



oL10 - Embedded Modern C++ Programming

Objectives

- Discover the modern C++ features
- Learn the language changes in C++11, C++14, C++17 and C++20
- Discover the new functionalities added to the standard library
- Learn advanced modern C++ features like perfect forwarding
- Moving from traditional C++ to modern C++
- Emphasizing the essential modern C++ features used in embedded application

Labs are conducted QEMU ARM-based board

Prerequisite

- Basic C++ Language knowledge (see our [oL3 - Embedded C++ Programming](#) course)

Course environment

- Theoretical course
 - PDF course material (in English)
 - Course dispensed using the Teams video-conferencing system
 - The trainer to answer trainees' questions during the training and provide technical and pedagogical assistance through the Teams video-conferencing system
- Practical activities
 - Practical activities represent from 40% to 50% of course duration
 - One Online Linux PC per trainee for the practical activities
 - The trainer has access to trainees' Online PCs for technical and pedagogical assistance.
 - Eclipse environment and GCC compiler
- Downloadable preconfigured virtual machine for post-course practical activities

Duration

- Total: 12 hours
- 2 sessions, 6 hours each (excluding break time)
- From 40% to 50% of training time is devoted to practical activities
- Some Labs may be completed between sessions and are checked by the trainer on the next session

Target Audience

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

Course Outline

First Session

Introduction to modern C++

- Overview
- Storage class specifiers
- Uniform initialization
- C++ Named Requirements
- Automatic type deduction
 - The auto keyword
 - The auto keyword as a return type from a function
 - Using auto for declaring function signatures
 - Automatic constant references
 - Forwarding references
 - Advantages of using auto in embedded systems

Exercise: Using auto to declare variables

Keywords

- Enum class
- override and final
- Inline variables
- nullptr
- static_assert
- noexcept
- constexpr and if constexpr
- decltype
- Defaulted and deleted functions
 - Implementing a thread-safe singleton

Exercise: Using modern C++ keywords

Exercise: Create a singleton using modern C++

New functionalities

- Structured binding
- Range-based for loops
- Nested namespaces and namespace aliases
- Alignment
 - Alignas
 - Alignof
- Move semantics and r-value references
 - Copy-constructing and Move-constructing
 - r-value references
 - Perfect forwarding

Exercise: Using the new for loop syntax

Exercise: Using std::tuple

Exercise: Move semantics performance advantages on embedded systems

Modern C++ Standard Library

- Standard Library
 - std::optional

- std::variant
- std::any
- std::byte
- std::hash
- Filesystem library
- Literals
 - Cooked literals
 - Standard literal operators
 - Raw literals
 - Raw string literals
- Random number generation
 - Random number generation engines
 - Random number generation distributors
- Containers
 - std::array
 - std::forward_list
 - Unordered associative containers

Exercise: Using the new elements added to the standard library

Exercise: Using std::optional

Second Session

String Manipulation

- New string Types
 - std::u16string
 - std::u32string
- Basic string view
- Converting between numeric and string types
- Elementary string conversions
- Input/output manipulators
 - std::get_money, std::put_money
 - std::get_time, std::put_time
 - std::quoted
- Regular expressions
 - Format of a string
 - Parsing the content of a string
 - Replacing the content of a string

Exercise: Using String class and String literals

Concurrency and Multithreading

- Introduction
- Thread
- Atomic operations
 - Atomic features
 - Non-class functions
 - Atomic flag
 - Memory order
- Mutex
 - Avoiding using recursive mutexes
- Sending notifications between threads
- Condition variables
- Future and Promise
- Task and Async
- Modern C++ and RTOS

Exercise: Blink synchronously 4 Leds

Lambda functions

- Syntax of lambdas
- Defining lambdas
- Using lambdas
 - Using lambdas with standard algorithms
 - Assigning lambdas to function pointers
 - Lambdas and `std::function`
 - Writing a function that accepts a lambda as parameter
- Polymorphic lambdas
- Recursive lambdas

Exercise: Understanding lambda

Exercise: Using lambda to modify and display a vector

Dynamic memory management

- Memory Management
- Memory Errors
- Smart Pointers
 - Raw Pointers
 - Automatic pointers
 - Unique Pointers
 - Shared Pointers
 - Weak Pointers

Exercise: Override new and delete

Exercise: Understanding unique and shared pointers