oD1 - Embedded Linux

Installing Linux on Embedded Systems

Objectives

- Understanding the architecture of the Linux system
- Create and use a cross-development toolchain
- Learn how to install Linux on your hardware
- Explore the Linux system architecture
  - Booting Linux
  - Initializing the system
- Install existing packages on the target
- Learn how to install Linux on flash chips

Labs are conducted QEMU ARM-based board
We use a recent version of Kernel

Prerequisite

- Good C programming skills (see our L2 course)
- Preferably knowledge of Linux user programming (see our D0 course)

Course Environment

- Theoretical course
  - PDF course material (in English).
  - Course dispensed using the Teams video-conferencing system.
  - The trainer answers 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.
  - Code examples, exercises and solutions
  - 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.
  - QEMU Emulated board or physical board connected to the online PC (depending on the course).
  - Some Labs may be completed between sessions and are checked by the trainer on the next session.
- Downloadable preconfigured virtual machine for post-course practical activities
- At the start of each session the trainer will interact with the trainees to ensure the course fits their expectations and correct if needed

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.

Evaluation modalities

- The prerequisites indicated above are assessed before the training by the technical supervision of the traineein his company, or by the trainee himself in the exceptional case of an individual trainee.
- Trainee progress is assessed in two different ways, depending on the course:
  - For courses lending themselves to practical exercises, the results of the exercises are checked by the trainer while, if necessary, helping trainees to carry them out by providing additional details.
  - Quizzes are offered at the end of sections that do not include practical exercises to verifythat the trainees have assimilated the points presented
- At the end of the training, each trainee receives a certificate attesting that they have successfully completed the course.
  - In the event of a problem, discovered during the course, due to a lack of prerequisites by the trainee a different or additional training is offered to them, generally to reinforce their prerequisites,in agreement with their company manager if applicable.

Plan

First Session

Linux overview

- Linux
  - History
  - Version management
- Linux architecture and modularity
- Linux system components
- The various licenses used by Linux (GPL, LGPL, etc)

Cross compiling toolchains

- Pre-compiled toolchains
- Toolchain generation tools
  - Crosstool-ng
  - Buildroot
- Manual toolchain compilation

Exercise: Creating a toolchain with crosstool-ng

Linux tools for embedded systems

- Bootloaders (UBoot, Redboot, barebox)
- C libraries (glibc, eglibc, uClibc)
- Embedded GUIs
- Busybox
- Embedded distributions

The U-Boot bootloader

- Introduction to U-Boot
- Booting the board through U-Boot
  - Booting from NOR
  - Booting from NAND
  - Booting from eMMC
  - Multistage Boot
- Secure Boot

- U-Boot environment variables
  - User-defined variables
  - Predefined variables
  - Variables substitution
- The U-Boot minimal shell
- U-Boot main commands
  - Booting an OS
  - Accessing flash chips
  - Accessing file systems (NFS, FAT, EXTx, JFFS2…)
- The full U-Boot shell
  - Script structure
  - Control flow instructions (if, for…)

Exercise: Booting the board on NFS, using pre-existing images

Second Session

Creating the embedded Linux kernel

- Downloading stable source code
  - Getting a tarball
  - Using GIT
- Configuring the kernel
- Compiling the kernel and its modules
  - Modules delivered in-tree
  - Out-of-tree modules
- Installing the kernel and the modules
- The Linux BSP overview
  - Structure
  - Device Drivers
  - Device Tree

Exercise: Configuring and compiling a target kernel for the target board

Creating a root file system

- Packages
  - Various package build systems (autotools, CMake, …)
  - Cross-compiling a package
- The all-in-one applications
  - Busybox, the basic utilities
  - Dropbear: encrypted communications (ssh)
- Manually building your root file system
  - Device nodes, programs and libraries
  - Configuration files (network, udev, …)
  - Installing modules
  - Looking for and installing the needed libraries
  - Testing file system consistency and completeness

Exercise: Configuring and compiling Busybox and Dropbear
Exercise: Creating a minimal root file system using busybox and dropbear

The Linux Boot

- Linux kernel parameters
- The Linux startup sequence
- Various initialization systems
  - busybox init
  - system V init
  - systemd
- Automatically starting an embedded system

Exercise: Boot Linux automatically starts a user application

Updating Linux

- Linux update solutions
  - SWUpdate
  - Mender

Appendix

Embedded file systems

- Storage interfaces
  - Block devices
  - MTD
- Flash memories and Linux MTDs
  - NOR flashes
  - NAND flashes
  - ONENAND flashes
- The various flash file system formats
  - JFFS2, YAFFS2, UBIFS
- Read-only file system
  - CRAMFS, SQUASHFS
- Standard Linux file systems
  - Ext2/3/4, FAT, NFS
- Ramdisks and initrd
  - Creating an initramfs
  - Booting through an initramfs
- Choosing the right file system formats
- Flashing the file system

Exercise: Building an initrd root file system

Renseignements pratiques

Duration : 12 hours
Cost : 2070 € HT