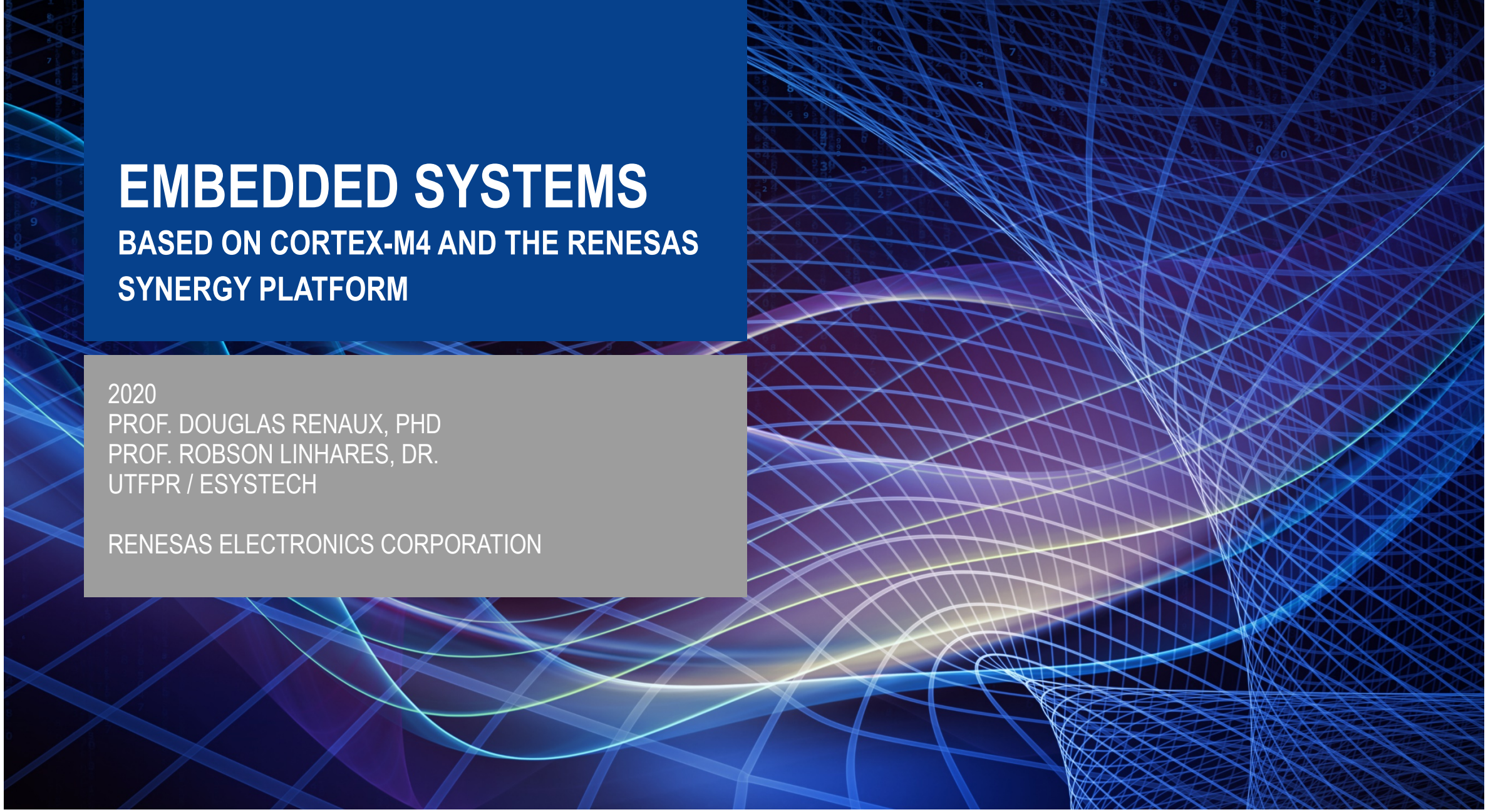

EMBEDDED SYSTEMS

BASED ON CORTEX-M4 AND THE RENESAS SYNERGY PLATFORM

2020
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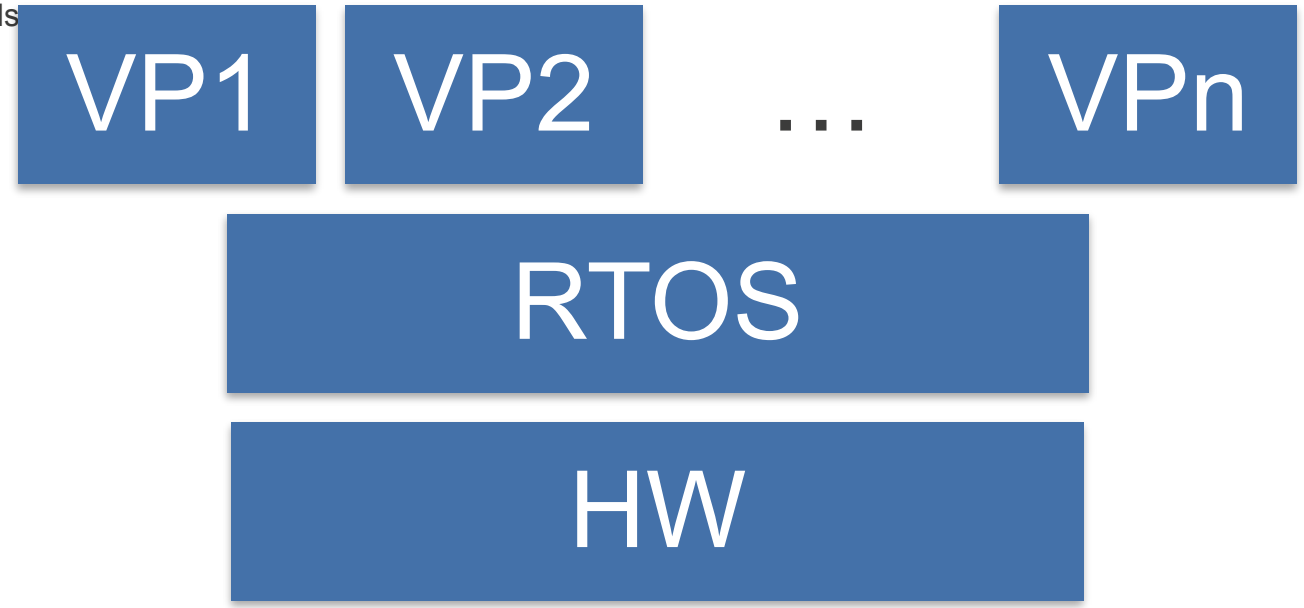
14 – RTOS – REAL-TIME OPERATING SYSTEM

- Introduction
- Thread Management
- Inter-thread communication and synchronization
- Timing Services
- Memory Management

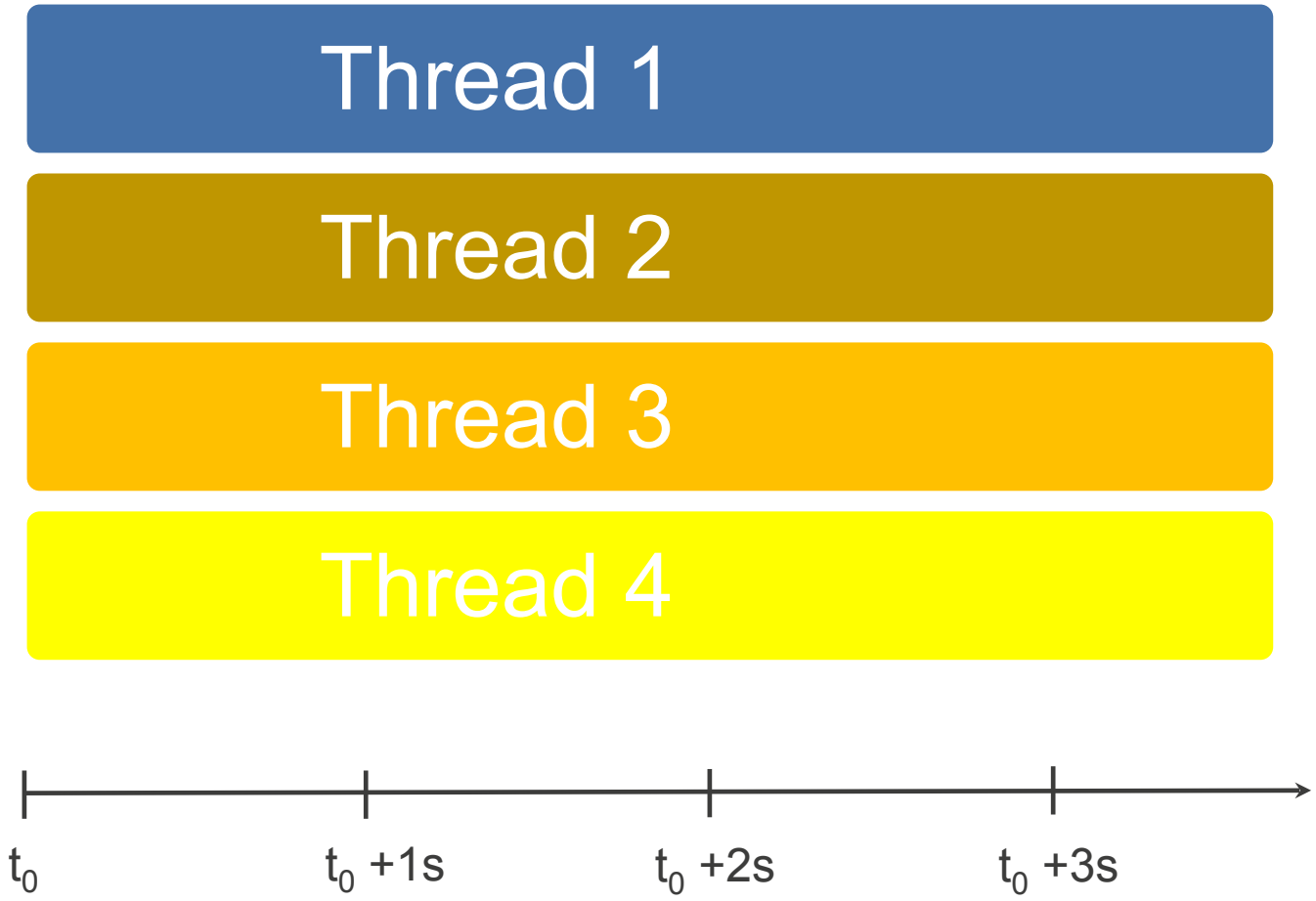
RTOS – INTRODUCTION

- An RTOS is a layer of Software between the hardware and the application software that allows the implementation of concurrent tasks implemented by multithreading.
- The RTOS manages the hardware, sharing resources among multiple “virtual processors”: VP1 to VPn so that each thread has the illusion of owning a processor and stack while sharing global data, heap, code area and peripherals
- The RTOS implements sharing of the processor via context switching and provides several important functionalities for the threads: timing, inter-thread communication and synchronization, and thread management.



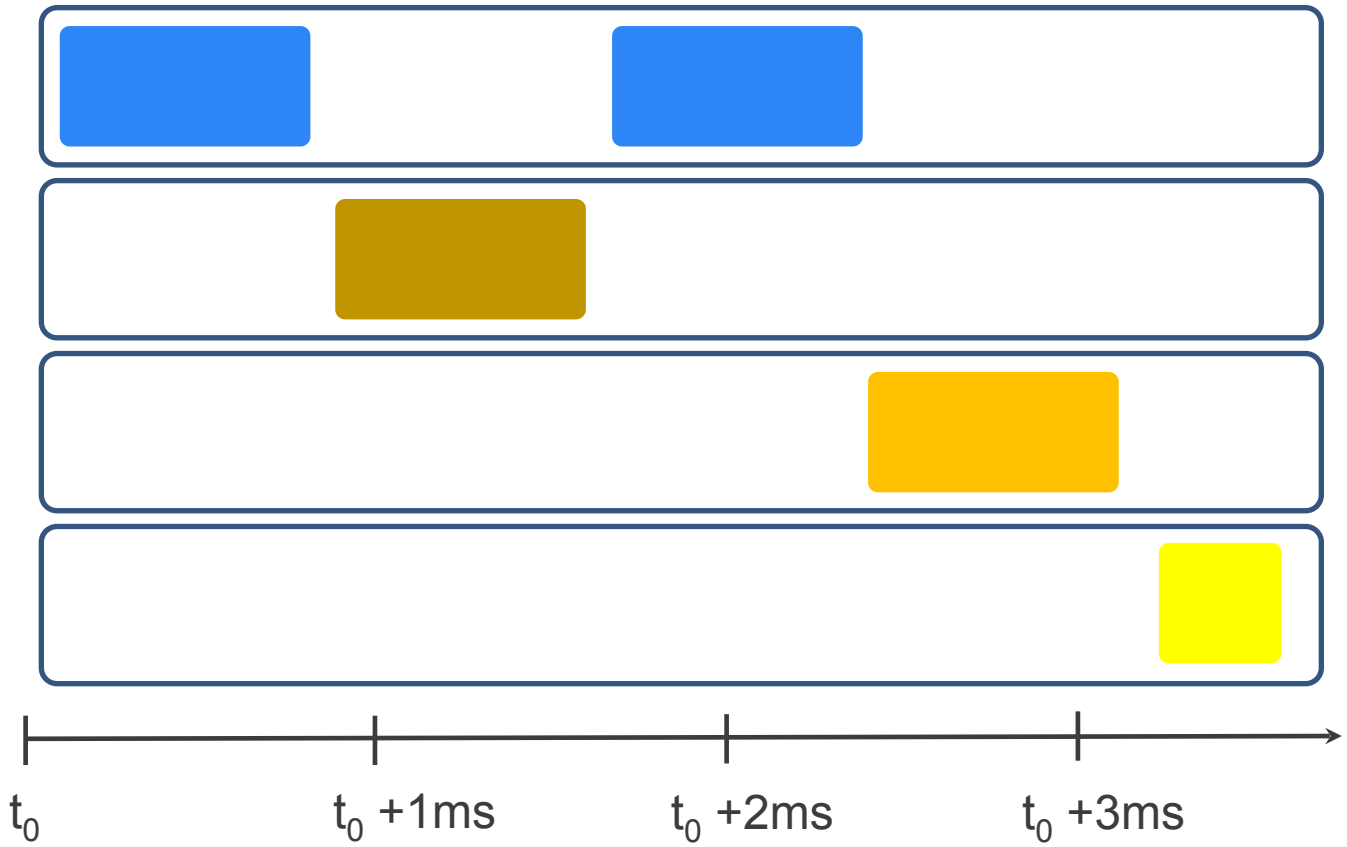
THREAD EXECUTION – LARGE GRAIN VIEW

Observing at a time scale of seconds, one has the impression that all threads execute in parallel.



THREAD EXECUTION – FINE GRAIN VIEW

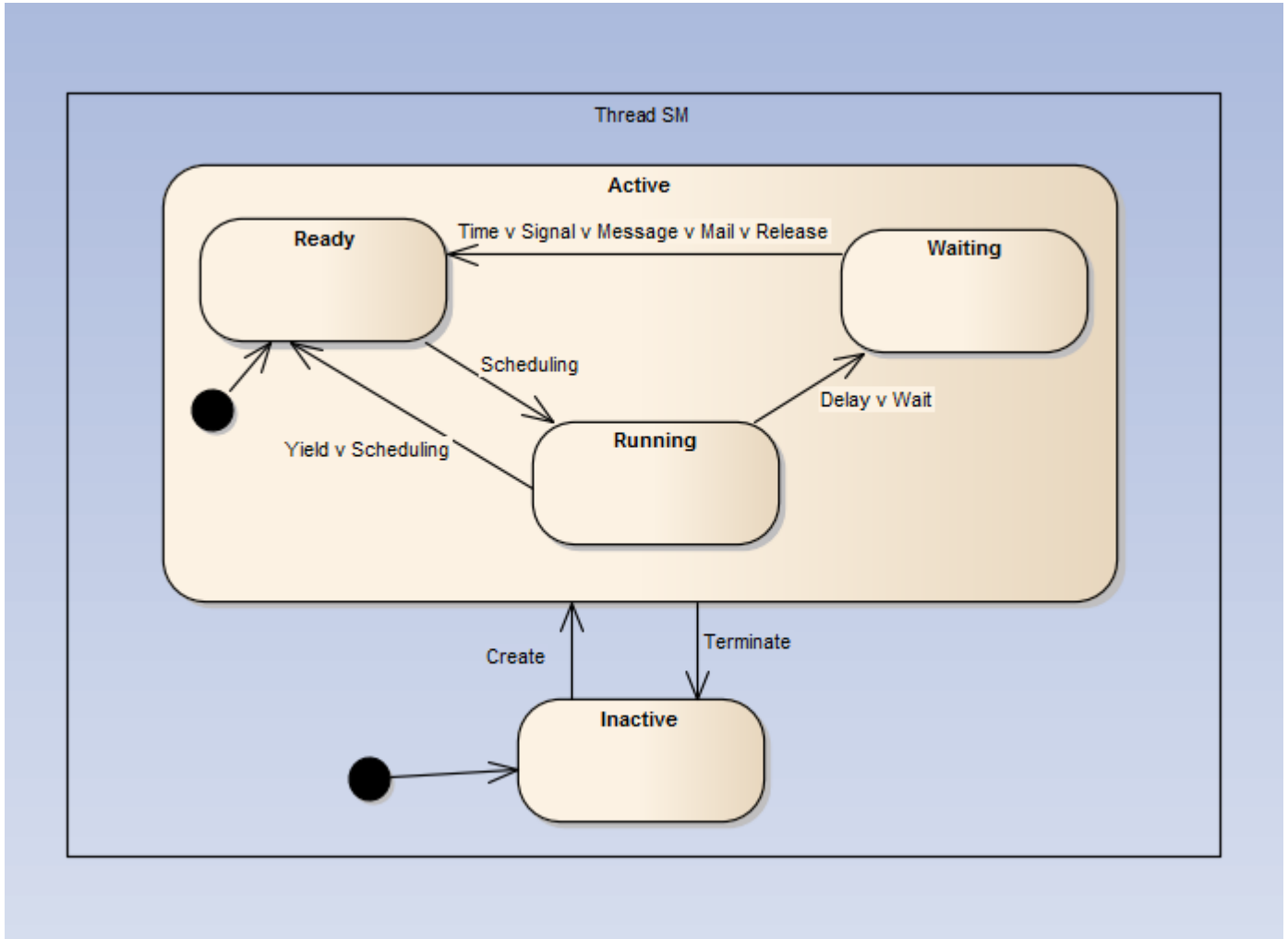
Observing on a fine grain scale (milliseconds) it is possible to realize that the tasks share the processor as the RTOS switches among them the utilization of the CPU.



TASK STATES

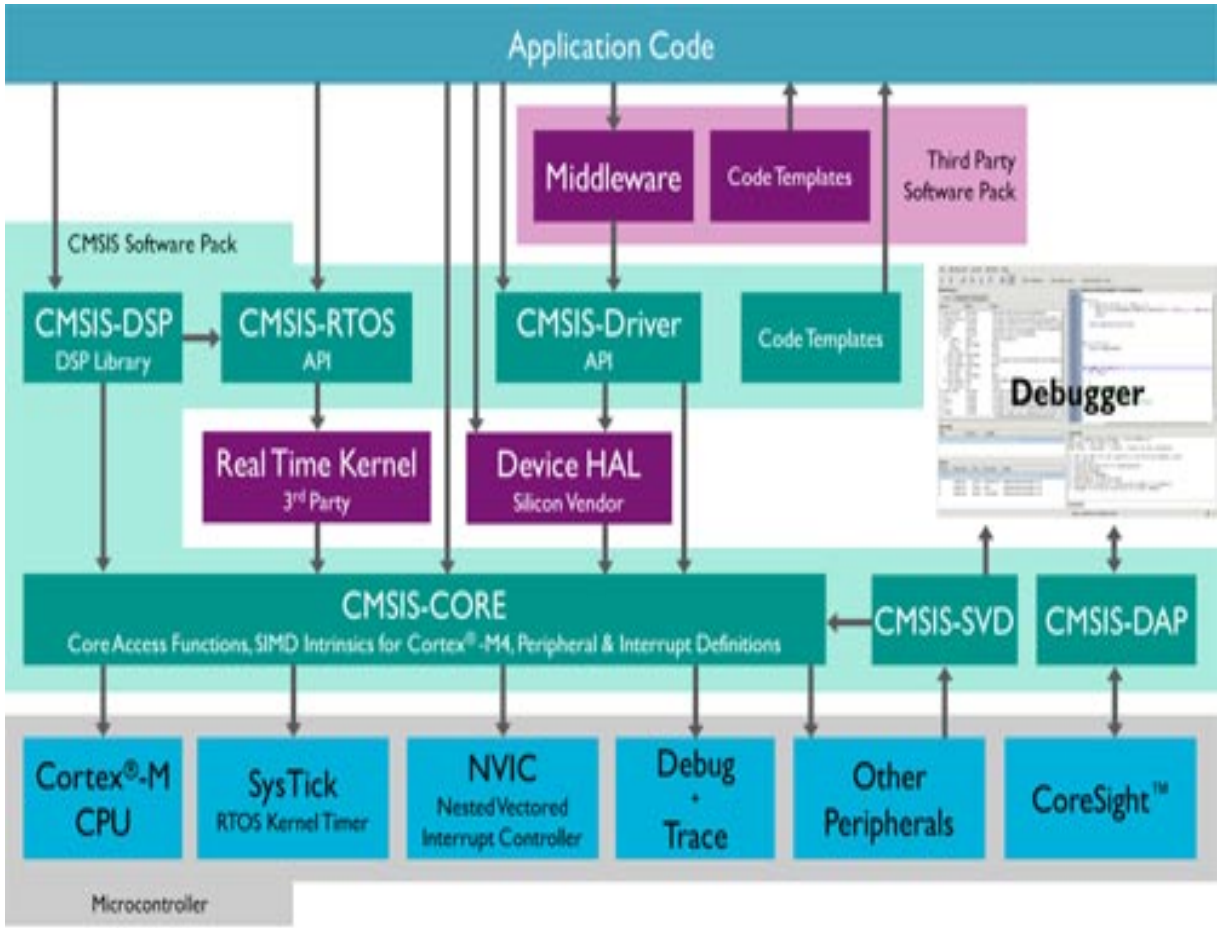
A typical state diagram of a task in a multithreaded environment:

- **Ready:** tasks that is willing to use the processor and is expected to be scheduled.
- **Running:** the state of the task that is using the processor.
- **Waiting:** tasks whose execution is blocked due due to time, synchronization or communication.



CMSIS (CORTEX MICROCONTROLLER SOFTWARE INTERFACE STANDARD)

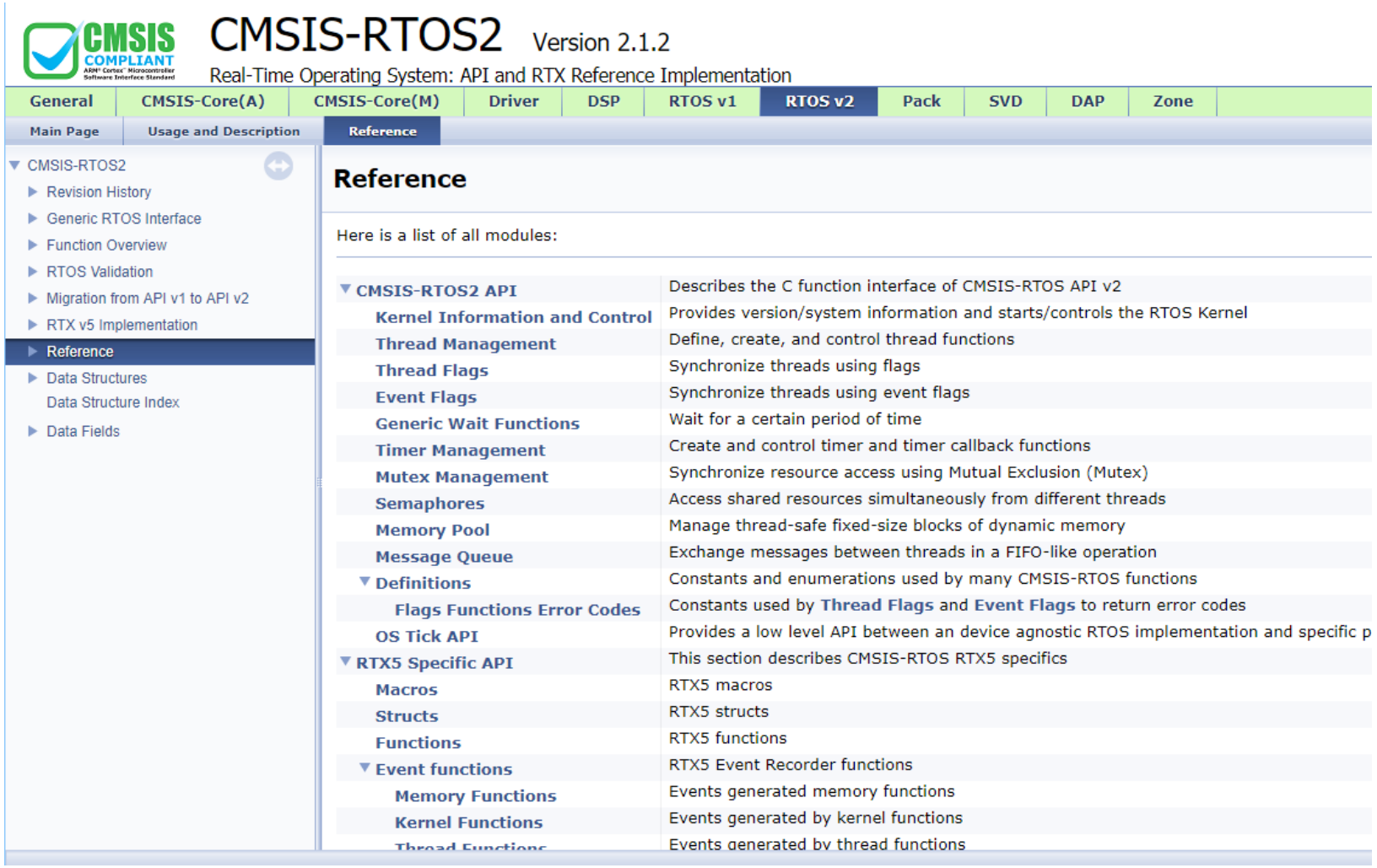
- v 1.0 (2008)
  - Drivers API
- v 2.0
  - DSP Lib
- v 3.0 (2012)
  - API RTOS
  - DAP (Debug)
- V 4.0 (2014)
  - CMSIS-Driver
  - CMSIS-Pack
- V 5.0 (2016) CMSIS-RTOS v2



As of March,2020, CMSIS is at version 5.6

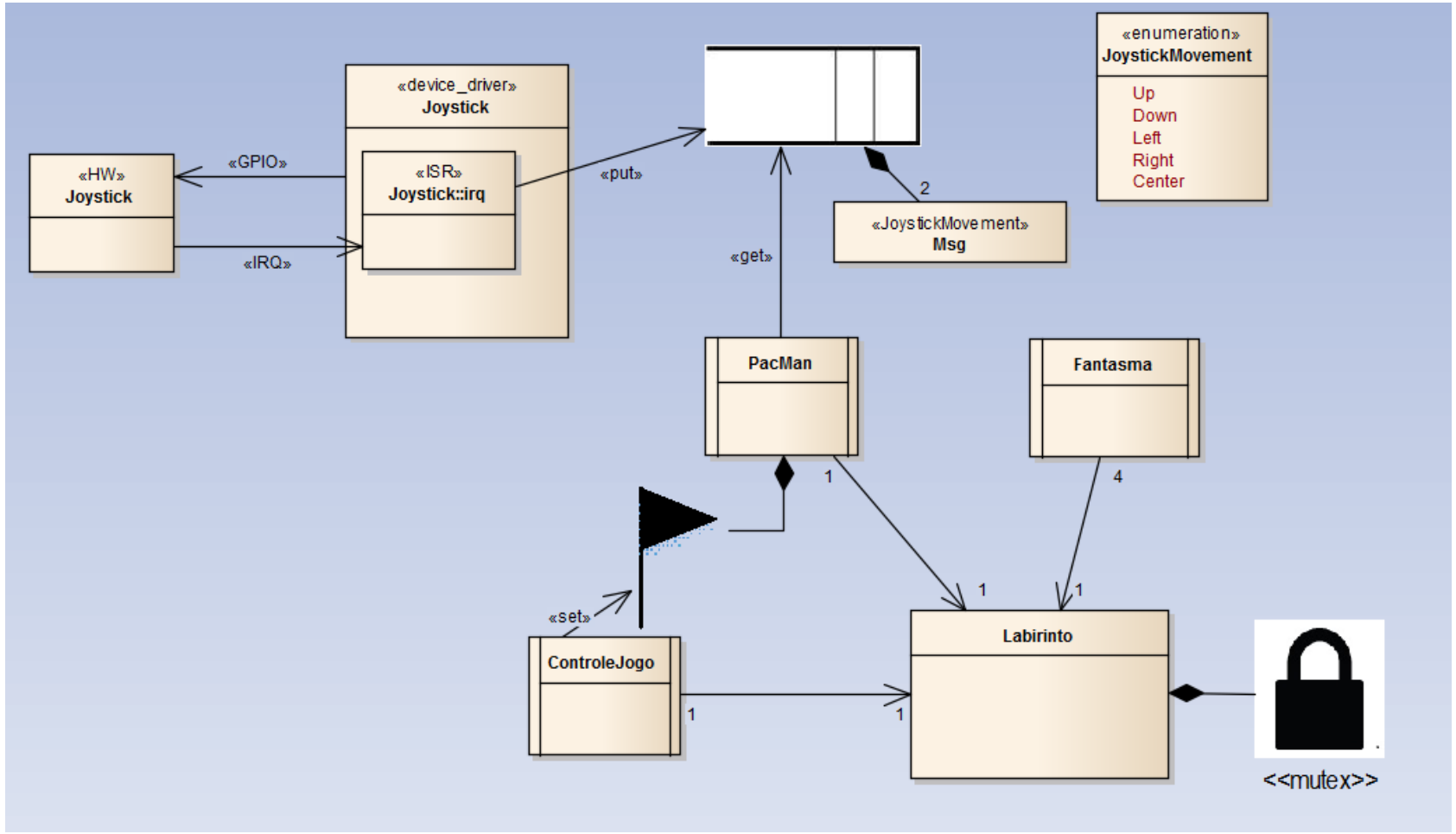
CMSIS-RTOS DOCUMENTATION

Available online



CMSIS code is available in GITHUB

PLANNING A MULTITHREADED APPLICATION



CMSIS-RTOS: OVERVIEW 1/4

Kernel Information and Control

- osKernelInitialize : Initialize the RTOS kernel.
- osKernelStart : Start the RTOS kernel.
- osKernelRunning : Query if the RTOS kernel is running.
- osKernelSysTick $: Get RTOS kernel system timer counter.
- osKernelSysTickFrequency $: RTOS kernel system timer frequency in Hz.
- osKernelSysTickMicroSec $: Convert microseconds value to RTOS kernel system timer value.

Thread Management

- osThreadCreate : Start execution of a thread function.
- osThreadTerminate : Stop execution of a thread function.
- osThreadYield : Pass execution to next ready thread function.
- osThreadGetId : Get the thread identifier to reference this thread.
- osThreadSetPriority : Change the execution priority of a thread function.
- osThreadGetPriority : Obtain the current execution priority of a thread function.

CMSIS-RTOS: OVERVIEW 2/4

Generic Wait Functions

- osDelay : Wait for a specified time.
- osWait $: Wait for any event of the type Signal, Message, or Mail.

Timer Management $

- osTimerCreate : Define attributes of the timer callback function.
- osTimerStart : Start or restart the timer with a time value.
- osTimerStop : Stop the timer.
- osTimerDelete : Delete a timer.

CMSIS-RTOS: OVERVIEW 3/4

Signal Management

- osSignalSet : Set signal flags of a thread.
- osSignalClear : Reset signal flags of a thread.
- osSignalWait : Suspend execution until specific signal flags are set.

Mutex Management $

- osMutexCreate : Define and initialize a mutex.
- osMutexWait : Obtain a mutex or Wait until it becomes available.
- osMutexRelease : Release a mutex.
- osMutexDelete : Delete a mutex.

Semaphore Management $

- osSemaphoreCreate : Define and initialize a semaphore.
- osSemaphoreWait : Obtain a semaphore token or Wait until it becomes available.
- osSemaphoreRelease : Release a semaphore token.
- osSemaphoreDelete : Delete a semaphore.

CMSIS-RTOS: OVERVIEW 4/4

Memory Pool Management $

osPoolCreate : Define and initialize a fix-size memory pool.

osPoolAlloc : Allocate a memory block.

osPoolCAlloc : Allocate a memory block and zero-set this block.

osPoolFree : Return a memory block to the memory pool.

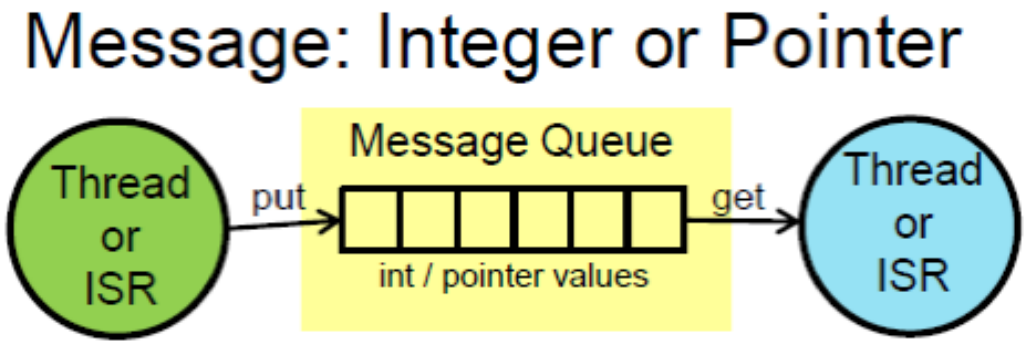
Message Queue Management $

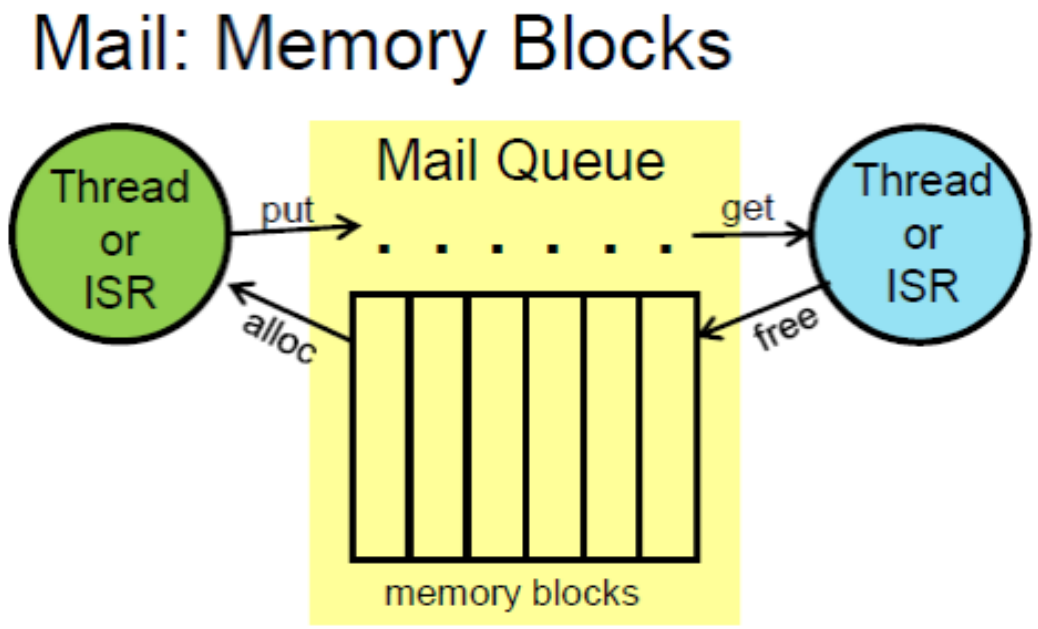
- osMessageCreate : Define and initialize a message queue.
- osMessagePut : Put a message into a message queue.
- osMessageGet : Get a message or suspend thread execution until message arrives.

Mail Queue Management $

- osMailCreate : Define and initialize a mail queue with fix-size memory blocks.
- osMailAlloc : Allocate a memory block.
- osMailCAlloc : Allocate a memory block and zero-set this block.
- osMailPut : Put a memory block into a mail queue.
- osMailGet : Get a mail or suspend thread execution until mail arrives.
- osMailFree : Return a memory block to the mail queue.

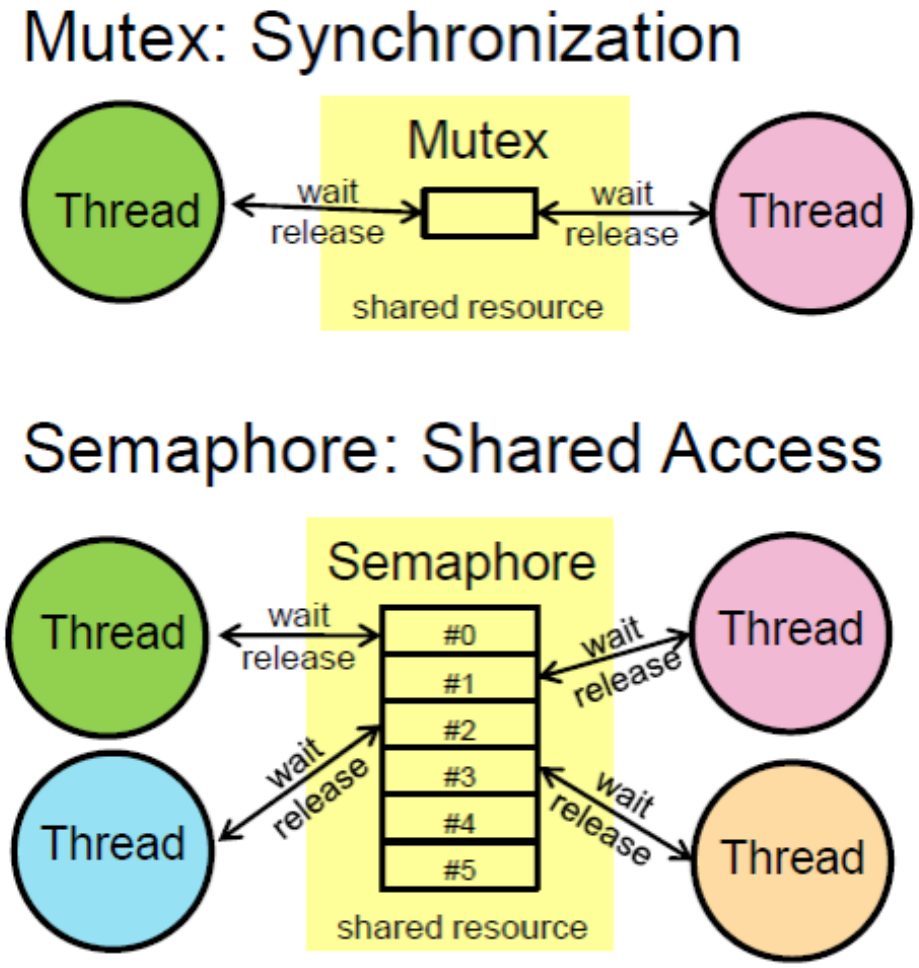
CMSIS-RTOS – INTER-TASK COMMUNICATIONS





Source: ARM, CMSIS documentation

CMSIS-RTOS – INTER-TASK COMMUNICATIONS



Source: ARM, CMSIS documentation

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