D.22 4BA2 Computer Modelling

D.22.1 4BA2 Part 1 - Computer Systems Analysis, Evaluation & Modelling

Lecturer Dr. Tony Redmond (CV on page 309).

Course Organisation

This course runs for the 9 weeks of Michaelmas Term. It comprises 2 lectures and 1 tutorial per week.

Lectures		Tutorials		Practicals	
Per Week	Total	Per Week	Total	Per Week	Total
2	18	1	9	0	0
Total Contact Hours: 27					

Course Description and Aims

This course is divided into three sections (1) introduction to the basic concepts of computer systems performance analysis, (2) an introduction to queueing systems modelling and (3) an introduction to simulation modelling.

In the first section, students get an introduction to systems theory leading on through (Hard) Systems Theory through Soft Systems Theory (Checkland) to the Systematic Approach (Coverdale). Measures of system performance are presented with some typical characteristic curves of modern computer system performance. The workload characterisation problem is discussed along with the concept of incremental performance improvement through the successive removal of bottlenecks.

In the second section, the ideas already discussed are illustrated through the use of a series of increasingly complex simple queueing models which give intuitive insights into computer system performance. The ability to understand and use (but not necessarily derive) queueing theory formulae as approximate models to get performance estimates is emphasised.

In the third section, simulation is introduced as a powerful general purpose technique which is often used as a method of last resort.

The students, in teams, are asked to write two essays addressing current topics of interest in measurement.

Learning Outcomes

Students will be able to

- use modern systems theory such as Soft Systems Theory and Systematic Approach in Computer System Performance problem situations;
- recognise the performance characteristics of modern computing systems;
- apply logically based strategies such as the incremental improvement of performance by the successive removal of bottlenecks for locating and improving problem situations;
- use queueing theory models to set bounds and support intuitions about computer system performance;

- use simulation models to set bounds and support intuitions about computer system performance;
- work better together as a team, researching a topic in depth and writing an engineering report;
- perform a Computer Systems Performance study effectively and efficiently.

Content of Course

- Section 1:
  - Systems and Different Views:
  - (Hard) Systems Theory, Soft Systems Theory, Systematic Approach
  - Initial Metrics of Interest and Surrogate Measures of Performance
  - Workload Characterisation
  - System Performance
  - Subsystem Performance and Measurement
  - Incremental Improvement in Performance by Successive Removal Of Bottlenecks
- Section 2:
  - Simple Infinite Source Models
  - Simple Finite Source Models and System Saturation
  - Central Server Model and Extensions
  - Simple Transient Solution Example
  - Metrics Measurement and Parameter Estimation
  - Implementing A Performance Study
  - System Performance Improvement
  - Multiple-CPU Performance
  - The use of queueing theory as a sequence of approximate models for system insights
- Section 3:
  - Simulation in Computer System Performance
  - Building a Simulation Model
  - Model Validity and Reliability; Model Parameters and Performance Measures
  - Time Incrementation
  - Generating Random Phenomena: Uniform Random Numbers
  - Multiplicative Congruential Method
  - Generating Random Variables: Inverse Transform Method
  - Design of Simulation experiments
  - Computer Simulation Languages
  - Major sources of error in simulation: Error control in simulation: Variance Reduction

Contribution to Programme

The course's contribution to the IEI Programme Areas and Outcomes are characterised in the following tables (H=high; M=moderate; L=low):

Science and Mathematics	Discipline Specific Technology	Information and Communications Technology	Design and Development	Engineering Practice	Social and Business Context
H	H	H	H	H	M

Contribution to IEI Programme Areas

(a) The ability to derive and apply solutions from a knowledge of sciences, engineering sciences, technology and mathematics	(b) The ability to identify, formulate, analyse and solve engineering problems	(c) The ability to design a system, component or process to meet specified needs	(d) An understanding of the need for high ethical standards in the practice of engineering, ...	(e) The ability to work effectively as an individual, in teams and in multidisciplinary settings ...	(f) The ability to communicate effectively with the engineering community and with society at large
H	H	H	M	H	M

Contribution to IEI Programme Outcomes

Teaching Strategies

The teaching strategy is a mixture of lectures, problem solving tutorials and some team essays on current topics. Students are encouraged to question the assumptions underlying the common (mis)perceptions of computer system performance particularly by using simple queueing models to generate answers which are sometimes counter-intuitive.

Cognisance is taken of the fact that senior sophister students are completing a major final year project so the current topic essays are spread over a team of four students. Some recent topics include The Future of the Mainframe, Moore's law - where's the Brick wall, Quantum Computing on the desktop - when?, The Mythical Megahertz etc.

Assessment

The group project account for 20% of the final mark and the exam 80%. Students must answer 6 out of 8 exam questions (three from part 1 and three from part 2). All members of the same group normally receive identical marks.

Recommended Texts

- *Measurement & Tuning of Computer Systems*, Ferrari, Serazzi and Zeigner.
- *Probability and Statistics with Computer Science Applications*, A. V. Allen Academic Press.
- *The Art of Computer Systems Performance Analysis (Techniques for Experimental design, Measurement, Simulation and Modeling)*, R. Jain.

Further Information

Exam paper: page 463.

D.22.2 4BA2 Part 2 - Communications

Lecturer Patroklos Argyroudis (CV on page 209).

Course Organisation

This course runs for the 9 weeks of Hilary Term. It comprises 3 lectures per week. There are no practical laboratory sessions, as this course covers theoretical aspects of contemporary computer networking.

Lectures		Tutorials		Practicals	
Per Week	Total	Per Week	Total	Per Week	Total
3	27	0	0	0	0
Total Contact Hours: 27					

Course Description and Aims

This course, which naturally follows 3BA3, covers telecommunications technologies as well as the upper layers of the Open Systems Interconnection (OSI) reference model. It is divided into three parts (1) Wide area broadband networking technologies (B-ISDN, ATM, DSL), (2) internetworking protocols and services and (3) network security based on applied cryptography. The course aims to provide students with an understanding of how data is communicated between interconnected entities and the issues involved in constructing robust and secure networked systems.

In the first part of 4BA2 Part 2, students receive a theoretical introduction to the fundamental elements of wide area broadband networking. Circuit and packet switching are introduced, analysed and compared as enabling technologies. The paradigm shift in digital communications instigated by packet switching is evaluated and compared to previous alternatives like circuit and message switching. Based on this knowledge, the course examines in depth technologies such as Broadband ISDN and ATM.

In the second part of the course, students receive a theoretical introduction to internetworking and the TCP/IP protocol suite. Protocol layering and its role in end-to-end system design are explained and analysed as key ideas. Principal concepts and architecture elements of heterogeneous networks and internetworking protocols such as ARP, IPv4, IPv6, ICMP, DNS, TCP, UDP and others are introduced. The students are given evaluations of each presented protocol which identify problems and shortcomings while prompted to propose alternative solutions.

The third part of the course introduces applied cryptography as an enabling mechanism of designing secure networking protocols. The aims of this part are to introduce the concept of a secure protocol and model the principals involved in secure protocols, and their capabilities. Furthermore, to demonstrate how basic cryptographic mechanisms can be used to design entity authentication and key distribution protocols suited to insecure networks.

Learning Outcomes

Students will be able to

- explain the key concepts and compare the complexities of converging wide area broadband networking technologies.

- explain the operation of layered protocols, standards and networking software components.
- describe how the basic networking components work and how they can be employed to design a new system.
- select, deploy and use internetworking protocols as building blocks in multiprotocol systems.
- design protocols for solving interaction problems between system components, appraise a design and identify its shortcomings.
- analyse and design secure protocols using applied cryptographic technologies.

Content of Course

- Part 1
  - Wide area broadband networking.
  - Circuit switching, message switching, packet switching.
  - Narrowband ISDN.
  - Broadband ISDN, ATM and virtual circuit switching.
  - DSL family of technologies.
- Part 2
  - Open Systems Interconnection (OSI) reference model.
  - Internetworking and the TCP/IP reference model.
  - Network layer: Addressing, IPv4, routing.
  - Advanced network layer topics: IPv6, MPLS, MobileIP.
  - Transport layer: UDP, TCP, congestion control.
  - Application layer: Naming for internets, DNS, electronic mail (SMTP), HTTP, network management (SNMP).
- Part 3
  - Symmetric cryptography concepts, the AES (Rijndael) algorithm.
  - Asymmetric cryptography concepts, the RSA algorithm.
  - Hybrid cryptosystems and key agreement, the Diffie-Hellman protocol.
  - Authentication and digital signatures.
  - Public key infrastructure (PKI) and the X.509 hierarchy.
  - Secure protocols (IPsec, SSL, Kerberos, SSH).

Contribution to Programme

The course's contribution to the IEI Programme Areas and Outcomes are characterised in the following tables (H=high; M=moderate; L=low):

Science and Mathematics	Discipline Specific Technology	Information and Communications Technology	Design and Development	Engineering Practice	Social and Business Context
L	H	H	H	M	-

Contribution to IEI Programme Areas

(a) The ability to derive and apply solutions from a knowledge of sciences, engineering sciences, technology and mathematics	(b) The ability to identify, formulate, analyse and solve engineering problems	(c) The ability to design a system, component or process to meet specified needs	(d) An understanding of the need for high ethical standards in the practice of engineering, ...	(e) The ability to work effectively as an individual, in teams and in multidisciplinary settings ...	(f) The ability to communicate effectively with the engineering community and with society at large
H	H	H	-	M	M

Contribution to IEI Programme Outcomes

Teaching Strategies

The lectures will provide the theoretical base for the subject by introducing the main topics and provide students with an understanding of the principles underlying the subject. The lectures will help the students to become familiar with the fundamental concepts of computer networking and posses a sound understanding by discussing the basic principles of data communications, leading to an outline of the OSI reference model layers, protocols and associated services and develop this into a discussion of industry standards. Also, detailed study of some common TCP/IP applications such as electronic mail, network news, file transfer protocols and world wide web services will extend the students understanding.

The students are also given research papers from the published literature related to concepts presented in the lectures in order to help them develop their critical thinking and analysis skills when investigating a problem.

Assessment

The group project accounts for 20% of the final mark and the written examination 80%. Students must answer at least 2, with a maximum of 3, out of 4 questions.

Recommended Texts

- *Computer Networks*, 3rd Ed., Andrew Tanenbaum
- *Computer Networks and Internets*, 4th Ed., Douglas Comer
- *Data Communications, Computer Networks and Open Systems*, 4th Ed., Fred Halsall

Further Information

Web site: http://ntrg.cs.tcd.ie/~argp/2005-4ba2/

Exam paper: page 463.