Led by Professor Mahnoosh Alizadeh, the main focus of the Smart Infrastructure Systems Lab is to design learning and control algorithms that promote responsible and efficient use of large-scale societal infrastructure systems. Consider the canonical example of modern transportation systems. Every day, we experience the societal impacts of poor coordination in how users make travel choices through traffic congestion, accidents, parking scarcity and increased air pollution. But, the mobility scene is changing rapidly as electric vehicle (EV) adoption rates increase in conjunction with the proliferation of ridesharing and connected and autonomous vehicle (CAV) technologies. These advancements hold great promise in improving efficiency and reducing travel delays, accidents, the need for new infrastructure, and the carbon footprint of our societal transportation needs. However, without proper coordination, pricing mechanisms, and infrastructure interoperability, this vision cannot be realized. Consider how EVs are advertised as an environmentally-friendly commute choice. If the battery charging of EVs is left uncontrolled, it is expected that EVs will result in major increases in peak load and generation capacity and require significant infrastructure upgrades, hence exerting significant strain on electric power systems and heavily reducing the environmental benefits of transportation electrification. Instead of renewable energy resources such as wind and solar providing battery charge, expensive and potentially environmentally unfriendly generators would have to be dispatched to meet the uncontrolled charging load. Furthermore, due to significant increases in peak load, capacity violations could occur in power distribution systems, requiring major and expensive upgrades in assets, or policy changes to prevent residents from charging their vehicles at home. This highlights the importance of the design of smart charging initiatives to guide EV owners toward greener charging patterns. Alternatively, consider the case of ridesharing platforms. We all have first-hand experience of the importance of good vehicle routing and ride pricing algorithms employed by the system operator in order to manage travel demand, ensure low wait times, and promote driver participation in the platform. Last but not least, by managing traffic flow and reducing intersection wait times using smart traffic lights that coordinate vehicles virtually, CAVs can significantly decrease travel times and reduce the need for building new infrastructure. But, these clearly require interventions that enable coordination and cooperation among vehicles and their owners.

All of the problems mentioned share the same interdisciplinary and interrelated challenges: How do we control a cyber-physical system such as the power grid when its operation is directly affected by the choices consumers make? How do we incentivize customers toward a more socially-optimal behavior that potentially conflicts with their personal gains? And, while we are learning the correct mechanisms to optimize customer behavior, how do we ensure that the physical and cyber safety requirements of our infrastructure systems are not violated (e.g., preventing capacity violations in power systems in order to avoid blackouts)? The Smart Infrastructure Systems Lab studies these questions through a mix of tools from stochastic control, distributed optimisation, signal processing, machine learning, and game theory.

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Optimization for...