Department of
Mathematics and Computing

Research Report
1997–98

September 1998

University of Southern Queensland
Faculty of Sciences

Editor: Louise Williamson

Contents

Chapter 1

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Chapter 2

Research and development activity

The Department of Mathematics and Computing has an active research and development programme covering many different fields. The main activities can be conveniently classified under the following headings.

1. Fluid mechanics
2. Mathematical modelling
3. Applied Computer Science
4. Databases
5. Parallel Computing
6. Statistics
7. Educational development
8. Miscellaneous

Descriptions of the research and development being undertaken in the above categories may be found on the following pages.

In addition, a Simulation and Statistical Consulting Group has been established and is supporting the research needs of staff and postgraduate students.

2.1 Fluid mechanics

2.1.1 Low dimensional modelling in fluid mechanics

(Suslov)

The most complete, accurate and reliable mathematical model describing a wide variety of fluid flows is the Navier-Stokes equations. In many cases it unfortunately accounts for too many minute details making it virtually impossible to simulate the nature of the phenomena using existing computer facilities. Moreover, even if results are obtained through direct numerical simulations, their qualitative interpretation frequently requires construction of a further simplified model to filter the main features of the flow from those which are of little interest in a given application. Thus there is a continuing need for accurate and reliable *low-dimensional models* capable of resolving the main physical characteristics of flows as well as of serving as an accurate tool for quantitative predictions in engineering applications. The derivation of such relatively simple models based on rigorous mathematical techniques such as centre manifold theory is the object of my current research.

2.1.2 The free surface of water

(Roberts, Smith)

Although the flow of water involving a free surface (e.g. the sea's surface) is a difficult problem to analyse mathematically, there are important physical problems which need to be solved.

The aim of this project is to construct and use efficient numerical algorithms and dynamic models to calculate intricate nonlinear, steady and time-dependent flows of liquids with a free-surface. In particular, a major theme is the simulation of the highly nonlinear interaction between floating bodies and the free-surface of water; this is a very important class of problems in marine engineering. This continues research in two-dimensional flows where we have: developed efficient algorithms to calculate the breaking of water waves; investigated the generation of waves in front of a two-dimensional barge and by a submerged cylinder; studied the form and stability of two-dimensional standing waves and

three-dimensional short-crested waves. However, problems of real engineering interest are necessarily three-dimensional; for example, the calculation of the wave drag of a ship, and the sloshing of liquid inside a moving and accelerating container.

To simulate the time-dependent dynamics of extreme water waves requires an enormous amount of computation. Supercomputers, both vector and parallel, are used as an integral part of the project.

2.1.3 Convection

(Roberts, Passmore)

Vertical heat transport in the ocean, atmosphere and mantle is dominated by the heat carried by the encompassing fluid. Simple convectional motion may be analysed mathematically. Variants of centre manifold theory are being used to develop accurate models of the complex, even chaotic, dynamics of convection between poorly conducting boundaries (representative of convection in the earth's mantle).

In particular, we are investigating the issue of how to specify boundary conditions for mathematical models of the complex dynamics. Such boundary conditions will take account of realistic physical effects of the boundaries.

2.1.4 Turbulent flood flow

(Roberts, Suslov and Li)

We are developing a new model for the dynamics of turbulent flood water. Conventional models are based on the 150 year old St Venant equations. Using the techniques of centre manifold theory described in the next section, the new model is based on the k-ϵ model of turbulence but rigorously simplified for shallow-water (or long-wave) flow. The new model should be of wide use in simulating and predicting floods, estuarine flows, and rivers.

2.1.5 Impact Delivery of Prebiotic Organics

(Brookshaw)

A significant fraction of the terrestrial planets' volatile inventory may have been acquired as a late-accreting veneer from impacts of carbonaceous asteroids and comets during the period of heavy bombardment 4.5×10^9 to 3.8×10^9 years ago. In addition to simple volatile molecules such as H_2O and short-chain hydrocarbons, carbonaceous asteroids and comets are also rich in complex organics. It has long been speculated that the earth accreted prebiotic organic molecules important for the origins of life from the impacts of carbonaceous asteroids and comets during the period of heavy bombardment. A comprehensive treatment of comet-asteroid interaction with the atmosphere, surface impact, and resulting organic pyrolysis is needed to quantify this source of prebiotic organic molecules.

This project (being done in conjunction with C.F. Chyba, Princeton and W. Davis, NASA Ames) is to extend early work that focused on the earth and quantify the sources of prebiotic organic molecules for Mars.

2.1.6 Impact Triggered Tsunamis

(Brookshaw)

A considerable amount of interest has been generated in the last few years on the problem of near earth object detection and interception. This interest has been fueled by so-called risk analyses of a catastrophic impact of an asteroid or comet on the surface of the earth. There is little doubt that an asteroid 10 kilometres in diameter (the size of the Cretacious-Tertiary impactor 65 million years ago) impacting the earth would cause global devastation, but the period of large impactors is approximately 25 million years. A far more likely scenario is the impact of an object tens of metres in diameter. The 20 Megaton explosion over Tunguska, Siberia in 1908 is thought to have been caused by a stony meteorite of this size.

Though smaller impactors are more frequent the devastation is localised when the impact occurs over land (the Tunguska explosion flattened 2,000 square kilometres of forest) The destructive potential of small impactors increases significantly if the projectile hits the ocean and can generate a tsunami. Little is known of small impactors ability to generate tsunamis, this project, using an hydrodynamic particle code to model the impact into water, and an incompressible finite difference code to model the subsequent wave motion, is making a study of the waves generated by a variety of *small* impactors. With these results a more informed risk analysis should be possible.

2.1.7 Hydrodynamics of Pulsar Driven Winds

(Brookshaw)

Eclipsing millisecond pulsars (*eg.* PSR 1957+20, PSR 1744-24A) are known to exist in binary systems. A stellar wind from the pulsar companion is induced by the high energy particles and radiation of the pulsar wind. The wind from the companion then interacts with the low energy radiation from the pulsar and a bow shock is formed. The bow shock geometry can explain many of the features of the observed eclipsing patterns.

Using a particle hydrodynamic numerical code we (this work is being done with M. Tavani, Columbia University) are modelling the expansion and bow shock geometry under different conditions relevant for vaporizing millisecond pulsars.

2.1.8 Hypervelocity Impacts

(Brookshaw)

Since 1994 a number of hypervelocity experiments testing scram-jet engines at the SHARP (Super High Altitude Research Project) facility at Lawrence Livermore National Laboratory, (LLNL) have been carried out. The SHARP gas gun is the largest two-stage light gas gun in the world and is used as a hypersonic research facility. Projectiles 1-10 kg in mass are fired horizontally into air, past high-speed diagnostic equipment (roughly 20 m flight path), and into a projectile-retaining area, a concrete bunker filled with sand.

The recent experiments testing scram-jet engines provide an opportunity to conduct hypervelocity impact experiments at no cost with a total energy (20 MJ) more than 3 orders of magnitude larger than previous studies.

The project is to compare numerical models with the experimental results from diagnostic equipment placed in the sand in the target bunker and is being conducted with P. Fiske, LLNL.

2.1.9 The dynamics of thin films of fluid

(Roberts, Simpson and Suslov)

Thin layers of fluids are of considerable importance in the world around us. They occur in many engineering situations including painting, coating and lubrication flows. The human body also uses such thin fluid layers to protect parts of the body and to transport or capture material. In this project, in collaboration with Dr Valery Roy of the University of Delaware, we are developing models for the flow of thin films viscous fluids and any material they transport. We look to model not only simple Newtonian fluid flows, but also the complex rheology of non-Newtonian fluids. Further, the models will properly account for curvature of the substrate as such curvature has a fundamental influence of the flow. We are also developing techniques to derive the correct initial conditions for such thin fluid film models.

2.2 Mathematical modelling

2.2.1 Thermally induced hysteresis in viscoelastic and pseudoelastic materials

(Melnik, Roberts and Harman)

The adequate description of thermomechanical behaviour of viscoelastic materials, ranging from viscous fluids to (pseudo) elastic solids, is an important and difficult task. The key points in such a description belong to the appropriate time scaling and to the choice of constitutive relations which couple stresses, deformation gradients, thermal fluxes and temperature. Our main emphasis in this project is given to the mathematical and numerical analysis of materials known as pseudoelastic. A typical example of such materials is provided by shape-memory alloys (SMA) which have a strong dependence of load deformation upon temperature. The key to the understanding of thermomechanical behaviour of SMA is in the mechanism of the phase transition from the low to high temperature known as the martensitic-austenitic transition. In this project we address the problem of the mathematical description of this transition taking into account the coupling of elastic and thermal fields. We develop efficient approximate models and apply them to the computational analysis of thermomechanical behaviour of shape-memory-alloy structures.

2.2.2 Constructive approximations and the mathematical analysis in coupled dynamic thermoelasticity

(Melnik, Roberts and Thomas)

Mathematical models describing dynamics of the interaction between mechanical and thermal fields in elastic materials have significant practical importance and are used in many applications such as structural mechanics, power engineering, electronic device design. However, the thermomechanics of materials that undergo large deformation and/or considerable thermal disturbances has not been studied with the assiduity it deserves. Mathematically, we consider a system of partial differential equations coupled by a characteristic parameter and by the boundary conditions. The system of such types does not belong to any classical types of partial differential equations as it contains both parabolic and hyperbolic modes. The key difficulty lies with the fact that the solutions of many practically important problems based on such models do not possess the degree of smoothness often postulated *a priori*. The construction and the justification of adequate approximate models of coupled dynamic thermoelasticity as well as the development of numerical procedures for their effective solution is the core of the project.

2.2.3 Mathematical and numerical analysis of the quasi-hydrodynamic model in semiconductor device theory

(Melnik, Roberts, Harman and He)

During recent years computational microelectronics has provided a wide range of challenging mathematical problems that require collaborative efforts of mathematicians, electrical engineers and physicists. In this project we address the problem of analysis of mathematical models for charge transport in semiconductors. Although the fundamental drift-diffusion model (DDM) of the semiconductor device theory has been extensively studied mathematically and by now is relatively weel understood, new models are required to account for non-equilibrium and non-local behaviour of semiconductor plasma. The aim of this project is to improve the mathematical and numerical analysis of non-local models for semiconductors.

2.2.4 Generalised solutions and discrete models in coupled field theory

(Melnik and Melnik)

Piezoelectricity is an example of phenomena where coupling two physical fields of different natures (namely mechanical and electrical fields) is a key factor to be taken into account in a variety of applications. It is just one of many important examples where two theories, originally developed independently of each other (in this case the theory of elasticity and the Maxwell theory of electromagnetic waves), have to be considered in intrinsic correlation. Such examples are usually assigned to the domain of coupled field theory. The main focus of this project is the analysis of nonstationary models in piezoelectricity. We develop efficient numerical techniques for the adequate description of wave phenomena in piezoelectric bodies. A further development of this project will include mathematical and numerical analysis of models describing the dynamics of multilayered periodic structures such as superlattices.

2.2.5 "Fingerprints" of linear operators in the solution of spectral problems

(Melnik and Spunde)

The study of eigenvalues has been revolutionised by the ready availability of computing power. Once the basic mathematical ideas have been understood, many practical problems from a variety of industrial and scientific areas involving large matrices and linear operators may be attacked. Surprising results, however, are quick to appear and present well-known, yet non-trivial, difficulties. In this project we analyse a number of phenomena where classical computation with such packages as MATLAB, MATHEMATICA, APL, MAPLE leads to misleading results. It is not a question of which software package does better, nor is it a choice between floating point or symbolic arithmetics that is of primary importance in the explanation of these phenomena, but rather a choice of what is feasible and appropriate to compute. We review some of the computational difficulties in the solution of spectral problems and show how the visualisation capability of readily available software packages may be used to present an approach with a somewhat altered perspective.

Such a perspective is based on the notion of pseudospectra and on the idea of relating information in the complex plane to the behaviour of matrices or, more generally, linear operators.

2.2.6 Deterministic and stochastic partial differential equations of the Hamilton-Jacobi-Bellman-Type and Markov Chain approximations

(Melnik)

In this project computational aspects of the mathematical modelling of dynamic system evolution are considered as a problem in information theory. The construction of mathematical models is treated as a decision making process with limited available information. Using this approach we consider a number of nonsmooth optimal control problems and study the conection between Pontryagin's maximum principle and Bellman's dynamic programming through a partial differential equation, known as the Hamilton-Jacobi-Bellman (HJB) equation. Its solution may not be smooth enough to satisfy the equation in classical sense. Under relaxed smoothness requirements, we derive and explore a number of deterministic and stochastic HJB-type equations in classes of generalised solutions and develop efficient numerical procedures for their solution using the Markov Chain Approximation method.

2.2.7 Optimal-by-accuracy and optimal-by-order quadrature and cubature formulae for fast oscillatory functions

(Melnik and Melnik)

The problem of computing finite integrals with oscillatory functions arises in many areas of mathematics. In mathematical literature some of the most frequently cited examples of this problem are connected with the computation of Fourier transformations and the solution of boundary value problems for partial differential equations. In applications we often come to the above problem when modelling optical and automated control systems, constructing direction diagrammes of antennas, solving problems in radioastronomy, crystallography, signal processing and image recognition and when statistically processing experimental data. Since *a priori* information about the integrand typically is given inaccurately in the majority of practical problems (as a result of measurements or physical experiments), optimisation issues in numerical integration of fast oscillatory functions become of primary importance.

2.2.8 Numerical solution of unsteady convection-diffusion-absorption problems with the Cayley transform technique

(Gavrilyuk and Melnik)

Convection-diffusion-reaction models arise in a wide range of applications and require quite sophisticated mathematical tools for their rigorous study. In this project we study one such model described by the convection-diffusion-absorption equations. A quite natural approach to the solution of such problems is to use the domain decomposition method (DDM). When applied to nonstationary problems such a technique is often used in conjunction with an implicit-in-time discrete differentiation. Unfortunately, this leads to a gradual deterioriation of accuracy due to the necessity of inverting certain operators associated with the problem at each time step. The same can be said about spectral and pseudospectral techniques when finite differences are used for temporal discretisation.

As an alternative, during recent years attempts have been made to construct DDMs with no iterations for nonstationary problems. Such methods employ the idea of a dynamic adaptation of the computed solution to the smoothness of initial data. This idea is developed further in this project. Recently Prof. Gavrilyuk, in a number of papers with other European mathematicians, established a one-to-one correspondence between the continuous initial value problem for some classes of differential equations and certain discrete initial value problems. Such a correspondence, that is essentially based on the Cayley transform technique, allows further development of the subject.

2.2.9 Principles and applications of dynamical modelling

(Roberts, Passmore and Suslov)

A significant achievement is the development of techniques, based on what is called centre manifold theory, for the rational and *complete* low-

dimensional modelling of complicated dynamical systems. These techniques, which are born out of the recent explosion of interest in dynamical systems, have been applied to a variety of physical problems and lead to many new insights—some of which are relevant to chaos, while the vast majority enable us to understand classic approximations and their success and failure.

The range of applications for these ideas is enormous, as the making of tractable approximations is crucial in mathematical modelling. Just some of the physical problems to which they have been applied are as follows: the dispersion of material in rivers and pipes where we have been able to derive models for the dispersion in a varying channel; the dynamical evolution of forced convection where accurate models of pattern selection are shown to be inherently non-local; the deformation of an elastic rod where the four principle modes of deformation, that of torsion, longitudinal, horizontal and vertical displacement, are neatly captured in the one scheme; the nature of the quasi-geostrophic approximation which underlies much of meteorologists understanding of the dynamics of the lower atmosphere; the derivation of an appealing dynamical view of the concept of a quasi-stationary distribution in applied probability.

We are extending the methodology to account for stochastic fluctuations in physical problems. The concepts also allow us to justify some important solutions, and to provide correct initial amplitude for the similarity solution. Recent work is the development of an holistic approach to the derivation of finite difference approximations.

2.2.10 Gaussian models of queues in telecommunication networks

(Addie)

Queues have been used to model a wide range of telecommunications systems. Whenever traffic shares a valuable resource, some queueing is likely to be involved. Queueing performance is of critical significance in the Broadband-ISDN, in signalling networks, and in the intelligent network, for example.

Recent work by R.G. Addie and M. Zukerman has made available results for queues with Gaussian traffic models. The advantage of a Gaussian model over previous traffic models is that all the first and second order statistics of the input traffic can be accurately modelled (including the entire autocovariance). In this work, the application to telecommunication networks will be emphasised. The following specific areas will be tackled.

- Formulate call acceptance criteria for use in a B-ISDN which take into account the mean, variance, and autocovariance of the traffic already in the network, and the traffic which is being offered.
- Investigate the effect upon the autocovariance function of a traffic process of being passed through the typical elements in a network, ie. switches, queues, buffers, and smoothing devices.
- Investigate algorithms for estimating packet delay and loss in B-ISDN networks.

Substantial progress has already been made towards meeting the above objectives.

2.2.11 Finite difference models for derivatives

(Harman)

Methods have been devised for modelling derivatives by finite difference based on non-uniform grids. In collaboration with Dr Neville Robinson of C.S.I.R.O.(Adelaide) the methods have recently been generalised to allow approximations of all orders. The results are being applied to various applications which involve singular points or regions of singularity.

2.2.12 Automatic Differentiation Techniques for the Solution of Differential Equations

(Spunde)

High order Taylor Series approximations have been shown to be a viable alternative to classical approximations for the solution of systems of ordinary differential equations through the application of techniques of automatic differentiation. Multipoint techniques applied to stiff systems are being investigated; and also multi-variable techniques for partial differential equations.

2.2.13 Road traffic flow modelling

(Plank)

The performance of non-signalised traffic intersections is affected by variability in vehicle behaviour due to differences amongst vehicles/drivers and inconsistency in individual driver behaviour. Research so far has partly quantified the effects of these two factors on measures of intersection performance such as capacity and delay for stationary flow conditions and for simple traffic conflicts. Insight has been gained into the importance of including inconsistency and/or inhomogeneity parameters in formulae which traffic engineers use to measure and predict the degree of congestion at uncontrolled urban intersections under realistic flow conditions. Ongoing and planned research include the modelling of more complex traffic conflicts, the impact of severe inconsistency and inhomogeneity on performance measures, and the development of a useful model for non-stationary flow conditions.

2.2.14 Modelling of Driers used in Sugar Factories

(Plank & McFarlane)

Sugar factories receive billeted cane and produce raw sugar by a number of complicated unit operations. The raw sugar has to conform to certain quality and physical characteristics to be able to be transported anywhere in the world in a variety of climatic conditions. It must also be able to be easily refined into white sugar.

To date, modelling of unit operations has, almost exclusively, assumed steady-state conditions. Unfortunately a variety of disturbances routinely occur in the cane supply, steam supply, mixing and chemical additives amongst others, some or all of which may impact on the raw sugar product.

This on-going project aims to examine the influence of variation in input variables on the raw sugar product using a stochastic process modelling approach. The ultimate intention is to model the entire sugar factory in order to better understand the nature of interactions amongst input variables and to devise control strategies to improve the output quality.

Work to date has concentrated on the final unit operation of the process - the drying stage. An existing steady-state model has been adapted to deal with variability in the input variables and a method developed of efficiently simulating the drying process in the presence of many input variables.

2.2.15 Dust Transport Modelling

(Butler)

In the last ten years most Australian capitals have been affected by major dust storms. The majority of this dust originated in the rich farming lands of rural Australia and carries a large amount of the nutrients/chemicals that were present in the soil. Current modelling work is aimed at producing a source based model that will accurately predict dust concentration downwind of the source. It is anticipated that this model will give us insight into where these nutrients/chemicals are being transported, and their effect on the various ecosystems in Australia.

2.3 Applied Computer Science

2.3.1 Broadband Network Analysis, Design, and Management

(Addie)

Recent work in modelling broadband and internet traffic by R. G. Addie and co-workers has important implications for the analysis, design, and management of communication networks. It has now been shown theoretically, and experimentally, that traffic becomes closer to Gaussian as it is aggregated. Furthermore, when the Gaussian approximation becomes valid, a law of increasing efficiency sets in which implies that network performance can be maintained at excellent levels despite utilisation approaching one hundred percent. These conclusions are explained in the paper of the August issue of the IEEE Communications Magazine. The central limit theorem result is to be published in the Journal of Statistical Planning and Inference. These results are further confirmed in experiments and in theoretical work in papers submitted to the 1999 International Teletraffic Conference by R. G. Addie with co-authors in Sweden and Finland.

Work in progress and planned over the next few years includes the following:

- Performance Models. This project entails research on continuous time Gaussian models

with realistic autocovariance and their implications and further refinement of the central limit theorem for network traffic.

- Architectural Principles for Communication Networks. The analysis tools and ideas already developed, and under development have important implications for network architecture, which will be explored. These include:
  - Multiplexing Gain (the fact that networks become more efficient as traffic grows)
  - Layering of networks : principles and practise
  - Differentiation of service : principles and practise
- Measurements. Further implications of the Gaussian analysis described above is the importance of short time-scale behaviour of network traffic. This needs to be understood better in order to provide a sound foundation for dimensioning broadband and IP networks. This work will include:
  - A program of measurements.
  - Statistical theory to support the measurements (including methods for estimating fine time-scale behaviour from more crude measurements)
- Simulation. Development of high speed (using importance splitting) simulations to support the analysis and measurement work described previously.
- Network Design. * Development of principles of network design applicable to broadband and IP networks.

2.3.2 Object Oriented Techniques

(Fuller)

Developing a curriculum for introducing the fundamental OO ideas and concepts via an object oriented design method that involves specifying the design in the eventual programming language, thus obviating the need to learn any other (possible) complex specification notations or diagramming techniques. Self-teaching materials, using Eiffel as the teaching language, are currently being developed. The curriculum will be adapted for teaching C++ in the near future.

2.3.3 Risk Analysis of Using Applets that are Running Multiple Threads

(Zhou)

Many internet browsers allocate a thread for each applet on a page, using that thread for all calls to the applet's major methods. Some browsers allocate multiple threads or a thread group for each applet. Multiple threads share more of their enrivonment with each other than singletasking. Threads may be distinguished by the value of their program counters and stack address while sharing a multiple address space and set of variables. The threads that the major methods are called from depends on the application that is running the applet, so that it is easy to kill or get the control part or all the threads that belong to a particular applet.

It is difficult to directly discover the flaws in the design and implementation of internet browsers. The current research is to design a risk analysis method to exploit weaknesses in the type checking of threads and Java applets and system-level flaws, in order to prevent the vulnerabilities caused by Java/applet applications, that possibly leak sensitive information, corrupt an application environment and cause great inconvenience.

2.3.4 Programming language design

(House)

A major problem in computing is designing computer languages that provide an effective medium for the design and implementation of large or complex systems. Some difficulties relate to specific language features, others to overall language design considerations.

This project addresses both of the above kinds of difficulties. The research focuses on methods of data and process encapsulation, and on methods of object declaration. A specific language feature success was the creation of a clean language feature for declaring scientific unit information that specifies allowable data combinations: for example, lengths and masses may be multiplied, but not added. An overall design issue tackled successfully was design of improved block-structuring rules for Algol-like languages. A new paradigm for language type systems is also near completion.

Present work focuses on design of an inverse object-oriented paradigm which, in combination

with existing object-oriented concepts, would permit unprecedented flexibility and clarity in a programming language.

A long-term goal is the design of a complete programming language that embodies these concepts.

2.3.5 Systems Simulation of Meat Processing

(McFarlane)

Systems simulation is a powerful strategy for modelling and analysing complex systems in which varying degrees of randomness impacts on the performance of tasks, the arrival and flow between processes, the availability of resources, and the interaction of subsystems competing for scarce resources.

The use of systems simulation as a decision support system is relevant to meatworks, enabling decision makers to explore the operational implications of adjustments to meat processing without the expense and associated risks of major alterations. In this way, managers can evaluate new/alternative technologies and examine the feasibility of implementation at minimal cost. Comparison of alternative technologies, plant design/layout can be made in relation to bottle-necks, capacity, efficiency and resource utilisation as a function of plant layout. The ability to evaluate new technology at minimal cost will lead to more confidence in the expected performance of that technology, allow labour utilisation within new systems to be determined and planned as part of the development and will encourage quicker adoption of technology into industry.

These projects are concerned with the development of 'standard' systems simulation models for all meat processing activities, related to slaughter floor and boning room operations. The development of sophisticated user interfaces and animated graphical displays will allow the models to be used interactively by managers.

2.3.6 Systems Simulation of Food Distribution at the Toowoomba Base Hospital

(McFarlane & Parker)

Systems simulation is a powerful strategy for modelling and analysing complex systems in which varying degrees of randomness impacts on the performance of tasks, the arrival and flow between processes, the availability of resources, and the interaction of subsystems competing for scarce resources.

This project involves the use of systems simulation in the comparison of alternate technologies involved in the preparation and distribution of food throughout a large hospital.

2.3.7 Comparison of Alternative Slaughter Floor Configurations

(McFarlane)

Systems simulation is a powerful strategy for modelling and analysing complex systems in which varying degrees of randomness impacts on the performance of tasks, the arrival and flow between processes, the availability of resources, and the interaction of subsystems competing for scarce resources.

This project is concerned with analysing performance differences between these modifications proposed by a large meat processor.

2.3.8 User interface design for software development environments

(Toleman & Welsh)

Computer-aided software engineering (CASE) tools have a vital role to play in software development and maintenance. In practice, however, the uptake of innovative CASE tools by software engineers is typically much slower than their designers expect, and the benefits are consequently limited. This slow uptake of CASE tools is often attributed to usability concerns, but use of systematic usability evaluation techniques to overcome such problems is certainly not common practice and has not been widely canvassed in the relevant literature.

The aim of this project is to apply usability evaluation techniques to a number of innovative CASE tool features, to determine the effectiveness of the evaluation techniques concerned in this context. If successful, the experiment will also provide valuable information on the potential of the innovative tool features evaluated.

The outcomes will be

- a documented case-study of the application of usability evaluation techniques to CASE tools,

which will be of significant general value to tool developers, and

- a systematic evaluation of the specific innovative features concerned, which will help to determine their usefulness in future CASE tool developments.

The project is a collaborative one between researchers at the University of Queensland who have developed the tool features concerned, and researchers at the University of Southern Queensland, whose expertise in usability evaluation will ensure an independent, well-designed experiment.

2.3.9 Generic Language-Based Editors

(Welsh & Toleman)

The generic editors UQ1 and UQ2 provide the platform for several other projects. This project is concerned with improving the quality and usability of these editors so they can function effectively as the front-end to a variety of software development environments, and with integrating the results of other projects into the generic UQ⋆ environment as they emerge.

2.3.10 Environment Description Language for UQ⋆

(Welsh & Toleman)

The introduction of relations and the associated provision of graphical presentation and manipulation of relational structures necessitate significant enhancement and restructuring of the enrivonment description language (EDL) in which UQ⋆ document and relation types, their structure, and presentation attributes are defined.

2.3.11 Debugging Lazy Functional Languages

(Watson & Salzman)

Lazy functional languages offer significant advantages over other language paradigms for rapid development of reliable code. Unfortunately, functional languages can be difficult to debug, and no complete debugging environments have been developed.

This project aims to build on earlier work devoted to generating a trace of a lazy computation in order to build a usable debugging environment for the Haskell language. The work involves collaboration with researchers at the University of Queensland.

2.3.12 Operating Systems

(Vance)

Research focuses on the following areas:

- File systems and directory services for supporting cryptographic operations and wide area naming.
- Distributed operating systems.

2.3.13 Real-Time Multicast Communication in ATM Networks

(Zhang and Jia)

Real-time multicast is an important communication mechanism required by many multimedia applications, such as interactive video conferencing systems, video-on-demand, distance education, and so on. However, little work has been done in supporting real-time multicast in ATM networks. This project has three major tasks:

1. develop a real-time analytical model to analyse delays in ATM networks;
2. develop a multicast routing algorithm which generates optimal routing trees (in terms of network cost) under real-time constraints;
3. develop a real-time multicast connection setup method which combines the multicast routing with the real-time verification of routing trees.

2.4 Databases

2.4.1 Spatial and Multimedia Database Processing

(Zhang, Roberts, Lai and Xiao)

In this project, we will develop techniques and algorithms:

- to support the graphic and logical representation of multimedia data such as documents and images, thus increasing the speed and accuracy of user's query formulation;
- to facilitate the information retrieval in spatial databases, image and multimedia databases by utilizing various index techniques;
- to improve the response time by better balancing the load and maximizing the performance of parallel spatial and image database processing.

2.4.2 Web-Based Internet Database Systems and Java Implementation

(Zhang, Roberts, Lai, Toleman and Fuller)

This work involves several specific subjects such as the World Wide Web, object-oriented modellings, internet, databases, transaction processing and Java.

In this project we will develop:

1. web-based object-oriented data model to support networking database schema integration;
2. database connections to connect databases over the internet through JDBC-ODBC implementation;
3. web interfaces to support database query and transactions over the internet through Java implementation;
4. transaction management to support advanced transaction processing such as interactive and cooperative transactions over multiple databases on the internet.

2.4.3 Normalization in Object-Oriented Database Design

(Zhang, Xiao, and Fuller)

Normalization theory is an aid which provides a rigorous procedure for relational database design. Although the relational model has provided database practitioners with a modelling methodology independent of details of physical implementation, many designers believe that the relational model does not offer a sufficiently rich conceptual model for problems that do not map onto tables in a straight forward fashion. The past decade has seen the emergence of numerous data models with the aims of providing increased expressiveness to the modeller and incorporating a richer set of semantics into the database. This collection of data models can be loosely categorized as object-oriented or "semantic" data models since their one unifying characteristic is that they attempt to provide more semantic content than the relational model.

In this project, we will investigate the normalization process for object-oriented database design, including the object normal forms and the normalization procedure.

2.4.4 Design and Management of Distributed Databases

(Zhang)

The design methodology and transaction managements for centralised database have been well studied and understood. Due to the development of network technology, mobile computing and the nature of decentralization of many nation-wide and world-wide organizations, the centralised database design and management do not meet the decentralised application requirements. To support distributed processing, one need to design distributed database systems, mobile distributed databases or integrate the existing database systems into a federated database system. In this project, we will develop algorithms or approaches for distributed database design and distributed transaction management, including concurrency control and recovery in federated databases and mobile distributed database systems.

2.4.5 Database Support for Cooperative Information System Design

(Zhang)

Although the traditional database transaction model is suitable for conventional database applications, it has limited applicability in many advanced applications such as software development environments. In those environments, transactions are usually very complex, have a need to access many complex data items, tend to be very long, and may need to cooperate with each other. For example, in cooperative environments, several designers might work

on the same project. Each designer starts up a cooperative transaction. Those cooperative transactions jointly form a transaction group. Cooperative transactions in the same transaction group may read or update each other's uncommitted object versions. Therefore, cooperative transactions may be interdependent. However, the traditional transaction technique does not support cooperation among the transactions. Cooperative applications may require different correctness criteria rather than serialisability theory. Cooperative transactions might be long and able to interact with each other. Therefore, there is a special need for research in cooperative transaction management.

In this project, we consider cooperative environments of systems design. We treat the cooperative transactions as a transaction group, and relax the requirement for atomicity and serialisability. We start at a case study of a cooperative document editing system, investigate and implement practical operation transformation rules for an effective synchronisation of editing operations among the cooperative transactions, and then generalize it to more general cooperative design tasks.

2.5 Parallel Computing

2.5.1 Advanced Model for Parallel and Distributed Programming

(Tang)

The aim of this project is to seek the appropriate programming model for the future parallel and distributed computing which offers both software productivity and efficiency. The existing models which are currently under investigation include Aspect-Oriented Programming (AOP) and Multiparty Interacting Process (IP) models.

2.5.2 Web Parallel Programming Environment

(Tang)

This project is to investigate Java-based environments for parallel computing on the Internet, also known as meta-computing. A preliminary study on Java-based meta-computing was summarized in the technical report USQ, SC-MC-9802, "Job Size for Internet Parallel Computing". The work has been extended for more general configurations.

2.5.3 Distributed Multimedia Programming

(Tang and Lai)

This project is to investigate distributed programming in the domain of multimedia applications and systems. In particular, we are looking at using the programming model and the meta-computing environment described above to implement multimedia applications.

2.6 Statistics

2.6.1 Locum service

(McFarlane)

A report detailing data collection, storage, and analytical strategies and methodologies, to monitor and evaluate the Locum Service intended to support Continuing Education activities and relief for rural doctors, was presented to the Cunningham Centre at the Toowoomba General Base Hospital.

2.6.2 Predictive and Structural Inference

(Khan)

Predictive inference is based on the prediction distribution. Construction of prediction regions and different types of tolerance regions. Multivariate models involving dependent but uncorrelated, and correlated responses.

Inference for the parameters of different kinds of multivariate models with dependent and correlated errors. Simultaneous Equation Model with multivariate Normal and Student-t errors.

2.6.3 Improved Estimation for Multivariate Models

(Khan)

The usual estimators, both the least square and maximum likelihood, can be improved by incorporating *uncertain prior information* in the form of a null hypothesis. The unrestricted estimator and the restricted estimators can be improved by using all available information and recently developed statistical techniques. the method of preliminary

test estimators (PTE) has been developed by Bancroft by using the 'Fisher's recipe' of testing out the uncertainty in the null hypothesis. The PTE depends on the levels of significance and is an extreme choice between the unrestricted and restricted estimators. Stein-type shrinkage estimator addresses those problems. However, the shrinkage estimator becomes unreliable when the value of the test statistic is close to zero. The positive rule shrinkage estimator provides further improvement in addition to solving the problem of the shrinkage estimator. Study of the above improved estimators are conducted for different multivariate normal and Student-t models. The later model based estimators are robust and include a family of elliptical models.

2.6.4 Variance Modelling in GLMs

(Dunn)

Generalised linear models (glm's) contain a very broad class of models that provide a uniform framework for regression modelling for many types of data. Glm's assume (among other things) that variance is proportional to some function of the mean. However, there are cases in which this mean-variance relationship fails or needs to be estimated. This research will examine the mean-variance relationship through the concept of double generalised linear models which assume link-linear predictors for both the mean and the dispersion. It will also examine statistical models whose responses are not members of the exponential family to extend the idea of generalized linear models.

2.7 Educational development

2.7.1 Calculus Reform

(Spunde)

The calculus/algebra reform program at USQ has been in effect since 1988. A computationally rich mathematics instruction program in first year mathematics was developed in a CAUT sponsored project providing an alternative approach to a first semester course in mathematics, and integrating work on both calculus and linear algebra. An Open Learning Quality Enhancement program builds on the work of the CAUT project to produce an alternative method of delivering the Foundation Mathematics course (MAT13) to open learning students equipped with a computer.

The USQ program is unique amongst calculus reform projects in that it concentrates attention on the direct numerical computation of functions, their derivative functions and indefinite integrals, and the application of the rules of calculus to the manipulation of numeric function tables rather that symbolic formulae (in the first instance). A workshop for teachers offered at APL95 by W. Spunde and R. Neidinger (Davidson, N.C.) demonstrated how these numerical ideas could be implemented in Mathematica, Maple, Matlab, APL, J and on the HP48G and the TI82 and TI85 calculators. Current development focuses on a hybrid language (J+TkTcl) for mathematics instruction.

The program aims to provide students with a strong background of computational experience on which to base an understanding of mathematical symbolism and symbolic manipulations.

A 1998 grant from CUTSD supports the development of this material together with the requisite software for interactive web-based delivery.

2.7.2 What Motivates the Study of Mathematics and Computing?

(Fuller, McDonald and Cretchley)

It is common knowledge that fewer females than males choose to undertake tertiary studies in Mathematics and/or Computing. Various explanations for why this is so have been put forward, with most focussing on why girls do NOT choose to enter these fields. Recently Patricia Cretchley, Anne Fuller and Christine McDonald began an investigation into the factors that influenced 1st year Mathematics Computing students to enter these courses. Students in Algebra and Calculus 1 have completed a questionnaire, and shortly we will be interviewing selected students to obtain more detailed data. This pilot study will be extended to all Queensland universities.

We hypothesise that girls enter Mathematics/Computing for different reason from boys. We further hypothesise the existence of regional (rural vs urban etc.) differences.

If we can identify any such motivational differences, we, and other universities, can better target potential students, both male and female.

2.7.3 Measuring Attitudes Towards Mathematics in Early Childhood and Primary Teacher Education

(Roberts C., Cretchley and Harman)

Changes in attitude have been measured over a semester of mathematics in the first year of Early Childhood and Primary teacher training. The unit of study is not a curriculum unit, is taught by mathematcians and explores mathematical ideas and experiences. The Fennema-Sherman Attitudes Scale was used to measure changes in *confidence, effectance motivation*, and *usefulness*. Analysis of the results indicates a challenging outcome - the only significant change was a drop in their perception of the usefulness of mathematics.

2.7.4 Enriching Distance Teaching and Learning of Undergraduate Mathematics using Videoconferencing and Audiographics

(Harman and Dorman)

An interactive teaching/learning model involving Desktop Videoconferencing and other audiographic facilities has been developed and trialled for distance education in undergraduate mathematics. It appears that very little has been reported previously in this area of mathematics teaching, certainly not on the scale of this development. Such teaching and learning requires the incorporation of a wide range of electronic communication tools which enable ideas to be explored using verbals, visuals, algebraic symbolism, geometric representation, and computer applications/graphics software. Most importantly, the medium must also facilitate the development of motivation and the communication of enthusiasm for the subject. Weekly teaching/learning sessions of two hours duration were held with a first-year group throughout the teaching semester. It was demonstrated that it was possible to integrate the systems used, together with applications software, to enable the representation of algebraic, geometric, and numeric concepts, all of which are essential for the development of higher level mathematical topics. Various qualitative measures were used for analysis of (i) complexity of the environment, (ii) effectiveness of the medium/methodology, (iii) improvement in skills, and (iv) the development of interactivity.

2.8 Miscellaneous

2.8.1 Fractal geometry

(Roberts)

The distribution of plants and animals in their environment is frequently patchy. Recent research has shown that this patchiness occurs, at least sometimes, on all scales in the distribution of the species. This appearance of structure on all scales leads naturally to a description of the distribution as a fractal object. Indeed analysis of the settlement and subsequent evolution of fucoids ("seaweed") off the coast of South Australia is showing the distribution to be a multi-fractal.

A current project is to overcome present limitations in estimating fractal dimensions and determining the multi-fractal spectra. Current methods are based on straight line fits on log-log plots. By generating artificial multi-fractals and comparing the underlying structure of neighbour-distance information, we can determine which multi-fractals best match the physical data. With this fit, we then use the analytically known information about the artificial multi-fractal to estimate the fractal nature of the original.

2.8.2 Airline Crew Scheduling

(Wark)

The application of repeated matching to determine cost-efficient tours of duty for airline crews was investigated. This work was carried out in association with Dr. Mikael Ronnquist from the University of Auckland.

An extension of the basic scheduling problem was dealt with, in that in addition to so-called "regular crews" there was the option of scheduling a third pilot for parts of the tour of duty of a regular two pilot crew. The inclusion of a third pilot allows longer duty times, which may enable more cost-efficient tours. However, this is at the expense of higher salary costs, and the need to find schedules for the "third pilots". Thus there is the need to simultaneously find schedules for both the regular crews and the third pilots. A complicating factor is

that the number of sectors requiring of third pilot is not known in advance.

Using data from an actual airline, we found tours of duty markedly superior to those used in terms of the overall costs. Our results were also better than those found by another investigator using a set partitioning approach.

2.8.3 Stochastic Vehicle Routing

(Wark)

In many real-world vehicle routing problems the demands of customers are not known in advance. Moreover, some customers may not need to be serviced in a particular service period, but that may not be known until after the vehicle servicing those customers has begun its travel. If vehicles are to be used efficiently, it is inevitable that on occasions a vehicle may not be able to service all customers on its intended route without an intermediate return to the depot. Thus vehicle routes need be determined to minimize the probability of *route failure*, or to minimize the total expected cost of routes. Investigations are being conducted to determine ways of finding good solutions for these stochastic vehicle routing problems.

2.8.4 Celestial mechanics and astronomical graphics on computers

(Forbes)

This is a well-established project which I have personally used to compare observations of satellite phenomena (eclipses, occultations, shadows, transits) of Jupiter and Saturn with computer program predictions.

A computer program shows images of the appearance of the planets and their satellites at any chosen time. Currently the rings of Saturn are invisible due to the plane of the rings being close to edge-on to the Earth and the Sun. The program is being used to predict the disappearance and reappearance of the rings. This means that the above satellite phenomena are now occurring for Saturn whereas they usually do not because of the large angle between the plane of Saturn's equator (and the ring plane) and the solar system's ecliptic plane. (This is as distinct from Jupiter, where such phenomena are always occurring frequently).

These events have caused me to recently refine the calculations for Saturn's rings and satellites and further refinement will no doubt be necessary after comparison with observations.

2.8.5 Two-dimensional spectral estimation using Pick Functions

(Forbes)

A very extensive chapter in my PhD dissertation was devoted to 1-dimensional spectral analysis using Pick functions. The method is new and appears to be successful.

Another chapter was on 2-D spectral analysis using Auto Regressive methods.

I am attempting to extend the Pick function method to 2 dimensions.

2.8.6 Mathematics in Sport

(Chris Harman)

A model has been developed for optimising baserunning trajectories for a baseballer. Previous studies have been able to determine time differences due to running on the curve for 200 m and 400 m sprints. These models assumed constant curvature (circular) and uniform speed. The baserunning model takes into account acceleration from rest and the problem of modelling the motion on general curves.

Chapter 3

Grants and presentations

3.1 Research, consulting and teaching grants

Research, consulting and teaching development projects to be supported by competitive grants include the following.

- C. Harman, O. Jegede and W. Tan: *Desktop Video Conferencing Technology to enhance teaching and learning in mathematics*, CUTSD (DEETYA Committee for University Teaching & Staff Development) Research Project, 1997 ($43,945).
- C. Harman, P. Cretchley, N. Ellerton and G. Fogarty: *Analysis of the effect of the use of powerful mathematical computing software on undergraduate attitudes towards Mathematics and Learning, both on-campus and in extension to distance education* USQ Project Team Research Grant. ($37,875).
- R.V. Melnik, A.J. Roberts, C.J. Harman, et al *Thermally Induced Hysteresis in Viscoelastic and Pseudoelastic Materials,* (PTRP Grant, 1998-1999, $57,165).
- R.V. Melnik & A.J. Roberts, *Constructive Approximations and the Mathematical Analysis in Coupled Dynamic Thermoelasticity* (ARC Small Grant, 1998-1999, $17,722).
- R.V. Melnik, A.J. Roberts & C.J. Harman, et al *Mathematical and Numerical Analysis of the Quasi-Hydrodynamic Model in Semiconductor Device Theory* (PTRP Grant, 1997-1998, $20,129).
- Y. Zhang, *Parallel Spatial Database Processing*, USQ Incentive Research Grant for 1998, ($12,000).
- Y. Zhang, A.J. Roberts, W. Lai, M. Toleman & A. Fuller *Web-based internet database processing and Java implementations*, USQ Project Team Research Program for 1998-1999 ($61,663).
- Y. Zhang, Roberts and Lai: *Efficient Query Processing in Multimedia Databases*, USQ Project Team Research Grant, 1997-1988 ($51,247).

3.2 Seminars

The department has an active seminar programme. Seminars organised during the year by the department include the following.

- Peter Dunn, *My Secret Life as a Climatologist (or: When it Rains, it Pours)* 26 February 1998.
- Bob Andersen, CSIRO Mathematical and Information Sciences, *Linking Mathematics to Data: The Molecular Weight Distribution Problem*, 11 March 1998.
- Sergey Suslov, Department of Mathematics and Computing, USQ, *Initial Conditions for Low-Dimensional Models of Dynamics*, 21 April 1998.
- Brad Butcher, Jeni Newman & Phillip Shelton, Department of Mathematics and Computing, USQ, *Systems Modelling Student Simulation Competition Finals Presentation*, 30 April 1998.
- Mike McFarlane, Department of Mathematics and Computing, USQ, *Current Trends in Systems Simulation Software - Study Leave Report*, 14 May 1998.

- Ron Addie, Department of Mathematics and Computing, USQ, *Application of the Central Limit Theorem to Networks*, 4 June 1998.
- Richard Watson, Department of Mathematics and Computing, USQ, *Types and Programming Languages*, 11 June 1998.
- Peiyi Tang, Department of Mathematics and Computing, USQ, *Job Size for Parallel Internet Computing*, 18 June 1998.
- David Smith, Department of Mathematics and Computing, USQ, *Computations in Unsteady Free Surface Hydrodynamics*, 25 June 1998.
- David J. Lilja, University of Minnesota, USA, *A Processor Architecture and Compilation Techniques for Hard-to-Parallelize Application Programs*, 10 July 1998.
- Xiaohua Jia, City University of Hong Kong, *An Overview of Multicast Routings for Advanced Network Applications*, 23 July 1998.
- James D. Meiss, Department of Applied Mathematics, University of Colorado, USA, *Homoclinic Bifurcations in the Henon Map and the Anti-Integrable Limit*, 31 July 1998.
- Keith Forbes, Department of Mathematics and Computing, USQ, *Some Mathematics Applied to the Theory and Practice of Sailing*, 13 August 1998.

3.3 Conferences and Presentations

Mrs. P. Cretchley was the Convenor of DELTA97: Symposium on Modern Undergraduate Mathematics, Brisbane, November 1997.

Dr. M. Toleman was a Programme Committee Member for the Third Australasian Conference on Computer Science Education (ACSE'98) held at the University of Queensland in Brisbane.

Dr. M. Toleman is a Programme Committee Member for the annual conference of the Computer Human Interaction Special Interest Group of the Ergonomics Society of Australia (OZCHI'98) to be held at the University of South Australia in Adelaide.

Dr. Y. Zhang is a program committee member of the following international conferences:

- The 5^{th} International Conference of Fundamentals of Data Organisation (FODO'98), Kobe, November 1998.
- Asia Pacific Web-Based Computing (APWEB'98), Beijing, September 1998.

Conferences attended by members of the department, and their presentations, are listed below.

- L. Brookshaw, *Large Scale Hypervelocity Impact Experiments*, Australian Applied Mathematics Conference, Queensland, 1998.
- A. Kindt, A. Hadjipanayi, P.J. Thomas and L. Brookshaw, *Simulating Colliding Asteroids*, NCUR 98, Salisbury, MD, USA, 1998.
- J.A. Godfrey, W.J. Ruffing, P.J. Thomas and L. Brookshaw, *Easing the Impact - A Web-Based Interface for a Smoothed Particle Hydrodynamics Simulation*, NCUR 98, Salisbury, MD, USA, 1998.
- P. Cretchley, A. Fuller and C. McDonald, *What factors attract students to the study of mathematics and computing at Queensland universities and are there significant gender differences?*, Presented at the Queensland Institute for Educational Research Forum, Brisbane, August 1998.
- P. Cretchley, *What factors really do improve learning? Warnings for undergraduate mathematics*, DELTA 97: Symposium on Modern Undergraduate Mathematics, Brisbane, November 1997.
- P. Cretchley, *Enhancing Achievement using Technology? Feedback is Effective*, International Conference on the Teaching of Mathematics, Samos, Greece, July 1998.
- P. Cretchley & C. Harman, *Enhancing conceptual and attitudinal Development in undergraduate Algebra and Calculus, using visual and numerical software*, Annual Conference of the Queensland Branch of ANZIAM, Alexandra Headlands, August 1998.
- P.K. Dunn, *Adding Generalised Linear Models to MATLAB's Statistical Armoury.* In Proceedings of the 1997 MATLAB User Conference, Sydney, 1997. Published on the Internet at:

`http://www.ceanet.com.au/visdyn/adding_generalised_liner_models.htm`

- A. Fuller, P. Cretchley & C. McDonald, *What factors attract students to the study of mathematics and computing at Queensland universities and are there significant gender differences?* Winds of Change Conference, Sydney, July 1998.
- C. Harman, "Who's on First! What? What's on second! And how 'What' got there on an optimal baserunning path." Accepted for publication - Fourth Biennial Conference on Mathematics and Computers in Sport, 1998. `http://www.sci.usq.edu.au/research/workingpapers/sc-mc-9818.ps`
- S. Khan, *Stein-type estimators for multivariate Student-t populations.* 51st Session of the International Statistical Institute (ISI), Istanbul, Turkey, 18-26 August 1997.
- S. Khan, *On improved estimations for some Student-t models.* Department of Computer Sciences, North South University, 12 August 1997.
- S.A. Treloar, C. McDonald and N.G. Martin, *Genetics of early cancer detection behaviours in Australian female twins*, presented at the 28th Annual Meeting of the Behaviour Genetics Association, Stockholm, Sweden, June 1998.
- R.V. Melnik *Steklov's Operator Technique in Coupled Dynamic Thermoelasticity*, the Xth International Conference for Numerical Methods in Thermal Problems, Swansea, UK, July 1997.
- I.P. Gavrilyuk & R.V. Melnik *Constructive approximations of the Convection-Diffusion-Absorption Equation based on the Cayley Transform Technique*, Fourth World Congress on Computational Mechanics, Buenos Aires, Argentina, July 1998.
- R.V. Melnik *A Hierarchy of Hyperbolic Macrodynamic Equations as a Model for Network Training*, IEEE International Symposium on Information Theory, Ulm, Germany, July 1997.
- R.V. Melnik & K.N. Melnik *Numerical Analysis of Hollow Piezoceramic Cylindrical Vibrators Under Nonstationary Conditions*, The 3rd Biennial Engineering Mathematics and Applications Conference, Adelaide, July 1998.
- R.V. Melnik & K.N. Melnik *Modelling of Nonlocal Physical Effects in Semiconductor Plasma Using Quasi-Hydrodynamic Models*, Computational Techniques and Applications Conference, Adelaide, September 1997.
- R.V. Melnik & K.N. Melnik *Simulation of Transient Behaviour of Semiconductor Devices with Quasi-Hydrodynamic Models*, the 34th Applied Mathematics Conference: ANZIAM'98, Coolangatta, February 1998.
- K.N. Melnik & R.V. Melnik *On Computational Aspects of Certain Optimal Digital Signal Processing Algorithms*, Computational Techniques and Applications Conference, Adelaide, September 1997.
- C. Roberts, P. Cretchley & C. Harman, Measuring attitudes towards mathematics in early childhood and primary teacher education. Proceedings of MERGA Conference, 1998.
- W.G. Spunde and P. de Voil, "A Web-interfaced Array-based Mathematics Course" *The Array Processing Language Conference Proceedings*, ItAPL, Rome, 1998.
- W.G. Spunde, "Potential Influences of Computer Notation on Mathematics Teaching", *International Conference on the Teaching of Mathematics*, 1998.
- S.A. Suslov & A.J. Roberts, *Initial Conditions for the Self-Similar Dynamics of Nonlinear Diffusion*, the 34th Applied Mathematics Conference, Coolangatta, February 1998.
- M. Toleman The Best Computers are the Ones You Never See, Open Day Public Lecture, The University of Southern Queensland August 1997.
- C.J.S. Vance, *PGP—Pretty Good Privacy*, CAUUG monthly meeting, Canberra, 1997.
- C.J.S. Vance, *A Plan 9 File Server Supporting PGP Public Key Encryption*, AUUG'97, Brisbane, September 1997.

- Y. Zhang, *A Declustering Algorithm for Minimizing Spatial Join Cost*, The Third Annual International Computing and Combinatics Conference, (COCOON'97), Shanghai, 1997.
- Y. Zhang, *Spatial Database Processing and/or Advanced Transaction Processing* at Chinese University of Hong Kong, City University of Hong Kong, Kyoto University, Kyushu University.

Chapter 4

Recent publications

This chapter lists the research papers written by members of the department for recognised journals and conferences since 1995.

The Department of Mathematics and Computing is also actively involved in the Faculty of Sciences Working Paper Series. These are listed in each staff members' publications as well. A full listing of the current working papers can be found at `http://www.sci.usq.edu.au/cig-bin/wp/research/workingpapers`. From 1998 they are accessible in postscript format.

4.1 R.G. Addie

- R.G. Addie. On Weak Convergence of Long-range Dependent Traffic Processes, accepted for publication in the Journal of Statistical Planning and Inference.
- R.G. Addie, M. Zukerman and T. Neame. Broadband traffic modelling: simple solutions to hard problems, *IEEE Communications Magazine*, August 1998.
- R.G. Addie, M. Zukerman and T.D. Neame. Application of Central Limit Theorem to Communications Networks, *Proceedings of the sixth IFIP workshop on performance evaluation of ATM networks*, July 1998.
- R.G. Addie. On the applicability and utility of Gaussian models for broadband traffic, *Proceedings of the International Conference on ATM*, Colmar, France, June 1998.
- R.G. Addie. On Weak Convergence of Long-range Dependent Traffic Processes, *Faculty of Sciences Working Paper Series, University of Southern Queensland*: SC-MC-9816, June 1998.
- R.G. Addie. On the Applicability and Utility of Gaussian Models for Broad Band Traffic, *Faculty of Sciences Working Paper Series, University of Southern Queensland*: SC-MC-9815, June 1998.
- R.G. Addie, M. Zukerman and T.D. Neame. Application of Central Limit Theorem to Communications Networks, *Faculty of Sciences Working Paper Series, University of Southern Queensland*: SC-MC-9819, June 1998.
- R.G. Addie. Multiplexing Gain in Large Networks of the Future. Submitted to ITC 1997.
- R.G. Addie. Traffic will be more Gaussian in Future. In *Proceedings of the Australian Telecommunication Networks and Applications Conference*. Melbourne, December 1996.
- R.G. Addie and M. Roberts. A Bootstrap Evaluation of the Variation of Rainfall Sample Histograms Estimated from Finite Historical Records. In *Proceedings of the second Australian Conference on Meteorology in Agriculture*, Brisbane, October 1996.
- R.G. Addie. Traffic will be More Gaussian in Future, *Faculty of Sciences Working Paper Series, University of Southern Queensland*: SC-MC-9617, August 1996.
- R.G. Addie, Darren Platt & M. Zukerman. Performance of a P_i Persistent Protocol Subject to Correlated Gaussian Traffic *Proceedings, IEEE Infocom 1996*, San Francisco, USA.
- R.G. Addie, M. Zukerman & T. M. Neame. Performance of a single server queue with

self-similar input, *International Conference on Communication*, Seattle, June 1995.

- R.G. Addie & M. Zukerman. Fractal Traffic: Measurements, Modelling and Performance Evaluation, *Proceedings of IEEE Infocom'95*, Boston, MA, USA, April 1995.

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