Department of
Mathematics and Computing

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Faculty of Sciences

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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 Frictional models of confinement of oil slick with floating barriers

(Strunin)

Confinement of oil spills in the ocean with floating barriers is an important practical problem. Of special interest is an interaction of oil slick with currents. It is necessary to predict conditions under which the oil does not leak under the barrier.

Within existing friction-free models of this phenomenon, it remains unclear whether a solution describing the confined oil slick is stable. By taking into account a friction force between the oil and water it is possible to get a stable model. While the water flow, outside a thin viscous layer, is still well described by a frictionless (potential) theory, the oil slick is essentially balanced by the friction and buoyancy forces.

Mathematically, the model leads to a system of nonlinear coupled integral equations governing a shape of the oil slick for given values of speed of the oncoming current, submerged depth of the barrier and amount of oil.

2.1.2 Scaling in decaying turbulent bursts

(Strunin)

Localized turbulent bursts are typical in wall turbulence and geophysical stratified flows where they play a determining role in transport of tracers (matter, temperature etc). An interesting theoretical and practical question is how strong the burst mixes up the tracers.

One can distinguish the following opposite trends in the burst's development. On one hand, the burst constantly involves surrounding fluid into the turbulent motion. This process acts towards making the fluid more homogeneous. On the other hand, the turbulent energy distributes over larger volumes of space and decays due to a viscous dissipation. These processes act in the opposite direction.

Evolution of the burst and the tracer are described by self-similar laws in the $(\kappa - \epsilon)$ model of

turbulence. Analytical solutions show that the fluid remains substantially nonuniform inside the burst. Of particular interest is to inspect if these solutions are attractors of other solutions originating from various initial conditions.

2.1.3 Principles of low dimensional dynamical modelling and applications to fluid mechanics

(Suslov, Roberts)

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 our current research.

2.1.4 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.

2.1.5 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.

2.1.6 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.

2.1.7 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.

2.1.8 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.

2.1.9 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.

2.1.10 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 Hyperbolic and nonlinear effects in coupled thermoelasticity

(Melnik, Roberts and Strunin)

This research is a development of the project on constructive approximations and mathematical analysis in coupled dynamic thermoelasticity.

The classical theory of thermoelasticity based on a parabolic-type heat equation leads to the physically unrealistic phenomenon of instantaneous heat propagation. This brings about well-known limitations of the classical theory of thermoelasticity when

applied to a number of practically important problems such as those dealing with sudden heat inputs or extremely low temperature regimes. By introducing thermal relaxation times, this difficulty can be overcome. Mathematical modelling with new models of hyperbolic thermoelasticity is the main focus of this project.

We investigate numerically coupling nonlinear and hyperbolic effects in sodium fluorine and bismuth crystals in the range of critical temperatures. By using the Rankine-Hugoniot compatibility conditions, we study the structure of the thermoelastic wave front in the vicinity of hot and cold shocks observed experimentally in these crystals.

The complexity of solving coupled problems of thermoelasticity has often led to different decoupling formulations in multidimensional models of thermoelasticity theory. However, such formulations become unsatisfactory for the problems with high spatial gradients giving rise to significant amount of thermal stresses. Starting with the general 3D model of hyperbolic thermoelasticity and using a computer algebra technique, we develop a low-dimensional model adequately describing coupled thermomechanical processes in materials that are subjected to sharp impulse heating of the surface.

2.2.2 Auto-solitons in various physical systems

(Strunin)

Solitons have been a subject of numerous studies over the last three decades. Upsurge of interest to the solitons was to a large extent motivated by wonderful integrability properties of certain classes of soliton-generating conservative systems. Not less interesting is a different type of solitons, called auto-solitons, which exist in dissipative systems with intrinsic source of energy. Unlike usual solitons the auto-solitons have unique amplitude and speed governed by the dynamical system. Typical system of such type is a combustion front where reaction plays a role of the energy source and heat conductivity plays a role of the dissipation.

We are interested in constructing new models of auto-solitons in connection with various physical systems, for example, unstable combustion fronts in solid-phase compounds and extended elementary particles. Despite being distant in scale and nature these systems may be described within a closely related mathematical models. Shape of spinning combustion fronts and action function corresponding to the elementary particle can be modelled by nonlinear PDEs of a similar structure. An attractive feature of such models is relative simplicity as they consist of a single equation with a minimal number of terms involved. This contrasts cumbersome multi-component models which are frequently characterized by poorly justified extra unknowns and extra coefficients. An interesting question that arises in connection with the proposed models is whether these are able to describe chaotic multi-soliton regimes.

2.2.3 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.

2.2.4 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.

2.2.5 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.

2.2.6 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.

2.2.7 "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.

2.2.8 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.

2.2.9 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.

2.2.10 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.

2.2.11 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.

2.2.12 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.

2.2.13 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.

2.2.14 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.

2.2.15 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.

2.2.16 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 Agent-based Intelligent Information Systems Development

(Z. Zhang)

Intelligent information systems have excelled conventional IS in capability of learning and adaptability to the changing environment. One approach to developing such kind of systems is to integrate artificial intelligence techniques with agent technique. This project aims to:

1. examiner intelligent processing techniques such as fuzzy logic, neural networks and genetic algorithms
2. exploit agent architectures and communication languages
3. develop techniques for the integration of intelligent agents

2.3.2 Risk Management Using Object-Oriented Techniques

(Zhou)

Current software, for example, web server software that is supplied by vendors always declare that their software is secure and provides a security model that implements certain security protocols. These security models have some problems:

- Did not include the analysis of system environment and simply implement certain cryptographic rules
- May not be sure that the server can continue its security operations
- May not be resistant to a determined attack over the Internet or from corporate insiders
- Most of the software is based on applets security models and cannot prevent the network application attack through indirect methods of applet applications
- Cannot balance the load among multiple servers
- Lack of implementing the security analysis of different system functions

The current research is to propose a Target Information Base (TIB) and Risk Information Base (RIB) system, an object-oriented risk analysis and management tool. It addresses a variety of risk information manipulations, including analysis of system Internet environments, system functions, data processing, rule-based analysis and risk calculations. Such a range of manipulations is not fully addressed by any single security model or programming approach. Because of its modular design, the TIB-RIB system can readily be customised to address the specific analytical needs of different system environments. Using object-oriented risk analysis, it would allow improved system security and reducing environmental Internet impact.

2.3.3 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 important 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.

2.3.4 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.

2.3.5 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.

2.3.6 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.

2.3.7 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.

2.3.8 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.

2.3.9 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.

2.3.10 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.

2.3.11 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.

2.3.12 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.

2.3.13 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.

2.3.14 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.

2.3.15 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 Visual Database Processing Over Internet

(Cao, Hou, Zhang)

Visual database processing concerns techniques for display and query processing based on database schema. In networking environments, the global schema or federated schema of networking databases may not be known, as the integration in many cases can not be automated due to the semantic conflicts. So that it is hard to display and view the complete distributed or global structure at any point in time.

We will start with a data model to describe database schema to be visualised, a 3-D visualization model and the mappings between the database schema and the visualization model. Based on these, a graphical user interface will be developed to guide users to formulate their database queries and to refine their queries dynamically.

We will then develop an efficient visual mechanism for schema integration, query formulation and information retrieval over the internet databases. This will provide effective navigational views for the user during their exploration of global or federated schemas and help users quickly gain the understanding of the federated schema. For schema integration, we will adopt object-oriented design techniques and also incorporate user's input to guide the integration.

2.4.2 Database Security and Electronic Commerce

(Zhang, Limthanmaphon)

Information stored in databases is often considered as a valuable and important resource for organisations. Database security, the protection of information from unauthorised disclosure either by direct retrieval or by indirect logical inference, is crucial to organisations. On the other hand, due to the tremendous growth of internet and in particular the WWW, businesses and organisations are restructuring themselves in order to interact with consumers and other organisations in a global online cooperative work and/or electronic commerce environment. This poses great challenges for supporting both database security and cooperative work at the same time, especially in the area of electronic commerce.

In this work, we investigate secure database design based on the security and collaboration requirements in addition to the traditional functional requirements, and develop a transaction processing model to support the workflow in electronic commerce environments.

2.4.3 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.

2.4.4 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.

2.4.5 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.

2.4.6 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.

2.4.7 Database Support for Cooperative Work and Advanced Transaction Processing

(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 with an advanced transaction model, develop its consistency and correctness criteria and then design cooperative concurrency control and synchronization mechanism.

2.5 Parallel and Distributed Computing

2.5.1 Interacting Processes (IP) for Parallel Computing

(Tang)

We started to work on the model of Interacting Processes (IP) for parallel computing in 1998. IP is a distributed programming model for interactive applications based on the concept of multiparty interaction proposed by Nissim Francis and Ira R. Norma. We found that the IP model is extremely

suitable for parallel programming. Work has been done on the suitability of the IP model for parallel programming with several examples. A paper to argue for the IP model for parallel programming will be published and presented at the 12th International Workshop on Languages and Compilers for Parallel Computing (LCPC99).

2.5.2 Algorithm for First-Order Multiparty Interactions

(Tang)

First-order multiparty interaction is one of the key abstractions in the distributed programming model called Interacting Processes (IP). We have worked out a new efficient algorithm for first-order multiparty interaction by taking advantage of multithreading supported by modern operating systems. This algorithm will be used to implement multiparty interactions for Java using a compile-time metaobject protocol (MOP) language called OpenJava.

2.5.3 Programming Model for Parallel and Distributed Computing

(Tang)

Work has been done on a unifying programming model for both parallel and distributed computing. We have been investigating three existing related models: IP model, Actor Model and Adaptive Programming model and are working on our own new model. The implementation of our new model is going to be based on the technique of compile-time metaobject protocols (MOP) and use a MOP language called OpenJava on top of Java.

2.5.4 Distributed Virtual Reality Programming

(Tang)

We are investigating Virtual Reality Modeling Language (VRML 2.0) and trying to use it as a base to build complicated distributed applications such as distributed games, virtual community, etc. The aim of the project is to study and investigate the effectiveness of our new programming model for parallel and distributed computing (see above) and the efficiency of its implementation in a context of real-world distributed 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 Inference

(Khan)

Prediction distribution is the basis of predictive inference. Unlike the common practice of estimating parameters of a model of performing tests of hypotheses regarding the parameters involved, often the aim of a researcher/practitioner is to predict the value of a future response from a given model. The technique of prediction is used in many real world situations as it has a common sense of appeal and simple interpretation. The prediction distribution is the probability distribution of one or more future (unobserved) responses, conditional on a set of observed responses from the same model. The method is useful in both univariate and multivariate problems. Predictive inference is possible for models with independent as well as dependent and correlated responses. Bayesian and other approaches can be adopted for the purpose of predictive inference. Available methods can handle the conventional normal model and non-normal robust models. Application of predictive inference includes problems in areas such as tolerance regions, model selection, process control, optimization, perturbation and many others.

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.

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.

2.7.5 Analysis of the effect of the use of powerful mathematical computing software on undergraduate attitudes towards Mathematics and Learning

(C. Harman, P. Cretchley, N. Ellerton and G. Fogarty)

The influence of introducing MATLAB into first-year mathematics is being analysed. The key factors studied are influences on attitudes and concept development.

2.8 Miscellaneous

2.8.1 Quality monitoring in acute hospitals

(Fahey)

The aim is to develop methods for detecting, reporting and responding to unusual variation in clinical performance between hospitals. The data source used is the NSW medical record front sheet which collects about 120 data items on each of the 1.5 million acute hospital admissions in that state each year. The analysis methods are centred on variation indexes which adjust for chance, 'usual' between hospital variation and confounding variables such as patient condition and patient characteristics. Reporting systems are designed to demonstrate variation in clinically meaningful terms (such as potential dollars saved or potential adverse outcomes averted). Response strategies are being investigated through workshops and collaboration with hospital-based quality practitioners. The research is conducted in collaboration with health services research groups at the University of Newcastle and Queensland University of Technology.

2.8.2 Holistic finite difference approximations

(Roberts)

We aim to develop accurate finite difference approximation to dynamical equations. The analysis is based upon centre manifold theory so we are assured that the finite difference model accurately

models the dynamics and may be constructed systematically. The trick to the application of centre manifold theory is to divide the physical domain into small elements by introducing insulating internal boundaries which are later removed. Burger's equation is used as an example to show how the concepts work in practise. In this example the resulting finite difference models are shown to be significantly more accurate than conventional discretisations, particularly for highly nonlinear dynamics. This centre manifold approach treats the dynamical equations as a whole, not just as the sum of separate terms—it is holistic. The techniques developed here will be used to accurately model the nonlinear evolution of quite general spatio-temporal dynamical systems.

2.8.3 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.

2.8.4 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.

2.8.5 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.

2.8.6 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.

2.8.7 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.

2.8.8 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.

2.9 PhD, Masters and Honours Students

2.9.1 James Sinnamon (Honours Student) – Design and Implementation of Interacting Processes

(Assoc Prof Peiyi Tang)

Interacting Processes (IP) is a high-level distributed programming model.[1]

The project will include:

1. Implementation of Interacting Processes in the Java language.
2. Experimentation with distributed applications in Interacting Processes.

2.9.2 Maurice Danaher (PhD Student) – A knowledge based expert system approach to preliminary structural design

(Supervisor: Dr Wei Lai)

Maurice is researching approaches to the problem of preliminary design. He is particularly interested in the approach of modelling design in a hierarchical manner commencing at the abstract and becoming detailed as the hierarchy is descended. He is developing a system to test this method.

2.9.3 Sagarmay Deb (PhD Student) – Content-Based Image Retrieval in Multimedia Databases with Emphasis on Emergence Index

(Supervisor: Dr Yanchun Zhang)

Based on input given, we study the emergence phenomenon in images of the multimedia databases and retrieve records that match input. Emergence phenomenon involves studying the implicit meaning or hidden shapes lying in an image.

[1] It is described in "Interacting Processes: A multiparty approach to Coordinated Distributed Programming" by Nissim Francez and Ira R. Forman, Addison Wesley 1996

2.9.4 Anne Fuller (PhD Student) – Web-based Multimedia Data Modelling

(Supervisor: Dr Yanchun Zhang)

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.

2.9.5 Jingyou Hou (PhD Student) – Web-Based Data Management

(Supervisor: Dr Yanchun Zhang)

This research project is to build a web-based data integration management system. To do this, we will start with connecting different relational databases by using JDBC and JDBC-ODBC implementation. On the basis of this work, we will use the object-oriented techniques and analysis methods to build the data models for web-based data, from which some common schema at the conceptual level will be built and the user can formulate transactions according to this schema. Then Java programming techniques and related database management methods will be developed to integrate the web-based data to form a web-based data management system. At last we will investigate the efficient algorithms for the web transaction management of the system we built.

The implementation of this research project will set a frame for integrating heretogeneous web-based data sources, which is important for information processing and management on networks. The corresponding data models and transaction management algorithms can be applied to other database management systems.

2.9.6 Zhenquan Li (PhD Student) – Modelling Shallow Turbulent Fluid Dynamics and Thin 3D Fluid Flows

(Supervisor: Prof Tony Roberts)

This dissertation develops the use of centre manifold techniques in the derivation of low-dimensional models of: turbulent long waves on shallow water based on the k-epsilon model of turbulence, similarity solutions of a generalised Burgers equation, and thin 3D fluid flows with inertia on curved substrates. These low-dimensional models provide good predictions for the dynamics in each case.

In collaboration with Mei and Roberts, Zhen has derived a low-dimensional model for the evolution of the water depth, vertically averaged flow velocity and turbulent parameters from the k-epsilon model for turbulence. This new model for the shallow water dynamics of turbulent flow includes interaction between turbulence and long waves and gives a rational alternative to classic models for turbulent environmental flows. Dam break flows are numerically simulated.

Burgers equation is one of the simplest nonlinear partial differential equations—it combines the basic processes of diffusion and nonlinear steepening. In some applications it is appropriate for the diffusion coefficient to be a time-dependent function; this we call a generalised Burgers equation. Using Wayne's and some other transformations, Zhen has derived 1-mode and 2-mode centre manifold models of the generalised Burgers equations for some time dependent coefficients. These similarity solutions of the generalised Burgers equation are calculated easily. The solutions of these models have attractivity and therefore extend existing results.

Zhen has also modelled the 3D flow of a viscous Newtonian fluid upon a curved substrate when the fluid film is thin as occurs in many draining, coating and biological flows. He derived a model of the dynamics of the film, the model being expressed in terms of the film thickness and the mean lateral velocities. The model accurately includes the effects of the curvature of substrate, fluid inertia and a gravitational body force, and may be used to describe

wave-like phenomena in the dynamics of such viscous fluid flows.

2.9.7 Benchaphon Limthanmaphon (PhD Student) - Database Support for Electronic Commerce

(Supervisor: Dr Yanchun Zhang)

Over the past few years, electronic commerce (EC) has emerged as a dramatic new mode of business. The Internet is used as a medium which could eventually support trading activities more efficiently. Early research focused mostly on security and payment mechanisms. Recent interesting projects investigated the use of software agents to improve the capabilities of EC systems. However, there are some major hurdles that are blocking EC, such as missing high-level interoperability of EC applications. This means it lacks ad-hoc collaborations in both of the virtual organisations and the dynamic business-to-business commerces. Furthermore, it lacks automated third party services such as virtual catalogues and electronic brokers. So the key requirements for global EC systems are openness, distributed and interoperable virtual marketplaces, secure and flexible payment mechanisms, and efficient protected mechanisms when information is exchanged over the networks. The essential functionalities that an EC system should provide are: information searching; data integrating from heterogeneous product catalogues; negotiation mechanisms among customers, providers and other third parties; secure payment mechanism and efficiency management of business transactions.

To achieve this level of support, the purpose of this research is to design and develop an open and configurable framework for a global electronic commerce system by using the enabling web technologies, databases, and distributed computing platforms such as CORBA, XML and Java. The expected outcome is the development of an open and flexible architecture and database transactional support for global electronic system. This architecture will serve as a testbase for conducting large scale market experiments.

2.9.8 Jitian Xiao (PhD Student) – On Processing of Spatial and Multimedia Data Processing

(Supervisor: Dr Yanchun Zhang)

Spatial data is involved more and more in multimedia systems since many multimedia applications require spatial information queries. A common feature of spatial data and multimedia data is that they might be very large in size. For example, a typical map in a spatial database contains tens of thousands of polygons (ie, millions of edges) that may need 10–100 Mbyte storage, while a two-hour movie in a multimedia database might be several gigabytes in size. Handling these new data types brings new challenges to traditional database models and structures.

The intersection of spatial data processing (SDP) and multimedia data processing (MMDP) calls for two research efforts. One is the search for efficient methods to retrieve information from very large amounts of data, and the other is the support of new complex data types. In this project, we investigate techniques to support the graphic and logical representation of multimedia data, and develop algorithms to facilitate the information retrieval in spatial and multimedia databases. By utilizing various index techniques and data partitioning strategies, we aim to improve the response time of spatial and multimedia database system.

The objective of this research can be stated as the following four subgoals:

1. to improve the performance in SDP for spatial data sets of small size;
2. to develop multilevel data partitioning approach to partition large amounts of objects into clusters;
3. to develop efficient scheduling techniques for clustered objects; and
4. to propose the uniform method to present different types of multimedia data including spatial and non-spatial data of large sizes.

Based on these, a data processing approach will then be developed to efficiently retrieve information from multimedia databases.

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.

- P. Cretchley & C. McDonald. *Factors influencing the Choice of Tertiary Study in Mathematics and Information Technology and the Exploration of possible Gender Differences (work done with A. Fuller)*, Faculty of Sciences Affirmative Action Grant, 1999 ($2,900).
- 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).
- Y. Zhang, *Parallel Spatial Database Processing*, USQ Incentive Research Grants for 1998 ($12,000) & 1999 ($12,000).
- 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).
- W. Spunde. *Development of a Web-Interfaced Array-Based Mathematics course* National Teaching Development Grant from the Committee for University Teaching and Staff Development (CUTSD) ($50,000).
- 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).
- 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).
- W. Spunde. *Development of computer based modules in introductory calculus and analytic geometry* Quality Enhancement Project Grant from the Open Learning Agency of Australia, 1994-6, ($32,000).
- W. Spunde. *Development of a Computationally Rich Mathematics Instruction Program*, National Teaching Development Grant from the Committee for the Advancement of University Teaching (CAUT), 1993, ($44,816).

3.2 Seminars

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

department include the following.

- 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.
- Yanchun Zhang, Department of Mathematics and Computing, USQ, *Web Data Management*, 3 July 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.
- Chris Harman, Department of Mathematics and Computing, USQ, *"Who's on First!", "What?", "What's on Second!", And How 'What' Got there on an Optimal Baserunning Path*, 10 September 1998.
- Yanchun Zhang, Department of Mathematics and Computing, USQ, *Web Database and Transaction Processing*, 17 September 1998.
- Tony MacKenzie, Department of Mathematics and Computing, USQ, *Water waves over variable depth and the mild-slope equation*, 12 November 1998.
- John Thatcher, Southern Sydney Institute of Technical and Further Education, *Fundamentals of Mathematically Modelling Stellar Atmospheres*, 19 November 1998.
- Ron Addie, Department of Mathematics and Computing, USQ, *Mathematical Modelling in Finland: Performance Formulae for Large Communication Networks*, 10 December 1998.
- Brad Butcher, Department of Mathematics and Computing, USQ, *TABU or not TABU: An approach to vehicle routing*, 15 December 1998.
- Jacek Radajewski, Department of Mathematics and Computing, USQ, *Tera FLOPS on demand with Scalable, Parallel, Beowulf Supercomputer Clusters*, 23 December 1998.
- Paul Howson, The Design Group Queensland, *New Tricks for an Old Publisher - Publishing Web Sites with xml*, 21 January 1999.
- Harsha Sirisena, University of Canterbury, New Zealand, *Dual-Dimensional ABR Control Scheme using Predictive Filtering of Self-Similar Traffic*, 27 January 1999.
- Shafiqur Rahman, Research Fellow, Department of Econometrics and Business Statistics, Monash University, *Transformed Chi-Square Family*, 18 February 1999.
- Pat Lehane, Department of Mathematics and Computing, USQ, *Monitoring System for a Small Refrigeration Plant*, 4 March 1999.
- Peiyi Tang, Department of Mathematics and Computing, USQ, *Parallel Programming with Interacting Processes*, 18 March 1999.
- Maolin Huang, Department of Computer Science & Software Engineering, University of Newcastle, *Online Information Visualization of Huge Data with Animated Interactive*, 25 March 1999.
- Peiyi Tang, Department of Mathematics and Computing, USQ, *On-Demand Coordination of First-Order Multiparty Interactions*, 25 March 1999.
- David Smith, Centre for Statistics in Medicine, Institute of Health Services, Oxford, United Kingdom, *Locally and Bayesian*

Optimal Designs for Binary Dose-Response Models with Various Link Functions, 1 April 1999.

- Bhavika Joshi, Department of Mathematics and Computing, USQ, *Comparative Study of Existing Electronic Payment Systems*, 7 April 1999.
- Andrew Hussey, Software Verification Research Centre, University of Queensland, *Patterns for safer human-computer interfaces*, 8 April 1999.
- Kevin Burrage, Department of Mathematics, University of Queensland, *Numerical Methods for Stochastic Differential Equations Part 1*, 20 April 1999.
- Ron House, Department of Mathematics and Computing, University of Southern Queensland, *Demonstration of the Assess mark and grade program*, 3 June 1999.
- Kevin Burrage, Department of Mathematics, University of Queensland, *Numerical Methods for Stochastic Differential Equations Part 2*, 9 June 1999.
- Jitian Xiao, Department of Mathematics and Computing, University of Southern Queensland, Multilevel Data Partitioning for Spatial Join Processing, 24 June 1999.

3.3 Conferences and Presentations

Mr. P. Fahey was the convenor of the Australasian Association for Quality in Health Care's 1999 Workshop "Quality Monitoring: Theory Meets Practice", conducted at the University of Newcastle on April 16–17, 1999.

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) held at the University of South Australia in Adelaide, November 1998.

Dr. P. Wark chaired a session on Vehicle Routing at the Optimization Days, 1999 conference held at the Centre de recherche sur les transports, Universite de Montreal, Canada, May 1999.

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

- The 1999 International Symposium on Database, Web and Cooperative Systems (DWACOS'99), August 3–4, 1999 in Baden-Baden, Germany.
- The Second International Symposium on Cooperative Database Systems for Advanced Applications (CODAS'99), March 27–28, 1999 Wollongong, Australia.

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

- IFIP 2.6 Working Conference Visual Database Systems–5, May 10–12 2000, Fukuoka, Japan.
- The 11^{th} Australasian Database Conference (ADC 2000) 31 January–2 February 2000, Australian National University, Canberra, Australia.
- The 7^{th} International Conference on Parallel and Distributed Systems (ICPADS'2000), Internet Data Management Track, July, 2000, Iwate, Japan.
- The 11^{th} International Conference on Systems Research Informatics and Cybernetics, August 2–6, 1999 Baden-Baden, Germany.
- The First International Conference on Data Warehousing and Knowledge Discovery (DaWaK'99), August 30–September 1, 1999, Florence, Italy.
- 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.

Dr. Y. Zhang is a guest editor for the following special issues of Journals:

- Guest Editor, Special Issues of International Journal of Cooperative Information Systems, Special Issues on Cooperative Databases and Applications, Vol. 9, No. 2 & 3, World Scientific, 2000.
- Guest Editor, Special Issue of Informatica, International Journal of Computing and Informatics, Vol. 24, No. 1, 2000.

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

- D.V. Strunin & S.-P. Zhu. A simple model for the flow near floating booms, *Proc. of the* 13^{th} *ASCE Engineering Mechanics Division Conference* ASCE, Baltimore, USA, 1999 accepted.
- S.-P. Zhu & D.V. Strunin. Modelling the confinement of spilled oil with floating booms, *The* 35^{th} *Applied Mathematics Conference ANZIAM-99* Australian Mathematical Society, Mollymook, Australia, 1999, 52.
- R.V.N. Melnik, A.J. Roberts & K.A. Thomas. *Modelling Dynamics of Shape-Memory-Alloys via Computer Algebra*, CA, USA, 1999.
- R.V.N. Melnik, A.J. Roberts & K.A. Thomas. *Math-l and Numerical Analysis of Hyperbolic models for Shape Memory Alloys*, International Congress on Industrial and Applied Mathematics, Edinburgh, 1999.
- Y. Zhang. 2nd International Symposium on Cooperative Database Systems for Advanced Applications (CODAS'99), Wollongong, March 1999.
- Y. Zhang. The 1999 International Symposium on Database, Web and Cooperative Systems (DWACOS'99), Baden-Baden, Germany, August 1999.
- J. Cao. *Natural Language Query Optimization and Translation in Chinese Database Systems*, 2nd International Symposium on Cooperative Database Systems for Advanced Applications (CODAS'99), Wollongong, March 1999.
- P. Wark. *Repeated Matching*, Optimization Days 1999, Centre de recherche sur les transports, Universite de Montreal, Canada, May 1999.
- R.V.N. Melnik. ANZIAM'99.
- R.V.N. Melnik. ANZIAM'98.
- S.A. Suslov & A.J. Roberts. *Centre Manifold Modelling of Turbulent Shallow Fluid Flow*, 51^{st} Annual Meeting of the Division of Fluid Dynamics, Philadelphia, PA, USA, November 1998.
- M.A. Toleman. *User Experiences and a Usability Inspection of an Electronic Services Environment for Students*, OCZCHI'98, Adelaide, November 1998.
- S. Paolucci & S.A. Suslov. *Mean Flow Characteristics of non-Boussinesq Mixed Convection Flow*, 51^{st} Annual Meeting of the Division of Fluid Dynamics, Philadelphia, PA, USA, November 1998.
- S.A. Suslov & A.J. Roberts. *Initial Conditions for the Self-Similar Dynamics of Nonlinear Diffusion*, The 34^{th} Applied Mathematics Conference, Coolangatta, Queensland, Australia, February 1998.
- D.V. Strunin & S.-P. Zhu. An experimental study of the confinement of spilled oil by floating booms, *Proc. of the* 3^{rd} *Int. Conference on Hydrodynamics ICHD-98* UIAM Publishers, Seoul, South Korea, 1998, 839–844.
- D.V. Strunin & S.-P. Zhu. A numerical model for the flow near floating booms used to collect spilled oil, *Proc. of the Int. Conference on Hydraulics in Civil Engineering HydraStorm-98* The Inst. of Engineers, Adelaide, Australia, 1998, 141–145.
- 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.
- B. Zhou. *Security Analysis of Using Java Applets over WWW*, International Conference

on Multimedia & Telecommunications Management, Hong Kong, 17-19 December 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. *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.
- 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.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.
- 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 & K.N. Melnik. *Numerical Analysis of Hollow Piezoceramic Cylindrical Vibrators Under Nonstationary Conditions*, The 3rd Biennial Engineering Mathematics and Applications Conference, Adelaide, July 1998.
- 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.

Chapter 4

Recent publications

This chapter lists the research papers written by members of the department for recognised journals and conferences since 1996.

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. Tails of Queues with Stationary Input, *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9907, May 1999.
- M. Fiedler & R.G. Addie. Verification and Application of a Second-Order Scale Symmetry for Queuing Systems, *Proceedings of the 16th International Teletraffic Congress*, UK, Elsevier, June 1999.
- R.G. Addie. P. Mannersalo & I. Norros. Performance Formulae for Queues with Gaussian Input *Proceedings of the 16th International Teletraffic Congress*, UK, Elsevier, June 1999.
- R.G. Addie, M. Zukerman & T.D. Neame. Application of Central Limit Theorem to Communications Networks *Proceedings of the 16th International Teletraffic Congress*, UK, Elsevier, June 1999.
- R.G. Addie. On Weak Convergence of Long-range Dependent Traffic Processes, accepted for publication in the *Journal of Statistical Planning and Inference*, 1999.
- 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. 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.

4.2 L. Brookshaw

- L. Brookshaw. An Equation of State for Serpentine, *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9813, April 1998.
- P. Thomas & L. Brookshaw L. "Organic Survival in Cometary Impacts" Chapter 5 in

Comets and the Origin of Life, (eds. P. Thomas, C. Chyba, and C. McKay) 1997, Springer-Verlag, New York.

4.3 L. Bull

- M. Nooriafshar, R. Temple-Smith and L. Bull. Forecasting Regional Housing Approvals using IV C System. In *Proceedings of the Second Australia-Japan Workshop on Stochastic Models in Engineering, technology and Management*. Gold Coast, July 1996.

4.4 H. Butler

- H.J. Butler, W.L. Hogarth and G.H. McTainsh. A source-based model for describing dust concentrations during wind erosion events: an initial study. *Environmental Software* 11(1-3): 45–52, 1996.

4.5 J. Cao

- X. Meng, S. Wang. X. Jia & J. Cao. Natural Language Query Optimization and Translation in Chinese Database Systems, *Cooperative Databases and Applications '99*, Eds. Y. Zhang, M. Rusinkiewicz and Y. Kambayashi, Proceedings of 2nd International Symposium on Cooperative Database Systems for Advanced Applications (CODAS'99), Wollongong, March 1999.
- C. Liu, X. Zhou, J. Cao & X. Lin. Global Transaction Management in a Cooperative Database System, Database, Web and Cooperative Systems, Vol. 1, *Proceedings of 1st International Symposium on Database, Web and Cooperative Systems (DWACOS'99)*, Baden-Baden, August 1999.
- J. Cao & M.W. Orlowski. Transactions classification and a concurrency control algorithm in a multidatabase system. *Proceedings of the 11th International Symposium on Computer and Information Systems (ISCIS-XI)* Antaly, Turkey, 1996.
- J. Cao & M.W. Orlowski. "On Transaction Recovery in Multidatabase Systems", In *Advances in Database and Expert Systems*, vol III, 1996.

4.6 P. Cretchley

- P. Cretchley, C. Roberts and C. Harman. Measuring Attitudes Towards Mathematics in Early Childhood and Primary Teacher Education, *Proceedings of the Twenty-First Annual Conference of the Mathematics Education Research Group of Australasia*, Gold Coast, July 1998.
- C. Roberts, P. Cretchley & C.J. Harman. Measuring Attitudes Towards Mathematics in Early Childhood and Primary Teacher Education, *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9808, April 1998.
- P. Cretchley. Enhancing Achievement using Technology? Feedback is Effective, *Proceedings: International Conference on the Teaching of Mathematics*, Samos, Greece, July 1998.

4.7 P. de Voil

- W.G. Spunde & P. de Voil. A Web-interfaced Array-based Mathematics Course, *International Conference on APL*, ACM SIGAPL, Rome, 233–237, 1998.

4.8 P. Dunn

- P.K. Dunn. Three Tools for Interactively Visualizing Some Distribution Theory Concepts, *the American Statistician*, Vol. 53. No. 2, May 1999.
- R.D. Connolly, J. Schirmer & P.K. Dunn. "A daily rainfall disaggregation model", *Agricultural and Forest Meteorology* 92 pp 105–117, 1998.
- P.K. Dunn. "Adding Generalised Linear Models to MATLAB's Statistical Armoury". In *Proceeding of the 1997 MATLAB User Conference*, Sydney, 1997. Published on the internet at: `http://www.ceanet.com.au/vis_dyn/adding_generalised_liner_models_.htm`

- P.K. Dunn and G. K. Smyth. "Randomized Quantile Residuals", *The Journal of Computational and Graphical Statistics*, Volume 5, pp 1–10, 1996.

4.9 A. Fuller

- A. Fuller. Web-based Multimedia Data Modelling Requirements, *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9908, May 1999.
- J. Xiao, Y. Fuller and X. Jia. "A Normalised Approach for Class Hierarchy Design in OO Databases", *Proceedings of TOOLS ASIA '97*, Prentice Hall, 1997.
- 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?" *Proceedings of Winds of Change: Women and the Culture of Universities*, Sydney, July 1998.

4.10 C.J. Harman

- C.J. Harman. "Who's on first?" "What?" "What's on second!" and how 'What' got there on an Optimal Baserunning Path. Keynote address. *Proceedings Fourth Biennial Conference on Mathematics and Computers in Sport*, ANZIAM & Bond University, pp217–223. Also *Faculty of Sciences Working Paper Series, University of Southern Queensland* `http://www.sci.usq.edu.au/research/workingpapers/sc-mc-9818.ps`
- C.J. Harman & M. Dorman. "Enriching distance teaching and learning of undergraduate mathematics using videoconferencing and audiographics". *Distance Education*, 19(2), 299–318. Also *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9812, April 1998. `http://www.sci.usq.edu.au/research/workingpapers/sc-mc-9812.ps`
- C.J. Harman, C. Roberts & P. Cretchley. "Measuring attitudes towards mathematics in early childhood and primary teacher education." *Proceedings–1998 MERGA Conference* also *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9808, April 1998. `http://www.sci.usq.edu.au/research/workingpapers/sc-mc-9808.ps`
- C.J. Harman, & N.I. Robinson. Higher order geometric difference operators. *International Journal of Computer Mathematics* Vol. 63, pp 265–274, 1997, Gordon & Breach.
- C.J. Harman, M. Dorman, W. Tan & O. Jegede. Desktop video conferencing technology to enhance teaching and learning in mathematics. Final report - 1997 CAUT National Teaching Development Grant. `http://probus.sci.usq.edu.au/caut/title.html`

4.11 R.T. House

- R.T. House. Attributes: Giving the programmer control over static type checking. *Australian Computer Journal*, Vol. 30, # 1, pp 20–29, 1998.
- R.T. House. Definition of the Programming Language gUd, *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9801, January 1998.
- R.T. House. Spans: Determining Object Lifetime Safety Statically Permits Dangling Pointer Protection and Efficient Garbage Collection, *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9603, June 1996.

4.12 S. Khan

- S. Khan. Shrinkage estimators for the Mean Vector of a Family of Multivariate Student-t Populations, *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9832, November, 1998.
- S. Khan & A.K.Md.E. Saleh. "Comparison of estimators of means based on p-samples from multivariate Student-t population", *Communications in Statistics: Theory & Methods*. **27**,pp 193–210 (1998).

- S. Khan. "On the estimation of the mean vector of Student-t population with uncertain prior information", *Pakistan Journal of Statistics* to appear (1998).
- S. Khan. "Likelihood based inference on the mean vectors of two multivariate Student-t populations", *Far East Journal of Theoretical Statistics*, **1**, pp 77–91 (1997).
- S. Khan. "Marginal likelihood estimation and prediction distribution for some linear models with first-order auto-correlation", *Journal of Statistical Research* **31**, pp 103–116 (1997).
- S. Khan & M.I. Bhatti. "Distribution of equi-correlated future responses for a multiple regression model", *Journal of Applied Mathematics and Computation*, (1997) to appear.
- S. Khan & A.K.Md.E. Saleh. "Shrinkage pre-test estimator of the intercept parameter for a regression model with multivariate Student-t errors", *Biometrical Journal*, **39**, pp 131–147 (1997).
- S. Khan. "Inference on the mean vectors of two multivariate Student-t populations" *Technical Report No. 224*, Department of Mathematical Sciences, King Fahd University of Petroleum and Minerals, Saudi Arabia, (1997).
- S. Khan. "Estimation of mean vector from two multivariate Student-t populations with uncertain prior information", *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9704, October 1997.
- S. Khan. "Estimation of the mean vector of the multivariate Student-t population under uncertain prior information", *Technical Report No. 222*, Department of Mathematical Sciences, King Fahd University of Petroleum and Minerals, Saudi Arabia, (1997).
- S. Khan & A.K.Md.E. Saleh. "Stein-type estimations for the multivariate Student-t population", *Bulletin of the International Statistical Institute: Contriuted Papers*, ISI 50th Session, 18-26 August 1997, Istanbul, pp 177–178.
- S. Khan. "The multilinear model prediction in presence of intraclass correlation" *Journal of Applied Statistical Sciences* **Vol. 4**, pp 83–96 (1996).
- S. Khan. "Predictive inference for the heteroscedastic multiple regression model with a class of spherical error" *The Aligarh Journal of Statistics*, **Vol. 15 & 16**, pp 1–17, (1996).
- S.Khan. "The multilinear model prediction in presence of intraclass correlation", *Journal of Applied Statistical Sciences*, Vol. 4, (1996).
- S. Khan. "Regression based prediction for two-stage survey data with correlation normal error", *Journal of Applied Mathematics and Computation*, to appear (1996).
- S. Khan. Estimating the parameters of two parallel regression lines with suspected equality of slopes, *Faculty of Sciences Working Paper Series, University of Southern Queensland*, SC-MC-9611, June 1996.

4.13 W. Lai

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