Course AC-401: Advanced C Programming

Course Description:
Many engineers work with the C programming language everyday for real-time embedded development. However, some hit a plateau and never feel comfortable with certain aspects of the language. This course aims to progress individuals and give them a fuller appreciation of the more advanced aspects of the language. Due to the requirements for programming real-time embedded systems, this course goes beyond just addressing the language issues and explores compile, link and run-time issues. In addition it covers interrupts and multi-tasking areas specific to C.

50% of the course is spent writing code for a real target.

Overview:
An intensive four day course covering the advanced aspects of C programming for the real-time embedded programmer.

Course Objectives:
- To become comfortable with the advanced aspects of the C programming language
- To gain an in-depth knowledge on what is happening at compile, link and runtime on a target processor
- To introduce good quality and style for real-time embedded programming
- To gain hands-on experience of programming up interrupts and real-time operating systems (RTOS).

Delegates will learn:
- Advanced aspects of the C programming language
- The traps and pitfalls of the language (e.g. structure packing, dynamic memory, etc.)
- Compile, link, and run-time memory models
- *MISRA-C (www.mira.org) guidelines*
- What parts of C should and should not be used in real-time embedded systems programming.

Pre-requisites:
- A good grasp of the fundamentals of C

OR
- Attendance of Feabhas course C-501 : C for Real-Time Programmers.

Who Should Attend:
This course is designed for engineers who want to improve their grounding and understanding of the C programming language. It is specifically aimed at issues relevant to real-time embedded software engineers.

Duration:
Four days

Course Materials:
- Delegate handbook

Related Courses:
- RTOS-201 Fundamentals of Real-Time Operating Systems
- OO-503 Real-Time Software Design with UML 2.0
- MC-101 Guidelines for Writing High Integrity Software in C
- C-501 C for Real-Time Developers

Course Workshop:
The course workshop uses the IAR compiler and the NXP LCP2129 ARM7TDMI microcontroller as a target for the hands-on sessions. Exercises are designed to stretch attendees' abilities and explore subtleties of the language. A good working knowledge of the C programming language is essential as some of the exercises involve extensive programming.

Course Outline:

Day 1

Introduction
Program Structure
- Importance of good structure
- Quality and style

Pointers, Arrays & Dynamic Allocation
- Arrays & pointers; compatibility and incompatibility

Function Pointers
- Basics
- Callbacks
- State machine

Unscrambling Declarations
- Rules
- Using typedef

Day 2

Enumerations, Structures and Unions
- Enum vs. #define
- Struct layout
- Uses of union

Interrupts
- Hardware interrupt models
- Software interrupts

Multi-Tasking (Multi-Threading)
- Terminology
- Advantages and disadvantages
- Intertask Communication & synchronisation

Day 3

The Linker
- Memory sections

Start-up, Runtime and the Stack
- What happens before main
- What is happening at runtime
- Estimation of stack requirements

Dynamic Memory
- Malloc, calloc and realloc
- Variable sized structures
- Dangers

Memory Management and Protection
- Memory protection
- MMU
- Segmentation and paging

Day 4

Writing Safer C
- MISRA-C Guidelines

OOP with C
- Object-based and object-oriented
- Classes, inheritance and polymorphism
- Associations and aggregation

Number Crunching
- Floating-point and fixed-point number systems
- IEEE Standard 754

The Standard Library
- Major issues

C99
- Summary of significant new features

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