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Introduction

The Automated Scheduling, Optimisation and Planning (ASAP) Research Group is one of four research groupings in the School of Computer Science and IT at the University of Nottingham. The School was awarded a grade 5 in the 2001 RAE exercise. Since our last report (2001 – 2002), ASAP has continued to expand. The group currently has 9 members of academic staff (previously 5), 13 postdoctoral research assistants (previously 8) and 34 PhD students (previously 24).

Our research funding has also continued to grow. As in previous years, much of our funding comes from the UK research councils but we have a significant portfolio of research income across a variety of funding sources (see pages 30-34). Since 2003, we have held 35 awards from EPSRC, BBSRC and ESRC which represents a total of £4.5M. This includes an EPSRC Platform award which provides flexible funding to internationally leading groups to enable them to retain key researchers. We have also been successful in obtaining significant EU support, having secured well over €1M. In addition, our industrial research support has seen significant expansion.

This level of industrial support reflects one of our over-riding research goals: to address the complexity and uncertainty that is inherent in a wide variety of real world decision support scenarios. Another main research challenge that the group is addressing is the question of how we can raise the level of generality at which optimisation systems can operate.

We take a broad inter-disciplinary approach to our research. Our core research into underlying search methodologies lies at the interface of Operational Research and Artificial Intelligence and our application areas range across a broad spectrum of academic disciplines and industrial settings.

The ASAP group is pleased to present this overview of our activity during 2003 and 2004. We present a significant amount of work, across a diverse range of applications, which has led to a number of major research achievements. With these achievements in place, and solid scientific foundations laid, we look forward to the exciting and demanding research challenges that lie ahead.
Innovative Decision Support

One of the long term goals of the ASAP group is to bring about a fundamental step change in the impact that decision support systems have on industry, commerce, science and government. Addressing the complexity, uncertainty and dynamic nature of real world problems represents a series of key scientific challenges in the development of intelligent and effective decision support systems. In order to achieve this long term goal, the group draws upon its broad inter-disciplinary experience at the interface of Operational Research and Artificial Intelligence to investigate and explore a wide range of techniques and methodologies.

A brief overview of the approaches and methods that have underpinned the group’s research into decision support methodologies is outlined below. Note that these methods are not developed in isolation and, indeed, most of our decision support methodologies are a hybridisation of two or more of these techniques.

**Heuristics:** A characteristic of the type of problem we address is that the search space is so large that we cannot usually generate the guaranteed best (optimal) solution. Instead, we have to develop heuristics which usually generate good results but offer no guarantees. A heuristic can be thought of as a rule of thumb.

**Simulated Annealing:** Hill Climbing is a very simple heuristic that always takes the best solution it can find until it finds no better solution in its neighbourhood. Its major drawback is that it gets stuck in local optima. Simulated Annealing is, essentially, a hill climbing algorithm that will sometimes accept lower quality solutions in order to escape from local optima.

**Tabu Search:** This approach is similar (in a certain sense) to Simulated Annealing. It is also based upon Hill Climbing and has a mechanism to escape from local optima. The basic approach employs a tabu list where certain moves are prohibited for a certain number of iterations.

**Evolutionary Algorithms:** Genetic Algorithms are motivated by the evolutionary process, in the sense that a population of solutions is maintained and the population evolves according to survival of the fittest. Genetic Programming draws on similar motivation but the population consists of programs rather than solutions. Co-evolution refers to techniques where different entities evolve in a co-operative or competitive environment. A Memetic Algorithm can be thought of as a hybridisation of a population based approach and a local search approach (such as Hill Climbing, Simulated Annealing or Tabu Search). The basic idea is that the local search algorithm is applied to each member of the population before the next generation is produced.
Swarm Optimisation Algorithms: These approaches mimic the way that animals, birds and insects collectively solve tasks. They are characterised by the emergence of group behaviour from simple individual actions. Perhaps the most often seen example of this type of behaviour is the way that birds flock together. Ant Algorithms are a well known example of this type of approach being employed as an optimisation technique. This method draws its inspiration from the way that ants forage for food.

Artificial Immune Systems: These are emerging as another form of biologically inspired computing. They take their inspiration from the natural immune system which protects our bodies from a wide variety of harmful bacteria and viruses. See page 18 for more details.

Variable Neighbourhood Search: Local search methods tend to use the same neighbourhood structure throughout the search process. Variable Neighbourhood Search enables this structure to change as the search progresses.

Hyper-heuristics: This term refers to heuristics to choose heuristics. It should not be confused with the well known term, meta-heuristics, which usually refers to the broad collection of modern methods that include Simulated Annealing, Tabu Search, Evolutionary Algorithms etc). The term hyper-heuristic simply refers to a search of a space of heuristics rather than a space of potential direct solutions to a problem. Most implementations of meta-heuristics operate on such a search space of direct problem solutions, but ASAP is developing meta-heuristics (and other) methods as hyper-heuristics.

Case Based Reasoning: This is an artificial intelligence methodology based on the premise that human reasoning processes are founded on specific experience rather than a set of general guidelines or first principles. In order to utilise past experience, solutions to earlier problem solving situations are memorised as cases. The memorised cases are organised in a case base and utilised for solving new problems. The retrieval of relevant previous cases is crucial to the success of this methodology. The usefulness of previous cases is determined by assessing the similarity of a new problem with the previous cases.

Fuzzy Reasoning: This constitutes a framework for modelling the decision making processes that we all carry out in the presence of many different forms of uncertainty in the real world. Mechanisms have been created for inferencing or reasoning within this framework.

Agent Based Methods: An agent can be thought of as some form of self-contained, autonomous entity capable of making decisions, either alone or in co-operation with other similar agents. Autonomous agents and multi-agent systems have been applied to solve problems in an increasingly wide range of complex applications.

Adaptive learning: This is a broad term which essentially refers to various computational methods that can adapt to the particular circumstances of the problem that they are trying to solve.

Multi-objective Decision Making: These methods enable constraints of a fundamentally different nature to be handled simultaneously and enable the system/user to make an appropriate compromise between them according to the regulations and requirements of the particular problem in hand.
Raising the Level of Generality: A *Platform* for the Future

Our belief is that the next generation of decision support methodology needs to be able to operate at a greater level of generality than is currently possible. The current state of the art tends to employ bespoke tailor-made algorithms (that have had problem specific information hard-coded into them). The development of such problem specific approaches is expensive and resource intensive.

There are, of course, many situations where it is critical to generate the best possible solution. However, in many other real world situations, a company or institution does not require close-to-optimal solutions. On the contrary what is often required are solutions that are "good enough – soon enough – cheap enough." The goal of building a more general methodology that can adapt to specific problem environments and learn about such environments represents one of the most significant research challenges to face the international community.

The ASAP group was awarded a prestigious *Platform* grant (GR/S70197) worth £422,908 by EPSRC in 2003, which is specifically concerned with this demanding research goal. Indeed, much of our work across several grants is seeking to investigate a range of research issues that impact upon this important scientific challenge.

Particular research themes being explored are:

1. **Hyper-heuristics (heuristics to choose heuristics):** The development of systems which can automatically select the right methodology for the particular problem solving environment in hand is one of the major motivations behind research into hyper-heuristics. Building on a major EPSRC award (GR/N36837), ASAP has been instrumental in driving forward the international research agenda in this area.

2. **Genetic Programming:** A recent EPSRC award (EC/C523385/1) is exploring Genetic Programming within a hyper-heuristic framework. The idea is to explore how heuristics can be evolved to suit different problem solving environments.

3. **Self Adaptation:** The group is investigating the development of self-adaptive programs/heuristics that can respond to changing environments and to changing problems.

4. **Knowledge Based Heuristic Selection:** Another exciting and radical research initiative being undertaken is the exploration of case based methodologies for heuristic selection. The group has developed a highly successful system to intelligently select timetabling heuristics under EPSRC grant GR/M95516/01.

Dr Kendall explains the concept of hyper-heuristics
**Timetabling**

The ASAP group has been at the forefront of research into automated educational timetabling for many years and plays a distinguished role in the international timetabling community.

ASAP has been instrumental in organising the international series of conferences on the Practice and Theory of Automated Timetabling (PATAT) and in attracting both researchers and practitioners to exchange their ideas and approaches to various timetabling problems. The 5th PATAT conference was held in Pittsburgh (USA) in August 2004, while the next will take place in Brno (Czech Republic) in August 2006.

The ASAP group played a major role in the foundation of the EURO (European Association of Operational Research Societies) Working group on Automated Timetabling (WATT). WATT now comprises 388 members from 69 countries.

The main aim of our timetabling research is to investigate novel methods for automatically solving various educational timetabling problems. The emphasis is on:

- The use of parameters which are readily apparent to the timetable officer, such as the time which the decision maker is willing to spend on the construction of a timetable and an estimation of the quality of the desired timetable.
- The development of search techniques which can efficiently search over a very large set of neighbourhood solutions.
- The investigation of hyper-heuristics which can intelligently select a low level heuristic to be applied at each step of timetable construction, by using reinforcement learning.
- Multi-criteria approaches to timetabling which can better reflect the preferences of the different groups of people who are affected by timetabling decisions.
- Case-based reasoning approaches to timetabling in which previous experience gained during solving timetabling problems is employed in solving a new problem.
- Fuzzy-sets and other fuzzy based approaches which handle uncertainties that are inherent in timetabling problems, such as assessing the difficulty of scheduling a course/exam, measuring the similarity between two timetabling problems, etc.
- The development of learning mechanisms which aim to improve the performance of knowledge based timetabling systems.
- The exploration of more general approaches to timetabling problems which can be successfully applied to a wide range of problems, thus reducing the time required for the development of a system for a specific instance of the problem, while at the same time offering high quality timetables.
Cutting and Packing

Cutting and packing problems cover a wide variety of industries and include cutting steel rods into certain lengths (a 1D problem), cutting cardboard for packaging (2D), cutting polycarbonate and glass for conservatory roofs (2D), cutting sheet metal for ducting (2D) and container loading (3D).

ASAP have been carrying out research into this type of problem for many years and we currently (end of 2004) have the very best results on all the standard international benchmark problems that have appeared in the literature in 2 dimensional rectangular packing and irregular packing. This represents over 80 benchmark datasets across both broad problem areas.

Two funded projects have recently been successfully completed (“Applying meta-heuristics and hyper-heuristics to stock cutting”: EPSRC CNA 00802329) and (“New Approaches to Produce Efficient Nesting Patterns”: Teaching Company project: TCS 3047). On both these projects we worked with Esprit Automation Ltd, a local engineering company. The results from these projects are being commercially exploited in the steel cutting industry by Esprit. In addition, we have recently established a new spin out company (see page 8) to commercially exploit the results of our work in other industries such as textiles, poly-carbonates and in container packing.

We are continuing to develop innovative heuristic and hybrid approaches to this challenging and industrially relevant problem. We are also undertaking a significant research effort to explore a series of issues surrounding the following unanswered research question: What is the role of a geometric structure (called the No Fit Polygon) in cutting and packing? We have recently secured a major EPSRC award, held jointly with the University of Southampton, to explore this question. The grant is entitled “An Investigation of Cutting/Packing and Planning using Automated Algorithm Selection” (GR/S52414/01).

The project aims to find a robust implementation of an algorithm to generate No Fit Polygons. Such an algorithm would have a major impact on cutting and packing research but, so far, its development has eluded the scientific community. However, the development of such an algorithm would also have applications beyond cutting and packing. For example, there could be major scientific gains to be made in robot obstacle avoidance. This is particularly appropriate for ASAP, given the investment we have just made in this research area (see pages 14-15).
Space Allocation

The ASAP group is at the forefront of the development of search methods for solving space allocation problems. These are large and difficult real-world problems in which the central issue is to design layouts which are able to allocate physical space in the most effective and efficient manner possible. Such problems are faced by managers across many different areas, and the development of advanced decision support technology is crucial to help them find adequate solutions. Examples of these problems are the management of office/teaching space and the design of layouts for the distribution of shelf space in shops.

ASAP has pioneered research into the application of modern search methods for these problems. Indeed, we have developed effective state of the art hybrid meta-heuristic methods to tackle the problem of allocating office space in academic institutions from both the single and the multiple objective perspectives. In addition, we have recently received significant EPSRC funding (£205K - grant GR/T26115/01) to continue our work in this important area. This project collaborates closely with Real Time Solutions Ltd (who market office space management software) and the School of the Built Environment (who will provide crucial input on space planning).

We have another EPSRC award (“An Investigation of Novel Methods for Optimising Shelf Space Allocation”: GR/R60577/01) to address the problem of effectively packing items onto supermarket shelves. This EPSRC funded research is also supported by Tesco. The problem can be thought of as a 3D packing problem, as a generalised knapsack problem or as a shelf space allocation problem.

Solutions to such problems are sometimes called planograms. These are graphical representations that show exactly the way in which products are located on shop shelves. The project has developed highly effective adaptive search techniques (hyper-heuristics) which can automatically deal with different instances of the problem and which can produce high quality planograms across a broad range of problem instances.

Efficient shelf stacking can provide an important competitive edge for companies such as Tesco.
Commercial Spin Outs

As mentioned in the Introduction, one of ASAP’s fundamental research goals is to address the high levels of complexity and uncertainty that are present in many real world problem solving environments. There is, of course, a significant level of algorithmic insight and understanding that can be gained from problem solving models which abstract away from the real world. Such work can offer an important foundation upon which the decision support community can build. However, there is also a major scientific challenge in modelling and solving complex real world problems which has (in the past) not received as much scientific attention as it deserves. The ASAP group’s overall research mission is underpinned by the goal of tackling this major research challenge.

One of the advantages of taking this approach is that our algorithms can often be readily employed in commercial systems. Indeed, the group’s research has directly led to the formation of two spin out companies which exist to market software that is underpinned by the ASAP group’s research achievements.

**eventMap Ltd.**

[Image nanxnan to nanxnan]

http://www.eventmaponline.com

eventMap is actually a spin out from two universities: Nottingham and Queen’s University of Belfast. The company represents a successful commercial collaboration between the two universities. eventMap markets innovative and effective educational timetabling software around the world.

Its systems have been implemented in Australia, France, New Zealand, USA and UK. More details about the group’s timetabling research can be seen on page 5.

**Aptia Solutions Ltd.**

[Image nanxnan to nanxnan]

http://www.aptiasolutions.com

Aptia Solutions is a brand new University of Nottingham spin out company that seeks to exploit the world-leading algorithms we have developed in two and three dimensional cutting and packing. The formation of the company was supported by HEFCE and the East Midlands Development Agency over two start-up grants. As at January 2005, the company has just been formed and we are in the process of formulating and implementing a marketing strategy and a business plan. Indeed, the two grants mentioned above have been awarded to address exactly these tasks.

Novel 3-dimensional packing algorithms
Production Scheduling

ASAP carries out a multi-disciplinary programme of research into production scheduling which attempts to draw together three research themes for solving difficult, uncertain and dynamic real-world scheduling problems: scheduling/rescheduling, fuzzy reasoning and multi-criteria decision making. ASAP has a large EPSRC grant (GR/R95319/01), held jointly with the Control Theory and Applications Centre (Coventry), which is supported by two industrial collaborators: Sherwood Press Ltd. and the Denby Pottery Company.

The main aim of our research is to develop new methodologies for automated production scheduling systems using multiple, usually conflicting scheduling criteria, in the presence of various identified sources and levels of uncertainty. Scheduling problems are modelled as decision analysis problems under uncertainty with the aim of giving scheduling experts a more interactive role than in classical approaches. The identified uncertain parameters and constraints are formalised using fuzzy logic and fuzzy set based techniques and reflect the preferences of the scheduler.

Providing easy to use visual interfaces is vital in industrial applications

A significant challenge in tackling real-world scheduling problems is to identify disruptions that occur on the shop floor (such as the dynamic arrivals of new jobs, machine breakdowns, cancellation of jobs, etc.) and to respond to them by modifying the existing schedule. The evaluation of the modified schedule is based both on measures of schedule performance and on schedule stability.

Within production scheduling we are also investigating printed circuit board assembly. This is the problem of placing electronic components onto a printed circuit board. The overall aim is to minimise the amount of time it takes to place all the components, so as to maximise production throughput. The problem can be modelled as a travelling salesman problem but this only solves part of the problem. Our industrial partner on this project, DIMA ST Systems, has presented us with many of the real-world constraints that impact on the problem. These include moving the robot head more slowly when transporting a large component and aligning the component whilst moving the robot head. We have had success in solving this problem using heuristic and hyper-heuristic based approaches.
Airport Runway Scheduling

The ASAP group is working with National Air Traffic Services Ltd (NATS) to investigate new meta-heuristic approaches to airport runway scheduling. This project is funded by EPSRC and NATS and was awarded through the auspices of the Smith Institute for Industrial Mathematics and Systems Engineering (Faraday Partnership). The project is concerned with airport problems across the UK but is specifically concentrating upon data from Heathrow Airport. The team are interacting closely with staff at Heathrow to ensure that the entire complexity and uncertainty that is inherent in the problem is tackled.

The overall goal is to develop the search methodologies which would underpin a decision support system to aid air traffic controllers in scheduling departing aircraft. The problem is essentially concerned with sequencing aircraft for departure in order to maximise the throughput of the airport and minimise delays. There are a number of constraints which need to be addressed when generating this sequence. For example, the minimum allowed amount of time between departing aircraft is one minute but, if a small aircraft is following a large aircraft, this may have to be increased to two, three or even four minutes. Other factors also affect the amount of time allowed between departing aircraft such as the departure path and the aircraft speed.

The aim is to have as many one minute gaps as possible. However, although the core of the problem is sequencing, it is absolutely essential to incorporate routing methods into the approach. There is no point in producing a high quality sequence of aircraft if it is not physically possible to move the aircraft past each other through the airport’s taxiway system in order to actually realise the sequence. Of course, this routing problem is entirely dependent upon an airport’s taxiway network. Such networks are not only very different at different airports but they are even completely dissimilar on different runways (and on different ends of the same runway) at the same airport.

Innovative hybrid meta-heuristic approaches to the problem are being investigated and one of the core issues is that such approaches need to be able to respond immediately to the constantly changing nature of the problem.

The meta-heuristic methodologies that the team are developing are already producing results, based on historical data from Heathrow, which represent significant improvements over the actual schedules that were produced at the time.
Airline Scheduling

ASAP is working closely with KLM Royal Dutch Airlines (and Air France – since the recent merger of the two companies) to explore a series of challenging research issues concerning the understanding and generation of robust airline schedules.

In a non-robust schedule, certain delays at critical points could lead to an escalating series of significant delays which could affect (in the worst case) the entire fleet. It is easy to generate robust schedules by introducing large amounts of idle aircraft time between flights. Then if a flight is delayed, the airline can simply bring one of the idle aircraft into operation instead of delaying the time of the next scheduled flight. The difficulty here is that idle aircraft are very expensive. So there is a trade-off between robustness and cost.

Of course, it is possible to reduce costs by reducing the robustness of the schedule. However, if this goes too far and the entire fleet is disrupted for a period of time then the incurred costs would be far higher than the savings generated by reducing the robustness. The goal is to provide an ideal balance between cost and robustness which, of course, amounts to a balance between cost and the risk of generating a breakdown in the schedule.

When an aircraft has finished a flight, it is re-fuelled and “turned around” as quickly as possible to be used on another scheduled flight. The term robust in the context of airline scheduling, refers to schedules which have the ability, at one level or another, to absorb the effect of delays to individual aircraft without leading to major knock-on effects to the rest of the schedule.

A simple way to generate robust schedules is to have more aircraft waiting for longer, but this is a costly solution.

The ASAP group is working with our colleagues at KLM and Air France to explore novel ways of measuring and understanding robustness. The goal is then to develop multi-objective decision support and machine learning methodologies for automatically generating robust schedules.
Healthcare Personnel Rostering

Recent years have seen an increased recognition of the importance of developing intelligent decision support systems for personnel scheduling, particularly in healthcare. The need to ensure adequate numbers of personnel with an appropriate skill mix in order to maintain a high standard of healthcare is a critical issue. For nurse scheduling, there is an absolute requirement to maintain 24 hour cover and high quality schedules should take into account resource utilisation, patient care and the preferences of personnel. The development of automated methods which can handle the wide variety of requirements that are generated by real world problems is a particularly challenging research issue.

The ASAP group has been awarded a number of research grants (GR/N35205/01, GR/S31150/01 and GR/R92899/01-02) in this area. These grants are investigating Case-Based Reasoning, Bayesian Modelling and Optimisation and other novel meta-heuristic approaches for the scheduling of doctors and nurses, and of clinics. These projects involve a number of UK and internationally leading research / commercial collaborators which include:

- The Intelligent Systems group from KaHo St.-Lieven (Belgium) who have carried out research into nurse rostering together with ASAP for several years;
- ORTEC, a consultancy company from The Netherlands that has commercial interest in healthcare administration;
- GOAL (UK), a software development company that produces optimisation/scheduling systems;
- The Queen’s Medical Centre, Nottingham;
- Beaumont hospital, Dublin; and
- The School of Nursing from the University of Nottingham.

Innovative 3D representations may aid in developing and visualising algorithms

Our research work on hybrid tabu search with KaHo St.-Lieven has provided the basis of a commercial package Plane which has been deployed in more than 40 hospitals in Belgium.

The overall aim of our research in this area is to investigate and develop new methodologies to tackle real world rostering problems. One particularly important aim is to increase the generality of the current state of the art and to facilitate the development of flexible systems which will be capable of solving a range of personnel scheduling problems with differing requirements and constraints.

Jingpeng Li (Research Associate) is exploring healthcare personnel rostering based on various probabilistic and adaptive learning techniques.
Radiotherapy Planning and Scheduling

Radiotherapy represents a significant part of the treatment for a large number of cancer patients. Radiotherapy planning and scheduling has been specifically targeted as a priority area by Government health authorities in recent years and, in conjunction with this, the Government has made a large investment in radiotherapy equipment. For example, 226 mammography machines, 46 ultrasound units, 33 MRI scanners, and 56 linear accelerators have been purchased since 1999. This equipment is very expensive and significant staff expertise is required to use it. In order to realise the major potential benefits of this investment, it is essential that these resources are used efficiently with the ultimate goal being to treat as many patients, to as high a standard of effectiveness, as possible.

ASAP, together with Coventry University, has recently been awarded a major EPSRC grant (worth £265,486 and £210,909, respectively) to address this problem. Two large hospital trusts (Nottingham City Hospital NHS Trust and University Hospitals Coventry and Warwickshire NHS Trust) are acting as collaborators on this project. The number of patients being referred for radiotherapy treatment in these hospitals (and also in other oncology departments throughout the UK) is increasing and, with the need to carry out more complex procedures, there is an increase in the time required to perform such tasks.

As a consequence, the problem of efficient radiotherapy planning and resource management, in terms of both manpower and the availability of equipment, is the key to the smooth running of a radiotherapy clinic. The aim of our research is to cut waiting times from referral to diagnosis and diagnosis to treatment through effective resource utilisation.

Two of the main objectives of this project are:

• To develop an intelligent decision support system to aid in the generation of the treatment plan for each patient. We will investigate the possibilities of using past therapy cases for planning the treatment of a new patient.

• To develop new scheduling models for radiotherapy treatments to deal with multiple resource types that are involved, namely machines (such as simulators and linear accelerators), and personnel (such as consultants, radiographers, medical physicists, nurses, technicians, etc.). The models should enable the dynamic scheduling/rescheduling of patients as a response to the changing environment in the clinic and to the clinical conditions of a patient.
Co-operative and Collaborative Decision Support

Humans often make decisions by taking into account a range of views, or tackle complex tasks by subdividing them into smaller, easier tasks which can be achieved individually in order to benefit the group as a whole. It has been a long standing problem in artificial intelligence research to try to get computers to simulate such co-operative and collaborative decision making, which is characterised by inherent imprecision and uncertainty. One of ASAP’s overriding research strategies is to investigate approximate decision making methodologies in order to inspire robust and effective solutions to difficult, real-world problems.

As part of an ongoing investment in e-science infrastructure, the ASAP group has secured £280K of SRIF2 funding in order to establish an experimental research facility in which such problems can be studied. This funding has provided the group with three main robotic environments:

1. A co-operative environment based around developing team strategies for robot football;
2. A generic resource for investigating distributed decision making based around a large number of small, independent robots; and
3. A group of high-powered robots for collaborative decision making.

In the robot football environment, two five-a-side teams test their collective strategies by competing against each other in an arena of fixed size. The robots have no autonomous sensing capabilities – their positions (and that of the ball and the opposition) are captured by fixed overhead cameras connected to a central computer, one per team. Each computer analyses the current position of all robots and the ball and issues commands to its team via Bluetooth.

A general purpose arena provides the facilities to undertake investigations into, for example, emergent swarming behaviour.

The pitch size, robot sizes and configurations, and camera and lighting conditions are all fixed in order to comply with international competition standards. National, European and International championships are held regularly in order to allow researchers to compare their strategies. Robot football represents a truly demanding environment in which to investigate adaptive, co-operative decision making in a competitive real-time environment. Important aspects of any solution include effectiveness, robustness (how the strategy behaves when dealing with similar scenario conditions), scalability and fault-tolerance (how the strategy behaves in the presence of faults in one or more robots). A project funded by EPSRC and Merlin Systems Corp. Ltd, awarded through the Smith Institute, is currently investigating these issues.

Robot football represents a challenging and competitive research environment in which individual robots must act co-operatively, as part of a team, in order to win.
Merlin Systems Corporation Ltd. are working closely with ASAP to create a bespoke research facility featuring the very latest robotic hardware and software.

The second infrastructure, based around the same Miabot Pro robot chassis, provides more freedom for advanced research as it is not constrained by the strict rules of the robot football competitions. In a rolling implementation due to be completed by the end of 2005, the ASAP group is working closely with Merlin Systems to design a bespoke research facility that will provide a wide range of scenarios to be investigated, including:

- **Swarm behaviour**: 32 robots will enable physical realisations of swarm optimisation to be studied.
- **Task allocation**: how to co-ordinate a team of robots with differing hardware characteristics in order to achieve a global objective.
- **Communication and negotiation**: how to balance local needs with global requirements.

The third infrastructure (supplied by ActivMedia Robotics) consists of a Pioneer ‘PeopleBot’ and five Pioneer DX3 robots, fitted with a variety of sonar, laser range-finders, cameras, grippers and manipulators. All feature a full PC motherboard capable of running the latest Linux or Windows operating systems and high-speed wireless Ethernet communications. Each robot has a rich selection of sensors to permit accurate localisation under a variety of external environmental conditions, together with the ability to manipulate the environment. In conjunction with the general purpose Miabot Pros, this infrastructure will permit the exciting possibility of linking high performance computing (accessible via the Grid) with the limited local resources of the individual robots in order to solve extremely complex task scenarios.

The Pioneer robots have significantly more on-board processing power and advanced sensors and actuators to permit complex tasks to be carried out.
Bioinformatics

The ASAP group is exploiting exciting multi-disciplinary synergies with the School of Chemistry, the Centre of Biomolecular Sciences, the School of Life Sciences, and others at the University of Nottingham in a range of bioinformatics research problems. All these collaborations are performed under the umbrella of the Inter-disciplinary Optimisation Laboratory.

ASAP is working closely with Prof. Jonathan Hirst – in the School of Chemistry – and the Computational Chemistry Research Group to investigate novel meta-heuristic and hybrid approaches to solve protein folding problems.

Folding a protein sequence to its three-dimensional structure, from first principles, is one of the most difficult research challenges currently facing bioinformatics. We are carrying out a far reaching investigation into the modelling of this demanding problem and exploring how meta-heuristics can be developed and employed to produce high quality solutions. We aim to develop methods to map real proteins onto the models and to apply and evaluate the developed strategies in the real world. This work is currently being funded by BBSRC and EPSRC under the Bioinformatics initiative (42/BIO14458).

As the large majority of applications of protein structure prediction impact into the quality of human life, it is important to have not only robust predictions, but also understandable predictions. To this aim, our grant “Robust Prediction with Explanatory Power for Protein Structure and Related Prediction Problems (GR/T07534/01)” seeks to instil explanatory power to ab initio (‘from scratch’) predictions of a protein’s native state.

In parallel to our research efforts in protein structure prediction, we have a complementary research thread on protein structure comparison. Although it may at first seem easier to compare two (or more) proteins than predicting a native state, current models for protein structure comparison are, in many cases, computationally intractable. At the same time, comparing the structure of various proteins lies at the heart of many pharmaceutical endeavours, hence providing effective solutions to this problem is both timely and challenging. Our BBSRC grant “Automated Grid-Aware, Three-tier, Protocol for Protein Structure Comparison” (BB/C511764/1) seeks to synergistically integrate our work in protein structure comparison and prediction with user friendly sophisticated interfaces.
ASAP and the School of Chemistry are also exploring ways of exploiting recent advances in meta-heuristic technology for parallel synthesis (the automated production of collections of chemical compounds). Meta-heuristic and hybrid optimisation techniques could lead to more efficient approaches for the discovery of new catalysts.

ASAP members also collaborate with The Pseudomonas Quorum Sensing Group, located within the Institute of Infection Immunity and Inflammation in the School of Pharmacy, at the Centre for Biomolecular Sciences. We are investigating the systems biology of Pseudomonas Aeruginosa. This pathogen is a very versatile organism that can adapt to many different environments and can cause diseases in plants, animals and humans. In particular, we are trying to integrate quorum sensing data – genomics, proteomics and metabolomics – into a unified systems biology framework for P. Aeruginosa.

Further bioinformatics research is being carried out within the EU funded (€6.4M) BIOPATTERN Network of Excellence (see page 20). Currently focussing on the causes and early diagnosis of Alzheimer’s disease, we are investigating the optimisation of molecular models of protein aggregation in conjunction with the School of Chemistry, and decision support systems for the analysis of single nucleotide polymorphisms (SNPs) to identify genetic factors that influence susceptibility to Alzheimer’s disease in conjunction with the Division of Clinical Chemistry.

The aim of BIOPTRAIN, an EU funded (€2M) early stage training network (see also page 20), is to establish a permanent European multi-centre interdisciplinary research training programme in bioinformatics optimisation algorithms. This programme involves cutting-edge research spanning areas such as:

- Theoretical and high performance bioinformatics search algorithms;
- Protein structure and folding optimisation algorithms;
- Sequence analysis / high throughput genotyping algorithms;
- Gene expression data mining; and
- Machine learning, statistical methods and data visualisation.

Molecular modelling techniques are being used to predict the aggregation of short fragments of proteins.
Artificial Immune Systems

The central challenge in computer security is determining the difference between normal and potentially harmful activity. For half a century, developers have protected their systems using rules that identify and block specific events. However, the nature of current and future threats in conjunction with ever larger IT systems urgently requires the development of automated and adaptive defensive tools.

A promising solution is emerging in the form of biologically inspired computing, and in particular Artificial Immune Systems (AIS). The natural immune system can detect and defend against harmful and previously unseen invaders, so can we not build a similar system for our computers? Perhaps such systems would then have the same beneficial properties as the natural immune system such as error tolerance, adaptation and self-monitoring.

The natural immune system protects against damage from an extremely large number of harmful bacteria and viruses, termed pathogens. It does this largely without prior knowledge of the structure of these pathogens. This property, along with the distributed, self-organised and lightweight nature of the mechanisms by which it achieves this protection, has in recent years made it the focus of increased interest within the computer science and intrusion detection communities. Seen from such a perspective, the natural immune system can be viewed as a form of anomaly detector with very low false positive and false negative rates.

An increasing amount of work is being carried out which attempts to understand and extract the key mechanisms through which the natural immune system is able to achieve its detection and protection capabilities. Here in Nottingham, we are currently exploring these issues funded by the largest EPSRC adventure grant (£657K) awarded under this prestigious scheme (GR/S47809/01). We are also actively involved at all levels with the UK wide Artificial Immune Systems Network funded by EPSRC (GR/S56627/01).
Grid Scheduling

The ‘Grid’ is the name given to the vision of the next stage in collaborative computing following the Internet and World Wide Web. In essence, the Grid consists of various digital resources connected together on the Internet in order to provide remote services. In its widest sense the Grid includes, for example, remote access to supercomputers and the creation of powerful distributed computers by linking together ordinary PCs, or remote data storage facilities through shared hard disks, and the Grid concept even extends to other scientific resources such as particle accelerators, telescopes or the Antarctic research stations.

However, although there are plenty of examples of limited cases of the Grid that are already functional, the full ‘grand vision’ is far from realisation. There are many challenging research issues that remain to be overcome before a fundamental objective, that users may submit jobs to the Grid and have them processed without knowledge of the underlying infrastructure, can be achieved. One of these research challenges is to tackle the difficult problem of efficiently scheduling Grid resources.

ASAP is addressing this problem, in collaboration with researchers from the University of Manchester, through an EPSRC funded project entitled Service Level Based Agreements for Grid Scheduling (GR/S67661/01).

In moving away from traditional and very simple approaches based on concepts such as ‘first-come, first-served’ and block booking of fixed timeslots, we are investigating the incorporation of advanced scheduling mechanisms within each local scheduler. These novel mechanisms will allow service level agreements (SLAs), a type of two-way contract between the user (requiring resources) and the service provider (providing resources), to be negotiated in a flexible manner, in order to satisfy both the users’ needs for the job to be completed by a certain time and the providers’ wishes to achieve the maximum possible resource utilisation.

Furthermore, the SLA framework can be extended to deal with the financial aspects of such contracts and SLA renegotiation in response to inevitable resource failures or the arrival of more important (costly) contracts.

Advanced scheduling algorithms will permit job requests to be negotiated and renegotiated despite the inherent uncertainties in the Grid environment.
European Collaborations

In addition to our numerous national and international links, the ASAP group has a wide range of links to other groups and individual scientists across the European Union (EU). We were active in the Fifth Framework Programme (FP5), are playing a leading role in several Sixth Framework (FP6) projects and are already anticipating the forthcoming FP7.

ASAP was a key node in the FP5 European Network for Intelligent Technologies (EUNITE), leading the Smart Adaptive Systems – Research Theory and Development committee, whose remit included contributing to an EU roadmap document outlining important future research issues in adaptive decision support.

This research includes investigations into protein aggregation (believed to be implicated somehow in the disease onset) and complex analysis of potential genetic markers, in collaboration with our colleagues in Computational Chemistry, the Queens Medical Centre and other European partners.

ASAP is also leading the €2M BIOPTRAIN FP6 project to establish an interdisciplinary postgraduate training programme in advanced optimisation algorithms for the analysis of bioinformatics problems. The five partner institutions collaborating in this ground-breaking initiative are:
- University of Nottingham, UK
- Katholieke Universiteit Leuven, Belgium
- Poznan University of Technology, Poland
- University of Firenze, Italy
- Borås Technical University, Sweden

Other formal links within the EU include EPSRC funded Visiting Fellowships to promote interactions with leading European scientists such as Prof. Peter Brucker (Germany) and Prof. Jacek Blazewicz (Poland), ASAP’s membership of the FP6 Nature Inspired Smart Information Systems (NiSIS) Co-ordinated Action, and the group’s major role in the foundation of the EURO Working group on Automated Timetabling (see page 5).

The first Biopattern Steering Committee meeting held on Lake Maggiore, Italy

Visiting the Commission in Brussels

The €6.4M BIOPATTERN FP6 Network of Excellence brings together 31 academic and industrial partners around the EU to investigate novel decision support in healthcare, with particular focus on diagnosis, prognosis and treatments for cancer and brain diseases. Within this Network, ASAP leads the Bioinformatics Special Interest Group, integrating post-genomic technologies with conventional medical indicators. As part of this, we are carrying out fundamental research into decision support methods to allow the early detection of Alzheimer’s disease.
The Inter-Disciplinary Optimisation Laboratory

The *Inter-disciplinary Optimisation Laboratory* is a leading research centre that was established in 2000 on the Jubilee Campus at the University of Nottingham. The laboratory is directed by Prof. Burke and the central focus is to support multi-disciplinary decision support research not only within the UK, but also in the international arena. We have been successful in establishing collaborative links with researchers from a wide range of disciplines. Current projects range across Chemistry, Environmental Engineering, Biology, Nursing, Clinical Sciences, Operational Research, Mathematics, the Built Environment, Life Sciences, Pharmacy, and Clinical Chemistry.

The Inter-disciplinary Optimisation Laboratory has received external funding for a number of inter-disciplinary projects. At present, projects carried out within the laboratory represent external funding of over £2.5M. The main externally funded projects that are being carried out within the laboratory are:

- Adaptive Multi-objective Heuristic and Meta-heuristic Approaches to Space Allocation – EPSRC grant GR/T26115/01.
- Robust Prediction with Explanatory Power for Protein Structure and Related Prediction Problems – EPSRC grant GR/T07534/01.
- Danger Theory: The Missing Link Between Artificial Immune Systems and Intrusion Detection – EPSRC grant GR/S47809/01.
- Hybrid Meta-heuristic Optimisation of Chiral Catalysts – EPSRC grant GR/S75765/01.
- Novel Approaches to Radiotherapy Planning and Scheduling in the NHS – EPSRC grant EP/C549511/1.
- BIOPTRAIN – Bioinformatics Optimisation Training – EU grant FP6-007597.
- BIOPATTERN FP6 Network of Excellence – EU grant FP6-508803.
- Hybrid Metaheuristics for Sequence Structure Function Problems – BBSRC/EPSRC grant 42/BIO14458.

Recently, we have been awarded Visiting Fellowships from the EPSRC to support inter-disciplinary research collaboration between ASAP and leading scientists including:

- Prof. Moshe Dror, from the University of Arizona, USA.
- Prof. Jacek Blazewicz, from the Poznan Institute of Technology in Poland.
- Prof. Amnon Meisels, from the Ben-Gurion University in Israel.
- Prof. Peter Brucker, from the University of Osnabrück in Germany.
Publications

Journals (Editorships / Associate Editorships / Guest Editorships)

- U. Aickelin: Associate Editor of the IEEE Transactions on Evolutionary Computation.
- E.K. Burke: Editor-in-Chief of The Journal of Scheduling.
- E.K. Burke: Area Editor (for Combinatorial Optimisation) of The Journal of Heuristics.
- E.K. Burke: Associate Editor of the INFORMS Journal on Computing.
- E.K. Burke: Associate Editor of the IEEE Transactions on Evolutionary Computation.
- J.M. Garibaldi: Guest Co-editor of a forthcoming special issue of IEEE Transactions on Fuzzy Sets on “Extensions to Type-1 Fuzzy Logic”.
- G. Kendall: Member of the editorial board of the International Journal of Systems Science.
- G. Kendall: Associate editor of INFOR, the journal of the Canadian Operational Research Society.
- N. Krasnogor: Member of the editorial board of the International Journal of Computational Intelligence.
- N. Krasnogor: Guest Co-editor of a special issue of Evolutionary Computation on “Memetic Algorithms”.
- N. Krasnogor: Guest Co-editor of a special issue of Fuzzy Sets and Systems on “Bioinformatics”.
- S. Petrovic: Member of the Editorial Board of the Yugoslav Journal of Operations Research.

Books


• G. Kendall and S. Lucas (editors) *Proceedings of IEEE Symposium on Computational Intelligence and Games*, Essex, UK, 4-6 April 2005.


**Book Chapters**


**PhD Theses**


Journal Papers

In Press and To Appear


2004


2003

Selected Refereed Conference Papers

In Press and To Appear


2004


2003


External Research Awards

An Investigation of the Role of Genetic Programming in a Hyper-Heuristic Framework (£227,672 to Nottingham from EPSRC; £246,984 to Essex from EPSRC; £15,000 from BT Group PLC)

Funding Body: EPSRC (EC/C523385/1)
Principal Investigator (Nottingham): E.K.Burke
Principal Investigator (Essex): R.Poli
Co-Investigators: G.Kendall, N.Krasnogor and E.Tsang
Collaborators: BT Group PLC
Start Date: 1st Oct 2005
Duration: 3 years
Notes: Joint with the University of Essex

Novel Approaches to Radiotherapy Planning and Scheduling in the NHS (£265,486 to Nottingham from EPSRC; £210,909 to Coventry from EPSRC; £70,000 from Nottingham NHS Trust; £25,000 from Coventry and Warwickshire NHS Trust)

Funding Body: EPSRC (EP/C549511/1)
Principal Investigator (Nottingham): S.Petrovic
Principal Investigator (Coventry): C.Reeves
Co-Investigators: E.K.Burke, J.M.Garibaldi, D.Petrovic, O.Haas
Collaborators: Nottingham City Hospital NHS Trust and University Hospitals Coventry and Warwickshire NHS Trust
Awarded: May 2005
Duration: 4 years
Notes: Joint with the University of Essex

BIOPTRAIN – Bioinformatics Optimisation Training Marie-Curie Early Stage Training (Approx. £580,000 to Nottingham)

Funding Body: EU (FP6-007597)
Co-Ordinator: J.M.Garibaldi
Co-Investigators (Nottingham): E.K.Burke, J.D.Hirst and N.Krasnogor
Start Date: 1st Sep 2005
Duration: 4 years
Notes: Joint with 4 other European institutions to support 12 PhD students, worth a total of over £2M

Robust Prediction with Explanatory Power for Protein Structure and Related Prediction Problems (£209,589)

Funding Body: EPSRC (GR/T07534/01)
Principal Investigator: N.Krasnogor
Co-Investigators: E.K.Burke and J.D.Hirst
Start Date: 1st Feb 2005
Duration: 3 years
Notes: Joint with the School of Chemistry

IDEAS Factory – Chemical Craftwork: Evolvable CHELLware (£77,658)

Funding Body: EPSRC (EP/D021847/1)
Principal Investigator: N.Krasnogor
Recognised Researcher: S.Gustafson
Start Date: 1st Oct 2005
Duration: 3 years
Notes: An IDEAS Factory project joint with the Universities of Edinburgh, Glasgow, Imperial College London, Leeds, Manchester, Oxford and Southampton

ASAP has held or secured over £6.5M of external funding since 2003 – this chart shows the split by funding source
Danger Theory: The Missing Link between Artificial Immune Systems and Intrusion Detection (£657,407 from EPSRC; £15,000 from HP Labs; £18,000 from ECSC / Tedesco)
Funding Body: EPSRC (GR/S47809/01)
Principal Investigator: U.Aickelin
Co-Investigators: J.McLeod, P.Treleaven
Collaborators: Hewlett Packard Labs, ECSC / Tedesco
Start Date: 5th Jan 2004
Duration: 3 years
Notes: Largest EPSRC Adventure Fund grant

Adaptive Multi-Objective Heuristic and Meta-Heuristic Approaches to Space Allocation (£205,378 from EPSRC; £112,500 from Real Time Solutions Ltd)
Funding Body: EPSRC (GR/T26115/01)
Principal Investigator: E.K.Burke
Co-Investigators: G.Kendall, B.Medjoub and J.D.Landa Silva
Collaborators: Real Time Solutions Ltd
Start Date: 1st Apr 2005
Duration: 4 years
Notes: Funded under EPSRC’s Mathematics for Business initiative

The Commercialisation of Internationally Leading Cutting and Packing Technologies (£6,000)
Funding Body: Nottingham Innovation and Regional Award (NIRA)
Principal Investigator: E.K.Burke
Co-Investigators: G.Kendall, P.H.Ford
Start Date: 1st Apr 2004
Duration: 1½ years
Notes: Supporting the spin-off of Aptia Solutions Ltd

Decision Support for the Textile and Leather Industries - A HEROBC Innovation and Regional Fellowship (£12,330)
Funding Body: HEFCE and East Midlands Development Agency (EMDA)
Principal Investigator: E.K.Burke
Co-Investigators: G.Kendall, P.H.Ford
Start Date: 1st Apr 2004
Duration: 1½ years
Notes: Supporting the commercialisation of cutting & packing research in the leather/textile industries (in conjunction with the above award)

Automated Grid-Aware, Three-Tier Protocol for Protein Structure Comparison (£66,314)
Funding Body: BBSRC (BB/C511764/1)
Principal Investigator: N.Krasnogor
Co-Investigators: E.K.Burke, J.D.Hirst, J.M.Garibaldi, H.Ashman, T.Brailsford
Start Date: 1st Feb 2005
Duration: 1½ years
Notes: Joint with the School of Chemistry

The Role of Management Practices in Closing the Productivity Gap – A Closing the Gap. Crossing the Levels IDEAS Factory Project (£118,936)
Funding Body: EPSRC (EP/D503949/1)
Principal Investigator: U.Aickelin
Start Date: 1st Oct 2005
Duration: 2½ years
Notes: An IDEAS Factory project joint with University of Cambridge, University of Sheffield and Aston University

SRIF2: Infrastructure for Collaborative Decision Making in Uncertain Environments (£280,000)
Funding Body: SRIF2
Principal Investigator: J.M.Garibaldi
Co-Investigator: E.K.Burke, G.Kendall
Start Date: 1st Oct 2004
Duration: 4 years
Notes: Part of a larger award for Ubiquitous eScience and Grid Infrastructure worth a total of £2.3M

Collaborative Decision Making in Uncertain Environments (£40,000 from EPSRC; £21,000 from Merlin Systems Corp Ltd)
Funding Body: EPSRC through the Smith Institute (Faraday Partnership)
Principal Investigator: J.M.Garibaldi
Co-Investigators: E.K.Burke
Collaborators: Merlin Systems Corp Ltd
Start Date: 1st Oct 2004
Duration: 3 years
Notes: A CASE studentship

Symposium on Computational Intelligence in Games (£3,880)
Funding Body: EPSRC (EP/C546024/1)
Principal Investigator: G.Kendall
Co-Investigator: S Lucas
Start Date: 1st Apr 2005
Duration: 1 year
Notes: Joint with the University of Essex
External Research Awards (Continued)

Models and Algorithms for Complex Scheduling Problems: A Visiting Fellowship (£21,240)

- **Funding Body:** EPSRC (GR/T23374/01)
- **Principal Investigator:** E.K.Burke
- **Co-Investigators:** J.M.Garibaldi
- **Start Date:** 1st Oct 2004
- **Duration:** 5 years
- **Notes:** Supporting a visiting fellowship for Prof. Peter Brucker, Osnaburk.

BIOPATTERN FP6 Network of Excellence (Approx. £220,000 to Nottingham)

- **Funding Body:** EU (FP6-508803)
- **Lead Researcher (Nottingham):** J.M.Garibaldi
- **Co-Investigators (Nottingham):** E.K.Burke, J.D.Hirst and N.Krasnogor
- **Start Date:** 1st Jan 2004
- **Duration:** 4 years
- **Notes:** The Network was awarded €6.4 million to a consortium of 31 partners

Prisoners Dilemma Competition: Celebrating the 20th Anniversary (£11,848 to Nottingham, £11,870 to Birmingham)

- **Funding Body:** EPSRC (GR/S63465/01)
- **Principal Investigator (Nottingham):** G.Kendall
- **Principal Investigator (Birmingham):** X.Yao
- **Start Date:** 1st Apr 2004
- **Duration:** ½ years

Hybrid Meta-heuristic Optimisation of Chiral Catalysts (£220,227)

- **Funding Body:** EPSRC (GR/S75765/01)
- **Principal Investigator:** J.D.Hirst
- **Co-Investigators:** E.K.Burke, B.Lygo
- **Recognised Researcher:** J.L.Melville
- **Start Date:** 1st Apr 2004
- **Duration:** 3 years
- **Notes:** Joint with the School of Chemistry

DNA Mapping by Combinatorial Optimisation – A Visiting Fellowship (£10,224)

- **Funding Body:** EPSRC (GR/S64530/01)
- **Amount Awarded:** £10,224
- **Principal Investigator:** E.K.Burke
- **Co-Investigators:** J.D.Hirst, G.Kendall, N.Krasnogor
- **Start Date:** 1st Sep 2003
- **Duration:** 5 years
- **Notes:** Supporting a visiting fellowship for Prof. Jacek Blazewicz, Poznan

Service Level Agreement Based Scheduling Heuristics (£141,492 to Nottingham, £202,916 to Manchester)

- **Funding Body:** EPSRC (GR/S67661/01)
- **Principal Investigator (Nottingham):** J.M.Garibaldi
- **Principal Investigator (Manchester):** R.Sakellariou
- **Co-Investigators:** E.K.Burke, S.Petrovic, T.A.Rodden, W.T.Hewitt, J.MacLaren
- **Start Date:** 1st Feb 2004
- **Duration:** 3 years
- **Notes:** Funded under the Fundamental Computer Science for e-Science call

PLATFORM: Towards More General Optimisation/Search Systems (£422,908)

- **Funding Body:** EPSRC (GR/S70197/01)
- **Principal Investigator:** E.K.Burke
- **Co-Investigators:** S.Petrovic, G.Kendall, J.M.Garibaldi, N.Krasnogor
- **Recognised Researcher:** K.A.Dowsland
- **Start Date:** 1st Feb 2004
- **Duration:** 5 years

Hybrid Methods for Space Allocation (£14,700)

- **Funding Body:** Real Time Solutions Ltd.
- **Principal Investigator:** E.K.Burke
- **Start Date:** 22nd Sep 2003
- **Duration:** 3 years
- **Notes:** Providing industrial support for a University of Nottingham funded CASE studentship

Co-operative and Collaborative Decision Support (£140,000)

- **Funding Body:** Merlin Systems Corp. Ltd.
- **Principal Investigator:** J.M.Garibaldi
- **Start Date:** 1st Oct 2004
- **Duration:** 4 years
- **Notes:** Providing generic industrial support for the e-science robotic infrastructure

An Investigation of Cutting/Packing and Planning using Automated Algorithm Selection (£153,670 to Nottingham, £150,105 to Southampton)

- **Funding Body:** EPSRC (GR/S52414/01)
- **Principal Investigator (Nottingham):** G.Kendall
- **Principal Investigator (Southampton):** J.Bennell
- **Co-Investigator:** E.K.Burke
- **Start Date:** 2nd Feb 2004
- **Duration:** 3 years
Novel Meta-heuristic Research Directions in Healthcare Personnel Rostering (£191,581 from EPSRC; £81,000 from ORTEC; £22,500 from Gower; £3,000 from KaHo)
Funding Body: EPSRC (GR/S31150/01)
Principal Investigator: E.K.Burke
Co-Investigators: S.Petrovic and G.Kendall
Collaborators: ORTEC BV, Gower Optimal Algorithms Ltd, KaHo St.-Lieven
Start Date: 1st Oct 2003
Duration: 3 years

An Investigation of Novel Methods for Optimising Shelf Space Allocation (£62,947 from EPSRC; £30,000 from Tesco; £8,800 from Space Software; £8,000 from Retail Vision)
Funding Body: EPSRC (GR/R60577/01)
Principal Investigator: G.Kendall
Co-Investigators: E.K.Burke, P.I.Cowling and S.Petrovic
Collaborators: Tesco Ltd, Space Software Solutions Ltd, Retail Vision
Start Date: 31st Jul 2002
Duration: 3 years

The Supervisor: Towards A Human Scheduling Algorithm (£69,282)
Funding Body: EPSRC (GR/R92899/02)
Principal Investigator: U.Aickelin
Start Date: 1st Jan 2003
Duration: 2½ years

Scheduling Agents for Distributed Timetabling and Rostering – A Visiting Fellowship (£10,350)
Funding Body: EPSRC (GR/S53459/01)
Principal Investigator: G.Kendall
Co-Investigators: E.K.Burke, S.Petrovic
Start Date: 20th Jul 2003
End Date: 19th Apr 2004
Notes: Supported a visiting fellowship for Prof. Amnon Meisels, Ben-Gurion

An Investigation of Non-Deterministic Fuzzy Reasoning (£62,451 from EPSRC; £5,000 from Neovaenta)
Funding Body: EPSRC (GR/S55085/01-02)
Principal Investigator: J.M.Garibaldi
Collaborators: Neovaenta Medical AB
Start Date: 27th May 2002
End Date: 18th August 2004

Fuzzy Multicriteria Approaches to Scheduling and Rescheduling Problems in Uncertain Environments (£211,593 to Nottingham from EPSRC; £210,743 to Coventry from EPSRC; £70,000 from Denby; £60,000 from Sherwood Press)
Funding Body: EPSRC (GR/R95319/01)
Principal Investigator (Nottingham): S.Petrovic
Principal Investigator (Coventry): D.Petrovic
Co-Investigators: E.K.Burke, G.Kendall, K.Burnham and C.Reeves
Collaborators: Sherwood Press Ltd and Denby Pottery Company Ltd
Start Date: 1st Jan 2003
Duration: 3 years
Notes: Joint with Coventry University

Hybrid Meta-heuristic Approaches for Air Traffic Control Scheduling (£40,000 from EPSRC; £21,000 from NATS Ltd)
Funding Body: EPSRC through the Smith Institute (Faraday Partnership)
Principal Investigator: E.K.Burke
Collaborators: National Air Traffic Services (NATS) Ltd.
Start Date: 1st Oct 2003
Duration: 3 years
Notes: A CASE studentship

Tutorials in Optimisation and Search Methodology (£3,000 from EPSRC; £2,000 from LMS)
Funding Body: EPSRC and London Mathematical Society (LMS), under the MathFIT initiative
Principal Investigator: E.K.Burke
Co-Investigators: G.Kendall
Co-Author: J.D.Landa Silva
Start Date: 1st Jan 2003
End Date: 31st Oct 2003
Notes: Supported the INTROS workshop

A Dual Examination of Scheduling Problems – A Visiting Fellowship (£7,800)
Funding Body: EPSRC (GR/S07124/01)
Principal Investigator: S.Petrovic
Co-Investigators: E.K.Burke and G.Kendall
Start Date: 2nd Sep 2002
End Date: 1st Oct 2003
Notes: Supported a visiting fellowship for Prof. Moshe Dror, University of Arizona
External Research Awards (Continued)

An Inter-disciplinary Scheduling Network (£62,985)
Funding Body: EPSRC (GR/R12268/01)
Principal Investigator: E.K.Burke
Co-Investigators: P.I.Cowling, S.Petrovic and G.Kendall
Collaborators: Over 60 universities and companies across many disciplines
Start Date: 1st May 2001
End Date: 30th April 2004

New Approaches to Produce Efficient Nesting Patterns (£86,268 from Teaching Company Directorate; £40,400 from Esprit)
Funding Body: Teaching Company Directorate and Esprit Automation Ltd (TCS 3047)
Lead Academic: E.K.Burke
Academic Supervisor: G.Kendall
Start Date: 1st Oct 2000
End Date: 30th Sep 2003

Applying Meta-heuristics and Hyper-heuristics to Stock Cutting (£28,920 from EPSRC; £13,200 from Esprit)
Funding Body: EPSRC (CNA 00802329)
Principal Investigator: G. Kendall
Collaborators: Esprit Automation Ltd.
Start Date: 1st Oct 2000
End Date: 30th Sep 2003
Notes: A CASE for New Academics Award

Using Real Time Information for Effective Dynamic Scheduling (£48,939 from EPSRC; £43,500 from Dash)
Funding Body: EPSRC (GR/N04225/01-02)
Principal Investigator: P.I.Cowling (University of Bradford)
Co-Investigators: S.Petrovic and E.K.Burke
Collaborators: Dash Optimisation
Start Date: 27th Apr 2000
End Date: 11th Jul 2004
Notes: Joint with the University of Bradford

A Case Based Approach to Heuristic Selection for Timetabling (£190,545)
Funding Body: EPSRC (GR/M95516/01)
Principal Investigator: E.K.Burke
Co-Investigators: S.Petrovic and P.I.Cowling
Start Date: 27th Mar 2000
End Date: 26th Oct 2003

A Hybrid Meta-heuristic Approach to Simplified Sequence-Structure-Function Problems (£134,844)
Funding Body: BBSRC/EPSRC Bioinformatics initiative (42/BIO14458)
Principal Investigator: J.Hirst (Chemistry)
Co-Investigators: E.K.Burke, P.I.Cowling, G.Kendall and S.Petrovic
Start Date: 20th Aug 2001
Duration: 3½ years
Notes: Joint with the School of Chemistry

An Investigation of Hyperheuristic Methods (£196,343 to Nottingham; £256,547 to Napier)
Funding Body: EPSRC (GR/N36837/01)
Principal Investigator (Nottingham): E.K.Burke
Principal Investigator (Napier): P.Ross
Co-Investigators: P.I.Cowling, S.Petrovic, G.Kendall and E.Hart
Start Date: 18th Dec 2000
End Date: 17th Jul 2004
Notes: Joint with Napier University

Representational Design Principles to Humanise Automated Systems (£264,650)
Funding Body: ESRC/EPSRC People At the Centre of Communication and Information Technologies (PACCIT) programme (L328253012)
Principal Investigator (Sussex): P.Cheng
Co-Investigator (Nottingham): E.K.Burke
Co-Investigator (Bradford): P.I.Cowling
Co-Investigator (Queen’s): B.McCollum
Start Date: 1st Dec 2000
End Date: 31st Apr 2004
Notes: Joint with Sussex University, Queen’s University of Belfast and the University of Bradford

Case Based Reasoning in Personnel Rostering (£58,684 from EPSRC; £24,000 from QMC)
Funding Body: EPSRC (GR/N35205/01)
Principal Investigator: S.Petrovic
Co-Investigators: E.K.Burke and P.I.Cowling
Collaborators: Queen’s Medical Centre, Nottingham
Start Date: 1st Dec 2000
End Date: 31st Aug 2004
Notes: Joint with the Queen’s Medical Centre and the School of Nursing
Professional Activities

Edmund Burke

- Member of the EPSRC Information and Communications Technologies (ICT) Strategic Advisory Team (2003-2005).
- Fellow of the British Computer Society (BCS).
- Member of the UK Computing Research Committee (UKCRC).
- Editor-in-Chief of the Journal of Scheduling.
- Area Editor (for Combinatorial Optimisation) of The Journal of Heuristic.
- Associate Editor of the INFORMS Journal on Computing.
- Associate Editor of the IEEE Transactions on Evolutionary Computation.
- Guest Co-editor of a forthcoming feature issue of the European Journal of Operational Research (EJOR) on “Evolutionary and Meta-heuristic Scheduling”.
- Director of Research for eventMAP Ltd.
- Director of Aptia Solutions Ltd.
- Member of the Scientific Committee of the Smith Institute for Industrial Mathematics and System Engineering (Faraday Partnership).
- Member of the Scientific Board of the Centre of Excellence for Research in Computational Intelligence and Applications (CERCIA).
- Chairman of the IEEE Computational Intelligence Society (CIS) Working Group on Evolutionary Scheduling and Timetabling.
- Chairman of the Advisory Committee and Co-ordinator of the EURO Working group on Automated Timetabling (WATT).
- Chairman of the Steering Committee of the international series of conferences on the Practice and Theory of Automated Timetabling (PATAT).
- Co-chair of the Programme Committee of the 8th International Conference on Parallel Problem Solving from Nature (PPSN VIII), Birmingham, UK, 18-22 September 2004.
- Chairman of the Special Programme Committee on Evolutionary Scheduling and Routing of the Genetic and Evolutionary Computation Conference (GECCO-2004), Seattle, USA, 26-30 June 2004.
- Member of the Programme Committee of the Mini Euro Conference (MEC) on Variable Neighbourhood Search, Tenerife, Spain, 23-25 November 2005.
- Member of the Programme Committee of the 2nd International Conference on Informatics in Control, Automation and Robotics (ICINCO 2005), Barcelona, Spain, 14-17 September 2005.
- Member of the Programme Committee of the 7th International Conference on Artificial Evolution (EA’2005), Lille, France, 26-28 October 2005.
- Member of Programme Committee of the 2005 UK Workshop on Computational Intelligence (UKCI 2005), London, UK, 5-7 September 2005.
- Member of Programme Committee of the Congress on Evolutionary Computation (CEC05), Edinburgh, UK, 2-5 September 2005.
• Member of the Programme Committee of the 6th Metaheuristics International Conference (MIC2005), Vienna, Austria, August 2005.
• Member of Programme Committee for 2nd Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA 2005), New York, USA, 18-21 July 2005.
• Member of Scientific Committee of the International Conference on Industrial Engineering and Systems Management (IESM05), Marrakech, Morocco, 2005.
• Member of Programme Committee of the 2005 Genetic and Evolutionary Computation Conference (GECCO-2005), Washington DC, USA, 25-29 June 2005.
• Member of Programme Committee of the 8th European Conference on Genetic Programming (EuroGP 2005), Lausanne, Switzerland, 30 March - 1 April 2005.
• Member of Programme Committee of the 5th European Conference on Evolutionary Computation in Combinatorial Optimization, (EvoCOP 2005), Lausanne, Switzerland, 30 March - 1 April 2005.
• Member of Programme Committee for the 23rd Workshop of the UK Planning and Scheduling Special Interest Group (PlanSIG 2004), Cork, Ireland, December 2004.
• Member of Programme Committee for the 5th International Conference on Recent Advances in Soft Computing (RASC2004), Nottingham, UK, 16-18 December 2004.
• Member of Programme Committee for the 2004 IEEE Conference on Cybernetics and Intelligent Systems (CIS), Singapore, 1-3 December, 2004.
• Member of Programme Committee of the 5th Asia-Pacific Conference on Simulated Evolution And Learning SEAL 2004, Busan, Korea, 26-29 October 2004.
• Member of Programme Committee of the 2004 UK Workshop on Computational Intelligence (UKCI2004), Loughborough, UK, 6-8 September 2004.
• Member of Programme Committee of the 2004 IEEE Symposium on Computational Intelligence in Bioinformatics and Computational Biology (CIBCB), La Jolla, California, 7-8 October 2004.
• Member of Programme Committee of the 1st International Conference on Informatics in Control, Automation and Robotics (ICINCO), Setubal, Portugal, 25-28 August 2004.
• Member of Programme Committee of the 17th European Conference on Combinatorial Optimisation (ECCO), Beirut, Lebanon, 24-26 June 2004.
• Member of Programme Committee of the Congress on Evolutionary Computation (CEC04), Portland, Oregon, USA, 20-23 June 2004.
• Member of International Advisory Committee of the 2004 Conference on Applied Mathematical Programming and Modelling Conference (APMOD04), London, UK, 20-23 June 2004.
• Member of the Scientific Committee of the 6th International Conference on Adaptive Computing in Design and Manufacture (ACDM 2004), Bristol, UK, 20-22 April 2004.
• Member of Programme Committee of the Fourth European Conference on Evolutionary Computation in Combinatorial Optimization (EvoCOP 2004), Coimbra, Portugal, 5-7 April 2004.
• Member of the International Advisory Board of the 2nd International Conference on Computational Intelligence, Robotics and Autonomous Systems (CIRAS), Singapore, 15-18 December 2003.
• Member of Programme Committee for the 22nd UK Planning and Scheduling SIG Workshop (PLANSIG 2003), Glasgow, UK, 9-10 December 2003.
• Member of Programme Committee of the 2003 UK Workshop on Computational Intelligence (UKCI-03), Bristol, UK, 1-3 September 2003.
• Member of Programme Committee of the 5th Metaheuristics International Conference (MIC03), Kyoto, Japan, 25 - 28 August 2003.
• Member of the Programme Committee of the Genetic and Evolutionary Computation Conference (GECCO-2003), Chicago, USA, 12-16 July 2003.
• Member of the International Programme Committee of the “Applied Mathematics, Operational Research and Optimization” Symposium. This is one of four symposiums which form the IMACS/IEEE Multi-conference (CESA’2003), Lille, France, 9-11 July 2003.
• Member of Programme Committee of the 6th International Conference on Industrial Engineering and Production Management (IEPM’03), Porto, Portugal, 26-28 May 2003.
• Member of Programme Committee of the Third European Workshop on Evolutionary Computation in Combinatorial Optimization (EvoCOP 2003), Essex, UK, 14-16 April 2003.
• Member of Programme Committee of the IFAC International Conference on Intelligent Control and Signal Processing (ICONS 2003), Faro, Portugal, 8-11 April 2003.
• Member of Programme Committee of the 6th Workshop on Models and Algorithms for Planning and Scheduling Problems (MAPSP 03), Aussois, France, 30 March - 5 April 2003.

**Graham Kendall**

• Member of the EPSRC Peer Review College (2003–2005).
• Chairman of the International Society of Interdisciplinary Scheduling (ISIS).
• Member of the Editorial Board of the *International Journal of Systems Science*, Taylor & Francis.
• Member of the editorial board of *Intelligent Systems in Accounting Finance and Management*, Wiley.
• Associate editor of INFOR, the journal of the Canadian Operational Research Society, University of Toronto Press.
• Guest Co-editor of Advances in Econometrics, vol. 19, 2004 (Applications of AI in Finance & Economics)
• Guest Co-editor of a forthcoming special issue of *Annals of Operational Research* on “Cutting, Packing and Layout”.
• Co-Chair of the Programme Committee of the 2nd Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA 2005), New York, USA, 18-21 July 2005.
• Co-Chair of the Programme Committee of Computational Intelligence and Games, Essex UK, 4-6 April 2005.
• Co-Editor of the proceedings of IEEE Symposium on Computational Intelligence and Games, Essex, UK, 4-6 April 2005. To be published by IEEE
• Co-Chair of the Programme Committee of Computational Intelligence and Games, Reno, USA, July 2006.
• Co-Chair of the Programme Committee of the 1st Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA 2003), Nottingham, UK, 17 - 21 August 2003.
• Technical Co-Chair for the IEEE Congress on Evolutionary Computation (CEC’06), Vancouver, Canada, 16-21 July, 2006.
• Member of the Programme Committee of the 2nd Indian International Conference on Artificial Intelligence (IICAI-05), Pune, India, 20-22 December 2005.
• Member of the Programme Committee of 2005 ICSC Congress on Computational Intelligence Methods and Applications (CIMA’2005) (First International ICSC Symposium on Advanced Computing in Financial Markets (ACFM 2005)), Istanbul, Turkey, 2-14 December 2005.
• Member of the Programme Committee of The 18th Australian Joint Conference on Artificial Intelligence (AI’05), 5-9 December 2005, Sydney, Australia
• Member of the Programme Committee of the 2nd International Conference on Artificial Life (ACAL’05), Sydney, Australia, 5-7 December 2005.
• Member of the Programme Committee the 2005 International Conference on Natural Computation (ICNC’05), Changsha, China, 27-29 September 2005.
• Member of the Programme Committee of the International Conference on Informatics in Control, Automation and Robotics (ICINCO), Barcelona, Spain, 14-17 September 2005.
• Member of the Programme Committee of the 6th Metaheuristics International Conference (MIC2005), Vienna, Austria, August 2005.
• Member of the Programme Committee of the 4th International Workshop on Computational Intelligence in Economics and Finance (CIEF’2005), Salt Lake City, USA, July 21-26 2005.
• Member of the Programme Committee of Genetic and Evolutionary Computation Conference 2005 (GECCO 2005), Washington DC, USA, 25-29 June 2005.
• Member of the Programme Committee of International Digital Games Research (DiGRA) Conference, Vancouver, Canada, 16-20 June 2005.
• Member of the Programme Committee of the OR Practice in Africa (ORPA), Ouagadougou, Burkina Faso, 7-8 April 2005.
• Co-Chair of the IEEE Symposium on Computational Intelligence and Games (CIG’05), Essex, UK, 4-6 April, 2005.
• Member of the Programme Committee of the 5th European Conference on Evolutionary Computation in Combinatorial Optimization (EvoCOP2005), Lausanne, Switzerland, 30 March - 1 April 2005.
• Member of the Programme Committee of the 5th European Conference on Genetic Programming (EuroGP2005), Lausanne, Switzerland, 30 March - 1 April 2005.
• Member of the Programme Committee of the 20th ACM Symposium on Applied Computing (SAC 2005), Santa Fe, USA, 13-17 March 2005.
• Member of the Programme Committee of the 5th International Conference in Soft Computing (RASC2004), Nottingham, UK, 16-18 December 2004.
• Member of the Steering Committee of The 2004 International Conference on Machine Learning and Applications (ICMLA’04), Louisville, USA, 16-18 December 2004.
• Member of the Programme Committee of the 17th Australian Joint Conference on Artificial Intelligence (AI 2004), Cairns, Australia, 6-10 December 2004.
• Member of the Technical Committee of the Second Annual International Workshop in Computer Game Design and Technology, Liverpool, UK, 15-16 Nov 2004.
• Member of the Programme Committee of the 2004 workshop on the Design and Evaluation of Advanced Hybrid Meta-Heuristics, Nottingham, UK, 3-4 Nov 2004.
• Member of the Programme Committee of the 2004 IEEE Conference on Cybernetics and Intelligent Systems (CIS’04), Singapore, 1-3 September 2004.
• Member of the Programme Committee of The Eighth International Conference on Parallel Problem Solving from Nature (PPSN VIII), Birmingham, UK, 18-22 September 2004.
• Member of the Programme Committee of the Ninth International Conference on Simulation and Synthesis of Living Systems (ALife IX), Boston, USA, 12-15 September 2004.
• Member of the Programme Committee of the International Conference on Knowledge Engineering and Decision Support (ICKEDS’2004), Porto, Portugal, 19-23 July, 2004.
• Member of the Programme Committee of The Fourth International Conference on Computers and Games (CG’04), Ramat-Gan, Israel, 5-7 July 2004.
• Member of the Programme Committee of The Genetic and Evolutionary Computation Conference (GECCO 2004), Seattle, USA, 26-30 June 2004
• Member of the Programme Committee of The Congress of Evolutionary Computation 2004 (CEC’04), Portland, USA, 19-23 June 2004. I co-organised (with Simon Lucas) a special session at this conference entitled Evolutionary Computation and Games.
• Member of the Programme Committee of the 4th European Conference on Evolutionary Computation in Combinatorial Optimization (EVOCOP2004), Coimbra, Portugal, 5-7 April 2004.
• Member of the Programme Committee of the ACM Symposium on Applied Computing (SAC 2004), Evolutionary Computing and Optimization (ECO) stream, Nicosia, Cyprus, 14-17 March 2004.
• Member of the Programme Committee of the Second International Symposium on Scheduling in Japan (ISS2004), 24-26 May 2004.
• Member of the Programme Committee of The Congress of Evolutionary Computation 2003 (CEC’03), Canberra, Australia, 8-12 December 2003.
• Member of the Programme Committee of The First Australian Conference on Artificial Life (ACAL2003), Canberra, Australia, 6-7 December 2003.
• Member of the Programme Committee of The International Conference on Artificial Intelligence (IC-AI’2003), Las Vegas, USA, 23-26 June, 2003.
• Member of the Programme Committee of The International Conference on Machine Learning and Applications (ICMLA’03), Los Angeles, USA, 23-24 June 2003.
Uwe Aickelin

- Assistant Editor of the Journal of the Operational Research Society.
- Associate Editor of the IEEE Transactions on Evolutionary Computation.
- Executive Board Member of ARTIST: A Network for Artificial Immune Systems (EPSRC).
- Invited Speaker at the 46th annual Operational Research Society Conference, York, UK, 7–9 September 2004 (Keynote Speaker on Heuristics and Artificial Immune Systems).
- Member of the Programme Committee of the 2nd Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA 2005), New York, USA, 18-21 July 2005.
- Member of the Programme Committee of the 8th European Conference on Artificial Life (ECAL 2005), Canterbury, UK, 5-9 September 2005.
- Member of the Programme Committee the 4th International Conference on Artificial Immune Systems (ICARIS 2005), Banff, Canada, 14-17 August, 2005.
- Member of the Programme Committee of the 3rd International Conference on Artificial Immune Systems (ICARIS 2004), Catania, Italy, 13-16 September, 2004.
- Member of the Programme Committee of the 8th International Conference on Parallel Problem solving from Nature (PPSN VIII), Birmingham UK, 18-22 September 2004.
- Member of the Programme Committee of the Congress of Evolutionary Computation 2004 (CEC 2004), Portland, USA, 19-23 June 2004.
- Member of the Programme Committee of the 2004 Genetic and Evolutionary Computation Conference (GECCO 2004), Seattle, USA, 26-30 June 2004.
- Member of the Programme Committee of the 1st Multi-Disciplinary International Conference on Scheduling: Theory and Applications (MISTA 2003), Nottingham, UK, 13-15 August 2003.
- Member of the Programme Committee of the Congress of Evolutionary Computation 2003 (CEC 2003), Canberra, Australia, 8-12 December 2003.
- Member of the Programme Committee of the Genetic and Evolutionary Computation Conference (GECCO 2003), Chicago, USA, 12-16 July 2003.

Jon Garibaldi

- Member of the EPSRC Peer Review College (2003–2005).
- Guest Co-editor of a forthcoming special issue of IEEE Transactions on Fuzzy Sets on “Extensions to Type-1 Fuzzy Logic”.
- Guest Co-editor of a forthcoming special issue of Applied Artificial Intelligence on “Methods for Adaptive Intelligent Systems”.
- Co-ordinator, Chairman of the Steering Committee and Lead Scientist of the BIOPTRAIN (Bioinformatics Optimisation Training) FP6 Marie-Curie Early Stage Training Centre.
- Chairman of the Bioinformatics Special Interest Group Committee of BIOPATTERN (Computational Intelligence for Biopattern Analysis in Support of eHealthcare) FP6 Network of Excellence, 2004-2008.

Invited Keynote Speaker at the Opening Session of the 1st International Meeting on Computational Intelligence Methods for Bioinformatics and Biostatistics (CIBB 2004), Perugia, Italy, 14-15 September 2005.

Invited Keynote Speaker at the Closing Session of the EUNITE 2004 International Conference on Smart Adaptive Systems, Aachen, Germany, 10-12 June 2004.


Organiser of an Invited Session on “Grid Scheduling” at the 2004 CORS/INFORMS International Conference, Banff, Canada, 16-19 May 2004.

Member of the Programme Committee of the 2005 UK Workshop on Computational Intelligence (UKCI2005), London, UK, 5-7 September 2005.

Member of the Programme Committee of the European Conference on Emergent Aspects in Clinical Data Analysis (EACDA 2005), Pisa, Italy, 28-30 September 2005.

Member of Programme Committee of the 2nd International Meeting on Computational Intelligence Methods for Bioinformatics and Biostatistics (CIBB 2005), Crema, Italy, 15-17 September 2005.

Member of the Programme Committee of the 2005 International Conference on Computational Intelligence in Medicine and Healthcare (CIMED2005), Lisbon, Portugal, 29 June - 1 July 2005.


Co-Chair of the Organising Committee of the 5th International Conference in Soft Computing (RASC 2004), Nottingham, UK, 16-18 December 2004.

Member of the Programme Committee of the Joint 2004 IEEE Conference on Cybernetics and Intelligent Systems (CIS) and IEEE Conference on Robotics, Automation and Mechatronics (RAM), Singapore, 1-3 December, 2004.

Member of the Programme Committee of First International Workshop on Grid Computing and its Application to Data Analysis (GADA’04), Larnaca, Cyprus, 25-29 October 2004.

Member of the Programme Committee of the 8th International Conference on Parallel Problem Solving from Nature (PPSN VIII), Birmingham, UK, 18-22 September 2004.


Member of Programme Committee of the 2004 UK Workshop on Computational Intelligence (UKCI-2004), Loughborough, UK, 5-7 September 2004.

Member of the Programme Committee of the IEEE International Conference on Fuzzy Systems (FUZZ-IEEE 2004), St. Louis, USA, 25-28 May 2003.

Sanja Petrovic

Member of the EPSRC Peer Review College (2003–2005).


• Member of the Programme Committee of the 2nd Multidisciplinary International Conference on Scheduling : Theory and Applications (MISTA 2005), New York, USA, 18-21 July 2005.
• Member of the Programme Committee of the 4th International Conference on Recent Advances in Soft Computing (RASC2004), Nottingham, UK, 16-18 December, 2004.
• Member of the Programme Committee of the 8th International Conference on Parallel Problem solving from Nature (PPSN VIII), Birmingham UK, 18-22 September 2004.
• Member of the Programme Committee for the 5th International Conference on the Practice and Theory of Automated Timetabling (PATAT 2004), Pittsburgh, USA, August 2004.
• Member of the Special Programme Committee on Evolutionary Scheduling and Routing of the 2004 Genetic and Evolutionary Computation Conference (GECCO-2004), Seattle, USA, 26-30 June 2004.
• Organiser of a Session on University Timetabling within the cluster on Scheduling/Timetabling at the CORS/INFORMS Joint International Meeting, Banff, Canada, 16-19 May 2004.
• Member of the Programme Committee of the Congress on Evolutionary Computation 2003 (CEC’03), Canberra, Australia, 8-12 December 2003.
• Organiser of the Session on Employee Timetabling within the track “Planning and Scheduling in Services and Manufacturing” at the Production and Operations Management Society (POM 2003), Savannah, USA, 4-7 April 2003.

Natalio Krasnogor
• Board member of the UK Society for the Study of Artificial Intelligence and Simulation of Behaviour.
• Member of the editorial board of the Artificial Intelligence and Simulation of Behaviour Quarterly,
• Member of the editorial board of the International Journal of Computational Intelligence
• Member of the editorial board of Evolutionary Computation.
• Guest Co-editor of a special issue of Evolutionary Computation on “Memetic Algorithms”, MIT Press.
• Guest Co-editor of a special issue of Fuzzy Sets and Systems on “Bioinformatics”, Elsevier.
• Member of the Organising Committee of the 1st Multidisciplinary International Conference on Scheduling; Theory and Applications (MISTA 2003), Nottingham, UK, 13 – 16 August 2003.
• Member of the Organising Committee International Workshop on Introductory Tutorials in Optimisation and Search Methodologies (INTROS ’03), Nottingham, UK, 12 August 2003.
• Member of the Programme Committee of the 7th World Multi-Conference on Systemics, Cybernetics and Informatics (SCI 2003), Orlando, Florida, 27 – 30 July 2003.
• Member of the Programme Committee of the Genetic and Evolutionary Computation Conference (GECCO 2005), Seattle, DC, USA, 25-29 July 2005.
• Member of the Programme Committee of the Genetic and Evolutionary Computation Conference (GECCO 2004), Seattle, Washington, USA, 26-30 July 2004.
• Member of the Programme Committee of the Genetic and Evolutionary Computation Conference (GECCO 2003), Chicago, USA, 12-16 July 2003.
• Co-chair of the Programme Committee of the 4th International Workshop on Memetic Algorithms (WOMA IV), Chicago, USA, 12 July 2003.
• Member of the Programme Committee for Congreso Mexicano de Computacion Evolutiva 2003 (COMCEV '03), Guanajuato, Mexico, 28 – 30 May 2003.
Dario Landa-Silva

- Co-chair of the 4th EU/ME International Workshop on Design and Evaluation of Advanced Hybrid Metaheuristics, Nottingham, UK, 4-5 November, 2005.
- Member of the Programme Committee for the 2005 IEEE Congress on Evolutionary Computation (CEC 2005).
- Member of the Programme Committee for the First Conference on OR Practice in Africa (ORPA 2005).
- Member of the Programme Committee of the 4th EU/ME International Workshop on Design and Evaluation of Advanced Hybrid Metaheuristics, Nottingham, UK, November 2005.
- Member of the Programme Committee for the 2005 International Conference on Evolutionary Multi-criterion Optimization (EMO 2005), Guanajuato, Mexico, 9-11 March 2005.
- Member of the Programme Committee for the 2004 IEEE Congress on Evolutionary Computation (CEC 2004), Portland, USA, 19-23 June 2004.
- Member of the Programme Committee for the 2nd EU/ME Workshop on “Multiobjective Metaheuristics”, Paris, France, November 2002.
- Member of the Organising Committee for the 1st Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA 2003), Nottingham, UK, 13 – 16 August 2003.

Djamila Oelhadj

- Member of the European Network of Excellence for Agent-based Computing (AGENTLINK).
- Member of the Programme Committee of the International Conference on Parallel Computing (EURO-PAR05), Portugal, 30 August - 2 September, 2005.
- Member of the Programme Committee of the First International Workshop on Knowledge and Data Mining Grid(KDMG05), Lodz, Poland, 6-9 June 2005.
- Member of the Programme Committee of the Seventh International Conference on Computational Intelligence and Natural Computing (CINC05), Salt Lake City, USA, 21-26 July, 2005.
- Member of the Programme Committee of the IADIS International Conference Applied Computing (CA05), Algarve, Portugal, 22-25 February, 2005.
- Member of the Programme Committee of the 35th International Computers & Industrial Engineering Conference (CIE05), Istanbul, Turkey, 19-22 June, 2005.
- Member of the Programme Committee of the 9th WSEAS International Conference on Computers (WSEA05), Athens, Greece, 14-16 July 2005.
- Member of the Programme Committee of the 2nd International Conference on Informatics in Control, Automation and Robotics (ICINCO 2005), Barcelona, Spain, 14-17 September 2005.
- Member of the Programme Committee of the 5th IEEE/ACM International Workshop on Grid Computing (GRID2004), Pittsburgh, USA, 8 November, 2004.
- Member of the Programme Committee of the International Symposium on Scheduling (ISS2004), Japan, 24-26 May 2004.
- Member of the Programme Committee of the 1st International Conference on Informatics in Control, Automation and Robotics (ICINCO04), Setubal, Portugal, 25-28 August 2004.
- Publicity Chair and Member of the Programme Committee of the Fourth International Conference on Intelligent Systems Design and Applications (ISDA04), Budapest, Hungary, 26-28 August 2004.
- Member of the Organising Committee of the First Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA 2003), Nottingham, UK, 12-16 August 2003.

Rong Qu

- Member of the Organising Committee of the First Multidisciplinary International Conference on Scheduling: Theory and Applications (MISTA 2003), Nottingham, UK, 12-16 August, 2003.

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Contact Details

Academic Staff

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Director of Inter-Disciplinary Optimisation Laboratory)
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Dr Natalio Krasnogor
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Dr Dario Landa Silva
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ASAP Personnel

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Dr Uwe Aickelin
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Dr Jon Garibaldi
Senior Lecturer

Dr Sanja Petrovic
Senior Lecturer

Dr Natalio Krasnogor
Lecturer

Dr Dario Landa Silva
Lecturer

Dr Djamila Ouelhadj
Lecturer

Dr Rong Qu
Lecturer

Administrative Staff

Mrs Emma-Jayne Dann
PA to Prof. Burke
Associated Staff

Prof. Jacek Blazewicz  
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Prof. Peter Brucker  
EPSRC Visiting Fellow

Prof. Moshe Dror  
EPSRC Visiting Fellow

Prof. Amnon Meisels  
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Prof. Patrick De Causmaecker  
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Research Staff

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Research Staff (Joint with School of Chemistry)

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PhD Students

Salwani Abdullah
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Tim Curtois
Aniza Mohamed Din

Adam Eckersley
Martin Geiger
Julie Greensmith
Limin Han
PhD Students (Continued)

Rob Hellier  Naimah Hussin  Lin Li  Scott Littlewood

Geert De Maere  Rahul Singh Majhail  Mazlan Mohamed  Baharuddin Bin Mohamed

Salang Musikasuwan  Ross O’Brien  Cyril Schoreels  Xeuyan Song

Kristian Spoerer  Mike Stout  Yan Su  Xiao Ying Wang

William Wilson  Razali Yaakob
How to Find Us

See [http://www.nottingham.ac.uk/campuses/jubilee](http://www.nottingham.ac.uk/campuses/jubilee) for full directions
ASAP Posters at EPSRC’s Operational Research Theme Day

Knowledge
The ASAP group

- Automated Scheduling, Optimisation and Planning Research Group (ASAP)
  - Total funding approx £1M over 21 grants
  - Investigating/developing innovative & powerful decision support methodologies
  - Addressing real world problems: building decision-support systems that can solve real world issues
  - Inter-disciplinary approach: both the underlying technology and the application areas
  - Raising the level of generality of decision support methodology

A selection of externally funded projects:

- EPSRC: [Project Title] (G070478/1) - Title of the project on a particular research area (EPSRC)
- EPSRC: [Project Title] - Another example of a project funded by EPSRC

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Exploration
ASAP research areas

- Heuristics and meta-heuristics
  - Including evolutionary computation
- Hyper-heuristics
- Knowledge-based systems and case-based reasoning
- Machine learning (adaptive learning)
- Multi-objective optimisation methods
- Artificial immune systems
- Expert systems
- Fuzzy approaches
- Hybridisations of all the above

A selection of externally funded projects:

- EPSRC: [Project Title] (G070479/1) - Title of the project on a particular research area (EPSRC)
- EPSRC: [Project Title] - Another example of a project funded by EPSRC

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Realisation
ASAP application areas

- Timetabling
- Healthcare personnel rostering
- Cutting/packing/spaces allocation
- Production scheduling
- Bio-informatics
- Airline fleet and runway scheduling
- Robotic co-operation
- Game Intelligence
- Intrusion detection systems
- GRF scheduling (e-science)
- Neonatal assessment

A selection of externally funded projects:

- EPSRC: [Project Title] (G070480/1) - Title of the project on a particular research area (EPSRC)
- EPSRC: [Project Title] - Another example of a project funded by EPSRC

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Diversity
Inter-disciplinary collaboration laboratory

- Established by The University of Nottingham in 2000
- Involves researchers in 8 Schools representing a variety of diverse disciplines (Computer Science, Chemistry, Psychology, Clinical Sciences, Built Environment, Operations Management, Mathematics and Nursing)
- Provides an infrastructure and focus for multi-disciplinary research themes and applications
- Funded from a wide variety of sources including 4 programmes within EPSRC (Mathematics, Information & Communication Technologies, Engineering and Chemistry), BBSRC, ESRC and the EU
- The laboratory collaborates with researchers from across the world

A selection of externally funded projects:

- EPSRC: [Project Title] (G070481/1) - Title of the project on a particular research area (EPSRC)
- EPSRC: [Project Title] - Another example of a project funded by EPSRC

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School of Computer Science and IT

Automated Scheduling, Optimisation and Planning (ASAP) Research Group

Report Addendum 2005

This is an update to the ASAP Research Group Report 2003-2004, detailing selected activities during 2005.
External Research Awards

ASAP has secured external research funding of more than £3 million since June 2005.

Next Generation Decision Support:
Automating the Heuristic Design Process
(£2,663,528)
Funding Body: EPSRC (EP/D061571/1)
Principal Investigator: Professor E.K. Burke
Other Investigators: Dr R. Qu, Dr S. Petrovic, Dr G. Kendall, Dr J.M. Garibaldi, Dr N. Krasnogor and Dr J.D. Landa Silva
Start Date: 1 March 2006
End Date: 28 February 2011

Hyper-heuristics for Scheduling, Rostering and Routing: An International Collaboration (£31,828)
Funding Body: EPSRC (EP/D027039/1)
Principal Investigator: Dr J.M. Garibaldi
Other Investigators: Professor E.K. Burke, Dr G. Kendall
Start Date: 1 March 2006
End Date: 28 February 2011
Notes: Supporting Professor M. Gendreau

NETWORK: Interdisciplinary Cutting, Packing and Space Allocation (£63,212)
Funding Body: EPSRC (EP/D031079/01)
Principal Investigator: Dr G. Kendall
Other Investigators: Professor E.K. Burke
Start Date: 1 March 2006
End Date: 28 February 2009
Notes: This is an inter-disciplinary network across academia and industry. A brief summary can be found in EPSRC's Research Portfolio.

IDEAS Factory Productivity Network - Closing the Gap, Crossing the Levels (£109,686)
Funding Body: EPSRC (EP/D036623/1)
Principal Investigator: Dr U. Aickelin
Start Date: 1 October 2005
End Date: 31 March 2009

Towards a Framework for Modelling Variation in Automated Decision Support
(£143,282)
Funding Body: EPSRC (EP/C542207/1)
Principal Investigator: Dr J.M. Garibaldi
Other Investigators: Professor E.K. Burke
Start Date: 1 January 2006
End Date: 31 December 2008

Multi Sensor Data Fusion for Threat Analysis in Computer Security (£59,464)
Funding Body: EPSRC through the Smith Institute for Industrial Mathematics and System Engineering.
Collaborators: NetFort Ltd. (£ 19,821)
Principal Investigator: Dr U. Aickelin
Start Date: 1 June 2005
End Date: 31 December 2008

Publications

Books

Journal Papers
In press and to appear


2006


2005


Refereed Conference Papers and Book Chapters

The group has published in a wide range of refereed international conferences and book chapters since the publication of our 2003/2004 report, with many more accepted or submitted to conferences due to be held in 2006. Full details will be included in the next research group report.
New Group Members

Mrs. Christine Fletcher
Group Support Coordinator

Mrs. Debbie Pitchfork
EPSRC Network Administrator

Peer-Olaf Siebers
Research Associate

Amanda Whitbrook
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Matthew Hyde
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