RT6 - Real Time Programming with Eclipse ThreadX

Real-time programming applied to ThreadX (previously Azure RTOS)

Objectives

- Get an overview on Cortex-M architecture
- Discover the concepts of real time multithreading
  - Understand Real Time constraints
  - Determinism
  - Preemption
  - Interrupts
- Understand the Azure RTOS architecture
- Discover the various Azure RTOS services and APIs
- Learn how to develop Azure RTOS applications
- Learn how to debug Azure RTOS applications

Course environment

- Example code, labs and solutions
- STM32L5 Board on STM32CubeIDE

Prerequisites

- Familiarity with embedded C concepts and programming
- Basic knowledge of embedded processors

Target Audience

- Any embedded systems engineer or technician with the above prerequisites.

Course Outline

First Day

Cortex-M Overview

- ARMv7-M Architecture
- Cortex-M Architecture
- Registers and Execution States
- Privileges, Mode and Stacks
- Reset Behavior
- Exception and Interrupts
- The System Timer
- Memory Model
- Power Management
- Cortex-M Advanced Features
  - ARM v7/v8 MPU
  - TrustZone Security Extension

Exercise: Create a new project
Exercise: Interrupt Management

Real-Time Concepts

- Base real time concepts
- The Real Time constraints
- Multi-task and real time
- Tasks and Task Descriptors
  - Content of the task descriptor
  - List of task descriptors
- Context Switch
- Task Scheduling and Preemption
  - Tick based or tickless scheduling
- Scheduling systems and schedulability proof
  - Fixed priorities scheduling
  - RMA and EDF scheduling
- Scheduling
  - Deterministic preemptive scheduling
  - Scheduling strategies
  - Cooperative scheduling
  - Hybrid scheduling

Exercise: Context Switch

Introduction to Azure RTOS

- The Azure ThreadX
- Azure RTOS Ecosystem
- Azure RTOS Features
- Installation and use of Azure RTOS

Second Day

Thread Management

- Thread Control Block
- Thread States
- Thread Creation
- Thread Deletion
- Preemption-Threshold
- Changing Thread Priority
  - Suspending Threads
  - Resume Thread Execution
  - Thread Sleep
- Terminate Thread Execution
- Time-Slice
- Thread States and Thread Design
- Thread Statistics
- Visual trace diagnostics using Tracealyzer

Exercise: Thread Management
Exercise: Periodic Threads
Exercise: Time-slice change
Exercise: Thread Statistics

Memory Management in Azure RTOS

- Azure RTOS Memory Managers
  - Memory Byte Pool
  - Memory Block Pool

- Out of Memory management
- Stack overflow detection

Exercise: Context Switch Measurement and memory problems detection

Resource Management

- Mutual Exclusion
- Critical Sections
- Mutexes
  - Recursive mutexes
- Gatekeeper Threads
- Lock-Free Data Structures

Exercise: Implement mutual exclusion between tasks

Third Day

Synchronization Primitives

- Queues
- Synchronization
- Semaphores
  - Binary and counting semaphores
- Events and Event Groups
- The Readers/writer problem

Exercise: Sending messages between tasks
Exercise: Synchronizing a task with another one (Producer/Consumer problem)
Exercise: Readers/Writer Problem

Interrupt Management

- Threads and Interrupts
  - Synchronization between threads and interrupts
- Interrupts on ARM Cortex-M
- Handler thread
- Azure RTOS Primitives Within An ISR
  - Queues Within An ISR
- Low Power Support

Exercise: Interrupt Management & Deferred interrupt processing
Exercise: Tickless and Low Power Mode

Application Timers

- Application Timers
- System Timer Thread
- One-shot timers
- Auto-reload timers
- Application Timer Commands

Exercise: Implement Soft Timers & Synchronize a task with a timer

Annexes

Data Structures

- FIFO
- Linked list

Memory Management and Real-Time

- Memory Management
- Memory Errors

CMSIS RTOS

- Overview
- Kernel Information and Control
- Threads Management
- Generic Wait Functions
- Communication and Resource Sharing
  - Semaphores
  - Mutex
  - Message Queue
  - Signal Events
  - Event Flags
  - Memory Pool
  - Mail Queue
- Timer Management
- Interrupt Service Routines