ORSNZ Annual Conference 2024

Operations Research Society of New Zealand (ORSNZ)

December 5-6, 2024

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

ORSNZ Conference Programme

Thursday 5th December 2024

9:00 - 9:30 am	**Registration**
9:30 - 9:40 am	**Opening**
9:40 - 11:00 am	**Session 1: Energy and Natural Resources** Sponsored by Green Energy Engineering Centre (GEEC) (Chair: Andrea Raith) Brent Young, *Simulation-based examination of hybrid biomass-electric energy systems for demand response and decarbonisation of industrial utilities* Madison L. Zegeer, *Assessing the Impact of Climate Change on Residential Energy Systems: Simulating Solar Photovoltaic and Heat Pump Yields for Future New Zealand Climate Conditions* Zainab Rizvi, *Multi Scale Analysis of Energy Systems with Microgrids* Andreas W. Kempa-Liehr, *Multi-level modelling with missing data for recovering the history of geothermal wells*
11:00 - 11:30am	Morning Tea Sponsored by GEEC
11:30 am - 12:30 pm	**Session 2: Plenary** (Chair: Andrea Raith) Jannik Haas, University of Canterbury, *A million decisions towards net zero: optimization tools to plan the required energy infrastructure*
12:30 pm 1:00 pm	*Lunch* ORSNZ AGM
1:40 - 3:00 pm	**Session 3: Uncertainty and OR in practice** (Chair: Sarah Marshall) Oscar Dowson, *MathOptAI.jl* Dominic Keehan, *Estimation of Shifting Probability Distributions using the Wasserstein Metric* E Grant Read, *Writing LP formulations for Market Clearing Problems in Legal Format* Juliette Foley, *Minimisation of Cost and Emissions for Supermarket Product Purchases Across Recipes*
3:00 - 3:30 pm	*Afternoon Tea*
3:30 - 6:00 pm	**Gurobi Community Networking Event** Old Government House *(requires registration)*
6:30 pm	**Conference Dinner** at Apéro Food & Wine, 280 Karangahape Road. Arrive from 6pm

Friday 6th December 2024

8:45 am	**Registration**
9:00 am	**Session 4: Transport** (Chair: Lisa Hillas) Yunlong Wang, *A Framework for Continuous Operation of Shared Autonomous Vehicles in Dynamic Traffic Environments* Jing Xiao, *Heterogeneous passenger guidance based on service fairness in an urban rail transit system* Evelyn Wen, *Enhancing public transport system efficiency with carpooling facilities as a first- and last-mile solution, a cost-neutral approach* Ahmed Abdelhadi, *Simulation-optimization approach for charging setup for E-Taxi adoption using Dynamic Charger Swapping for Optimal Distribution and Location*
10:20 - 10:40 am	*Morning Tea*
10:40 am - 12:00 pm	**Session 5: OR in Industry** (Chair: Paul Rouse) Oliver Weide, *Airline Optimisation Challenges and Opportunities* Siamak Moradi, *One Size Doesn't Fit All: Real Stories of Supply Chain Solutions in Action* Isaac Cleland, *From PhD to Startup: Scaling Operations Research for Enterprises* Discussion - *Opportunities of OR in Aotearoa NZ*
12:00 pm 12:30 pm	*Lunch* ORSNZ Council meeting
1:00 – 1:40 pm	**Session 6: Plenary** (Chair: Andreas Kempa-Liehr) Yun Sing Koh, University of Auckland, *Turning Algorithms into Action: Machine Learning for Social Good*
1:40 - 2:00 pm	Mike O'Sullivan (Jr), *Empowering Healthcare Delivery using Digital Ecosystems*
2:00 - 2:20 pm	*Afternoon Tea*
2:20 - 3:40 pm	**Session 7: Scheduling and Integer Programming** (Chair: Andrew Mason) Oliver Sinnen, *Column generation algorithm for task scheduling in parallel systems* Akhilnandh Ramesh, *Digital Twin-Integrated Fuzzy Flexible Job Shop Scheduling with Real-World Machine Preference Constraints and Schedule Stability Optimization* Basile Blayac, *Neighbourhood Pricing applied to the Generalized Assignment Problem* Thomas Adams, *Icelandic Groundfish Survey Formulations*
3:40 - 4:00 pm	**Prizegiving and Closing**

Thursday 5th December 2024

Session 1: Energy and Natural Resources – 9:40am-11:00am, Room 423-340

Sponsored by Green Energy Engineering Centre (GEEC) Chair: Andrea Raith

Simulation-based examination of hybrid biomass-electric energy systems for demand response and decarbonisation of industrial utilities

5 Dec
9:40-10:00am
Room 423-340

Brent Young, Michael Kalpage, and Wei Yu
University of Auckland

Electrification of industrial sites holds potential in decarbonisation of industrial processes, but fluctuation in electricity price in highly renewable-integrated grid systems is daunting for industry. Demand response can potentially aid in this, but challenges are faced by the process industries, where interruption is not feasible due to quality concerns. Combining electricity with biomass in a hybrid system allows for biomass to serve as mitigation against electricity price volatility and enabling demand response when advantageous. This work presents a simulation-based approach and examines biomass-electric boiler systems applied to the NZ food process industry in a case study, with both techno-economic and environmental criteria used for assessment. The focus of the study includes examining the ideal sizing of the system across various scenarios, considering factors such as different years for electricity prices and oversizing. The results indicate that biomass-electric systems engaging in demand response can reduce costs by between 12-28%, with even systems not engaging in demand response being more economical than pure biomass systems when the electricity price is more stable. Oversizing to allow for future increases in heat demand is highly cost-effective, with the ideal size of an electric boiler being 52-54% of the overall utility system capacity. Different demand response strategies are also examined in the work and a sensitivity analysis conducted.

Assessing the Impact of Climate Change on Residential Energy Systems: Simulating Solar Photovoltaic and Heat Pump Yields for Future New Zealand Climate Conditions

5 Dec
10:00-10:20am
Room 423-340

Madison L. Zegeer, Rebecca A.M. Peer, and Jannik Haas
University of Canterbury

We investigate how higher temperatures resulting from climate change impact the energy system. Specifically, we examine the cumulative effects of fluctuating solar photovoltaic (PV) generation performance, heating and cooling demand, and heat pump efficiency on such days.

To achieve this, we used the climate analogue space, which maps a given city's future climate to an existing one. By employing climate analogues, we can predict the impact of higher temperatures by 2050. This approach avoids reliance on historical weather data, which many energy system models use. We used this future climate time series as an input to a residential energy system model for cities in New Zealand. The residential energy system model simulates solar PV generation output via mapping of experimental data, building thermal characteristics via grey-box resistance-capacitance (RC) modelling, and hourly coefficient of performance (COP) for air source heat pumps (ASHP) via linear regression. Our findings revealed that a future climate doubles the cooling demand and reduces the heating demand by one-third, with the heat pump demand peak load projected to be higher than the current demand. Although solar PV generation experiences a slight decrease in efficiency, there is an increase in annual direct usage of ASHP. Despite the high cooling demand, the combined yearly electricity demand for heating and cooling decreased overall, and the system saw an improvement in demand fulfilment. However, the system performance volatility at hotter-than-normal temperatures and the potential for significant energy shortfalls remain concerns. The shift from a predominantly heating to a cooling environment is a critical design condition that should be considered in energy expansion planning and future electrification.

The framework and time series developed in this work can be expanded and applied to other energy system modelling exercises. The resulting energy demand vector can be incorporated into deterministic model scenarios for further analysis.

Multi Scale Analysis of Energy Systems with Microgrids

5 Dec
10:20-10:40am
Room 423-340

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

In this research, we are testing the hypothesis that models of the New Zealand Electricity System, like vectorized Scheduling Pricing and Dispatch (vSPD), can be used to explore a variety of energy management problems with different levels of energy supply and demand magnitude. vSPD, a linear program to solve the New Zealand electricity distribution problem, can be used to model changes in the electricity system, such as the energy transition from carbon-intensive sources to renewable ones. Here, we present initial experiments with vSPD as a first step

towards digital twin modeling to ensure that the transition to renewable energy sources provides an equitable distribution of societal benefits and burdens.

However, the changes we are observing take place in a complex system. We are studying the impact of deployments of (various sizes of) Microgrids on the overall national grid and how the national grid would integrate with (small-scale) Microgrids. We intend to use sensitivity analysis of the system to identify tipping points for Microgrid adoption. This analysis may look at changes that take place within a region, e.g., Microgrid adoption within that region, and include that region's specific socioeconomic and environmental needs, or it might look at the level of adoption of Microgrids at a national scale. Either of these scenarios can be investigated using the approach presented here.

We approach this problem by modelling the effect of Microgrid adoption for an entire region on the central grid through vSPD. vSPD emulates the national grid through a static network model of supply and demand nodes (geographical locations where electricity is either injected into the system or where electricity demand is aggregated). To explicitly include the region of interest, Tai Rāwhiti, we modify demand for Tuai, the node TUI1101. We evaluate different levels of Microgrid adoption in terms of the cost of electricity generation, the price at which electricity is sold at each node, and indirect the use of coal/gas for power generation. We have selected the flood-affected area of Tai Rāwhiti as there was a clear need for resilient, distributed energy systems, and Microgrids are one suitable technology for these types of systems. This research aims to perform an initial cost comparison for satisfying energy demand from Tai Rāwhiti with and without Microgrids in place.

Multi-level modelling with missing data for recovering the history of geothermal wells

5 Dec
10:40-11:00am
Room 423-340

Andreas W. Kempa-Liehr, Daniel Clark, Michael Terekhin, John O'Sullivan, and Michael Gravatt

University of Auckland

Geothermal reservoir modelling requires detailed historical extraction data to predict a geothermal system's future state accurately. However, this data is rarely available to modellers. Often, wells are sparsely measured, while grouped measurements, such as the mass flow at a separator, occur more frequently. Previously, the data history of individual wells has been estimated manually, leading to an inaccurate and subjective dataset with unquantifiable uncertainty. This inaccuracy is a severe problem for geothermal reservoir models, which rely on having accurate, well-by-well data to generate reliable predictions.

This presentation outlines the process undertaken to develop methods of estimating the history of individual wells from sparse observations. We are discussing two data-driven models to address this issue. The first method minimises a problem-specific loss function while considering both the data's hierarchy and sparsity.

The second method uses Gaussian Process Regression (GPR) to solve the sparse data problem. GPR is a Bayesian approach that assumes temporal correlation between dense data points based on a kernel function. This approach was modified so

that the total mass flow at the separator was taken into account. Both methods were tested on synthetic data and data from an operational geothermal field. The results of these methods both show merit in providing solutions recovering the history of individual geothermic wells from sparse observations.

Session 2: Plenary – 11:30am-12:30pm, Room 423-340

Chair: Andrea Raith

A million decisions towards net zero: optimization tools to plan the required energy infrastructure

5 Dec
11:30am-12:30pm
Room 423-340

Jannik Haas
University of Canterbury

My keynote will focus on energy transitions. These are huge(!) optimization problems spanning over multiple regions, decades, and hundreds of technologies, resulting in millions of possible decisions. The solution is non-trivial, and it might even surprise you.

Session 3: Uncertainty and OR in practice – 1:40pm-3:00pm, Room 423-342

Chair: Sarah Marshall

MathOptAI.jl

5 Dec
1:40-2:00pm
Room 423-342

Oscar Dowson
JuMP

We present MathOptAI.jl, a JuMP extension for embedding trained AI, machine learning, and statistical learning models into a JuMP optimization model. As a motivating application, we consider the minimum cost optimization of a power system subject to stability constraints. Offline, we train a neural network classifier to predict whether an electricity network will be stable given nodal power injections, and then we embed that neural network into a AC optimal power flow optimization model to determine the optimal dispatch and transmission, subject to the constraint that the classifier predicts the system will be stable.

Estimation of Shifting Probability Distributions using the Wasserstein Metric

5 Dec
2:00-2:20pm
Room 423-342

Dominic Keehan and Edward Anderson
University of Auckland

In many practical situations historical data is drawn from probability distributions which shift unpredictably over time. We study a distribution estimation problem where at each time period shifts are penalised according to the Wasserstein metric. The resulting distribution estimate may be used to inform a downstream stochastic optimisation problem. We take this approach in an application involving forecasting the future market prices of certain dairy commodities.

Writing LP formulations for Market Clearing Problems in Legal Format

5 Dec
2:20-2:40pm
Room 423-342

E Grant Read
University of Canterbury

Market clearing formulations are formulated as mathematical programmes, and in particular linear programmes (LPs). Academics like compact LP formulations, elegantly formatted in LaTeX. Few outside academia understand such formulations, though, or find them "commercially credible". Thus, the Microsoft Word equation editor is often used to present electricity market clearing formulations in a much more extensive form, using long "self explanatory" variable names. But those formulations are still aimed at an audience with strong mathematical backgrounds. And they stand in stark contrast to the main market rules, structured into clauses, sub-clauses, sub-sub clauses etc , such as a lawyer or executive might be expected to understand. This presentation addresses the challenge of writing market-clearing LP formulations for sectors where participants and advisors do not have such strong mathematical backgrounds, in a form consistent with the remainder of the market rules.

Minimisation of Cost and Emissions for Supermarket Product Purchases Across Recipes

5 Dec
2:40-3:00pm
Room 423-342

Juliette Foley
University of Auckland

Growing consumer interest in sustainability has highlighted the need for greater transparency regarding the environmental impact of food choices. This study presents an optimisation model that minimises both grocery costs and life cycle emissions by selecting weekly recipes based on products from a New Zealand supermarket.

The model integrates recipes with ingredient-specific emissions data and real supermarket product options. Key challenges addressed include the lack of standardisation in food naming and categorisation, variability in recipe measurement units, and differences in emissions for similar products due to country of origin and

farming practices. These issues underscore the complexity of accurately assessing food-related emissions.

The model allows users to prioritise the weighting towards cost reduction or emissions minimisation, catering to varying willingness and ability to pay for lower-emission food options. This approach aims to help clarify the relationship between emissions, costs, and grocery choices, intending to support more environmentally informed consumer decisions.

Friday 6th December 2024

Session 4: Transport – 9:00am-10:20am, Room 423-340

Chair: Lisa Hillas

A Framework for Continuous Operation of Shared Autonomous Vehicles in Dynamic Traffic Environments

6 Dec
9:00-9:20am
Room 423-340

Yunlong Wang, Minh Kieu, and Prakash Ranjitkar
University of Auckland

The rapid advancement of artificial intelligence is paving the way for shared autonomous vehicles (SAVs), which are expected to replace private vehicles and enhance transportation efficiency.Dynamic Wireless Charging (DWC) technology has emerged as an ideal solution to enable continuous operation of SAVs, allowing SAVs to charge while driving. However, conventional vehicle routing algorithms are inadequate for SAVs' pickup, delivery, and charging problems, lack flexibility in dynamic traffic, and fail to incorporate DWC. Given this, we introduce a Two-Stage Deep Reinforcement Learning framework (TDRL) to address these challenges. This framework develops global routing strategies considering route costs, state of charge (SOC), and route re-planning strategies that can handle dynamic traffic. The first stage of TDRL employs a heterogeneous attention mechanism to integrate diverse node information for DWC node selection. The second stage uses this global route as a baseline, re-assessing current traffic to enable strategic route adjustments, including the deletion and re-insertion of node pairs under a dynamic Mask scheme. Experimental results demonstrate that TDRL outperforms existing heuristic algorithms in reducing route costs and maintaining SOC stability.Moreover, TDRL significantly mitigates the impact of traffic fluctuations on route costs (16.2% for the 50-node model and 23.7% for the 100-node model) and SOC distribution, and the dynamic Mask scheme exhibits good robustness during different traffic peak periods.

Heterogeneous passenger guidance based on service fairness in an urban rail transit system

6 Dec
9:20-9:40am
Room 423-340

Jing Xiao and Andrea Raith
University of Auckland

As metro ridership grows, the conventional demand management approach, Passenger Allocation and Control (PAC) is inadequate for addressing operational challenges, such as station congestion and service inequity, while potentially disrupting passengers' travel plans and causing suboptimal travel experiences. Trip Reservation (TR) offers a promising solution by enabling passengers with special travel needs to submit applications, which metro operators can then adjust, accept, or reject. However, unresolved challenges remain in applying TR to metro demand management, including which applications to accept and adjust and how to control other passengers effectively. We propose a nested Heterogeneous Passenger Guidance (HPG) model that integrates TR with PAC to address these problems. This model generates an HPG scheme considering passengers' heterogeneity, satisfying some travel needs while ensuring service fairness across the network. Moreover, it improves operational efficiency and passenger travel experiences. The HPG model's effectiveness is validated in a unidirectional subway line, where it reduces station congestion by 31.97% and 19.04% compared to scenarios without TR and with static reservations, respectively, and enhances service fairness by reducing the maximum number of missed trains from 2 to 1. Furthermore, the HPG model reduces peak-period flows by adjusting and accepting some applications, mitigating safety risks and operational pressures.

Enhancing public transport system efficiency with carpooling facilities as a first- and last-mile solution, a cost-neutral approach

6 Dec
9:40-10:00am
Room 423-340

Evelyn Wen
University of Canterbury

First- and last-mile connections to urban public transport networks are essential for linking homes and workplaces to transit hubs, encouraging public transport commutes, thereby mitigating congestion and carbon emissions. However, challenges, such as diverse landscapes, inadequate infrastructure, and financial constraints, demand innovative and cost-neutral solutions. This research aims to devise strategies that integrate customer feedback, spatial and temporal analyses of commuter movements, and an assessment of economic costs and benefits, particularly in Wellington where a significant portion of employment is concentrated in the Central Business District (CBD).

We propose free carpooling facilities and paid single-occupancy carparks at train stations in Wellington, supported by AI CCTV surveillance. This initiative is designed as a solution to the first- and last-mile connectivity challenges to encourage share riding to train stations. It is expected that carpool parks would bring in additional regular train commuters and generate additional revenue from their train

fares. The anticipated would then be reinvested to enhance peak-hour service frequency, thereby improving accessibility and operational efficiency without necessitating changes to the current funding model for existing train services. By optimising resource allocation and maximising the impact of transportation investments, this research offers a sustainable approach to addressing the first- and last-mile challenges while adhering to financial constraints.

Simulation-optimization approach for charging setup for E-Taxi adoption using Dynamic Charger Swapping for Optimal Distribution and Location

6 Dec
10:00-10:20am
Room 423-340

Ahmed Abdelhadi and Andrea Raith
University of Auckland

As the transportation industry, particularly the taxi sector, moves towards electrification, taxi companies may be hesitant to adopt all-electric fleets due to concerns about charging infrastructure, long wait times, charging duration, and the risk of missing paid trips due to insufficient state-of-charge. To address these concerns, we propose a framework designed to simulate electric taxi (E-taxi) services and optimize the configuration of charging units at predefined locations. The core of our approach is a local search algorithm that iteratively improves the configuration of charging stations. Starting with an initial configuration, the E-taxi simulation evaluates system performance such as the number of missed trips and the total queuing time. For each charging station, two types of neighborhoods are explored: relocating a charging unit at the charging station while keeping the same charger type, and changing the charger type. Each neighboring configuration is evaluated by simulation, and the configuration with the lowest number of missed trips is chosen. The process repeats until no further improvements can be found, resulting in a series of configurations and their corresponding performance metrics. The analysis of the results reveals that configurations with a higher number of wireless charging units tend to result in fewer missed trips. Conversely, increasing the number of plug-in charging units is associated with a higher number of missed trips. Queuing time does not show a strong relation with either wireless or plug-in charging units, suggesting other factors may influence it more significantly. Configurations with a balanced mix of wireless and plug-in units yield mixed results, with some setups performing better than others. Notably, certain configurations emerge as good compromises, achieving relatively low missed trips and queuing times. Overall, having more wireless charging units appears beneficial for minimizing missed trips, while the impact on queuing time varies

---

Session 5: OR in Industry – 1:20-2:40pm, Room 423-340

Chair: Paul Rouse

6 Dec
1:20-1:40pm
Room 423-340

Airline Optimisation Challenges and Opportunities

Oliver Weide

WePlan

---

6 Dec
1:40-2:00pm
Room 423-340

One Size Doesn't Fit All: Real Stories of Supply Chain Solutions in Action

Siamak Moradi

Supply Chain Company

Supply chain solutions are not one-size-fits-all. The key to success lies in aligning business needs, data quality, and complexity to deliver measurable results. This presentation showcases our experiences in developing tailored approaches—from pure optimization models and AI-driven forecasting to heuristic methods and simulation—to address challenges such as scalability, irregular demand, and data variability. Discover how our solutions have driven meaningful outcomes across diverse business contexts.

---

6 Dec
2:00-2:20pm
Room 423-340

From PhD to Startup: Scaling Operations Research for Enterprises

Isaac Cleland

RosterLab

Transitioning from a PhD in Engineering Science to founding the startup RosterLab, I will share my experiences moving from academic optimisation models to creating an enterprise online solution. This talk will delve into building a scalable OR solution, the day-to-day life of a technical startup founder in operations research and how to raise funds as an OR expert. Drawing from my firsthand experience at RosterLab, I'll discuss the importance of accommodating imperfect user input and how dynamic model checkers can facilitate this process. I'll highlight the value of multi-level user systems across multiple areas that promote optimisation benefits and drive adoption across organisations. We'll explore strategies for implementing scalable technology that supports multiple generations of users without added complexity. This includes enhancing speed and scalability for rapid improvement cycles, having implicit rostering rules and using abstractions instead of explicit enumerations to simplify user interactions. Beyond the technical aspects, I'll offer a glimpse into juggling various roles as a startup leader. I'll also share insights on core selling points that are useful when fundraising for an OR company.

Session 6: Plenary – 1:00pm - 2:00pm, Room 423-340

Chair: Andreas Kempa-Liehr

Turning Algorithms into Action: Machine Learning for Social Good

6 Dec
1:00-1:40pm
Room 423-340

Yun Sing Koh
University of Auckland

Machine learning (ML) presents transformative opportunities to address some of society's most pressing challenges, from safeguarding biodiversity to enhancing climate resilience and advancing public health. This talk explores how machine learning for social good translates innovative algorithms into impactful real-world applications. Central to the discussion is our flagship biodiversity conservation project, which leverages state-of-the-art ML techniques and global best practices to create AI-driven solutions for animal re-identification and predator monitoring. We will also highlight the TAIAO programme, now in its fourth year of a seven-year initiative. TAIAO focuses on developing cutting-edge methods for analysing dynamic and complex environmental datasets, providing a foundation for adaptive and sustainable solutions. Together, these projects showcase the potential of ML to generate actionable insights and deliver substantial societal and ecological benefits.

Empowering Healthcare Delivery using Digital Ecosystems

6 Dec
1:40-2:00pm
Room 423-340

Mike O'Sullivan
University of Auckland

Cutting edge digital technology, such as digital twins and artificial intelligence (AI), is often seen as out of reach for front-line healthcare clinicians, let alone patients within the healthcare system. The new paradigm of digital ecosystems looks to integrate communities of people, e.g., clinicians in a healthcare organisation and/or patients in a healthcare area, within the design and deployment of a digital technology solution to create a digital ecosystem. Digital ecosystems can then empower people to both contribute data to as well as interact with integrated data, digital models - including digital twins - and AI to provide a platform for people to be engaged with and involved in their healthcare delivery and, hence, give them a voice in how healthcare is delivered by and/or to them. In addition, the place-based and federated nature of digital ecosystems means that the data sovereignty fundamentals of data privacy and data providers realising benefits from their data are respected.

This presentation will summarise the concept of digital ecosystems and explain how a digital ecosystem for healthcare delivery may work. A more detailed vision of how a digital ecosystem for surgical scheduling could help improve and transform the delivery of surgical services will be described and the existing precursors of such a digital ecosystem discussed.

Session 7: Scheduling and Integer Programming – 2:20pm -3:40pm, Room 423-340

Chair: Andrew Mason

Column generation algorithm for task scheduling in parallel systems

6 Dec
2:20-2:40pm
Room 423-340

Oliver Sinnen, Sergei Ogai, and Jake Bowden
University of Auckland

Today, virtually all computers are parallel systems with multiple processors. To efficiently use such a system it is crucial to carefully map and schedule the tasks of a program onto the processors. This is a very hard optimisation problem and can be described as a Mixed Integer Linear Program (MILP). Despite extensive research, only small instances can be computed optimally by modern solvers today. Delayed Column Generation is an algorithm that has been successfully deployed for large MILP in other domains. The advantage is that not all possibilities need to be enumerated. In this presentation we will be investigating the modelling and implementation of the task scheduling problem with a Column Generation algorithm. We present here early results for a simplified scheduling problem.

Digital Twin-Integrated Fuzzy Flexible Job Shop Scheduling with Real-World Machine Preference Constraints and Schedule Stability Optimization

6 Dec
2:40-3:00pm
Room 423-340

Akhilnandh Ramesh
University of Auckland

Mass customisation and Personalisation have resulted in a transition to High-Mix-Low-Volume (HMLV) Manufacturing. HMLV manufacturing is characterised by small batch production in Flexible Job Shops with varied process plans, uncertainty in processing times, and the need to consider machine-specific constraints on the shop floor. The resulting challenge has necessitated modifications to the Flexible Job Shop Scheduling Problem (FJSP) to incorporate mechanisms for handling processing time uncertainties while integrating real-time dynamicity. Addressing this, we propose a digital twin-integrated Fuzzy Flexible Job Shop Rescheduling algorithm that efficiently generates real-time production schedules by accounting for processing time and task progress uncertainties. This solution enables production rescheduling in response to disruptive events such as job arrivals, cancellations and dynamic task delays while accommodating real-time machine preference constraints. As a part of the solution, firstly, a five-dimensional architecture of the FJSP digital twin is presented. This is followed by a discussion of a service-oriented real-time production rescheduling mechanism that can provide real-time task progress visibility, identify disruptive events and initiate rescheduling. The proposed mechanism is integrated into a Flexible Job Shop Scheduling algorithm utilising Triangular Fuzzy

Numbers for representing processing times and NSGAII to optimise makespan, total weighted tardiness and schedule stability while accounting for machine capacity and structural rigidity constraints. A real-world case study from a machine shop manufacturing precision-engineered fluid transfer components is utilised to validate the developed rescheduling algorithm, and its performance is benchmarked against a set of FJSP dispatching rules.

Neighbourhood Pricing applied to the Generalized Assignment Problem

6 Dec
3:00-3:20pm
Room 423-340

Basile Blayac, Andrew Mason, and Andrea Raith
University of Auckland

Column generation-based optimization methods are commonly used to tackle various kinds of scheduling problems, such as airline rostering and staff rostering. During his PhD, Isaac Cleland explored the incorporation of neighbourhood constraints within a column generation procedure to solve staff rostering problems, a technique known as "neighbourhood pricing". It gave interesting results, including a significant improvement over traditional methods. Building on these findings, we apply a similar approach to another scheduling problem: the Generalized Assignment Problem (GAP). This problem consists of assigning different jobs to a given set of machines, while respecting knapsack constraints and minimizing total assignment costs. In this study, we investigate the impact of neighbourhood pricing on the GAP and evaluate its effectiveness on multiple aspects.

Icelandic Groundfish Survey Formulations

6 Dec
3:20-3:40pm
Room 423-340

Thomas Adams, Gary Kessell, Dana Smith, Cameron Walker, and Tómas Rúnarsson
University of Auckland

Every year since 1985 the Marine and Freshwater Research Institute of Iceland has carried out the Icelandic Groundfish Survey. The survey involves four vessels travelling to about five hundred sampling stations around Iceland over two weeks and trawling for fish at each location. The results from the survey are used to inform the Icelandic government about the stock levels of the groundfish species and set sustainable fishing limits.

During the survey each vessel completes a number of trips where they leave from a port, travel to and catch fish at some stations, and then return to a port. Generally the vessels are not able to visit all of the required stations in one trip because they do not have enough capacity to hold all of the fish caught or it has been too long since the first fish were caught and they need to be unloaded at a port while still fresh. The largest costs associated with completing the survey are the researchers' time on board the vessels and the fuel consumed by the vessels. Both of these can

be reduced by constructing trips that visit all the stations while minimising the distance travelled.

The problem of creating trips that visit all the stations and minimise the distance travelled can be formulated as a capacitated vehicle routing problem. We compare a traditional vehicle routing formulation with several other formulations. By testing on several problem instances the new formulations are shown to offer better computational performance.

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