F20SC/F21SC Overview

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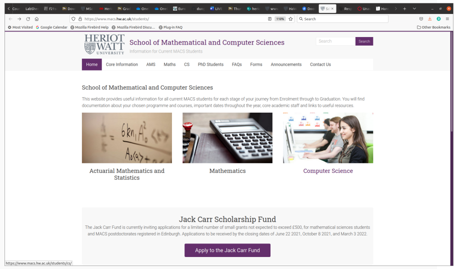
School of Mathematical and Computer Sciences,
Heriot-Watt University, Edinburgh

Semester 1 — 2021/22

Welcome (back) to Heriot-Watt University



School of Mathematical and Computer Sciences
Information for Current MACS Students

School of Mathematical and Computer Sciences

This website provides useful information for all current MACS students for each stage of your journey from Enrolment through to Graduation. You will find documentation about your chosen programme and courses, important dates throughout the year, core academic staff and links to useful resources.

Actuarial Mathematics and Statistics

Mathematics

Computer Science

Jack Carr Scholarship Fund

The Jack Carr Fund is currently inviting applications for a limited number of small grants not expected to exceed £500, for mathematical sciences students and MACS postdoctorates registered in Edinburgh. Applications to be received by the closing dates of June 22 2021, October 8 2021, and March 3 2022.

This year we will use a combination of online and face-to-face teaching (hybrid).

Weekly Schedule

- Lectures will be asynchronous, online: watch the screencast of the lecture in your own time
- The online slots will be used for overview of the new material in that week, for Q&A sessions, and exercises
- See the *Week Overview* item for that week on Canvas with all necessary links
- Scheduled slots for the course are:
  - Mon 11:00-12:00 (online, sync lecture): overview of lecture material for that week
  - Tue 13:00-15:00 (online, sync lab): Q&A session and lab exercises for that week
  - Fri 17:00-18:00 (face-to-face lab): in-person lab session in Windows (C#) or Linux lab (Python)

Overview of F20SC/F21SC "Industrial Programming"

Key course characteristics:

- This course is about the programming skills
- We will cover:
  - Systems languages: C#
  - Scripting languages: Python
- It assumes *solid prior knowledge of an object-oriented language*, eg. Java.
  - It is about quickly picking up a new language of a familiar paradigm.
  - It is not a gentle introduction to programming.

Learning Outcomes

- Appreciation of role of different programming paradigms in configuring/managing systems:
  - Object-oriented: good at structuring large code
  - Imperative: good at performance
  - Functional: good at abstraction
  - Logic: good at reasoning
- Autonomous problem analysis/solution:
  - Really understand the problem to pick the right paradigm/approach for producing a solution
- Understanding of core characteristics of contemporary operating systems: make good use of available resources

Learning Outcomes

- Appreciation of role of “language as glue wear” in configuring/maintaining systems:
  - Scripting languages combine existing code
- Knowledge of key abstractions across programming languages:
  - Write reusable and maintainable code
- Technical proficiency in advanced techniques in different programming paradigms:
  - Learn the Best of all Worlds

Topics to cover

- Overview & Linux introduction (induction week)
- Core C# programming (3 weeks)
- Advanced C# programming (3 weeks)
- Reading Week (1 week)
- Python programming (4 weeks)
- Revision (1 week)

Lecture Plan

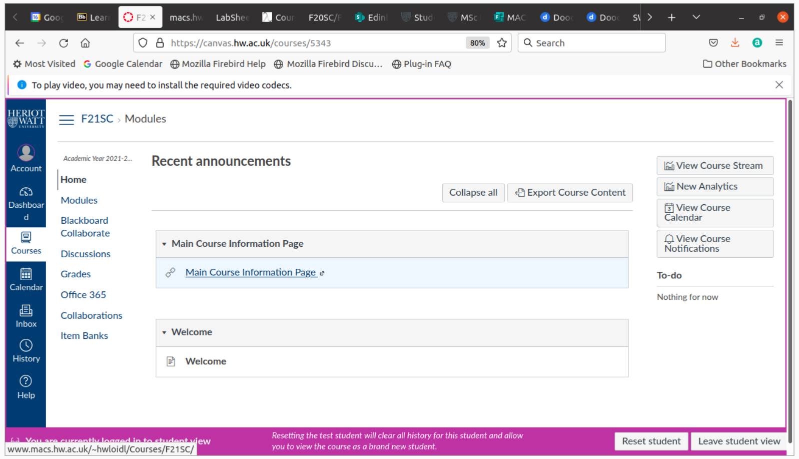
- Week 0: Linux Introduction (with shell scripting)
- Week 1: .Net and C# Introduction, C# Fundamentals
- Week 2: C# Objects & Classes, C# Concurrency
- Week 3: C# Data Manipulation, Database access in C# and LINQ, C# GUI development
- Week 4: Threading in C#, C# Systems Programming
- Week 5: Advanced C# Features, C# Revision
- Week 6: Reading Week

Lecture Plan (cont'd)

- Week 7: Parallel Programming in C#
- Week 8: Python Introduction and Data Types
- Week 9: Python Control Structures and Functions
- Week 10: Python Classes and Advanced Language Constructs
- Week 11: Python Libraries and Tools
- Week 12: Revision

Course material is available via the Canvas system:
http://canvas.hw.ac.uk/
Main course information page:
http://www.macs.hw.ac.uk/~hwloidl/Courses/F21SC/

Starting from Canvas . . .



To play video, you may need to install the required video codecs.

Recent announcements

Main Course Information Page

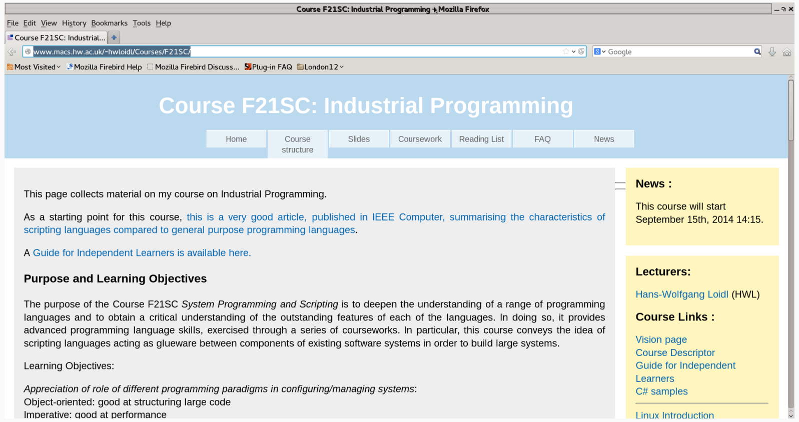
Welcome

You are currently logged in to student view

Resetting the test student will clear all history for this student and allow you to view the course as a brand new student.

www.macs.hw.ac.uk/~hwloidl/Courses/F21SC/

Main course information page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Course F21SC: Industrial Programming

This page collects material on my course on Industrial Programming.

As a starting point for this course, this is a very good article, published in IEEE Computer, summarising the characteristics of scripting languages compared to general purpose programming languages.

A Guide for Independent Learners is available here.

Purpose and Learning Objectives

The purpose of the Course F21SC *System Programming and Scripting* is to deepen the understanding of a range of programming languages and to obtain a critical understanding of the outstanding features of each of the languages. In doing so, it provides advanced programming language skills, exercised through a series of courseworks. In particular, this course conveys the idea of scripting languages acting as glueware between components of existing software systems in order to build large systems.

Learning Objectives:

Appreciation of role of different programming paradigms in configuring/managing systems:
Object-oriented: good at structuring large code
Imperative: good at performance

News :

This course will start September 15th, 2014 14:15.

Lecturers:

Hans-Wolfgang Loidl (HWL)

Course Links :

Vision page
Course Descriptor
Guide for Independent Learners
C# samples

Linux Introduction

Assessment

- Assessed Coursework (2×): 100%
- There is no exam for this module

Coursework:

- Project 1: C# programming project (50%)
- Handout: Week 3; *Deadline: Week 7*
- Project 2: Python programming project (50%)
- Handout: Week 8; *Deadline: Week 13*

There will be no individual deadline extensions. If you have a case you must submit a "Mitigating Circumstances" form.

Skills tested in the Coursework

- Composing bigger applications out of existing components
- Rapid prototyping
- Resource conscious programming
- GUI programming
- Concurrency

Software Infrastructure

- Visual Studio 2019 with C# (Windows)
- Alternatively, stand-alone C# compiler with libraries needed for GUI etc programming
- sh or bash scripting languages (Unix)
- Python interpreter
- Overall: heavy use of libraries!

Reading List

C#

- Jesse Liberty, Brian MacDonald, “Learning C# 3.0”, O’Reilly, 2009.
- Ian Griffiths, “Programming C# 8.0”, O’Reilly, May 2019.
- Joseph Albahari, Ben Albahari, “C# 7.0 in a Nutshell: The Definitive Reference”, O’Reilly, 2017.
- Kurt Normark, “Object-oriented Programming in C# for C and Java Programmers”, 2011. on-line
- Eric Gunnerson, “A programmer’s Introduction to C# 5.0”, Springer, 2012
- Andrew Birrell, “An Introduction to programming with C# Threads”, Microsoft, 2005.
- Arnold Robbins, “Classic Shell Scripting: Hidden Commands that Unlock the Power of Unix”, O’Reilly, 2005.

Characteristics of Systems Languages

- Build algorithms and data structures from scratch
- Use strong typing to help manage complexity of large pieces of software
- Focus is often on speed of execution
- Easy access to low-level operating system is crucial
- Examples: C, C#

Characteristics of Scripting Language

- Their main purpose is to glue software together
- Focus is on rapid-prototyping
- Safety aspects are of a lesser concern
- Thus, scripting languages are often type-less
- Modern scripting languages incorporate features of general purpose programming languages, especially object-oriented (o-o) features, higher- order functions
- Easier to learn for casual programming
- Examples: sh, php, python, perl, ruby, lua

A Short History of Scripting Languages

- Developed as an abstraction over assembler programs
- They are higher-level by introducing abstraction mechanisms to manage large pieces of code.
- They provide fewer safety mechanisms and are typically type-less (or dynamically typed)
- They delegate some control of the underlying machine to (external) libraries and operating system
- Together this drastically increases programmer productivity

Classifying Scripting Languages

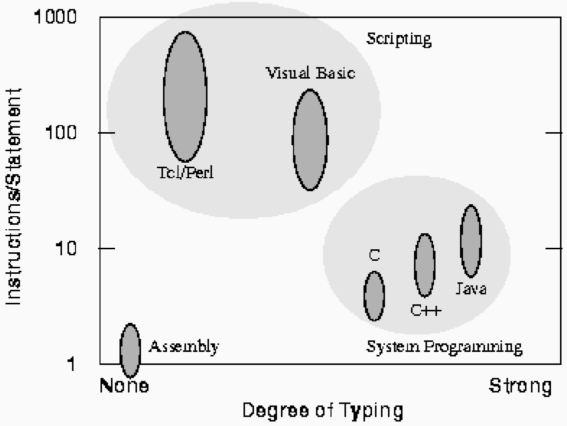


Figure 1. A comparison of various programming languages based on their level (higher level languages execute more machine instructions for each language statement) and their degree of typing. System programming languages like C tend to be strongly typed and medium level (5-10 instructions/statement). Scripting languages like Tcl tend to be weakly typed and very high level (100-1000 instructions/statement).

A Short History of Scripting Languages

- *First Generation:* simple composition of command-line jobs (espec. Unix systems); also called batch-languages
- Very little language abstraction
- Slightly different syntax in different languages
- Rich libraries for low-level coordination with the operating-system (OS)
- Examples: sh, bash, tcsh ...

A Short History of Scripting Languages

- *Second Generation*: Trying to combine many different language features into one language
- Addresses the problem that different batch languages do the same thing slightly differently
- Thus, the language becomes huge
- The mixture of concepts makes it hard to read third-party code.
- Also, extended support for graphical user interfaces (GUIs)
- Examples: perl, tcl

A Short History of Scripting Languages

- *Third Generation:* increasingly use modern programming language abstractions to make programming simpler
- In particular, heavy use of o-o concepts
- Also, concepts from other programming paradigms such as higher-order functions and polymorphism
- *Examples:* php, python, ruby, lua, go, dart

Relevance of Scripting Languages

- Increasing speed of processor makes the application of interpreted languages viable
- Existence of large libraries makes the development of new software from scratch less common-place
- Heterogeneous environment make a write- once run-everywhere approach appealing
- New technologies, such as the internet, make the issue of composing services even more important

Common Features of Scripting Languages

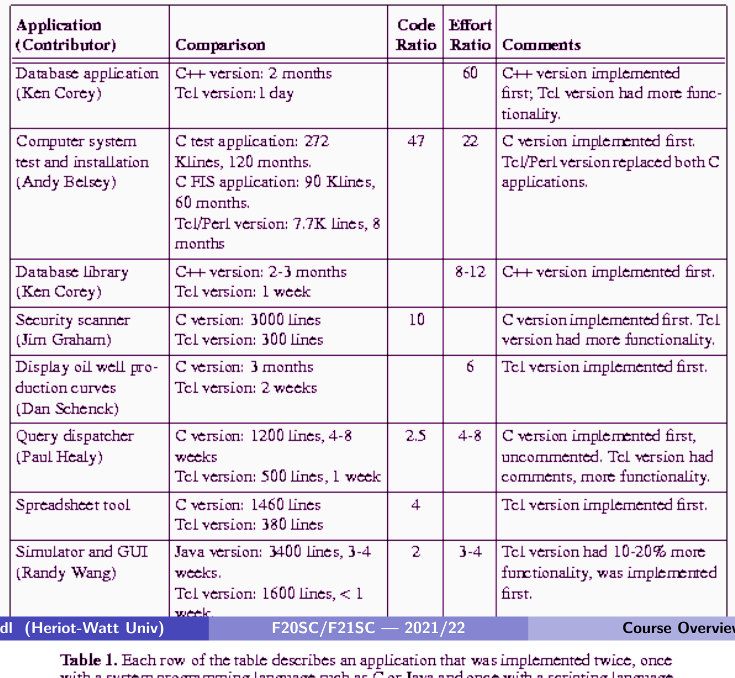
- Scripting languages are usually typeless: no (type) restrictions on the use of the input/output to/from existing components are imposed
- This enhances the flexibility of the language but reduces the safety
- Example from Unix shells: pipeline mechanism:

  ```
  select | grep scripting | wc
  ```
- This reads the text currently selected in a window, passes it to a search for the word “scripting” and counts the number of lines in the output

- Modern scripting languages provide a limited amount of type information to re-gain type safety
- To avoid frequent conversion functions between types, class hierarchies and implicit type conversions are used
- In contrast to systems languages, some type checks are performed at run-time rather than compile-time (dynamic typing)

- Scripting languages are usually interpreted rather than compiled
- This gains rapid turnaround time in writing and testing code
- It increases flexibility, since the program can generate strings that are in themselves programs
- It loses performance compared to executing compiled code; but typically the amount of code in the scripting language is small and performance is dominated by the code in the components

- Scripting languages are often higher-level than system languages, espec. for the latest generation
- For example many scripting languages have powerful, built-in mechanisms for regular expression substitution
- In the latest generation high-level concepts such as class hierarchies are included, too.



Application (Contributor)	Comparison	Code Ratio	Effort Ratio	Comments
Database application (Ken Corey)	C++ version: 2 months Tcl version: 1 day		60	C++ version implemented first; Tcl version had more functionality.
Computer system test and installation (Andy Belsey)	C test application: 272 Klines, 120 months. C FIS application: 90 Klines, 60 months. Tcl/Perl version: 7.7K lines, 8 months	47	22	C version implemented first. Tcl/Perl version replaced both C applications.
Database library (Ken Corey)	C++ version: 2-3 months Tcl version: 1 week		8-12	C++ version implemented first.
Security scanner (Jim Graham)	C version: 3000 lines Tcl version: 300 lines	10		C version implemented first. Tcl version had more functionality.
Display oil well production curves (Dan Schenck)	C version: 3 months Tcl version: 2 weeks		6	Tcl version implemented first.
Query dispatcher (Paul Healy)	C version: 1200 lines, 4-8 weeks Tcl version: 500 lines, 1 week	2.5	4-8	C version implemented first, uncommented. Tcl version had comments, more functionality.
Spreadsheet tool	C version: 1460 lines Tcl version: 380 lines	4		Tcl version implemented first.
Simulator and GUI (Randy Wang)	Java version: 3400 lines, 3-4 weeks. Tcl version: 1600 lines, < 1 week.	2	3-4	Tcl version had 10-20% more functionality, was implemented first.

Table 1. Each row of the table describes an application that was implemented twice, once with a system programming language such as C or Java and once with a scripting language

When to use Scripting Languages

- Is the application's main task to connect pre-existing components?
- Will the application manipulate a variety of different kinds of things?
- Does the application involve a GUI?
- Does the application do a lot of string manipulation?
- Will the application's functions evolve rapidly over time?
- Does the application need to be extensible?

When to use Systems Languages

- Does the application implement complex algorithms or data structures?
- Does the application manipulate large data sets?
- Are the application's functions well-defined and changing slowly?

Application Domains for Scripting

- Graphical User Interfaces
  - Fundamentally "gluing" nature
  - Large percentage of code in modern apps
- Internet
  - Main role: connecting a huge number of existing computations and data (see success of perl)
  - Web services as the next level of gluing
- Component Frameworks
  - A flexible method of assembling components into applications

Summary

- Be aware of the characteristics of systems and scripting languages
  - Decide early on in a project which class of language to use
  - Today's trends in programming languages will be tomorrow's features in scripting languages
- Main reference:
  "Scripting: Higher Level Programming in the 21-st Century", John K. Ousterhout, IEEE Computer, March 1998. URL: http://home.pacbell.net/ouster/scripting.html