51st Annual Convention of Operational Research Society of India & International Conference (ORSI 2018)

Mumbai, 16 - 19 December, 2018

Program Guide
&
Book of Abstracts

Indian Institute of Technology Bombay
Mumbai 400076

Our Sponsors

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Contents

1 Message from ORSI President

Our best wishes to the participants of the conference on "Emerging Trends in Operations Research and Management Science (OR/MS)" to be held at IIT-Bombay from December 17th-19th, 2018. This is the 51st annual convention of the Operational Research Society of India (ORSI). Founded in 1957 by the eminent statistician Professor P.C. Mahalanobis, ORSI benefited from a close association with the Indian Statistical Institute in Kolkata and has enjoyed a lasting relationship with many advanced academic centres and industry research organizations around the nation. ORSI is also a member of the International Federation of Operational Research Societies (IFORS). The flagship journal of the Society OPSEARCH, published by Springer Nature, has over the years provided the international Operational Research community with a high quality platform for research communications. The headquarters of ORSI remain in Kolkata with active local chapters distributed in urban centres around the country.

This international conference is the leading platform in India to share information, among academia and industry, on the latest theory, methods, techniques, applications of Operations Research. An important new feature of this year's conference is the start of a new competition called "ORSI Competition on the Practice of Management Science and Analytics" . This is an organization level contest where the six finalist projects will be presented and compete for the top award on the second day of the conference.

We congratulate the program committee of the conference for attracting a large number of contributed and invited papers and abstracts this year. The committee has selected high quality submissions for presentation over the tightly packed and exciting three days of the conference as described in this book of abstracts. In addition, seven distinguished invited speakers, including Professor Nicholas Hall, President of INFORMS, will be delivering the Keynote addresses.

We hope you find the three days valuable and exciting and invite you to become active student, individual or institutional members of ORSI if you are not already so.

Prof. Vijay Chandru
President ORSI, 2017-2018

Prof. Goutam Dutta
President ORSI, 2019-2020

2 Message from Conference Chairs

It is out great pleasure to welcome all the delegates for the 51st Annual Convention of Operational Research Society of India and International Conference (ORSI-2018), organised at Indian Institute of Technology Bombay, Mumbai, India. The theme of ORSI-2018 is Emerging Trends in Operations Research and Management Science. ORSI-2018 continues the tradition of high quality and international participation in all areas of Operations Research. We have shortlisted 123 technical papers for presentation at the conference, apart from keynote addresses, invited talks, tutorial sessions, and panel discussion from eminent people in the field of operations research. We are also happy to host the final round of the inaugural Best Practice Award, constituted by ORSI for industries. For those of you who have something more to share, we have arranged for Blitz talks on the foyer.

The successful organisation of the conference requires dedication and time of our volunteers and strong support from our sponsors. We thank all our sponsors - Optym, JDA, Palisade, Spashta Technologies, Opex Analytics, Springer Publishers, IITB Diamond Jubilee Office - for their immense & immediate support. Special appreciation to our reviewers and program coordinators for putting together an excellent set of talks. We thank all our keynote speakers and invited speakers for readily accepting our invite and participating in the conference. Finally, we are grateful of the support of all the staff and students of IEOR, IIT Bombay and ORSI-Mumbai chapter members for their outstanding service in putting together such an excellent conference.

We invite all of you join us in the Cultural programme followed by Gala Dinner on the evening of 18th December 2018. We hope that you find the conference both enjoyable and valuable, and the conference gives you a good opportunity to interact with your colleagues.

Prof. Jayendran Venkateswaran
Organising Chair

Prof. N. Hemachandra
Programme Chair

3 ORSI 2018 Committee

Organization Committee

- Jayendran Venkateswaran (Overall Coordinator), Industrial Engineering & Operations Research, IIT Bombay
- Pankaj Dutta, SJM School of Management, IIT Bombay
- Milind Patil, Supply Chain Services, Tata Consultancy Services
- K.S. Mallikarjuna Rao, Industrial Engineering & Operations Research, IIT Bombay

Program Committee

- N. Hemachandra (Overall Coordinator), Industrial Engineering & Operations Research, IIT Bombay
- Gajendra Adil, SJM School of Management, IIT Bombay
- Ashutosh Mahajan, Industrial Engineering & Operations Research, IIT Bombay

Advisory Committee

1. Bijan Sarkar, Jadavpur University
2. G. Raghuram, IIM Bangalore
3. Goutam Dutta, IIM Ahemdabad
4. M.R. Rao, ISB Hyderabad
5. Siddhartha Sengupta, TCS & IIT Bombay
6. Vijay Chandru, IISc, Bengaluru
7. Vivek Borkar, IIT Bombay
8. Y. Narahari, IISc, Bengaluru

Best Practice Award Jury

1. Prof. Sankarshan Basu, IIM Bangalore
2. Prof. Gautam Dutta, IIM Ahmedabad
3. Dr. Sanjay Kumar Prasad, IBM
4. Prof. M.K. Tiwari, IIT Kharagpur
5. Dr. Siddhartha Sengupta, TCS/ IIT Bombay

Referees

1. Gajendra Adil, IIT Bombay
2. R K Amit, IIT Madras
3. P. Balamurugan, IIT Bombay
4. Avinash Bharadwaj, IIT Bombay
5. Nomesh Bolia, IIT Delhi
6. Pankaj Dutta, IIT Bombay
7. Anirban Ghatak, IIM Visakhapatnam
8. Ravindra Gokhale, NITIE
9. Haripriya Gundimeda, IIT Bombay
10. Manu Kumar Gupta, IRIT Toulouse
11. Manjesh Hanawal, IIT Bombay
12. N. Hemachandra, IIT Bombay
13. K.S. Mallikarjuna Rao, IIT Bombay
14. Veeraruna Kavitha, IIT Bombay
15. Ashutosh Mahajan, IIT Bombay
16. Rahul Marathe, IIT Madras
17. Saral Mukherjee, IIM Ahmedabad
18. Vishnu Narayanan, IIT Bombay
19. Sundaravalli Narayanaswami, IIM Ahmedabad
20. Rahul Patil, IIT Bombay
21. Narayan Rangaraj, IIT Bombay
22. Goutam Sen, IIT Kharagpur
23. Yogendra Shastri, IIT Bombay
24. Sayli Shiradkar, IIT Bombay
25. Vikas Singh, IIT Delhi
26. Shreevardhan Soman, IIT Bombay
27. Jayendran Venkateswaran, IIT Bombay

4 Venue & Overall Schedule

The conference will be held in the ground floor of Victor Menezes Convention Center (VMCC) IIT Bombay. All the mains sessions will be conducted in the Prof. B. Nag Auditorium. The parallel sessions will be conducted in Room 02, 03, 04, 05 at VMCC. The pre-conference workshops will be conducted in Room 02, 03 at VMCC and the Bits Lab, CC building. Lunch and Dinner will be served at the cafeteria area of the VMCC building.

The Exhibit Hall is located at the Ground Floor Foyer area of VMCC and will feature booths by our sponsors **Optym** (Gold Sponsor), **JDA**, **Palisade**, **Spashta** and **Springer**. The booths will be open on all days of the conference.

Blitz Talks of 3-5 minutes duration is arranged during the tea and lunch breaks at the foyer of VMCC. This is the chance for you to share anything you want with the OR community – be it introducing yourself/your work, or invite audience to your talk at the conference, or simply sharing your idea with the community. You can talk about any relevant topic under the sun. Slides are optional. Participation is by spot registration only. Contact Registration Desk on conference days for details.

Sunday, 16th December

9:45 - 14:00	Registration
10:15 - 1:30	Preconference Tutorial Session A1 Room 02, VMCC Design of Markets and Service Systems with Strategic Agents Krishnamurthy Iyer, Cornell University
	Preconference Tutorial Session A2, Room 03, VMCC Introduction to Machine Learning Manjesh Hanawal and N. Hemachandra, IIT Bombay
1.30 - 2:30	Lunch
2:30 - 7:30	Preconference Workshop B1, Bits Lab, CC Building Workshop on Computational Optimization IEOR and FOSSEE teams, IIT Bombay
	Preconference Tutorial Session B2, Room 03, VMCC Risk Modeling and Optimization using Simulation Pankaj Dutta, IIT Bombay

Monday, 17th December

8:00 - 18:00	Registration VMCC Ground Floor
8:00 - 8:55	Breakfast, VMCC Ground Floor Foyer
9:00 - 10:30	Inauguration Chief Guest: Prof. PV Balaji, Dean R&D, IIT Bombay ORSI Presidential Lecture by Prof. Vijay Chandru
	Inaugural Talk Learning Enabled Optimization: A New Generation of Stochastic Programming Models Suvrajeet Sen, University of Southern California
10.30 - 11:00	Tea Break/Blitz Talks*
11:00 - 11:55	Keynote Talk Stochastic Networks: Performance Analysis, Optimization and Scaling Limits Kavita Ramanan, Brown University
12:00 - 13:30	Parallel Sessions MB02-MB05 MB02: Data Analytics and Machine Learning I, Room 02 MB03: Supply Chain Management I, Room 03 MB04: Pricing & Revenue Management, Room 04 MB05: Invited Session I, Room 05
13.30 - 14:30	Lunch VMCC Garden Cafeteria/Blitz Talks*
14:30 - 16:00	Parallel Sessions MC02-MC05 Optimization Methods & Applications I, Room 02 MC03: Health Care, Room 03 MC04: Game Theory and Its Applications, Room 04 MC05: Invited Session II, Room 05
16:00 - 16:30	Tea Break/Blitz Talks*
16:30 - 17:20	Keynote Talk: INFORMS, Analytics, Research and Challenges Nicholas Hall, The Ohio State University
17:20 - 18:15	ORSI Endowment Lecture Sample complexity of partition identification using multi-armed bandits Sandeep Juneja, TIFR
18.30 - 19:45	ORSI AGM Open for all ORSI Members
19:45	Dinner, VMCC Garden Cafeteria

Tuesday, 18th December

Tuesday	December 18
8:00 - 18:00	Registration VMCC Ground Floor
8:00 - 8:55	Breakfast, VMCC Ground Floor Foyer
9:00 - 10:30	Parallel Sessions TA02-TA05 TA02: Optimization Methods & Applications II, Room 02 TA03: Supply Chain Management II, Room 03 TA04: Stochastic Models I, Room 04 TA05: Invited Session III, Room 05
10.30 - 11:00	Tea Break/Blitz Talks*
11:00 - 11:50	Keynote Talk: Game Theoretic Analysis of Competitive Routing over Wireless Links Eitan Altman, INRIA Sophia Antipolis
12:00 - 13:30	Parallel Sessions TB02-TB05 TB02: Multiobjective Optimization, Room 02 TB03: Simulations and Statistics I, Room 03 TB04: Best Practice Award Finals I, Room 04 TB05: Transportation and Logistics I, Room 05
13.30 - 14:30	Lunch VMCC Garden Cafeteria/Blitz Talks*
14:30 - 16:00	Parallel Sessions TC02-TC06 TC02: Optimization Methods & Applications III, Room 02 TC03: Transportation and Logistics II, Room 03 TC04: Best Practice Award Finals II, Room 04 TC05: Urban Planning and Ecology, Room 05 TC06: Invited Session IV , TBC
16:30 - 16:30	Tea Break/Blitz Talks*
16:30 - 17:20	Keynote Talk Mixed-Integer Derivative Free Optimization Sven Leyffer, Argonne National Laboratory
17:20 - 18:15	Keynote Talk Trends in Industrial Engineering Louis Rabelo, University of Central Florida
18.30 - 19:45	Cultural Program, P.C. Saxena Auditorium (TBC)
19:45	Dinner, VMCC Garden Cafeteria

Wednesday 19th December

8:00 - 14:00	Registration VMCC Ground Floor Registration Desk
8:00 - 8:55	Breakfast, VMCC Ground Floor Foyer
9:00 - 10:30	Parallel Sessions WA02-WA05 WA02: Data Analytics and Machine Learning II, Room 02 WA03: Simulation and Statistics II, Room 03 WA04: Stochastic Models II, Room 04 WA05: Invited Session V, Room 05
10.30 - 11:00	Tea Break/Blitz Talks*
11:00 - 11:50	Keynote Talk Modeling and Analysis of Distributed Control Algorithms Vittal Prabhu, Pennsylvania State University
12:00 - 13:30	Parallel Sessions WB02-WB05, WB02: Scheduling, Room 02 WB03: Inventory Management, Room 03 WB04: Quality Control and Management, Room 04 WB05: Invited Session VI, Room 05
13.30 - 14:30	Lunch VMCC Garden Cafeteria/Blitz Talks*
14:15 - 15:30	Panel Discussion Emerging Trends in OR and Management Science
15:30 - 16:00	Award Ceremony M.C. Puri Award, P.C. Mahalanobis Award ORSI Fellowship, Best Practice Award Vote of Thanks
16:00 - 16:30	High Tea, VMCC

5 Technical Session Chairs

Monday, 17th December

Time	Session	Venue	Chair	Co-Chair
12:00 - 13:30	MB02	Room 02	Avanish Kumar	Sandhya Tripathi
	MB03	Room 03	Gajendra Adil	Tejas Ghorpade
	MB04	Room 04	S Narayanaswami	Swapnesh S
	MB05	Room 05	Ravindra Gokhale	Meenarli Sharma
14:30 - 16:00	MC02	Room 02	N. Ravichandran	Ranbir Singh
	MC03	Room 03	Vijay Chandru	Puja Sahu
	MC04	Room 04	Anirban Ghatak	Ravikant Rai
	MC05	Room 05	Mathirajan M	Prashant Palkar

Tuesday, 18th December

Time	Session	Venue	Chair	Co-Chair
9:00 - 10:30	TA02	Room 02	Sayli Shiradkar	Meenarli Sharma
	TA03	Room 03	Milind Patil	Hamidur Rahman
	TA04	Room 04	Manasa Mandava	Venkateswara Rao
	TA05	Room 05	Ashutosh Mahajan	Shraman Bhaduri
12:00 - 13:30	TB02	Room 02	Anjali Awasthi	Chhavi Sharma
	TB03	Room 03	Louis Rabelo	Swapnesh S
	TB04	Room 04	Sankarshan Basu	Ranbir Singh
	TB05	Room 05	Sven Leyffer	Manoj Kumar
14:30 - 16:00	TC02	Room 02	Yogendra Shastri	Mustafa Vohra
	TC03	Room 03	Faiz Hamid	Alisha Arora
	TC04	Room 04	Sankarshan Basu	Hamidur Rahman
	TC05	Room 05	Mangesh Gharote	G. Chandra Mouli
	TC06	Prof. B. Nag	Sarang Jagdale	Prashant Palkar

Wednesday, 19th December

Time	Session	Venue	Chair	Co-Chair
9:00 - 10:30	WA02	Room 02	Manjesh K Hanawal	Sandhya Tripathi
	WA03	Room 03	Pankaj Dutta	Anirban Karmakar
	WA04	Room 04	V Kavitha	Venkateswara Rao
	WA05	Room 05	Ajeet Misra	Arun Verma
12:00 - 13:30	WB02	Room 02	PG Awate	Hamidur Rahman
	WB03	Room 03	Siddhartha Sengupta	Ravikant Rai
	WB04	Room 04	George Easaw	Swapnesh S
	WB05	Room 05	N. Hemachandra	Tejas Ghorpade

6 Abstracts: Inaugural Talk, Keynote Talks and ORSI Endowment Lecture

Learning Enabled Optimization: A New Generation of Stochastic Programming Models

Suvrajeet Sen, University of Southern California

Several emerging applications call for a fusion of statistical learning (SL) and stochastic programming (SP). The Learning Enabled Optimization (LEO) paradigm fuses concepts from these areas in a manner which not only enriches both SL and SP, but also provides a framework which supports rapid model updates and optimization, together with a methodology for model-validation, assessment, and selection. Moreover, in many "big data/big decisions" applications, these steps are repetitive, and realizable only through a continuous cycle of data analysis, optimization, and validation. In order to accommodate such workflow, we adopt a Stochastic Decomposition (SD) framework which is a successive sampling algorithm (also known as incremental sampling) for SP.

Under certain assumptions, SD is known to possess the following important properties: a) it produces a solution sequence which converges in expectation, at a rate of approximately $O(N-1)$ with high probability; b) it reduces bias and variance simultaneously via a new concept of compromise solutions. For some of the most challenging instances to date, the algorithm has produced near-optimal solutions on desk-top machines within a fraction of the CPU time it takes other methods, such as sample average approximation (SAA) using Benders decomposition and its variants. These properties are particularly important for LEO models which require both SL and SP in the workflow.

This lecture will begin with a discussion of LEO models, and their applications. With this motivation, we will review SD, clarifying the methodology and its computations for SP. Finally, we will resume our path to the future where we show how SD provides distribution-free statistical optimality, and supports the LEO workflow, with novel guidelines for model assessment, and selection. Time permitting, we will also present some research challenges for the LEO paradigm. (This work draws upon joint work with several colleagues, as well as current and former students.)

Stochastic Networks: Performance Analysis, Optimization and Scaling Limits

Kavita Ramanan, Brown University

Stochastic networks are ubiquitous and model phenomena in diverse fields including telecommunications, service systems for call centers and health care, computer networks and biological systems. These networks are typically too complex to admit an exact analysis. However, it is often possible to obtain tractable approximations of both transient and equilibrium behavior that can provide key insight into network performance. The accuracy of these approximations in a suitable network parameter regime can be rigorously justified through "scaling limit theorems". We will provide a survey of different types of approximations that arise for different classes of networks, describe some key mathematical methods required to justify these approximations, with an emphasis on recent developments, and also illustrate through a number of concrete examples how these approximations can be used to develop new scheduling algorithms and optimize network design.

INFORMS, Analytics, Research and Challenges

Nicholas Hall, The Ohio State University & INFORMS

This talk will cover four topics at a nontechnical level. The first part of the talk should be of interest to the leaders of the OR and analytics profession. It describes INFORMS' organization, strategic goals, current situation and activities. A particular focus is INFORMS' first ever national Policy Summit to be held on Capitol Hill in Washington, May 21st.

The second part of the talk should be of interest to researchers and practitioners. The speaker will provide his perspectives on Analytics, what it means and does not mean, where it is leading the field, and some unintended consequences.

The third part of the talk should be of interest to younger scholars and graduate students. The speaker will discuss the currently active directions and research potential of three topics: the sharing economy, precision healthcare, and project management.

The last part of the talk provides a brief discussion of the challenges faced by the operations research and analytics profession currently and over the next 10 years.

Sample complexity of partition identification using multi-armed bandits

Sandeep Juneja, TIFR

Given a vector of probability distributions, or arms, each of which can be sampled independently, we consider the problem of identifying the partition to which this vector belongs from a finitely partitioned universe of such vector of distributions. We study this as a pure exploration problem in multi armed bandit settings and develop sample complexity bounds on the total mean number of samples required for identifying the correct partition with high probability. This framework subsumes well studied problems in the literature such as finding the best arm or the best few arms. The partitions considered include half spaces, polytopes or their complements, or more generally, convex sets or their complements. In these settings, exploiting problem geometry, we characterise the lower bounds on mean number of samples for each arm. Further, we propose algorithms that can match these bounds asymptotically with decreasing probability of error. Applications of this framework are diverse. We briefly discuss one associated with nested Monte Carlo and its applications to finance.

Game Theoretic Analysis of Competitive Routing over Wireless Links

Eitan Altman, INRIA, Sophia Anitpolis

Analysis of routing in a competitive context is already 100 years old. It has become central in road traffic engineering and only in the last 25 years it started to penetrate into computer networks. Key differences between road traffic and road traffic models are (1) in road traffic a player (driver) is not expected to be lost where as in computer networks there are losses due to queueing overflow, to collision in the access to the network, to interference and to noise (2) in road traffic, the decisions of a single player (a driver) have a negligible impact on the performance of other players which implies modeling the drivers as continuum flows. In computer networks the action taken by a decision maker may have a non-negligible impact on other players. In some cases this creates further difficulties in handling a discrete action space rather than a compact convex one. We shall

present some examples that illustrate these two modelling issues in routing games and present novel tools from discrete convex analysis to study the properties of equilibria in such games.

Mixed-Integer Derivative Free Optimization

Sven Leyffer, Argonne National Laboratory

Many design and engineering applications result in optimization problems that involve so-called black-box functions as well as integer variables, resulting in mixed-integer derivative-free optimization problems (MIDFOs). MIDFOs are characterized by the fact that a single function evaluation is often computationally expensive (requiring a simulation run for example) and that derivatives of the problem functions cannot be computed or estimated efficiently. In addition, many problems involve integer variables that are non-relaxable, meaning that we cannot evaluate the problem functions at non-integer points.

In the first part of our talk, we survey applications of MIDFO from a range of Department of Energy applications. The design of nano-photonic devices involves integer decision variables due to manufacturing limitations, and each function evaluation requires a finite-element simulation that takes several hours to run on a cluster. Similarly, automatic performance tuning of code snippets for high-performance computing involves non-relaxable integer variables such as loop-unroll-factors and compiler options and require several runs to eliminate random measurement errors. Finally, the design and operation of concentrating solar plants, requires forward simulations that take hours on a desktop and involve unrelaxable decision such as the number of panels on the receiver.

In the second part of our talk, we present a new method for non-relaxable MIDFO that enables us to prove global convergence under idealistic convexity assumptions. To the best of our knowledge this is the first globally convergent method for non-relaxable MIDFO apart from complete enumeration. Our method constructs hyperplanes that interpolate the objective function at previously evaluated points. We show that in certain portions of the domain, these hyperplanes are valid underestimators of the objective, resulting in a set of conditional cuts. The union of these conditional cuts provide a nonconvex underestimator of the objective. We show that these nonconvex cuts can be modeled as a standard mixed-integer linear program (MILP). Unfortunately, this MILP model turns out to be prohibitively expensive to solve even with state-of-the-art MILP solvers. We

develop an alternative approach that is computationally tractable, and provide some early numerical experience with our new method.

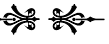
Co-Authors: Prashant Palkar (IIT Bombay) and Jeffrey Larson and Stefan Wild (Argonne)

Trends in Industrial Engineering

Luis Rabelo, University of Central Florida

As we look to the future, the pace of technological development is impressive. Opportunities for new research that contribute to expanding knowledge are plentiful. The most recent technological trends revolve around several concepts, such as big data, advanced engineering analytics, "internet of things", real-time optimization, hybrid simulation, model-based engineering, and blockchain. Industrial engineering is taking a very important role, and can also benefit greatly from these trends, which continue to develop. There are several trends in industrial engineering that have caught our attention and are already impacting at this time. Big data and analytics. Analytics, which refers to methods and techniques to extract patterns and new information from structured, semi-structured or unstructured data, will now have to adapt to big data. The large data generated in many applications are huge in terms of volume, variety, speed and accuracy. It has been shown that the use of data analysis techniques represents advantages to improve business. Several reports explain that many organizations agree that these techniques can be used to optimize companies. This knowledge allows us to achieve and manage four objectives that are fundamental for an organization: capital performance, growth, risk management and innovation. The analytics includes tools of evolutionary computation, deep learning, neural networks, machines with support vectors, fuzzy logic, decision trees, expert systems, and the tools of traditional statistics and the calculation of probabilities. The internet of things (or industrial internet). The Internet of Things (IoT), from the point of view of computation, is the evolution and convergence of high throughput computing (HTC) and high performance computing (HPC) with other developments, such as grid computing and the peer-to-peer (P2P) networks. The IoT is a vision of an integrated network that covers physical objects capable of collecting and exchanging data. The IoT allows previously disconnected devices and devices to connect through the equipment of devices with communication technology, such as sensors and radio frequency identification (RFID) tags. To get an idea of how ubiquitous the concept of the internet of things is, we just have to see how we interact with our electronic items on a

daily basis. All our phones and tablets are linked to an ecosystem of numerous machines. These "invisible" machines support all the basic functions that keep things with minimal human intervention. The sharing revolution. The phenomenon of sharing is seen in the shared economy. Shared economy is a general term with a series of meanings, often used to describe the economic and social activity that involves online transactions. Also known as share-economy, an academic concept that refers to a hybrid market model. Shared economy can take various forms, including the use of information technology to provide individuals information that allows the optimization of resources through mutualization of excess capacity in goods and services. A common premise is that when the information about the goods is shared, the value of those goods may increase for the entire ecosystem and all stakeholders. Real-time optimization for supply chains. With the implementation of "smart" sensors has emerged how to predict, monitor and coordinate the Real-time systems performance. This transformation requires methodologies and solutions capable of analyzing and modeling the signals of these "sensors" to support optimal decision-making strategies. Artificial intelligence and optimization techniques allow decisions to be made almost instantaneously, which observe and affect business environments that change rapidly, enabling significant savings of costs. Real-time route optimization platforms, alerts in case of detection of anomalies, adjustment options and dynamically changing routes, which take into account the behavior of drivers, customers, times of travel and service, in addition to traffic and weather conditions, are the new trends in logistics operations and supply chains. Hybrid simulation and the life cycle of the systems with the supply chain. The discrete-continuous hybrid simulation model of the company and the life cycle of the systems is very important. This set of models consists of dynamics models of systems, continuous models of higher and more abstract hierarchical levels, which are connected with discrete event simulations for operational functions, tactics and phases of the life cycle of the system. For example, the dynamics modeling of systems is better suited to the macroscopic nature of activities at higher levels management, while discrete models are better suited to nature microscopic of the operational and tactical levels of the company. Dynamics models of systems can represent the nature of the architecture of the system, while that discrete models represent the operations of a particular system. In the last decade, system engineers have begun to replace the process of traditional documentation with simulation modeling approaches. The simulation models provide engineers with a more rigorous means of capturing and integrating System requirements, design, and verification information using Blockchain.



Modeling and Analysis of Distributed Control Algorithms

Vittal Prabhu, Pennsylvania State University

This presentation will provide an overview of a methodology for controlling discrete-event systems by formulating these problems as continuous variable feedback control problems resulting in a unified mathematical and computational framework. The science-base of this work includes theories of discontinuous differential equations, Lyapunov stability, adaptive control, and nonlinear control theory, which can be used to prove convergence properties and to characterize emergent behavior of the resulting control systems. This has resulted in scalable parallel/distributed algorithms for a variety of applications including Just-in-Time production scheduling, maintenance scheduling, batch sequencing, inventory control, transportation, and distributed supply chains. Computational complexity of these control theoretic algorithms typically increases linearly with the number of events to be controlled, and worst case is of the order $O(n^2)$.

We will discuss some of the salient features of this approach along with applications. In the manufacturing context, we will discuss how the approach can be used for simultaneously controlling production, capacity, maintenance, and energy. In the context of services, we will discuss how the approach can be used for just-in-time delivery for green fleets as well as crowdsourced delivery services. In the later part of this presentation we will present some of our recent and ongoing efforts addressing ways to smarten service systems using techniques from operations research in our SEE 360 initiative at Penn State. The presentation will conclude with some thoughts on integrating OR and AI techniques with this feedback control problem as well integrating IIoT sensors for improving fidelity.

7 Pre-Conference Workshop Abstracts

Design of Markets and Service Systems with Strategic Agents

Krishnamurthy Iyer, Cornell University

The last two decades have seen the rise of a number of online markets and service systems, ranging from auction markets for online advertising to platform markets for peer-to-peer transportation, freelance labor and shared housing. In such systems, the agents' behavior is often the result of the incentive structure induced by the design of the system. Consequently, quantifying how participants act is an important step in the analysis of the system performance and in the evaluation of different system designs.

Game theory provides a standard set of tools to analyze the outcome of an interaction among a group of agents. In this tutorial, we will briefly introduce the basic game theoretic concepts, and study their applications in the design and analysis of markets and service systems. Specifically, we will focus on stochastic/queueing models and study the impact of various controls: pricing, scheduling and information sharing.

Introduction to Machine Learning

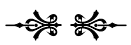
Manjesh Hanawal and N. Hemachandra, IIT Bombay

In this tutorial, we will cover various algorithms in machine learning. We will discuss the following topics:

1. Supervised learning methods: regression, classification, support vector methods, boosting, decision trees, random forest.

2. Model selection and assessment: feature engineering, cross-validation methods.

3. Unsupervised learning: K-means clustering, spectral methods, EM algorithm, time series analysis.



Workshop on Computational Optimization

IEOR and FOSSEE team, IIT Bombay

This workshop will be held in three 90-minute sessions, each focussing on modeling and solving different types of optimization problems. Techniques will be described briefly so that more time is devoted to modeling and solving problems on a computer. Participants will be expected to install and run various solvers on a computer. The number of registrations is limited to 30. Basic knowledge of linear optimization and familarity with modeling linear programs is assumed. The details of the sessions are as follows.

1. Linear and nonlinear optimization:

   Simple realistic examples of different types of optimization problems: linear, quadratic and nonlinear programs will be modeled and solved using the FOSSEE Scilab Optimization Toolkit (FOT). Various ways of modeling a problem and setting solver parameters will be discussed. Demonstrations on how to understand solver outputs including duals will be given.

2. Mixed-integer nonlinear optimization

   Algorithms for solving convex and nonconvex nonlinear problems with integer variables will be introduced with some motivating examples. Main components and design of solvers for such problems will be described using the open-source Minotaur solver as an example. Examples on how to combine various components for implementing customized algorithms will be demonstrated.

3. Derivative free optimization

   Optimization problems for which evaluating the function values is expensive and derivative information is missing are quite challenging to solve even when the number of variables is small. A brief overview of such problems and some well known solvers will be presented. A novel approach called Constrained Scaled Conjugate Gradient Based Direct Search (CSCG-DS) will be discussed and demonstrated.

More information about hardware and software requirements will be added soon. The Team consists of Siddharth Agarwal, Ashutosh Mahajan, G. Chandra Mouli, Prashant Palkar, Rupak Rokade and Meenarli Sharma.

Risk Modeling and Optimization using Simulation

Pankaj Dutta, IIT Bombay

This session introduces you to the risk modeling and simulation of business problems. After providing a brief concept of various decision models in management with examples pertaining to different domains, risk analysis would be carried out in the context of business simulation using advanced excel spreadsheet. @Risk software would be used to illustrate the business problems under risk and subsequent statistical analysis would be drawn to address various real world business problems.

Generally, optimization models ignore uncertainty but Risk optimizer helps to find risk associated with each strategy; accordingly we can seek out strategies that will help to minimize risks while achieving desired goals. It uses the Monte Carlo Simulation, which is one of the widely used techniques by corporate managers and scientists as an aid for decision making and performance analysis.

8 Parallel Sessions Abstracts

Parallel Session: MB02, 12.00pm - 1.30pm, Monday December 17, Room 02, VMCC

Comparison of Logarithmic Goal Programming Method and Conjoint Analysis in Developing Utility Function

Sumeetha Natesan and Goutam Dutta

The utility function is defined as a linear combination of various attributes that are considered by the customers in choosing a product/service. There are various methods in developing utility function. In this paper, we develop a linear utility model for vehicle insurance policies using two approaches: Logarithmic Goal programming Method (LGPM) and Conjoint Analysis approach. We compare these two methods used for developing utility function for vehicle insurance policies. The utility scores of various vehicle insurance policies can help the customers to compare and choose a vehicle insurance that is suitable to them. We also derive a choice probability of the vehicles insurance policies available in market by developing a multinomial logit choice model. This gives a relative comparison about the two methods among the various vehicle insurance policies. We also study the consistency indicators of the respondents.

Business Process Flow Prediction using Machine Learning Algorithms

Dhawal Thakkar and Balamurugan Palaniappan

In today's data driven world, implementation of Machine Learning (ML) Algorithms has gained pace in industry. This extended abstract covers a specific case of application of ML algorithms. In certain industries, many recurring problems are tackled each time as new problems despite having occurred earlier. Hence it becomes necessary to avoid such bottleneck activities and automate them. Here we address the problem of identifying business process flow in insurance domain. The business process follows certain paths to finally converge to certain end points, which are labeled as primary zones or non-primary zones. Primary zones are the

desired outcomes. Prediction of convergence of the flow to primary zones is essential. We apply ML classification algorithms to predict the outcome based on a real data-set. We found that among several ML methods, Decision trees and SVM give promising results.

Project MCube - Accelerate SLOB Reduction Through Application of Advanced Analytics at Johnson & Johnson

Abhishek Dhruwanshi, Subhodeep Dey and Saurabh Jawaharya

Slow and Obsolete inventory (SLOB) is a term that refers to inventory that is at the end of its product life cycle and has not seen any sales or usage for a specified period (typically, 6 months). This type of inventory must be written off and can cause large financial loss for the company. Jonson & Johnson has defined target levels and tolerance for SLOB which is in the range of – of Net Trade Sales (NTS). However, in practice, the demonstrated performance is far below the normal and can go up to – of the total NTS. The Project enabled proactive management and mitigation of SLOB throughout the Consumer value chain. The success was achieved through deployment and adoption of a Self-Service Tool leveraging advanced analytics. It also led to creation of a governance mechanism to identify business processes that lead to SLOB generation.

Predictive Maintenance of Air Pressure System using Boosting Trees: A Machine Learning Approach

Mrugank Akarte and N Hemachandra

This paper presents an approach to minimize maintenance cost of Air Pressure System (APS) in Scania trucks using a supervised machine learning approach, gradient boosting trees. The maintenance cost includes the cost of breakdown due to unobserved faulty part and the cost of needless check on satisfactory parts. The dataset consists of highly skewed and unbalanced data with faulty APS cases, referred as positive class and remaining cases as negative class. Skewness is reduced by Log transformation while imbalanced data is addressed by assigning additional class weight to a rare event. Comparison of two models trained using XGBoost, one using equal class weights and one using unequal class weights

for positive and negative class is presented. Findings suggest that classifier with unequal class weights with a suitable threshold value achieves better performance compared to classifier using equal class weights with a threshold value of 0.5 in case of unbalanced dataset.

Parallel Session: MB03, 12.00 pm-1.30 pm, Monday December 17, Room 03, VMCC

A Two-warehouse Integrated Inventory Model with Imperfect Production under Stock Dependent Demand with Deterioration

Dr. Payel Mandal and Mousumi Sikdar

In globalized economy, business professionals realize that if individual members are concerned about their own profit and willing to gain advantages over others, then ultimately it causes diminish of profit of supply chain. Article develops an integrated vendor-buyer model with two warehouses of the buyer. Production of defective items is a natural phenomenon in any supply chain. In this work, vendor produces some amount of defective items and the demand at the buyer is dependent on the on-hand stock. The present work is to develop a vendor-buyer integrated model incorporating aforementioned practical situations. The objective is to determine the vendor's shipment scheme so that the average total cost of the integrated system is minimized. For a numerical example, the optimal solution of the integrated inventory model is obtained to illustrate the proposed model and effects of key model-parameters on the optimal solution are examined to develop the managerial insights.

Operationalizing Localization: A Case study of solar PV based technology Intervention in Rural India

Jigar Panot, Deepak Choudhary, Sayli Bhide, Jayendran Venkateswaran and Chetan S Solanki

Access to clean, affordable and reliable energy is essential for sustainable future and is a part of Sustainable Development Goals (2015). However, the cost of providing traditional electricity and its maintenance is high, especially in

sparsely populated areas. In such a scenario, how do we provide clean, reliable and affordable electricity in the fastest possible manner? Solar can be one of the potential solution. Solar lamps projects had been implemented in the country since decades, but weren't successful because either they were given as freebies or there wasn't any service facilities available, hence not sustainable. The solar study lamps intervention was tried out at a large scale in rural India wherein the localization was emphasized. This paper presents the design of agile supply chain, production planning and control, quality control and after sales service for a technology based intervention. The standard operating procedure for setup and operation of local micro assembly centers and repair service centers owned by the local trained people were studied and evaluated quantitatively through clustering based algorithms. Based on the performance results, a sample micro assembly centers were considered for mixed quantitative and qualitative survey. Further, key operational challenges and their solutions therein are discussed. We feel that addressing the challenges in operationalizing localization could lead to a more widespread adoption of technology based innovative solutions. The same standardized processes can be used in dissemination of other products/services by replicating the operational processes.

Supply chain replenishment decisions under the trade credit policy

Vandana and Prof. Arshinder Kaur

The main purpose of this paper is to investigate the supply chain entities optimality under trade credit policy, where supplier offer trade credit to the retailer for settlement of the account and retailer will pass this offer to their customer's for getting profit. The demand face by the retailer and the supplier is considered as based on the credit time. Shortages are considered only one side that is retailer will only face shortages. Then, we have modeled the supplier and the retailer's optimality system as a profit maximization problem to determine the retailer's optimal replenishment decisions and optimal credit time and supplier's optimal credit time under the supply chain. Some useful theorems are developed to determine the optimal decisions variables. Next, numerical examples are given to illustrate the theorem. At last, we will discuss the managerial phenomena and conclusion of the proposed model.

Supply Chain models for deteriorating items with maximum lifetime under downstream partial trade credits to credit-risk customers by discounted cash-flow analysis

Jobin George Varghese

Financial shortcomings in the past have made it difficult to get loans or credit from banks. As a result, majority of companies offer their products for short term with trade credits to customers. Instead of applying DCF to revenue and other costs numerous researchers and academicians apply DCF analysis merely to compute, the interest earned and charged during the credit period. For a rigorous analysis, we have applied DCF on all relevant costs. Also, continuous deterioration of majority of products results in no sale after their maximum lifetime. In this paper, a SRC system is developed in which the retailer gets an upstream full trade credit from the supplier whereas offers a downstream partial trade credit to credit-risk customers, the deterioration rate is non-decreasing over time and are close to its expiration date and considered time varying demand to more realistic approach. Several numerical examples and sensitivity analysis are performed.

Multi-item inventory model for deteriorating items under the effect of trade credit

Himanshu Rathore

This study presents a preservation technology model for deteriorating items with constant rate of deterioration. The requirements for the items are received as a function of advertisement frequency and selling price. The two types of trade credit is the main focus of this study. First one is provided by the supplier to the retailer and another one is the partial trade credit offered by the retailer to the customer. The optimal policy is presented to earn maximum profit with optimal values of selling price, advertisement frequency, preservation technology and total cycle length. The study is numerically verified with sensitivity analysis to check the sensitivity of the model.

Parallel Session: MB04, 12.00 pm-1.30 pm, Monday December 17, Room 04, VMCC

A Customized Price Response Curve for Electricity Consumers

Krishnendranath Mitra and Goutam Dutta

In this paper we propose a mathematical model for optimally determining the price curve in response to the estimated consumption of electricity by a consumer in a day. The model develops a nonlinear price function for individual consumers by estimating his consumption from the appliances, battery and renewable energy that he plans to use over a day. Based on estimated consumption, the optimization model determines the convexity of the said price response curve such that the consumer's daily expenditure is close to what he would have paid for a flat price with his planned consumption. The nonlinear price curve obtained from this model is converted to piecewise linear curve closely resembling it. This curve is provided as input to the load scheduling model for the consumer as described in (Mitra & Dutta, 2018). The model is analyzed with different combinations of appliance ratings, appliance operating windows and appliance operation times.

Hybrid Mechanism Pricing Design for Profitable Online Aggregator Taxi Services

Swaminathan Rammohan, Rahul R. Marathe and Nandan Sudarsanam

Online aggregator taxi services, such as Ola and Uber operate on posted price channel, where the passenger and driver payments are computed based on data driven approach. The rigidity of this posted price channel leaves the passengers and taxi drivers with no option, but to accept or reject taxi rides. This paper proposes a hybrid channel that combines the currently used posted price channel along with the hybrid auction at the same time to increase the aggregator profit by enhancing the overall efficiency. The mechanism design using hybrid auction channel is modeled in two stages: passenger bidding for a ride and taxi drivers competing for the passenger ride through auction.

Designing a Geography location based Pricing strategy under Competition and Product Differentiation

Arnab Adhikari and Tania Saha

A retailer who performs business operations in multiple markets, the selection of an appropriate pricing strategy to achieve better profitability emerges as an important question. There is less literature in depicting the holistic picture by designing a pricing mechanism that incorporates both spatial differentiation and product differentiation under competition. We design a retailer's pricing strategy when he has monopoly power in one market and engages in competition with another retailer in the other market. We consider different scenarios where both retailers adopt coordinated pricing strategy i.e. either spatially-differentiated or uniform pricing and both retailers adopt uncoordinated pricing strategy i.e., one selects spatially-differentiated and other retailer selects uniform pricing. We determine the equilibrium price and profit of the retailers under sequential decision making. We analyze the impact of product differentiation, market size, a shift in pricing strategy (from spatially- differentiated to uniform or vice-versa) on the equilibrium price/profitability and dominance/coordination conditions.

Fare-Box Revenue Management of the Indian Railways

Sundaravalli Narayanaswami and Lakshya Saini

Indian Railways (IR) is one of the oldest and single largest public transportation organizations in the world. Many of the routes and services are not profitable, but IR, being a state operator is obliged to operate them for political and social obligations. We developed a framework to compute the operational cost per trip of an IR passenger service using actual data. The total operational cost was evaluated against generated revenue, and it was found that break even could not always be attained. The proposed framework mandates significant changes in IR thought process and operational policy decisions, but it is pragmatic, viable and does not compromise customer benefits, we believe. We present the framework; illustrate the same using real data from few premium services and our detailed analysis.

Parallel Session: MB05, 12.00 pm-1.30 pm, Monday December 17, Room 05, VMCC

A Linear Programming Primer: From Fourier to Karmarkar

Atlanta Chakraborty, Vijay Chandru and M R Rao

The story of linear programming is one with all the elements of a grand historical drama. The original idea of testing if a polyhedron is nonempty by using a variable elimination to project down one dimension at a time until a tautology emerges dates back to a paper by Fourier in 1823. This gets re-invented in the 1930s by Motzkin. The real interest in linear programming happens during World War II when mathematicians ponder best ways of utilising resources at a time when they are constrained. Dantzig's Simplex Method is announced and Rand Corporation becomes a hot bed of computational mathematics. The range of applications of this approach grows and the powerful machinery numerical linear algebra becomes a major driver for the advancement of computing machines.

In the 1970s, constructs of theoretical computer science indicate that linear programming may in fact define the frontier of tractable problems that can be solved effectively on large instances. This raised a series of questions: Is the Simplex Method a polynomial-time method and if not can we construct novel polynomial time methods, etc. And that is how the Ellipsoid Method from the Soviet Union and the Interior Point Method from Bell Labs make their way into this story as the heroics of Khachiyan and Karmarkar. We have called this talk a primer on linear programming since it only gives the audience a quick narrative of the grand historical drama. Hopefully it motivates a reader to delve deeper and add another scene to the play.

Challenges in Teaching Operations Research

N. Ravichandran, Indian Institute of Management Ahmedabad

In this talk based on the experience of teaching several operations research related courses,we abstract the challenges in teaching this discipline to management students..We draw our experience from teaching core and elective courses..The impact of the course is a function of the student profile,course content,pedagogy used and the reputation of the instructor.

Parallel Session: MC02, 2:30 pm-4.00 pm, Monday December 17, Room 02, VMCC

A capacitated set covering location model for improving utilization of primary health care facilities

Kaushal Kumar and Amit Kumar Bardhan

In India, the cost of health care is majorly borne by patient out-of-pocket payments. This trend is observed in primary care too. Recent studies have pointed out; patients often skip nearby government clinics providing free consultation for distant private care providers. Reasons for this behavior include; longer waiting times at government clinics, perception regarding quality of care etc. Due to this change in preference, government run facilities are unevenly utilized. In this article, we propose a location optimization model that can improve utilization of public-funded primary care facilities by means of up-gradations and de-gradations and suggest contracting of private service providers, wherever needed. The objective of this optimization model is to reduce the out-of-pocket expenses of patients. The model assumes limited capacities at all facilities, location dependent costs for capacity management activities and a limited budget. Numerical experiments and an efficient solution procedure are also discussed.

Redistribution of Teachers in the Indian School System

Abhishek Bhatnagar and Nomesh Bolia

Indian school education system has enough teachers to cater to a minimum student teacher ratio requirement at the national level, and at the state level in most cases. However, the distribution of teachers at the school level does not adhere to this criteria at the primary school level. There exist differences in distribution even within a state or a district as indicated in various studies conducted by the government of India. There are shortage of specialized subject teachers at the secondary school level. Teachers prefer to stay in urban areas for better facilities and are reluctant to travel longer distances from their home to school in rural areas due to lack of transportation facilities. This calls for teacher rationalization, dealt with in the present study, which is an effort to have an equitable distribution of teachers across the states or districts.

Mathematical Programming Approach to Solve Airlines Disruption Management

Deepmala

The airline industry is one of the most successful examples of applying operations research methods and tools for the planning and scheduling of resources. In this paper, we propose a mathematical model for the airlines disruption management. Finally, we indicate the future course of research about the problem.

Identification of job competencies for an improved customer service performance: an AHP approach

Shanujas V and T. Radha Ramanan

The study aims to identify and rank different job competencies required by the cooperative bank employee to provide improved customer service. The present study employs an Analytic Hierarchy Process (AHP) to identify the job competencies based on five major criteria: relationship management competency, cognitive competency, self-management competency, teambuilding competency, and technical competency. A total of 25 sub-criteria are classified under the main criteria. Data is collected from twenty employees working in different job positions in the fifty-three branches in the Malappuram District Cooperative Bank, Kerala, India. The geometric mean of the data is computed to make further analysis. The results of AHP indicate that relationship management competency has the most significant role in providing better customer service of employees (27%), which is closely followed by cognitive competency (24%) and self-management competency (21%). The technical competency (13%) and teambuilding competency (15%) seem to be less influencing.

Parallel Session: MC03, 2:30 pm-4.00 pm, Monday December 17, Room 03, VMCC

A non-parametric model for prediction of dengue incidence

Atlanta Chakraborty and Vijay Chandru

Disease surveillance is essential not only for the prior detection of outbreaks but also for monitoring trends of the disease in the long run. In this paper, we aim to build a tactical model for the surveillance of dengue, in particular. Most existing models for dengue prediction exploit its known relationships between climate and sociodemographic factors with the incidence counts, however they fail to capture the dynamics of the disease. Additionally, such models cannot be extended to other diseases whose causes are not well understood or where the strength of association with several covariates are not yet studied. This has been the motivation for the methodology used in our paper. We build a non-parametric, Gaussian Process (GP) regression model that solely relies on past dengue incidence counts, and show that the GP model performs accurately, thus proving to be a good tactical model for health authorities to plan their course of action.

The study of perception towards self-medication in blood pressure conditions

Nupur Kajarekar, Palak Swain, Priyanka Dash and Sarat Jena

In this paper, the perception of individuals towards self-medication in hypertension/hypotension condition is investigated. Self-medication is described as usage of drugs without the advice of healthcare professionals for prescription, diagnosis or treatment. Studies have proved that in developing countries, like India, the prevalence of self-medication and intake of non-prescribed drugs has increased significantly over the past 10 years (Varun Kumar el at., 2015). However, consumption of drugs without the knowledge about efficacy and safety can lead to fatal effects. In 2017, Ramkumar et al. stated that hypertension is one of the most common conditions for self-medication among the non-communicable diseases in India. However, till date significant studies regarding the factors affecting decisions for self-medication in blood pressure conditions are not conducted. Therefore, an empirical model is developed to understand the important factors contributing towards the decision of self-medication in blood pressure conditions.

Socio-Cultural Barriers to Antenatal Care Utilization among Reproductive Age Women in Wushishi and Zungeru Communities in Niger State, Nigeria: Logistic Regression Approach

Phillips Obasohan, Dorcas Nike Obasohan, Egbako Umar Ahmed, Audu Makada and Muhammad Jibril Toroko

World Health Organization (WHO) world health statistics revealed that in 2015 only 61% of Nigerian pregnant women had attended ANC at least once during their pregnancy period and only 51% met the WHO standard of a minimum of 4 visits. This is undoubtedly lower than the WHO African region average of 77%. This paper aims to determine the sociocultural impediments to accessing ante natal care services among reproductive aged women in Wushishi and Zungeru Communities of Niger State using a Multivariate Logistic Analysis. A total of 150 subjects were involved in this study comprising 83 from Zungeru and 67 from Wushishi. The instrument for data collection was a structured questionnaire which consists of 17 items. The results indicated that ethnicity and preference for traditional birth attendant are major influences to accessing ANC in these communities.

Application of time-flow study to enhance efficiency and reduce patient waiting time in hospital operations

Deepak Yaduvanshi, Ashu Sharma and Praful More

This study aims at exploring the impact of waiting time on efficiency in hospital operations. Patient waiting time is a crucial parameter in the assessment of healthcare quality and queue is one of the major challenges faced by healthcare services. Thus, this study aims to assess patient waiting time at leading hospitals in Jaipur, India using time-flow study to enhance efficiency of hospital operations. The study involved an extensive literature review and data collection from patients, doctors and staff members through varied methods including in-depth interviews, and surveys. To address this challenge, time-flow study was conducted for In-Patient Department (IPD) at hospitals which resulted into dissecting the Waiting Line problem and to arrive at results for meaningful conclusion and inferences. Additionally, after examining the problem analytically, findings of this study include measures that suggested to improve the delay points for reducing patient waiting time and efficient enhancement of patient satisfaction.

Health care analytics on blood service operations in indian context

Ramaa Ananthamurthy, Narahari N S and Rajeswara Rao K V S

Blood service operations are a key component of the healthcare system and yet the modelling of such systems from a complete supply chain network perspective have been lacking due to their associated unique challenges. The intention of this paper is to understand the working of a blood supply chain in the Indian context by modeling the process. The model was developed based on data collected from the blood banks and was run for a replication length of one year using Arena. Control variables like safety inventory, quantity collected at blood donation camps and the frequency of such camps and response variables like the number of out dates and fulfillment of patient requests were considered. Arena's Process Analyzer was used to examine the effect of these control parameters on the response variables. Based on the indicative results obtained, it was concluded that safety inventory was found to be the important parameter.

Parallel Session: MC04, 2:30 pm-4.00 pm, Monday December 17, Room 04, VMCC

Two Person Zero Sum Matrix Game involving I-Fuzzy Parameters

Deeba Naqvi, Imran Khan, Abha Aggarwal and Geeta Sachdev

This paper proposes an extension of Tanaka and Asai approach to study Atanassov's I-fuzzy two person zero sum matrix games where the parameters of the problem are prescribed by I-fuzzy numbers. The primary advantage of the proposed method is that, it is independent of any defuzzication or ranking function and also provides the precise degrees of belief and disbelief of the optimal solutions in achieving the goals of the two players. It is shown that solving such a problem is equivalent to solving a non-linear programming problem, with the help of a small numerical example. Here, solving the I-fuzzy two person zero sum matrix games is equivalent to solving non-linear programming problems for the two players, respectively. To the best of our knowledge, Tanaka and Asai's approach has not been attempted so far to study I-fuzzy matrix games.

Queueing Games in Outpatient Services

S Srivatsa Srinivas and Rahul R. Marathe

We consider a single server outpatient service queueing system serving two types of strategic patients - appointments and walk-ins. Our queueing model aims to find the doctor's service rate given the patients' strategic behavior. We build the model in a game-theoretic framework where the outpatient service provider makes a service rate choice while the appointments and walk-ins make follow-up visit decisions. We find the equilibrium conditions under which the service provider maximizes her profits and patients maximize their utilities.

A game theoretic approach to rail intermodal terminal fortification

Hassan Sarhadi, David Tulett and Manish Verma

A crucial issue in modern supply chains is to guarantee continuity and efficiency in the event of natural and man-made threats. This task is challenging, especially given the finite resources and the complexity of the transportation infrastructure. We make use of a game theoretic approach to determine the optimal strategy for fortifying a given number of rail-truck intermodal terminals, such that the losses (or inefficiencies) resulting from an intentional attack are minimized. The complexity of the resulting tri-level mathematical model motivated the development of a decomposition-based heuristic solution technique, and the two were used to study a realistic size case study from published literature. Finally, we present some managerial insights and directions for future research.

Trust, Altruism, Reciprocity: A Solution to the Problem of Trust in Online Marketplace

Anirban Ghatak

The problem of finding methods to establish trust and reputation in an online marketplace has attracted many researchers for the last two decades, as the transactions in online marketplaces are anonymous, geographically sparse, and sequential in nature. In this paper, for the first time in the study of shaping digital reputation,

I have designed a system where I have shown that establishing trust and ensuring reputation can be possible within the domain of Reciprocal Review. I have developed a game theoretic model of the review/rating mechanism and shown that the equilibrium of the proposed system ensures accurate review from both the parties in the marketplace, thus ensuring the level of trust in the market.

Parallel Session: MC05, 2:30 pm-4.00 pm, Monday December 17, Room 05, VMCC

Using ML Techniques to boost Traditional Supply Chain Functions

Tushar Shekhar

Recent advancement in machine learning tools and techniques have abstracted away the Operations Research in its traditional form. However, it is trivially obvious that the heart of deep machine learning is in Operations Research and robust Mathematics. There is a lot of impetus on deriving greater value from traditional planning functions like Master Planning, Sales and Operations Planning etc. using newer techniques of ML. Many of these applications rely on better modelling of input and better understanding of the output. Making the time-honored global optimal algorithms work with new generation of ML techniques is challenging and has a lot of potential for squeezing out more supply chain surplus. The topic details some of the challenges and benefits of efficient usage of ML techniques with traditional OR tools like Multi Objective Optimization and MILP, where the deployment at large scale supply chain enterprise have resulted in better supply chain KPIs as well as better alignment to supply chain strategy.

Workshop on Beer Game

Opex Analytics

The beer game is a widely used in-class game that is played in supply chain management classes to demonstrate a phenomenon known as the bullwhip effect. The game involves four players representing four stages of a beer supply chain: Retailer, Wholesaler, Distributor, and Manufacturer. Each player must decide how

many cases of beer to order from its upstream partner, given the order quantity that it received in the current time period.

The players' goal is to minimize the total cost of the supply chain, but they cannot communicate with their teammates during the game. Moreover, in the basic version of the game, the players do not have insight into the inventory levels or ordering decisions at the other players—each player only has access to local information.

Players go into the game with the goal of minimizing costs. The outcome of the game, however, is usually a demonstration of the bullwhip effect, which describes the increase in order volatility as you move upstream in the supply chain. Instructors can use this result to discuss the importance of supply chain communication and visibility.

The Opex Analytics Beer Game is the first and only beer game that lets you play with an artificial intelligence (AI) agent on your team. Or, you can let the AI play the game without you and see who earns the better score! Our goal was to provide a fun new interface to a classic game while also demonstrating what's possible when using AI for inventory management and many other operational problems faced in industry today.

In the workshop participants (around 30) will play the beer game and analyse the outcomes in 30 mins. 15 mins will be for the discussion. This workshop is conducted by the team from Opex Analytics.

Parallel Session: TA02, 9:00 am-10.30 am, Tuesday December 18, Room 02, VMCC

Evaluation and optimization on unplanned change in vehicle mass model with wheelbase time delay

Syeda Darakhshan Jabeen

We propose an intelligent optimization technique based on chaotic artificial bee colony (ABC) optimization to mitigate the vibration response of running vehicle with context to safety and comfort. The dynamics of the vehicle has been modeled as half-car by passive suspension and passengers with known input time delay. To two main key techniques are used in our analysis. Firstly, we estimate how changing mass in the form of a passenger in a vehicle affects the vibration behavior

of the dynamic by simulating the model over different bumpy roads using the R-K method of 4th order. Thereby, distinguishing between the causal roles of mass, safety and comfort, we formulate technological constrained optimization problems and implement techniques to optimize the vibration levels and design suspension parameters. The study also analyses the extreme range of vibration levels and comfort relationships for several road conditions to estimate the net effect of vehicle weight change.

Higher order strict minimizers in vector variational problems and variational type inequalities

Anurag Jayswal and Sarita Choudhury

In this paper, we aim to introduce the concept of higher order strict minimizers for vector variational problems. We study the relationship between higher order strict minimizers of the considered vector variational problem and their vector critical points with the solutions of vector variational type inequalities by using the concept of higher order strong convexity. We also introduce the notion of pseudomonotonicity for a functional derivative and hence prove the equivalence of the solutions of Stampacchia weak vector variational type inequality and Minty weak vector variational type inequality under certain assumptions. We construct certain examples to give a better insight to the proved results.

Entropy Convergence Criterion for Bee Colony Optimisation

Suvechcha Sengupta and Sanjeev Panandikar

Complex to solve but wide range of applications ensures continuous research towards obtaining solutions for the Travelling Salesman Problem. The use of approximate evolutionary algorithms have extensively helped the cause however a major concern lies in the number of iterations involved in such a process. Pang, Wang, & Hu (2009) have discussed convergence of Ant Colony Optimisation using entropy convergence as termination criterion for the algorithm and discuss the implementation of the same for the salesman problem. In our study we have implemented the entropy convergence criterion to a Bee Colony Optimisation algorithm. As a result optimum travelling route with minimum iterations and nearly the same quality of solutions under the same conditions is obtained when a Bees algorithm is compared to one with entropy convergence.

Production Optimization at Indofil Industries Ltd. Using Linear Programming

Ashwin Murali, Vishwas Shah, Narayan Rangaraj and Ashutosh Mahajan

This submission is about the usage of Linear Programming to solve a real-life problem of product mix optimization faced by Indofil Industries Ltd., an agrochemical company based out of Mumbai. One of Indofil's plants at Dahej, near Surat in Gujarat, has three manufacturing lines (setups) for manufacturing a variety of agrochemicals (fungicides). Each line has specific products that can be made on it and the existing system requires some products to be produced 2 or 3 times every year in different campaigns due to seasonality. With varying cost structure, market demand and profitability for the products, the company faced a problem of optimizing the production mix within the constraints of demand which had a strategic lower bound and a maximum possible upper bound. With the application of Linear Programming, an optimization model was developed which was used by the company to overcome this problem of product mix optimization.

Parallel Session: TA03, 9:00 am-10.30 am, Tuesday December 18, Room 03, VMCC

Quantitative Approach to Measure Performance of a Resilient Supply Chain-A Case Study

Ajeet Kumar Yadav and Cherian Samuel

The present business environment is highly unstable and competitive in nature, for success, it requires an efficient and effective supply chain management approach. Past few decades, has witnessed that the incidence and the intensity regarding natural disasters, threats due to terrorism, piracy and cybercrime has multiplied and the nature of the global market has become more turbulent. The geographical extent and globalization lead to spread of disruptions beyond the national boundaries and the business sectors. Some of the traditional management strategies are, risk management, agility, lean, just in time, resilient, etc. SCR aims to minimize the cause and impact of disruptions, adapt or learn from the situation to regain its initial or even better stable state. In our work, we attempt to, identify the enablers

of the resilient supply chain through literature, prioritize the enablers using Fuzzy AHP method and finally resilient performance of a supply chain is calculated.

An Efficiency analysis of Indian Leather Industry: A Non-Parametric Approach

Aparajita Singh and Haripriya Gundimeda

Indian leather industry is an important manufacturing sector in the economy owing to meeting two important policy goals of employment and export generation. But currently, the industry is facing issues of strict environmental regulations and loss of competitiveness in the global leather market. In the context of the recent initiatives taken by the Government to boost the leather sector, the present paper evaluates its economic performance using data envelopment analysis. The study uses the Annual Survey of Industries data for years from 2000-01 to 2013-14. A decline in the efficiency of leather firms is found in the post-crisis period of 2008-09. Meta-group frontier analysis shows that efficiency of leather firms differ with their organizational structures, location, and within sub industrial leather groups. The paper suggests investing in plant and machinery, lower energy consumption, skilled labors, higher vertical integration, and merging of small firms to boost its performance in the future.

Optimization in Selection of an Appropriate Variables of Suppliers using An Interpretive Structural Modeling (ISM) at Initial Stage for DEA

Dr. Mohd. Rizwanullah

Traditionally suppliers are selected on certain components like their ability to meet quality requirements, delivery patter and price offered. ISM is interpretive as the judgment of the group decides whether and how the variables are related. Data envelopment analysis (DEA) is one of the most powerful non-parametric methods to assess the relative efficiency of each Decision making units (DMU's).

The objective of this paper is to identify the important decision criteria relevant to current global business environment at initial stage and then provides an effective tool to decide the preferences of suppliers one over another with respect to the

need of organization. This paper also shows that DEA Lingo Model can offer more information than standard LP approach with exclusion of Simulation modeling approach. The advantages of this approach are modesty, flexibility and visualization. The results by comparison of variables will be helpful for organization management to select the supplier.

Integration of supplier selection with closed-loop supply chain for adhesive industries

Priyanka Verma and Gaurav Dhaudiyal

In this paper we develop a linear multi-stage mixed integer facility location model, which determines the location of warehouses for forward supply and collection centres for reverse supply simultaneously, accounting for transportation economies of scale and service time. With the facility plan, we integrate the supplier selection based on the requisite criteria for a closed loop supply chain (CLSC). The model developed for adhesive industries is later tested in GAMS. We furthermore, examine the effects of selected variables on the complexity/runtime of the model by a multiple regression analysis.

Resilient and optimal design of supply chain for biomass to energy system considering supply uncertainty

Ashish Soren and Yogendra Shastri

An optimization model for the biomass to energy system has been proposed, which considers disruption in biomass supply. The components in the system include farms, Regional Biomass Pre-processing Depots (RBPD), and biorefineries. The disruption is a result of drought and the farms are assigned a specific disruption probability, and level of associated loss. Penalty on the shortfall in fuel production and price of short-term procurement during disruption was incorporated in the design. The objective function minimizes the total cost of the system considering disruption. The model was applied to a system with 452 farms spread across a grid of 450 kmX450 km. The design decisions and total cost of the proposed design were compared with a design which ignores disruption. For a penalty of $ 310/Mg on shortfall and a 50% penalty of short-term biomass procurement, a 2.7% lower cost was observed for the proposed design.

Parallel Session: TA04, 9:00 am-10.30 am, Tuesday December 18, Room 04, VMCC

Matrix analytic method for obtaining joint distributions for M/M(a,b)/1 queue

Gulab Patel and Anuradha Banerjee

This article considers a single server infinite buffer bulk service Poisson queue where the customers arrive at the service facility according to the Poisson process. The customers are served in batches according to the 'general bulk service' (GBS) rule. The service time of the batches is considered to be exponentially distributed. Such type of queues have potential applications in manufacturing, computer and telecommunication system, group testing etc. The matrix analytic method (MAM) is used to obtain joint distribution of the number of the customers in the queue and number of customers in service. Various performance measures, which are useful in determining optimal service policy and controlling congestion in the system, are also presented. Finally, few numerical results are presented to validate our analytical results.

On the power of two choices for general randomized load balancing networks

Pooja Agarwal and Kavita Ramanan

Randomized load-balancing algorithms play an important role in large-scale networks. We consider a network of N parallel queues in which incoming jobs with independent and identically distributed service times are routed on arrival using the join-the-shortest-of-d-queues routing algorithm. For a large class of service distributions that satisfy a finite moment condition, any invariant state of the hydrodynamic equations of a sub-critical network with finite mean queue length exhibits double exponential tail decay. We support our analytical results with numerical evidence. The proofs entail the analysis of a coupled system of deterministic measure-valued equations, which may be of independent interest.

An M/G/1 queueing-inventory system with positive lead time

Keerthana Murugan, Sivakumar Balasubramanian and Arivarignan Gunaseelan

In this article, we consider a continuous review inventory system with service facility. The customers arrive according to a Poisson process and the successive service times are assumed to form independent, identically distributed sequences with general distribution. The operating policy is (s; S) policy, that is, whenever the inventory level drops to s an order for Q(= S - s) items is placed. The ordered items are received after a random time, which is distributed as exponential. The stationary distribution of the underlying Markov chain is obtained in matrix-analytic form. The joint probability distribution of the number of customers in the system and the inventory level is obtained in the steady-state case. Various system performance measures are computed and the long run total expected cost rate is derived.

Sufficiency of Markov Policies in Continuous-Time Markov Decision Processes

Eugene Feinberg, Manasa Mandava and Albert Shiryaev

One of the most basic fundamental results in the theory of discrete-time Markov decision processes is that for any policy there exists a randomized Markov policy with the same marginal state-action distributions. This result was established by Derman and Strauch and it implies the sufficiency of randomized Markov policies for basic objective criteria such as expected discounted and non-discounted total costs as well as average costs per unit time. In this paper we establish a similar result for Continuous-Time Markov Decision Processes (CT-MDPs). Even though it is possible to consider general past dependent policies for CTMDPs, most of the existing facts such as optimality of certain policies are established within the class of randomized Markov policies (called relaxed Markov policies in this paper for the reasons explained below); see Guo and Hernandez-Lerma. Thus, this paper implies that the previously established results on the optimality of certain policies within the class of relaxed Markov policies, hold within the class of all policies.

Parallel Session: TA05, 9:00 am-10.30 am, Tuesday December 18, Room 05, VMCC

A Time-Space Network based Approach to Optimize Airline Schedule

Ruchir Santuka

Southwest Airlines is one of the largest airlines in the world operating close to 4000 flights every day across 100 airports with a fleet size of about 800 aircrafts and 4 different types of fleet. Their annual revenue exceeds $21 billion per year.

A typical scheduling problem for any flight carrier is to find a schedule which honours all operational and strategic constraint and maximizes profit. Some of the constraints are hard and must be satisfied, some are highly important, and some are soft constraints. Southwest repeats its schedule on weekly basis and the schedule can change between different days of the week, hence the 7-day problem must be solved to generate a better profitable plan.

Our approach to solve this problem uses MIP model over a time-space network. Since the problem is too large and complex to be solved in one go, we have designed an algorithm that solves multiple small MIPs iteratively to improve the overall solution. Using these embedded heuristics, stepped approach and iterative solve method, we were able to solve the combined 7-day airline scheduling problem of Southwest Airlines in reasonable time. We have been able to successfully demonstrate over 10% savings in cost which would not be possible with current manual and optimization approaches. This presentation will focus on the details of the approach we took to tackle this problem and how it has benefited the Southwest airlines planning team.

Using Simulation-based Optimization in Less-than Truckload Industry

Aniket Modi

LTL (Less-Than-Truckload) carriers move shipments between thousands of origin destination terminal pairs through a hub-and-spoke network and the estimated per year linehaul cost for US based national carriers ranges anywhere between $500 Million to $1.5 Billion. Thus, even a saving of 2-5% improvement in planning can have a huge impact in meaningful reduction of operating cost and time.

Widely adopted planning process in the LTL industry uses two major steps. First, shipment routing using cost computation on spatial network; and second, manual scheduling of trucks. As per our analysis, shipment routing on spatial network is not optimal for carriers with wide slack on shipments, with multiple operating windows and having operations over the weekend. These carriers often end up depending on a lot of manual planning which can lead to sub-optimal solutions. Over the last few years, our team at Optym has developed and improvised a simulation-based optimization approach that can significantly benefit LTL carriers. This approach uses simulations on a time-space network for cost computation and every simulation run feeds to the neighborhood search algorithm for effective overall cost optimization. Though easy to understand, this method has tremendous impact and has brought our model closer to actual operations and is helping planners reduce manual planning efforts and help implement plan changes faster.

This presentation will showcase the benefits of our approach of using neighborhood search algorithms with embedded simulation, followed by the challenges that we may face.

Parallel Session: TB02, 12:00 pm-1.30 pm, Tuesday December 18, Room 02, VMCC

Fuzzy programming with exponential, trigonometric and quadratic membership functions for multiobjective solid transportation problem with mixed constraints

Amal Kumar Bit.

The multiobjective solid transportation problem with mixed constraints in which the supply, demand and capacity constraints are mixed (equality and inequality) types and the objectives are equally important, non-commensurable and conflicting in nature. Our proposed algorithm and the fuzzy algorithm with linear membership functions are applicable to all types of multiobjective solid transportation problems and the vector minimum problems. This algorithm can be applied to the variants of multiobjective solid transportation problem and similar linear multiobjective programming problems. This paper is to be seen as a first step to introduce fuzzy programming with exponential, trigonometric, and quadratic (nonlinear) membership functions for solving a multiobjective solid transportation problem with mixed constraints. This paper also shows that representation of

membership functions is not unique. The value of membership function of an objective represents the satisfaction level of the objective.

Comparison of Fuzzy Multi-Objective Programming and Lexicographic Approaches for Integrated supplier selection and Order Allocation in Steel Industry

Priyanka Verma, Ravindra Gokhale and Ishu Tyagi

This study involves the application of Fuzzy TOPSIS for Supplier selection and evaluation by considering both qualitative and quantitative criteria for a Steel Industry. The Quantitative Criteria are dealt during the order allocation process carried out with the help of Fuzzy Multi-Objective Linear Programming. The work further extends to the use of Lexicographic approach and its comparison with the Fuzzy Approach.

Interval-valued Pythagorean Fuzzy TOPSIS through Entropy Measure for Multicriteria Group Decision Making

Biswajit Sarkar and Animesh Biswas

In this article a new entropy measure for an interval-valued Pythagorean fuzzy set is developed to determine the weights of the criteria in solving multicriteria group decision making problems using TOPSIS-based methodology. At first, interval-valued Pythagorean fuzzy entropy measure is initiated using Minkowski distance measure. In the decision making process, interval-valued Pythagorean fuzzy weighted arithmetic averaging operator is applied to identify the ideal opinion which is subsequently used in TOPSIS. Weights of the criteria are determined using entropy weight model through the newly defined entropy measure and then other steps of TOPSIS are carried out corresponding to each decision maker. Finally, the score values of the alternatives are aggregated to obtain the overall ranking of the alternatives to avoid loss of information throughout the process. An illustrative example is considered, solved and compared with existing method.

A ranking algorithm for bi-objective quadratic fractional integer programming problems

Vikas Sharma

An algorithm to solve bi-objective quadratic fractional integer programming problems is presented in this paper. The algorithm uses ϵ-scalarization technique and a ranking approach of the integer feasible solution to find all nondominated points. In order to avoid solving non- linear integer programming problems during this ranking scheme, the existence of a linear or a linear fractional function is established, which acts as a lower bound on the values of first objective function of the bi- objective problem over the entire feasible set. Numerical examples are also presented in support of the theory.

Bicrtieria Scheduling On Parallel Machines Involving Weighted Flowtime and Total Tardiness in Fuzzy Environment

Dr Sameer Sharma, Dr Deepak Gupta and Dr Seema Sharma

This paper pertains to a bicriteria scheduling on parallel machines in fuzzy environment which optimizes the weighted flow time and total tardiness simultaneously. The fuzziness, vagueness or uncertainty in processing time of jobs is represented by triangular fuzzy numbers (TFN). The objective of the paper is to find the optimal sequence of jobs processing on parallel machines so as to minimize the secondary criteria of weighted flow time (WTF) without violating the primary criterion of total tardiness. A numerical illustration is also carried out to the test efficiency of the proposed algorithm.

Parallel Session: TB03, 12:00 pm-1.30 pm, Tuesday December 18, Room 03, VMCC

Manufacturing Lines Decision Analysis using DES and other manufacturing factors

Jagdish Gosavi, Jyoti More, Aditya Agrawal, Hitesha Nemade and Anivesh Kumar

For a seamless flow of products on a manufacturing line to meet the desired throughput, one of the critical factors in line design is the way products are moved from one station to the next. Selection of right type of line is an important decision since it is long-term and huge investment, which is most of the time irreversible. Based on the method of moving products from one station to the next, manufacturing lines are divided into two broad categories called Synchronous Lines and Asynchronous Lines. The case study focuses on definitions, constraints, and trade-offs of these two-line types. The conclusions of the case study are derived from Discrete-Event Simulation models. The conclusions will help factories to ask the right questions while selecting the type of manufacturing line in the design phase, and it will help them to take the right decision at the right time.

Hybridization of an integrated model used for sustainability assessment

Neeraj Hanumante, Yogendra Shastri and Andrew Hoadley

Abstract: Sustainability, being an interdisciplinary subject, needs a model that would assist in its formal study. In 2006, the US-EPA developed a compartment based integrated mathematical model covering ecological-economical-social/legal system. This model is a rudimentary representation of the Earth, covering a food web across tropic levels, and industrial and economic activity. However, complete human species has been represented by a single compartment. Hence, a crucial aspect of diversity in humans caused by different economic development could not be captured. The work proposed here attempts to address this deficiency by incorporating some aspects of agent-based modeling, into the human compartment of this model, and classify humans from an economic perspective. Initial results

report the behaviour to be sustainable for projected population trends whereas increased consumption scenario is unsustainable. The overall objective of the development of this model is to determine unsustainable behaviours or possible catastrophic events in the system for different scenarios.

Engineering Analytics Framework for Human Talent Management using System Dynamics and Agent Based Simulation

Mario Marin, Nafeeza Ibrahim, Edgar Gutierrez, Oloruntomi Joledo, Sayli Bhide, Luis Rabelo and Fahad Alasim

In today's advanced technology world, enterprises are in a constant state of competition. As the intensity of competition increases the need to continuously improve organizational performance has never been greater. Managers at all levels must be on a constant quest of finding ways to maximize their enterprises' strategic resources. Enterprises can develop sustained competitiveness only if their activities create value in unique ways. The significance of human capital is even greater now, as the intangible value and the tacit knowledge of enterprises' resources should be strategically managed to achieve a greater level of continuous organizational success. This research effort seeks to provide managers with means for decision making for their human talent (workforce) management. A framework for modelling and managing human capital to achieve effective workforce planning strategies is developed and applied to a case study to assist the enterprise in its long term strategic organizational goals.

Deterministic modelling and simulation of vessel scheduling in ports

Mitrabarun Ghosh

Although scheduling of cargo handling operations is considered one of the primary areas of research, modeling, and analysis of vessel scheduling, considering different variables, parameters, and factors, unique to any port, have not been extensively conducted. Thus it was felt that in order to mathematically model vessel scheduling, the model should start from ideal deterministic to the complex

stochastic, and it should further be verified and validated by the vessel-related data collected from seaports, which, in every sense, is unique to for each port. A deterministic model has been proposed using simulation in this paper to address the typical vessel scheduling operation in ports as well as recommendations have been given on extending the model with necessary changes to fit into the scheduling decision problem under risk, and uncertainty.

Mixed rail-traffic simulator: use for rail-section simulation, capacity estimation and bottleneck identification

Devendra Shelar, Soumya Dutta, R. Vidyadhar, Ayush Agrawal, Narayan Rangaraj and Madhu Belur

This paper describes the 'Mixed Rail Traffic Simulator' developed at IIT Bombay: 'mixed' here refers to the trains being of different priorities - high-speed passenger trains to freight-trains. The simulator uses a mesoscopic model of rail traffic on sections of track between major junctions, with sufficient detail for the purpose of operations analysis. For a given infrastructure, the simulator can be used for section capacity estimation, bottleneck identification and generating a de-novo timetable. Though freight trains earn the most amount of revenue, being of lowest priority amongst the mix of various priority trains, freight trains are affected most adversely by congestion in a rail-network. The simulator helps in identifying freight paths requiring less amount of time, and thus better quality freight paths. Effects due to infrastructure upgradation can be accurately quantified thus helping in investment decisions. This paper describes the tool in detail.

Parallel Session: TB04, 12:00 pm-1.30 pm, Tuesday December 18, Room 04, VMCC

Predictive asset availability optimization for underground trucks and loaders in the mining industry

Sunil D Patil

This project was started by Sandvik Mining and Rock Technology along with IBM as its innovation and technology partner to bring about a multigenerational

shift in how heavy equipment maintenance is managed in the mining industry, and to augment its analytical offering, OptiMine® Analytics, with IBM's predictive capability. In many cases, more than half of the total maintenance time is spent on unplanned downtime. Unplanned downtime events do lead to significant reduction in operational efficiency and take up two and a half times as long to resolve compared to the same in a planned manner. To address this, Sandvik and IBM teamed up to develop a customized service for fleet management and predictive maintenance for Sandvik mining equipment and improve Overall Equipment Efficiency (OEE) for Sandvik's customers.

Use of artificial neural network to predict fuel consumption in HD785-7 dump trucks

Manish Mishra, Ram Prakash Mali, Sanjit Adhya, Rahul Kishore and Sunny Soarabh

Fuel cost in open pit mining activity is one of the important precursors to overall cost competitiveness. The cost of running hauling fleet is 30-35% of the total operating cost of mining. However, there are multiple factors that govern the dynamics of the rate of fuel consumption. An artificial neural network-based model was built using a back-propagation algorithm to predict fuel rate for HD-785 Komatsu series dump trucks for mines of Tata Steel. The proprietary vehicle health (VHMS) and operation data retrieved from the fleet management system were used for the purpose. It was observed that there were different parameters including but not limited to blow-by pressure, engine rpm, engine oil pressure, the accelerator pedal position and that affected fuel rate. The model was trained using the retrieved data and the predicted values were compared with the real-time data, a mean absolute deviation of 5% was observed.

Prediction of Coke Strength after Reaction (CSR) using Time Series Model in Coke Plant # 10 & 11

Satish Agarwal

Coke is raw material for blast furnace for production of hot metal. Good quality raw material produces low cost hot metal and one of the important quality parameter for blast furnace is Coke Strength after Reaction (CSR), as it refers to coke

"hot" strength, generally a quality reference in a simulated reaction condition in an industrial blast furnace. In this research, the effects of coal properties and process parameters on the Coke CSR were studied by Time Series forecasting model. The Time Series method was used for historical data of last 3 years to estimate the CSR value. In this investigation, thirty-four input parameters such as moisture, volatile matter, ash, fluidity, battery temperature etc. used. A Time Series UCM model was found to be optimum with nine parameters of coal properties and other process parameters with an accuracy of 78%, 76% and 76%, on the train, test and validation dataset.

Parallel Session: TB05, 12:00 pm-1.30 pm, Tuesday December 18, Room 05, VMCC

Coordination in Ride Hailing Platforms: An Agent-Based Approach

Harit Joshi and Saral Mukherjee

Global taxi market is estimated to be worth more than 100 billion USD in 2017. It has witnessed an evolution from a traditional decentralized model in which taxis operated independently to organizations owning and managing the fleet to multi-sided platforms matching supply and demand. Coordination is central to unlocking value through matching demand and supply. The value of coordination has not received due importance in the literature on ride-hailing models. Through this research, we aim to understand the value of coordination for different stakeholders like drivers and customers in various ride-hailing platforms. We propose a network-based model to analyze the ride-hailing phenomenon. We present analytical results for simple cases and propose an agent-based simulation (ABS) for more realistic situations. We aim to understand the impact of different decision-making rules for agents as well as the interaction between driver and customer agents on coordination using an ABS model.

Rake Linking and Train Platform Allocation – A Constraint Programming Approach

Rajnish Kumar, Goutam Sen, Samarjit Kar and Manoj Kumar Tiwari

A train entering large Terminal has multiple choice of halting platform. Train Platform Allocation (TPA) is a problem of finding an allocation of most preferred platforms for arriving trains in a railway station.Rake Linking is the process of using sets of railway coaches, collectively referred to as a rake, for multiple train services in a Railway Network. The Rake linking decisions and the TPA are interlinked as the platform occupancy duration and commuters convenience are important considerations for both rake linking and TPA. The platform allocation is also dependent on the services, their arrival and departure routes, which are linked by a rake. As a case study, we consider TPA and Rake Linking decisions based on real data for Howrah Railway Station, the largest and one of the busiest in Indian rail network.We also use a new Constraint Programming approach in place of traditional MILP models to solve the problem.

Generation of Locality Polygons using Open Source Road Network Data and Non-Linear Multi-classification Techniques

Rahul Kumar and Kabir Rustogi

One of the principle problems in the developing world is the poor localization of its addresses. This inhibits discoverability of local trade, reduces availability of amenities such as creation of bank accounts and delivery of goods and services (e.g., e-commerce) and delays emergency services such as fire brigades and ambulances. In general, people in the developing World identify an address based on neighbourhood/locality names and points of interest (POIs), which are neither standardized nor any official records exist that can help in locating them systematically. In this paper, we describe an approach to build accurate geographical boundaries (polygons) for such localities, leveraging GPS location data, Open Source Road Network Data and Non-Linear Multi-classification Techniques.

Optimizing large scale upgradations involving movable assets

Swapnesh S and Narayan Rangaraj

Product upgradations are common, as it is practical and economical in many cases, compared to complete replacement. Proper planning and scheduling using quantitative techniques can be helpful, in the case of large scale upgradations involving movable assets, like rolling stock. There is a possibility of doing the upgradation of the asset in multiple locations and there can be operational constraints involved in executing the process. Literature on modeling for optimizing the scheduling of large scale upgradation, involving movable assets could not be found. In this paper a model using Integer Programming is proposed for optimizing the execution of these types of upgradations. A case involving retrofitting of bio-toilets in Indian Railways is used as an example. The central unit will make decisions on number of items to be retrofitted in each facility and facilities to be upgraded based on the output of the optimization model. There are other problems in industry, involving other movable assets like automobiles and naval vessels, where extension of these models may be useful.

Parallel Session: TC02, 2.30 pm-4.00 pm, Tuesday December 18, Room 02, VMCC

Higher-order B-(p, r)-invexity and duality for minimax fractional programming with square root terms

Vivek Singh

In this paper, we present new class of higher-order B-(p, r)-invexity and formulate higher-order duality for a nondifferentiable minimax fractional programming problem. An example is constructed to examine the existence of the introduced class of functions, which is more general than previously defined functions. Based on the new definitions, we establish appropriate higher-order duality results. These results extend several known results to a wider class of programs.

Duality in nondifferentiable minimax fractional programming with generalized invexity

Sonali, Navdeep Kailey and Vikas Sharma

In this paper, duality theory is discussed for nondifferentiable minimax fractional programming problems. We study a parametric dual model for nondifferentiable minimax fractional programming problem. We establish sufficient optimality conditions for an optimal solution to the problem and obtain appropriate duality theorems under $(pr) - \rho - (\eta, \theta)$-invex assumptions.

Correspondence Between a New Class of Generalized Cone Convexity and Higher Order Duality

Arshpreet Kaur, Navdeep Kailey and Mahesh Kumar Sharma

In this paper, a new class of generalized higher order cone convex functions is introduced. This class of functions contains several classes of generalized convex funtions existing in literature. A fractional nondifferentiable vector optimization problem is discussed in which each component of objective and constraints contain support function of some compact convex sets. Then a dual model is constructed for this vector optimization problem. Lastly weak and strong duality theorems are formulated and proved with the help of our new cone convex functions.

A decomposition based approach to solve large scale biorenery optimization problems

Varun Punnathanam and Yogendra Shastri

The biorefinery system based on agricultural residue primarily consists of feedstock procurement and processing which need to be taken into consideration together in order to obtain a globally optimal design. This generally results in large-scale Mixed Integer Linear Programming (MILP) models that scale rapidly based on the number of technology and location options, resulting in highly complex and challenging optimization problems. This work considers a case study based setting up a biorefinery system for the state of Maharashtra, and employs the Dantzig-Wolfe decomposition approach to solve this problem. An approximation

strategy is proposed to handle the binary variables. Our approach results in a significant reduction obtained in computational time (up to 92%). The problem size is also varied and we present the reduction in computational time for varying problem sizes. The approach can be used to solve other large-scale optimization problems of various fields with a similar structure.

The KKT conditions for multiobjective fractional interval valued optimization problems

Indira P. Debanth and S. K. Gupta

In this article, we focus on a class of a fractional interval multivalued programming problem. For the solution concept, LU-Pareto and LS-Pareto optimality are discussed. The ideas of LU-V -invex and LS-V -invex for a fractional interval problem are introduced. Using these assumptions, we establish the KKT optimality conditions for the problem assuming the functions involved to be gH-differentiable. Non-trivial examples are also discussed to make a clear understanding of the results established.

Parallel Session: TC03, 2.30 pm-4.00 pm, Tuesday December 18, Room 03, VMCC

Policies for Dynamic Assignment for Full Truckload One to One Pick up and delivery problem

Tejas Ghorpade and Narayan Rangaraj

Pick up and Delivery demands are usually dynamic with uncertain travel or service times. For such applications, instead of planning routes in advance, the vehicles are assigned to requests in real time. We formulate a mathematical model for static version of this problem assuming all demands are known prior to beginning of the planning process. In order to cater to the dynamic demands we model this problem as a Markov Decision Process. Different strategies resulting into four policies i.e. Minimum Empty Distance, Minimum Net Service Time, Minimum Maximum Service time and Proactive Empty Movement are discussed. These are based on available information without necessity of reoptimizing at every

time step. We test the long term performance of these strategies with respect to each other and against the desired objectives like minimizing empty distance or service time.

Last-Mile Optimisation for Ecommerce Logistics by Leveraging Subcontracting Options and Location Intelligence

Aditi Gupta, Anurag Paul and Kabir Rustogi

The "Last Mile" of the e-commerce logistics (e-logistics) supply chain in India contributes to about 30% of the entire delivery cost of a shipment. Contributing factors largely include highly variable demand and poor localization of customer addresses. Many e-logistics companies tackle this problem by subcontracting deliveries that are worst affected by these factors to local "mom and pop" stores. Such stores are able to provide good unit economics for highly localized catchment areas since they are able to cross utilize their staff for doing local deliveries. However, their capacity is limited. Hence, to minimize the cost of last-mile deliveries, an e-logistics company must determine an optimal allocation of shipments to their fixed fleet and to the sub-contractors. Route optimisation for the fixed fleet is also crucial for cost minimisation. This paper discusses a solution approach for these problems that leverages Lexicographic Goal Programming and Vehicle Routing Problem.

An investment framework to mitigating risk from railroad transportation of hazardous materials

Ali Vaezi and Manish Verma

Railroad is one of the primary modes for transporting hazardous materials (hazmat) in North America. In this study, we investigate the viability of a novel technique to mitigate hazmat risk from rail shipments. More specifically, we propose a methodology that first assesses hazmat risk of the given railroad, and then generates a list of high-risk candidate locations for possible infrastructure investment consideration. The bi-level optimization program is applied to study the railroad network in Canada, and to recommend optimum investment options for network risk reduction.

Optimization Models for Railway Crew Management - An Overview

Tabish Haque and Faiz Hamid

Crew planning/scheduling problems in railway are commonly addressed at various stages of decision support - strategic, tactical and operational - based on the planning horizon. Issues at strategic level include amendments in key policies related to work regulations, relief locations in a network, crew forecasting, resource acquisition, etc., that might affect the local operations when integrated. Strategic issues are relatively intractable by optimisation approaches due to extremely long planning horizons. Tactical level initiates with deciding elementary timetable updated either annually or on a seasonal basis. Issues allied in tactical crew planning aim at finding the minimum number of crews required in a region to operate the train services which concern the mediumterm use of the available resources. A handful of important tasks at this stage include rolling stock scheduling, networking train routes, station track management, maneuver, maintenance, etc. The core of the crew scheduling process is to draft crew duties that are feasible, efficient, and acceptable. Feasibility in general associates scheduling plan satisfying valid constraints, and robustness to tackle external disruptions in the network. To inculcate robustness in the solution as well as to avoid delay propagation from one train to the next an extra cushion of time is added between train changes; the planner also includes several penalty costs to bound the train changes within a duty. Efficiency governs by stratifying each task as productive or non-productive and percentage of time spent in each. Finally, acceptability, a qualitative facet (quality of life of the crew), of a schedule is transmuted quantitatively by introducing several penalty costs in the objective function. Operational level issues in planning problems are of the highest gravity as they implement the final assignment of the crew to duties considering workload balance besides avoiding infeasibility concerning connectivity of schedules. Operational level crew planning can be carried out on monthly/bimestrial basis or even daily. Disruption an ineluctable part of railway networks has inclined researchers recently to exploit robustness in the solutions and tools for disruption management. Railway disruption management, an iterative process, embraces in order timetable adjustment, rolling stock rescheduling, and crew rescheduling respectively. The crew rescheduling process aims at finding a new feasible crew schedule that covers as many tasks as possible while minimising the number of modified duties. Advent of new technologies like GPS-based systems explores new areas in real-time crew rescheduling which helps to improve reliability of solutions further. This paper presents literature on crew management in railways, portrays different techniques applied in problem formulation and

prominent solutions methodologies at various stages of the decision support for real-world applications.

Tolerance approach to sensitivity analysis in multiobjective transportation problem

P. Paratane and A. K. Bit

This paper represents ordinary sensitivity analysis and tolerance approach to sensitivity analysis (tolerance analysis) in supply and demand values of multiobjective transportation problem. Our proposed approach allows the simultaneous and independent changes in parameters of multiobjective transportation problem. As we are unable to get the unique optimal solution of multiobjective transportation problem, we can obtain the best compromise solution using fuzzy programming technique. In our paper we have used the best compromise solution for the postoptimality analysis of multiobjective transportation problem. The aim of this paper is to find the ranges for each supply and demand values within which the changes can occur without affecting the current basis of the best compromise solution. The feasibility condition for existence of the best compromise solution is taken into consideration throughout all calculations. The approach is illustrated by one numerical example.

Parallel Session: TC04, 2.30 pm-4.00 pm, Tuesday December 18, Room 04, VMCC

Tata Steel Outbound Network Optimization post GST using AIMMS software

Jagjit Singh, Subrata Basak, R Krishna, Anil Harshana, Pankaj Kumar and Nikhil Maheshwari

rior to implementation of goods and service tax (GST) in India, supply chain network was designed keeping taxation as the focal point with the customer demanding material from the state same as that of customer due to value added tax (VAT). Post implementation of GST in India this was no longer true. Mixed integer linear programming (MILP) with branch and bound algorithm is used in

the model to optimize the amount of shipments for transportation in the existing supply chain network of FGs for Tata Steel. This optimization model achieves two objectives, (1) Opening and closing of stockyards generating maximum revenue, and (2) Minimizing the total freight cost.

Automated Data Harmonization (ADH) using Artificial Intelligence(AI)

Anjan Dutta, Tomal Deb and Shrikant Pathak

Our Automated Data Harmonization (ADH) solution comprised of a mixture of Fuzzy Text Similarity, Natural Language Processing, and different Machine Learning techniques. It has been implemented on the Big Data stack for better performance and scalability. In order to streamline the overall business process, we have implemented runtime rules and workflow.

Even as the technologies and algorithms used in building the solution are widely available and continuing to evolve, the solution is unique and tailored to meet a set of specific business requirements. However, the solution approach can be extended for similar requirements like Media metadata standardization across multiple devices, Author name and citation resolution in scholarly journals, Leads resolution in multi-channel marketing and ad campaigns and more.

Application of Data Science to Forecast Accurate Variable Cost of Power Generation and Optimal Scheduling and Coal Blending Among Different Units in a Power Station, A Case Study of JSW Energy Ratnagiri Thermal Power Plant

Kartikeya Misra and Yatish Chhabra

This is a case study about use of data science, statistics and analytics in operation of thermal power plant where amount of up to 3 to 5 paisa per kWhr has been saved. This paper describes a new methodology to forecast boiler efficiency, Turbine heat-rate and Auxiliary power consumption in a thermal power station. This is used to forecast power generation cost of a thermal power station for various types of coal and at different load. The equation so produced are used in linear programing to obtain optimal scheduling of generation as well as coal

blends among different generators in a thermal power plant. The cost of generation depends upon cost of coal, Efficiencies of Boiler, Turbine and APC. Normally efficiency of Boiler and Turbine is measured using complex formula as per ASME PTC. This also require multiple data from power plant. Hence accurate forecasting of cost of generation is very difficult, the problem is further complicates when a power plant uses different types of coal in different blend ration. In this paper, a new methodology has been described using data science to prepare mathematical model for forecasting turbine heat rate. Boiler Efficiency and Auxiliary power consumption under different loading condition and while using a variety of coal in different blends. This involves a regression of historic data of Turbine and boiler process parameter along with type of coal and load generated in generator.

Parallel Session: TC05, 2.30 pm-4.00 pm, Tuesday December 18, Room 05, VMCC

Optimization of differential entropy to estimate uncertainty in a multivariate normally distributed ecological model

Kakali Karmakarsur

In this paper we intend to estimate the maximum individual uncertainty in multivariate ecological differential entropy model using the “Maximum Entropy Principle”. Differential entropy a concept in information theory was introduced by Shanon.Let X be a continuous random variable with probability density function p(x), the differential entropy is given by where is the support set of X. If the prior probability distribution is not known, we shall maximize the Shanon entropy subject to all constraints being satisfied using MEP. Bayesian estimation for differential entropy and relative entropy have previously been derived for the Gaussian. A common approach to estimate differential entropy is to find the maximum likelihood estimate for the parameters and then substitute them into the differential entropy formula. Then optimization of differential entropy completes the journey of uncertainty measurement.A numerical example has been developed in support of theoretical discussion.

Flash Flood Analysing Tool using GIS and Remote Sensing

Johny Samuael

Flash Floods are one of the most alarming disasters in the world requiring efficient routing of water, with the help of intelligent analysing software. In this paper, a Geo-spatial tool is proposed for analysing and evaluating flash flood disasters using an innovative methodology, which traces the route of entry of water and marking its flow in any desired location. This analysis is carried out using a multi directional, self-calibrating algorithm which finds the possible route of entry of flooding water and the possible degree of floods at various sources. Apart from mapping flash flood flow, this analysis provides results for tsunami and finds the route of entry of water from any cardinal direction. The Algorithm uses customised Artificial Intelligence and highly efficient sensing formulas to classify the topography of the location regardless of the nature of the terrain and provide results with precision.

Multidimensional analysis of water sector performance in India: An Index approach

Ashish Chopra and Parthasarathy Ramachandran

This article is about the development of a new index for integrated assessment of water sector performance in India. Water Poverty Index (WPI) is a multidimensional index used internationally at different scales and levels for performance analysis of water sector. The methodology used to calculate WPI is based on subjective weight method i.e. equally weighted average of its five components, namely resources, access, capacity, use and environment. The main objective of this study is to remove the subjectivity in assigning weights by using data envelopment analysis (DEA).

In this study 11 major states of India are considered to assess the role and impact of geographical and institutional constraints on the overall water sector performance. DEA methodology have been used to benchmark and to calculate the aggregate index for different states of India. A total of 20 variables, capturing the multidimensional aspect of water sector have been used in this analysis.

Competing for End-of-Life Vehicles: Dismantlers' Strategies in Recycling Markets

Krishna Mohan T V and R K Amit

Recycling of complex products such as end-of-life vehicles (ELVs) provide opportunities for material recovery. ELV recycling is performed in two ways - either in an environmentally sound way by formal dismantlers or in an inefficient way with poor occupational and technological practices by informal dismantlers. The presence of formal and informal dismantlers in an economy may lead to competition between them. We model these competition through a system dynamics model for an emerging economy, where the informal dismantlers are predominant and the formal dismantlers are beginning their operations. Using Indian data, the simulation results show that the dismantlers are worse off due to competition. The competition adversely affect the informal dismantlers and they gradually exit from the recycling markets.

Parallel Session: TC06, 2:30 pm-4.00 pm, Tuesday December 18, TBC

Workshop on Beer Game II

Opex Analytics

The beer game is a widely used in-class game that is played in supply chain management classes to demonstrate a phenomenon known as the bullwhip effect. The game involves four players representing four stages of a beer supply chain: Retailer, Wholesaler, Distributor, and Manufacturer. Each player must decide how many cases of beer to order from its upstream partner, given the order quantity that it received in the current time period.

The players' goal is to minimize the total cost of the supply chain, but they cannot communicate with their teammates during the game. Moreover, in the basic version of the game, the players do not have insight into the inventory levels or ordering decisions at the other players—each player only has access to local information.

Players go into the game with the goal of minimizing costs. The outcome of the game, however, is usually a demonstration of the bullwhip effect, which describes

the increase in order volatility as you move upstream in the supply chain. Instructors can use this result to discuss the importance of supply chain communication and visibility.

The Opex Analytics Beer Game is the first and only beer game that lets you play with an artificial intelligence (AI) agent on your team. Or, you can let the AI play the game without you and see who earns the better score! Our goal was to provide a fun new interface to a classic game while also demonstrating what's possible when using AI for inventory management and many other operational problems faced in industry today.

In the workshop participants (around 30) will play the beer game and analyse the outcomes in 30 mins. 15 mins will be for the discussion. This workshop is conducted by the team from Opex Analytics.

Parallel Session: WA02, 9:00am - 10:30am, Wednesday December 19, Room 02, VMCC

Intuitionistic Fuzzy Proximal Support Vector Machine

Scindhiya Laxmi and Shiv Kumar Gupta

Support vector machine is a powerful machine learning technique for classification and regression problems. In binary data classification problems, it classifies points by assigning them to one of the two disjoint halfspaces. Fuzzy membership degree is assigned to each data to reduce the effects of noises and outliers. We developed the intuitionistic fuzzy proximal support vector machine, which classifies points according to its proximity of the two parallel planes (in input or feature space) that are kept as distant from each other as possible. There is an intuitionistic fuzzy number associated with each training point which is framed by its degrees of membership and hesitation in the feature space. The solution of the optimization problem to get the optimal classifier is obtained by inversion of a nonsingular matrix rather than solving a larger sized quadratic programming problem. It can handle large datasets with less computational time and perform better classification.

Formation of Global Plan Analytics at Johnson & Johnson

Saurabh Jawaharya and Subhodeep Dey

J&J management understood that the data-analytics revolution now underway has the potential to transform how companies organize, operate, and create value. The mission is to compete with best in class to stay afloat to provide a competitive advantage to the team and with this objective to drive the disruptive changes in business, Global Plan analytics team has been established in the supply chain as Analytics- center of excellence. GPA aims to provide a focal point for consumer SC data and insights, with the overall goal being the ability to capture new knowledge and practices from inside and outside of the business. GPA enable value through driving efficiency and designed a separate strategy for Run the business and change the business objectives. GPA for Consumer sector enables the business to build a robust data, insights and advanced analytics services for Supply Chain function for Consumers sector.

Application of Earth Movers Distance together with Neural Network, on problems in Image Recognition

Manoj Kumar and Narayan Rangaraj

We consider the problem of matching two images taken at different time instants using different distance measures. In this paper, we will demonstrate the Earth Movers distance, together with the deep neural network and K-means algorithms to match the images. Most research papers on the Earth Movers Distance focus on the theoretical aspects and although some applications to retrieve images are available, none uses deep neural networks.

Fundamental Analysis Using Logistic Regression for Stock Selection A Study on BSE Sensex

Selvan Simon

This study developed logistic regression (Logit) models for stock classification using fundamental analysis. It reviewed the machine learning models in ratio analysis for financial classifications which included Logit models as a benchmark.

It adopted the most commonly used conventional classifier Logit for stock selection from Bombay Stock Exchange (BSE). It reviewed the concepts and constructed models applying seven steps in classification learner application of the MATLAB. It included nine financial ratios of companies for the predictor variables. It applied the moving window system for dataset construction that allowed to include recent past records in training. It repeated the experiments for finding optimal period of records to be included in training. Furthermore, it investigated optimal number of replications required for mitigating the oversampling. As the result, it developed 156 models each served for one-time binary classification. They identified top performing stocks for next fiscal year from the companies listed on BSE Sensex. The selected stocks were included in equally weighted portfolios to win the market. The model performance was measured using annual returns of the portfolio and compared with BSE Sensex as benchmark. The Logit models for equities screening and the investment strategy with BSE Sensex improved the long-term returns. The optimal training set for modeling included just the recent past one-year records. Moreover, the replications of minority cases twice in the training sample provided the best results. This study used a small set of companies as investment universe. Ideally, a larger set of companies may be considered for further experiments.

Parallel Session: WA03, 9.00 am-10.30 am, Wednesday December 19, Room 03, VMCC

Consequence analysis of resource depletion using dynamic modelling

Vinod Vijay Kumar, Andrew Hoadley and Yogendra Shastri

The depletion of natural resources is a key issue for the present as well as future generations. Some of the existing evaluation methods consider substitution of scarce resource with an alternative resource, but do not consider a frame of time for the substitution. In this paper, a dynamic resource-depletion methodology based on consequence analysis is proposed. The methodology is demonstrated for a case study of natural gas scarcity in New Zealand. A system dynamics model predicts the gas price and the rates of gas consumption. The predicted gas consumption is used to determine the potential environmental impacts using life cycle assessment (LCA), and coupled with plausible scenarios. The scenarios include resource substitution of domestic gas with black coal and with imported liquefied natural gas (LNG) during gas shortage. For the New Zealand case, the

substitution resulted in an increase in the economic and environmental impacts under both the scenarios.

Estimation of Population Mean under the Problems of Random Non-Response in Two-Occasion Successive Sampling

Mohd Khalid and G N Singh

In this paper, we have considered the problems of estimation for the population mean on current (second) occasion in two-occasion successive sampling under random non-response situations. Some modified exponential type estimators have been proposed and their properties are studied under the assumptions that the number of sampling unit follows a discrete distribution due to random non-response situations. The performances of the proposed estimators are compared with linear combinations of two estimators, (a) sample mean estimator based on a fresh sample and (b) ratio estimator based on the matched sample under the complete response situations. Results are demonstrated through empirical studies which present the effectiveness of the proposed estimators. Suitable recommendations have been made to the survey practitioners.

Application of DES in Manufacturing Industry: Today Vs Tomorrow

Jagdish Gosavi

Discrete Event Simulation has been used by the manufacturing industry for virtual verification and validation of the manufacturing systems. This session will cover different aspects related to application of the DES in manufacturing processes like Assembly, Paint, Weld, Fabrication, Machining along with material flow logistics. It will throw light on purpose of DES applications like design of the systems, validation of the systems and most importantly for day-to-day decision making. The session will also cover the level of accuracy that we can expect out of these models. The session will touch base Simulation Based Optimization

applications and its value proposition for the organization. The session will also throw light on the integration of latest technologies and lean fundamental in DES. Lastly the value proposition, way ahead and the challenges for DES applications in manufacturing industry will be presented.

Environmental Impact Assessment of Coal Mining using System Dynamic Modeling – A Study in Dhanbad

Mr Hasanuzzaman and Chandan Bhar

Increased supply of modern energy is the primary requirement for economic growth in India, which is mainly fulfilled by coal. It leads to increase coal demand and subsequent production. However, coal mining causes intense socio-environmental catastrophe. Keeping this in consideration, the study has developed a framework using system dynamic modelling method to assess environmental impact of coal mining covering air, water, noise and land pollution. Hence, this study has used secondary data collected from published environmental reports of coal mining industry and journal articles for the period of 2004-2018. The framework has been used to simulate the environmental impact for next 10 years. It is found that the impact on air and land is increases with increasing production but reduces for water due to recycle and reuse. However, noise level remains above the permissible limit. Findings of this study can be used for strategic decision making to reduce environmental impact.

A discrete event simulation model to evaluate congestion mitigation scenarios at ports

Vignesh Alageshan and Anjali Awasthi

Container ports are facing the growing problem of congestion. Globalization, growth of trade and increasing consumer demand have further added to this complexity which has resulted in increased greenhouse gas emissions at the ports. Several measures are being undertaken by the ports to reduce this problem and improve port sustainability. Examples of these measures are implementing advanced technology equipment, implementing extended gate hours, changing the arrival patterns of trucks, and implementing variable gate lane policies. The objective

of the paper is to develop a discrete event simulation (DES) model to investigate the congestion mitigation scenarios to improve terminal productivity and reduce truck turn times at ports. A case study is conducted. The results of our simulation study yield upgrade of technology at the terminals as the best solution followed by managing the arrival patterns, changing gate lanes and extended gating hours.

Parallel Session: WA04, 9.00 am-10.30 am, Wednesday December 19, Room 04, VMCC

Controllable Multiprocessor Interdependent Queueing System with Discouragement and Additional Service Positions

Anamika Jain and Madhu Jain

The controllable arrival rate for the queue dependent heterogeneous multiprocessor queueing system with discouragement is considered. The system consists of r permanent and s additional processors, which activate whenever the queue length of jobs in the system reaches a pre-specified threshold values and continues till queue length again decreases to the previous level. The queue size distribution and other performance indices are determined using recursive approach.

Bivariate PGF method approach to analyze infinite buffer batch service Poisson queue with singular vacation

Gagan Kumar Tamrakar and Anuradha Banerjee

The Poisson queues, bulk service queues, vacation queues are widely used in literature to model telecommunication and compute communication networks by the engineers. In this paper, we consider a single serve, infinite buffer, bulk service Poisson queue with general bulk service (GBS) rule and single vacation. Using bivariate probability generating function (PGF) method we obtain the steady-state joint distributions of the queue content and server content (when server is busy), and joint distribution of the queue content and type of the vacation taken by the server (when server is in vacation), instead of obtaining only queue length. Here 'type of the vacation' means the queue length at vacation initiation epoch. The information about these joint distributions may help in increasing the system

performance. We have presented several important performance measures and few numerical examples to illustrate the numerical compatibility of the analytical results.

Numerical Solution of Large Discrete-time Markov Chains by Three-step Alternating Iteration Method

Rakesh Nandi, Sujit Samanta and Debasisha Mishra

We analyze the numerical solution of large size structured discrete-time Markov chains encountered in queueing models. Solving large size Markov chain is still an open and challenging problem for the most advanced algorithms currently available for their solutions. The discrete-time Markov chains with large state space arise in many applications including reliability modeling, queueing network analysis, communication systems to analyze the system performance evaluation. Due to the very large number of states of many real-world problems, there has been increasing interest in recent years to develop parallel algorithms for Markov chain computation. Iterative methods based on matrix splittings are more effective and efficient than the direct methods when the size of the matrix is large. In this article, we present a new iteration scheme called three-step alternating iterations using the matrix splittings, for computing the stationary probability distribution vector of finite QBD, M/G/1 and G/M/1 type discrete-time Markov chain.

A Brief Note on Analytical Aspects and Consecutive Losses in Finite-buffer Queues under Batch-size-dependent/Non-renewal Bulk-service and Batch Markovian Arrival Process

Souvik Ghosh, Abhijit Datta Banik and Dibyajyoti Guha

This paper analyzes a nite-buffer queueing systems where the customers arrive in batches and the accepted customers are served in batches by a single server according to batch-size dependent general bulk service rule. The inter-batch-arrival times of batches are assumed to be correlated and it's representation is expressed through the batch Markovian arrival process (BMAP). The queue-length distribution at batch-service completion and arbitrary epoch have been discussed. The computation of the consecutive loss probabilities under the renewal service process

is carried out considering batch-size-dependent service time distribution. Further, the above finite-buffer bulk-service queueing model has also been investigated considering correlated service times which is presented through Markovian service process (MSP). The phase-dependent consecutive loss probabilities for the correlated service times are determined. A variety of numerical results for different service time distributions are presented in this paper in the form of tables and graphs.

Parallel Session: WA05, 9.00 am-10.30 am, Wednesday December 19, Room 05, VMCC

Interactive planning in dynamic supply chain

Jayan Moorkanat and Seshadri Lakshminarayanan

Decision makers in the supply chain are dealing with an increasingly dynamic and complex environment. Traditional solutions that support them are batch processes that resemble black boxes. What is needed are solutions that blend with the workflow of the decision maker at every step. In this presentation, we will discuss the nature of these interactive solutions. They are different from the traditional one in that they offer the following features - UX for constant interaction with users, Planning algorithms offering options on incremental planning, Adjustment of the plan based on near real-time inputs, & Enabling trade-off analysis in near real-time.

Analytical Decision Making using ®RISK and the DecisionTools Suite

Vivek Hinduja, Palisade

In this we will explore some of the ways in which organisations are applying Palisade tools for analytical business decision making under risk and uncertainty. From oil and gas, insurance and finance through to healthcare, defence and construction, ®RISK and the other tools in the DecisionTools Suite enhance the decision making capabilities of some of the world's most successful companies.

Palisade's flagship software, ®RISK, is used for Quantitative Risk Analysis using Monte Carlo simulation on models you make in Excel. Having been around

since 1984, ®RISK is used by more than 95% of Fortune 100 and 76% of Fortune 500 companies. Through a live demo of ®RISK, we will try to demonstrate how easy – and necessary – it is to implement quantitative risk analysis in any business.

Parallel Session: WB02, 12.00 pm -1.30 pm, Wednesday December 19, Room 02, VMCC

Flowshop scheduling problem of minimum makespan with bounded processing time

Meenakshi Sharma, Manisha Sharma and Sameer Sharma

Three-machine flowshop scheduling problem with nondeterministic processing time is addressed in this paper. The objective is to obtain the optimal sequence of jobs corresponding to minimum makespan when neither the actual processing time nor the probability distribution of these times is known. There are many practical situations where the actual processing times can't be determined unless the processing of job is completed on available system of machines, however these times are bounded by known lower and upper bounds. In such situations there may exist multiple optimal sequences for different realizations of processing times that dominates all the other sequences. In this paper a global and local dominance relations are proposed to reduce cardinality of set of sequences that optimize the referred problem of flowshop scheduling environment.

Design, Implementation, and Application of Network Flow Based KSA

Hyunwoo Jung

Automatic Timetable Generator

The purpose of this paper is to design and implement an algorithm to generate timetable of KSA(Korea Science Academy of KAIST) based on information of course registration of students, assigned teachers for each course, and available timeslots for each teacher so that it can be applied to real administration work process to make timetable of KSA which has been done manually until now by taking at least three weeks for 15 years since KSA has been founded. KSA timetable

construction problem is very general one which can be applied to most of schools. In this paper, a network flow based algorithm is designed and implemented to generate feasible timetable within one hour automatically. The algorithm in this paper was used to make timetable of KSA at the 2nd semester in 2018 by using 36 timeslots.

Application of Multi-Party, Multi-Skill Job Scheduling in a product testing facility

Franklin Varghese

In manufacturing facilities, quality checks are done to ensure conformance to design-specifications. Conventionally companies try to schedule these jobs manually using tools like excel. In practice this turns out to be a very time consuming and significantly complex task to carry out. While applying concepts from job scheduling literature, some tough and challenging requirements arise such as how to efficiently allocate tasks to multi-skilled operators. In this paper a novel approach is presented to formulate a function which rewards periodic scheduling of test simultaneously for all jobs using law of diminishing marginal utility and proposes a new type of constraint to allocate multi-skill operator using the property of prime numbers. This model was applied at HILTI Manufacturing Ltd. and was used to create a dynamic plan for day-to-day operations and has proven to be a reliable tool to schedule all jobs according to their priority and forecast expected delivery dates.

A Heuristic to Minimize Makespan with No-wait Flowshop Scheduling

Kewal K. Nailwal, Deepak Gupta and Sameer Sharma

This paper describes a heuristic algorithm for n-job, m-machine flowshop scheduling problem under no-wait constraint with the objective of minimizing makespan. As n-job, m-machine flowshop scheduling problem under no-wait constraint is NP-hard, the heuristic algorithms become the need to find optimal or near

optimal solution in simple manner. The results obtained using proposed heuristic are compared with the with benchmark heuristics. A numerical illustration is also given to illustrate the proposed algorithm.

Scheduling time-relaxed double round-robin tournaments with availability constraints

David Van Bulck and Dries Goossens

In the time-relaxed double round-robin sports scheduling problem with availability constraints, we are given a set of time slots and a set of teams that meet one another a fixed number of times. Furthermore, each team provides time slots in which it can host a game, and time slots in which it cannot play at all. Since time-relaxed schedules contain (many) more time slots than there are matches per team, the difference in the number of matches played per team can become large, and the rest period between teams' consecutive matches can vary considerably. To solve this problem, we propose relax-and-fix methods with team and time based decompositions. Second, we propose an adaptive large neighborhood search method that repeatedly destroys and recreates a solution. For numerous artificial and real-life instances, these heuristics generate near-optimal schedules using considerably less computational resources compared to integer programming (Gurobi).

Parallel Session: WB03, 12.00 pm -1.30 pm, Wednesday December 19, Room 03, VMCC

Production Network, Technology Choice, Capacity Investment and Inventory Sourcing: Operational Hedging under Demand Uncertainty

J. Prince Vijai

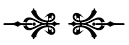
We model a firm's technology investment, capacity acquisition and inventory sourcing decisions under demand uncertainty as a two-stage stochastic optimization problem. Our objective is to study the strategic choice between alternative technologies in the production network and examine for conditions under which flexible technology to be chosen over dedicated technology and vice-versa. We

study the effect of cost of flexible capacity on optimal technology choice in the production network via numerical experiments. We show that the level of stocks required to be reserved at upstream plant, as input supplies to downstream plant, is more for flexible technology than dedicated technology in production network. We, hence, conclude that investing in flexible technology in production network requires more reservation of input stocking units at supply channel (or upstream plant) than dedicated technology, in order to hedge against demand uncertainty.

A Two warehouse inventory model with ramp-type demand for random deteriorating items under inflationary condition

Monika Vishnoi and Shivraj Singh

In this article, an inventory system for items that are stored in two-warehouses when randomly deteriorating items has been developed with demand rate as a ramp type function of time. In real life situations, the impact of time value of money and inflation cannot be ignored while deciding optimal inventory policies. Shortages at the owned warehouse are also allowed subject to partial backlogging. The purpose of this study is to find the optimal replenishment policies for minimizing the total relevant inventory costs. The solution methodology provided in the model helps to decide on the feasibility of renting a warehouse. Furthermore, numerical examples are provided to illustrate the proposed model. Comprehensive sensitivity analysis of the optimal solutions with respect to major parameters is carried out and some managerial inferences are obtained.



Multi-modal Supply Chain Distribution Problem

Hussain Kharodawala, Ashutosh Mahajan and Jayan Moorkanat

We discuss a multi-modal supply chain distribution problem where the aim is to minimize cost of transportation, inventory, backlog and lost-sales over a time-horizon. The problem can be represented as a time-space network. Each node defines the state of a facility at a given time-period and the arcs between these nodes are either transportation, inventory or backlogs. The time-horizon consists of discrete time-periods and the transportation flows are required to be an integer multiple of predefined lot-sizes. There are business rules which are posed on

transportation modes incoming to a facility or posed on its suppliers that are to be followed. The problem stated above is first modeled as a MILP and solved using solver. We propose an integer rounding-heuristic to get a feasible solution. Using this feasible solution as an MIP-start in solver helps us in reaching optimal solution in lesser time.

An integrated imperfect production-inventory model with proportional size shipment policy and process quality control

Oshmita Dey and Laboni Khan

The proposed work is based on an integrated imperfect single-vendor single-buyer production-inventory model with stochastic demand and optimal vendor investment under the proportional-ratio size shipment policy. It is assumed that the first shipment is of size q with the subsequent batch-sizes increasing by a multiplicative factor β i.e., the n-shipment policy is of the form $q, \beta q, \beta^2 q, \beta^3 q, \ldots, \beta^(n-1)q$. The expected annual total cost is developed under these assumptions with the control parameters as the order quantity (lot-size), number of shipments, safety stock factor and percentage of defectives. Owing to the potential non-convexity of the cost expression, an algorithm is proposed to minimize the expected annual total cost incurred by the integrated system under these assumptions thereby yielding the optimal values of the control parameters.

Deterministic Inventory Model for Deteriorating Items with Time Dependent Demand and Time Dependent Holding Cost

Madhu Jain and Anshul Kumar

Inventory management is an important task for the higher profitability of any firm. The concept of Economic Order models has been widely used to predict the optimal order size and other inventory metrics of deteriorating items. The total cost consists of two major components, first is the ordering cost and second is the holding or the carrying cost. Consider the holding cost used given by a piecewise function. The time dependent holding cost can be seen for many products. To illustrate, we consider an example of an android mobile phone; if any model A of mobile phone has less features and more cost, then newly launched model B of

mobile phone having less cost and more features will become more popular after sometime and its demand goes on increasing as time passes. The demand function of the proposed deterministic EOQ model is taken in such a way that it is constant for sometime (say 'a') and then after that, it increases because of the popularity of the item in the market. So, by realizing the fact that the demand may be time dependent, in the present study, we formulate an EOQ model for deteriorating items for which the holding cost as well as the demand function are time dependent.

Parallel Session: WB 04, 12.00 pm -1.30 pm, Wednesday December 19, Room 04, VMCC

An empirical study on quality control practices in a supply chain network

Alisha Arora and Jayendran Venkateswaran

This work studies the quality control practices in a supply chain network, benchmarks its performance and suggests improvement for the same. The supply chain network under study consists of suppliers who supplies all components of the product (solar study lamp) in knock-down kit form, which are then assembled into the final product form at various assembly centers. A supplier supplies to multiple assembly centers. The transport is only via road (full truck loads), with each truck delivering to 1-3 assembly centers per trip. Before dispatch, the lot is inspected at the Supplier location. This inspection before the dispatch of lamp kit material from the vendor site is called Pre-Dispatch Inspection (PDI). This paper aims to evaluate the sampling process used in Pre-Dispatch Inspection.

Manufacturing Performance Improvement Analysis using Six Sigma DMAIC Methodology: A case study

Pardeep Gupta, Ankesh Mittal and Pushpinder Yadav

The aim of this paper is to presents a case study on the implementation of Six Sigma - DMAIC methodology with a purpose to reduce the defectives produced during the manufacturing of rubber weather-strips. Weather-strips are used in both right hand side and left hand side of rear doors and front doors of cars. The

rejection rate of rubber weather-strips manufactured by XYZ Ltd. (name changed) was significantly high. The company was keen to reduce this high rejection rate with the application of Six Sigma approach with a purpose to improve quality of products and profitability of the company. The overall rejection rate of rubber weather-strip was up to 5.5% causing a huge loss to the company. The company set the target to reduce this high rejection rate to 2%. Finally the company remained successful in reducing the rejection to 2% with the application of Six Sigma DMAIC methodology.

A study on implementing TQM as a business tool for improving organizational performance in an Indian Industry

Pardeep Gupta, Aman Hooda and Ankesh Mittal

XYZ Ltd. is a leading tractors manufacturing industry situated in Punjab, India manufacturing about 300 tractors per day. The company is operating two tractor plants and manufactures wide range of tractors from 20 to 75 Hp. The company was facing some major challenges and thus adopted TQM in 2007 as business tool to counter both the external and internal challenges for realizing the vision of the company i.e. "To be within top two brands in India". The company set goals, business objectives and established its strategies in line with the vision of the company. The TQM journey remained highly successful in XYZ Ltd. and as a result the company got the Deming Award in 2012. The aim of this paper is to highlight a brief TQM implementation methodology, the issues faced by the company prior to TQM, and investigate the effectiveness of its implementation through a brief case study.

Estimation of factors criticality for core quality: An integrative GDM-CCMA-AHP approach

Ashutosh Mishra and Priyanka Verma

Quality of used products (cores) plays crucial role for the economic growth of secondary (flea) market corroborates sustainability concerns. This study focuses on the classification of factors in before and after core acquisition phases with impact on quality states with the help of progressive hybrid GDM-CCMA-AHP approach

which is validated on a case study of automobile engine. The peculiarity of CCMA optimized AHP consists bringing down the inconsistencies of pairwise comparison matrices (PCMs) without any manual intervention considerably as well as valuing and weighing of the quality factors confirms criticality in respective acquisition phases sufficiently. Results shows that inspection processing time, functionality of the core, its warranty period, and destructive separation are most indispensable factors that affect the core quality.

Improving Product Quality and Customer Satisfaction in Industry through Quality Assurance System: A case study

Ankesh Mittal, Pardeep Gupta and Sachit Vardhan

The aim of this paper is to present a study on the implementation of Quality Assurance System in a tractors manufacturing industry ABC Ltd. The TQM implementation at ABC Ltd. was initiated in 2007 and the company got Deming Prize in 2012 with its successful implementation. TQM implementation helps the organizations to excel in quality, cost and delivery, provide products of wide range and gain operational excellence. The focus of the traditional approach was only on 'Inspection and Control' but after TQM the focus got shifted to 'Assurance & Prevention'. Implementation of TQM initiatives helped the industry under study to double the revenue, triple the profit in just three years. The customer satisfaction index improved from 76 to 106, sales volume increased from 27000 to 67000 tractors in a year and market share enhanced from 9.1 to 12.6 percent after TQM within a period of five years.

Parallel Session: WB05, 12.00 pm -1.30 pm, Wednesday December 19, Room 05, VMCC

Applications of OR/MS

Dr Satyam Suraj Sahay, John Deere Fellow Materials Engineering

Choice of materials significantly impact the design, manufacturing as well as supply management in an OEM. In this talk, specific use cases would highlight the complexity of the materials related decision making while considering their

influence on all these adjacent functions. The importance of simultaneously optimizing material choice, design and manufacturing process instead of just making materials conversion will be demonstrated. Furthermore, it will be shown that the asymmetric commodity price fluctuations with time could change these optimal choices with time. Complexity associated with these multifunctional projects and their business transition will be presented. This work will also highlight some of the operations research problems in materials processing - such as recipe management, scheduling and controls algorithms as well as usage of advanced analytics like machine learning and deep learning algorithms.

Queueing Systems, Achievable Region, Complete Family of Schedulers

V. Kavitha

Queueing systems are central in analysing many applications. A queueing system can probably be defined by the waiting line(s), customers, scheduling policies etc. A very important aspect is to derive performance of the given system under the given a strategy/scheduling policy. It is more important to identify 'important' family of schedulers. The term 'important' is relevant when one is interested in designing 'optimal systems'.

Achievable region is the space of all possible performance vectors, one component for each customer type, when parsed through all 'possible' schedulers. Complete family of schedulers is the sub-family of schedulers that are sufficient to achieve important part of the achievable region. This talk focuses on these aspects and some more.

9 Panel Discussion, Prof. B Nag Auditorium, VMCC Emerging Trends in Operations Research and Management Science

The last technical session of ORSI 2018 will be a Panel Discussion on "Trends of emerging concepts in Operations Research and Management Science". The panelists are a group representing different facets of the hard-to-define area or profession called Operations Research. They are

1. Y.Narahari, Professor, Computer Science and Automation, Indian Institute of Science, Bengaluru
2. Arvind Kumar, Managing Director of Optym in Bengaluru
3. R. Badri Narayan, Executive Director, Computers and Information Systems at the Railway Board in Delhi in the Ministry of Railways, India
4. Girikanth Avadhanula, Director - Supply Chain Solutions, SAP-India, in Pune

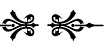
The panelists will give their views on how the field of Operations Research may evolve in the near and long term, given the various technological developments, especially in the area of data sciences and exciting possibilities in machine learning, as well as the pull from different professions and application areas. The allied term of Management Sciences gives an organizational flavour to the subject, and this will also be explored through an open discussion.

10 Practice Award Finalists Abstracts

Application of Data Science to Forecast Accurate Variable Cost of Power Generation and Optimal Scheduling and Coal Blending Among Different Units in a Power Station, A Case Study of JSW Energy Ratnagiri Thermal Power Plant

Kartikeya Misra and Yatish Chhabra

This is a case study about use of data science, statistics and analytics in operation of thermal power plant where amount of up to 3 to 5 paisa per kWhr has been saved. This paper describes a new methodology to forecast boiler efficiency, Turbine heat-rate and Auxiliary power consumption in a thermal power station. This is used to forecast power generation cost of a thermal power station for various types of coal and at different load. The equation so produced are used in linear programing to obtain optimal scheduling of generation as well as coal blends among different generators in a thermal power plant. The cost of generation depends upon cost of coal, Efficiencies of Boiler, Turbine and APC. Normally efficiency of Boiler and Turbine is measured using complex formula as per ASME PTC. This also require multiple data from power plant. Hence accurate forecasting of cost of generation is very difficult, the problem is further complicates when a power plant uses different types of coal in different blend ration. In this paper, a new methodology has been described using data science to prepare mathematical model for forecasting turbine heat rate. Boiler Efficiency and Auxiliary power consumption under different loading condition and while using a variety of coal in different blends. This involves a regression of historic data of Turbine and boiler process parameter along with type of coal and load generated in generator. Based on this principle we have prepared mathematical model for Turbine Heat rate, Boiler Efficiency and Auxiliary power consumption leading to accurate forecast of cost of generation Application of data science to forecast accurate variable cost of power generation and most optimal scheduling and coal blend among different units in a power station.



Predictive Asset Availability Optimization for Underground Trucks and Loaders in the Mining Industry

Sunil D Patil, Abhishek Mitra, Krishnaveni T Katarikonda and Jan-Douwe Wansink

Mining industry is at an inflexion point. On one side, prolonged adverse global market conditions, slowing of economy, sustained low commodity prices, and skilled labour shortages have pushed the industry to introduce significant cost rationalization and intense focus on continued operational optimization. On other side, Industry 4.0 is here. Even traditionally late-adopters of innovation in the mining industry are turning toward technology to create value to the business of mining. For mining OEMs, this has created both a challenge, in terms of constant pressure to reduce machine downtime and improve asset utilization, and an opportunity to leverage all the advances in sensors, data storage, machine learning combined with intelligent machines to create an unassailable competitive advantage. To address this, Sandvik Mining and Rock Technology and IBM developed a customized service for fleet management and predictive maintenance for Sandvik's mining equipment and improve Overall Equipment Efficiency (OEE). This customized service is augmented with Sandvik's analytical offering, OptiMine®. Analytics, with IBM's predictive analytics capability. This paper will discuss the application of analytics practice to reduce machine downtime and improve asset availability. It will also discuss the various challenges faced and how these challenges are addressed. It further shows that how this work made significant impact in financial terms and the client testimonials received.

Prediction of coke strength after reaction (CSR) using time series model in Coke Plant # 10, 11

Satish Agarwal, Shweta Shrivastava, Adity Ganguly, Abhishek Kumar, Siddharth Maheshwari and Ramesh Kumar

Coke is raw material for blast furnace for production of hot metal. Good quality raw material produces low cost hot metal and one of the important quality parameter for blast furnace is Coke Strength after Reaction (CSR), as it refers to coke "hot" strength, generally a quality reference in a simulated reaction condition in an industrial blast furnace. In this research, the effects of coal properties and process parameters on the Coke CSR were studied by Time Series forecasting

model. The Time Series method was used for historical data of last 3 years to estimate the CSR value. In this investigation, thirty-four input parameters such as moisture, volatile matter, ash, fluidity, battery temperature etc. were used. A Time Series UCM model was found to be optimum with nine parameters of coal properties and other process parameters with an accuracy of 78%, 76% and 76%, on the train, test and validation dataset respectively. The operating range of coal properties and controllable process parameters is derived from model developed to operate for consistent Coke CSR of 65.5% and above.

Tata Steel Outbound Network Optimization post GST using AIMMS software

Jagjit Singh , Subrata Basak, R Krishna, Anil Harshana, Pankaj Kumar and Nikhil Maheshwari

This paper deals with optimization of outbound logistics supply chain in Tata steel ltd. (TSL). There are three main drivers of cost in a company like TSL, (1) Production cost, (2) Dispatch cost, and (3) Raw material procurement cost. Tata Steel strives to be lowest cost steel manufacturer in the world and thus it is targeting all the three levers. Prior to implementation of goods and service tax (GST) in India, supply chain network was designed keeping taxation as the focal point with the customer demanding material from the state same as that of customer due to value added tax (VAT). Post implementation of GST in India this was no longer true and companies got a golden opportunity to simplify network and route to serve so as to bring efficiency in logistics & supply chain. In FY 2016 – 17, TSL had 26 stockyards pan India, which serve more than 2000 customers. Complexity in TSL finished goods (FG) outbound logistics supply chain network originates from factors like 2 manufacturing plants i.e. Jamshedpur and Kalinganagar, 11 loading mills like hot strip mill (HSM), cold roll mill (CRM) etc., 34 types of material, more than 60,000 stock keeping units, through multimodal transport mechanism comprising of any combination of rail, road and sea. For railway transportion mode, TSL has three types of rakes, (1) Conventional rakes (CFs) from Indian railways (2) Special freight train operator rakes (SFTO) (3) Container rakes (CNs), where CFs are destined for public railway sidings owned by ministry of Indian railways (PRS) and SFTOs and CNs are destined for privately owned freight terminals (PFTs) or privately owned railway sidings (PORSs). Now, these rakes can

be further broken down into wagon of five types, (1) Bogie type flat side discharge wagon (BFNS), (2) Bogie type flat side discharge large wagon (BFNSM), (3) Bogie open type side discharge wagon (BOXN), (4) Bogie type rapid discharge wagon (BRN), and (5) Box type open side discharge tanker wagon (BOST). This model also accomodates a dynamic factor called as idle freight or dead freight, which varies with the type of wagon and type of material. Mixed integer linear programming (MILP) with branch and bound algorithm is used in te model to optimize the amount of shipments for transportation in the existing supply chain network of FGs. This optimization model achieves two objectives, (1) Opening and closing of stockyards generating maximum revenue, and (2) Minimizing the total freight cost.

Automated Data Harmonization Using Artificial Intelligence

Anjan Dutta, Tomal Deb, Shrikant Pathak

Organizations in the business of Information Services deal with very large volumes of data which is collected from a variety of proprietary, as well as, public sources in multiple languages with different formats, naming conventions, and context. Mapping such data into enterprise master data in order to make multi-disciplinary reporting and prediction is an effort-intensive, and time- consuming process which is prone to errors. On the other hand, machines cannot match these sources and map to master data accurately.

Enterprises are now eager to automate the human intensive tasks of data harmonization so that their resources can focus on finding the insights to drive the business. TCS undertook one such automation initiative for a global Market Research Major (MRM) and achieved a significant level of success leveraging Artificial Intelligence (AI) techniques.

Our Automated Data Harmonization (ADH) solution comprises of a mixture of Fuzzy Text Similarity, Natural Language Processing, and different Machine Learning techniques. It has been implemented on the Big Data stack for better performance and scalability. In order to streamline the overall business process, we have implemented runtime rules and workflow.

Even as the technologies and algorithms used in building the solution are widely available and continuing to evolve, the solution is unique and tailored to

meet a set of specific business requirements. However, the solution approach can be extended for similar requirements like media metadata standardization across multiple devices, author name and citation resolution in scholarly journals, leads resolution in multi-channel marketing and ad campaigns, and more.

Use of artificial neural network to predict fuel consumption in HD785-7 dump trucks

Sunny Soarabh, Tata Steel Ltd

Fuel cost in open pit mining activity is one of the important precursors to overall cost competitiveness. The cost of running hauling fleet is 30-35% of the total cost of mining. However, there are multiple factors that govern the dynamics of the rate of fuel consumption. An artificial neural network-based model was built using a back-propagation algorithm to predict fuel rate and fuel injection for HD-785 Komatsu series dump trucks for mines of Tata Steel. The proprietary vehicle health (VHMS) and operation data retrieved from the fleet management system were used for the purpose. It was observed that there were different parameters including but not limited to blow-by pressure, engine rpm, engine oil pressure, the accelerator pedal position and that affected fuel injection. The model was trained using the retrieved data and the predicted values were compared with the real-time data, a mean absolute deviation of 5% was observed. It is expected that the sensitivity analysis of the model would result in the development of practical guidelines for reducing fuel rate.

11 Connecting to Wifi Network

Credentials to connect to the wifi network in the conference area:
Network name = IITB-Guest, userid = orsi2018.wifi and password = $ERU#vJv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