

Control systems and Computer Networks

Module Overview

Dr Alun Moon

Lecture 0.1

What will I learn?

On this module you will learn about computer networks and networked embedded control systems. Many systems now use a network of small computers and devices, from modern cars to the Internet of Things. This module looks at the interaction between devices (sensors and actuators) and the controlling computer. The various networking and communications technologies that connect these systems together, their infrastructure and protocols, will be discussed while considering cybersecurity architecture and operations as appropriate.

from the Module Specification

What will I learn?

You will learn how to control hardware attached to computers. This involves understanding the basics of the electronic circuits used in attaching the hardware, the features of the processors that interact with hardware and the writing of device drivers (the code that controls the devices). You will learn about microprocessor organisation with respect to Input / Output (I/O) and software development for networked control systems using an appropriate language.

from the Module Specification

Teaching Team

Module Tutor Dr Alun Moon alun.moon@northumbria.ac.uk
Dr Michael Brockway
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Teaching Structure

Lectures 2×1 h lectures

- ▶ roughly split into 2 interweaving streams
- ▶ will try to keep step with labs (no promises)

Labs/Seminars 1×2 h sessions

- ▶ Main practical work
- ▶ Largely self-contained

Directed Study Where appropriate I'll point you in the direction of resources to read

Independent Learning A further 9 h

Teaching Plan I

- Week 1
 - Seminar Digital I/O
 - Lecture 1 Introduction and Overview
 - Lecture 2 Digital Signals
- Week 2
 - Seminar Events and interrupts
 - Lecture 1 Memory mapped I/O
 - Lecture 2 Discrete time & Interrupts
- Week 3
 - Seminar Analogue I/O
 - Lecture 1 I2C, SPI, CAN, busses
 - Lecture 2 Analogue Signals
- Week 4
 - Seminar LCD & serial comms
 - Lecture 1 Display code
 - Lecture 2 Sensors
- Week 5
 - Seminar Control & feedback
 - Lecture 1 Control of systems

Teaching Plan II

Lecture 2 Finite state machines

Week 6 Seminar Assembler and ABI

Lecture 1 Sampling & Nyquist limit

Lecture 2 ARM architecture and assembler, ABI,

Week 7 Seminar Data logging

Lecture 1 Formats, XML, Json, Yaml

Lecture 2 TCP stack, RFC1122, RFC1123, RFC768

Week 8 Seminar ?

Lecture 1 Server logging and analysis

Lecture 2 Application layer, RFC2616, RFC7540, RFC1123

Week 9 Seminar ?

Lecture 1 Authentication, validity, md5 hashes, sha/NIST
FIPS 180-4

Lecture 2 TLS RFC5246, SSH / HTTPS RFC2818

Teaching Plan III

- Week 10 Seminar ?
Lecture 1 Encryption
Lecture 2 PGP RFC4880
- Week 11 Seminar Assignment support
Lecture 1 Assignment support
Lecture 2 Assignment support

Knowledge & Understanding:

- ▶ Demonstrate knowledge and critical understanding of the interaction between physical systems, computer hardware and software, including control theories, network protocols, and cybersecurity architecture and operations
- ▶ Apply principles of design and implementation of stack models, network protocols, control systems, and security

Intellectual / Professional skills & abilities:

- ▶ Design, implement, test, document and evaluate a networked embedded control system
- ▶ Apply software development tools and best practice to produce, test and debug software for small networked control systems using specifications for embedded devices and associated hardware

Personal Values Attributes (Global / Cultural awareness, Ethics, Curiosity) (PVA):

- ▶ Demonstrate independent, critical and reflective thinking and practice in the development of a networked control system, and engagement with appropriate professional and technical literature to support and communicate such development

Software tools and resources

Hardware

FRDM k64F an ARM Cortex M3 based Micro-controller in an Arduino like form factor

MBED Application Shield an Arduino compatible shield providing more IO Devices

Loans

- ▶ that they can come and sign out an MBED board from the FEE equipment loans facility in PAN 113/114
- ▶ The loans room will be open from 10-1 every weekday
- ▶ for the remainder of the semester.

YOU HAVE BEEN WARNED

- ▶ Overdue returns will be subject to a fine
- ▶ Any lost or damaged equipment must be paid for or replaced.

Software tools and resources

Software

Git Github is used for disseminating exercises and examples]]
And for submission of the assignment

Atom a good text-editor and development environment

PlatformIO a framework for Atom that supports embedded systems and IoT development

LLVM- CLang used by atom and platformio for managing source code, providing syntax highlighting, syntax checking, and auto-completion.

Mercurial another version control system, many of the Mbed libraries are available via a Mercurial repository. With mercurial platformio can automatically download these.

Availability

- ▶ All the tools are Open-Source and available for free for Linux, Apple OSX, and Windows
- ▶ I have build code for the K64F on all three OSs using this framework
- ▶ I've build code for
 - This platform K64F
 - the previous platform (LPC4088)
 - Arduino Uno (ATmega328P) using
 - the Arduino language framework (C++)
 - bare metal C
 - assembly language