
void MX_FREERTOS_Init(void)
{
  /* Create the thread(s) */
  /* definition and creation of defaultTask */
  osThreadDef(defaultTask, StartDefaultTask, osPriorityNormal, 0, 1024);
  defaultTaskHandle = osThreadCreate(osThread(defaultTask), NULL);
}

/* USER CODE BEGIN Header_StartDefaultTask */
/* @brief  Function implementing the defaultTask thread */
/* USER CODE END Header_StartDefaultTask */
void StartDefaultTask(void const * argument)
{
  /* init code for LWIP */
  MX_LWIP_Init();
  /* USER CODE BEGIN StartDefaultTask */
  /* Create tcp_ip stack thread */
  // tcpip_init(NULL, NULL);  --->   MX_LWIP_Init();
  /* Initialize the LwIP stack */
  // Netif_Config();         --->   MX_LWIP_Init();
  /* Initialize webserver demo */
  http_server_netconn_init();

  /* Infinite loop */
  for(;;)
  {
      osDelay(500);
      HAL_GPIO_TogglePin(GPIOB, LD2_Pin);
  }
  /* USER CODE END StartDefaultTask */
}
```

Add code

Why Enabled USE_TRACE_FACILTY and USE_STATS_FORMATTING_FUNCTIONS ?

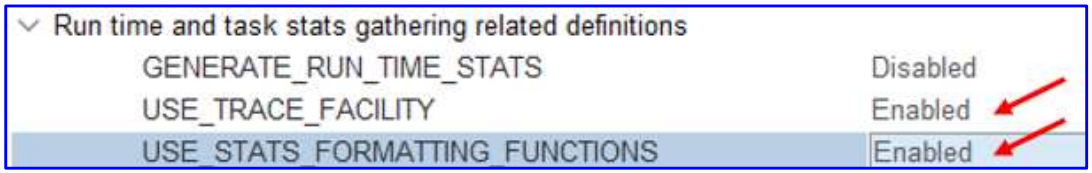
```
/* cmsis_os.c */ // line 1535

/* Lists all the current threads, along with their current state and stack usage high water mark. */
osStatus osThreadList (uint8_t *buffer)
{
#if ( ( configUSE_TRACE_FACILITY == 1 ) && ( configUSE_STATS_FORMATTING_FUNCTIONS == 1 ) )
  vTaskList((char *)buffer);
#endif
  return osOK;
}
```

```
// Need to enable the below two settings defined in

/* FreeRTOS.h */

#ifndef configUSE_STATS_FORMATTING_FUNCTIONS     // line 785
#define configUSE_STATS_FORMATTING_FUNCTIONS  0
#endif

#ifndef configUSE_TRACE_FACILITY      // line 793
#define configUSE_TRACE_FACILITY  0
#endif
```



Part of the **FreeRTOSConfig.h**

STM32CubeMX




```
/* Application specific definitions */

/* USER CODE BEGIN Includes */
/* Section where include file can be added */
/* USER CODE END Includes */

/* Ensure definitions are only used by the compiler, and not by the assembler. */
#if defined(__ICCARM__) || defined(__CC_ARM) || defined(__GNUC__)
    #include <stdint.h>
    extern uint32_t SystemCoreClock;
#endif
#define configENABLE_FPU                        0
#define configENABLE_MPU                        0

#define configUSE_PREEMPTION                    1
#define configSUPPORT_STATIC_ALLOCATION         1
#define configSUPPORT_DYNAMIC_ALLOCATION        1
#define configUSE_IDLE_HOOK                     0
#define configUSE_TICK_HOOK                     0
#define configCPU_CLOCK_HZ                      ( SystemCoreClock )
#define configTICK_RATE_HZ                      ((TickType_t)1000)
#define configMAX_PRIORITIES                    ( 7 )
#define configMINIMAL_STACK_SIZE                ((uint16_t)1024)
#define configTOTAL_HEAP_SIZE                   ((size_t)63488)
#define configMAX_TASK_NAME_LEN                 ( 16 )
#define configUSE_TRACE_FACILITY                1
#define configUSE_STATS_FORMATTING_FUNCTIONS    1
#define configUSE_16_BIT_TICKS                  0
#define configUSE_MUTEXES                       1
#define configQUEUE_REGISTRY_SIZE               8
#define configUSE_PORT_OPTIMISED_TASK_SELECTION 1
```

Hands-On LwIP HTTP Server Netconn RTOS

Part of the **`httpserver-netconn.c`**

```c
/* Includes */
#include "lwip/opt.h"
#include "lwip/arch.h"
#include "lwip/api.h"
#include "lwip/apps/fs.h"
#include "string.h"
#include "httpserver-netconn.h"
#include "cmsis_os.h"

#include <stdio.h>

/* Private typedef */
/* Private define */
#define WEBSERVER_THREAD_PRIO    ( osPriorityAboveNormal )

/* Private macro */
/* Private variables */
u32_t nPageHits = 0;

// copy from fsdata_StartPage.c after this line
/* raw file data (1581 bytes) */
static const unsigned char PAGE_START[] = {
0x3c,0x21,0x44,0x4f,0x43,0x54,0x59,0x50,0x45,0x20,0x68,0x74,0x6d,0x6c,0x20,0x50,
0x55,0x42,0x4c,0x49,0x43,0x20,0x22,0x2d,0x2f,0x2f,0x57,0x33,0x43,0x2f,0x2f,0x44,
0x54,0x44,0x20,0x48,0x54,0x4d,0x4c,0x20,0x34,0x2e,0x30,0x31,0x2f,0x2f,0x45,0x4e,
0x22,0x20,0x22,0x68,0x74,0x74,0x70,0x3a,0x2f,0x2f,0x77,0x77,0x77,0x2e,0x77,0x33,
0x2e,0x6f,0x72,0x67,0x2f,0x54,0x52,0x2f,0x68,0x74,0x6d,0x6c,0x34,0x2f,0x73,0x74,
0x72,0x69,0x63,0x74,0x2e,0x64,0x74,0x64,0x22,0x3e,0x0a,0x3c,0x21,0x2d,0x2d,0x20,
0x73,0x61,0x76,0x65,0x64,0x20,0x66,0x72,0x6f,0x6d,0x20,0x75,0x72,0x6c,0x3d,0x28,
. . .
```

`httpserver-netconn.h`

```c
#ifndef __HTTPSERVER_NETCONN_H__
#define __HTTPSERVER_NETCONN_H__

void http_server_netconn_init(void);
// void DynWebPage(struct netconn *conn);

#endif /* __HTTPSERVER_NETCONN_H__ */
```

Hands-On LwIP HTTP Server Netconn RTOS

```
. . .
0x6e,0x20,0x73,0x74,0x79,0x6c,0x65,0x3d,0x22,0x66,0x6f,0x6e,0x74,0x2d,0x66,0x61,
0x6d,0x69,0x6c,0x79,0x3a,0x20,0x56,0x65,0x72,0x64,0x61,0x6e,0x61,0x3b,0x22,0x3e,
0x4e,0x75,0x6d,0x62,0x65,0x72,0x20,0x6f,0x66,0x20,0x68,0x69,0x74,0x73,0x3a,0x20,
0x3c,0x2f,0x73,0x70,0x61,0x6e,0x3e,0x3c,0x2f,0x73,0x6d,0x61,0x6c,0x6c,0x3e,0x3c,
0x2f,0x62,0x6f,0x64,0x79,0x3e,0x3c,0x2f,0x68,0x74,0x6d,0x6c,0x3e,0x00};
// add at the end, 0x00

/* Private function prototypes -----------------------------------------------*/
static void http_server_serve(struct netconn *conn);
static void http_server_netconn_thread(void const *arg);
void DynWebPage(struct netconn *conn);
/* Private functions ---------------------------------------------------------*/

/* @brief serve tcp connection
  * @param conn: pointer on connection structure
  * @retval None
*/
static void http_server_serve(struct netconn *conn)
{
    struct netbuf *inbuf;
    err_t recv_err;
    char* buf;
    u16_t buflen;
    struct fs_file file;

    /* Read the data from the port, blocking if nothing yet there.
       We assume the request (the part we care about) is in one netbuf */
    recv_err = netconn_recv(conn, &inbuf);
```

```
if (recv_err == ERR_OK)
{
  if (netconn_err(conn) == ERR_OK)
  {
    netbuf_data(inbuf, (void**)&buf, &buflen);

    /* Is this an HTTP GET command? (only check the first 5 chars, since
    there are other formats for GET, and we're keeping it very simple )*/
    if ((buflen >=5) && (strncmp(buf, "GET /", 5) == 0))
    {
      /* Check if request to get ST.gif */
      if (strncmp((char const *)buf,"GET /STM32F767_files/ST_DigiPen.jpg",35)==0)  //ST.gif
      {
        fs_open(&file, "/STM32F767_files/ST_DigiPen.jpg"); //ST.gif
        netconn_write(conn, (const unsigned char*)(file.data), (size_t)file.len, NETCONN_NOCOPY);
        fs_close(&file);
      }
      /* Check if request to get stm32.jpeg */
      else if (strncmp((char const *)buf,"GET /STM32F767_files/stm32.jpg",30)==0)
      {
        fs_open(&file, "/STM32F767_files/stm32.jpg");
        netconn_write(conn, (const unsigned char*)(file.data), (size_t)file.len, NETCONN_NOCOPY);
        fs_close(&file);
      }
      else if (strncmp((char const *)buf,"GET /STM32F767_files/logo.jpg", 29) == 0)
      {
        /* Check if request to get ST logo.jpg */
        fs_open(&file, "/STM32F767_files/logo.jpg");
        netconn_write(conn, (const unsigned char*)(file.data), (size_t)file.len, NETCONN_NOCOPY);
        fs_close(&file);
      }
      else if (strncmp((char const *)buf,"GET /STM32F767_files/digipen.gif", 32) == 0)
      {
        /* Check if request to get DigiPen logo.jpg */
```

```
        else if (strncmp((char const *)buf,"GET /STM32F767_files/digipen.gif", 32) == 0)
        {
          /* Check if request to get DigiPen logo.jpg */
          fs_open(&file, "/STM32F767_files/digipen.gif");
          netconn_write(conn, (const unsigned char*)(file.data), (size_t)file.len, NETCONN_NOCOPY);
          fs_close(&file);
        }
        else if(strncmp(buf, "GET /STM32F767TASKS.html", 24) == 0)
        {
          /* Load dynamic page */
          DynWebPage(conn);
        }
        else if((strncmp(buf, "GET /STM32F767.html", 19) == 0)||(strncmp(buf, "GET / ", 6) == 0))
        {
          /* Load STM32F767 page */
          fs_open(&file, "/STM32F767.html");
          netconn_write(conn, (const unsigned char*)(file.data), (size_t)file.len, NETCONN_NOCOPY);
          fs_close(&file);
        }
        else
        {
          /* Load Error page */
          fs_open(&file, "/404.html");
          netconn_write(conn, (const unsigned char*)(file.data), (size_t)file.len, NETCONN_NOCOPY);
          fs_close(&file);
        }
      }
    }
  }
  /* Close the connection (server closes in HTTP) */
  netconn_close(conn);

  /* Delete the buffer (netconn_recv gives us ownership,
   so we have to make sure to deallocate the buffer) */
  netbuf_delete(inbuf);
}
```

Part of the **`httpserver-netconn.c`**

```c
/* @brief  http server thread */
static void http_server_netconn_thread(void const *arg)
{
    struct netconn *conn, *newconn;
    err_t err, accept_err;
    /* Create a new TCP connection handle */
    conn = netconn_new(NETCONN_TCP);

    if (conn != NULL)
    {
        /* Bind to port 80 (HTTP) with default IP address */
        err = netconn_bind(conn, NULL, 80);

        if (err == ERR_OK)
        {
            /* Put the connection into LISTEN state */
            netconn_listen(conn);

            while(1)
            {
                /* accept any incoming connection */
                accept_err = netconn_accept(conn, &newconn);
                if(accept_err == ERR_OK)
                {
                    /* serve connection */
                    http_server_serve(newconn);

                    /* delete connection */
                    netconn_delete(newconn);
                }
            }
        }
    }
}
```

Hands-On LwIP HTTP Server Netconn RTOS

Part of the **`httpserver-netconn.c`**

```
/**
  * @brief  Initialize the HTTP server (start its thread)
  * @param  none
  * @retval None
  */
void http_server_netconn_init()
{
    // sys_thread_new("HTTP", http_server_netconn_thread, NULL, DEFAULT_THREAD_STACKSIZE * 2,
                                                                        WEBSERVER_THREAD_PRIO);

    osThreadDef(TASK_HTTP, http_server_netconn_thread, WEBSERVER_THREAD_PRIO, 0,
                                                                    configMINIMAL_STACK_SIZE*2);
    osThreadCreate (osThread(TASK_HTTP), NULL);

    // note: 1. Heap size must be large enough (63488 bytes) to have (configMINIMAL_STACK_SIZE*2),
    //          else (configMINIMAL_STACK_SIZE) is working too for this program
    // note: 2. If sys_thread_new() is used, http_server_netconn_thread(void const *arg) must be
    //          reduced to http_server_netconn_thread(), i.e., no passing of argument in
    //          http_server_netconn_thread().
    // note: 3. Set configMINIMAL_STACK_SIZE = DEFAULT_THREAD_STACKSIZE = 2014 words
}
```

Hands-On LwIP HTTP Server Netconn RTOS

Part of the **`httpserver-netconn.c`**

```c
/**
  * @brief  Create and send a dynamic Web Page. This page contains the list of
  *         running tasks and the number of page hits.
  * @param  conn pointer on connection structure
  * @retval None
  */
void DynWebPage(struct netconn *conn)
{
  portCHAR PAGE_BODY[512];
  portCHAR pagehits[10] = {0};

  memset(PAGE_BODY, 0, 512);

  /* Update the hit count */
  nPageHits++;
  sprintf(pagehits, "%d", (int)nPageHits);
  strcat(PAGE_BODY, pagehits);
  strcat((char *)PAGE_BODY, "<pre><br>Name          State  Priority  Stack   Num" );
  strcat((char *)PAGE_BODY, "<br>-------------------------------------------<br>");

  /* The list of tasks and their status */
  osThreadList((unsigned char *)(PAGE_BODY + strlen(PAGE_BODY)));
  strcat((char *)PAGE_BODY, "<br><br>-------------------------------------------");
  strcat((char *)PAGE_BODY, "<br>B : Blocked, R : Ready, D : Deleted, S : Suspended<br>");

  /* Send the dynamically generated page */
  netconn_write(conn, PAGE_START, strlen((char*)PAGE_START), NETCONN_COPY);
  netconn_write(conn, PAGE_BODY, strlen(PAGE_BODY), NETCONN_COPY);
}
```

Hands-On LwIP HTTP Server Netconn RTOS

Generated Code in **Lwip.c**

```
/* LwIP initialization function  */
void MX_LWIP_Init(void)
{
  /* IP addresses initialization */
  IP_ADDRESS[0] = 192;
  IP_ADDRESS[1] = 168;
  IP_ADDRESS[2] = 1;
  IP_ADDRESS[3] = 205;
  NETMASK_ADDRESS[0] = 255;
  NETMASK_ADDRESS[1] = 255;
  NETMASK_ADDRESS[2] = 255;
  NETMASK_ADDRESS[3] = 0;
  GATEWAY_ADDRESS[0] = 192;
  GATEWAY_ADDRESS[1] = 168;
  GATEWAY_ADDRESS[2] = 1;
  GATEWAY_ADDRESS[3] = 1;

/* USER CODE BEGIN IP_ADDRESSES */
/* USER CODE END IP_ADDRESSES */

  /* Initilialize the LwIP stack without RTOS */
  lwip_init();

  /* IP addresses initialization without DHCP (IPv4) */
  IP4_ADDR(&ipaddr, IP_ADDRESS[0], IP_ADDRESS[1], IP_ADDRESS[2], IP_ADDRESS[3]);
  IP4_ADDR(&netmask, NETMASK_ADDRESS[0], NETMASK_ADDRESS[1] , NETMASK_ADDRESS[2], NETMASK_ADDRESS[3]);
  IP4_ADDR(&gw, GATEWAY_ADDRESS[0], GATEWAY_ADDRESS[1], GATEWAY_ADDRESS[2], GATEWAY_ADDRESS[3]);

  /* add the network interface (IPv4/IPv6) without RTOS */
  netif_add(&gnetif, &ipaddr, &netmask, &gw, NULL, &ethernetif_init, &ethernet_input);
```

For a different router (gateway):

```
IP_ADDRESS[0] = 192;
IP_ADDRESS[1] = 168;
IP_ADDRESS[2] = 50;
IP_ADDRESS[3] = 205;
NETMASK_ADDRESS[0] = 255;
NETMASK_ADDRESS[1] = 255;
NETMASK_ADDRESS[2] = 255;
NETMASK_ADDRESS[3] = 0;
GATEWAY_ADDRESS[0] = 192;
GATEWAY_ADDRESS[1] = 168;
GATEWAY_ADDRESS[2] = 50;
GATEWAY_ADDRESS[3] = 1;
```

Hands-On LwIP HTTP Server Netconn RTOS

STM32F767

Not secure | 192.168.1.205/STM32F767.html

Hwee Choo LIAW WhatsApp

STMicroelectronics DigiPen life.augmented

STM32F767 Webserver Demo

Based on the LwIP TCP/IP stack

Home Page	List of Tasks

STM32F7 Series

The STM32F7 devices are the world's first ARM Cortex-M7 based 32-bit microcontrollers, setting the benchmark in performance.

Taking advantage of ST's ART Accelerator™ as well as an L1 cache, the STM32F7 microcontrollers deliver the maximum theoretical performance of the Cortex-M7 core, regardless if code is executed from embedded Flash or external memory: 1082 CoreMark / 462 DMIPS at 216 MHz f_{CPU}

The STM32F767 home page

About this demonstration

This webserver is a part of a demonstration package developed on the top level of the LwIP TCP/IP stack.

The package contains nine applications:

1. Applications running in standalone (without an RTOS):

Hands-On LwIP HTTP Server Netconn RTOS

STM32F767

Not secure | 192.168.1.205/STM32F767.html

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The package contains nine applications:

1. Applications running in standalone (without an RTOS):

   - A Webserver.
   - A TFTP server.
   - A TCP echo client application
   - A TCP echo server application
   - A UDP echo client application
   - A UDP echo server application

2. Applications running with FreeRTOS operating system:

   - A Webserver based on netconn API.
   - A Webserver based on socket API.
   - A TCP/UDP echo server application based on netconn API.

About LwIP

LwIP, pronounced lightweight IP, is an open source TCP/IP stack developed by Adam Dunkels at the Swedish Institute of Computer Science and is maintained now by a world wide community of developers.

LwIP features:

- IP (Internet Protocol) including packet forwarding over multiple network interfaces
- ICMP (Internet Control Message Protocol) for network maintenance and debugging
- UDP (User Datagram Protocol) including experimental UDP-lite extensions
- TCP (Transmission Control Protocol) with congestion control, RTT estimation
  and fast recovery/fast retransmit
- Specialized raw API for enhanced performance
- Optional Berkeley-alike socket API
- DHCP (Dynamic Host Configuration Protocol)
- PPP (Point-to-Point Protocol)
- ARP (Address Resolution Protocol) for Ethernet

For more informations you can refer to the website: http://savannah.nongnu.org/projects/lwip/

Web server list of task page

STM32F767TASKS

Not secure | 192.168.1.205/STM32F767TASKS.html

Hwee Choo LIAW WhatsApp

STM32F767 List of Tasks and their Status

Home Page	List of Tasks

Number of hits: 76

Name	State	Priority	Stack	Num
HTTP	X	4	1721	6
tcpip_thread	R	3	797	3
IDLE	R	0	1001	2
defaultTask	B	3	892	1
LinkThr	B	2	2014	5
EthIf	B	6	260	4

B : Blocked, R : Ready, D : Deleted, S : Suspended