MIP Insights

The newsletter of the Mixed-Integer Programming Society

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The 2024 MIP Workshop

The 2024 Mixed-Integer Programming Workshop was held on **June 3 - 6, 2024, at the University of Kentucky**. The workshop showcased presentations from 19 experts from around the world; we invite everyone to view pictures from the event at www.mixedinteger.org/2024/. The workshop had over 120 participants with about 70 of them being students. The participants traveled from 10 different countries spread across 4 continents. In addition to the regularly scheduled presentations, MIP 2024 hosted (1) the Third Annual Computational Competition, (2) the traditional poster session, and (3) the first ever MIP summer school.

The topic for the 2024 computational competition was MIP Presolve. Congratulations to **Yongzheng Dai and Chen Chen (Ohio State University)** for their winning submission on 'Two-Column Probing for MIPs'. The committee also recognized the work **Rolf van der Hulst (University of Twente)** titled 'Implied integer detection using totally unimodular submatrices' with an honorable mention. Congratulations to Yongzheng, Chen, and Rolf!

The 2024 poster competition saw a record number of applicants with 30 chosen as finalists. The poster committee awarded two honorable mentions for the best poster award: one to **Noah Weninger (University of Waterloo)** for the poster 'Interdiction of Minimum Spanning Trees and Other Matroids Bases' and one to **Siddharth Prasad (Carnegie Mellon University)** for the poster 'New Sequence-Independent Lifting Techniques for Cutting Planes and When They Induce Facets'. The committee awarded the best poster award to **Dahye Han (Georgia Institute of Technology)** for the poster 'Aggregation of Bilinear Bipartite Equality Constraints and Application to FEM Update Problem'. **Noah Weninger** also received the most popular poster award. Congratulations to Dahye, Noah, Siddarth, and all poster presenters!

MIP 2024 hosted the first ever MIP summer school. The topic of this school was cutting planes with speakers **Santanu S. Dey (Georgia Institute of Technology), Robert Hildebrand (Virginia Tech),** and **Jean-Philippe Richard (University of Minnesota)**. Thanks to Santanu, Robert, and JP for their help!

Thank you to all of our industry and university sponsors, the University of Kentucky, and the local organization (Yuan Zhou, KT Griffis, Aaron Davis, Kat Henneberger, and Ford McElroy)!

The 2025 MIP Workshop

The **2025 Mixed Integer Programming Workshop** will be held on **June 3–6, 2025** at the **University of Minnesota**. This will be the twenty-second edition of the series, returning to Minneapolis twenty years after it hosted the second MIP workshop. MIP 2025 will continue many of the essential traditions that have made this annual workshop a gathering place for the community, and we invite you to join us and participate in

- A **single track of 21 invited experts** across a wide array of topics in theoretical, computational, and applied aspects of integer programming and discrete optimization.
- A **poster session**, including a competition among selected student finalists for the best poster award, for which submissions will open later this year.
- A **computational competition** on Primal Heuristics for MIQCQP, for which rules and details are to be announced in mid-November and the tentative deadline for submissions is March 7, 2025.

Please keep an eye out for more information by visiting the website at https://www.mixedinteger.org/2025. See you in Minneapolis!

Call for locations for MIP 2026

If you are interested in hosting MIP 2026, please email akazachkov@ufl.edu. We kindly ask you state your interest by February 1, 2025, at which time the program committee will start to evaluate potential locations. The committee will continue to evaluate potential locations until an appropriate one is chosen.

MIP International Workshop in Mumbai

The inaugural MIP International Workshop is being organised at IIT Bombay, Mumbai, India from Dec 2 - 6, 2024. The MIP International Workshop aims to facilitate growth of discrete optimization research and research collaborations across the globe. The event is specifically designed to provide ample time for discussion and interaction between the participants. The workshop will consist of a single track of invited talks and a poster session. The registration for the workshop and the poster competition for students are now open. More details are available on the event website.

Organizing Committee: Avinash Bhardwaj (IIT Bombay) and Vishnu Narayanan (IIT Bombay)

Program Committee: Mathieu Van Vyve (Chair, UC Louvain), Kavitha Telikepalli (Tata Institute of Fundamental Research), Diego Moran (Rensselaer Polytechnic Institute), Chen Chen (Ohio State University), and Sriram Sankaranarayanan (Indian Institute of Management Ahmedabad).

MIP European Workshop 2025

The MIP International Workshop Series is coming to Europe. On July 1-3, 2025 we will meet for a three-day workshop in Clermont-Ferrand, France. This will be a single-track workshop with invited talks and a poster session. Speakers, registration, travel support, and other information will be posted soon on the event website.

Organizing Committee: Rafael Colares, Renaud Chicoisne, Sophie Huiberts

Program Committee: Mathieu Besançon, Alexander Black, Claudia D'Ambrosio, Christopher Hojny, Sophie Huiberts

Discrete Optimization Talks (DOTs)

The Mixed-Integer Programming Society supports **Discrete Optimization Talks (DOTs)**, a virtual seminar series on all aspects of integer and combinatorial optimization. In the coming semester, DOTs will be held on the **second Friday of the month** at 12:00 pm Eastern Time over Zoom. Visit talks.discreteopt.com to find information on the Fall 2024 season of DOTs and view recordings of previous talks. To receive the link to participate, join the mailing list and add "lists@mixedinteger.org" to your approved addresses. If you are interested in giving a DOT, let us know. We look forward to seeing you!

MIP Committee Elections (COMIPS)

As outlined in our bylaws, the current term of our elected COMIPS members will conclude on June 30, 2025, and new elections will be held. We will open the call for candidates in **January 2025**, with the elections taking place in **March 2025**. We especially encourage candidates who will broaden how the committee represents our community in terms of gender, research, geography, and other attributes.

Grid-aware Electric Vehicle Scheduling Problems

by Andrea Lodi

Electrification of transportation is one of the key transitions to reduce CO_2 emissions in energy consumption, particularly in urban areas. It is widely understood that meeting this objective requires an intelligent approach towards their charging schedules and a variety of methods have already been proposed in the literature to harness the flexibility of individually owned electric vehicles and car fleets (see, e.g., the reviews [16, 1, 18]).

The focus of this short discussion is the scheduling of fleets of medium and heavy-duty electric vehicles and, in particular, Electric buses (E-buses). By 2025, more than 1.2 million internal combustion engine (ICE) buses are expected to be replaced by electric buses, representing almost half of the market share for municipal buses [4]. This will clearly lead to a significant increase in electricity demand. Just to put it into a NYC perspective, the Metropolitan Transportation Authority (MTA) has close to 6,000 buses for public transport whose rate of charge (each) is in the range 40-125 kW for Combined Charging Type 1 connectors, while a house in the US has on average a little over a 1 kW electric load.

Given a set of timetabled trips, the classical problem of scheduling a fleet of public transportation buses requires to cover the trips in the cheapest possible way by building sequences of trips, called routes, that each bus will do. For ICE buses, this is known in the literature as the *vehicle scheduling problem* (VSP) [5] and the cost of each route depends on the gas used (roughly proportional to the traveled distance on the route), plus the cost of the driver(s) and of the bus itself. The VSP is an NP-hard problem that is classically solved by column generation [15, 7, 9].

There is already an extensive literature on the electrification of bus services (see, e.g., the reviews [19, 14, 6]), with contributions in several areas as charging facility planning [28, 25, 26], scheduling charge at the depot (see, e.g., [21, 3, 20, 10]), and scheduling wireless charge of electric bus systems [22, 24, 23]. We focus our attention to the bulk of work on the so-called *electric* vehicle scheduling problem (EVSP), i.e., the VSP extension in which the classical scheduling becomes more complex due to the need to account for the charging of the E-bus.

Although there exists a significant amount of literature on EVSP considering how to optimally cover the trips by fulfilling different constraints and cost objectives regarding energy consumption [17, 11, 8, 27], we argue that a particular aspect has received very little attention, namely how the decisions on where and when to recharge the E-buses affect the electric grid congestion and, in turn, the electricity cost. More precisely, the (overlooked) complexity relies on fully considering the interaction between the two congested systems: on the one side, the need to use the fleet of vehicles as much as possible to cover trips, thus minimizing the driving cost and, on the other side, give the grid the required flexibility so as to unlock low-cost charge.

Defining this cost is precisely where the coupling between the two systems happens and becomes critical: being a large electricity consumer, the E-bus fleet can change the whole-sale electricity price with its charging schedules and, at the same time, the possible charging schedules depend on the trips in between charging sites that should be selected based also on the electricity cost. In fact, the cost of charging is not simply proportional to the amount of energy charged into the E-bus battery, because the retail price – which appears constant – is in reality a function of the whole-sale price of electricity, in turn a function of the grid congestion, i.e., dynamic in space (charging site) and time. In congested routes, i.e., when the number of trips to be covered is large and an E-bus is in service for a long period of time, the additional degree of freedom of choosing where and when to charge, ensuring route coverage and low electricity costs, requires revisiting the classical VSP approach so as to design flexible charging patterns that can respond to grid congestion and deal with the coupling between route cost and grid congestion.

Interestingly, some E-bus services have yet another degree of freedom in their interaction with the electric grid. This is the case of school E-buses, where trips are concentrated in certain hours of the day. Indeed, there are periods where there is sufficient slack for charging and it is conceivable to use the E-bus fleet as grid storage that can provide vehicle to the grid (V2G) services, i.e., discharging energy to the grid to shave peak demand, see, e.g., [13, 12, 2, 3].

We argue that scheduling electrified public transportation in a grid-aware fashion poses some significant and exciting new challenges at the intersection of several scientific communities, like transportation, discrete optimization, market equilibria, energy, just to name a few.

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In 2022, the Mixed-Integer Programming Society (MIPS) was established as a technical section of the Mathematical Optimization Society. In the MIP Insights *newsletter, we announce important news for the community, promote and summarize events supported by the society, and host expository presentations. Avinash Bhardwaj, Silvia Di Gregorio, Sophie Huiberts, Aleksandr M. Kazachkov, Andrea Lodi, Gonzalo Muñoz, and Joseph Paat contributed to this issue.*