Computer Science
— Graduate Student Handbook
2006

Department of Computer Science

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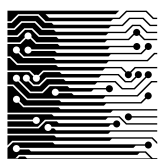
Department of Computer Science
University of Cape Town

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compiled by Patrick Marais

Contents

OUR MISSION

As the Department of Computer Science, our mission is to develop and impart knowledge and skills in the field of computer science.

OUR VISION

The Department of Computer Science strives to be a department of the first rank in both an international and an African context, sustaining

- high respect for its research and post-graduate education;

- excellence in teaching in order to produce graduates who possess the skills that are needed whenever decision making or creative thinking takes place;

- an influential role in industry and the Information Technology community.

The University of Cape Town is committed to policies of equal opportunity and affirmative action which are essential to its mission of promoting critical inquiry and scholarship.

1 Introduction

The volume of that body of knowledge, which has become known as computer science, has grown exponentially since its beginning in the early sixties. A wealth of new concepts and techniques have been introduced, yielding a myriad of widely diverse applications. Computer science is one of the youngest sciences and it has only recently and gradually been assuming a clear identity. It has developed a clear experimental focus on top of a theoretical foundation based on Mathematics. Computer Science draws upon commercial practice and engineering design disciplines.

Daily, researchers worldwide are producing better algorithms, better software tools, more usable user interfaces, improved methods of software development and faster processors. In the marketplace, industry demand for computer science skills is unlikely to be met for decades to come.

2 Graduate Studies

Welcome to the Department of Computer Science of the University of Cape Town and congratulations on choosing one of the best computer science departments in the country for pursuing your graduate work. We are building up a stable group of well qualified researchers in this department and we believe we have brought together some of the best people in this country, with doctorates and experience from some of the world's leading computer science institutes. That alone does not make us great, but it does show that we are trying.

There is a significant, but subtle, difference between studies for an undergraduate and a graduate degree. It is assumed that if you register for the course, it is because you have an interest in your studies in general and computer science in particular. As a graduate student, you are expected to:

- be responsible for identifying much of your study material yourself and managing your own study programme;

- work largely unsupervised and independently;

- display evidence of independent and original thought;

- be prepared to evaluate, criticise and justify;

- show an appreciation of concepts and principles;

- communicate ideas clearly and succinctly;

- learn together with staff members.

This booklet contains details of the structure of the various graduate courses, covering the Honours Year (fourth year) Masters Degree and Doctoral Degree, as well as some information about the department itself.

The Honours year, in particular, is hard full-time work; we hope that you enjoy the course. The department wishes you every success for the year.

3 Role of the Department

In general the role of the Department is to

- produce graduates with knowledge and skills relevant to both the International and the South African Information Technology community;

- carry out innovative research which adds to basic understanding;

- produce service courses and provide research assistance in the fields of science and engineering;

- provide services to Industry through technology transfer and applied research;

- take an active part in the academic and governance affairs of the University;

- to provide opportunities and support for students from disadvantaged backgrounds to realise their potential;

- to promote, support and advise schools in the teaching of CS Technology.

In our graduate programme our role is more specifically to produce individuals who are well read, articulate, and able to exercise critical judgement in the field of Information Technology. Its core function, therefore, is not that of providing vocational training, but to impart the fundamental skills that are needed whenever decision making or creative thinking takes place. These skills have to be nurtured in the special environment of the university, where orthodoxies can be challenged and ideas can be developed.

We therefore educate our students in the principles, theory and practice of computer science. We do not aim to train people how to use computers and become programmers, although you will learn those things as a matter of course. We want our students still to be useful scientists a decade from now, rather than be trained for the immediate demands of the marketplace.

4 The Department

4.1 Staff

The academic staff members are:

Sonia Berman (Professor), who joined the department in 1980 after completing her Honours degree, obtained her MSc in Computer Science at UCT in 1983 and her PhD in 1991. Dr Berman spent her study leave in 1993 at the University of Glasgow, and maintains regular contact with academics there. In 1999 Dr Berman was on sabbatical. Dr Berman has NRF support for her research.

Edwin Blake (Professor) holds a BSc in Physics and Applied Mathematics from UCT and honours in Applied Mathematics from Wits. In 1988 he completed his PhD in Computer Science at Queen Mary College, London University. He then worked for the Centre for Mathematics and Computer Science (CWI) in Amsterdam as a senior researcher in Interactive Systems. He joined the Department in 1992.

Professor Blake is a member of the Collaborative Visual Computing Laboratory. He has NRF support for his research. He recently successfully lead the multi-million Rand Innovation Fund research project on the Collaborative African Virtual Environment System (CAVES).

Pieter Kritzinger (Professor) obtained an MSc in Electrical Engineering from Wits in 1968 before going to Canada in August 1969. He completed his Ph.D. 30 months later at the University of Waterloo, Canada, still considered one of the 10 best computer science departments in North America. He subsequently became an Assistant Professor at that university for 2 years. This was followed by 2 years of teaching at Imperial College, University of London, before returning to South Africa as a Senior Lecturer at Stellenbosch University where, inter alia, he was a co-founder of ITR, the Institute for Applied Computer Science. Professor Kritzinger spent 1984 on study leave at the IBM Zürich Research Laboratory (ZRL) before being invited to join UCT as a full professor in July 1985. He was Head of the Computer Science Department for 8 years starting in 1989. He spent 1992 on study leave at the Abteilung für Informatik at the Universität Dortmund and has visited the Universität Erlangen-Nürnberg for several shorter study periods since. During 2004 Pieter again spent 4 months at the ZRL and subsequently his research group entered a Joint Research Agreement with ZRL. Professor Kritzinger is a grant-holder in the NRF Information and Telecommunications Focus Area, the Franco/South African Research Cooperation programme and the Telkom/Siemens Centre of Excellence programme. Pieter was elected a Senior Member of the American Institute for Electronic and Electrical Engineers in September 1998 and he is an invited member of IFIP Working Groups 6.1, 6.3 and 7.3. Pieter has published more than 40 research papers in peer-reviewed international journals or

research conferences and has successfully supervised 25 Masters and Doctoral students to date.

Ken MacGregor (Professor and Head of Department) studied at the University of Strathclyde in Glasgow, obtaining his B.Sc. in Mathematics in 1966. He then studied at the University of Glasgow where he obtained a Diploma in Computer Science in 1967, and his MSc in 1971. Professor MacGregor lectured Computer Science for three years at Glasgow University before joining UCT in 1972.

Gary Marsden (Associate Professor) graduated with a first class BSc(Hons) in Computing Science from Stirling University in 1992. After completing a brief research assistantship in expert systems, he began his PhD on the design and usability of end user programming systems. During his PhD he has held two full time lecturing posts - first at Stirling and then later at Middlesex University. He has also formed a company which sells neural network software and has been involved in consultancy with a wide range of firms. Most recently he has been working on UK government funded research projects in collaboration with Reuters and cellular telephone manufacturers.

Dr James Gain (Senior Lecturer) received his BSc(Hons) and MSc degrees in Computer Science from Rhodes University in 1994 and 1996 respectively. During 1996 he lectured part-time. Near the beginning of 1997 he joined the Rainbow Graphics Group at the University of Cambridge and, in 2000, obtained a PhD in Computer Graphics. He joined the Computer Science Department at UCT in October 2000.

Dr Michelle Kuttel (Senior Lecturer) completed a BSc in Chemistry (1995, UCT) and a BSc(Hons) in Computer Science (1996, UCT). She completed an MSc (1999, UCT) and a PhD (2003, UCT) in Computational Chemistry. She joined the Department in January 2003. She is currently a member of the UCT node of the National Bioinformatics Network and is involved in a number of collaborative projects involving scientific simulation and parallel computing.

Dr Mike Linck (Senior Lecturer) studied Physics at UCT, obtaining his PhD in 1970. He subsequently lectured in Computer Science at the University of Natal for nine years, before joining the department in 1979.

Dr Patrick Marais (Senior Lecturer) completed his BSc (Hons) in Applied Mathematics in 1991, before enrolling in the Computer Science Department at UCT to begin an MSc. He spent the last 3 months of his MSc working at the Centre for Mathematics and Computer Science (CWI) in Amsterdam. After completion of his MSc in 1994, he joined the Robotics Reseach Group at the University of Oxford. He completed his DPhil in medical imaging in 1998, and joined the Department in November of the same year.

Dr Hussein Suleman (Senior Lecturer) obtained his undergraduate and M.Sc. degrees from the University of Durban-Westville. He then moved to Virginia Polytechnic Institute and State University to pursue a Ph.D., which he completed in 2002. He joined the staff at UCT in January of 2003.

Donald Cook (Lecturer) studied a BSc (Hons) in Computer Science at UCT and also obtained a Teaching Diploma. He joined the department in 1989 after working at the Teaching Methods Unit at UCT. Donald spent a sabbatical at the University of Illinois Urbana Champaigne where he began work on his

MSc in Computer Supported Collaborative Work.

Anet Potgieter (Lecturer) obtained her MSc in 1992 and her PhD in 2004, both from the University of Pretoria. She did software engineering as well as research in industry from 1982 until July 2002 when she joined UCT as a lecturer. She was part of the software development team of the Rooivalk attack helicopter, developing software for its health-monitoring unit and its navigation system. She was part of the DTI consortium (Deloitte & Touche, ISIS) that engineered the Saldanha Steel scheduling system. This project involved the integration of an expert system, database system and ERP system to do the scheduling of the steel plant. She was involved in various military research projects for example combining artificial intelligence techniques with parallel processing to do real-time model-based image understanding.

Dr Andrew Hutchison (Part-Time Lecturer) obtained his MSc in Computer Science from UCT in 1991 and his PhD in Computer Science from the University of Zurich, Switzerland in 1996. He also holds a Higher Diploma in Education (with distinction) from UCT. After completing his MSc, he worked as a software engineer for Netsys International, Pretoria before joining the IBM Zurich Research Laboratory where he worked while doing his doctorate. Dr Hutchison is a consultant specialising in information security. He previously spent 4 years as a senior lecturer in the department and continues to give some lectures on a part-time basis.

Matthew West is the UNIX Systems Administrator in the department. He is currently completing his BSc in Computer Science at UNISA.

Samuel Chetty is a Systems Administrator in the department. He is a Microsoft Certified Professional.

The administrative staff consist of **Freda Parker**, **Shanaaz Shaffie**, **Eve Gill** and **Bernie Sam**. Ms. Parker is the departmental Administrative Assistant, and is the first person to approach if you have an administrative query. Ms. Shaffie is the departmental secretary and is assisted by Ms. Sam. Ms. Gill deals with research administration and funding in a part-time capacity. Ms. Sam is responsible for the distribution of tutorials, lecture notes, and other course materials. She is a good source of information on the operation of the department.

Masters students may also be involved in the teaching of Honours students. Please enquire which Masters students are involved and their interests, since they can often give you invaluable advice about the course.

4.2   Research in the Department

The research activities in the department are informally grouped into laboratories. The current fields of interest include computer networks, database systems, interactive computer graphics, distributed systems and data visualization.

4.2.1   Collaborative Visual Computing Laboratory
Edwin Blake, James Gain, Patrick Marais, Gary Marsden.

The CVC lab brings together expertise in graphics, interface design and psychology. Typical areas of research include: virtual modelling, visualisa-

tion, mobile computer interfaces, scene rendering and collaboration in virtual environments.

4.2.2 Advanced Information Management

Sonia Berman, Michelle Kuttel, Gary Marsden, Ken MacGregor, Anet Potgieter and Hussein Suleman

The Advanced Information Management laboratory is a new research collaborative in the department, with a strong focus on the use of information, from computational, representational and distribution perspectives. This broad spectrum of research areas includes databases, knowledge management systems, scientific and high performance computing, complex adaptive systems, distributed artificial intelligence, distributed computing, Web-based systems, component-based systems, digital libraries and information storage, retrieval and visualisation.

4.2.3 Data Network Architectures Laboratory

Pieter Kritzinger, Andrew Hutchison.

This area includes the functional and temporal analysis of discrete, reactive systems, in particular telecommunication systems and their protocols. Research concerns all aspects from the design, specification, and analysis to the implementation of such systems. Current emphasis is on SDL and tools for the use of SDL and Message Sequence Charts (MSC) whereas Petri nets, stochastic and queuing theory remain an important part of the work of the laboratory. The issues surrounding security protocols are another area of focus.

4.2.4 Individual Research Interests

Students are encouraged to become involved in projects undertaken by the staff.

Professor Blake's research is experimental and centres on the interaction of people with computers. His current research interests include authoring and effectiveness of Virtual Environments and how to use Information Technology for Social and Economic Development.

Professor Kritzinger's areas of research interest are in the specification and modelling of discrete, reactive systems in general and computer networks, including mobile networks in particular.

Professor MacGregor's areas of interest and research cover two and three tier client/server computing, object technology, particularly distributed objects, and operating systems.

Prof. Berman's interests include databases, conceptual modelling, persistent programming languages and object-oriented databases.

Dr Gain's interests lie primarily in Computer Graphics. He is currently researching improvements in virtual sculpting (the computerised design of free-form shapes), compression of geometric models, and interfaces to generating procedural environments (fractal landscapes).

Dr Kuttel's research interests are in Computational Science, simulation and High Performance Computing. She is interested in the application of parallel algorithms to time-consuming scientific simulations, particularly in the fields of Molecular Modelling and Structural Bioinformatics.

Dr. Linck's interests include parallel processing and software development to aid the educational process and Neural Networks.

Dr Marais' interests include 3D model compression and level of detail representations for realistic rendering. Other areas: medical imaging/image analysis, 3D deformation/modelling and compression in general.

Dr Marsden's interest is in why technology can be hard to use and how we, as computer scientists, can design systems which are easier to use. His interests lie in hand held computers (looking at problems from portable Web browsing to cellular telephone interfaces) and virtual reality (creating interesting and engaging environments).

Dr Suleman comes from a background in the emerging discipline of Digital Libraries. In this field, he works primarily on system architecture and interoperability issues as they are related to networked information systems. He also is interested in computer networking and network protocols, Web services, information retrieval, artifical intelligence and high performance computing.

Mr. Cook is interested in computer supported education, approaches to teaching computing, and the interaction of people with computers. He is currently researching the application of computers in collaborative work and learning environments.

Mrs Potgieter's research centres on the integration of distributed artificial intelligence into the software engineering lifecycle using distributed Bayesian networks components.

Dr Hutchison's area of research interest is computer networks, focusing in particular on performance modelling and security issues. Recent work has addressed group authentication protocols, security protocol analysis, smartcards, biometrics and intrusion detection.

4.3   Computing Resources

Computing resources include servers and workstations running FreeBSD, OpenBSD, NetBSD, Sun Solaris, Ubuntu Linux and other Linux distributions, Microsoft: Windows XP Professional, Windows 2003 Enterprise Server Edition. Software resources for teaching and development are drawn from Public Domain offerings, third party releases (eg. IBM Rational Suite) and the Microsoft Developer Network Academic Alliance software program. Laser printers are available for printing. Specialized hardware peripherals cater for Virtual Reality applications and include Head-Mounted Displays, magnetic trackers, stereo glasses and spatial/surround sound. Advanced graphics hardware is available to drive these. A range of PDA computers are available for research into the wireless and mobile computing environment.

Computers are connected to 100Mb switched network, whilst servers are connected via 1Gb links. A wireless infrastructure provides connectivity for 802.11b wireless peripherals and notebook computers.

5 Honours in Computer Science Programme

The Honours programme in Computer Science, CSC4000W/4016W, is designed to provide students with the basis for a career path in the computer industry, and/or to embark upon a research programme at Masters level.

The course rounds off your training as a computer professional and provides further advanced study in some selected topics of Computer Science. A key aspect of the programme is to enable you to function both independently and in teams. By the end of the course you are able to read relevant literature and formulate research and development proposals. You will gain practical experience in team work by initiating and managing a major project. Emphasis is placed on the effective communication of ideas and results.

5.1 Admission Requirements

The number of places in the Honours programme is limited and students are selected on merit from the list of applicants each year. Criteria for selection are your computer science mark achieved in each of your three years of undergraduate studies and, to a lesser degree, the marks achieved in mathematics. Students who have not achieved at least a 65% average in their final year of computer science will only be admitted in exceptional circumstances.

5.2 Honours Module Credits

A honours course work credit corresponds to 12 lectures worth of material. A 2 credit course would thus correspond to 24 lectures on the university timetable. In order to take account of the heavy practical demands of certain modules, the number of lectures may be reduced. This does not effect the final credit allocation for that module in any way. For a practical module, the standard 2 credit allocation is 16 lectures of course work, with the remainder given over to practicals/assignments.

5.3 Structure

A total of 30 credits must be obtained during the course of the academic year. These credits are awarded as follows:

Elective Modules	12 credits
Major Project	10 credits
Core Modules	
Research Methods	2 credits
Computer Graphics	2 credits
Artificial Intelligence	2 credits
Network Security	2 credits

A compulsory set of *core* modules must be completed by every student. You may select any remaining module as an elective, subject to the credit limits cited in Section 5.4.

5.3.1 Work Load

This is an intensive full time course and may not be taken together with other courses or employment without the permission of the Programme Coordinator.

For each lecture hour you should allocate at least **two** hours of extra work to review material and for the associated tutorials and practicals[1]. For some modules credits can be obtained with proportionally fewer lectures since they have a necessary, and compensating, heavier practical load (see Section 5.2 above).

Approximately 8 weeks has been reserved in the final term to allow students to focus entirely on their Honours Project. All lectures and practicals will be concluded before this period commences.

Although this 2 month project block is available, you should allocate at least 3 hours per week to supervisor meetings, planning your project, reading background material etc.

You should also allocate one hour per week to attend departmental colloquia. Please note that attendence of at least 50% of the colloquia on offer is mandatory. A register will be kept if necessary.

Your weekly work load (before the project period commences) will therefore be at least:

Lecture hours	11	hours (average of 14 lectures)
Practicals and review of material	28	(minimum)
Colloquium	1	
Major Project	3	
Total	43	

5.4 Course Work

The department offers sufficient modules at Honours level for you to fulfill your course work requirement. You may take modules from other departments, provided they are of an appropriate level and have some relevance to computer science. Section 7.2 provides a list of typical computer science modules.

To fulfill the course work requirement the following rules apply:

1. You must complete the 8 *core* credits listed above

2. You must obtain at least 12 credits of *elective* material (you may take at most 16)

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[1]These two hours could be allocated as one hour of theory review and one hour of practical work for a standard module or some other appropriate combination for a more practical or theoretical module

3. The best 20 course work credits (including the core) will count towards your final mark. *Of these:*

   (a) At least 12 credits must be from Computer Science Honours

   (b) At least 16 credits must be from either Computer Science Honours or Mathematics of Computer Science Honours.

   (c) At most 4 credits from outside the department will be taken into consideration.

Students are urged to take a least one module outside the department to broaden their education. Note, however, that any module you register for outside the department must be approved by the programme coordinator and will be weighted according to its relevance to computing in general.

5.4.1 Lecture Periods

Lectures are scheduled for periods 2—5. The timetable is drawn up in consultation between students and lecturers to best accommodate the lecture commitments of both. Computer Science colloquia are normally held during the lunch hour. Please note that courses which are 3 credits or more will have at least some lectures scheduled after lunch.

5.4.2 Module Registration

A list of the actual modules available for the year will be handed out before registration. At registration you will be given a module registration form on which to indicate your choice of modules. You may not register for more than 24 course credits. Only the registered modules will be considered in calculating your final mark.

Additional modules for credit may be offered during the year to take advantage of the expertise of visiting lecturers.

Apart from such additional modules you may only drop or add a module with the approval of the lecturer concerned and the programme coordinator. Such approval must be requested and given in writing and will not be granted if more than $\frac{1}{6}$th of the lectures have already been given in the module concerned.

5.4.3 Examinations

Modules are usually examined during the University examination periods (May/June and October/November). However, the Department is free to schedule examinations at any sensible time after the completion of the relevant coursework. Examinations written outside the department are scheduled by the department in question. There is typically one two-hour examination per two credit module in Computer Science Honours. Open book and take-home examinations are preferred by some lecturers. Modules with a substantial practical component may have up to 50% of the final mark derived from the practical work.

The examination timetable is the responsibility of the class representative(s) in consultation with the class and lecturers concerned and is drawn up shortly before the examination period.

After the mid-year examinations, students will be given an *indication* of how they performed. *Note that* only a provisional symbol is released after the mid-year examination as (1) it is University policy to release only a single mark for the whole Honours course and (2) the exam papers will not have been seen by the external examiner at this stage.

5.5   The Major Project

Students are required to complete a major project under the supervision of a member of staff. The project topics will be presented to students at the end of March. A block of 8 weeks has been set aside in the last term, to allow students to work solely on their projects. However, students are expected to meet weekly with their project supervisors throughout the year. Time should also be allocated to properly plan for the project period, and to read background material etc.

The honours project allows students an opportunity to develop a substantial piece of software according to sound software engineering and design principles. Projects involving multiple students are encouraged, but will only be permitted if the project has *readily identifiable components which each individual can design and implement*. In the case of group projects, integration of the various components will be paramount and students will be heavily penalized if they do not engineer a well integrated solution. Note that each student project must constitute a piece of work that can be *independently assessed*.

Students may submit their own written project proposals. The department welcomes proposals from students on condition that the project has a significant Computer Science content and that a staff member can be found to oversee the project, possibly in conjunction with an outside supervisor. The proposal must also be approved by the programme coordinator and the department reserves the right to reject a proposal. The written proposal must follow the format of the departmental project proposals.

It is your responsibility to discuss the proposed projects with the supervisors concerned. Once you are satisfied with your choice you should fill in the required form and list your preferences. The form must contain a list of the other members of your proposed group. You have about two weeks in which to make your choice after receiving the list of projects. As soon as possible thereafter the projects will be allocated. Every attempt will be made to accommodate your wishes and queries in this regard should be directed to the programme coordinator.

A great deal of importance is placed on making regular progress throughout the project period. A detailed list of milestones has been drawn up to help you plan your work. It contains deadlines and specifications of what has to be handed in or presented. The list is handed out when the projects are assigned.

Each project group is required to produce a formal project proposal which will be vetted by the staff in May. A poster, web page and research paper are

also required. Guidelines for each of these will be distributed once the projects have been approved.

The final project report must be handed in to the Honours convener no later than the specified due date. A maximum of 3 days beyond the official handin time is permitted, but the project/document will be penalized by 5% per day. Extensions are only granted if the delays in completing the project are beyond the reasonable control of the student(s) concerned.

The project report should constitute a comprehensive description of your project, detailing both the software engineering and technical aspects of your work. The former will cover issues such as specification and design, whilst the latter will provide a detailed description of the theoretical/research issues you considered. A document detailing what such a report should contain will be handed out when the projects are allocated. **No report may be submitted without the prior approval of the project supervisor**. The supervisor may require alterations and so the final draft must be available in good time for it to be read by your supervisor and revised by you. The final project presentations will be scheduled soon after the hand in date.

The final mark for the project is computed from a formal project proposal (5%) and presentation in April, a poster (5%), a project web page (5%), the research paper (10%) the final presentation in October (5%), and the project report (70%).

5.6 GSB Entrepreneurship/Business Planning Module

The UCT Graduate School of Business (GSB) offers a course on entrepreneurship tailored to suit the needs of future Computer Science entrepreneurs. The course provides the skills necessary to prepare a successful business plan to launch a new company. The course outline is supplied by the GSB and will be available prior to the commencement of the course.

5.7 Credit Requirements

5.7.1 Computing the final mark

The final course mark will be computed as follows:

- The project mark counts 1/3 of the total.

- The remaining 2/3 of the mark is calculated from the 20 best course work. The modules which come into consideration for this mark are specified in Section 5.4.

5.7.2 Subminima

The following subminima are applied for the Honours in Computer Science programme:

1. At least 40% must be achieved in the project.

2. At least 40% must be achieved in the research methods module, including full participation in the professional communications module and attendance at least half of the departmental colloquia and other research meetings for Honours students.

3. An average mark of 50% must be attained in the modules making up the best 20 course credits.

4. No module will be considered for course credits unless a student has obtained at least 40% in that module.

5. The final mark, which will be calculated as explained in 5.7.1 above, must be not less than 50%.

A student who achieves each of the above subminima will pass the course. Students are reminded that the University does not allow a student to repeat an Honours course.

6 Honours in Mathematics of Computer Science

The departments of Mathematics and Computer Science offer a joint Honours degree in the Mathematics of Computer Science in the School of Mathematics. The Programme convener for this course is Prof Vasco Brattka, of the Mathematics Department.

This specialized programme provides the background for a further research career in theoretical computer science. A wide range of advanced modules are offered and by the end of the course you will be able to read the relevant literature and formulate further research proposals. Adequate experience and appreciation of the practice of computer science is provided by the project which all students have to complete. Emphasis is again placed on the effective communication of ideas and results.

The entrance requirements and available modules are listed in the Mathematics department prospectus.

Further Study

The Honours degree could lead to a Masters degree either in the Department of Computer Science or the Department of Mathematics.

7 Honours Programme Miscellaneous

7.1 Programme Coordinator

The programme coordinator is Dr Patrick Marais, Room 309, Computer Science Building (email: patrick@cs.uct.ac.za). There will also be class representatives to whom satisfaction, complaints or otherwise must be addressed. Apart from the issues mentioned above which must be resolved in consultation with the programme coordinator, any queries regarding the programme should first be addressed to the departmental administrative assistant; if the matter needs to be brought to the attention of the programme coordinator, she will do so.

7.2 Financial Assistance

Financial assistance is available for prospective Honours students—enquiries should be directed to the Postgraduate Scholarships Office, Cottage No. 4, Lovers' Walk. The NRF provides a *limited* number of bursaries to South African citizens, while the University offers similar bursaries to non-citizens. No guarantee of a bursary can be given, unlike in the past. Unsuccessful NRF applicants who had a third year average of more than 70% have in the past been automatically considered by UCT for assistance. The closing date for NRF bursaries is usually around the 30 September; the notification date is February of the next year. A number of other bursaries are also available. You are advised to apply for all bursaries as early as possible.

In addition to these bursaries, some members of the department have funds available for research purposes, which may be available to students involved in projects undertaken by these members of staff. Students with legitimate financial difficulties may also receive departmental support. Any queries in this regard should be addressed to the programme coordinator.

8 Honours Modules

Modules offered at the Honours level vary from year to year depending on the interests of the staff. The following list of modules is provisional. An updated list will be placed on the honours web site if amendments are necessary. Additional modules offered by the Department of Mathematics and Applied Mathematics are listed in their departmental handbook.

8.1 Core Modules

These modules are compulsory for all Computer Science honours students.

8.1.1 Introduction to Computer Graphics

Prerequisites: data structures and algorithms; basic mathematics (including matrices, vectors and geometry). It is very important that you revise your linear algebra *before* undertaking this course.

Course Objectives: This module teaches the basic techniques of computer graphics and how they may be applied.

Credits: 2 credits (16 lectures and practicals)

Lecturer or Convenor: Prof E. Blake

Course Content:

- **Introduction:** graphics pipeline, graphics architectures, primitives and viewing, introduction to OpenGL
- **Basics of 3D graphics:** homogenous transformations, viewing, persepective projection, shading
- **Practice:** implementing a renderer, hidden surface removal, object hierarchies, scene graphs

Practicals: 2 programming assignments

Prescribed Book: "Interactive Computer Graphics: a top-down approach with OpenGL" (3rd Ed.), E. Angel, Addison-Wesley, 2003.

8.1.2 Intelligent Systems

Prerequisites: Familiarity with basic statistics and basic mathematics such as linear algebra and calculus.

Course Objectives: The course introduces the key concepts of Artificial Intelligence (AI). It highlights the differences between the deliberative and reactive approaches to AI, including overviews on Neural Networks, Machine Evolution and Robot Vision.

Credits: 2 credits

Lecturer or Convener: Dr. Anet Potgieter

Course Content: The course will cover material in the following areas:

- Reactive Artificial Intelligence (including Neural Networks, Machine Evolution, Robot Vision)
- Deliberative Artificial Intelligence (Including Search in State Spaces, Knowledge Representation and Planning)
- Distributed Artificial Intelligence

The course will consist of 16 lectures, tutorials, a practical and an exam.

Prescribed Book: *Artificial Intelligence: A New Synthesis*, N. J. Nilsson, Morgan Kaufmann Publishers, 1998.

8.1.3 Network and Internetwork Security

Prerequisites: none

Course Objectives: The objective of this course is to introduce cryptographic techniques and protocols for secure exchange of information on networks and internetworks, and to examine the deployment of these in emerging technologies.

Credits 2 credits — 16 lectures An optional (Non-Core) 1 credit may be taken based on additional (afternoon) seminars and research work on specific topics which will be covered after the NIS module has completed. This latter programme will be largely aimed at students who may wish to pursue further post-graduate studies in the area of security.

Practicals and Assignments: A practical involving deployment of cryptographic algorithms will be conducted (in groups). An essay covering a selected topic in the field of information security and/or cryptography will be set (to be written individually).

Assessment: In addition to the coursework, a 2 hour written examination will be used to evaluate the course.

Lecturer or Convenor: Adjunct Professor A Hutchison

Course Contents: The course covers security services; conventional encryption (classical encryption techniques, DES/AES, key distribution, key generation); public-key cryptology (RSA algorithm, key management, certification hierarchies); authentication and digital signatures; LDAP

directory services for authentication & authorisation ; intruders, viruses and worms (intrusion detection); cryptographic algorithms (MD5, SHA, IDEA, SKIPJACK); authentication and key exchange (Kerberos, Diffie-Hellman). Deployed security solutions such as SET (secure payment), PGP (secure messaging), SSL (secure transport layer) and WS-Security (secure web services) will also be studied.

Prescribed Book: "Network Security Essentials" by William Stallings, Publisher: Prentice Hall; 2nd edition (November 20, 2002) , ISBN: 0130351288

8.1.4 Research Methods

Prerequisites: None

Course Objectives: The research methods module forms part of your practical training as a researcher and computer professional. The course emphasizes communication skills and introduces basic research methodology.

Credits: 2 credits

Lecturer or Convener: Dr. J. Gain

Course Content: The course covers the following topics:

- communication and presentation skills (PCU)
- project management
- scientific and technical writing
- experimental design and validation

The practical aspects of the work will be evaluated through an exam and the Professional Communications course.

Please note that you must obtain at least 40% for this module in order to continue with honours.

The final module mark will be composed of the PCU module mark (25%) and any examinable material (75%).

Prescribed Book: Notes will be distributed.

8.2 Elective Modules

These modules may be taken as long as you satisfy any listed module prerequisite.

8.2.1 Agents

Prerequisites: Intelligent Systems (core module)

Course Objectives: Agents are commonly viewed as the next-generation model for engineering complex, distributed systems. This course covers agents, agent architectures and complex adaptive systems. Three different types of agent architectures are covered, namely reactive, deliberative and adaptive agent architectures. Multi-agent systems and complex adaptive systems are covered, including collective learning, collective emergent behavior, and the engineering of emergence in these systems.

Credits: 2 credits

Lecturer or Convener: Dr. Anet Potgieter

Course Content: The course will cover material in the following areas:

- Definition of agents
- Agent architectures - the difference between reactive, deliberative and adaptive agent architectures
- Complex adaptive systems, hyperstructures and emergence
- Adaptive agent architectures
- The engineering of emergence
- Applications of adaptive agent architectures

The course will consist of 16 lectures, tutorials, a practical, and an exam.

Prescribed Book: *Artificial Intelligence: A New Synthesis*, N. J. Nilsson, Morgan Kaufmann Publishers, 1998.

8.3 Advanced Computer Graphics

Prerequisites: CSC400W Introduction to Computer Graphics

Course Objectives: This course combines advanced theory and practice. It introduces selected topics reflecting the current state of the art in modelling, rendering and animation for computer graphics.

Credits: 2 credits (12 lectures, 2 seminars and a project)

Practicals: The Advanced Graphics practical involves designing the graphics and behaviour of a fleet of star-ships participating in simulated space combat. Rendering will be handled by OGRE (the Object-oriented Graphics Rendering Engine), an open source real time 3D rendering engine and students will be expected to make calls to the OGRE API for handling graphical events. A framework will be provided for handling the simulated physics of starship and torpedo movement and collisions.

This practical has two components:

1. Modelling: The shape and appearance of a spacecraft and the torpedoes that it fires, including the mesh, texture and any animations, will need to be created.

2. Behaviour: The agent AI for each ship, specifically how it accelerates in response to the changing battle environment and when and in what direction it fires torpedoes, will need to be programmed.

Lecturer or Convener: Dr James Gain.

Course Contents: The course covers advanced topics in Computer Graphics under three broad headings: modelling, rendering and animation. In more detail the syllabus includes:

1. Modelling: Constructive (CSG, Spatial Deformation, etc.), parametric (polynomial curves and surfaces) and procedural (fractals and L-systems).

2. Rendering: Radiosity, Texture and Painterly Rendering

3. Animation: Motion Capture, Physics-based Animation and Quaternions

Participants will also be responsible for reading, analyzing and writing a two page report on a number of research paper. There will be a group-based critical discussion of each paper.

The aims of this course are:

1. To improve technical writing, presentation and critical reading skills.

2. To familiarize participants with the state of the art in computer graphics.

Research Papers A selection of 4 seminal papers in Computer Graphics will be provided at the start of the course.

Prescribed Book "Interactive Computer Graphics: A Top-Down Approach with OpenGL" [3rd ed.], E. Angel, Addision-Wesley, 2003.

8.3.1 Parallel Computing

Prerequisites: No specific course prerequisites. However, knowledge of Linux/Unix and C/C++ is assumed.

Course Objectives: Parallel High Performance Computing is becoming increasingly important for solving large computational problems. This course provides an introduction to parallel architectures, programming techniques and applications, with the emphasis on message passing approaches to parallel programming.

Credits: 2 credits

Lecturer or Convener: Dr Michelle Kuttel

Course Content: The course covers material in the following areas:

- Parallel architectures
- Parallel programming models
- Parallel programming using the Message Passing Interface (MPI)
- Parallel applications
- Performance evaluation, load balancing and benchmarking of parallel applications
- Parallel file systems and parallel IO.

Assignments: Two assignments together comprise 60 % of the year mark.

Final Exam: The final exam is 2 hours long and contributes 40% of the final mark.

Prescribed Book: No prescribed book, notes and handouts will be provided.

Recommended Books: 1. Parallel Programming, B. Wilkinson and M. Allen, 1999, Prentice Hall

2. Using MPI, 2nd Ed., W. D. Gropp, E. Lusk, and A. Skjellum, (MIT Press, 1999)

8.3.2 Distributed Computing

Prerequisites: None

Course Objectives: To expose the students to the concepts of writing distributed component applications and exposing them to the different types of middleware.

Credits: 2 credits — 16 lectures.

Practicals: Two programming exercises.

Lecturer: Prof. K MacGregor

Course Contents: Overview of the models of distributed computing, Features required in distributed component systems. Implementation of distributed component middleware. Wireless Middleware and its uses. Cluster middleware.

Prescribed Book: Course Notes by K MacGregor

8.3.3 Introduction to Image Processing and Computer Vision

Prerequisites: Familiarity with basic mathematics such as linear algebra and calculus. Ability to draw pixels/lines using some API.

Course Objectives: The course introduces concepts from image processing and computer vision, and applies these to tasks such as segmentation (the extraction of a required part of a data set from the whole data set), filtering (for smoothing of data and the detection of interesting features) and image compression.

Credits: 2 credits (16 lectures and practical work)

Lecturer or Convener: Dr. P. Marais

Course Content: The course covers selected topics in the following areas:

- One and two dimensional Signal Processing
- Image Transformations
- Shape and Data Descriptions
- Feature Detection
- Segmentation of 2D and 3D structures
- Genetic Algorithms for Computer Vision

The practicals will allow students to implement and investigate a number of the techniques covered in the course. A number of topical papers will also be dicussed and will form part of the course assessment.

Prescribed Book: Notes will be distributed.

Recommended Book: *Algorithms for Image Processing and Computer Vision*, J. R. Parker, Wiley Computer Publishing, 1997.

8.3.4   Internet Interoperability

Prerequisites: CSC305: Web-based computing.

Course Objectives: Interoperability is one of the latest buzzwords in system design, especially in the Internet arena where standardisation is critical. This course will present various approaches to interoperability - philosophies, problems, solutions and case studies - from the perspective of using the Internet to collect, store, manage and disseminate information in a rapidly evolving and massively distributed community.

Credits: 2 credits (16 lectures and practical work)

Lecturer or Convener: Dr. H. Suleman

Course Content: The course will cover material in the following areas:

- What is Interoperability: Definitions and concepts
- Semantic and syntactic interoperability
- Data-level interoperability
- Metadata and metadata repositories

- Protocol-level interoperability
- OAI-PMH
- RSS
- Information retrieval interoperability: SRW/SRU
- Google and Amazon
- Component-level interoperability
- The Semantic Web
- Preservation through interoperability
- IPR and interoperability
- Future trends and research directions

The practicals will give students hands-on experience in using, evaluating and building interoperable tools and systems.

Prescribed Book: Notes and pointers to relevant material will be available on-line.

Recommended Book: *Digital Libraries*, William Y. Arms, MIT Press, 2000. Available from

http://www.cs.cornell.edu/wya/DigLib/new/index.html

8.3.5 Second Course in Database Systems

Prerequisites: CSC303S module in Database Systems

Course Objectives: The aims of the course are to introduce new developments in database systems, to study how to use such technology effectively and to provide an understanding of established techniques as well as research issues in these areas.

Credits: 2 credits — 16 lectures.

Practicals: 1 assignment.

Lecturer: Assoc. Prof S Berman

Course Contents: Object-Relational and object-oriented systems; Distributed databases; Data warehousing, OLAP and data mining; Spatial and temporal data management.

Prescribed Book: "Database System Concepts", Silberschatz Korth and Sudarshan (4th ed), McGraw-Hill 2001, supplemented by notes available from the Department.

8.3.6 Interaction Design: how to design and implement usable and useful computer systems

Prerequisites: None

Course Objectives: Equip programmers with design ideas and evaluation techniques for interactive computer systems.

Credits 2 credits (16 lectures and practicals)

Practicals: Evaluation will be by submission of a report, a code simulation of an interactive device and by examination.

Lecturer or Convenor: A/Prof G Marsden

Course Contents: So you have developed a system using strict development standards to produce a quality, robust implementation. But this is only half the story. Ultimately, real users will have to be able to work the system, otherwise it will fail.

This course is about providing you with sound design ideas and evaluation techniques to ensure that you build useful systems that users can use. Although the techniques apply to almost any computer system, the majority of examples and case studies will be from the realm of mobile computing.

8.3.7 Analysis of Computer Systems (EEE536F)

Prerequisites: Introductory Networks course or equivalent

Course Objectives: The objective is to familiarize students with theoretical methods and tools for the analysis of general computer systems.

Credits: 2

Lecturer: Pieter Kritzinger

Course Contents: Different from the past where we presented the theoretical tools and left the application to an exercise, we will this year visit as many of the computer/comunication systems listed and understand which theory and tools can be applied to model and analyze what part of the systems.

- Systems we shall learn about:
    1. Wireless networks, including GSM and 3G and ad-hoc networks
    2. RAID systems
    3. Grid computing
- Theory and tools to learn about:
    1. Markov theory and queuing theory, Poisson processes and Bernoulli and Poisson Modulated Markov Processes.

2. Formal specification methods, including Stochastic Petrinets and SDL/UML 2.0

This is a courageous endeavor for a mere 12 hours and we reserve the right to change topics, limit the material to only part of that planned etc, depending on the class and the general progress. Thus the course is not for passengers since students will have to participate in identifying problems and the methods for solving them. In fact if you are sure that you will not continue to do a Masters degree then this course is not for you.

8.3.8 Software Engineering

Prerequisites: Software Engineering undergraduate Course, and Prof Communication. course mathematics.

Objectives: Study of selected topics in Software Engineering

Credits: 2 credits — 16 lectures.

Lecturer or Convener: Dr M H Link

Course Organization: (a) Some introductory lectures by lecturer, followed by (b) Lecture on a specified topic by each student

Course Contents: In conjunction with the lecturer, each student chooses a topic of interest in Software Engineering. Each student prepares and presents the chosen topic to the class. In addition an appropriate handout is prepared by the student. Note: course enrollment will be limited to 16 students.

8.4 Effective Virtual Environments

Prerequisites: A basic understanding of Interactive Computer Graphics will be useful. Doing the honours course on Interaction Design will add depth to some of the issues addressed.

Course Objectives: This course introduces Virtual Environments (VEs) with an emphasis on making such environments useful and engaging to users. It will convey the essential theory and concepts. It will train participants in practical skills for creating and evaluating such environments.

Credits: 2 credits (16 lectures and practicals).

Practicals: Creating a virtual environment and performing a simple test of its effectiveness.

Lecturer or Convener: Prof E H Blake

Course Contents: This course has been given in a number of versions and draws on the work of many collaborators. The latest version is based on the practical experience in VR authoring with the CAVES project run by the Collaborative Visual Computing (CVC) laboratory of the Department.

This will be an advanced course given by Prof Edwin Blake with possible guest lectures by other members of the CVC lab.

The topics are still being finalized and will be drawn from the following:

1. Introduction
   - What are VEs?
   - VE Systems
   - Low-cost VR Platforms
2. Authoring and Scripting
   - Methodologies for designing VR.
   - Managing VR Projects
   - Modelling
   - Using the CAVEAT system to create CVEs
3. Presence & Co-Presence
   - Presence and Perception
   - Shared (Collaborative) VEs and Co-Presence
   - Measurement of Presence in VEs
4. Multi-modality and Spatialized Audio
5. Applications of VR, for example, in Culture Representation (with a focus on African Culture and Storytelling), VR therapy (including HIV/Aids counseling), and education.

Prescribed Book: There is no prescribed book, selected readings and notes will be provided.

8.5 Mathematics of Computer Science Modules

Additional information can be obtained from the Department of Mathematics. Only certain coures will be considered for credit, specifically those dealing with the formal aspects of computing or other pertinent topics such as quantum computing. These courses are usually counted as 4 credits within the department (36 lectures + pracs).

The courses available in 2005 were:

- Advanced Topics in Computability and Complexity: Quantum Computing

- Computability and Complexity Theory

- Formal Methods of Computer Science

9 The Masters Programme

It is possible to study for a Masters degree in the Department by either coursework and dissertation or by dissertation alone. The normal duration of the course is two years, although it may be completed in one year. It is also possible to do the course on a part-time basis; see Section 11.2 below.

Further details on general requirements can be found in Section 10.1.

9.1 MSc in Computer Science by Dissertation

The degree of Master of Science may be conferred after the satisfactory completion of a dissertation embodying research under the guidance of an approved supervisor. This choice is known as CSC5000W. The guidelines for the dissertation are that it must be a detailed report on the conduct of a research project and the analysis of the results produced. It isn't essential that it be a contribution to knowledge nor does the project necessarily have to be original, although if this is the case then the degree is likely to be awarded with distinction.

The examiners are asked specifically to say if the dissertation indicates:

- sufficient knowledge of the relevant literature;

- familiarity with research methods in science;

- satisfactory presentation;

- that the candidate has originality and has advanced the field of knowledge of Computer Science;

- it is worthy of publication in recognized international journals in Computer Science.

9.2 MSc in Computer Science by Coursework and Dissertation

The degree of Master of Science may be conferred after the satisfactory completion of an advanced course of study (CSC5001W) as well as a dissertation (CSC5002W) embodying research under the guidance of an approved supervisor. The guidelines for the dissertation are that it must indicate that the student

- has sufficient knowledge of the relevant literature;

- is familiar with research methods in science;

- moreover, the dissertation must

- be satisfactory presented.

9.3 Admission Requirements

A student is not normally be admitted to the either Masters program unless (s)he has completed an Honours degree in computer science and achieved at least an upper second or has demonstrated academic maturity in some other way. Admission is moreover subject to the student finding

1. a suitable research topic acceptable to an approved supervisor, who

2. has to ensure that adequate computing equipment is available to the student to carry out the proposed research.

Where practical, no student will be admitted without a personal interview with the Committee for Graduate Studies comprising the Head of Department and senior staff members.

9.4 M.IT — Conversion Masters in Information Technology

This programme is aimed at those who wish to participate in the current Information Technology revolution but do not possess formal undergraduate IT, CS or IS qualifications. It will equip the student in understanding how various IT technologies can impact and be applied to a wide variety of problems. It is aimed primarily at students who:

- want to work in the IT field and want a broad overview of current technology rather than hone in on one area.

- already work in the IT field and would like to fill in gaps in their knowledge, update their knowledge and/or obtain a formal qualification in IT.

- work in a non-IT field but would like to learn more about IT in order to apply this knowledge to their work.

This programme is not suitable for students who:

- want to do computer science or programming-intensive research.

- want to progress to a PhD in Computer Science.

As prerequisites, it is required that:

- You must have at least an undergraduate degree, in a subject other than computer science. Students with more than one year of computer science education will have their applications reviewed on an individual basis. Note that you do not need to have a degree in a scientific discipline - as long as you have a degree.

- You will need access to a computer and Internet connection.

- You will need to be able to attend UCT at the start and end of each semester for registration and examination purposes. This is not a distance education course and will not be administered as such.

The course comprises eight coursework modules taken over two semesters in the first year: Object Oriented Programming in Java, Advanced Programming, Web Programming, Cyberlaw and Ethics, Computer Networks, Database Systems, Human Computer Interaction and Software Engineering.

The second year is devoted to a year-long research module, including a course on Research Methods in the first semester if no such course has been taken in a prior degree (usually in an Honours degree).

Material for coursework modules is delivered via CDROM and the World Wide Web. Module content, software required for accessing the content and software for completing the coursework is provided on CDROM for easy and inexpensive offline access. Additional learning resources, particularly interactive resources and updates to notes, are provided through an Online Learning Environment. Email and discussion fora and chat-room facilities are used extensively by the students for interaction with staff and peer to peer communication and collaboration.

Assessment for most modules is a combination of coursework and unseen written examinations, which take place at the end of each semester on site at UCT. Coursework in these cases entails individual written assignments or programming assignments. The research module is assessed on the basis of your final dissertation, by a team of examiners, both internal and external. This is in keeping with standard procedures for Masters degree examinations.

Finally, upon completion, If you already possess an undergraduate B.Sc. degree, you will be awarded an M.Sc. (Information Technology) - otherwise you will be awarded an M.Phil. (Information Technology).

10 The Doctoral Programme

Supervision for PhD study is provided by the academic staff in their areas of research. This course is known as CSC6000W, PhD in Computer Science.

10.1 Admission Requirements

A student is not normally be admitted to the Doctoral programme unless she or he has completed a Masters degree in computer science and demonstrated that she or he is an exceptionally good researcher who should benefit from further study in their chosen area of computer science. A proposal of the proposed research has to be submitted the Doctoral Degrees Board of the university.

Admission is moreover subject to the student finding

1. a suitable research topic acceptable to an approved supervisor, who

2. has to ensure, where applicable, that adequate computing equipment is available to the student to carry out the proposed research.

3. approval by the Doctoral Degrees Board of the proposed research proposal.

Where practical, no student will be admitted without a personal interview with the Committee for Graduate Studies comprising the Head of Department and senior staff members.

The Dean of the Faculty of Science may allow a student registered for the Masters degree to change his or her registration to that for the Doctoral degree.

11 General Requirements for Masters and Doctoral Studies

Note that these sections about Doctoral and Masters studies supplement, and do not replace, the *Rules for degrees* in the Faculty of Science handbook. The Faculty of Science has also produced an informative booklet for MSc and PhD students which can be obtained from the Science Faculty Office.

11.1 Queries

Any queries in concerning post-graduate study in the Department of Computer Science should be addressed to the Chair, Committee for Graduate Studies (currently Prof Gary marsden).

Department of Computer Science
University of Cape Town
Private Bag
RONDEBOSCH
7700

Telephone: (021) 650 2663
e-mail: `dept@cs.uct.ac.za`
URL: `http://www.cs.uct.ac.za/`

Application Procedures for Students from other Universities

Applications from students who have not completed their previous studies at UCT must be submitted *in writing* to the Chair, Committee for Graduate Studies and must include

1. the academic record of the applicant,

2. an indication of the research area of interest, as well as

3. a motivation from the student in his or her own words as to his or her reasons for wishing to study towards the MSc/PhD degree at UCT.

Students should also apply to the University for admission in the normal way (See URL: `http://www.cs.uct.ac.za/newstudents/postgrad.html`).

11.2 Part-Time Study

The Department encourages part-time study with a strong industry involvement provided satisfactory commitment to the study is evident. The following would constitute such a commitment and should be guaranteed in writing:

- A contract is entered into where the student spends at least 60% of his or her time on degree studies. This can take the form of a contract where the student spends 20 weeks per year with the company of which 10 weeks are in the University summer vacations.

- When the student is not working for the company concerned then he or she must be on campus.

11.3   Progress Reports

As soon as possible, but within no more than six months of first registering, a student is expected to submit a research proposal spelling out their planned study programme for that year and the milestones they expect to achieve by the end of June and the end of December of that year. This proposal must be approved by the supervisor and signed by both the student and the supervisor.

The Committee for Graduate Studies in consultation with the supervisor will decide whether the proposal is acceptable and milestone reports will be called for in time for the deadlines in June and December.

If in June, a student has not made sufficient progress according to the milestones set, the student will be warned that unless he or she achieves (the possibly revised) milestones for December, the Department will not approve his or her re-registration.

In the event that the student concerned then does not achieve these milestones the student is automatically excluded from the Department.

11.4   Financial Assistance

Financial assistance is available for full-time students registered for the Masters or Doctoral degree in Computer Science at the University of Cape Town. As far as is possible, we try to ensure that no student is prevented from studying for financial reasons.

Failure to Graduate.   Successful applicants are expected to complete the degree for which the bursary was awarded within the normal time-frame, otherwise the bursary will have to be refunded.

NRF Bursaries

The National Research Foundation (NRF) provides bursaries to South African citizens or holders of permanent residence permits who are accepted as full-time students. The amount of the NRF bursary is not fixed, but will be determined on the basis of each application.

The NRF has two mechanisms of student support: grantholder-linked bursaries and free-standing prestigious bursaries. A grantholder is someone who has received research support and funding for bursaries from the NRF for an approved research project. The grantholder-linked bursaries will be the major source of student support.

In 2006 a maximum amount of R 20 000 may be awarded for Masters and R 35 000 for Doctoral students. The value of NRF bursaries will be determined on the basis of the financial circumstances of each applicant.

Furthermore, Computer Science students qualify to apply for an additional NRF "Scarce Skills" or a "Prestigious" scholarship which could substantially increase the NRF award.

Research Related Funding

Some members of the Department have funds available for research, which may be available to students involved in projects undertaken by these members of staff.

Temporary Employment

Opportunities to work in the Department as teaching assistants and tutors (for a maximum of 9 hours per week) are available to Masters and Doctoral students. Such students will earn at least R 6 000 per annum (currently a study permit does allow foreign students to perform such duties that are related to their study).

Foreign Students

The University has very limited resources for supporting Foreign Students. The amounts awarded are usually related to, but somewhat lower than, the equivalent NRF bursaries. There is a firm deadline of the 30th September for applications for such bursaries. Students should consult the International Office and the Post-graduate Funding Office.

Applications for Financial Assistance

Applications for NRF prestigious scholarships and equity scholarships should be submitted via the Department. The closing dates are generally in mid-August and students should enquire beforehand and in good time from the Department. Very few such bursaries are awarded.

Financial support from members of the department, and this includes the grantholder-linked bursaries from the NRF, should be discussed with the individuals concerned.

Enquiries about UCT merit scholarships and bursaries should be directed to the Postgraduate Scholarships Office, Cottage No. 4, Lovers' Walk, where booklets describing the relevant *Student Fees* and *Financial Assistance for Postgraduate Study* are available.

11.5 Departmental Colloquia

A number of research colloquia will be held during the course of the year. Attendance at these colloquium meetings is compulsory for **all graduate students**. Students who cannot attend must get permission from the departmen-

tal administrative assistant who will keep a record of the student's reasons for non-attendance.

Students are invited to participate in the colloquia by speaking about their own research and projects.

12   Post-Doctoral Study

Positions are available for post-doctoral fellowships, and NRF funding may be applied for. Internships are also possible, this is where funded post-doctoral students gain practical experience by working in industry for extended periods so as to aid the interchange between universities and the community.

13   Research in the Department

Research in the Department is loosely organized into three well-equipped groups funded by international, governmental and industrial sponsors. These are:

- Collaborative Visual Computing

- Data Network Architectures

- Advanced Information Management

Details of each group and the major research projects with which they are associated are given below.

13.1   Advanced Information Management

The Advanced Information Management laboratory is a new research collaborative in the department, with a strong focus on the use of information, from computational, representational and distribution perspectives. This broad spectrum of research areas includes databases, knowledge management systems, scientific and high performance computing, complex adaptive systems, distributed artificial intelligence, distributed computing, Web-based systems, component-based systems, digital libraries and information storage, retrieval and visualisation.

This varied collection of disciplines is supported by an equally diverse staff membership: A./Prof. Sonia Berman, Dr Michelle Kuttel, A./Prof. Gary Marsden, Prof. Ken MacGregor, Dr Anet Potgieter and Dr Hussein Suleman.

Particular examples of the very much current and relevant research conducted within the group include investigations related to Web Services, Beowulf clusters, the Semantic Web and interoperability of online systems.

13.1.1   Dr. Hussein Suleman

Husseins primary research area is digital libraries, with particular focus on the development of standards and practices for interoperability and architecture of highly distributed information systems. Digital libraries is a relatively new research area, at the intersection of computer science, computer networking and information sciences. From a computer science perspective, there are various technical issues that need to be resolved to support the ultimate aim of enabling simpler access to more information of a higher quality to all users of online and electronic systems. Hussein works closely with the Open Archives Initiative (http://www.openarchives.org) and the Networked Digital Library of Theses and Dissertations (http://www.ndltd.org), thus collaborating with

institutions and individual researchers on a wide and distributed scale in keeping with the nature of the area of interoperable digital libraries. Specific topics of interest follow:

Large Scale Information Management Systems   Current research in information management systems has progressed to the point where many large repositories of information are publicly accessible. However, high quality services based on this information are still rare. This is partly due to the complexity of building search engines and other information services based on massive quantities of constantly evolving data. There is a dire need for mechanisms to deal with the problems of a) how to build efficient dynamic indexing mechanisms b) how to parallelise algorithms for information management and c) how to increase the availability of popular services. Solutions may lie at the intersection of data warehousing, grid computing, agent technology and cluster computing, but little research has been done in this area to date. In the new information arena where rapidly changing data collections are no longer part of the hidden Web, can we discover/locate such data easily, and can such solutions eventually be applied to personal and community memory libraries as they emerge in the future?

Digital Library Architecture   In attempting to move closer to the goal of making information readily available to users, managed and flexible information systems must be placed within the grasp of all institutions and archivists. As such, the architecture of digital libraries needs to be simple but flexible. Ongoing research in this area, at UCT and with various international collaborators, is producing component models, frameworks, visual interfaces and specification languages for the construction of custom digital libraries without the need for custom software development. There is still much scope for additional work in these aspects as well as methodologies for component packaging and user interface workflow definition that is relevant not only to digital libraries but all online systems.

Web-based Component Testing   With the rapid acceptance of Web Services and Web-based technology, there is a growing proliferation of services that can be accessed remotely through well-defined interfaces. Past experience in protocol development has shown that well-defined interface specifications are not sufficient to ensure compliance with a standard and this usually results in multiple non-conformant interpretations and, generally, problems for human and machine users of the services. The incompatibilities among Web browsers is possibly the best contemporary example that illustrates why standards-compliance and compliance-testing are crucial in networked environments. In the digital library community, Hussein has worked with the Open Archives Initiative in developing protocol testing tools such as the Repository Explorer (a local mirror is at http://re.cs.uct.ac.za) and this has greatly influenced the success of the standard it tests. This is, however, a first generation testing tool. Much work remains to be done in generalising the testing framework so that testing

tools can be automatically generated or driven by specifications. In an ideal environment, any Web-based protocol should be specified formally, in order to generate testing tools and test cases automatically. This work can have a major impact on the success of emerging digital library protocols and standards based within the Web Services initiative in general.

Innovative Document Management   Currently, there are a number of digital repository software toolkits to support centralised archiving of electronic resources. However, all of these tools require user intervention where users are required to explicitly submit items with associated descriptions. This has long been recognised as the bottleneck in acquiring and archiving material. Innovative techniques are required to support users and incorporate archiving (and sharing when appropriate) into their routine tasks by integrating document management into desktop software and other systems. An example of such a system would be one that transparently and efficiently archives all versions of a word processor document at the level of the filesystem. An example from a different extreme would be a system to replace photocopying for archival purposes with a scanner and software to automatically tag, organise and manage short-term and long-term duplicate copies of documents. Personal archiving is very relevant in an age where we produce a growing number of digital artefacts such as email messages, digital photos, PDA schedule entries and electronic documents how do we effectively manage such fluid information in a connected world where digital photos may be shared on one website, research documents on others and everything related to an individual must be periodically archived?

Next Generation Information Services   Traditionally, designers of information systems have concentrated on basic textual search and retrieval functionality. However, as these are being standardised, there is growing interest in non-standard metaphors for finding and accessing information. 2-D, 3-D and multi-dimensional navigation mechanisms are still in their infancy. Some research has delved into the retrieval of digital objects by similarity of sound and image but there is much scope for refinement of these techniques, application to real-world data collections and generalisation of the interfaces to connect such novel services into a general framework. Summarisation is still a rarity in production information systems when a collection of data is displayed on Google, shouldnt there be an overall picture of the most relevant results so that users need not have to visit the first 20 websites to get a summary? How does one summarise a single image, a collection of images or an audio stream automatically? How do users interact with information systems beyond the desktop computer using PDAs, mobile phones, video cameras, sketchpads and custom-built IO devices, such as sensors to detect human presence or co-presence and activate information seeking and notification systems appropriately (e.g., switch on an audible email notification when an employee enters her/his office or let a person at a cocktail party know who they should be talking to based on common concepts dynamically mined from information about

individuals)?

Hussein is interested in working with motivated postgraduate students who share his somewhat idealistic passion for improving the lives of people by removing barriers to information access. The ideas listed above are far from exhaustive and all wild and wacky ideas are welcome and encouraged.

13.1.2 Prof Sonia Berman

Prof Berman is looking for PhD and MSc students in the areas below.

XML Databases The goal of this research is to facilitate the integration of two disparate kinds of information, namely databases and semi-structured XML documents, so that users can access both kinds of information source in simple, flexible and efficient ways. Effective techniques for storing, querying, updating, mapping and distributing XML and hybrid data systems need investigation. One MSc student in the group is currently working on temporal XML databases, another on querying of hybrid systems; a number of related issues are open for study.

Peer-to-peer Database Systems In a peer-to-peer system a number of autonomous databases join together, for different intervals of time, in a system which has no global schema and no central administration authority, yet is usable as if it were a single store. Aspects to investigate include network topologies, clustering and routing policies, query evaluation and issues of trust in P2P systems. A current MSc student in the group has built a prototype peer-to-peer database system which can be used as a basis for experiments in this field.

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Advanced Database Applications Suitable models and tools are essential for databases to be easily and effectively exploited in complex application systems. Some examples are given below.

- As the amount of online information rapidly escalates, we need to provide better knowledge management systems to organize this more effectively and make finding and sharing information simple and efficient. Knowledge sharing by trusted individuals with common interests should be an important benefit of the Web, but we have a way to go to ensure this is done using appropriate structures, tools and collaboration approaches

- With the increasing use of personal information devices, we need to address the issue of how to provide an information-centric experience for the end user across devices. Code deployment, personal databases, and the ability to update replicated information from many devices while connected or disconnected, poses challenges for applications running on the small devices and also for central management of such systems.

- In a GIS (Geographic Information System) the spatial and temporal nature of data affords new challenges as regards modelling, design, storage, visualization and analysis of large data sets. Research in this field can range from engineering methodologies for GIS design through to indexing structures for spatio-temporal data. Recent MSc graduates, and some current thesis students, have developed models and tools to facilitate working correctly with maps and related GIS data, and we have several partner organizations involved in this work with us.

Object Store Engineering Research in this area concentrates on developing better techniques for object databases/object stores. Since the structure and use of such stores is very different from that of the simpler relational model, new mechanisms and approaches are needed to handle distribution, store organization, query optimization, compile-time optimization, code in databases, class evolution, etc. Recent MSc graduates produced an object store and caching mechanism which can be built upon if you wish. If you are interested in working at this level, another avenue of research is main memory database systems. Main memory can now be so large that accommodating entire structures such as indexes or database partitions in memory is a viable option. This requires very different approaches to indexing, caching, store organisation, etc. which have yet to be explored.

Note: Prof Berman is willing to look at other ideas for post-graduate work in the database field if you have any specific interests.

13.1.3 Dr. Michelle Kuttel

Dr Kuttel has interdisciplinary research interests in the fields of scientific and parallel computing. Scientific computing refers to the use of numerical methods to solve scientific problems, with applications ranging from genetic sequence matching to stock market simulations. These problems are often extremely expensive computationally and thus are prime candidate problems for running on parallel supercomputers.

Flexible Docking of Molecules into Electron Micrographs (with Dr James Gain) Low-resolution 3D models of molecular complexes can be obtained using cryo-electron microscopy (EM). However, though these maps provide very useful information for the overall shape of a complex, their resolution is too low to provide insight into the molecular interactions within a complex, which are of great importance for the interpretation of molecular function and mechanism. Structures of the molecular components are typically manually

docked as puzzle pieces into an EM map of the assembly to provide a pseudo-atomic structure. However, automated docking is the preferred approach, as it typically provides a measure of the "goodness-of-fit". Recent investigations have shown certain graphical filtering methods to provide innovative solutions to the problem of automated docking of high-resolution atomic structures into low-resolution electron density maps. The aim of this project will be to develop novel methods for docking of atomic models into EM graphs.

ScienceUCT Projects like SETIhome and Folding@home have attracted millions of participants who donate their spare CPU cycles to solving a scientific problem. The aim of this project would be to develop a peer-to-peer system along the lines of SETIhome for performing a distributed scientific simulation. The aim would be for the system to scavenge spare CPU cycles across campus and ultimately nation-wide, creating a cheap virtual supercomputer.

Dr Kuttel also has collaborative projects available in the areas of modelling of financial derivatives, bioinformatics and molecular simulation.

13.1.4   Prof. Ken MacGregor

Prof. MacGregor's area of research covers distributed computing in all its aspects, that is, the distribution of applications between different computer systems, irrespective of the network type. With the growth of network technology especially the Internet and wireless communications, the use and development of distributed applications in rapidly increasing, however tools for the development and analysis of such applications are still not properly understood. The techniques used to develop commercial client/server systems across corporate networks are not necessarily suitable to implement distributed applications over inherently unreliable networks. In South Africa with its wide geographic distribution of population and shortage of skills this area of computing has many particular sociological advantages and challenges. The research covers three specific areas in which Prof MacGregor is looking for PhD and MSc students. These are:

Wireless Middleware Middleware is the name given to the software that enables the communication between distributed applications. In a wireless world where connections can be intermittent and unreliable, a greater emphasis is placed on the functioning of the middleware. Different requirements exist for synchronisation of diaries in wireless devices as distinct from non-idempotent transactions. This research considers the requirements of wireless middleware and its production.

Open Source Operating Systems The purpose of this research is to adapt the available Open Source Software and make it more user friendly and generally usable. The research is currently looking at a number of areas:

- Operating Systems the LINUX family from full LINUX on a server to mLINUX on a PDA or cell phone.

- Application development tools for ease of usage

- Desktop software

Peer-to-Peer File Systems   The increasing availability of bandwidth presents new opportunities for distributed computing. Instead of the traditional message passing paradigm, which puts an additional overhead on the application, the more natural peer-to-peer paradigm could be adopted. In this method of distribution the application can discover what file resources are available on other computers and access them as if they were on their own systems. In this type of environment many user applications can cooperate accessing this common shared file system. The project is implementing a peer-to-peer wireless file system, consider its limitations, investigating the algorithms for ensuring the concurrency and integrity of the data, and researching the effects of bandwidth on the implementation. The software is being developed on a standard Open Source operating.

13.1.5   Anet Potgieter

Adaptive agents are the basic building blocks of a complex adaptive system. These agents act together, interact with each other and the environment, and collectively adapt to changing environmental conditions. This technology is poised to transform the way we model the enterprise and build information systems.

My research interests include the development of simple agents that achieve adaptivity through collective behaviour. These agents form agencies that are distributed in open environments such as the Internet to perform complex intelligent tasks. Each agent can perform only simple operations. When joined together in agencies, intelligence is achieved. I would like to invite MSc and PhD students to join research, using the above technology, in any related area of their choice. Example research areas include:

Complex Adaptive Enterprises   The complex adaptive enterprise can learn from and react to global events faster than the competition because of its self-awareness and its ability to adapt. An enterprise is self-aware if it understands the interdependencies between its own resources and how these resources and interdependencies contribute to its own competitive advantage. The complex adaptive enterprise then uses this understanding to adapt its business processes and strategies in order to sustain its competitive advantage. In this project, we will research how simple software agents can be integrated into the enterprise in order to enable the enterprise to function as a complex adaptive enterprise.

Adaptive Value Networks   Most leading companies are rapidly trying to develop the ability to leverage scale, outsource key functions and to make products to customer demand, in the most flexible way possible. Current software offerings do not integrate process, value management and intelligence in a

way that can exploit opportunities within markets, across business functions, and between businesses in a value network, and cannot fully enable these new ways of doing business. This project will allow a unique combination of adaptive agents, cost and value management, and collaboration across processes that will drive significant, sustainable competitive advantage.

Adaptive Knowledge Management   Knowledge management is concerned with issues involved with identifying, collecting, storing, evaluating, indexing, structuring, extracting, and presenting knowledge used to improve an organization's productivity. This project will research how adaptive agents can contribute to adaptive knowledge management by collecting knowledge and presenting knowledge in a just-in-time fashion.

13.2   Collaborative Visual Computing

The CVC lab is focusing on four major research themes:

Geometry Interest Group (Dr James Gain and Dr Patrick Marais)   This group addresses fundamental issues in computer graphics, particularly those relating to the efficient manipulation and representation of surface meshes. Current work involves mesh compression, level-of-detail rendering, 3D modelling and applications of spatial deformation techniques.

Socially Aware Computing (Prof Edwin Blake and Prof Gary Marsden)   The CVC group is involved in practical research whose outcomes addresses the development of the underprivileged areas of our country. This work produces practical applications and content (for example, novel ways of accessing digital libraries in remote areas) and policy implications of new developments in Information Technology (IT). The emphasis is on involving the end users in the design process (by using techniques such as Action Research and participatory design) and assessing the impact of IT based interventions on a community.

VR Methodology (Prof Gary Marsden and Prof Edwin Blake)   The creation of useful content for advanced computer applications such as Collaborative Virtual Environments (CVEs) is complicated by the gap that exists between the creative people who develop novel technology and the creative people who can provide the content for that technology. This group is developing ways of bridging the gap by understanding how people create new content for CVEs and then capturing that as a set of guidelines for content creators and software designers.

VR Interfaces (Dr James Gain and Prof Edwin Blake)   This group pursues the twin aims of developing good tools and interfaces for authoring Virtual Environments (VEs) and demonstrating the success of the systems by evaluating specially selected applications for their impact on target users.

13.2.1 Prof Edwin Blake

I am mainly interested in Experimental Research on People relating to Computers.

During 2006 I would like to continue my investigations in the following two area:

1. I would like to do a follow up study on our very successful project, the CyberTracker (see http://www.cybertracker.co.za/). This project enabled animal trackers to use a PDA and GPS system to record field observations. This was intended to make their expertise available to the world and to improve their position. How well did this work? This is a unique opportunity to investigate a key empowerment/indigenous knowledge system, measure its impact and suggest future directions. The work would involve field trips.

2. How can we develop software for rural and disadvantaged communities? This research builds on pervious work that set out to develop and deploy useful systems for these kinds of users. We build systems and then reflect on the design method that will enable us to have a useful and sustainable impact. This project is well funded by Dutch and Canadian funders. It would involve site visits and possible travel to neighbouring countries to demonstrate replicability of the work.

I am looking for students who are interested in these fields and would like to pursue masters or doctoral study.

13.2.2 Dr James Gain

Dr. Gain is looking for Masters and Doctoral students in the following areas but is willing to consider students with their own topics in Computer Graphics and Virtual Reality:

Compressing Mesh Geometry and Connectivity (to be co-supervised with Dr. P. Marais)   Despite steady increases in the storage capacity of computers this has been outstripped by the growth in the size of geometric models. For instance a scan of Michaelangelos David produced a 500GB model. With limited transmission bandwidth (especially in a South African context) compressing these models is increasingly important. One area for potential compression is the connectivity (edges between vertices) of polygon-mesh models.

Dynamic Capture of Hand Positions using Image Processing Techniques (to be co-supervised with Dr. P. Marais)

Using 3D input mechanisms (datagloves and position trackers) for 3D tasks has distinct advantages over conventional 2D input (keyboard, mouse). However, these 3D input devices tend to be both cumbersome and expensive. The use of the whole hand as an input device by tracking its position, orientation and relative morphology using digital cameras is an ideal solution to these

problems. We envisage that a user will wear white gloves with markers positioned at key locations and that several relatively inexpensive digital cameras will be used to locate the 3D position of the markers. This research involves developing efficient image processing algorithms for recovering the hand parameters from camera images.

Point Cloud Analysis for African Archaeological Heritage (to be co-supervised with Prof. Hein Rther, Geomatics) The Geomatics department is involved in an initiative to create an integrated database of architectural cultural heritage sites in Africa. The condition of these sites is deteriorating and given their importance in understanding and interpreting humankinds history, a permanent digital record is essential.

Photogrammetric capture of architectural structures and entire towns produces a dense cloud of textured points. These point clouds require special-purpose analysis and rendering. The focus here will be on identifying features (e.g. sharp corners and surface detail) in the original data to aid visualisation.

Reconstructing District Six Architecture from Archival Photographs (to be co-supervised with Dr. Patrick Marais) It is possible to digitally reconstruct a three-dimensional model of a building from a sparse collection of uncalibrated photographs. They are uncalibrated in the sense that parameters such as the focal length and camera position are initially unknown and sparse in that a complete model can be recreated from less than a dozen photographs. In this process the user creates a rough initial model of the building with simple constraints (such as the roof resting on the walls). Using the initial model and edges marked on the photographs the exact building dimensions and camera parameters are calculated. Finally, the building is visualized by projecting textures from appropriate photographs onto the building surface.

There are additional challenges in the area of cultural heritage where photographs may come from different time periods using different types of camera. This project will involve extensive collaboration with the District Six museum.

Virtual Sculpting (to be co-supervised with Dr. P. Marais or Dr. G. Marsden)
Incorporating elements of traditional clay sculpting has long been recognized as a means of shielding a user from the complexities inherent in computer-based free-form shape design. This research is aimed at developing software tools, which automatically generate manipulations that mimic real world sculpting devices, such as throwing wheels, smoothing spatulas or a sculptor's hands. This will be combined with the use of Virtual Reality I/O devices to enable Virtual Sculpting.

There are three projects in this area:

1. Traditionally deformation techniques have been applied to vertex data but a recent volumetric shape representation, Adaptive Distance Fields, has proven compact and versatile. This project will investigate applying Spatial Warping to Adaptive Distance Fields.

2. There are a wide variety of techniques for Virtual Sculpting but no comprehensive usability comparison has been made of their relative effectiveness. This project will involve building basic versions of a number of methods and comparing them with user trials.

3. Virtual Sculpting tends to emphasise the transformation of shape but most models also require colour and/or texture information. This project will explore painting metaphors for applying colour and texture to a digital shape model.

13.2.3 Dr Patrick Marais

Dr Marais' research interest are in the area of surface mesh compression, level of detail techniques and 2D/3D image analysis, particularly in the area of medical imaging. Masters/doctoral students are sought in the following areas:

Computer Graphics Work in this area currently focuses on two main areas: mesh compression and level-ofdetail rendering techniques.

Compressing Geometry and Connectivity (with Dr J Gain) We are particularly interested in combining a new connectivity encoder we have developed with a robust geometry encoder. The main issues revolve around the full and efficient use of available geometric and connectivity data to derive compact codes for vertex positions. The connectivity encoding paradigm can also be improved.

Point-Based Modelling and Rendering (with Dr J Gain) Point-based rendering is rapidly gaining prominence as an alternative to traditional triangle-based approaches. We are interested in developing techniques to allow realistic modelling or sculpting of 3D shapes composed of point primitives. This needs to happen in real-time and preserve the accuracy of the point representation.

Medical Imaging There is a great deal of scope for useful research in this area. The following are areas in which research is actively being pursued.

Proton Therapy Treatment (with Dr J Gain) The Department is collaborating with iThemba labs (formerly the National Accelerator Centre) on the development of techniques and algorithms for their new Robot Patient Positioning System (PPS). The PPS will be used in conjunction with a new proton treatment facility to allow faster and more accurate treatment of cancerous tumours. The following projects are of particular interest:

1. Robot Path Planner and Collision Detection Framework (ensuring the robot can navigate speedily and safely through its environment)

2. Proton Therapy Treatment Planning and Validation (ensuring that the proton beam is controlled at all times and minimizes damage to healthy tissue)

These components are key to the successful utilisation of the new system. Bursaries are available for these projects, which are aimed at MSc candidates (R40,000 from the NRF).

The Detection and Analysis of Bone Fractures   Work has already been completed on a simple segmentation system to analyse volumetric (CT) bone data. Currently only simple fractures can be detected, and there is no way to classify the recovered fractures. Further work would require the extension of the fracture detection framework to deal with fine-grained fractures and more complex compressional fractures. Classification would require the integration of a knowledge base with the segmentation system. Issues of speed and accuracy are also paramount. The Groote Schuur Radiology Department has a great deal of expertise which can be mobilised to assist in the evaluation of the system, and to provide help on clinical issues.

Other possibilities for research and extension include the segmentation of Magnetic Resonance (MR) images, particularly of the brain where voxel classification is difficult. This may prove particularly relevant should the new UCT Brain Behaviour Initiative be funded by the government.

13.2.4   Dr Gary Marsden

Dr Marsden is looking for masters and PhD students in the following areas:

Mobile Computing Interaction   : This is a project funded by Microsoft Research and undertaken in conjunction with the University of Waikato in New Zealand. The aim is to investigate new interaction paradigms for mobile computing applications. We have already built some sample applications which allow users to do Web searching off-line and are working on building other applications to support education environments.

Digital libraries and Web design   The Computer Science department at UCT is now a mirror site and partner in the Greenstone digital library project. This project provides digital library support to a variety of institutions including the United Nations and UNESCO. Whilst the technology of delivering the documents is well understood, we aim to look at developing new interfaces to the library collections. This work will inevitably involve elements of Web design, but we are particularly keen to look at the issue of cross-cultural interfaces and what type of presentation would work best in South Africa.

Usability of Open Source Software I believe that the adoption of Open Source software will be limited by how easy end users can install and use the applications. There is much work underway in developed countries, but little is happening in the developing world; sad, when it is possible that open source could have a greater impact here. This project will require students to conduct extensive usability tests and ethnographic observations to inform software design.

HCI Methodologies for the Developing World Most work in HCI has taken place in the developed world. The output from this research has advocated user centred design methods, where the users are consulted at all stages of interface design. Underlying these techniques is the assumption that the users understand the technology. In the developing world, this is not the case. We are therefore looking to develop new usability techniques which empower users who are less familiar with technology.

Mobile Access to Virtual Environments The Department is currently working with the District Six Museum to build a virtual recreation of District Six. We want visitors to the museum to be able to access this environment using mobile devices such as PDAs. Ultimately, visitors could walk around the physical space of District Six, but use the PDA to view how that spot would have looked in 1965.

Usability of Routers The number of ADSL users in South Africa is growing daily. Many of these users are not experts in configuring computer networks, yet are required to configure routers in order to set up their home network in a usable yet secure fashion. This project would be conducted in conjunction with Telkom and look at using visualisation techniques to improve router configuration for novice users.

13.3 Data Network Architectures Group

This group, currently comprising three full-time or part-time academic staff members conducts research and teaching in the area of concurrent communicating systems and telecommunications systems in particular since 1986.

With a wide network of international collaborators the group does not believe that science knows national borders, only applications do. Since the first objective of graduate research is to train excellent individuals in the techniques of scientific research the focus of the group is external to overseas groups from whom the DNA group can benefit through collaborative research and graduate courses.

The Group conducts research which in particular relates to

- the modelling and design of concurrent communication systems (CCS) and in particular mobile network systems.

- the implementation of CCS using best practice software methodology.

- the most important aspect of *security* of such systems (preventing cyber crime), and

- formal description methods and modelling theory for the development and analysis of CCS.

The focal point for the group is the development of a *Telecommunications Engineering Workbench* for the design and analysis of all aspects of telecommunication systems. The group also receives funding from the Telkom Centre of Excellence, the National Research Foundation (NRF) and until recently, a research cooperation programme with institutions in France sponsored by the French government.

13.3.1   Dr Andrew Hutchinson

Goal Oriented Protocol Generation   The Security Protocol Engineering and Analysis Resource (SPEAR and SPEAR II) work has been a focal point for security protocol related projects in the DNA group. Various projects have addressed protocol specification, analysis and code generation. Projects relating to analysis (incorporation of Strand Spacemodelling/analysis technique) and code generation (verification of protocol code) are underway in 2003–2004 as Masters projects.The intention of this project is to provide an expert 'front-end'to the security protocol engineering process, that enables users of the SPEAR tool to define and achieve a set of goals in a particular protocol. The benefit of such an approach is that it ensures that the protocol engineering activity is consistent with what the protocol should achieve. A possible scenario for achieving this is to incorporate libraries of existing protocols,and to select from these according to the goals stated by the user. Explicitly describing protocol goals would also allow the cryptographic logic / strand-space analysis modules to be pre-configured for checking certain traits and attributes of a protocol.

Web Services Security   Web Services are increasingly being recognised as a means to provide system interoperability, and also as an attractive way to 'wrap' legacy and/or proprietary systems. In such an approach, encapsulation of an existing system presents the opportunity to incorporate additional security components as part of an overall web service. Specifically, the concept of this is to introduce a 'mediation layer' between the existing system and the web service interface. Of particular interest is the extent to which IDS/A (host based intrusion detection, as developed by PhD student Marc Welz) can be depoyed as part of such a secure web service. The associated rules and/or anomaly detection module would have to be defined and developed. In addition this module could also act as a reference monitor for the web service, if appropriate. Other components of such a mediation layer could also be provided, for example to handle privacy, information security policies (e.g. compulsory encryption depending on content labelling) etc.

Identity Management as Enabler of Secure Enterprise Environment Identity Management is a concern for enterprises. This project should consider what information is required for an authentication and authorisation model in support of enterprise identity management. The links (and automatic account management) between an identity management module and underlying LDAP repositories should be considered. The OpenLDAP system could be used as an experimental system in this regard. Consideration should also be given to how cryptographic key management can / should be co-ordinated within an enterprise, and in particular how this can be associated with the greater identity management activity. Use of cryptographic keys, associated with authenticated and authorised principals, should also be brought within the consideration of this project. In this way a unified approach to enterprise security can be pursued. Deployment for tasks such as secure communication (between pairs or groups) over an Instant Messaging mechanism could also be considered as an example environment. The challenge of the project is to address each of the three aspects (identity management, key management, secure communication) individually, but also to look at the intersections, and how these topics can inter-relate to achieve a secure enterprise environment.

13.3.2 Prof Pieter Kritzinger

Software engineering — Modeling software system requirements Telecommunication requirements are susceptible to change, not only after releasing the product but also during the iterative software development process. For example in the development of UMTS there are typically 20,000 requirements per core node distributed across many different platforms using varying and complex technologies. Customers change, organizations change, technologies change, standards change and hence requirements change. Requirement management is the process in charge of supervising these software requirements changes, it should be integrated as a subprocess in the software development life cycle.

Requirements traceability is defined as the ability to describe and follow the life of a requirement from inception to implementation, passing through all the related specifications. Requirements traceability allows us to assure the continuous concordance between the stake holders requirements and the artifacts produced along the software development process.

Requirements are easily visualized in UML using class and object diagrams. The goal is introduce a complete solution for setting up requirements, dependencies and traceability in UML class and object diagrams. UML has shown to be an excellent and adaptive modeling language used in various domains. Despite this, UML is not widely use for requirement traceability. Using UML extension mechanisms we can adapt our approach in a natural way as project needs change.

Objective

In this project we will develop a reference meta model for requirements traceability that is based on UML and that would integrate textual specifications as much as UML model elements obtaining a unambiguous represen-

tation for all the software development artifacts and traceability links among them.

Enterprise Storage Systems   Disk storage subsystems are an integral part of the future SOA. Their performance has however not kept up with the speed of processors. Processor performance has been increasing at a much higher rate than that of disk drives and consequently storage subsystems have become a bottleneck in the present computer systems.

With the proliferation of applications which involve large volumes of data stored on direct access storage there is an increasing focus on the performance and reliability of such systems. Applications requiring large volumes of storage include data warehousing, image processing, digital video editing, transaction processing, decision support systems, scientific and engineering simulations etc. IBM and HP are among several organizations doing research in the development of high performance storage systems called Enterprise Storage Systems (ESS) providing protection against disk failure using RAID methods in some cases.

Testing ESS Open Source software
Objective
Understand the operation of I/O systems and RAID in particular under Linux and to test its operation for correctness.

RAID and Reed-Solomon Error Codes
Forward error correcting (FEC) is a very old technique. In recent years however, with the advent of its use in mobile communication, the error or redundancy coding techniques have drawn a lot of attention from the research community. FEC is not only relevant for mobile communication but also in storage media. At issue in this project is the use of Reed-Solomon codes for redundancy coding of ESS drive storage at the sector level.

The work proposed here is of direct relevance to the IBM Zurich Research Laboratory with whom the DNA Group currently has a Joint Research Agreement.
Objective
One of the objectives would be to understand redundancy coding in general and Reed-Solomon codes as applicable in various types of communication systems such as UMTS.

Not only is the storage and the impact on I/O-traffic an issue when using Reed-Solomon error codes, but so is the processing involved. The objective would thus be to determine the cost in terms of processing and I/O-request overhead as a function of the level of redundancy achieved.

Intelligent de-clustering of ESS
The best way to distribute a stripe across the available disks in a RAID configuration so as to optimize parallelism is a topic which has received *some* interest but much remains to be done, in particular if the striping is dynamic, as a function of the I/O-reference per drive, so as to avoid so-called *"hot spots"* in the ESS.
Objective

Develop a way of de-clustering taking into account I/O-reference locality for RAID systems.

Communication systems — Grid computing and its implication for computing in the future *Grid computing* has emerged as an important new field in the context of SOA, distinguished from conventional distributed computing by its focus on large-scale resource sharing, innovative applications, and, in some cases, high-performance orientation.

In this project our objective is to become familiar with this new field and its relevance for the long-term future of computing as a utility. First, we will investigate the "Grid problem," which is defined as flexible, secure, coordinated resource sharing among dynamic collections of individuals, institutions, and resources-what is referred to as virtual organizations.

In such settings, one encounters unique authentication, authorization, resource access, resource discovery, and other challenges. It is this class of problem that is addressed by Grid technologies.

Next, we shall come to grips with extensible and open Grid architectures, in which protocols, services, application programming interfaces, and software development kits are categorized according to their roles in enabling resource sharing. We will determine requirements that any such mechanisms must satisfy and learn the importance of defining a compact set of intergrid protocols to enable inter-operability among different Grid systems.

Objective

The first objective in this project will be to understand and document the concepts and terminology used in grid computing. How is it different from cluster computing and why is it not the same as the Internet?

13.4 Research Programmes

The major cooperative research programmes within the Department are:

13.4.1 Centre of Excellence in ATM & Broadband Networks and their Applications

The objective of the Centre of Excellence (CoE) is to promote research, development and dissemination of technology in high bandwidth networks and their applications.

The major supporters of the project are Telkom SA Limited, Siemens Telecommunications Limited, and the Technology and Human Resources for Industry Programme (THRIP), a joint programme of the NRF and the Department of Trade and Industry.

The CoE incorporates activities of the Collaborative Visual Computing laboratory and the Data Network Architectures laboratory of this Department, as well as the Communications Group Laboratory in the Department of Electrical Engineering at UCT, and the Department of Computer Science at Stellenbosch. The details of the proposed research can be found under the programmes of the individual researchers and laboratories.

13.4.2 Interfacing to Virtual Environments

The full title of this research programme is "Creating Effective Scalable Interfaces for Complex Collaborative Virtual Environments". The team members on the project are Edwin Blake (Principal Grantholder), James Gain, Patrick Marais, Gary Marsden and Bill Tucker (UWC).

The key issues are twofold, firstly to give users with different expertise and infrastructure access to the sophisticated information rich collaborative environments and secondly give a wide variety of authors access to tools and methodologies to create such environments. Along the way we will tackle some key applications and produce marketable products.

13.4.3 Databases and Distributed Systems

One research direction in the AIM laboratory is object database engineering and its application in GIS, knowledge management and distributed systems. Prof Sonia Berman and Prof Ken MacGregor are grantholders of an NRF funded research project on "Databases and Distributed Systems" which investigates models, methodologies and tools for effective use of object databases and distributed applications.

While the majority of database systems today are relational, there has been over the past decade a growing interest in object-oriented databases, which are better suited to the complexity of new application areas such as GIS and knowledge management systems. At the same time, the growth of computer networks and wireless communication has led to an increase in the development of distributed applications. In these areas, tools for development and analysis of applications are not properly understood. In South Africa with its wide geographic distribution of population and its shortage of skills, this area of computing has many particular sociological advantages and challenges.

13.4.4 SANPAD Project

The South Africa - Netherlands Research Programme On Alternatives In Development (SANPAD) is funding research on "Voice over IP to Build Bridges across the Digital Divide in South Africa".

The Digital Divide refers to the tendency of Information and Communications Technologies (ICTs) to enhance the advantages of the advantaged and further disadvantage the already disadvantaged. Our hypothesis is that this effect is not always and necessarily a natural consequence of the technology. We propose to conduct an action research intervention to discover if a particular technology, namely Voice over IP (VoIP - essentially the use of voice over internet-type connections), can be used, within an appropriate application and with appropriate content, to bridge the digital divide.

We wish to reflect critically on the ramifications of using VoIP technology in the face of proposed South African Government communication policies which severely restrict its usage. Our research could have a major critical function with respect to the proposed communications policies.

Our research should also form part of an ongoing critique of the technological measure of "Quality of Service" (QoS) that is used in modern data networks. QoS currently refers to low level technical measures such as bandwidth, latency and packet loss. This measure seems not to describe the needs of users adequately and need to be extended or embedded within an analysis of wider user requirements.

14 Recent MSc and PhD Graduates

The following masters and doctoral degrees were awarded since 1999.

PhD graduates

00 Mason, A.E.W. "Predictive Hierarchical Level of Detail Optimization" (E.H. Blake)

03 Nirenstein, S. "Fast and Accurate Visibility Preprocessing" (E.H. Blake)

03 Welz, M. "Modulating Application Behaviour For Closely Coupled Intrusion Detection" (A. Hutchison)

MSc graduates

00 Nelte, M.A. "Using Fingerprints on Smartcards for Personal Authentication" (A. Hutchison)

00 Nuñez, F. "An Extended Spreadsheet Paradigm for Data Visualisation Systems, and its Implementation" (E.H. Blake)

01 Azbel, I. "Epistemology as the Basis for a Corporate Memory Model" (S. Berman)

01 Casanueva, J. (Distinction) "Presence and Co-presence of Collaborative Virtual Environments" (E. H. Blake)

01 Davies, I. (Distinction) "Symbolic Techniques for the Performance Analysis of Generalised Stochastic Petri Nets" (P. Kritzinger)

01 Godfrey, A. "Distributed Shared Memory for Virtual Environments" (E. H. Blake/K. MacGregor)

01 Saal, O. "Visualisation of ATM Network Connectivity and Topology" (E. H. Blake)

01 Saul, E. (Distinction) "Facilitating the Modeling and Automated Analysis of Cryptographic Protocols" (A. Hutchison)

01 Voges, E. "A Framework for Building Spatiotemporal Applications in Java" (S. Berman)

01 Yavwa, Y. "Investigating Cost Effective Communication Alternatives for Geographically Hostile Regions" (P. Kritzinger)

02 Feng, J. "Visualisation of ATM virtual path connection networks" (E.H. Blake)

02 Johns, C. "The spatial learning method: facilitation of learning through the use of cognitve mapping in virtual reality" (E.H. Blake)

02 Schulz, M. "Garbage collection of the plava object store" (S. Berman)

02 Southern, R. "Quality control tools for interactive rendering of 3D triangle meshes" (E.H. Blake, P. Marais)

02 Williams, J. (Distinction) "Extraction of surface texture data from low quality photographs to aid the construction of virtual reality models of archaeological sites" (E.H. Blake, H. Rüther)

03 Nunez, D. "A Connectionist Explanation of Presence in Virtual Environments" (E.H. Blake)

04 Marte, O. (Distinction) "Model driven segmentation and the detection of bone fractures" (P. Marais)

04 Perkins, S. "Identification and Reconstruction of Bullets from Multiple X-Rays" (P. Marais)

04 Lesoana, M. "Interactive Storytelling" (Edwin Blake)

04 Lifson, F. "Specification and Verification of Systems Using Model Checking and Markov Reward Models" (P. Kritzinger)

04 Lyness, C. (Distinction) "Perceptual depth cues in support of medical data visualisation"' (E.H. Blake and P. Marais)

04 Mwelwa, C. "A methodology for analysing power consumption in wireless communication systems" (P. Kritzinger)

04 Steyn, B. "Topology alteration of meshes using directly manipulated free-form deformations" (J. Gain)

04 Walters, L. "Web browsing workload for Simulation" (P. Kritzinger)

04 Wong, B. "Using access information in the dynamic visualisation of web sites" (G. Marsden)

05 Bierowski, C. "The Use of Floorplans in Creating Virtual Environments" (G. Marsden)

05 Chetty, M. (Distinction) "Developing locally relevant applications for rural South Afica: a telemedicine example" (E. Blake)

05 De Wet, N. (Distinction) "Model Driven Communication Protocol Engineering and Simulation based Performance Analysis using UML 2.0" (P. Kritzinger)

05 Eyambe, L. "A Digital Library Component Assembly Environment" (H. Suleiman)

05 Hamza, S. "The Subjective Response of People Living with HIV to Illness Narratives in VR" (E. Blake)

05 Hendricks, Z. "A meta-authoring tool for specifying behaviour in VR environments" (E. Blake)

05 Landman, J. (Distinction) "Analytical Models of IP Traffic on UMTS Mobile Networks" (P. Kritzinger)

05 Malan, K. "Visualising Uncertaintity" (G. Marsden)

05 Ryndina, K. (Distinction) "Improving Requirements Engineering: An Enhanced Requirements Modelling and Analysis Method" (P. Kritzinger)

05 Schroder, R. "Laid Back Searching" (G. Marsden)

05 Tangkuampien, J. (Distinction) "A Virtual Environment Authoring Interface for Content-Expert Authors"(G. Marsden)

05 Tobler, B. (Dictinction) "A Structured Approach to Network Security Protocol Implementation" (A. Hutchison)