INTRODUCTION TO MURASAKI

An STM32 Peripheral Class Library

STAY HOME

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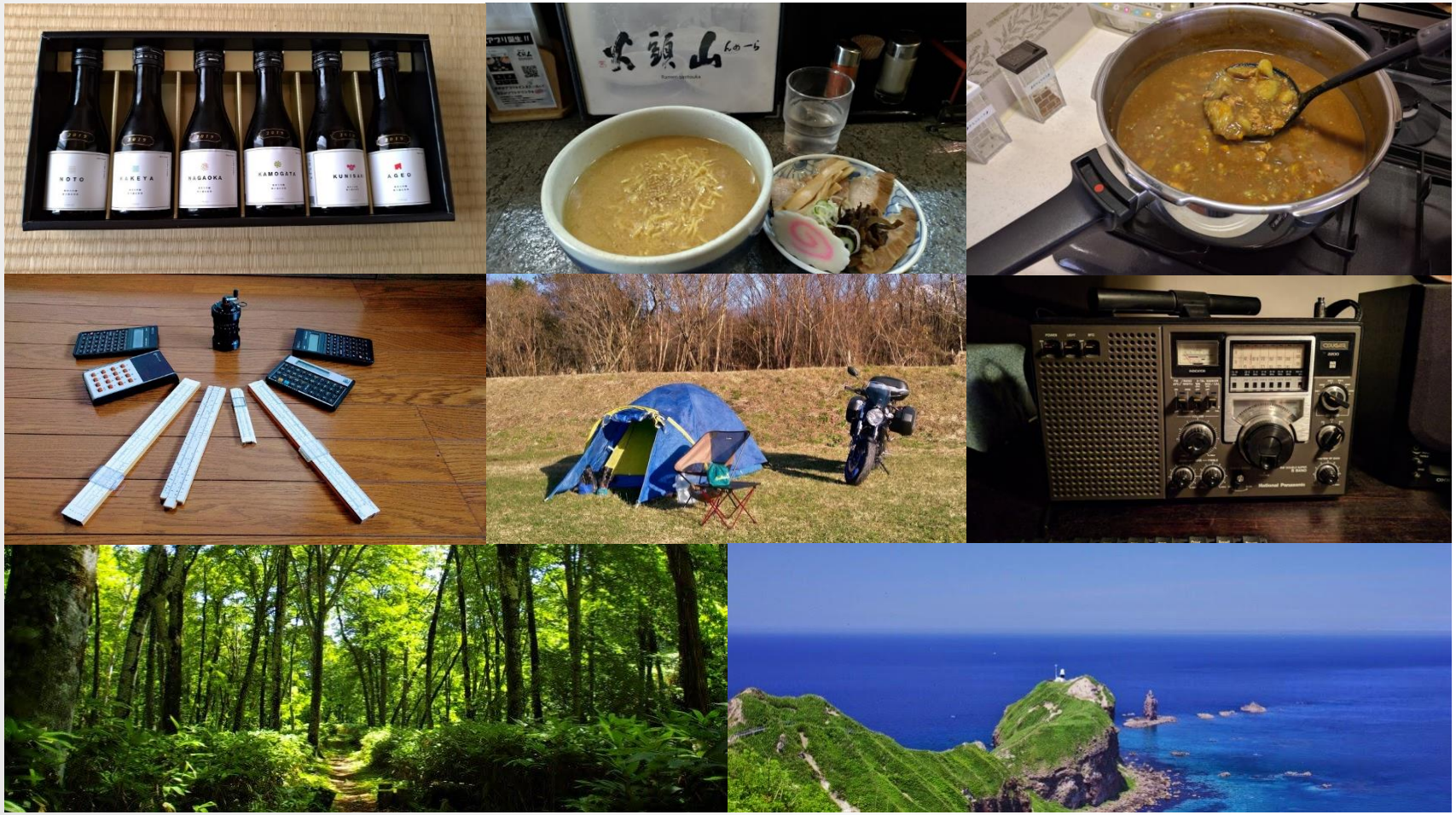
INTRODUCTION

WHO AM I?



WHAT IS MURASAKI?

Photo by Daniele Levis Pelusi on Unsplash

IN THIS SECTION

- What is Murasaki?
- What is the target processor?
- What is the development environment?
- What is the overview of the classes?

OVERVIEW

- A collection of the peripheral wrapper class
  - UART, SPI, I2C, ADC, Encoder, SAI, I2S, EXTI, GPIO
- RTOS aware classes are available
  - Task, Synchronizer, CriticalSection
- IO APIs are :
  - Wrapped by Class.
  - Synchronized : IO call returns when IO function is complete.
  - Blocking : If IO is occupied, wait until it becomes vacant.
- Hosted by GitHub
  - https://github.com/suikan4github/murasaki

TARGET

- STM32 microcomputer series.
- Core pressor is not matter.
- Providing one unified API through the STM32 variants

- Tested Target
  - STM32F0 : CORTEX-M0
  - STM32G0 : CORTEX-M0+
  - STM32L1 : CORTEX-M3
  - STM32F4 : CORTEX-M4
  - STM32G4 : CORTEX-M4
  - STM32F7 : CORTEX-M7
  - STM32H7 : CORTEX-M7

REQUIRED ENVIRONMENT

- Linux or Windows
  - Developed on Ubuntu 16.04 LTS
  - Windows 10 + WSL is confirmed
  - MacOS is not tested
- CubeIDE 1.3
  - Device Configuration Tool is essential
  - Makefile build must be acceptable. But not tested.
- Other tools
  - Doxygen
  - pdflatex
  - Terminal emanator

MOTIVATION

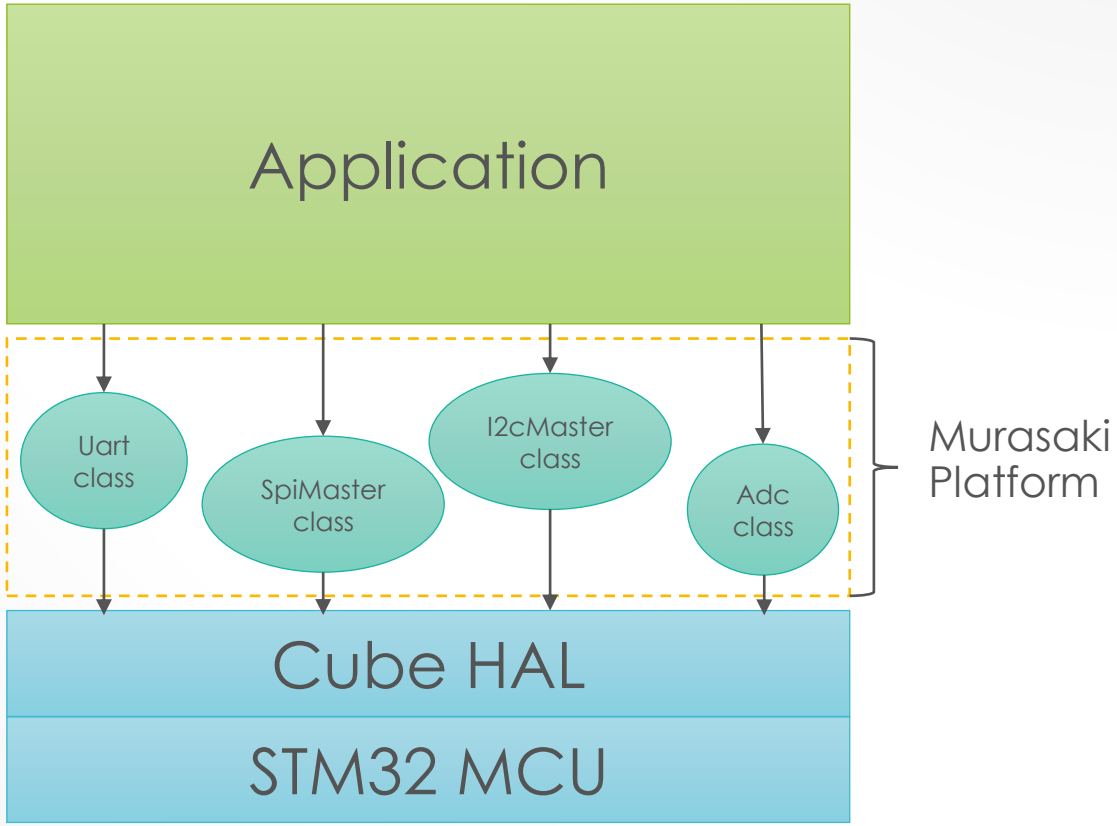
- A class library which doesn’t bother the development.
  - Strict name space
  - Strict parameter typing
  - Synchronous and blocking IO API
  - Multi-task aware
  - Enough speed to support audio DMA data
- Strict parameter checking
- Context free printf()

OUT OF SCOPE

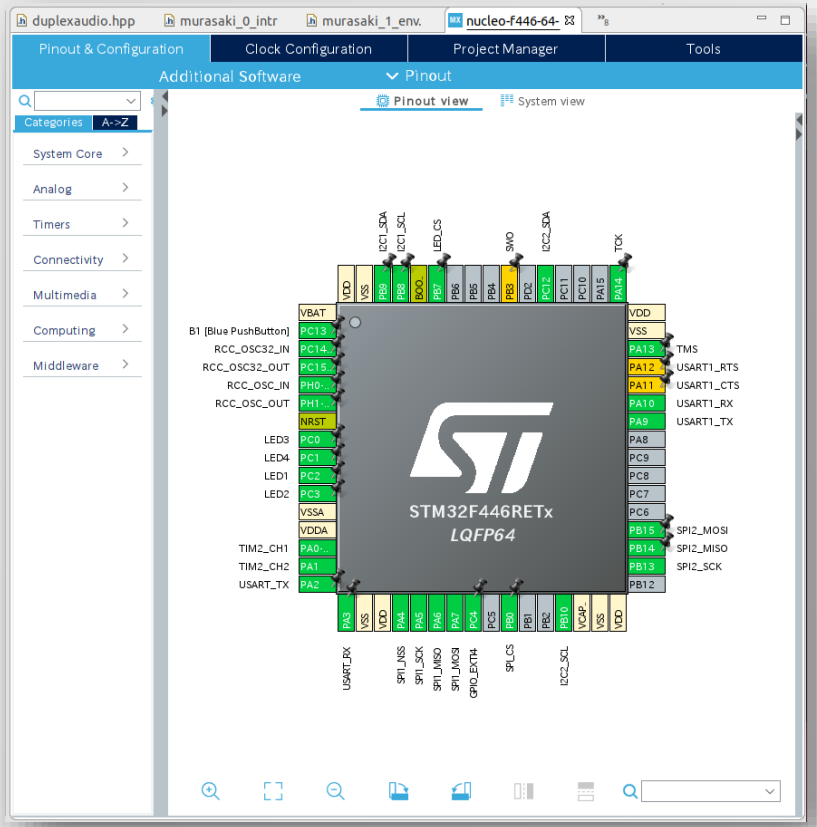
- Very quick response processing
  - Motor control
  - Power supply control
- Very low power operation
  - Mouse
  - TV remote controller
- Very small memory footprint
- High reliability application

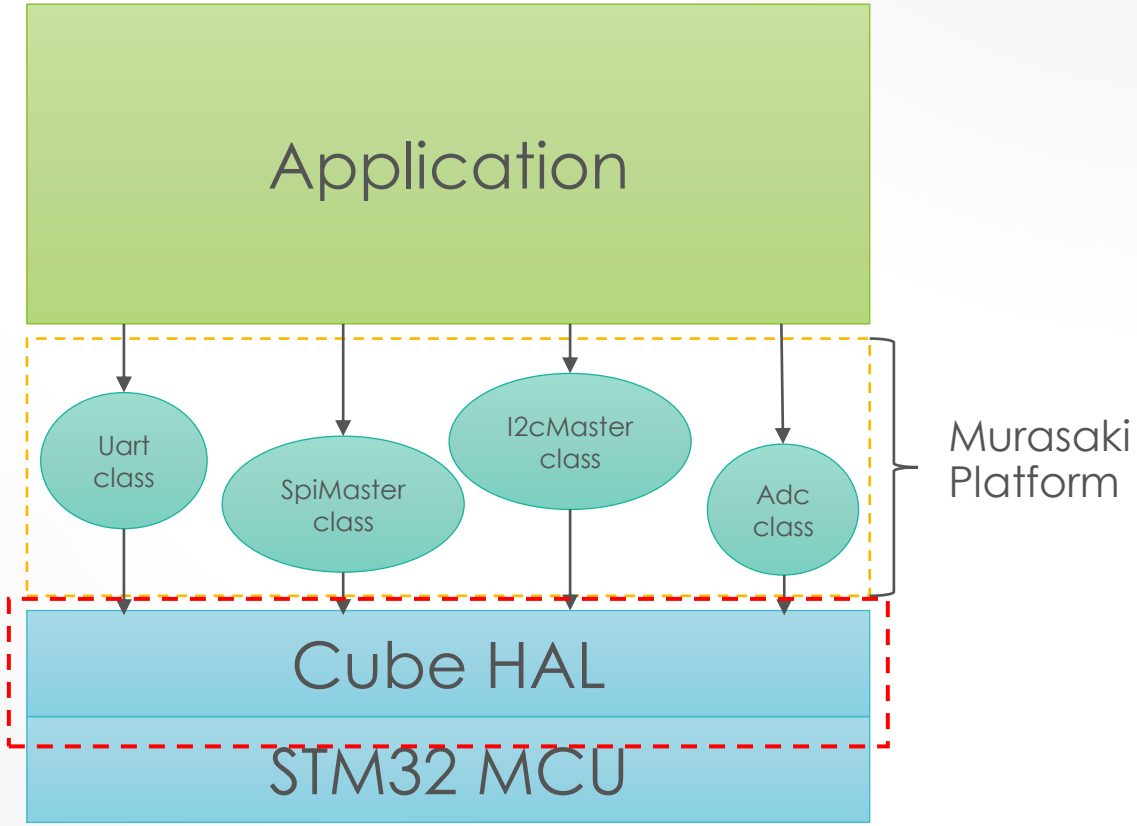
PLATFORM AS ABSTRACT LAYER

- Murasaki provides dedicated class for each peripheral
- Application will use the peripheral through these class variable.
- Programmer can create these class variable as he/she wants.



CUBE IDE AND MURASAKI





PRINTF() DEBUG SUPPORT

- A dedicated Printf() function is available.
- Thread safe
- Bi-context
  - Can use from both task and interrupt context
- Buffered
  - As soon as text is stored in the buffer, Print() returns.

```
116 void ExecPlatform()
117 {
118
119     murasaki::debugger->Printf("¥n");
120     murasaki::debugger->Printf("    Mandelbrot set by NUCLEO-G431RB¥n");
121
122     // Render the set.
123     for (int y = 0; y < YPICSIZE; y++) {
124         for (int x = 0; x < XPICSIZE; x++)
125             // print a message with counter value to the console.
126             murasaki::debugger->Printf("%c",
127                                        mapper[mandelbrot(XPOS(x),
128                                                          YPOS(y),
129                                                          sizeof(mapper) - 1)]);
130         murasaki::debugger->Printf("¥n");
131     }
132     // Loop forever
133     while (true) {
134         // Blink LED
135         murasaki::platform.led->Toggle();
136         // wait for a while
137         murasaki::Sleep(500);
138     }
139 }
140
141
```

UART

- UART is packed in the Uart class.
- Transmit() / Receive () member functions are :
  - Synchronous
  - Blocking

```
155 void Test101Master(void) {
156     // Start UART simple test.
157     murasaki::platform.test_state = cmd_101;
158     murasaki::platform.test_success = false;
159
160     murasaki::platform.sync_command->Release();     // tell slave tas
161
162     murasaki::platform.uart->Transmit(
163                                     tx_data_uart,
164                                     sizeof(tx_data_uart)
165                                     );
166
167     murasaki::platform.sync_ack->Wait();
168     murasaki::debugger->Printf(
```

I2C

- I2C is packed in the I2cMaster and I2cSlave class.
- Transmit () / Receive() member functions are :
  - Synchronous
  - Blocking

```
murasaki::platform.sync_command->Release();     // tell slave task next

murasaki::platform.i2c_master->Transmit(
                                        i2c_device,
                                        tx_data_i2c,
                                        sizeof(tx_data_i2c),
                                        &transfered_count);
```

SPI

- SPI is packed in the SpiMaster and SpiSlave class.
- TransmitAndReceive() member function is :
  - Synchronous
  - Blocking

```
murasaki::platform.sync_command->Release();     // tell slave task next test

murasaki::platform.spi_master->TransmitAndReceive(
                                                murasaki::platform.slave_adapter,
                                                tx_data_spi_master,
                                                rx_data_spi_master,
                                                sizeof(tx_data_spi_master));
```

BY THE WAY, SPI IS CONSIDERED HARMFUL

- The clock polarity and the clock phase is up to the slave.
  - For each time to access different slave, the master have to be re-configured.
- Muarsaki uses the SpiSlaveAdapter class to specify these configuration.

```
// CPOL and CPHA follows pin configration of SPI 1.
murasaki::platform.slave_adapter = new murasaki::SpiSlaveAdapter(
                                                                  0,
                                                                  0,
                                                                  SPI_CS_GPIO_Port,
                                                                  SPI_CS_Pin);
```

```
murasaki::platform.sync_command->Release();     // tell slave task next test

murasaki::platform.spi_master->TransmitAndReceive(
                                                murasaki::platform.slave_adapter,
                                                tx_data_spi_master,
                                                rx_data_spi_master,
                                                sizeof(tx_data_spi_master));
```

AUDIO

- Audio is packed in the DuplexAudio class.
- TransmitAndReceive() member functions is :
  - Synchronous
- DuplexAudio is not blocking IO.
  - This IO doesn't assume multiple task access the IO randomly
- Both I2S and SAI port are supported

```
    while (true)  // Talk Through
    {
        // Wait the end of current audio transmission & receive.
        // Then, copy the tx buffer to tx DMA buffer.
        // And then copy the rx DMA buffer to rx buffer.
        murasaki::platform.audio->TransmitAndReceive(
                                                    tx_left,
                                                    tx_right,
                                                    rx_left,
                                                    rx_right);
        // Copy RX to TX : talk through
        for (int i = 0; i < AUDIO_CHANNEL_LEN; i++) {
            tx_left[i] = rx_left[i];
            tx_right[i] = rx_right[i];
        }

        // Blink status.
        murasaki::platform.led_st0->Toggle();
        murasaki::platform.led_st1->Toggle();
    }
}
```

GPIO

- GPIO class
  - GpIn
  - GpOut
- Simple bit operations

```
    // Initiate the LED on the AKSAHI-02 board
    murasaki::platform.led_st0->Clear();
    murasaki::platform.led_st1->Set();



    while (true)  // Talk Through
    {
        // Wait the end of current audio transmission & receive.
        // Then, copy the tx buffer to tx DMA buffer.
        // And then copy the rx DMA buffer to rx buffer.
        murasaki::platform.audio->TransmitAndReceive(
                                                    tx_left,
                                                    tx_right,
                                                    rx_left,
                                                    rx_right);
        // Copy RX to TX : talk through
        for (int i = 0; i < AUDIO_CHANNEL_LEN; i++) {
            tx_left[i] = rx_left[i];
            tx_right[i] = rx_right[i];
        }

        // Blink status.
        murasaki::platform.led_st0->Toggle();
        murasaki::platform.led_st1->Toggle();
    }
}
```

OTHER PERIPHERALS

- ADC is packed in the Adc class.
- Convert member function is :
  - Synchronous
  - Blocking
- EXTI is packed in the Exti class.
- Wait member function is :
  - Synchronous
- Exti is not blocking.
  - Only one task wait for specific interrupt.

MULTI-TASKING

- Task is easy to create.
- Syncronizer class for
  - Wait
  - Release
- CriticalSection class for
  - Inter-task exclusive resource access.

```
    // For demonstration of FreeRTOS task.
    murasaki::platform.task1 = new murasaki::SimpleTask(
                                                        "task1",
                                                        256,
                                                        murasaki::ktpNormal,
                                                        nullptr,
                                                        &TaskBodyFunction
                                                        );
    MURASAKI_ASSERT(nullptr != murasaki::platform.task1)
```

```
/* ------------------ User Functions ------------------------- */
/**
 * @brief Demonstration task.
 * @param ptr Pointer to the parameter block
 * @details
 * Task body function as demonstration of the @ref murasaki::SimpleTask.
 *
 * You can delete this function if you don't use.
 */
void TaskBodyFunction(const void *ptr) {

    while (true)  // dummy loop
    {
        murasaki::platform.led->Toggle();  // toggling LED
        murasaki::Sleep(700);
    }
}
```

AUTOMATIC INTERRUPT HANDLING

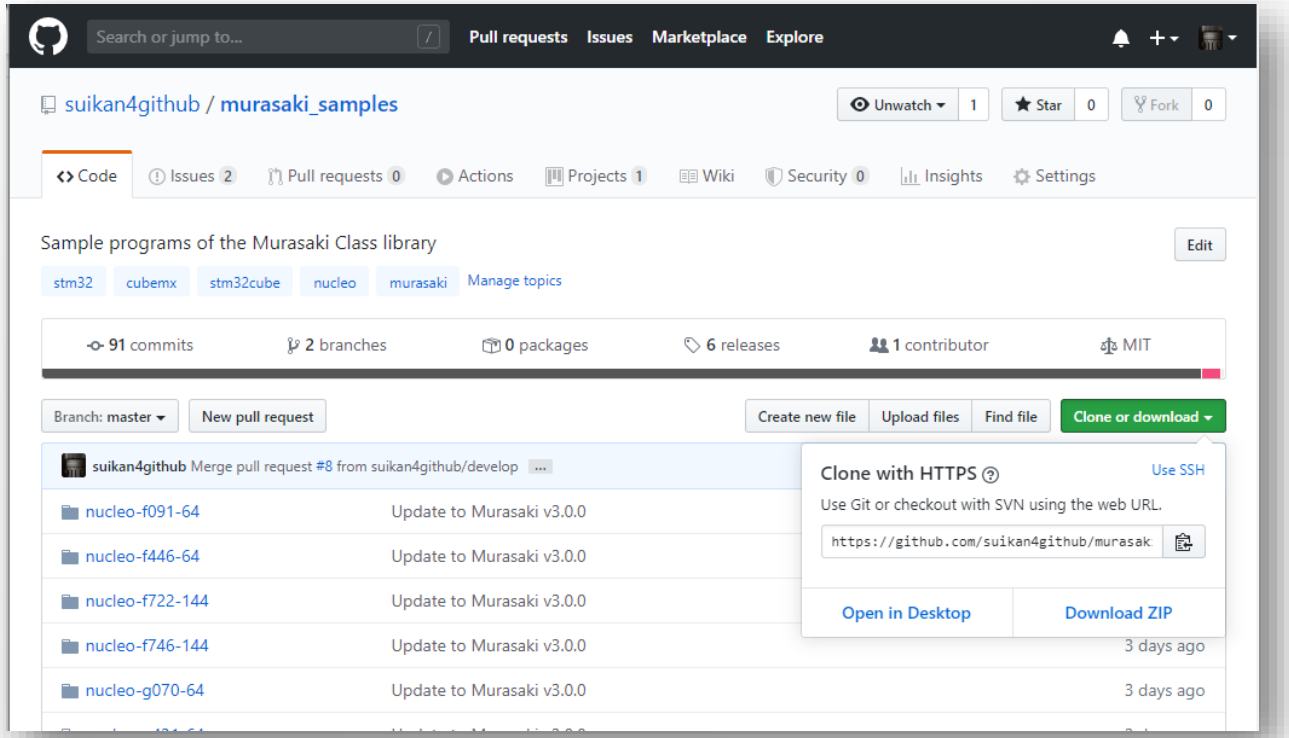
- Peripheral interrupts are handled internally.
- Programmer doesn’t need to care.

IMPORT AND RUN

Photo by Daniele Andy Li on Unsplash

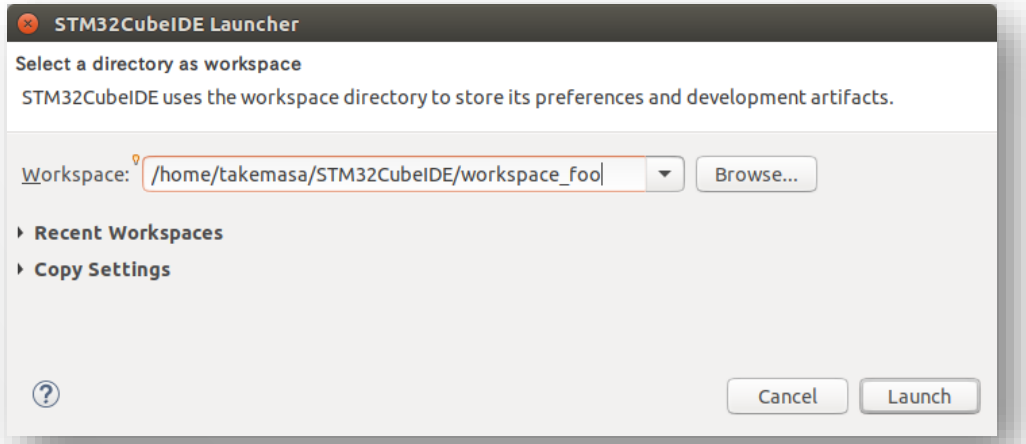
IN THIS SECTION

- We fetch the sample programs from github, and import
- Run the program
- Walkthrough the program
- See the debug functionality

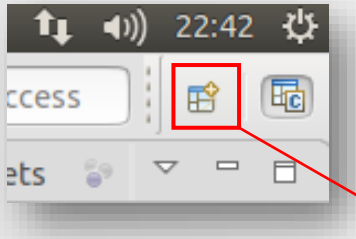


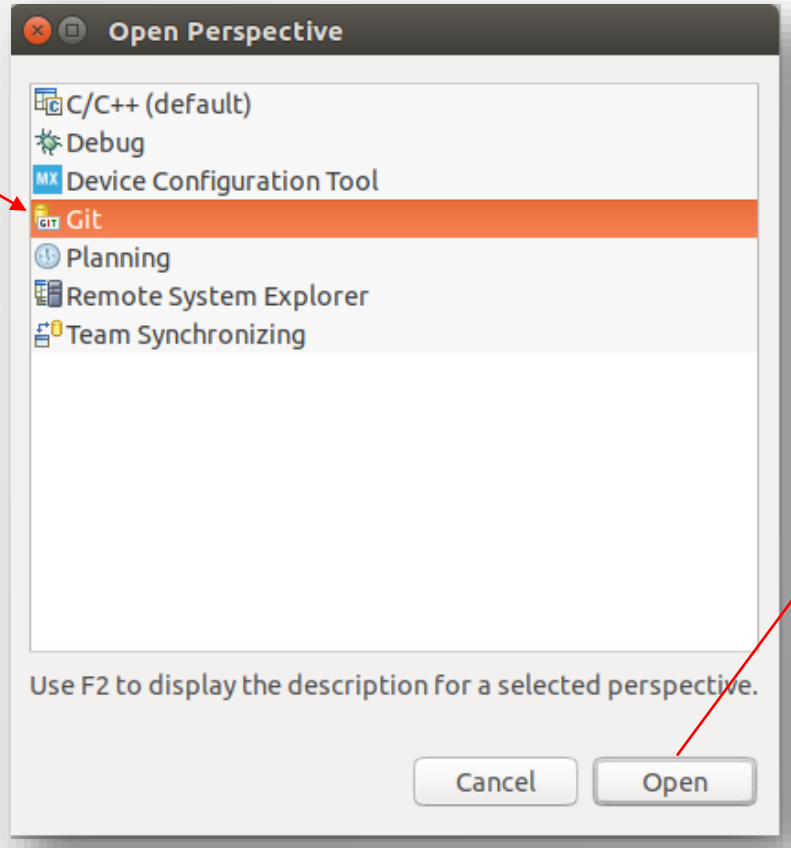
1.OPNE A NEW WORKSPACE

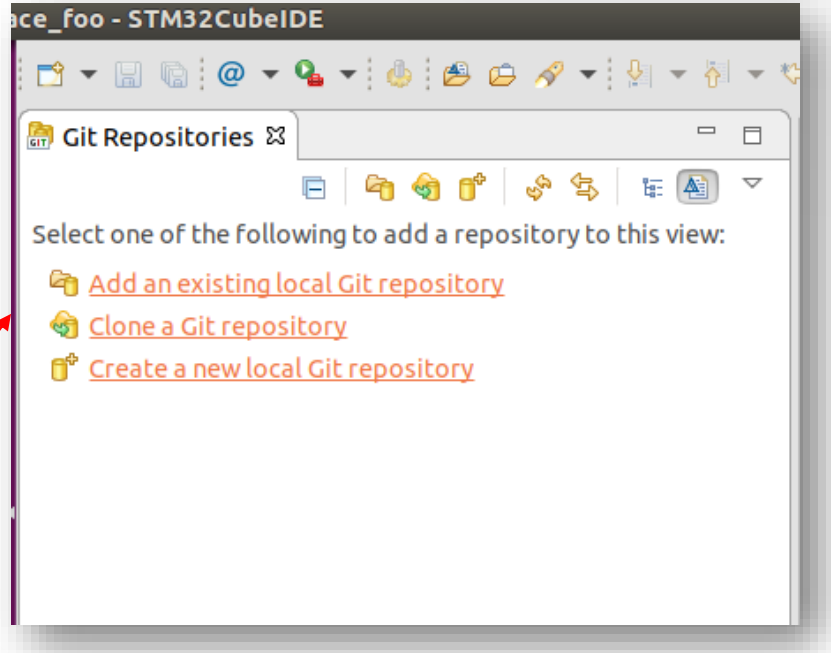
- Create a new workspace



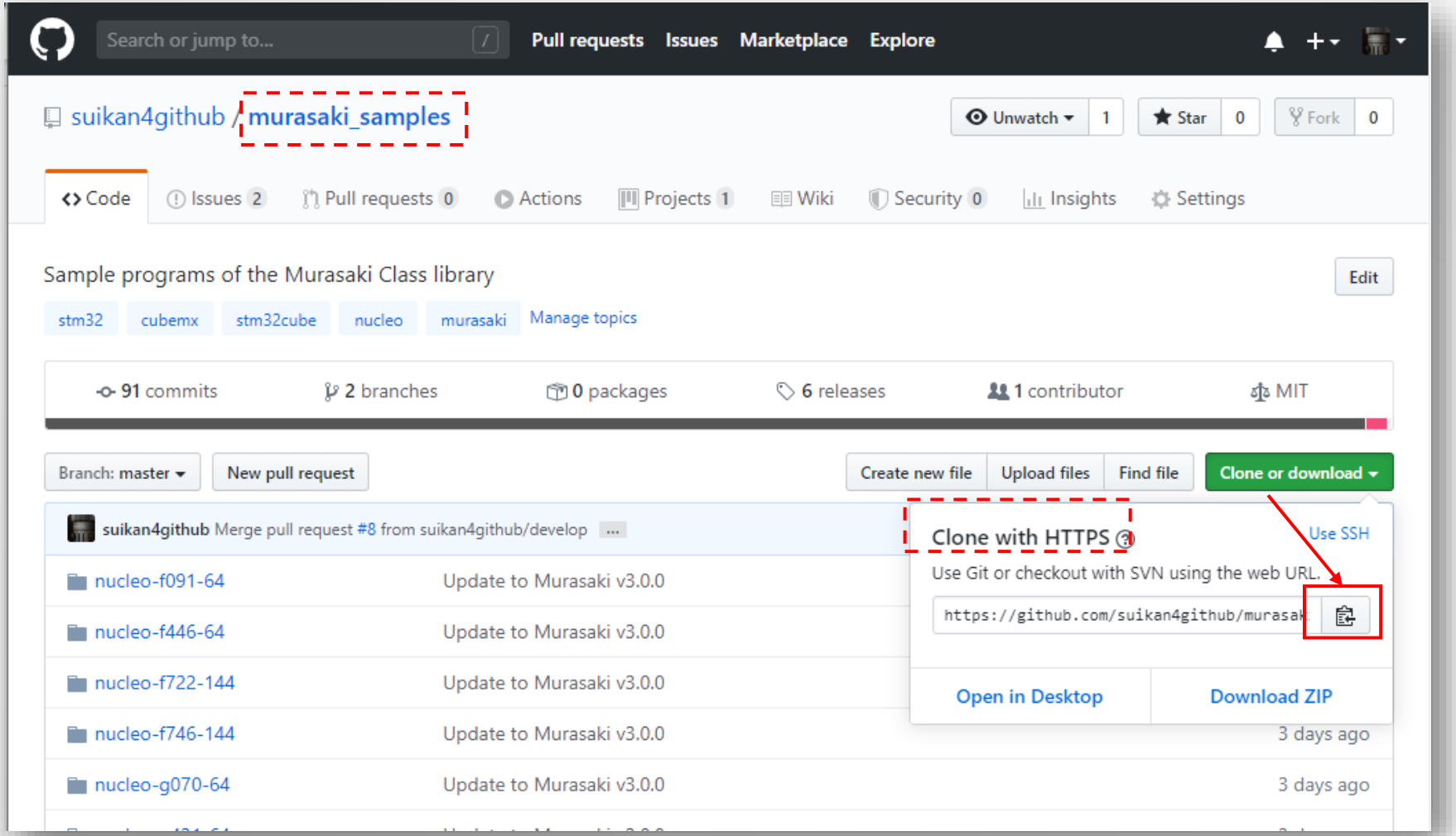
2.OPEN THE GIT PERSPECTIVE



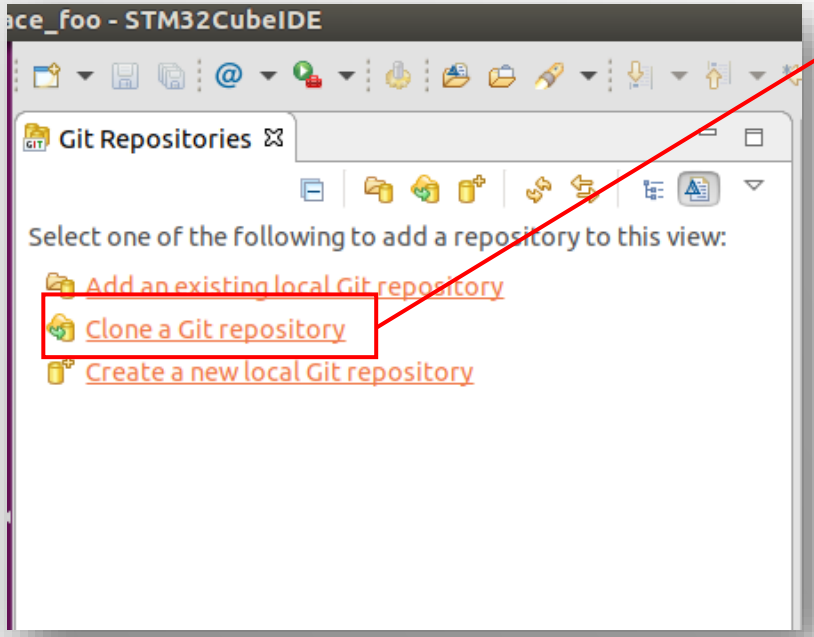


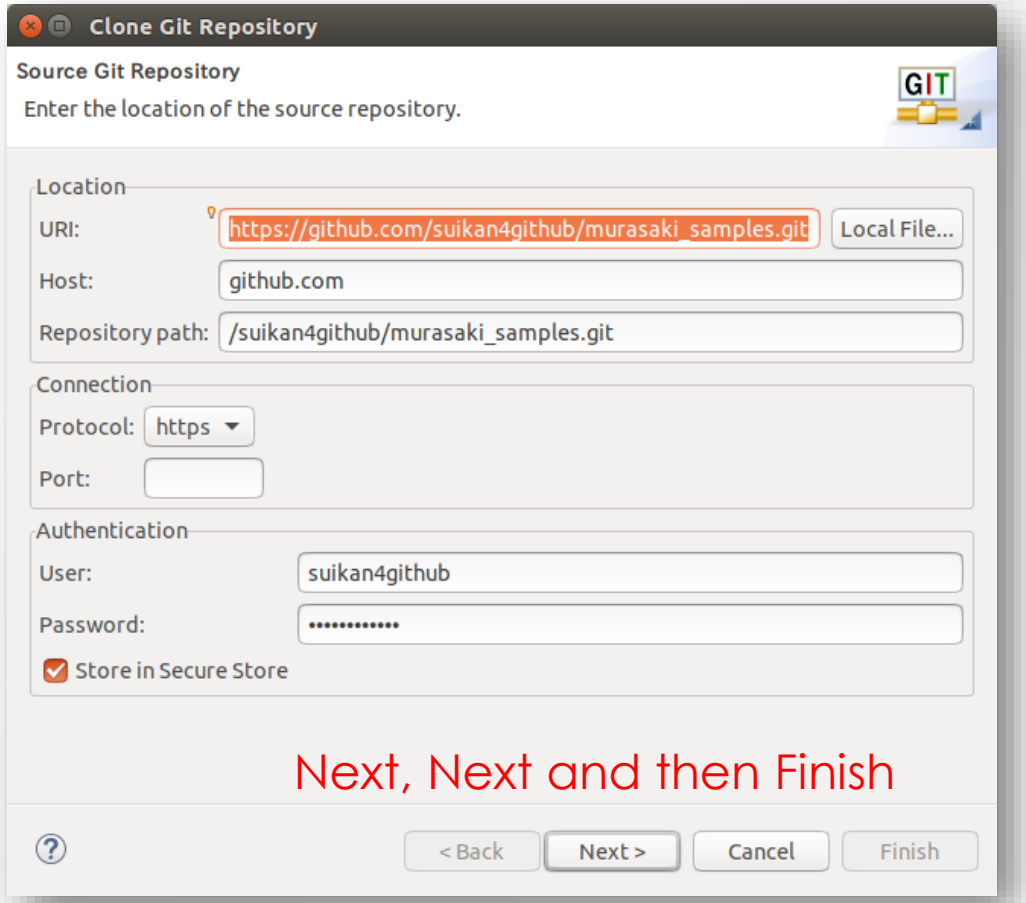


3.COPY AN URL OF THE REPOSITORY

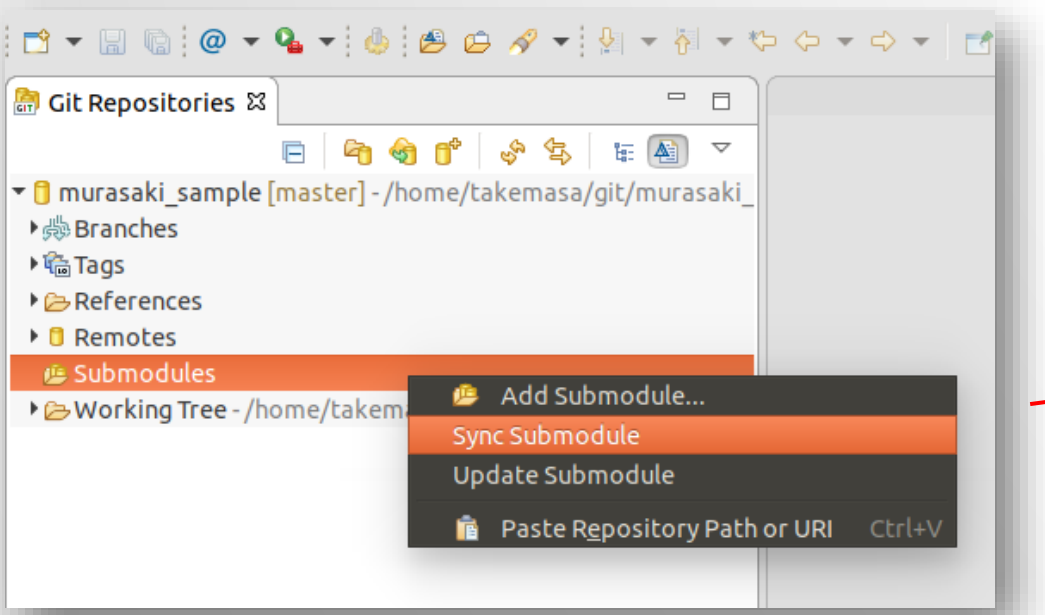


4.CLONE THE REPOSITORY



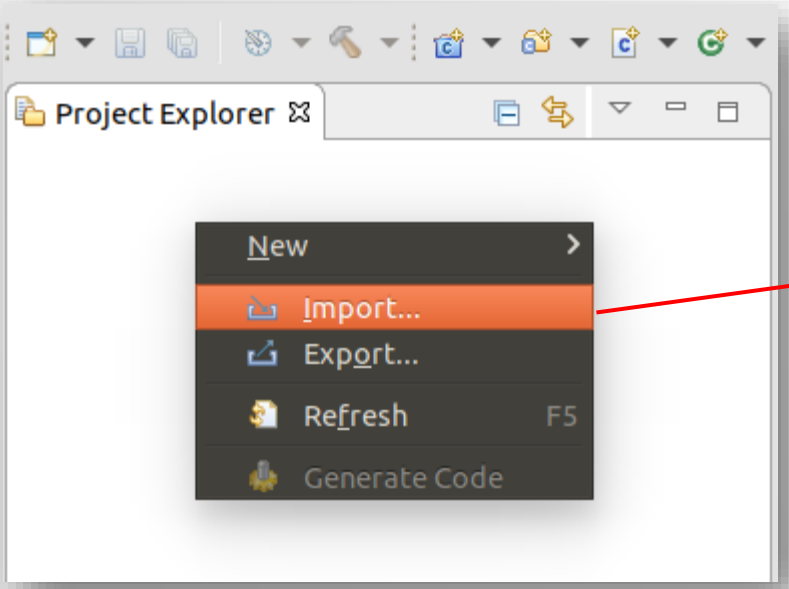


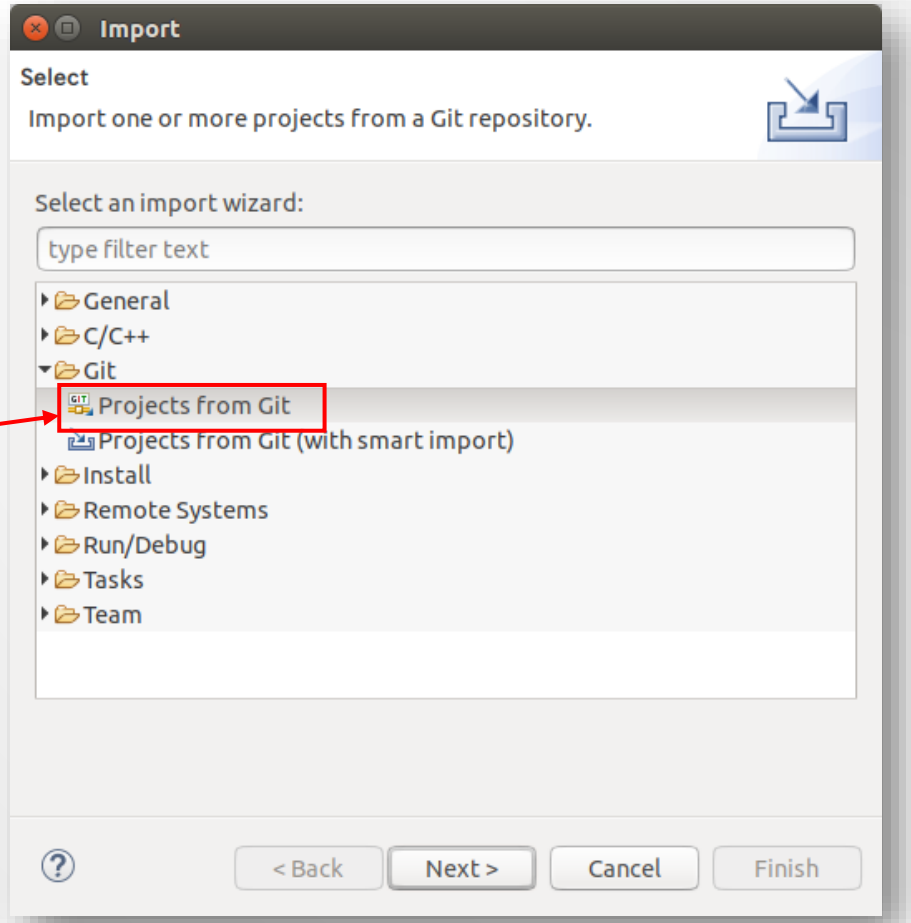
5.UPDATE SUBMODULES



Go to C perspective

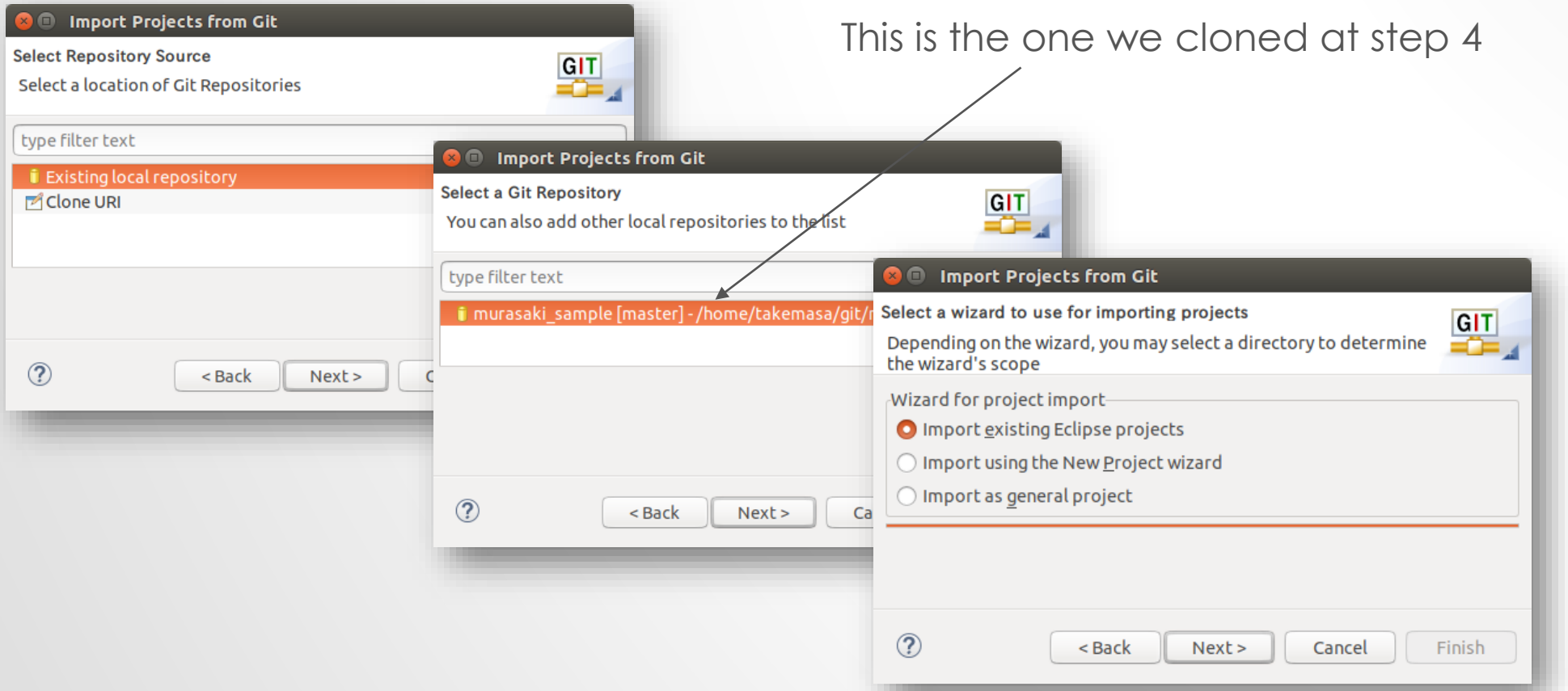
6.START TO IMPORT





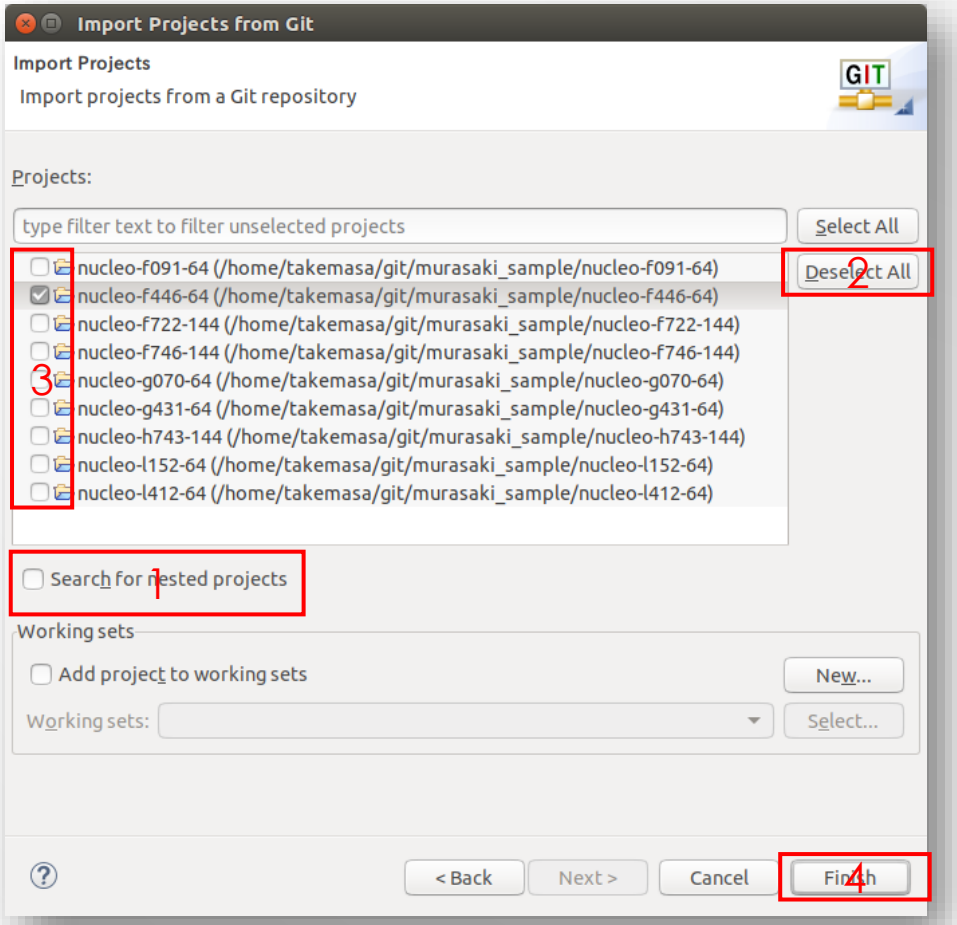
7.SPECIFY THE REPOSITORY

This is the one we cloned at step 4



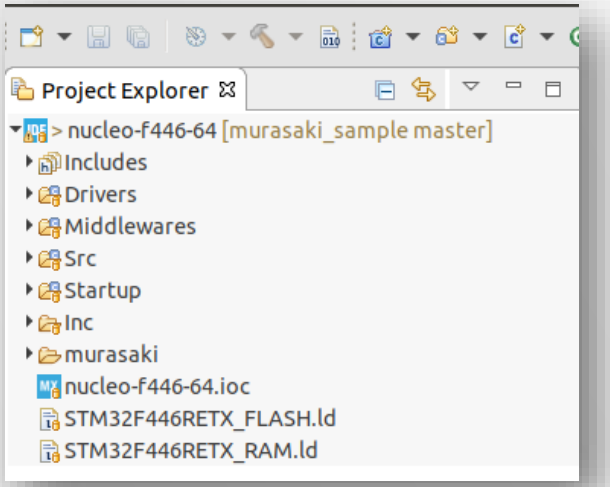
8.SPECIFY A PROJECT TO IMPORT

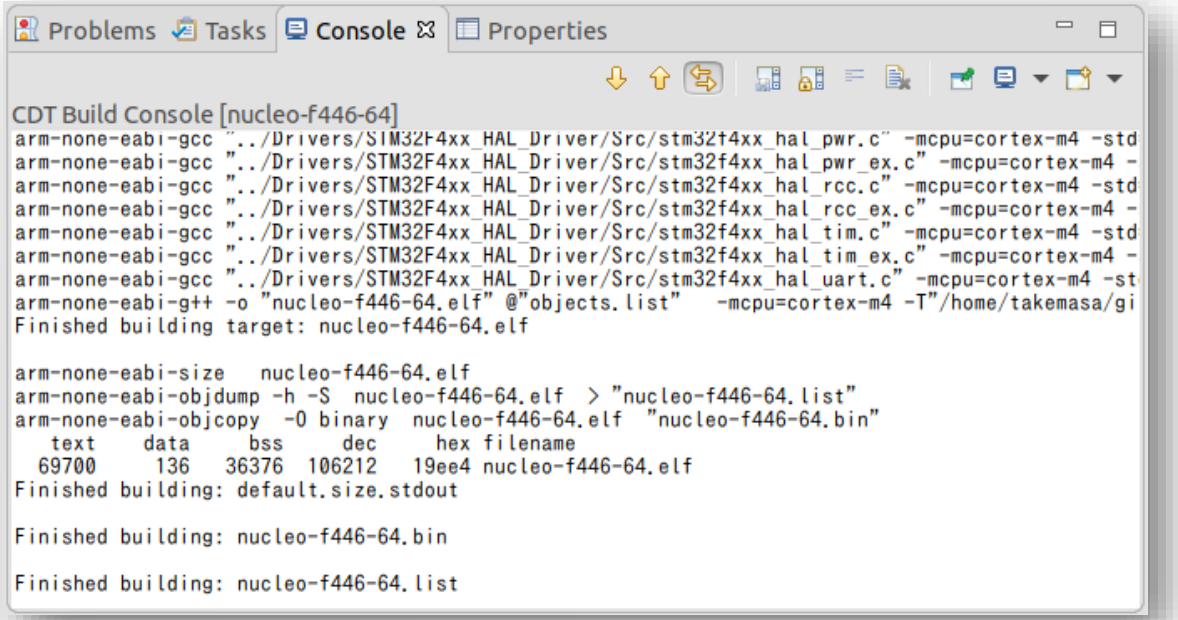
1. Uncheck “Search for nested project”
2. Click “Deselect All”
3. Check desired project.
4. Click “Finish”



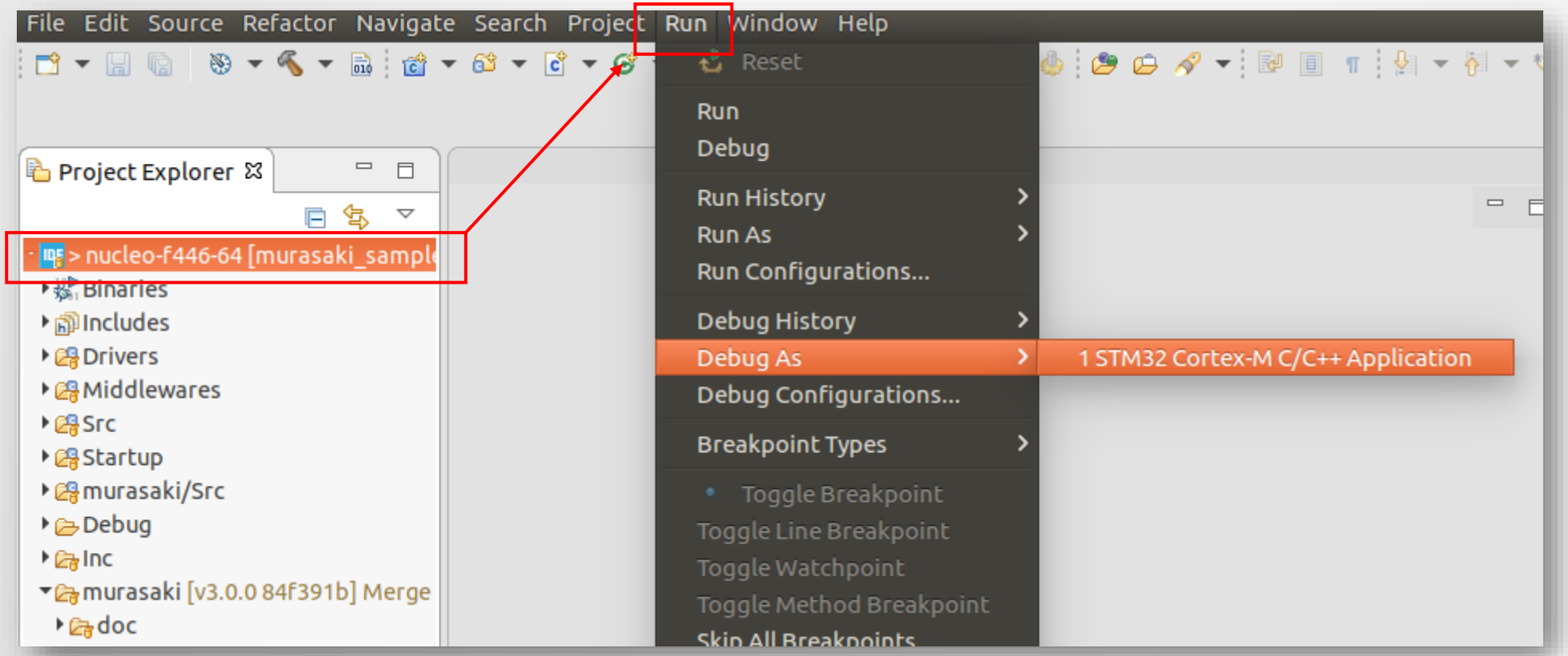
9.TRIAL BUIDL

- Now, we have a sample project in the workspace
- Ctrl-B to build





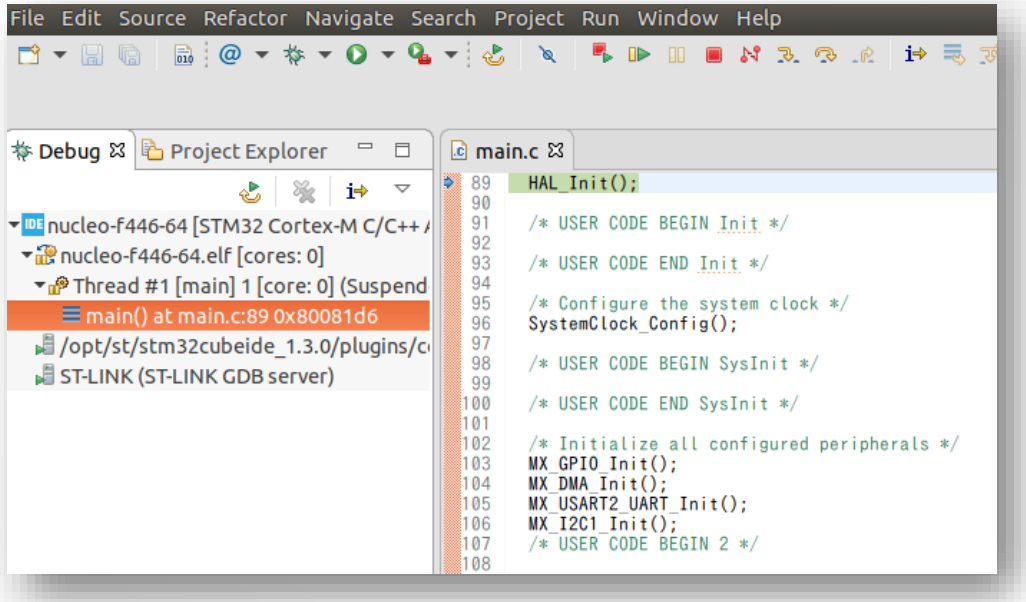
10.START THE DEBUGGER



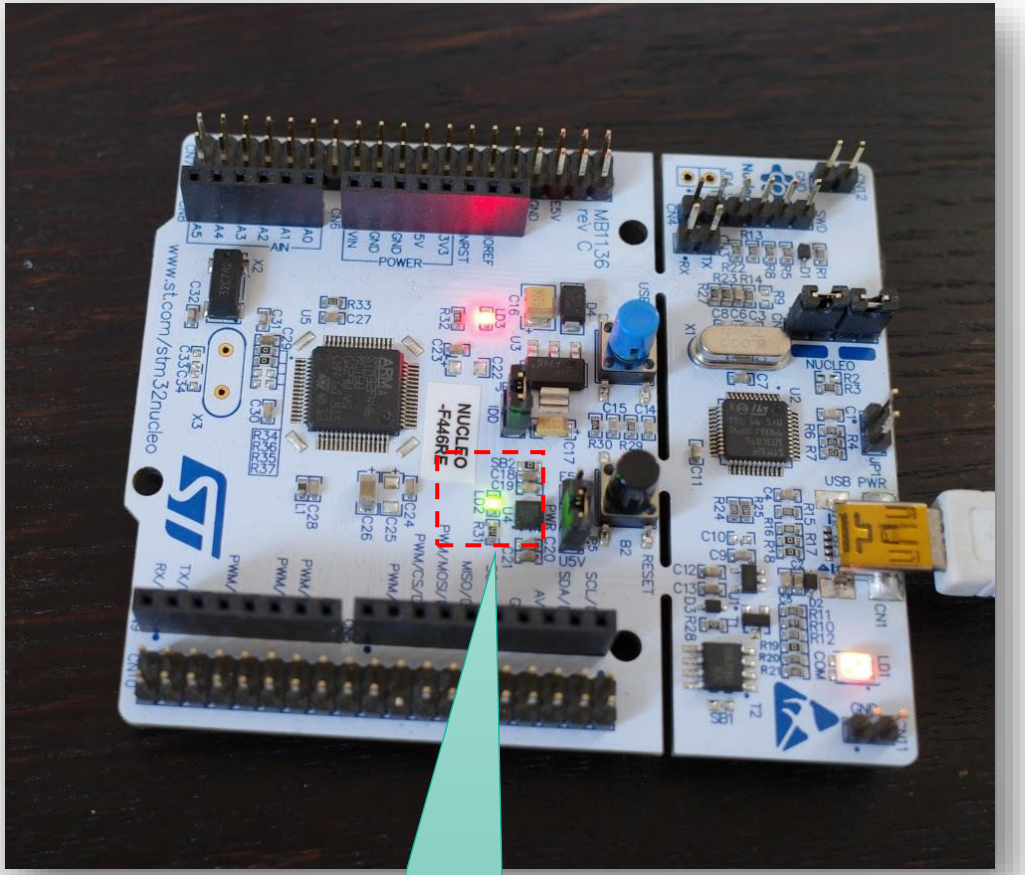
Make sure the Nucleo is connected through USB

11.READY TO RUN

- Make sure a terminal emulator is waiting the serial communication

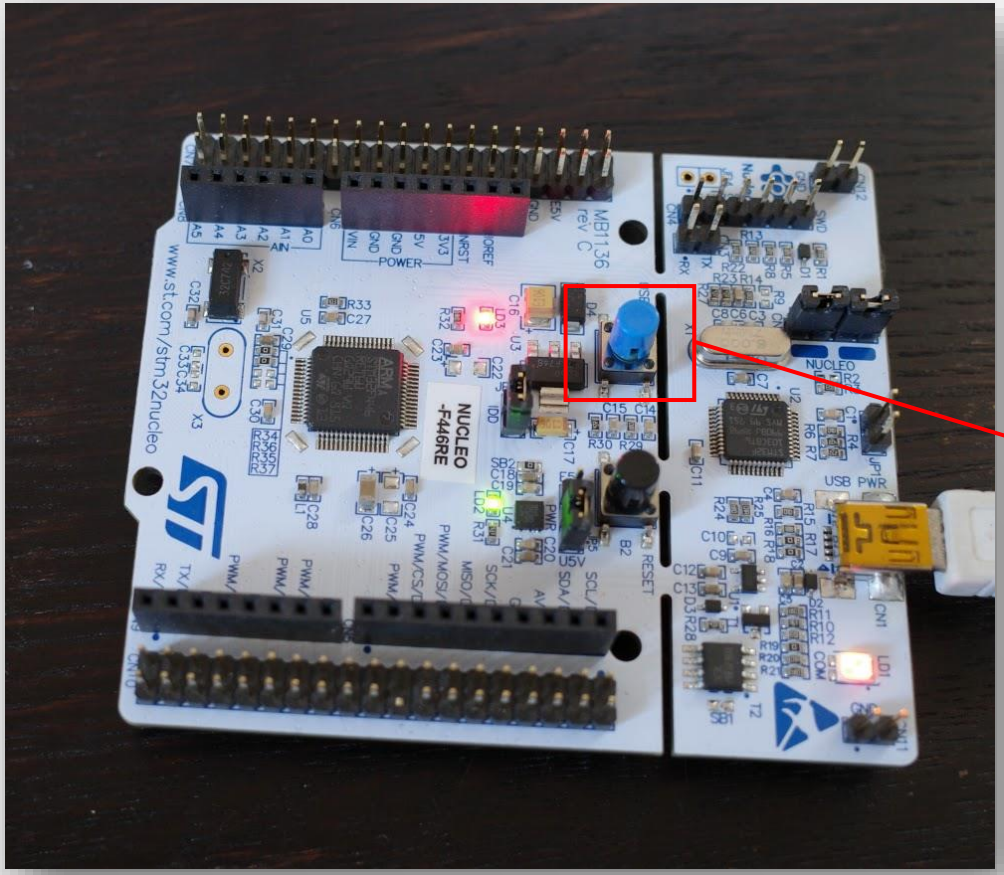


12.RUN THE PROGRAM




```
takemasa@vm: ~/git/shared_foo/script
takemasa@vm:~/git$ cd shared_foo/
takemasa@vm:~/git/shared_foo$ ls
book-introducing-python  halide_study      kica
6
cpp-opencv               jupyter-notebook  mana
takemasa@vm:~/git/shared_foo$ cd script/
takemasa@vm:~/git/shared_foo/script$ ls
configure-github-global  configure-github-local
v2  terminal
takemasa@vm:~/git/shared_foo/script$ ./terminal
C-Kermit 9.0.302 OPEN SOURCE:, 20 Aug 2011, for
 Copyright (C) 1985, 2011,
  Trustees of Columbia University in the City o
Type ? or HELP for help.
(/home/takemasa/git/shared_foo/script/) C-Kermi
Connecting to /dev/stlink_console, speed 115200
 Escape character: Ctrl-\ (ASCII 28, FS): enabl
Type the escape character followed by C to get
or followed by ? to see other options.
----------------------------------------------
WW!!! Push blue button to start the demo
```

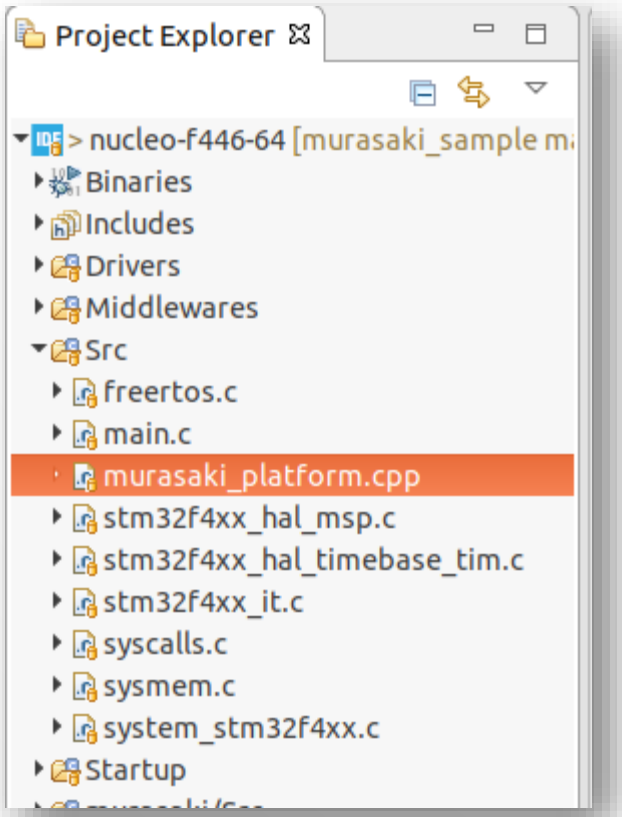
13.PUSH THE BLUE BUTTON



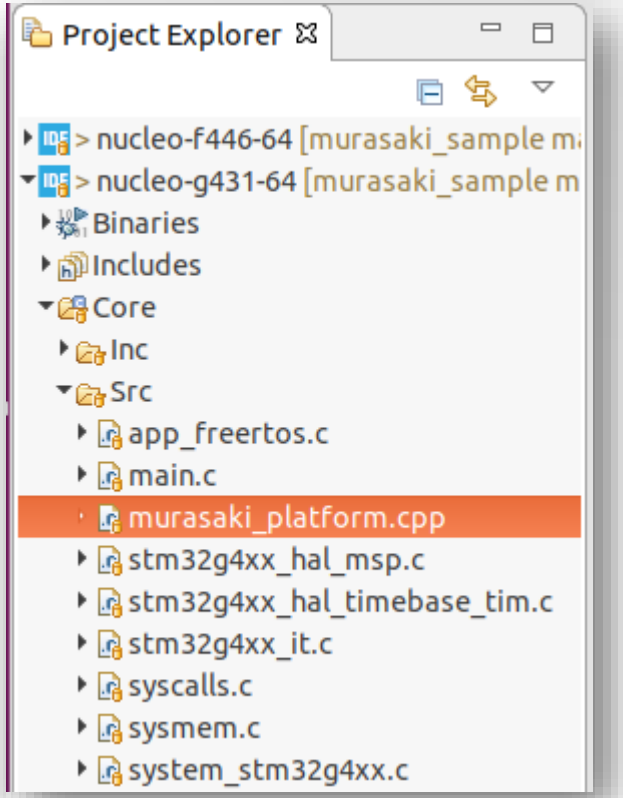

```
takemasa@vm: ~/git/shared_foo/script
(/home/takemasa/git/shared_foo/script/) C-Kermit>c
Connecting to /dev/stlink_console, speed 115200
 Escape character: Ctrl-\ (ASCII 28, FS): enabled
Type the escape character followed by C to get back,
or followed by ? to see other options.
----------------------------------------------------
WW!!! Push blue button to start the demo

            Probing I2C devices
   | 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
---+-------------------------------------------------
 0 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
10 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
Hello 0
Hello 1
Hello 2
```

TWO STRUCTURES OF PROJECT

- The CubeIDE introduce “Advanced Project structure”
- In the “Advanced” structure, the Src directory is under the Core directory.
- Let’s open the murasaki_platform.cpp file



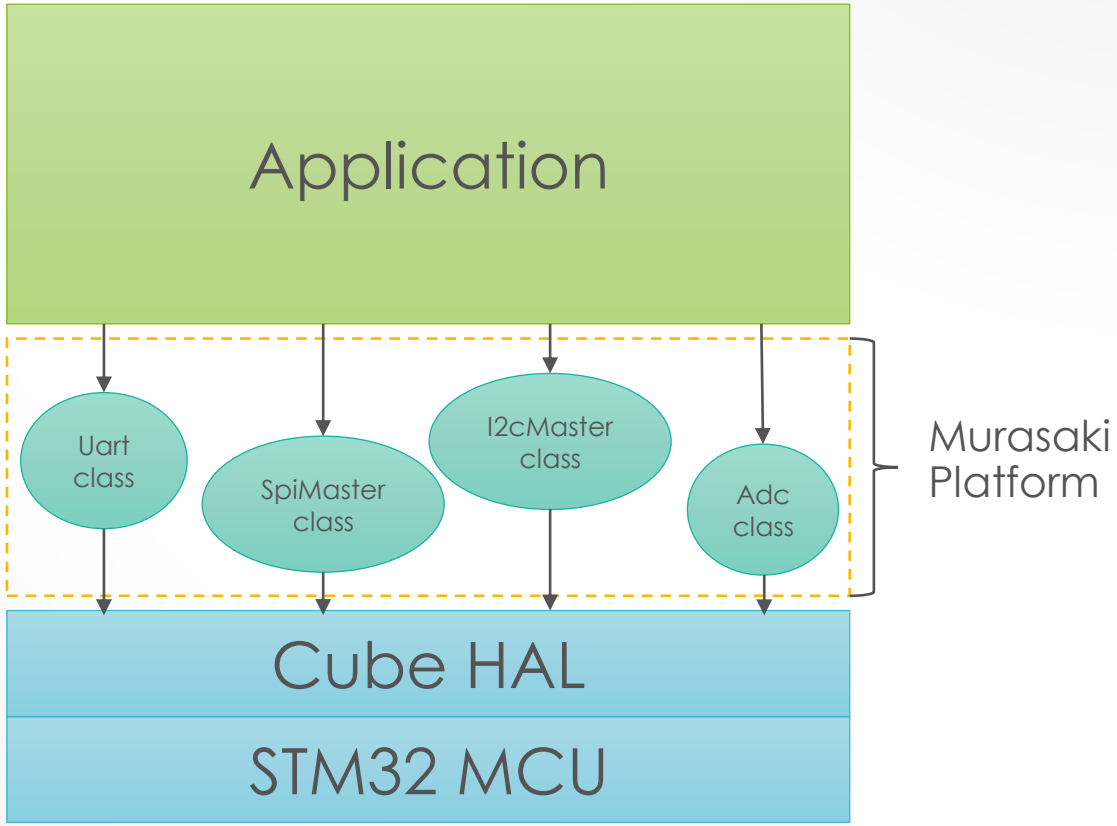
Old structure



Advanced structure

INSIDE MURASAKI_PLATFORM.CPP

- InitPlatform()
  - Initialization of Murasaki
  - Programmer must edit this function to initialize his/her platform
- ExecPlatform()
  - Execution body of application.



INSIDE EXECPLATFORM()

1. Start a new task
2. Print a message
3. Then, wait for the blue button
   1. This task halt here and wait for the interrupt from blue button

```
void ExecPlatform()
{
    // counter for the demonstration.
    int count = 0;

    // Start LED blink
    murasaki::platform.task1->Start();

    // waiting for the Button push.
    murasaki::debugger->Printf("!!! Push blue button to start the demo ¥n");
    murasaki::platform.b1->Wait();

    // List up connected I2C device to the console.
    I2cSearch(murasaki::platform.i2c_master);

    // Loop forever
    while (true) {

        // print a message with counter value to the console.
        murasaki::debugger->Printf("Hello %d ¥n", count);

        // update the counter value.
        count++;

        // wait for a while
        murasaki::Sleep(500);
    }
}
```

1

2

3

```
Type the escape character followed by C to get
or followed by ? to see other options.
----------------------------------------------
!!! Push blue button to start the demo
```

AFTER BUTTON PUSHED

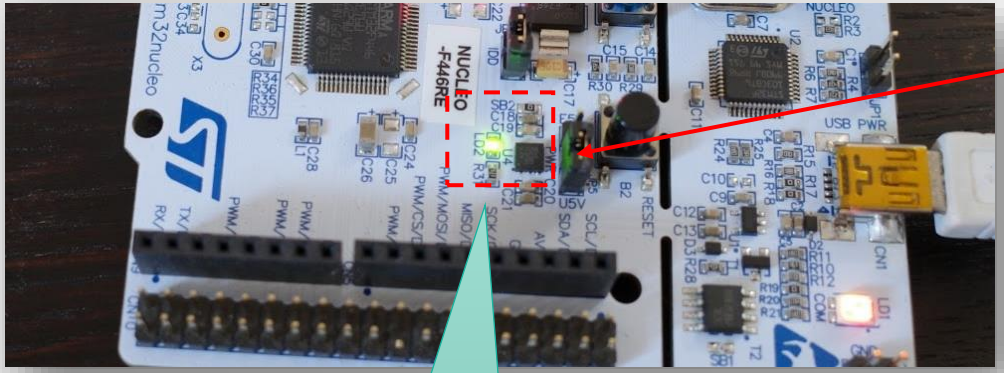
- An utility function I2cSerch() is called.

```
Probing I2C devices
   | 00 01 02 03 04 05 06 07 08 09 0A 0B 0C 0D 0E 0F
---+-------------------------------------------------
 0 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
10 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
20 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
30 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
40 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
50 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
60 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
70 | -- -- -- -- -- -- -- -- -- -- -- -- -- -- -- --
Hello 0
```

```
void ExecPlatform()
{
    // counter for the demonstration.
    int count = 0;

    // Start LED blink
    murasaki::platform.task1->Start();

    // waiting for the Button push.
    murasaki::debugger->Printf("!!! Push blue button to start the demo ¥n");
    murasaki::platform.b1->Wait();

    // List up connected I2C device to the console.
    I2cSearch(murasaki::platform.i2c_master);

    // Loop forever
    while (true) {

        // print a message with counter value to the console.
        murasaki::debugger->Printf("Hello %d ¥n", count);

        // update the counter value.
        count++;

        // wait for a while
        murasaki::Sleep(500);
    }
}
```

INSIDE STARTED TASK

- The started task just blinks LED.




```
140 void TaskBodyFunction(const void *ptr) {
141
142     while (true)  // dummy loop
143     {
144         murasaki::platform.led->Toggle();  // toggling LED
145         murasaki::Sleep(700);
146     }
147 }
```

Blinking

POWER OF NAME SPACE

- Alt-/ shows the candidate of the keywords/identifiers.
- This makes programming easy
- Strict namespace of Murasaki narrowing down the candidate by minimum timing.

```
140⊖ void TaskBodyFunction(const void *ptr) {
141
142     while (true)  // dummy loop
143     {
144         mu
145         mu
146     }
147 }
148
```

- murasaki
- mutable
- # MURASAKI_ASSERT(COND)

```
140⊖ void TaskBodyFunction(const void *ptr) {
141
142     while (true)  // dummy loop
143     {
144         murasaki::
145         murasaki::
146     }
147 }
148
```

- debugger : Debugger *
- platform : Platform

```
140⊖ void TaskBodyFunction(const void *ptr) {
141
142     while (true)  // dummy loop
143     {
?144        murasaki::platform.l
145         murasaki::Sleep(700
146     }
147 }
148
```

- led : BitOutStrategy *
- logger : LoggerStrategy *

```
140⊖ void TaskBodyFunction(const void *ptr) {
141
142     while (true)  // dummy loop
143     {
144         murasaki::platform.led->
145         murasaki::Sleep(700);
146     }
147 }
148
149
150
151
152
```

- Clear(void) : void
- Get(void) : unsigned int
- Match(void * peripheral_handle) : bool
- Set(unsigned int state = 1) : void
- Toggle(void) : void

DEBUG : PRINTF

Let's add Murasaki::debugger->Print() and run

```
102 void ExecPlatform()
103 {
104     // counter for the demonstration.
105     int count = 0;
106
107     // Start LED blink
108     murasaki::platform.task1->Start();
109
110     // waiting for the Button push.
111     murasaki::debugger->Printf("!!! Push blue button to start the d
112     murasaki::platform.b1->Wait();
113
114     murasaki::debugger->Printf("Hello, %d ¥n", 2020);
115
116     // List up connected I2C device to the console.
117     I2cSearch(murasaki::platform.i2c_master);
118
119     // Loop forever
120     while (true) {
121
122         // print a message with counter value to the console.
123         murasaki::debugger->Printf("Hello %d ¥n", count);
124
```

```
Escape character: Ctrl-\ (ASCII 28, FS): enab
Type the escape character followed by C to get
or followed by ? to see other options.
----------------------------------------------
!!! Push blue button to start the demo
Hello, 2020
```

DEBUG : ASSERTION

Let's add Murasaki::debugger->Print() and run

```
102 void ExecPlatform()
103 {
104     // counter for the demonstration.
105     int count = 0;
106
107     // Start LED blink
108     murasaki::platform.task1->Start();
109
110     // waiting for the Button push.
111     murasaki::debugger->Printf("!!! Push blue button to start the demo ¥n");
112     murasaki::platform.b1->Wait();
113
114     MURASAKI_ASSERT(1 == 2)
115
116     // List up connected I2C device to the console.
117     I2cSearch(murasaki::platform.i2c_master);
```

Push button

Debug | Project Explorer

nucleo-f446-64 [STM32 Cortex-M C/C++ A
nucleo-f446-64.elf [cores: 0]
Thread #1 [main] 1 [core: 0] (Suspend
HardFault_Handler() at stm32f4xx_i
<signal handler called>() at 0xfffffff
prvPortStartFirstTask() at port.c:26
xPortStartScheduler() at port.c:379
/opt/st/stm32cubeide_1.3.0/plugins/c
ST-LINK (ST-LINK GDB server)

Resume again

```
takemasa@vm: ~/git/shared_foo/script
!!! Push blue button to start the demo
--------------------
!! Assertion failure in function ExecPlatform(), at line 114 of file murasaki_platform.cpp !!
Fail expression : 1 == 2

Spurious exception or hardfault occured.
Stacked R0  : 0x00000000
Stacked R1  : 0xFFFFFFFD
Stacked R2  : 0x00000000
```

DEBUG : SYSLOG

Let's add Murasaki::SetSyslogFacilityMask() and SetSyslogSeverityThreshold()

```
102⊖ void ExecPlatform()
103  {
104      // counter for the demonstration.
105      int count = 0;
106
107      // Start LED blink
108      murasaki::platform.task1->Start();
109
110      murasaki::SetSyslogFacilityMask(murasaki::kfaExti);
111      murasaki::SetSyslogSererityThreshold(murasaki::kseDebug);
112
113      // waiting for the Button push.
114      murasaki::debugger->Printf("!!! Push blue button to start the der
115      murasaki::platform.b1->Wait();
116
117      // List up connected I2C device to the console.
118      I2cSearch(murasaki::platform.i2c master);
```

```
takemasa@vm: ~/git/shared_foo/script
                                                !!! Push blue button to start the demo
    66164, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  199, Wait(): Enter
557825001, 0, kfaExti, kseDebug: exti.cpp, line  256, isReady(): Enter
557837878, 0, kfaExti, kseDebug: exti.cpp, line  264, isReady(): Exit with true
557851576, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  238, Match(): Enter
557864315, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  241, Match(): Matched. Exit with true
557878601, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  218, Release(): Enter
557891519, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  238, Match(): Enter
557904255, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  241, Match(): Matched. Exit with true
557918800, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  221, Release(): Matched and release
557933484, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  225, Release(): Exit with true.
557951601, 0x200023e8, kfaExti, kseDebug: exti.cpp, line  211, Wait(): Exit with 0
```

DEBUG : TASK STACK HEADROOM

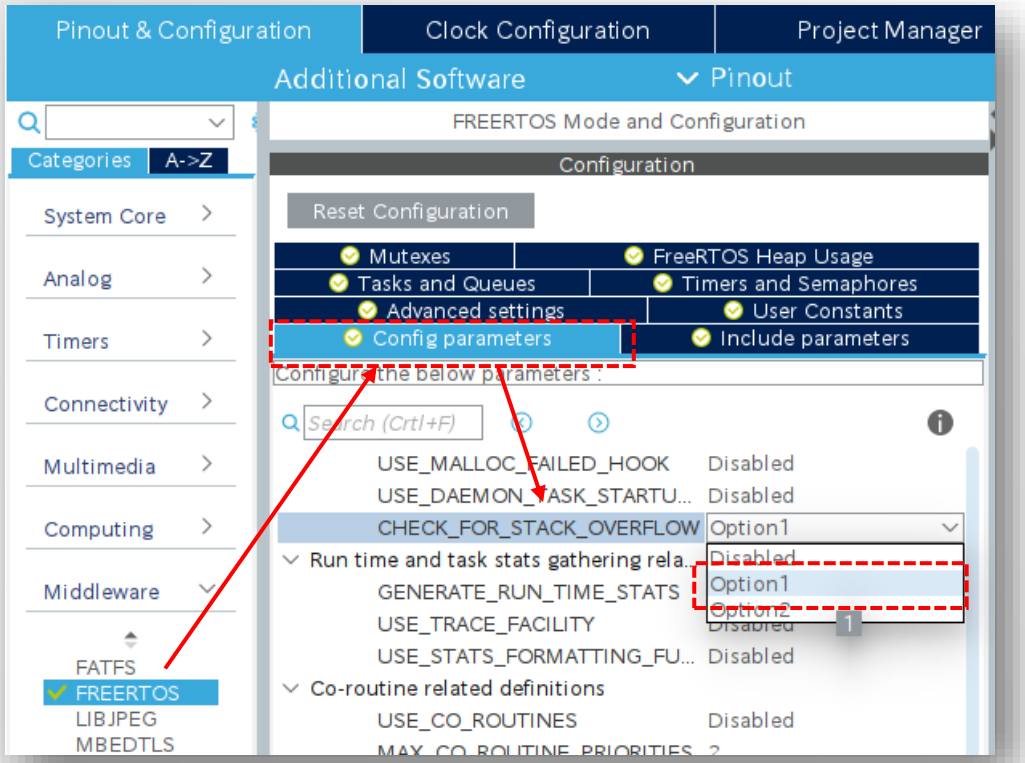
Let's add member functions of TaskStrategy class

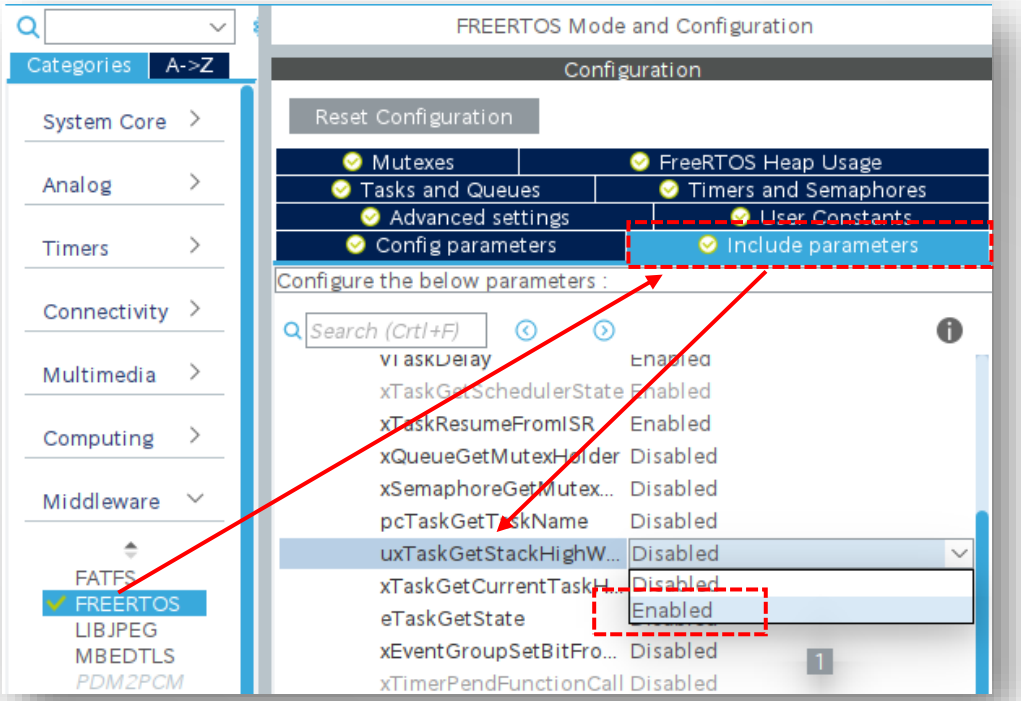
```
102 void ExecPlatform()
103 {
104     // counter for the demonstration.
105     int count = 0;
106
107     // Start LED blink
108     murasaki::platform.task1->Start();
109
110     // waiting for the Button push.
111     murasaki::debugger->Printf("!!! Push blue button to start the demo ¥n");
112     murasaki::platform.b1->Wait();
113
114     int depth = murasaki::platform.task1->getStackDepth();
115     int head_room = murasaki::platform.task1->getStackMinHeadroom();
116     murasaki::debugger->Printf("Stack headroom is %d/%d ¥n",
117                                head_room,
118                                depth);
```

```
takemasa@vm: ~/git/shared_foo/script
!!! Push blue button to start the demo
Stack headroom is -1/256
```

-1 ?

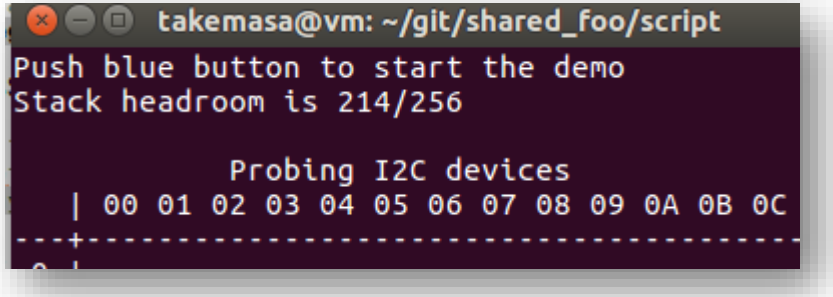
WE NEED ADDITIONAL SETTINGS





RESULT OF TASK HEADROOM

- We can see the “rest of stack” for each task.
- The unit is byte.
- Check FreeRTOS Configuration for details :
  - configCHECK_FOR_STACK_OVERFLOW



DEBUG : HARD FAULT

```
102 void ExecPlatform()
103 {
104     // counter for the demonstration.
105     int count = 0;
106
107     // Start LED blink
108     murasaki::platform.task1->Start();
109
110     // waiting for the Button push.
111     murasaki::debugger->Printf("!!! Push blue button to sta
112     murasaki::platform.b1->Wait();
113
114     typedef void (*FUNCTYPE)(void);
115
116     FUNCTYPE funcPtr = reinterpret_cast<FUNCTYPE>(0);
117     funcPtr();
118
119     // List up connected I2C device to the console.
120     I2cSearch(murasaki::platform.i2c_master);
121
122     // Loop forever
```

```
takemasa@vm: ~/git/shared_foo/script
!!! Push blue button to start the demo

Spurious exception or hardfault occured.
Stacked R0  : 0x00000000
Stacked R1  : 0x00000000
Stacked R2  : 0x00000007
Stacked R3  : 0x00000000
Stacked R12 : 0xA5A5A5A5
Stacked LR  : 0x080087F7
Stacked PC  : 0x00000000
Stacked PSR : 0x40000000
       CFSR : 0x00020000
       HFSR : 0x40000000
       DFSR : 0x00000000
       AFSR : 0x00000000
       MMAR : 0xE000ED34
       BFAR : 0xE000ED38
(Note : To avoid the stacking by C compiler, use rele
```

DOCUMENTATION

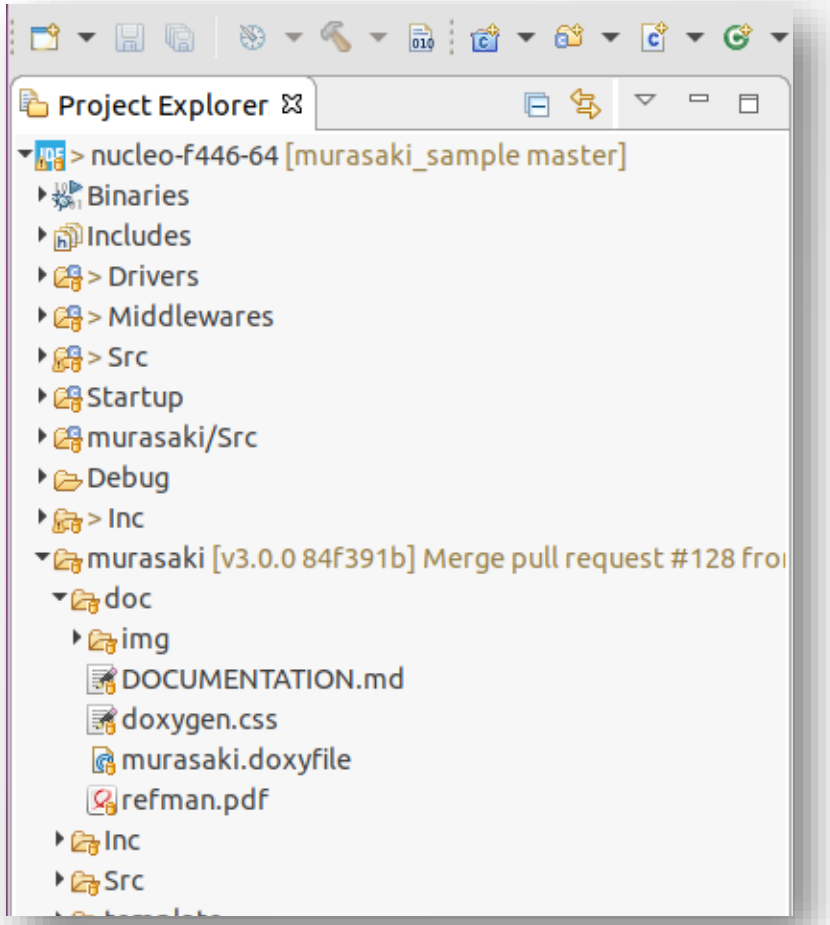
Photo by Debby Hudson on Unsplash

IN THIS SECTION

- Location of PDF document
- Making Doxygen document
- Tour of Doxygen document
- WIKI

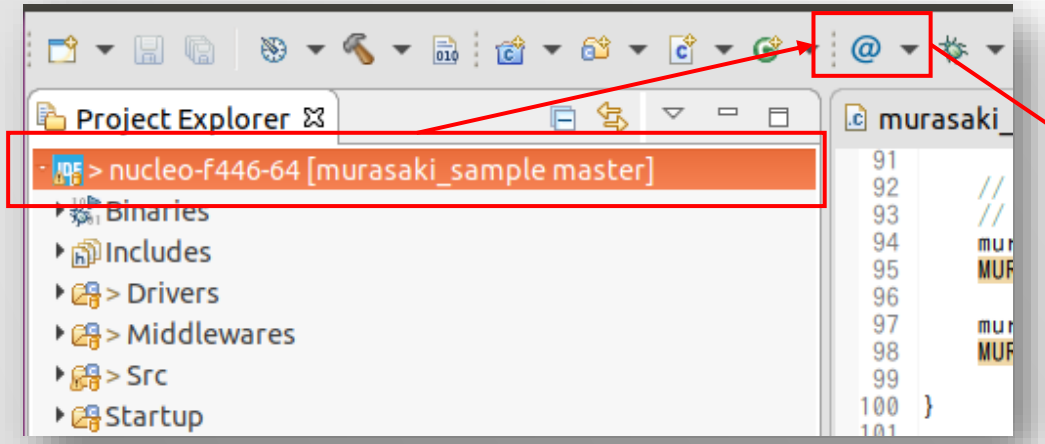
LOCATION OF PDF DOCUMENT

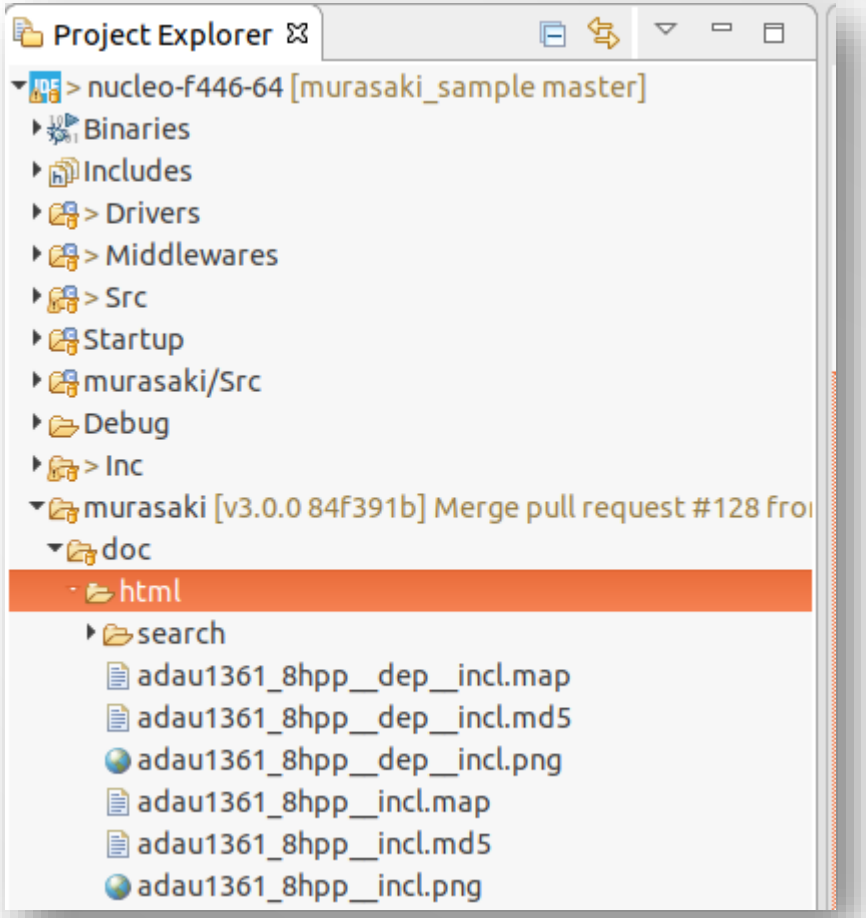
- murasaki/doc
- PDF document is same contents with HTML document
- Just a matter of format



MAKING DOXYGEN DOCUMENT

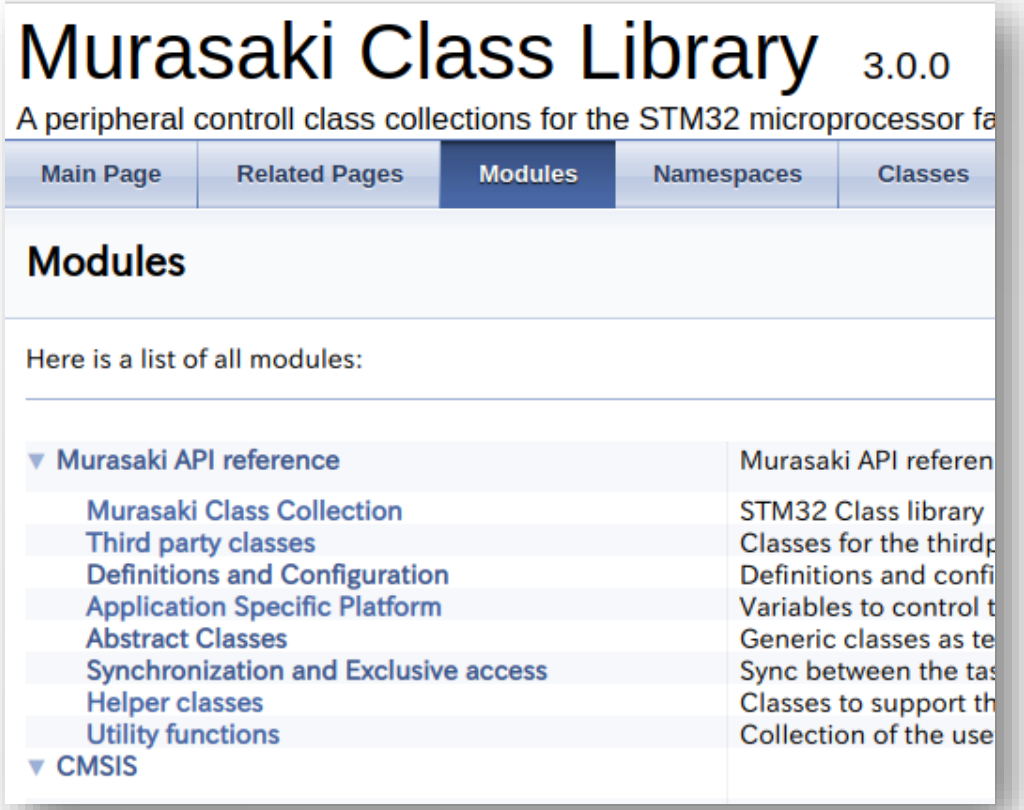
Install Eclox, to create the document





HTML DOCUMENTATION

- Classes and Functions are grouped by “Module”
- “Murasaki Class Collection” module is a list of the peripheral classes.
  - Usually, application programmer uses classes in this module.



MURASAKI CLASS COLLECTION

- Peripheral like UART, SPI, I2C, ADC, GPIO, SAI, I2S are controlled by these classes.
- Algorithm class like SimpleTask or DuplexAudio are also listed here.

Murasaki Class Library 3.0.0

A peripheral controll class collections for the STM32 microprocessor family

Main Page | Related Pages | Modules | Namespaces | Classes | Files

Murasaki Class Collection

Murasaki API reference

STM32 Class library. More...

Collaboration diagram for Murasaki Class Collection:

Murasaki API reference ← Murasaki Class

Classes

class	murasaki::Adc STM32 dedicated ADC class. More...
class	murasaki::BitIn General purpose bit input. More...
class	murasaki::BitOut General purpose bit output. More...
class	murasaki::Debugger Debug class. Provides printf() style output for both task and ISR context. More...
class	murasaki::DuplexAudio Stereo Audio is served by this class. More...
class	murasaki::Exti EXTI wrapper class. More...
class	murasaki::I2cMaster Thread safe, synchronous, and blocking IO. Encapsulating I2C master. Based on ST

DEFINITIONS AND CONFIGURATION

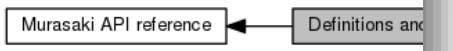
- These macros configures Murasaki
  - Buffer size
  - Use of Debug
- To change the configuration, define these macros in the platform_config.hpp

Definitions and Configuration

Murasaki API reference

Definitions and configuration collection of murasaki platform. More...

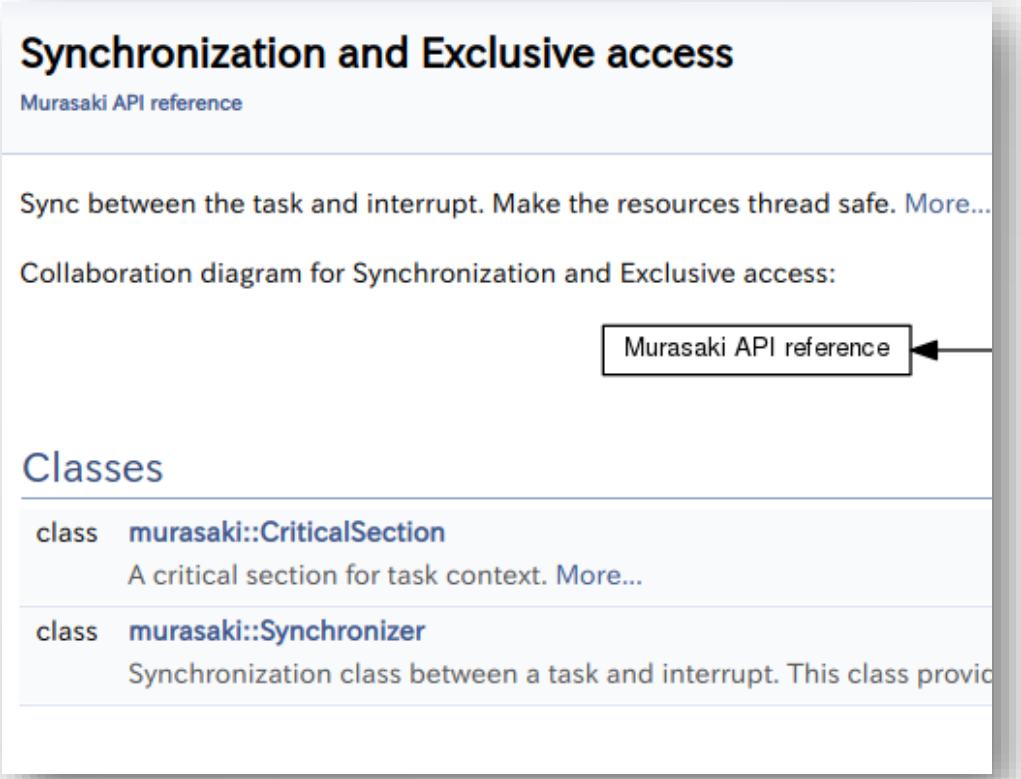
Collaboration diagram for Definitions and Configuration:



#define	PLATFORM_CONFIG_DEBUG_LINE_SIZE 256 Size of one line[byte] in the debug printf. More...
#define	PLATFORM_CONFIG_DEBUG_BUFFER_SIZE 4096 Size[byte] of the circular buffer to be transmitted through the serial port. More
#define	PLATFORM_CONFIG_DEBUG_SERIAL_TIMEOUT (murasaki::kwmsIndefinitely Timeout of the serial port to transmit the string through the Debug class. More
#define	PLATFORM_CONFIG_DEBUG_TASK_STACK_SIZE 256 Size[Byte] of the task inside Debug class. More...
#define	PLATFORM_CONFIG_DEBUG_TASK_PRIORITY murasaki::ktpHigh The task proiority of the debug task. More...
#define	MURASAKI_CONFIG_NODEBUG false Suppress MURASAKI_ASSERT macro. More...
#define	MURASAKI_CONFIG_NOCYCCNT false Doesn't run the CYCCNT counter. More...
#define	NUM_OF_CALLBACK_OBJECTS 8 The number of the interrupt callback handling objects. More...
#define	NUM_OF_EXTI_OBJECTS 8 The number of the EXTI callback handling objects. More...

SYNCHRONIZATION AND EXCLUSIVE ACCESS

- Inter-task synchronization
- Interrupt vs. task Synchronization
- Inter-task exclusive acsses.



Synchronization and Exclusive access

Murasaki API reference

Sync between the task and interrupt. Make the resources thread safe. More...

Collaboration diagram for Synchronization and Exclusive access:

Murasaki API reference

Classes

class **murasaki::CriticalSection**
A critical section for task context. More...

class **murasaki::Synchronizer**
Synchronization class between a task and interrupt. This class provid

UTILITY FUNCTIONS

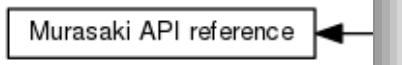
- Cycle counter control
- I2C device search
- Other functionality may added

Utility functions

Murasaki API reference

Collection of the useful functions. More...

Collaboration diagram for Utility functions:



Functions

void	murasaki::I2cSearch (murasaki::I2cMasterStrategy *master) I2C device serach function. More...
void	murasaki::InitCycleCounter () Initialize and start the cycle counter. More...
unsigned int	murasaki::GetCycleCounter () Obtain the current cycle count of CYCCNT register. More...

USAGE GUIDES

- Beside of APIs, Murasaki has different aspect of documents.
  - Usage Introduction
  - Program flow explanation
  - Porting Guide

Main Page | Related Pages | Module

Related Pages

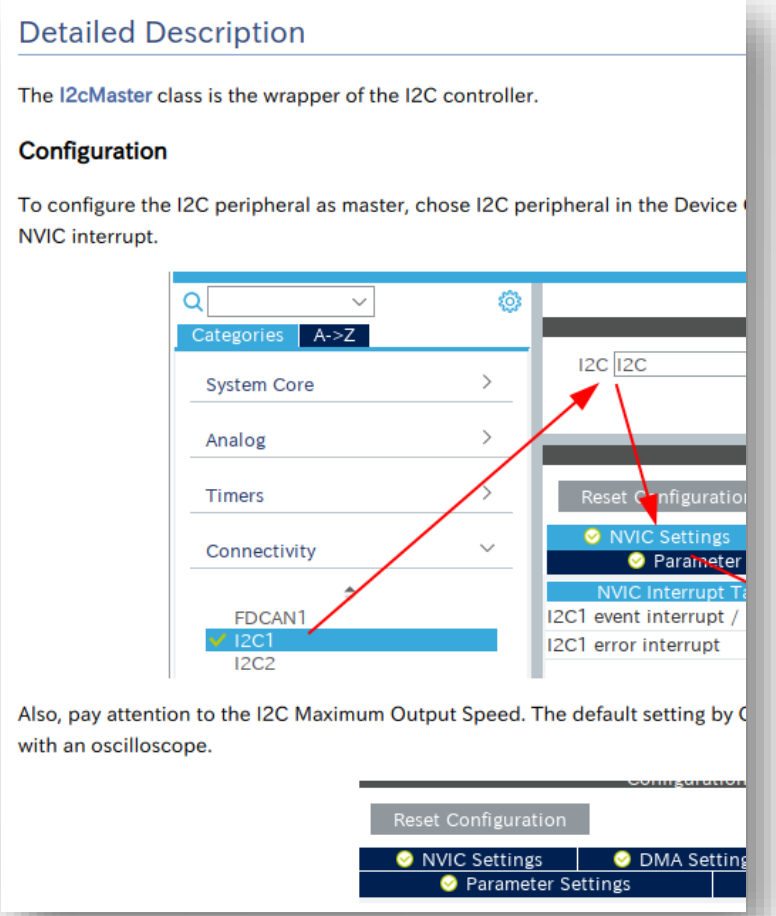
Here is a list of all related documentation pa

- Preface
  - Simplified IO
  - Preemptive multi-task
  - Synchronous IO
  - Thread-safe IO
  - Versatile printf() logger
  - Guard by assertion
  - System Logging
  - Configurable
- Target and Environment
- Usage Introduction
  - Message output
  - Serial communication
  - Debugging with Murasaki.
  - Tasking
  - Other peripherals
    - I2C Master
    - I2C Slave
    - SPI Master
    - SPI Slave
    - GPIO
    - Duplex Audio
- Program flow

- Program flow
  - Application flow
  - HAL Assertion flow
  - Spurious Interrupt flow
  - Assertion flow
  - General Interrupt flow
  - EXTI flow
- Porting guide
  - Directory Structure
  - CubeIDE setting
    - Heap Size
    - Stack Size
    - Task stack size of the default task
    - UART peripheral
    - SPI Master peripheral
    - SPI Slave peripheral
    - I2C peripheral
    - EXTI
  - Configuration
  - Task Priority and Stack Size
  - Heap memory consideration
  - Platform variable
  - Routing interrupts
  - Error handling
  - Summary of the porting

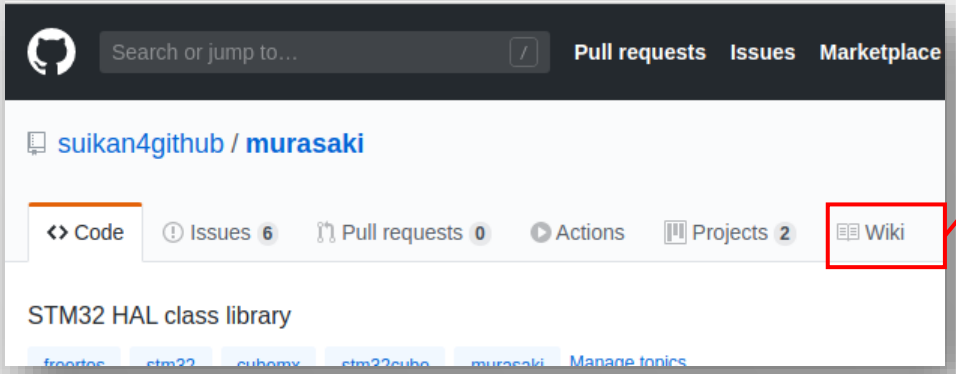
CONFIGURATION OF PERIPHERAL

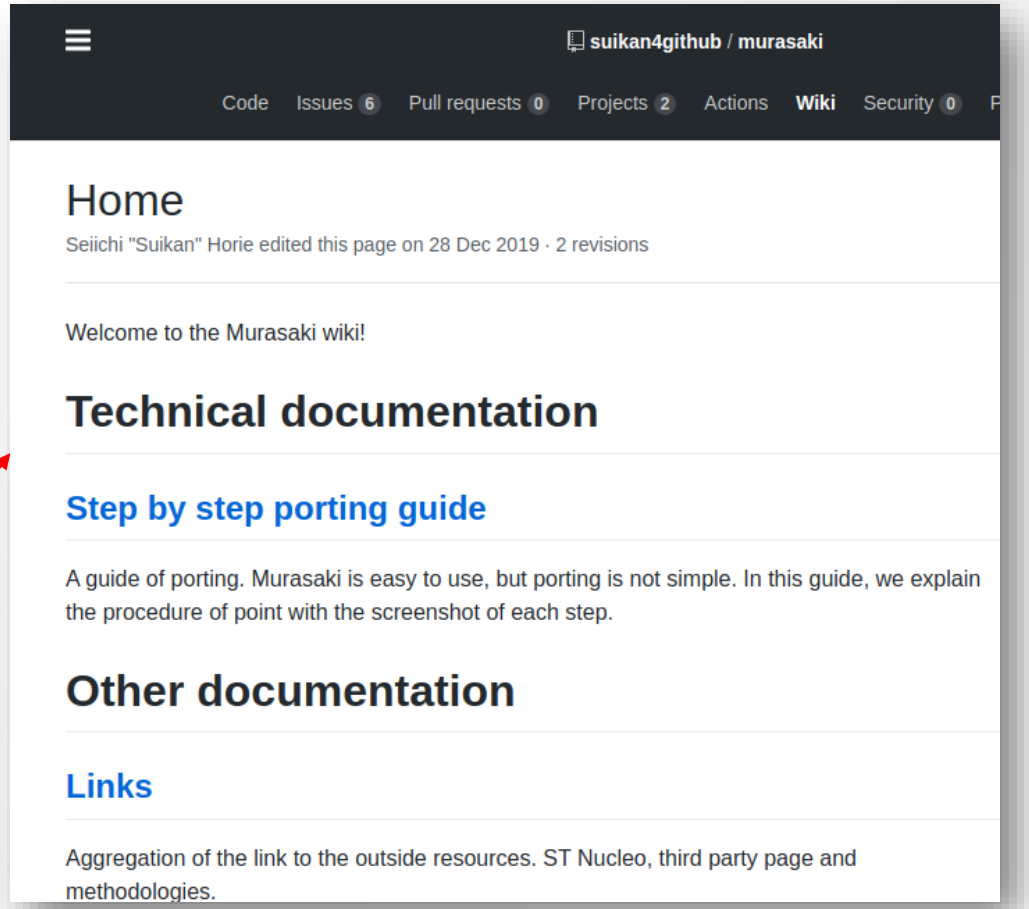
- Also, each peripheral class describes :
  - How to configure the device
  - Interrupt handling
  - IO operations



WIKI

- Murasaki project has its own wiki.
- Supplemental information will be placed here





HOW TO CREATE YOUR OWN APPLICATION

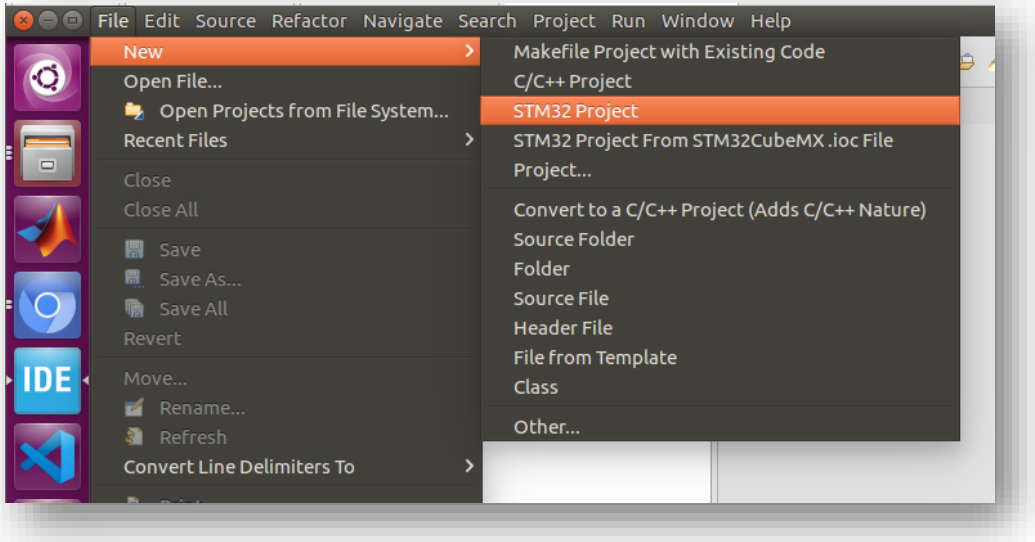
Photo by Sneaky Elbow on Unsplash

IN THIS SECTION

- Create a new project to your Nucleo
- Configure the device by CubeIDE Device Configuration Tool
- Clone Murasaki into the project
- Install Murasaki
- Set up the project to use Murasaki
- Build
- Adjust to the target Nucleo

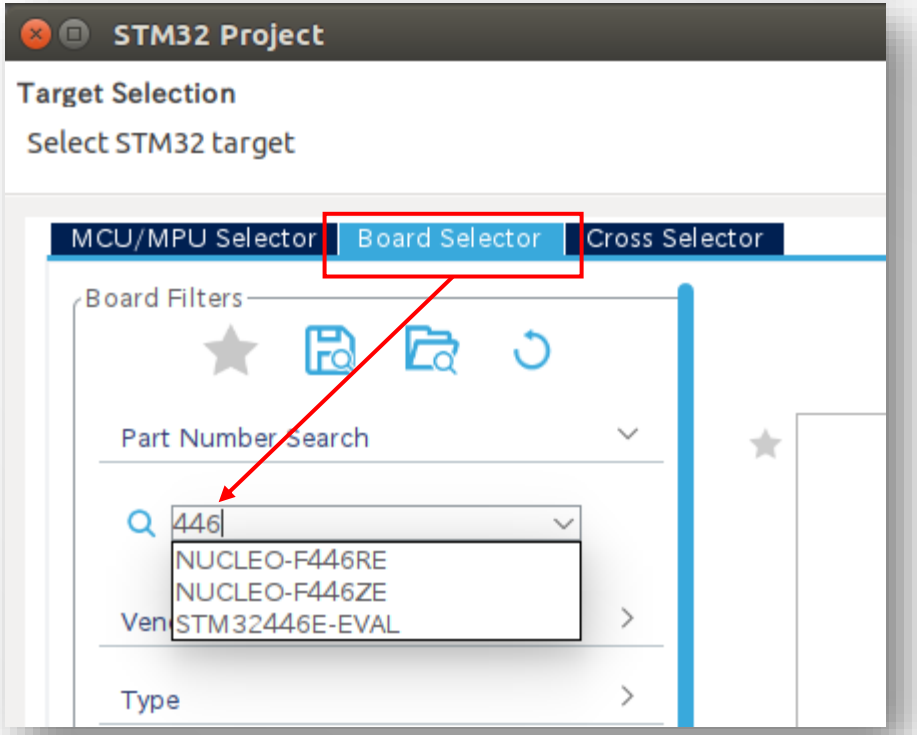
CREATE AN C++ PROJECT FOR YOUR NUCLEO

- First of all, create a new STM32 Project into your work space.
- File -> New -> STM32 Project



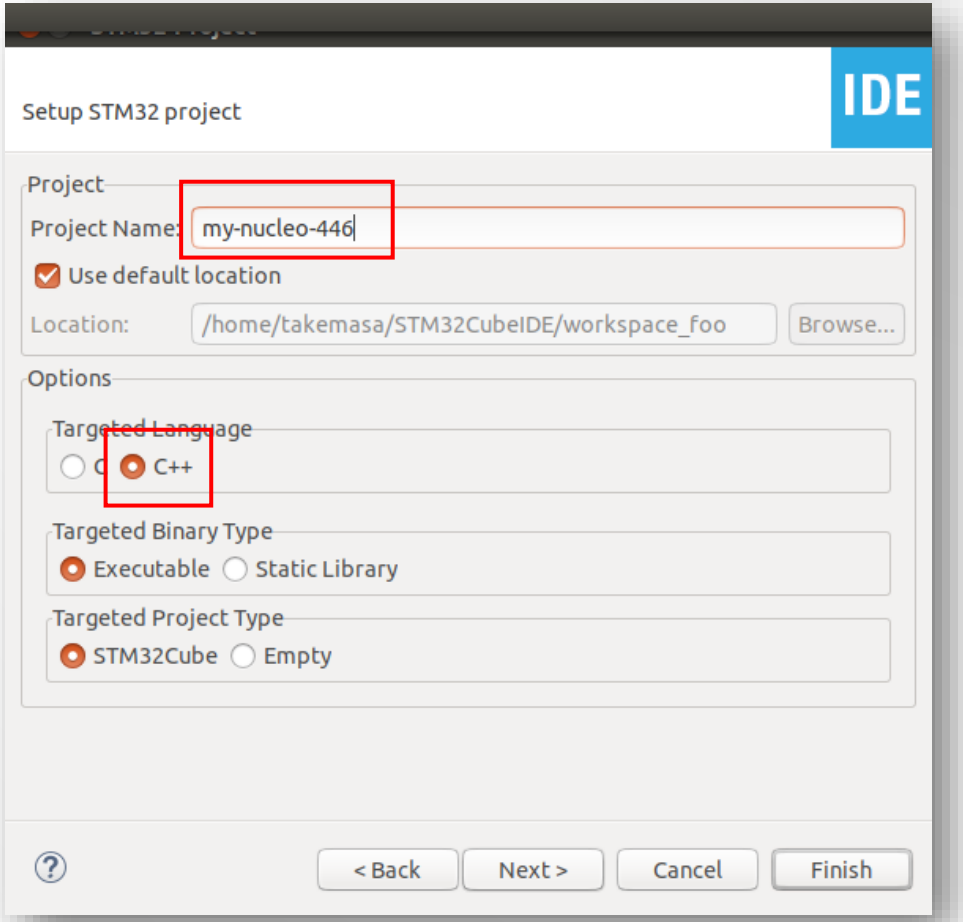
SPECIFY THE CORRECT NUCLEO NAME

- Follow the procedure :
  1. Select board selector
  2. Type the name of the Nucleo to the Number search
  3. Select correct Nucleo board
  4. Then, click “Next”



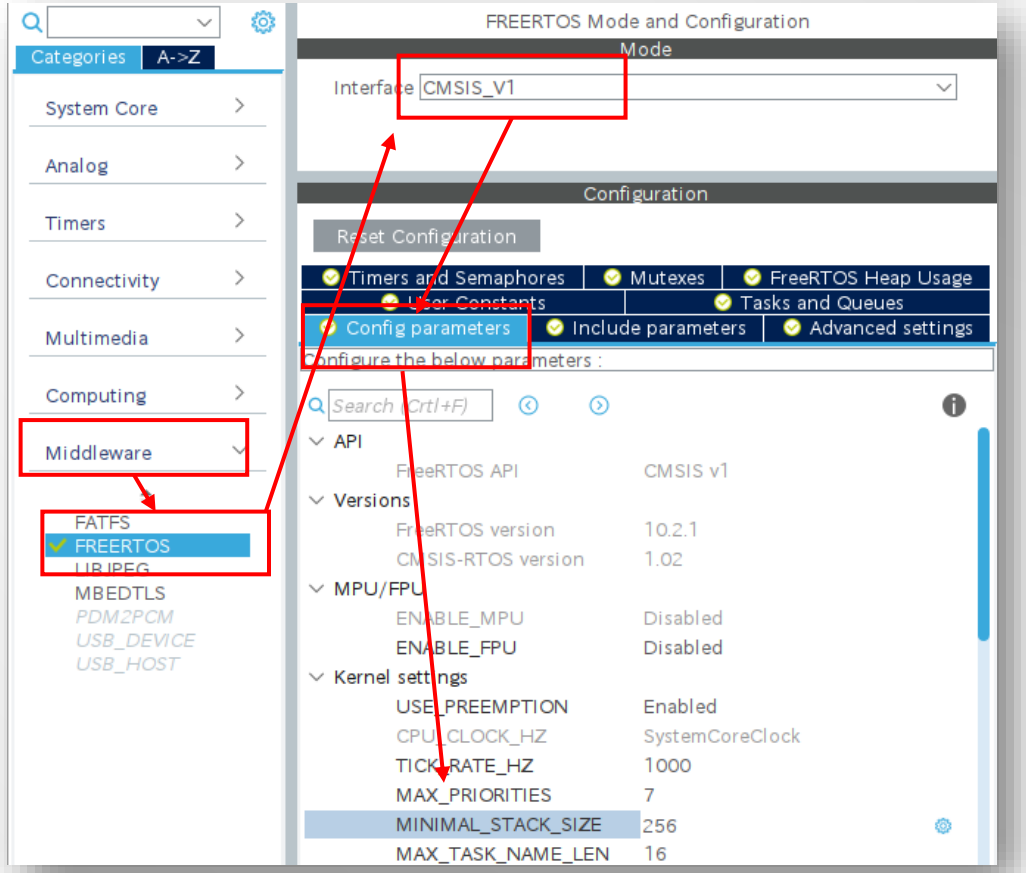
SPECIFY THE PROJECT NAME

- Follow the procedure :
  1. Specify the name in to “Project Name”
  2. Make sure to select the “C++” as the Target Language
  3. Then click “Finish”
  4. Regarding the default pin state and Eclipse perspective, click OK for a while
  5. Now, the Device Configuration Tool appears



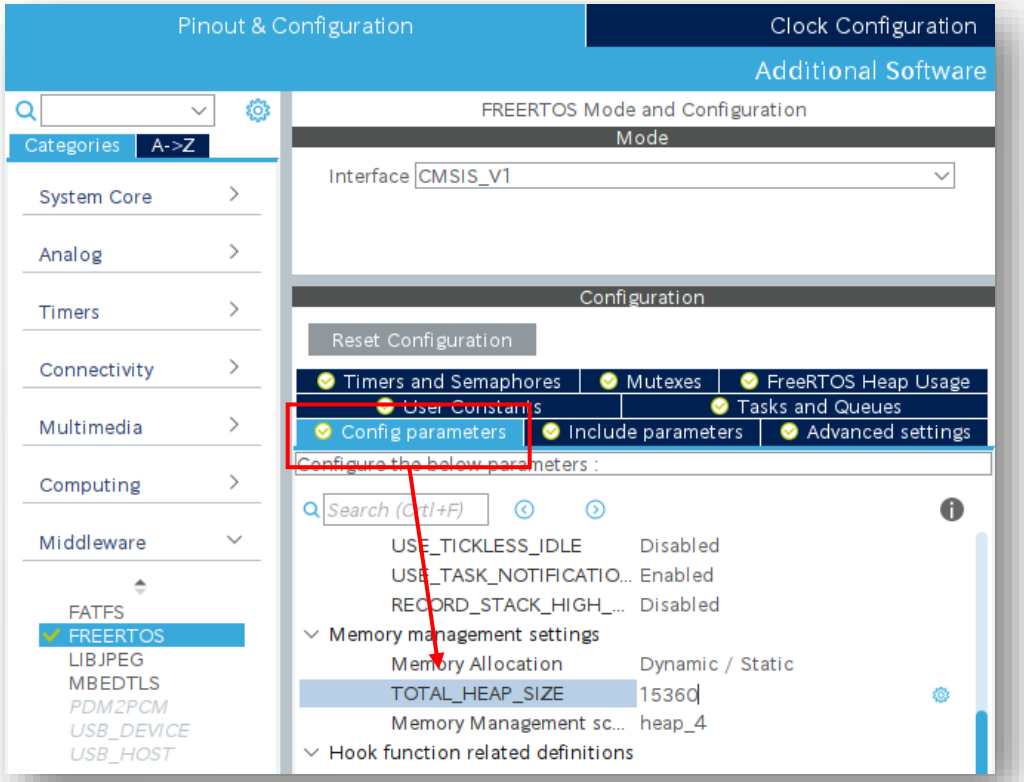
CONFIGURE THE FREERTOS

- Choose CMSIS_V1 as FreeRTOS interface.
- Set the Minimal_stack_size as 256
  - This will increase the stack size of the default task



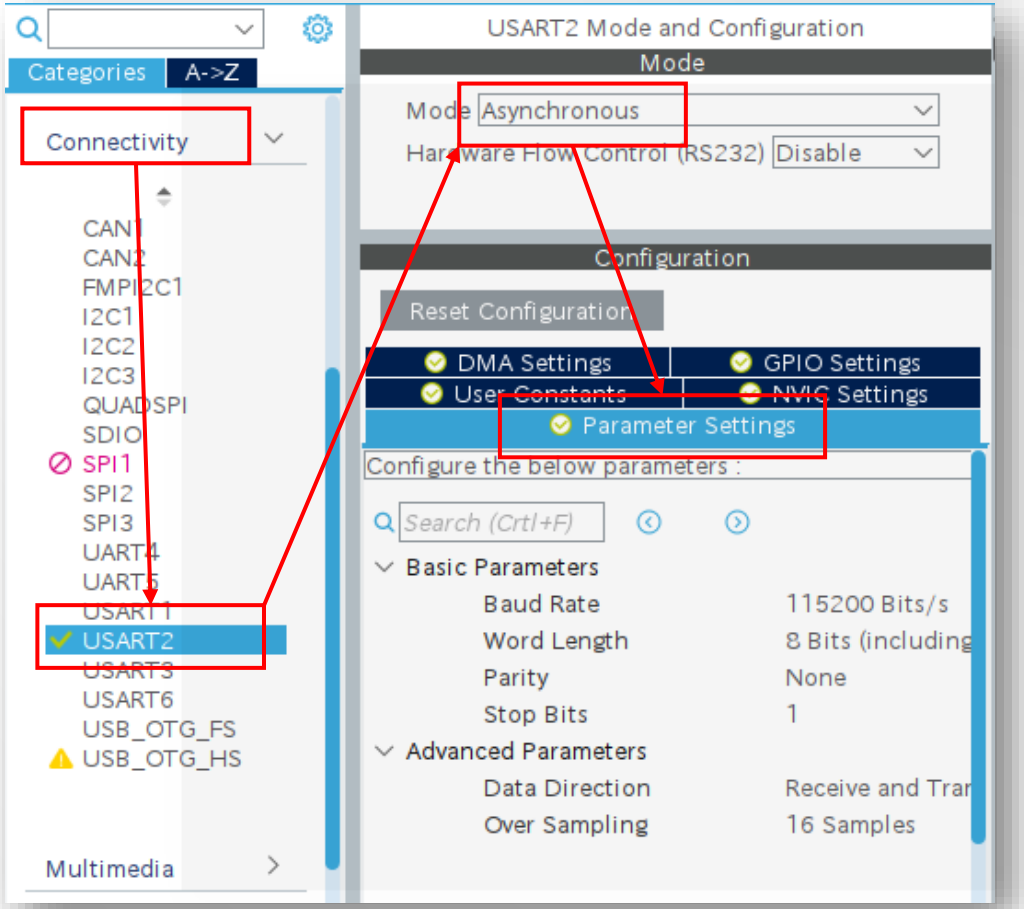
CONFIGURE THE HEAP SIZE

- Set TOTAL_HEAP_SIZE 12kB or more.
- Murasaki uses FreeRTOS heap for all activity.
- At least 12kB is require.



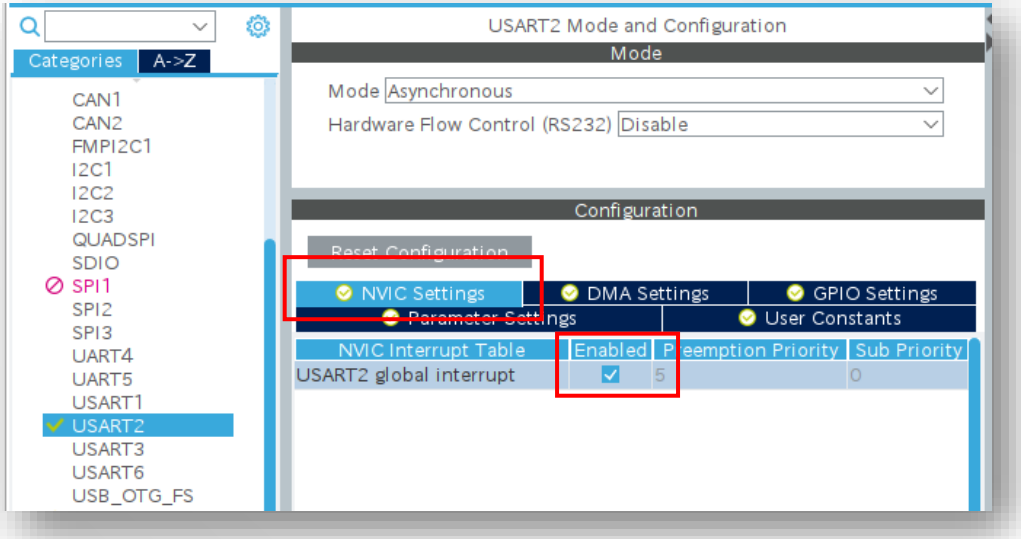
CONFIGURE THE UART

- Nucleo Uses one UART as USB serial port.
- The port is up to the Nucleo
  - UART
  - USART
  - LPUSART
- By default, appropriate port is asynchronous, by CubeIDE
- Make sure the parameters are:
  - 115200bps
  - 8bit
  - No parity
  - 1 stop bit



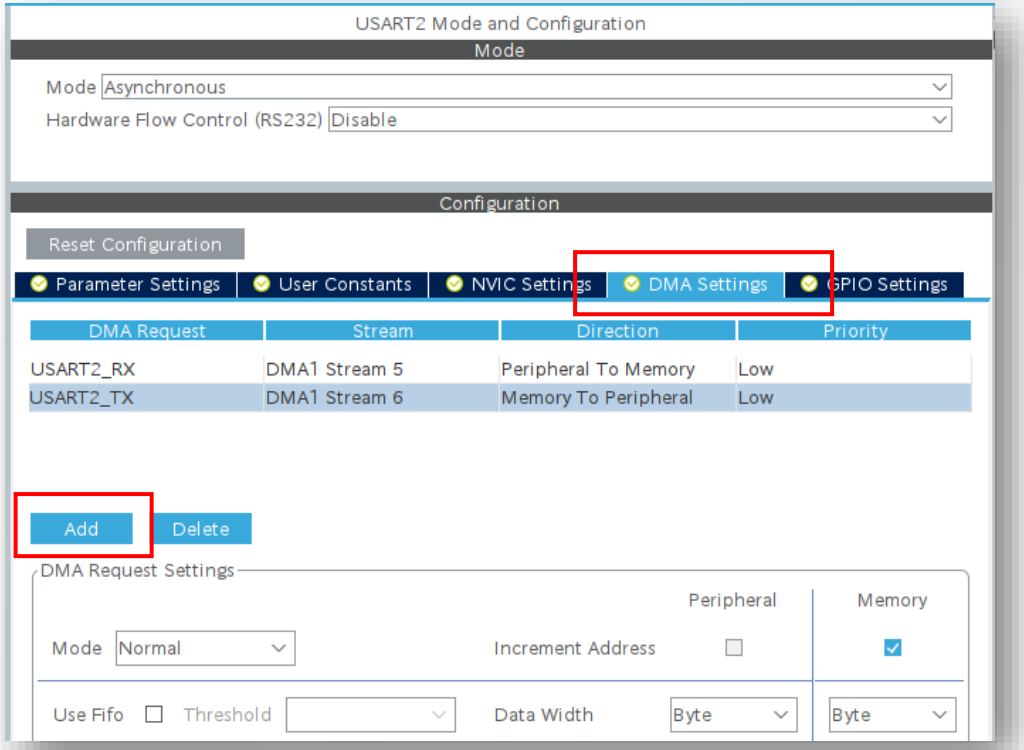
CONFIGURE THE UART NVIC

- Check the Global interrupt



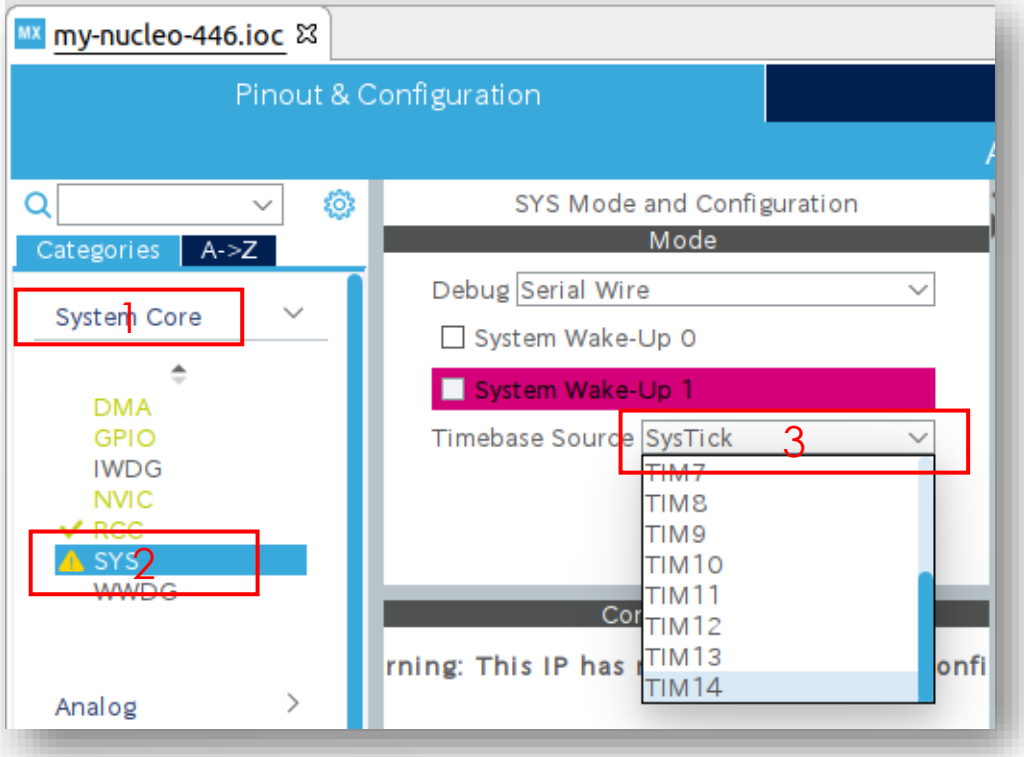
CONFIGURE THE UART DMA

- Follow procedure :
  1. Select the DMA settings
  2. Add a DMA
  3. Configure it as TX
  4. Add one more DMA
  5. Configure it as RX
  6. Leave the Mode and Width as default
     - Normal
     - Byte



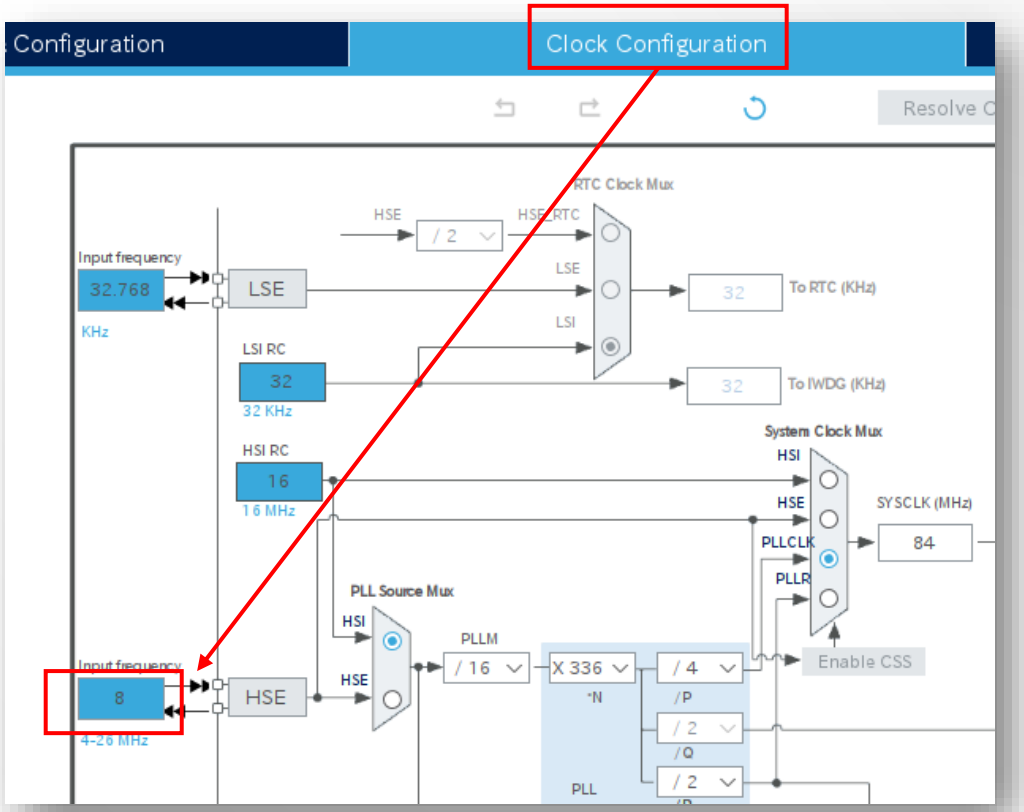
CHANGE THE TIME BASE

- QubeHAL uses its own time base
  - By default, this time base is SysTick
  - Also FreeRTOS uses it.
- Follow the procedure :
  1. Select “System Core”
  2. Select “SYS”
  3. Choose any Timebase Source except SysTick



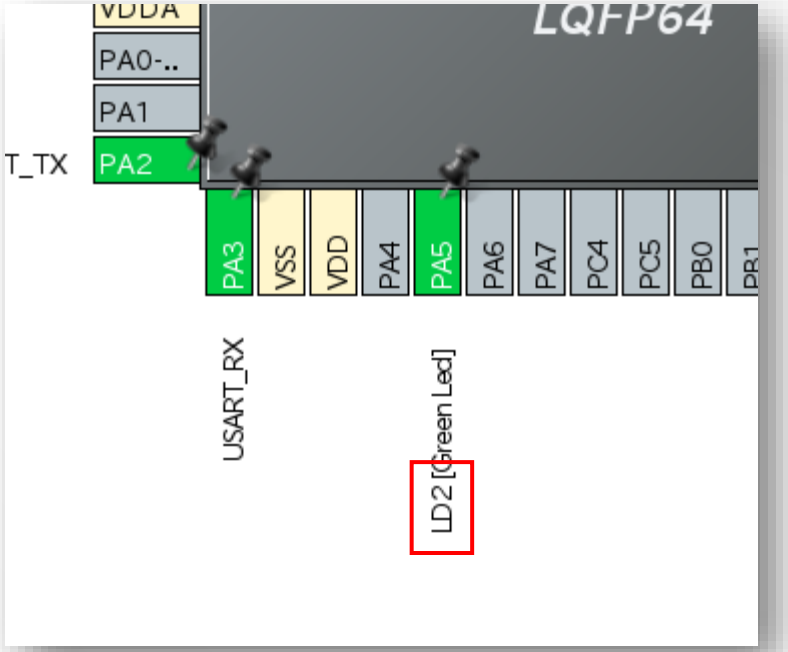
CONFIGURE THE CLOCK (F722 ONLY)

- CubeIDE has bug of Nucleo F722 clock configuration
- Follow the procedure to fix :
  1. Select “Clock Configuration”
  2. Change the “Input Frequency” to 8 MHz.
     - By default, it is 25MHz



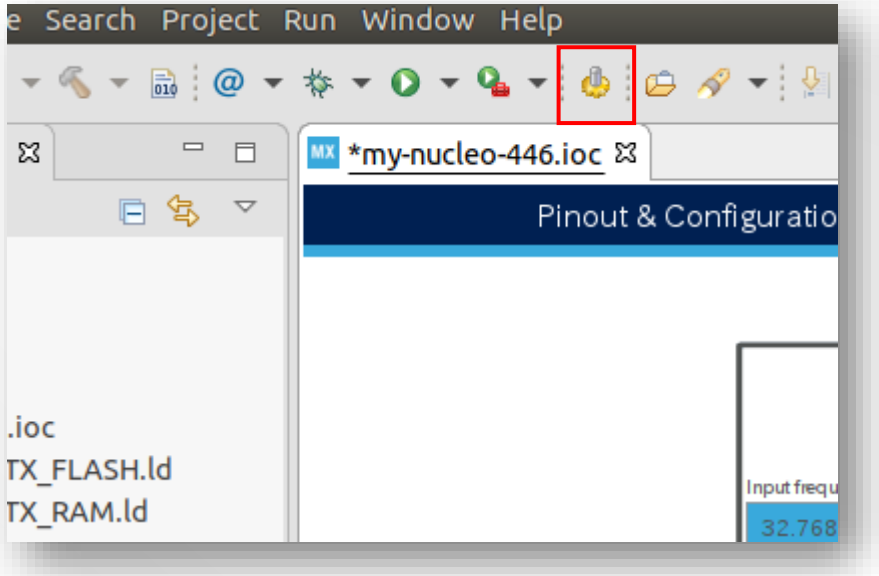
CHECK THE NAME OF LED PIN

- We use LED pin in the Skelton code
- Check the name of LED pin
  - It is board dependent



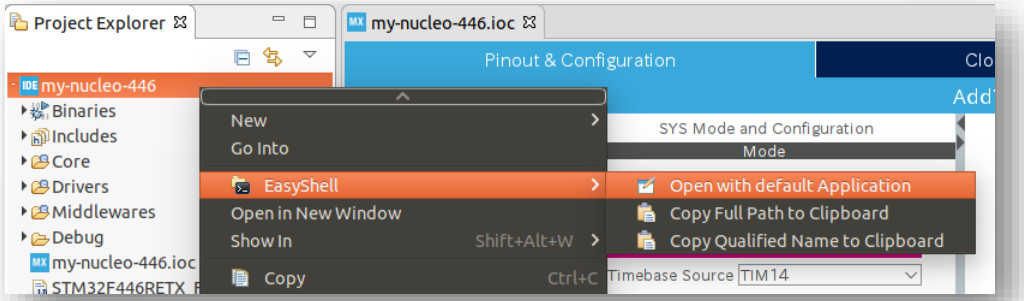
GENERATE A CODE

- Now, time to generate a code.
- Once generated, type Ctrl-B to build.
- Build must be OK.



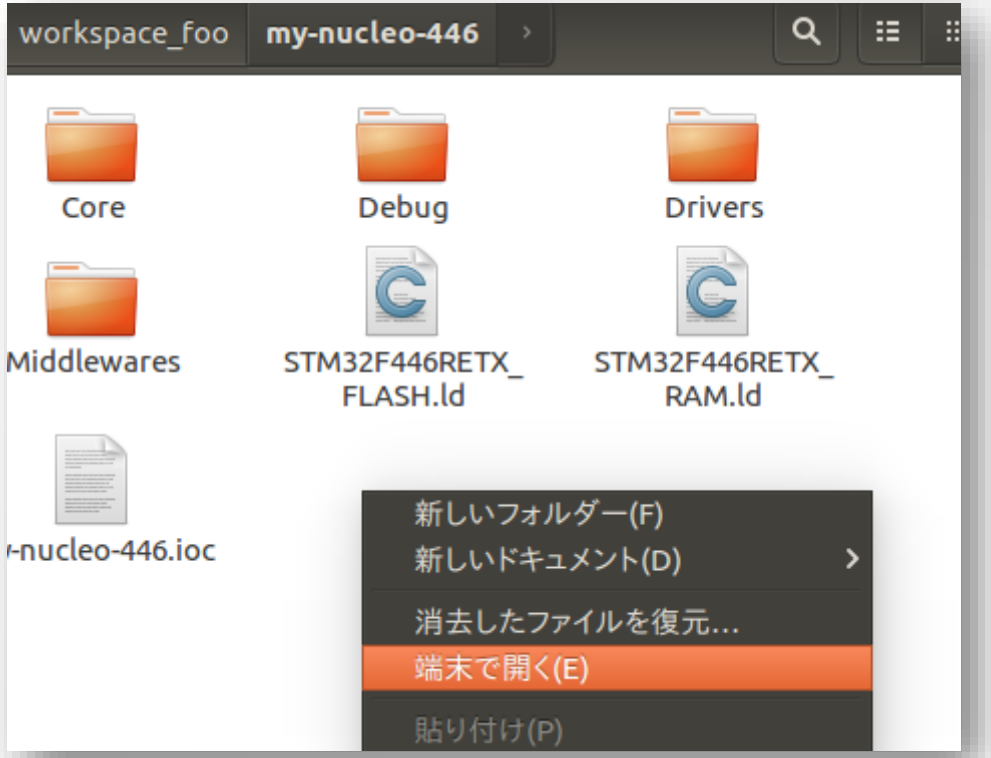
OPEN THE PROJECT LOCATION

- This is most tricky part.
- If you have installed EasyShell, execute “Open with default Application”
  - On Linux, project location is opened by Nautilus file browser
  - On Windows, project location is opened by command prompt window
- If you have not installed EasyShell, go to the project by yourself



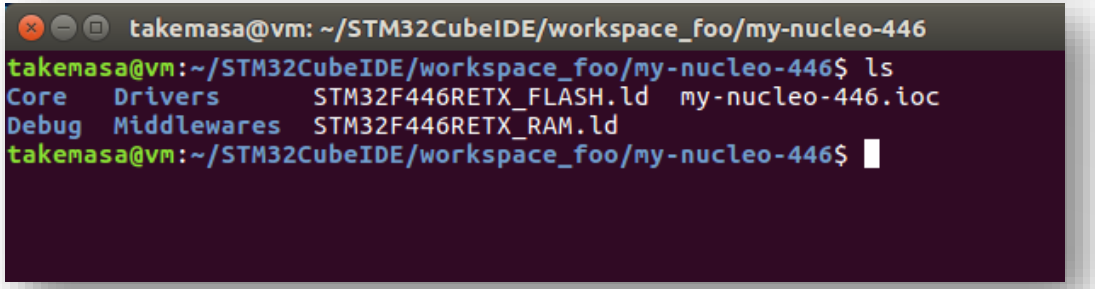
OPEN THE SHELL WINDOW

- Linux only
- From the context menu open the shell window

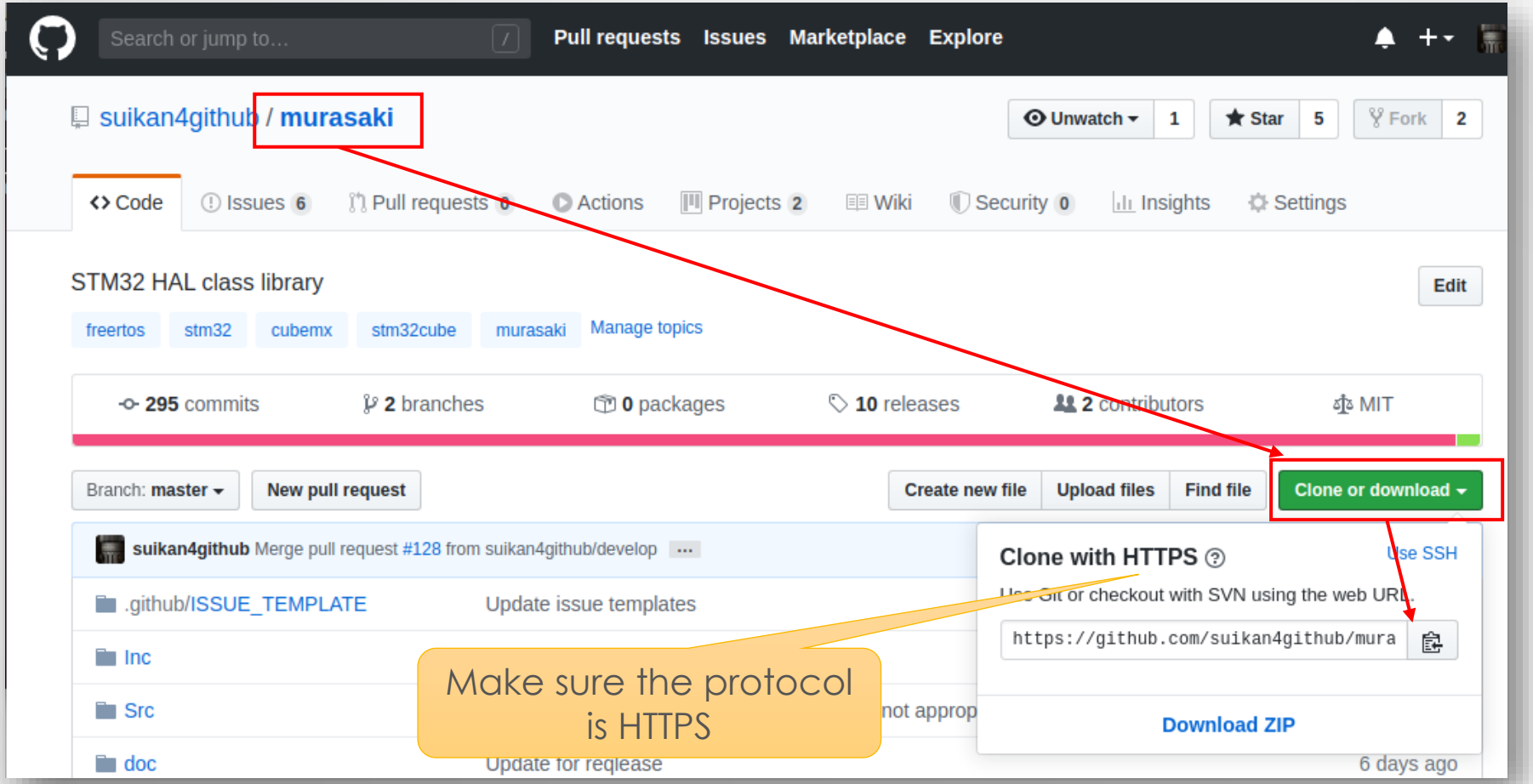


SHELL WINDOW IS OPEN

- Shell window is located at project
- Make sure the project contents exist
- Now, we are ready to clone the Murasaki repository



COPY THE REPOSITORY URL



CLONE THE REPOSITORY

```
takemasa@vm: ~/STM32CubeIDE/workspace_foo/my-nucleo-446
takemasa@vm:~/STM32CubeIDE/workspace_foo/my-nucleo-446$ ls
Core    Drivers       STM32F446RETX_FLASH.ld  my-nucleo-446.ioc
Debug   Middlewares   STM32F446RETX_RAM.ld
takemasa@vm:~/STM32CubeIDE/workspace_foo/my-nucleo-446$ git clone https://github
.com/suikan4github/murasaki.git
Cloning into 'murasaki'...
remote: Enumerating objects: 197, done.
remote: Counting objects: 100% (197/197), done.
remote: Compressing objects: 100% (179/179), done.
remote: Total 1898 (delta 119), reused 91 (delta 15), pack-reused 1
Receiving objects: 100% (1898/1898), 12.06 MiB | 5.31 MiB/s, done
Resolving deltas: 100% (1341/1341), done.
Checking connectivity... done.
takemasa@vm:~/STM32CubeIDE/workspace_foo/my-nucleo-446$
```

```
git clone https://github.com/suikan4github/murasaki.git
```

INSTALL MURASKI TO PROJECT

```
# Linux
cd Murasaki
./install
```

```
REM Windows
cd Murasaki
wsl ./install
```

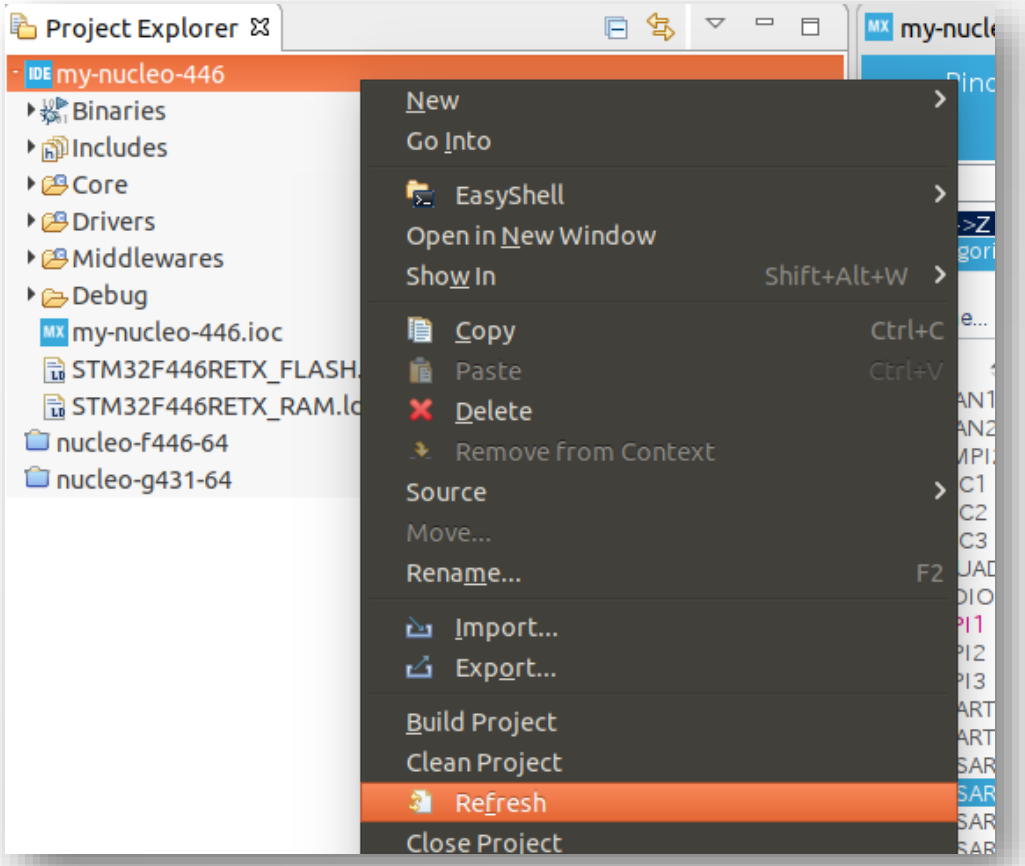
```
takemasa@vm: ~/STM32CubeIDE/workspace_foo/my-nucleo-446/murasaki
remote: Enumerating objects: done.
remote: Counting objects: 100% (1 7), done.
remote: Compressing objects: 100% (17 9), done.
remote: Total 1898 (delta 119), reused 91 lta 15), pack-re 1701
Receiving objects: 100% (1898/1898), 12.06 Mi 5.31 MiB/s, ne.
Resolving deltas: 100% (1341/1341), done.
Checking connectivity... done.
takemasa@vm:~/STM32CubeIDE/workspace_foo/my-nucleo-446$ cd murasaki/
takemasa@vm:~/STM32CubeIDE/workspace_foo/my-nucleo-446/murasaki$ ./install
Found ../Core/Src as the source directory.
Found ../Core/Inc as the include directory.
Found ../Core/Startup as the startup directory.
template files copied
../Core/Src/main.c modified.
../Core/Startup/startup_stm32f446retx.s modified.
../Core/Src/stm32f4xx_it.c modified.
../Core/Inc/murasaki_include_stub.h created.
takemasa@vm:~/STM32CubeIDE/workspace_foo/my-nucleo-446/murasaki$
```

WHY DO WE NEED INSTALLATION?

- There are several point which CubeIDE Skelton calls Murasaki.
  - InitPlatform()
  - ExecPlatform()
  - HAL’s assertion failure hook
  - Spurious Interrupt
  - Hard fault
- These call must be coded by programmer
  - No weak binding routines
- The installer script is the best way to avoid the routine works

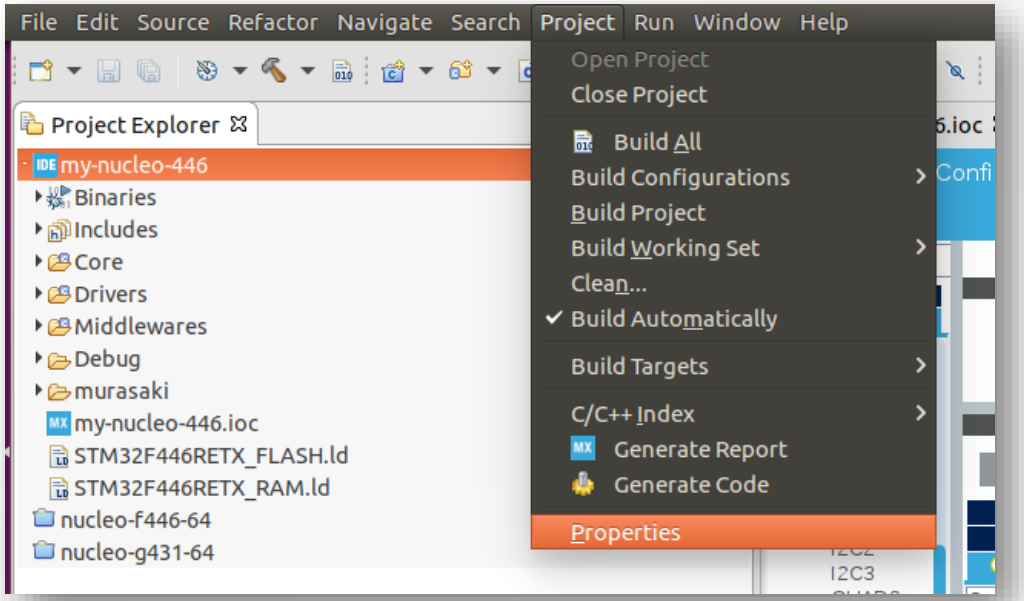
REFRESH THE PROJECT

- While we installed on the shell command, Eclipse doesn't know that
- Follow the procedure :
  1. Select project
  2. Open the context menu
  3. Execute "Refresh"
  4. Now, you can see "Murasaki" in the project



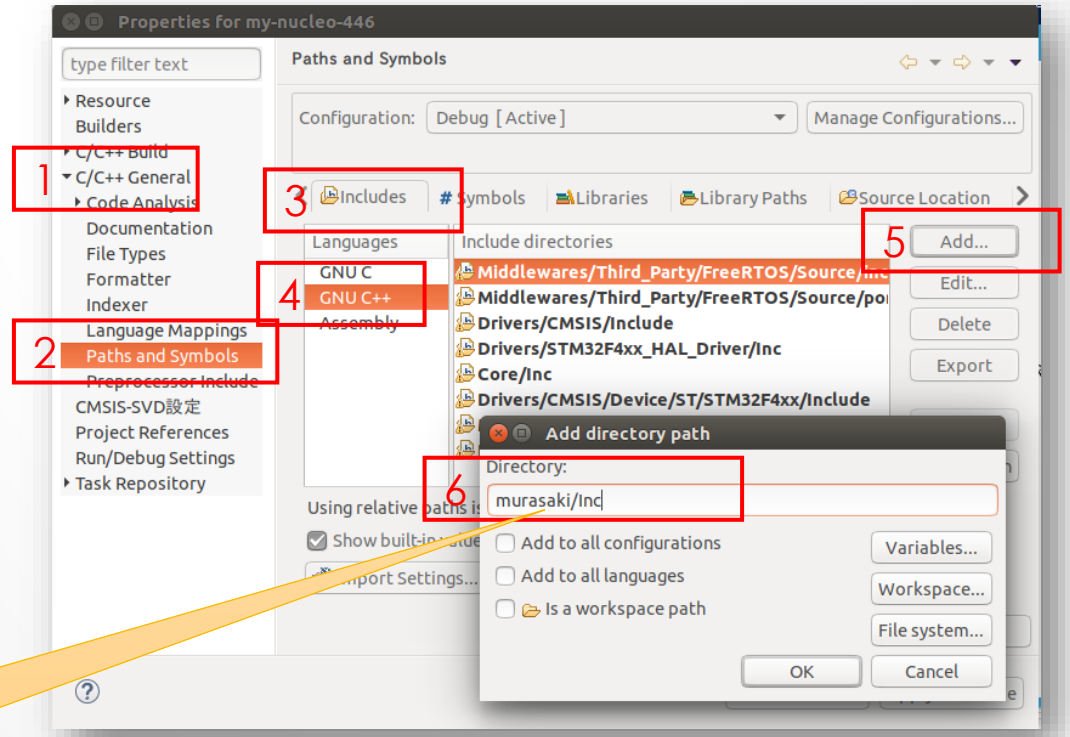
OPEN THE PROPERTY

- Now, we open the project to set :
  - Include directory
  - Source directory



ADD INCLUDE PATH

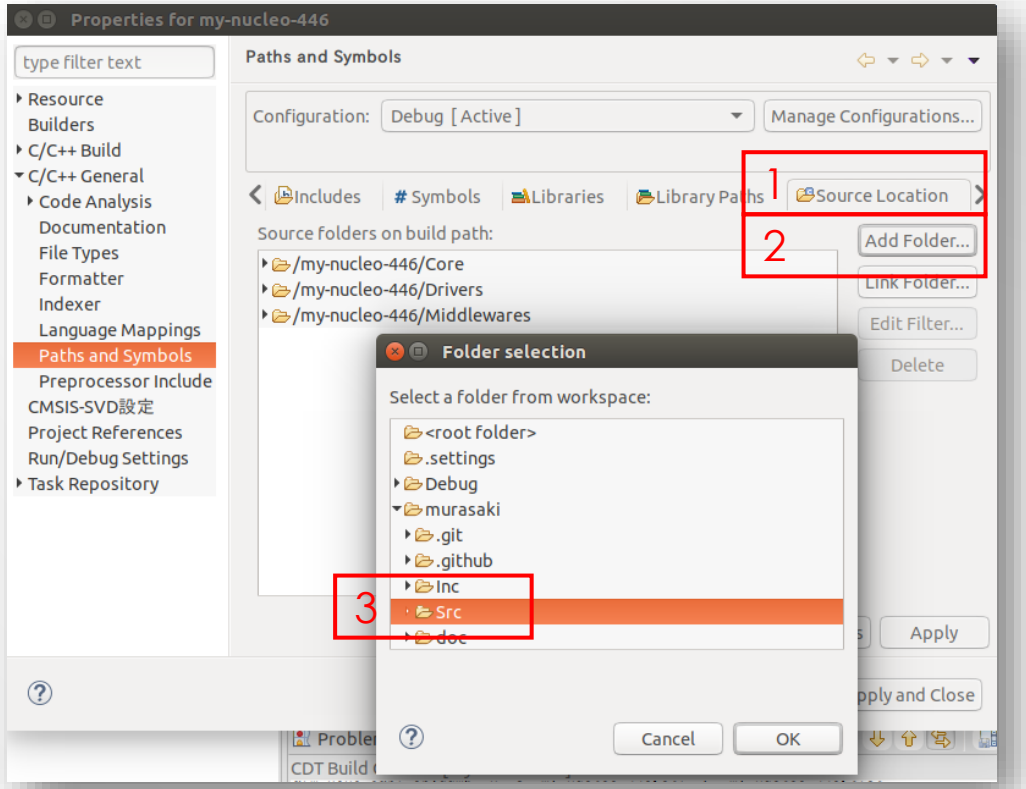
- Follow the procedure :
  1. Open “C/C++ General”
  2. Select “Paths and Symbols”
  3. Select “Includes tab”
  4. Select “GNU C++”
  5. Click “Add”
  6. Write “murasaki/Inc”
  7. Click “OK”



murasaki/Inc

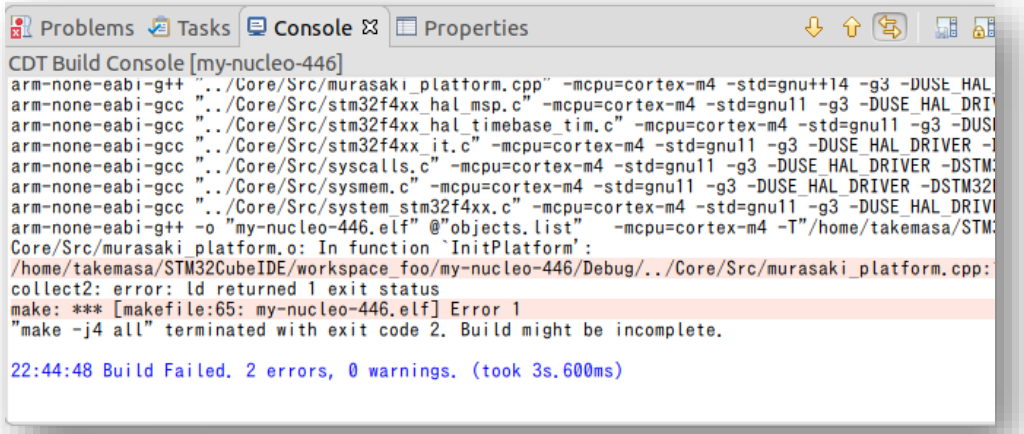
ADD SOURCE LOCATION

- Follow the procedure :
  1. Select “Source Location”
  2. Click “Add Folder…”
  3. Select “murasaki/Src”
  4. Click “OK”



BUILD MAY FAIL

- The result of build is up to Nucleo board
  - F722, F746, H743 : No error
  - Nucleo 64 :
    - UART port may be different
    - LD name may be different
- Fix depends on the target.



FIX THE UART PORT IDENTIFIER

- The correct UART port is defined in main.c
- Apply this identifier to the murasaki_platform.cpp

main.c

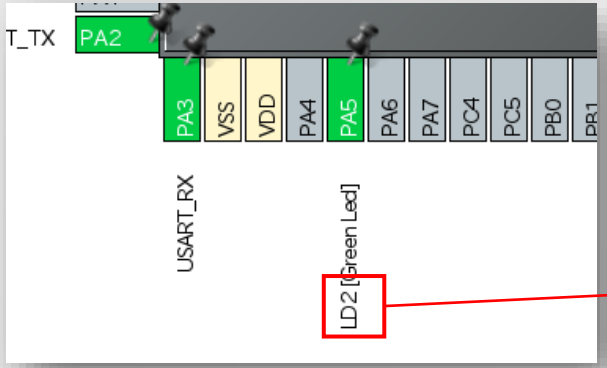
```c
/* USER CODE END PM */

/* Private variables ---------------------------------------------------------
UART_HandleTypeDef huart2;
DMA_HandleTypeDef hdma_usart2_rx;
DMA_HandleTypeDef hdma_usart2_tx;

osThreadId defaultTaskHandle;
/* USER CODE BEGIN PV */
```

murasaki_platform.cpp

```cpp
 */
// Following block is just sample.
// Original declaration is in the top of main.c.
#if 0
extern I2C_HandleTypeDef hi2c1;
extern I2C_HandleTypeDef hi2c2;
extern SPI_HandleTypeDef hspi1;
extern SPI_HandleTypeDef hspi4;
extern UART_HandleTypeDef huart2;
#endif
extern UART_HandleTypeDef huart3;

/* -------------------- PLATFORM Prototypes ------------------------- */

void TaskBodyFunction(const void *ptr);

/* -------------------- PLATFORM Implementation ------------------------- */

// Initialization of the asystem.
void InitPlatform()
{
#if ! MURASAKI_CONFIG_NOCYCCNT
    // Start the cycle counter to measure the cycle in MURASAKI_SYSLOG.
    murasaki::InitCycleCounter();
#endif
    // UART device setting for console interface.
    // On Nucleo, the port connected to the USB port of ST-Link is
    // referred here.
    murasaki::platform.uart_console = new murasaki::DebuggerUart(&huart3);
    while (nullptr == murasaki::platform.uart_console)
        ;  // stop here on the memory allocation failure.
```

ADJUST THE LED IDENTIFIER

- The LED name is generated by the Device Configuration Tool
- Port name and Pin name have to be adjusted
  - LDx_GPIO_Port
  - LDx_Pin

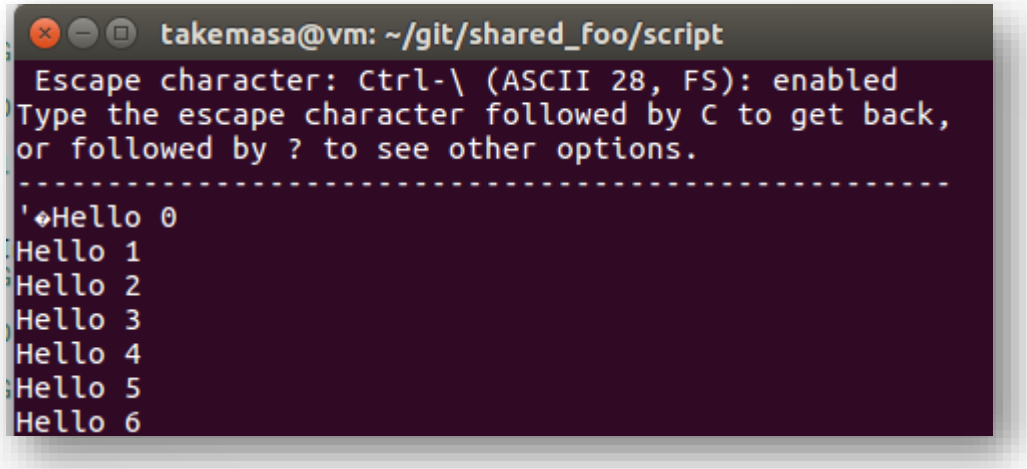


murasaki_platform.cpp

```cpp
void TaskBodyFunction(const void *ptr);

/* -------------------- PLATFORM Implementation ------------------------ */

// Initialization of the asystem.
void InitPlatform()
{
#if ! MURASAKI_CONFIG_NOCYCCNT
    // Start the cycle counter to measure the cycle in MURASAKI_SYSLOG.
    murasaki::InitCycleCounter();
#endif
    // UART device setting for console interface.
    // On Nucleo, the port connected to the USB port of ST-Link is
    // referred here.
    murasaki::platform.uart_console = new murasaki::DebuggerUart(&huart3);
    while (nullptr == murasaki::platform.uart_console)
        ;  // stop here on the memory allocation failure.

    // UART is used for logging port.
    // At least one logger is needed to run the debugger class.
    murasaki::platform.logger = new murasaki::UartLogger(murasaki::platform.uart_cons
    while (nullptr == murasaki::platform.logger)
        ;  // stop here on the memory allocation failure.

    // Setting the debugger
    murasaki::debugger = new murasaki::Debugger(murasaki::platform.logger);
    while (nullptr == murasaki::debugger)
        ;  // stop here on the memory allocation failure.

    // Set the debugger as AutoRePrint mode, for the easy operation.
    murasaki::debugger->AutoRePrint();  // type any key to show history.

    // For demonstration, one GPIO LED port is reserved.
    // The port and pin names are fined by CubeIDE.
    murasaki::platform.led = new murasaki::BitOut(LD2_GPIO_Port, LD2_Pin);
    MURASAKI_ASSERT(nullptr != murasaki::platform.led)

```

FINALLY WE CAN RUN

- Build the target
- Debug the target
- And then, resume



FURTHER PROGRAMING WITH MURASAKI

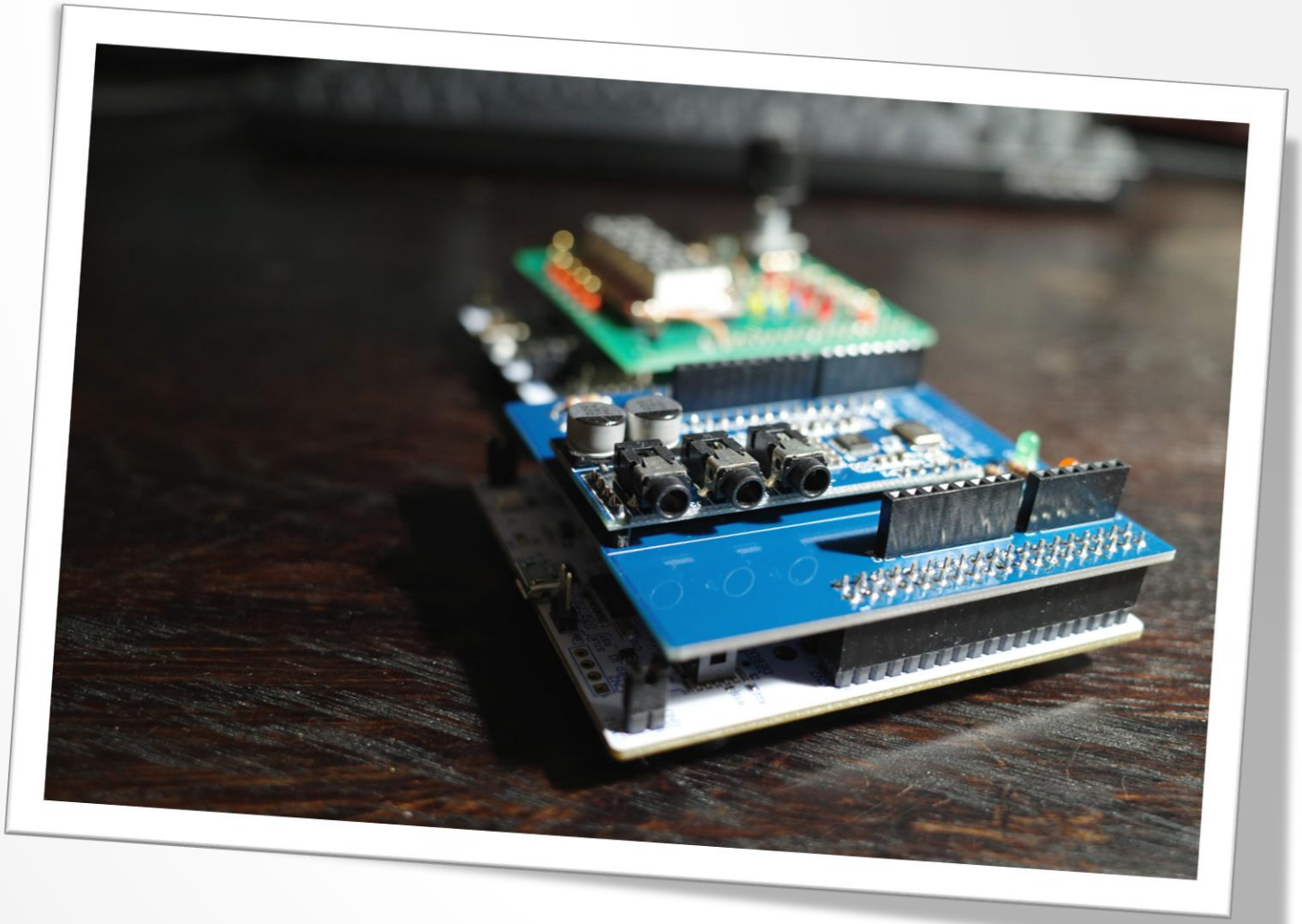
- Platform variable is defined in Inc/platform_def.hpp
  - Programmer must modify the Murasaki::Platform type
  - And must configure the device by Device Configuration Tool
  - And then Initialize them
- There is no Global Interrupt Mask
  - Murasaki assumes the peripheral IO control is in task context
  - Thus, inter-task exclusive access is enough
- If you need to control the IO which is not covered by Murasaki
  - You can control them through the HAL in a Murasaki task
  - You can use its HAL callback as you want
  - Murasaki doesn’t interfere such the IO

SUMMARY

Photo by Aaron Burden on Unsplash

MURASAKI

- A class library for STM32 series
  - Multi-task native
  - Synchronous and blocking IO
  - Strict name space and IDE’s name completion helps coding
  - Automatic interrupt handling
  - Rich debugging method
- Supporting multiple STM32 MCU series
- Hosted and managed by GitHub repository / tools
- Documentation by Doxygen



THANKS & STAY HOME