ORSNZ Annual Conference 2023

Operations Research Society of New Zealand (ORSNZ)

November 23-24, 2023

Opening

Whakataka te hau ki te uru	Cease the winds from the west
Whakataka te hau ki te tonga	Cease the winds from the south
Kia mākinakina ki uta	Let the breeze blow over the land
Kia mātaratara ki tai	Let the breeze blow over the ocean
E hī ake ana te atakura	Let the red-tipped dawn come with a sharpened air
He tio, he huka, he hau hū	A touch of frost, a promise of a glorious day.

Tīhei mauri ora!

Welcome

Tēnā tatou e hoa ma	Greetings to us all
Kua haere mai nei Ki te ako I ngā whakaaro	Who have come here To learn The ideas/concepts/thoughts/views
Ka mihi ki te iwi kāinga, ki a Ngāti Whātua Ōrākei	We acknowledge and give thanks to Ngāti Whātua Ōrākei as the people on whose lands we are meeting
Kānui te mihi atu Mō tō koutou aronui Ki te aro mai I ngā kaupapa	Great is the thanks/appreciation For your interest To attend The programme
Otirā, kua mutu i konei ā ku mihi mō tēnei wā Nō reira, tēnā koutou, tēnā koutou, ā, tēnā tātou katoa.	Thus, I end my greeting here for the present. Therefore, greetings and honour to one and all.

Contents

Opening **iii**

Welcome **v**

Programme Summary **1**

Thursday November 23, 2023 **3**

Hans Daellenbach Plenary – 9:50-10:50am, Room 423-342 3

Hans Daellenbach Plenary (*Andrew Mason*) 3

Session 2: Algorithms for Scheduling and Production – 11:10am-12:30pm, Room 423-340 4

Solving the mass customised sawmill planning problem using cutting pattern enumeration (***Daniel Kulasingham****, Cameron Walker, Michael O'Sullivan*) 4

Multistage production planning and price modelling (***Dominic Keehan****, Andy Philpott, Andrew Mason*) 5

State-space search to find energy-aware Pareto-efficient optimal task schedules (***Yasith Udagedara****, Andrea Raith, Oliver Sinnen*) 5

Towards the development of a Virtual Safety Officer — Few-Shot-Learning prototype (***Mostafa Papen****, Michael O'Sullivan, Yang Zou, Daniel Kulasingham*) 6

Session 3: Modelling and Insights 1 – 1:20-2:00pm, Room 423-340 6

Digital thread-enabled smart factory inventory control for New Zealand manufacturers (***Akhil Ramesh****, Yuqian Lu*) 6

Improving allocation of mentees and mentors in a Women in STEM mentoring programming (***Sarah Marshall****, Mahsa Mohaghegh*) 7

Friday November 24, 2023 **9**

Session 4: ORSNZ SIG on Healthcare Analytics Session – 11:00am-12:20pm, Room 423-340 9

An Analysis of Oncology Drug Prescription Patterns using Hidden Markov Models (***Shirekha Layangani, LDC****, Fernando S. Oliveira, and Valery Pavlov*) 9

Pandemic Resilience – Developing an AI-calibrated ensemble of models to inform decision making (***Michael O'Sullivan***, *Nathaniel Hupert, Patrick McSharry, Risto Miikkulainen, Olivier Francon, Jamieson Warner, Victoria Agyepong, Sobhan Chatterjee, Nathan Allen, Arnaud Quenneville-Langis, Sahar Bahrami, Ahmed Farid*) 10
Equitable Surgery Scheduling (***Tom Adams***) 10
A biobjective math-heuristic for patient transport scheduling (***Andrea Raith***, *Andrew Mason, and Melanie Reuter-Oppermann*) 11
Session 5: Energy and Natural Resources SIG Session – 1:20-2:40pm, Room 423-340 11
Optimisation of Inductive Power Transfer Modules for In-Road EV Charging (***Brian Gu***, *Michael O'Sullivan, Seho Kim, Grant Covic*) 11
Multi Scale Analysis of Energy Systems with MicroGrids (***Zainab Rizvi***, *Con Lu, Cameron Walker, Michael O'Sullivan*) 12
An LP-based Exchange to Maximise the Value of Delivered Water, while Managing Multiple Environmental Impacts (***E Grant Read***) 14
Planning renewable electricity capacity using JADE (*Andy Philpott, Jarand Hole, Anthony Downward, Oscar Dowson*) 14
Session 6: Modelling and Insights 2 – 3:00-4:20pm, Room 423-340 15
Designing Service Menus for Bipartite Queueing Systems (*Rene Caldentey, Varun Gupta,* ***Lisa Aoki Hillas***) 15
Behavioral Enablers of Servers in Queueing Systems (*Valery Pavlov,* ***Aida Shams***) 15
Visualising the column generation processes for the airline crew rostering problem (***Michael Zhang***, *Andrea Raith, Andrew Mason*) 16
JuMP: the year in review (***Oscar Dowson***) 16

Closing **19**

Author Index **21**

Young Practitioner Prize (YPP) Papers **23**

Programme Summary

Thursday November 23, 2023

8:40-9:30am	Registration
9:30-9:50am	**Opening**
9:50-10:50am	**Hans Daellenbach Plenary – Assoc Prof Andrew Mason**
10:50-11:10am	*Morning Tea*
11:10am-12:30pm	Session 2 – Algorithms for Scheduling and Production Algorithms for Scheduling and Production (Chair: Sarah Marshall) 1. Daniel Kulasingham, *Solving the mass customised sawmill planning problem using cutting pattern enumeration* 2. Dominic Keehan, *Multistage production planning and price modelling* 3. Yasith Udagedara, *State-space search to find energy-aware Pareto-efficient optimal task schedules* 4. Mostafa Papen, *Towards the development of a Virtual Safety Officer — Few-Shot-Learning prototype*

Friday November 23, 2023

9:00-9:20am	Coffee/Tea
9:20-10:40am	**Annual General Meeting**
10:40-11:00am	*Morning Tea*
11:00am-12:40pm	Session 4 – ORSNZ SIG on Healthcare Analytics Session (Chair: Andrea Raith) 1. Shirekha Layangani, LDC, *An Analysis of Oncology Drug Prescription Patterns using Hidden Markov Models* 2. Mike O'Sullivan, *Pandemic Resilience - Developing an AI-calibrated ensemble of models to inform decision making* 3. Thomas Adams, *Equitable Surgery Scheduling* 4. Andrea Raith, *A Biobjective Mathheuristic for patient transport scheduling*

Thursday November 23, 2023

12:30-1:20pm	*Lunch*
1:20-2:20pm	Session 3 – Modelling and Insights 1 (Chair: Andy Philpott) 1. Akhil Ramesh, *Digital thread-enabled smart factory inventory control for New Zealand manufacturers* 2. Sarah Marshall, Mahsa Mohaghegh *Improving allocation of mentees and mentors in a Women in STEM mentoring programming*
2:30-6pm	**Gurobi Community Event 2.0**
Location	Sofitel Auckland Viaduct Harbour
Registration	(note that you need to register separately for the Gurobi event) `https://www.gurobi.com/events/optimization-community-auckland-23112023/`
Agenda	
2:30pm	Arrival and registration
3:00pm	Introducing Gurobi 11
3:25pm	Customer Guest Speaker
3:50pm	Partner Guest Speaker (Gurobipy. pandas)
4:20-6:00pm	Networking Drinks & Canapes

Friday November 23, 2023

12:40-1:40pm	*Lunch*
1:40-3:00pm	Session 5 – Energy and Natural Resources SIG Session (Chair: Andrew Mason) 1. Brian Gu, *Optimisation of Inductive Power Transfer Modules for In-Road EV Charging* 2. Zainab Batool Rizvi, *Multi Scale Analysis of Energy Systems with Micro-Grids* 3. E Grant Read, *An LP-based Exchange to Maximise the Value of Delivered Water, while Managing Multiple Environmental Impacts* 4. Andy Philpott, *Planning renewable electricity capacity using JADE*
3:00-3:20pm	*Afternoon Tea*
3:20-4:40pm	Session 6 – Modelling and Insights 2 (Chair: Tom Adams) 1. Lisa Aoki Hillas, *Designing Service Menus for Bipartite Queueing Systems* 2. Aida Shams, *Behavioral Enablers of Servers in Queueing Systems* 3. Michael Zhang, *Visualising the column generation processes for the airline crew rostering problem* 4. Oscar Dowson, *JuMP: the year in review*
4:40-5pm	**Prizegiving and Closing**

Thursday November 23, 2023

Hans Daellenbach Plenary – 9:50-10:50am, Room 423-342

Chair: Mike O'Sullivan

Hans Daellenbach Plenary

23 Nov
9:50-10:50am
Room 423-342

Andrew Mason
University of Auckland

Associate Professor Andrew Mason has been active in the New Zealand Operations Research community since his first ORSNZ Conference in 1988 which he attended while an undergraduate in the School of Engineering. At this meeting he was awarded the Student Paper prize for a paper on using matching algorithms in stereo speaker manufacturing. Following this he completed a PhD at Cambridge University before returning to Auckland take up an academic position in the Department of Engineering Science in 1992. Since then, he has risen through the ranks at the University of Auckland where he now holds the position of Associate Professor.

Andrew's research has several themes. He is a skilled computer programmer and has produced successful open-source software packages such as OpenSolver and SolverStudio. These are tools that enable the integration of large-scale mixed integer programming packages into Excel spreadsheets that avoid the default size settings of the Excel Solver as well as providing more robust and numerically stable implementations of linear and mixed integer optimization algorithms. OpenSolver has had over 600,000 downloads since 2010, and SolverStudio has had 11,000 downloads. Andrew was awarded the CoinOR Cup by INFORMS in 2011 for OpenSolver.

Andrew has also developed state-of-the-art staff rostering software (used by Air New Zealand and New Zealand Customs), fibre-optic cable network design software (used by Telstra in their fibre deployment in Auckland, Wellington and Christchurch) and ambulance scheduling software (implemented by his startup Optima Corporation which was eventually sold to a US-based corporation). He was part of the Coka Coders team that came third in the 2019 Verolog Challenge. In all his work Andrew has focused on the end-user's problem and produced enduring and successful solutions. These are the finest exemplars of Operations Research success.

Andrew's latest focus is leading a spearhead project in the Science for Technological Innovation National Science Challenge. This project, Te Tātari Raraunga - Analytics to identify and connect successors to whenua, is creating smart data analytics tools in collaboration with Parininihi ki Waitotara to help track down rightful

Māori shareholders to connect them to their land. Andrew's work uses clever OR techniques (such as dynamic programming) to sift through noisy and often corrupted data sources to deduce genuine relationships between various Māori individuals and their whakapapa. Although the outcomes of this work have yet to be fully realized, Andrew's work has received some publicity on National Radio, and promises to yield some important publications for him in future years.

Through his work with OpenSolver, Andrew has established an enviable international reputation. He publishes consistently in high impact journals, and is a popular speaker at INFORMS meetings. His papers are cited regularly in the international literature (125 Google cites per year) attesting to their relevance. Locally his talks are always a highlight of ORSNZ conferences, and his students always produce work of a high quality. Many of his students have pursued advanced degrees at overseas universities and gone on to have eminent careers.

It is hard to think of any individual who has made a greater contribution to the ORSNZ. Since his first conference in 1988, Andrew has been an enthusiastic advocate of the Society. Andrew was President of the ORSNZ from 2008 till 2013, instituting many improvements to the Society to ensure its relevance and longevity. He designed and built the first web site for ORSNZ, and maintained this selflessly for many years, updating it with the latest conference information, latest newsletters, photographs and names of prize winners, and creating an archive of the Society's history. Andrew was also a founding member of the New Zealand Analytics Forum, a group that has grown to 2000 members since its inception in 2013.

The time has come to acknowledge all of these contributions and recognize the excellent work that Andrew has sustained over the last 30 years, by awarding him the 2022 Hans Daellenbach Award.

Session 2: Algorithms for Scheduling and Production – 11:10am-12:30pm, Room 423-340

Chair: Sarah Marshall

23 Nov
11:10-11:30am
Room 423-340

Solving the mass customised sawmill planning problem using cutting pattern enumeration

Daniel Kulasingham, Cameron Walker, Michael O'Sullivan
Sequal, University of Auckland

Sequal, a sawmill in New Zealand that produces custom-sized timber, uses predominantly manual ad hoc production planning methods. This allows the planning and production at Sequal to be agile to fluctuations in demand requirements. However, these processes are not scalable as it requires specialised knowledge in many areas of production and business processes. As demand grows, production planning becomes exponentially more complex to solve using manual methods. While there are many applications of optimisation techniques used in sawmill manufacturing and sawmill production planning, there have not been any that acknowledge the specific

requirements of optimised production planning for customised manufacturing. This paper explores a potential solution method for the customised sawmill planning problem (SPP). The problem is solved in two steps. An algorithm generates all feasible and useful cutting patterns for the SPP. These cutting patterns are then used to solve a mixed integer linear program. The methods are tested on a standard waste minimisation problem using constraints and demand from the Sequal sawmill. The customised context of the problem leads to very large models that are unsuitable for use in real-world production planning. However, we investigate the use of different solving strategies that would make this solution method viable.

Multistage production planning and price modelling

23 Nov
11:30-11:50am
Room 423-340

Dominic Keehan, Andy Philpott, Andrew Mason
University of Auckland

We study a model of the multistage stochastic optimisation problem faced by Fonterra when planning what dairy products to produce and sell on the international market. Planning decisions are complicated by the uncertain nature of future market prices and small sample sizes. Production plans that are optimised with forecast prices often require updating when these forecasts turn out to be wrong. For this reason it is of interest to understand how committing to a fixed production plan with decisions determined entirely in advance of any realised market prices would perform out-of-sample. We show that if future market prices are independent of current market prices, then a fixed production plan is optimal. We then compare the performance of a fixed production plan to a dynamic one by testing both on real data.

State-space search to find energy-aware Pareto-efficient optimal task schedules

23 Nov
11:50am-12:10pm
Room 423-340

Yasith Udagedara, Andrea Raith, Oliver Sinnen
University of Auckland

Bi-objective scheduling, in particular with the objectives to minimize makespan and energy, has been well studied in the literature. Numerous works have proposed algorithms that use Dynamic Voltage and Frequency Scaling (DVFS) as the mechanism to reduce energy consumption. Given the NP-hard nature of the task scheduling problem, these algorithms are mostly heuristics, producing only a single or few schedules for a given instance.

This research explores bi-objective task scheduling with the goal to find the set of Pareto-efficient solutions for a given small instance, using DVFS to balance energy and performance. We undertake this using a branch-and-bound depth-first search within an allocation-ordering state space model. Varying scaling factors and static energy models are considered. The proposed approach is evaluated with a dataset of small graphs resulting in thousands of produced schedules. In contrast to heuristics, our approach computes numerous trade-off solutions for a given problem instance as a Pareto-efficient set.

Towards the development of a Virtual Safety Officer — Few-Shot-Learning prototype

23 Nov
12:10-12:30pm
Room 423-340

Mostafa Papen, Michael O'Sullivan, Yang Zou, Daniel Kulasingham
University of Auckland

This paper explores the feasibility of developing an earmuff detector using few-shot learning (FSL) methods, requiring only a small labeled dataset. FSL enables learning from limited examples by computing prototypical representations of each class. We utilize two YOLOv5 models to detect the person and head, extract features using EfficientNet-B2, and classify images as "Muff" or "NotMuff" using a prototypical network. Initial testing on a video achieved 83.6% accuracy using only 8 images as the support set. This paper demonstrate the capability of FSL for this task despite minimal data. This is significant, as constructing large datasets is challenging due to time, cost, and ethical constraints. By eliminating extensive data requirements, FSL paves the way for affordable development of safety-enhancing computer vision applications. The proposed approach could be extended to detect various personal protective equipment and safety violations, assisting human safety officers in creating safer workplaces.

Session 3: Modelling and Insights 1 – 1:20-2:00pm, Room 423-340

Chair: Andy Philpott

Digital thread-enabled smart factory inventory control for New Zealand manufacturers

23 Nov
1:20-1:40pm
Room 423-340

Akhil Ramesh, Yuqian Lu
University of Auckland

Manufacturing in New Zealand contributes to 10% of the GDP (over NZD 24 billion) and is the most significant contributor to exports (over NZD 44.5 billion), with an employment base of 248,000. However, high labour costs, smaller domestic market, and geographical isolation have resulted in manufacturers concentrating on High-Mix-Low-Volume manufacturing of varying batch sizes. To ensure undisrupted product delivery, organisations often stock up high on inventory, schedule orders in larger batches and switch between outsourcing and in-house production in an ad-hoc manner, resulting in a significant loss of working capital. Dynamic inventory control systems, which integrate classical inventory control policies with data-driven algorithmic models, can enable intelligent lot sizing and bring in real-time inventory control, thereby allowing manufacturers to balance economic production scheduling and sourcing with heterogenous customer pull. This research presents the design of one such digital thread-enabled smart factory inventory control system based on evolutionary algorithms. The developed model has been validated through a real-world case study of a production-inventory system with a Kiwi manufacturer. The

results of the trials reveal that the system has been able to reduce lead times by 54.26% while pre-empting production orders in the wake of incoming production demand and achieving a fill rate of close to 1.

Improving allocation of mentees and mentors in a Women in STEM mentoring programming

23 Nov
1:40-2:00pm
Room 423-340

Sarah Marshall, Mahsa Mohaghegh
University of Auckland, Auckland University of Technology

It is well-known that women are significantly underrepresented in science, technology, engineering, and mathematics (STEM) fields. Some studies have shown that positive mentoring relationships could mitigate typical barriers women face when working and studying STEM. With this in mind, the AUT Women in Tech Mentoring programme was established in 2019. The allocation of mentees and mentors within this programme is currently performed manually. As the popularity of the mentoring programme has grown, allocation has become an increasingly time-consuming process. Our study aims to address this issue by providing both rule-based heuristics and linear programming models for allocating mentees and mentors. Numerical experiments are conducted to compare the performance of the approaches across various scenarios. The approaches are also applied to historical data from the AUT Women in Tech mentoring programme and are found to outperform the manual process on several performance characteristics.

Friday November 24, 2023

Session 4: ORSNZ SIG on Healthcare Analytics Session – 11:00am-12:20pm, Room 423-340

Chair: Andrea Raith

An Analysis of Oncology Drug Prescription Patterns using Hidden Markov Models

24 Nov
11:00-11:20am
Room 423-340

Shirekha Layangani, LDC, Fernando S. Oliveira, and Valery Pavlov
University of Auckland

This article investigates the prescription patterns of oncology Named Patient Drugs (NPDs). This is a complex problem due to the uncertainties surrounding the dynamic nature of drug prescription patterns, the interaction between national and hospital-level policies, and the idiosyncrasies of various oncologists. While traditional statistical analysis has yielded valuable insights into the utilization of oncology drugs, it is apparent that previous literature still needs to address the uncertainties surrounding oncology drug prescription patterns. To bridge this gap, our study introduces an innovative model that utilizes Hidden Markov Models (HMMs) to identify oncology drug prescription patterns. We chose HMMs for their ability to capture longitudinal profiles, model hidden dependencies, and effectively handle the uncertainties associated with cancer diagnosis and treatment. We fit our model using procurement data collected from a Sri Lankan hospital, and the findings offer insights into the evolving prescription patterns from 2015 to 2021, particularly in distributing NPDs across various cancer diagnoses. This approach empowers hospital management to comprehend the dynamic nature of oncology drug prescription patterns. The study reveals prescription trends by calculating transition and joint probabilities, providing insights into shifts in drug selection approaches. These insights can optimize inventory management, inform prescription guidelines, and enhance patient care and resource allocation. This knowledge empowers healthcare management to refine oncology drug prescription practices, ensuring more effective treatments and resource allocation, particularly under budgetary constraints.

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24 Nov
11:20-11:40am
Room 423-340

Pandemic Resilience – Developing an AI-calibrated ensemble of models to inform decision making

Michael O'Sullivan, Nathaniel Hupert, Patrick McSharry, Risto Miikkulainen, Olivier Francon, Jamieson Warner, Victoria Agyepong, Sobhan Chatterjee, Nathan Allen, Arnaud Quenneville-Langis, Sahar Bahrami, Ahmed Farid

Global Partnership of AI (GPAI), University of Auckland, Cornell University, Carnegie Mellon University Africa, University of Texas at Austin, Cognizant AI Labs, CEIMIA, Beyond3Generations, McGill University, Sudanese Standards and Metrology Organization

The use of ensemble modeling of infectious diseases can enable better data-driven decisions and policies related to public health threats in the face of uncertainty. This presentation will discuss research that demonstrates how Artificial Intelligence (AI)-driven techniques can automatically calibrate ensemble models consistently across multiple locations and models. The ensembling, calibration, and evidence-generation presented was conducted by an interdisciplinary team recruited by the Pandemic Resilience project team via the Global Partnership on Artificial Intelligence (GPAI) Pandemic Resilience living repository. This diverse team co-developed and tested a collaborative ensemble model that assesses the level of use of Non-Pharmaceutical Interventions (NPIs) and predicts the consequent effect on both epidemic spread and economic indicators within specified locations. The disease of interest was COVID-19 and its variants.

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24 Nov
11:40am-12:00pm
Room 423-340

Equitable Surgery Scheduling

Tom Adams

University of Auckland

When scheduling surgeries it is important to take into account that not every operation on the waiting list is equally urgent. Instead the urgency of each patient can depend on the many factors such as: the particular condition they have, their age, any other comorbidities, and how long they have been waiting.

In this work we assume that the patients on the waiting list can be ranked in terms of most to least urgent. Given such an ordering we examine several algorithms for scheduling operations into operating room sessions and explore the consequences in terms of both equitable principles such as impartiality and consistency, and the efficient use of resources.

A biobjective math-heuristic for patient transport scheduling

24 Nov
12:00-12:20am
Room 423-340

Andrea Raith, Andrew Mason, and Melanie Reuter-Oppermann
University of Auckland, University of Twente, University of Auckland

We investigate the problem of planning patient transports where patients need to be picked up at one location and dropped off at another. Those patient transports are often part of the emergency medical services system, as is the case for instance in Germany. While patients should be transported at the requested time without delaying them, the costs for the transports also need to be considered. A biobjective mixed-integer programming (MIP) formulation is presented and additional objectives are discussed. Due to problem size and complexity of solving biobjective integer programmes, the MIP approach is only feasible for small problem instances. For larger problems a math-heuristic is introduced, which extends the idea of a columnwise neighbourhood search heuristic to the biobjective case. We explore performance of the proposed biobjective columnwise neighbourhood search heuristic under different configurations for test cases that resemble real-world problem instances.

Session 5: Energy and Natural Resources SIG Session – 1:20-2:40pm, Room 423-340

Chair: Andrew Mason

Optimisation of Inductive Power Transfer Modules for In-Road EV Charging

24 Nov
1:20-1:40pm
Room 423-340

Brian Gu, Michael O'Sullivan, Seho Kim, Grant Covic
University of Auckland

Globally, there are significant investments in electric vehicle (EV) chargers. Inductive power transfer (IPT) provides an alternative solution of wireless in-road charging. While this is an attractive premise, the cost, mechanical robustness, and different power requirements of EVs remain a significant design challenge. This work applies operations research thinking by using metaheuristic optimisation to design the IPT system architecture. In the first design example, IPT modules are designed using a genetic algorithm optimiser. Due to the non-linear behaviour of magnetic fields, ANSYS finite element analysis (FEA) simulation is executed in parallel to resolve design parameters. The optimisation is shown to be effective in designing robust and design compliant IPT modules over a heuristic approach. Furthermore, the scalability of this approach requires a fast optimisation framework robust to changes in design criteria. To this end, a neural network is trained as a surrogate model to replace the computationally expensive ANSYS solver. This model uses the time-consuming simulations during the training process allowing for quicker accurate predictions. As a result, repeating the optimiser for different weightings of

design criteria is trivial. With this optimisation framework tested, the next step will be to incorporate more design possibilities and address more challenging design contexts, such as dynamic roadway charging.

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24 Nov
1:40-2:00pm
Room 423-340

Multi Scale Analysis of Energy Systems with MicroGrids

Zainab Rizvi, Con Lu, Cameron Walker, Michael O'Sullivan
University of Auckland

In this research, we are testing the hypothesis that JADE can be used to model energy management problems at varying levels of energy supply and demand magnitude in New Zealand. JADE is an optimization software program which encapsulates New Zealand hydro-power generation scheduling and future water value prediction. It can be used to model the energy transition from carbon-intensive sources to renewable ones. This exercise aims to ensure that the said transition is an equitable distribution of benefits and burdens within the society.

Countries are facing energy management problems in the face of the growing energy demand. In some cases, the drive towards development and economic dominance is causing countries to ramp up production, leading to greater demand for dispatchable power. In countries like New Zealand, the drive to achieve net carbon zero means that it needs to accelerate the country's electrification, mainly in the transport and industrial sectors [1]. This national-level policy will result in a surge in electricity demand. The caveat is that the increased electricity demand has not been met with equal electricity production from renewable resources. This increased demand could lead to increased coal-based power production in the interim and increased electricity bills in the next decade to cover the cost of increasing renewable resource-based electricity production and transmission capacity. Additionally, the increased incidence of extreme weather incidents is testing the resilience of the existing legacy infrastructure. The problem is twofold: The energy system in New Zealand needs to be more resilient and must have greater capacity.

Increasing power production will put a load on a fallible, complex, centralized power system that does not have the capacity to transmit said power [2]. One solution is to build a distributed power system based on renewable energy. This is a complex endeavour which will require the participation of all the independent entities in the electricity market supply chain [3]. The alternative is to build a decentralized energy system based on community Microgrids [3]. Microgrids are electricity distribution systems containing loads and distributed energy resources, (such as distributed generators, storage devices, or controllable loads) that can be operated in a controlled, coordinated way either while connected to the main power network or while islanded [4]. Such a design can be started at a small scale, targeting areas needing a resilient energy system capable of standing alone in case of power supply disruption from the centralized distribution system.

However, the problem we are trying to solve deals with a complex system i.e., the New Zealand energy system. We are studying the impact of a small entity, microgrids, on the overall national grid and vice versa. We intend to find the emergent behaviour in the system to find the tipping point for microgrid adoption within a

region, given its specific socioeconomic and environmental needs [5], for optimal cost and energy generation balance.

We have approached the problem by modelling the impact of microgrid adoption on the central grid at a small, regional scale. Mixed Integer programming techniques work well with energy management problems. JADE is a Stochastic Dual Dynamic Programming model encapsulating New Zealand hydro-power generation and future value prediction. It is used by the New Zealand Electricity Authority to set the electricity prices. The model predicts the amount of power that can be generated using hydropower, how much power will be generated by other sources like geothermal and coal to make up for any shortfall, and the overall cost of power generated. In this research, we will extend the model to predict the change in power production requirements if parts of New Zealand adopt Microgrids.

It must be noted that the problem is more complex than simply deploying Microgrids. Solar or wind-based power has an intrinsic stochasticity, which makes it challenging to harness the power generated [2,6]. Additionally, the excess power in the energy system must be dispatched. The energy system allows for minimal power to reside in the system [7]. Therefore, a model is needed to simulate the variable energy produced, its dispatch, and the effect on the overall energy system at the national level. Such an exercise is an application of multi-scale analysis [5].

Using JADE, we will evaluate different levels of adoption in terms of cost of electricity generation, transmission costs, coal consumption, and water reservoir levels. As an initial study, we have selected the flood-affected area of Tairawhiti (Gisborne) as there was a clear need for resilient, distributed energy systems. It would take time and resources to inject the required level of resilience and capacity into the traditional energy system, which would, in turn, drive up the energy cost such that it will not be affordable to the already vulnerable communities.

Tairawhiti (Gisborne) in New Zealand is connected to the centralized power infrastructure via one node at Tuai, meaning there is no fail-over option if the link to the central grid is disrupted. Additionally, it is challenging to reinstate the connection in a timely manner in case of extreme weather events. In this paper we explore a community Microgrids based solar array solution for Tairawhiti. We will model the impact of such microgrids on the New Zealand energy system through JADE.

The goal of this research is to find the balance between economic feasibility, resilience, and capacity for Microgrid adoption by the electricity consumers in Tairawhiti.

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24 Nov
2:00-2:20pm
Room 423-340

An LP-based Exchange to Maximise the Value of Delivered Water, while Managing Multiple Environmental Impacts

E Grant Read

[Organisation]

Traditionally, LP has mainly been used to perform "top-down" optimisation of decisions controlled by a single decision-maker. More recently, it has been used to create "smart markets" , coordinating short-term decision-making by multiple competing decision-makers. And, in the electricity sector, it has been supplemented by trading of long-term financial instruments, hedging the risks arising from such short-term markets. For some years we have been researching ways of applying the lessons in electricity markets to water, and water-borne pollutants. But the sector is different, in several ways, and here we propose a re-interpretation of the LP-based smart market/hedging paradigm to create an exchange more suited to that environment

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24 Nov
2:20-2:40pm
Room 423-340

Planning renewable electricity capacity using JADE

Andy Philpott, Jarand Hole, Anthony Downward, Oscar Dowson

Electric Power Optimization Centre, University of Auckland

JADE is a stochastic dual dynamic programming model of the New Zealand electricity system written in Julia. It was developed by Lea Kapelevich based on the SDDP.jl Julia package developed Oscar Dowson. JADE stands for Just Another Doasa Executable since it is essentially a replica of the DOASA C++ model developed in the early 2000's by Pritchard, Philpott, Guan and de Matos. We describe the JADE software and its application to planning wind and peaker capacity in New Zealand. The role played by potential energy storage at Lake Onslow will also be discussed.

Session 6: Modelling and Insights 2 – 3:00-4:20pm, Room 423-340

Chair: Tom Adams

Designing Service Menus for Bipartite Queueing Systems

24 Nov
3:00-3:20pm
Room 423-340

Rene Caldentey, Varun Gupta, **Lisa Aoki Hillas**
University of Chicago, University of Auckland

We consider a multi-class multi-server queueing system, in which customers of different types have heterogeneous preferences over the many servers available. The goal of the service provider is to design a menu of service classes that balances two competing objectives: (1) maximize customers' average matching reward and (2) minimize customers' average waiting time. A service class corresponds to a single queue served by a subset of servers under a FCFS-ALIS service discipline. Customers act as rational self-interested utility maximizing agents when choosing which service class to join. That is, they join the class that maximizes their expected ex-ante net utility, which is given by the server-dependent service reward they receive minus a disutility based on the mean steady-state waiting time of the service class they join. We study the problem under (conventional) heavy traffic conditions, that is, in the limit as the traffic intensity of the system approaches one from below. For the case of two servers, we provide a complete characterization of the possible menus and their delay-reward tradeoffs. For a general number of servers, we prove that if the service provider only cares about minimizing average delay or maximizing total matching reward, then very simple menus are optimal. Finally, we provide Mixed Integer Linear Programming (MILP) formulations for optimizing the delay-reward trade-off within a fairly rich and practically relevant families of menus.

Behavioral Enablers of Servers in Queueing Systems

24 Nov
3:20-3:40pm
Room 423-340

Valery Pavlov, **Aida Shams**
University of Auckland

In this research, we explore the interplay between queue configuration and server performance. Based on the recent findings in behavioral queueing, we design two lab experiments. In the first lab experiment, we investigate the group dynamics of servers operating in various queue configurations. We discover that shared queue structures tend to heighten servers' perceptions that their individual efforts cannot be identified, and that their contributions are dispensable, both of which can demotivate servers and lead to a decrease in their working speed. In the second lab experiment, we examine servers' perceptions of goal characteristics and feedback levels within different queue configurations. Our findings indicate that, provided social loafing is controlled, there is no significant performance difference between servers in shared and dedicated queues in terms of work rate and persistence. However, dedicated queues foster an environment conducive to more specific goal-setting

and improved perception of feedback, which can enhance performance by empowering servers to devise smarter strategies to accomplish their tasks. This research contributes to our understanding of server behavior in queueing systems, and offers significant managerial implications by delivering empirically-validated and theory-supported recommendations for practitioners in the service sector.

Visualising the column generation processes for the airline crew rostering problem

24 Nov
3:40-4:00pm
Room 423-340

Michael Zhang, Andrea Raith, Andrew Mason
University of Auckland

The airline crew rostering problem is an optimisation problem solved by many airlines to assign crew members to flights while adhering to all the airline rules and regulations. The linear programming formulations that can arise are commonly solved with a technique known as column generation. To solve large-scale problems in practice, we must apply acceleration techniques and heuristics in conjunction with column generation to obtain a good solution in a reasonable time frame.

We use the vast amount of solution process data obtained during the solution process to develop a suite of visualisation tools. These tools help us visualise the characteristics of solutions in the iterative process that alternates between solving linear programs and generating new columns. The tools highlight the intricacies of the solution process while also allowing us to garner valuable insight into the solution process.

This presentation will begin with an outline of the airline crew rostering problem and the column generation solution process. We then utilise our visualisation tool to illustrate a few examples of insights into algorithm performance our tools enable us to obtain.

JuMP: the year in review

24 Nov
4:00-4:20pm
Room 423-340

Oscar Dowson

We present our now annual update on recent improvements to JuMP, a modeling language for mathematical optimization in Julia. A summary of the new features includes:

- an entirely rewritten nonlinear programming API
- support for multi-objective programs
- support for nonlinear mixed-complementarity programs
- support for complex variables

- support for constraint programming, including MiniZinc support and Boolean logic constraints
- support for generic number types, including exact rational arithmetic and extended precision.

Closing

Unuhia, unuhia	Draw on, draw on,
Unuhia ki te uru tapu nui	Draw on the supreme sacredness
Kia wātea, kia māmā, te ngākau, te tinana, te wairua i te ara takatā	To clear, to free the heart, the body and the spirit of mankind
Koia rā e Rongo, whakairia ake ki runga	Rongo, suspended high above us (i.e. in 'heaven')
Kia tina! TINA! Hui e! TāIKI E!	Draw together! Affirm!

Author Index

Adams
Tom, 10
Agyepong
Victoria, 10
Allen
Nathan, 10
Aoki Hillas
Lisa, 15

Bahrami
Sahar, 10

Caldentey
Rene, 15
Chatterjee
Sobhan, 10
Covic
Grant, 11

Downward
Anthony, 14
Dowson
Oscar, 14, 16

Farid
Ahmed, 10
Francon
Olivier, 10

Gu
Brian, 11
Gupta
Varun, 15

Hole
Jarand, 14
Hupert
Nathaniel, 10

Keehan
Dominic, 5
Kim
Seho, 11
Kulasingham
Daniel, 4, 6

Layangani
Shirekha, 9
Lu
Con, 12
Yuqian, 6

Marshall
Sarah, 7
Mason
Andrea, 11
Andrew, 3, 5, 16
McSharry
Patrick, 10
Miikkulainen
Risto, 10
Mohaghegh
Mahsa, 7

O'Sullivan
Michael, 4, 10–12
Oliveira
Fernando, 9
O'Sullivan
Michael, 6

Papen
Mostafa, 6
Pavlov
Valery, 9, 15
Philpott
Andy, 5, 14

Quenneville-Langis

Arnaud, 10

Raith
Andrea, 5, 11, 16
Ramesh
Akhil, 6
Read
E Grant, 14
Reuter-Oppermann
Melanie, 11
Rizvi
Zainab, 12

Shams
Aida, 15
Sinnen
Oliver, 5

Udagedara
Yasith, 5

Walker
Cameron, 4, 12
Warner
Jamieson, 10

Zhang
Michael, 16
Zou
Yang, 6