EL-503: Developing for Embedded Linux

Course Description:
Linux is often used as an embedded operating system, and yet many still regard it as something of a black art. This sheds light and brings clarity by showing exactly how to deploy Linux on a typical embedded target board through a combination of theory and practice.

Starting a board without an operating system, delegates will go through a simulated product cycle during which they will build and boot a Linux kernel, build a root file system, write a device driver and a multi-threaded application. Finally, they will review the performance of the resulting system and consider what changes could be made to improve it's real-time performance.

Overview:
A five day course showing how to implement Linux on a typical development board (ARM core).
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Course Objectives:
- Describe the four essential components of an embedded project: toolchain, kernel, bootloader and root file system
- Demonstrate how to control hardware from a device driver (in outline, see EL-504 for a more in-depth treatment)
- Provide an overview of application development, profiling and debugging
- Show how to configure NOR and NAND flash memory for robust code and data storage
- Consider the issues of real-time and Linux

Delegates will learn:
- How to configure and build a customised Linux 2.6 kernel
- How to construct a compact root file system from scratch
- How to develop and debug code for the target board, using the Eclipse IDE
- How to write single and multi-threaded programs using POSIX functions
- Which aspects of the system affect real-time performance and how to reduce scheduling latencies

Who Should Attend:
Software engineers who are developing applications for embedded or real-time Linux. Engineers wishing to assess the suitability of Linux for their next application.

Pre-Requisites:
- Good 'C' programming skills
- General knowledge of an RTOS or embedded operating systems
- Experience of using Linux or a version of Unix is useful, but not essential

Duration:
Five days.

Course Materials:
Student workbook.

Related Courses:
- EL-504: Developing Linux device drivers
- EL-301: Graphics for embedded Linux

Course Workshop:
The course presents embedded and real-time concepts applied to Linux using an ARM9 development board as the target (a Digi ConnectCore Wi-9C). The host development system is a standard PC running Linux. We use the target as an example of a simple embedded system which can control hardware via a simple digital I/O interface. Lab sessions follow a logical sequence, and result in "the world's first Linux-powered web-controlled washing machine"

Course Outline:

Introduction
- Linux in an embedded context
- The 4 basic elements: toolchain, bootloader, kernel, root file system

The Linux Kernel
- Virtual memory
- configuration and cross-compiling

Booting Linux
- The Linux boot sequence
- boot-loaders: U-boot
- loading images using TFTP

The root file-system
- Creating a minimal root file-system using Busybox
- The C library: glibc vs uClibc.
- Creating a RAM disk image

Network configuration
- Static and dynamic IP addresses
- mounting the root file system over NFS

Device drivers
- How to write a simple driver to access GPIO pins
- kernel modules

Debugging
- Logging using , syslogd
- remote debugging using Eclipse and gdbserver.

POSIX programming:
- Processes: fork and exit, scheduling
- signals and signal handlers
- time and timers
- pipes, message queues, semaphores, shared memory

POSIX Threads
- Threads vs processes
- synchronising threads using mutexes and condition variables.

Flash memory
- the Linux Memory Technology Devices Layer

File systems
- File-system suitable for embedded applications
- Study of cramfs, tmpfs, jffs2 and yaffs

Real time Linux
- Typical Interrupt latency. kernel pre-emption modes
- the real-time patch
- practical considerations

Profiling
- Profiling using using gprof and Oprofile
- The Linux Trace Toolkit

Real time sub-kernels
- Introduction to writing hard real-time tasks using RTAI

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