My research interests lie at the intersection of large scale cyber-physical systems and artificial intelligence. In particular, I am interested in the resilience and optimization of multi-agent societal scale cyber-physical systems (CPS) such as transportation networks, electric power grids, and emergency response infrastructures, which form the the backbone of modern life. A common theme across these CPS is that complex decisions have to be made under uncertain and often non-stationary conditions considering the impact to the system's objective (often involving multiple attributes), its safety, and overall future. Traditional approaches including classical model-predictive control, combinatorial optimization often are insufficient at such scales. Furthermore, modern AI approaches, including Generative AI, while transformational for images, natural language and speech also do not perform well when used for non-myopic optimization in such systems with physical and temporal constraints.

Table 1: Summary of Research Impact (as of November 18, 2025)

Research Funding	58 projects: PI on 38 totaling \$24.0M (VU share: \$10.9M) and Co-PI on 20 totaling \$45.1M; At Tenure: 39 projects with PI on 22 totaling \$8.3M (VU share: \$4.9M) and Co-PI on 17 totaling \$27.6M.
Scholarship	253 refereed publications; 51 journal papers; 63 highly selective conference papers (acceptance rate $<33\%$); H-index 40; 5846 citations. Recent highly selective publications include: NeurIPS 2025 (NS-Gym, ESCORT) [1, 2], ICLR 2025 and AAMAS 2024 (Decision Making Under Uncertainty and Non-stationarity) [3, 4], ICAPS 2025 (POMDP belief updates), ICCPS 2025 and AAMAS 2025 (Vehicle to Building Adaptive Planner) [5, 6], ICCPS 2024 (Online Decision Making For Transit Vehicles) [7], AAMAS 2025 and ECAI 2024 (explainable CPS planning) [8, 9] . At Tenure: 172 refereed publications; 33 journal papers; 19 highly selective conference papers; H-index 27; 2564 citations.
Students	PhD Graduated: 6; MS Graduated: 3. Current PhD Advisees: 10 across CS and EE; Current postdocs/research scientists: 4; Past postdocs: 4. At Tenure: PhD Graduated: 3; MS Graduated: 2;
Awards	NSF CAREER (2022); Best Paper Awards: ICCPS 2024, IJCAI 2022, SmartComp 2019, ICAS 2012; Equity in Transportation Award at INFORMS 2024; Multiple Best Paper Finalists (AAMAS 2025, SmartComp 2025).
Recognition	Vanderbilt Chancellor Faculty Fellow (2024–26), Community Impact Research Award (2025), Catalyst Innovation Award (2023), Google Cloud Research Champion (2023–25).
Patents	Energy-aware mixed-fleet forecasting (2023); EV charging control devices (2024); Dynamic vehicle routing (2024).
Software	ARINC 653 emulator [10]; CHARIOT [11]; DeepNNCar [12]; ReSonAte [13]; TRANSAX [14]; Anti-CARLA [15]; Smart Transit [16]; Statresp [17]; RIAPS [18]; MODICUM [19, 20]; DREMS [21]; OPTIMUS [22].
Startups	Co-founder and CSO of Mobius AI (2023–), delivering SaaS for fleet management and energy-aware routing.
Impact	Operational solutions for CARTA, WeGo, Nissan, Siemens, TDOT, and Nashville Fire Department (paratransit optimization, predictive school bus routing, fire station planning).
Leadership	General Chair, ICCPS 2024; Steering Committee, ICCPS (2025–); Program Co-Chair (ICCPS 2023, ICAA 2023); Director of SCOPE Lab (2016–); NSF CISE CNS Program Director Co-leading CPS, S&CC and CIVIC programs.

Working with my team over the last fifteen years I have focused on a research trajectory that has combined sensing, prediction, planning, middleware, failure detection, resilience into a cohesive full-system design principle with an emphasis on real-world impact partnering with community partners such as Nashville Metro Transit Authority (WeGo), Chattanooga Area Regional Transportation Authority (CARTA), Williamson County School District, Nashville fire department (NFD), Tennessee Department of Transportation (TDOT), and the Nashville Department of Transportation (NDOT) in addition to industrial partners such as Siemens, Nissan and Cisco. These collaborations have enabled us to deliver production-ready solutions including paratransit planning system in Chattanooga, predictive school bus routing in Williamson County and fire station planning in Nashville. Further, the core foundational advances in this area have led to several best paper awards and finalist nominations at ICCPS, AAMAS, INFORMS, and IJCAI, as well as faculty honors including the Vanderbilt Chancellor Faculty Fellowship and the Community Impact Research Award.

Table 2: Past Team Members (as of November 18, 2025)

Michael Wilbur [Ph.D. 2023]	Data-Driven Algorithms for Smart Transportation Systems (energy-aware transit optimization, forecasting). Now CTO of Mobius AI.
Ava Pettet [Ph.D. 2022]	Principled Algorithms for Real-time Sequential Decision Making for Large-Scale CPS (decision-making under uncertainty).
Shreyas Ramakrishna [Ph.D. 2022]	Dynamic Safety Assurance of Autonomous CPS (safety monitoring, assurance frameworks).
Scott Eisele [Ph.D. 2020]	Resolving Challenges in Multi-Stakeholder CPS Using Distributed Ledgers (blockchain for resilience).
Fangzhou Sun [Ph.D. 2018]	Co-Mentored with Prof. Jules White. Algorithms for Context-Sensitive Prediction, Optimization and Anomaly Detection in Urban Mobility.
Subhav Pradhan [Ph.D. 2017]	Co-Mentored with Prof. Aniruddha Gokhale. Algorithms and Techniques for Managing Extensibility in Cyber-Physical Systems (modularity and extensibility middleware).
Matthew Buruss [M.S. 2020]	Enhancing the Robustness of Deep Neural Networks Against Security Threats Using Radial Basis Functions.
Sanchita Basak [M.S. 2020]	Spatiotemporal Anomaly Detection and Prediction of Anomaly Propagation Path Using LSTM Networks
Chinmaya Samal [M.S. 2019]	Time-dependent and Privacy-Preserving Decentralized Routing using Federated Learning.
Ava Pettet [Postdoc]	Resilience and decision-making;
Saideep Nannapaneni [Postdoc]	AI safety and manufacturing CPS

Table 3: Current Team (as of November 18, 2025)

Sophie Pavia	Dynamic decision procedures for public transit system
Rishav Sen	Resilient Optimization of Mobility Energy Systems
Yunuo Zhang	Decision Procedures for Partially Observable Complex Systems
Baiting Luo	Scalable Neuro-symbolic Decision Procedures for Non-stationary environments.
Jacob Bucklew	Neuro Symbolic Planning and Optimization for Large Combinatorial CPS Problems.
Agrimma Khanna	Dynamic Decision Procedures for Multimodal Microtransit
Ammar Zulqarnain	Planning and Digital Twins for Emergency Response.
Samir Gupta	Dynamic Decision Procedures for Real-time Autonomous CPS
Vakul Nath	Human AI Teaming for Disruption Management for School Buses.
Fangqi Liu [Postdoc]	Decision making for high-dimensional CPS. Fangqi currently leads the Nissan V2B investigation and Williamson County School Bus Disruption Management Policy
Jose Paolo Talusan [Postdoc and Now Research Scientist]	AI decision making for CPS; now working as a research scientist with us.
Ayan Mukhopadhyay [Research Scientist and now Faculty at W&M]	CPS Decision Procedures for Societal Scale CPS, Multi-agent systems.

A summary of key research impacts is shown in the Table 1. Overall, these research efforts can be viewed from three perspectives, artificial intelligence, especially decision making under uncertainty for high dimensional systems, resilient design and operations of cyber-physical systems and lastly through the perspective of mobility and energy domain. It is important to emphasize that my research philosophy has been to ensure that the foundational research we conduct as engineers is grounded in the challenges of real-world and my focus on mobility and energy systems has provided that. Overall, my work has been supported through partnership with several graduate students, postdocs and research scientists over my career (see Tables 2 and 3). Recently, this work has been translated into a startup called Mobius AI, which operationalizes our research in AI-driven fleet management and energy-aware routing. Below I provide a summary of key research directions and summarize future plans.

Decision Making Under Uncertainty

A central thrust of this work, and the focus of my *NSF CAREER Award*, is the development of *foundational methods for AI-driven decision-making in societal-scale CPS*. Decision-making problems in societal-scale CPS –

emergency response fleets, public transit networks and power grids are often computationally intractable at scale, their operating environments are inherently non-stationary. Classical combinatorial optimization approaches fail to address both the scale as well as the non-stationary challenges. Even classical offline reinforcement learning methods fail when faced with changing environment conditions. Therefore, fundamentally my work has leveraged methods built around online search and policy augmentation methods. We describe them below.

- **Multi-agent Decision Support Systems**: We have developed adaptive multi-agent anytime decision-making algorithms that use the upstream prediction models for resource allocation to improve system performance using a predict and optimize framework. We formulate the problem as a semi-markovian decision process (SMDP). Often, it is not possible to do this in real-time due to the size of the decision space. Therefore, we use the Monte-Carlo Tree Search (MCTS) family of algorithms, which evaluate actions by sampling from many possible scenarios [23]. To account for communication failures and further scalability challenges, we have also developed a decentralized multi-agent MCTS (MMCTS) approach. In MMCTS, individual agents build separate trees focused on their actions rather than having one monolithic centralized tree, dramatically reducing their search space. Our innovation lies in adding the concept of action filtering to the standard MCTS approach to resolve global conflicts. To scale these methods further, we have designed hierarchical planning [24] procedures based on available communication resources and real-time situational awareness. Further, in our ICML work [25], we further improved the results by integrating reinforcement learning to set coarse resource distribution targets across the city, while lower-level agents handle fine-grained routing and dispatch.
- **Addressing Non-Stationarity** Non-stationarity implies the change in plant or environment dynamics during operations. While there has been significant research on out of distribution detection, adapting to changes online has been harder. Thus, we have been focusing on investigating online adaptive planning. Our work, "*Decision Making in Non-Stationary Environments with Policy-Augmented Monte Carlo Tree Search*" [26] demonstrated that if the changes are bounded, we can use offline 'prior' policies to explore further, utilizing past information as heuristics. Most recently, "Decision Making in Non-Stationary Environments with Policy-Augmented Search" generalized the PA-MCTS framework [27]. In "Act as You Learn: Adaptive Decision-Making in Non-Stationary Markov Decision Processes", we leveraged this idea and introduced *Adaptive MCTS (ADA-MCTS)* [3], explicitly disentangling epistemic uncertainty (what the agent does not yet know about the new regime) from aleatoric uncertainty (inherent randomness). ADA-MCTS uses this distinction to dynamically shift between risk-averse and performance-seeking behavior, effectively balancing safety and efficiency as the agent "acts while it learns" in changing environments. "Dynamic Simplex: Balancing Safety and Performance in Autonomous Cyber Physical Systems" [28] then showed how to maintain safety while switching between policies and controllers, connecting planning to runtime assurance. Finally, to give the community a principled way to study such phenomena, we released *NS-Gym* [2], the first open-source toolkit for non-stationary MDPs. NS-Gym cleanly separates environment evolution from agent logic, provides a taxonomy of drift types, and establishes benchmarks that move the field beyond ad-hoc experiments.
- **Addressing Partial Observability** Many CPS decision problems are have observability challenges and have to be modeled as partially observable MDPs (POMDPs). We have recently started investigations in this direction, focusing on the problem of belief update and particle degeneration. In "Observation Adaptation via Annealed Importance Resampling for POMDPs" [29], we developed belief-update and planning algorithms tailored to CPS, we combined tree search with particle-based belief representation and annealed importance resampling. Our core innovation has been to focus on gradual refinement of prior based on observations to ensure that we do not lose significant modal information in the belief distribution, enabling recovery in case of bad observations. We extended this idea in the "ESCORT: Efficient Stein-variational and Sliced Consistency-Optimized Temporal Belief Representation for POMDPs" [1], focusing on higher dimensional problems. Unlike standard particle filters that resample aggressively, ESCORT treats belief evolution as an optimization problem, transporting a set of particles toward the posterior while avoiding collapse. This is essential in CPS contexts where multi-modal uncertainty is common. Overall, these approaches are now

being integrated with our broader augmented-search agenda.

- **Addressing Scalability** Scalability is a key issue in cyber physical systems. While temporal concerns can be mitigated to some extend by utilizing value function augmentation in the search process, we have to fundamentally solve the learning problem as well. Our approach in this direction relies on *temporal abstraction* fine-grained action into macros. In our recent work, we introduced the *Latent Macro-Action Planner (L-MAP)* [4], a general-purpose framework for scalable decision-making in stochastic, continuous-action environments. It builds a discrete latent space of macro-actions using a state-conditioned Vector Quantized Variational Autoencoder (developed Aaron van den Oord et. al.), and then builds a *latent transition model* implemented via a transformer to learn the system dynamics over the macro-actions. Subsequently, online the planning process using MCTS operates in this abstract space, reducing the computational complexity. Similar ideas, however, with domain-specific refinements were used in our work with Vehicle-to-Building (V2B) systems [6], where charging decisions taken every few minutes interact with sparse, month-scale demand charges.
- **Addressing Explainability** Finally, we have been focusing on the explainability challenge of these 'decision-theoretic' optimization systems. We work in where operators must be able to ask "why" and get an answer they can trust. Collaborating with Prof. Ma from Vanderbilt we recently introduced a framework that overlays Computation Tree Logic (CTL) on top of MCTS, enabling formal queries in "Enabling MCTS Explainability for Sequential Planning Through Computation Tree Logic" [8]. Building on this, "Combining LLMs with a Logic-Based Framework to Explain MCTS" [9] proposed LogiEx, which uses large language models strictly as translators: natural-language questions are mapped to logical formulas, checked against the planner, and then turned back into fluent, grounded explanations. This is still a nascent area of research, though there is significant activity in research community in this direction.

Core Cyber-Physical Systems Research

At the heart of my research agenda is a long-term effort to develop the algorithmic foundations needed for adaptive, resilient, and trustworthy decision-making in societal-scale cyber-physical systems (CPS). Addressing these challenges requires not only robust algorithms but also a new generation of platforms capable of implementing these advanced capabilities at the network edge, where low-latency decision-making is paramount. A narrative of key contributions along these aspects is provided in the list that follows.

- **Platforms and Middleware for Resilient CPS**: My early work focused on creating *platforms* to ensure resilience in complex, real-time systems. This began with component-based models that enforce strong isolation, such as the *ARINC-653 Component Model (ACM)* [10], which combines spatial and temporal partitioning with component-level monitoring of *pre- and post-conditions on method invocations*, *state invariants*, *resource usage*, and *timing behavior*. This work was extended to distributed systems with the *DREMS (Distributed Real-Time Embedded Managed Systems)* component model [30, 31, 32, 33, 21, 34], which featured *fine-grained privileges* and a novel *Multi-Level Security (MLS)* information sharing policy [32, 35, 36, 34]. A parallel thrust developed methods for erformance prediction and capacity planning [37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49], including adaptive management under degraded scenarios [50, 30, 51, 52] and uncertainty [53, 54, 55, 56, 57]. Subsequently, we focused on network's edge in CPS. A key contribution is the *Resilient Information Architecture Platform for Smart Systems (RIAPS)*, a decentralized, fault-tolerant middleware now part of the Linux Foundation [58, 59, 60, 18, 61, 62]. RIAPS enables secure, peer-to-peer applications and underpins our transactive energy platform, *TRANSAX*, which uses a hybrid solver pattern [58, 63, 64] and verifiable smart contracts [65, 66, 67] to create a safe and private energy market [14, 68, 69]. This work also led to *MODICUM*, a middleware for spot computation markets at the edge [19], enabling deployment of AI policies, and frameworks for the *scalable testing of IoT applications* [70, 71].

  In addition to middleware platforms, a key requirement is efficient simulation models for training as well as runtime inference. To address this, we developed open-source platforms including *NS-Gym* for non-stationary RL environments [2], *Power-Attack* for cyber-attack simulation in power grids [72], *E-Transit*

Bench for electric mobility simulation [73], and *OPTIMUS* for vehicle-to-building charging optimization [22]. Together, these tools integrate system behavior into both training and operational decision-making.

- **Fault Isolation and Anomaly Detection**: My work in this area has shown that if a CPS is constructed using a component-based design, the behavior and failure propagation across the assembly can be deduced [74, 75, 76, 51, 77, 78, 79, 80, 81]. A challenge, however, is that system topologies change over time, introducing new failure modes specific to the operation or lack of operation of the protection components. We developed an extension of Temporal Failure Propagation Graphs called Temporal Causal Diagrams (TCD) to resolve these challenges by augmenting the model with the behavior of local observers and fault masking patterns [82]. For anomaly detection, my work has shown that when data can be collected from spatial neighborhoods, the variance from the collective group and time-dependence can be used to detect anomalies. An early statistical approach using Pythagorean mean-based metrics [83] was sensitive to neighborhood size, but we found that adding domain knowledge, such as modeling road interactions [84, 85] or using graph neural networks to capture network structure [86], significantly improves performance. For high-dimensional data, our work has shown that latent representations from variational autoencoders can detect problems, especially for AI components where the runtime data distribution may differ from the original training distributions [87, 88]. Further, we have developed techniques using conditional normalizing flows [89, 90] to not only identify anomalies efficiently at scale when testing labels are not present, but also synthesize training sets that can be used to train more efficient classifiers eventually.
- **Resilience and Recovery**: Once a fault is isolated, recovery is critical. My work has advanced beyond prescriptive, rule-based strategies [91, 50] to planning-based Software Health Management and deliberative runtime reconfiguration. The key idea was to use the design space of the CPS—encoding resources, faults, and goals using domain-specific languages [92, 31, 93] developed for the System-F6 and CHARIOT projects—to search for alternatives when faults occur [11, 94, 95]. To manage risk at runtime, we introduced the ReSonAte dynamic risk estimation framework, which reasons over Bow-Tie Diagrams capturing hazard propagation paths [13]. For recovery, we used a dynamic simplex strategy to transition to a safe controller by creating a weighted ensemble of the two control outputs, balancing safety and performance [96, 97, 28].

Mobility and Energy System Research

My research program leans heavily on use-inspired aspects, driven by the conviction that scientific advances must be validated against the complexities of real-world operational environments. This philosophy is most evident in our sustained, collaborative work within the critical, and interconnected, domains of intelligent mobility and resilient energy systems. By partnering directly with public transit agencies, city and state departments of transportation, utilities, and industry leaders, we ensure that our work is grounded in pressing operational needs. This approach creates a powerful feedback loop where practical challenges motivate foundational inquiry, and theoretical breakthroughs enable robust, deployable solutions that have a measurable impact on community well-being, efficiency, and resilience. This section details these translational efforts in each of the domains.

1. **Emergency Response**: My research in mobility is defined by sustained partnerships with public agencies to solve high-stakes operational problems, moving from predictive analytics to proactive, AI-driven optimization. Our work with the Nashville Fire Department began with predictive analytics to understand incident patterns [98, 99, 23], which revealed the limitations of reactive models and motivated a shift toward proactive resource allocation. This directly intersected with our foundational science on scalable planning, leading to a *hierarchical planning framework* that decomposes the city-scale emergency response problem into tractable sub-problems, significantly improving response times in validation with real-world data [100]. Building on this, we introduced proactive spatio-temporal stationing and dispatch algorithms [24], which demonstrated substantial gains in reducing urban emergency response times. These advances were further supported by uncertainty modeling using *Uncertain Concept Graphs (UCGs)* to represent incomplete or conflicting information in dispatch operations [101], improving robustness under noisy incident reports. To extend scalability and adaptivity, we developed multi-agent decision-support systems based on decentralized Monte Carlo tree search [102], enabling distributed yet coordinated response planning. Most recently, this line of work has advanced to multi-agent reinforcement learning for stationing and dispatching ambulances to incident,

which reduces decision time substantially while preserving robustness [25]. This ongoing collaboration was recently accelerated by a Nashville Innovation Alliance grant to create actionable and accessible tools for NFD's strategic planning [103]. Together, these contributions establish a pipeline from predictive analytics to explainable, adaptive, and scalable emergency response optimization in partnership with public safety agencies.

2. **Mobility Systems**: A similar trajectory unfolded in public mobility systems, evolving from predictive analytics to creating end-to-end optimization solutions. Early collaborations with Nashville WeGo focused on delay prediction [104] and managing service during the COVID-19 pandemic, which led to a data-driven analysis of its impact on ridership and accessibility [105]. Our work with the Chattanooga Area Regional Transportation Authority (CARTA) has been particularly impactful, beginning with foundational data-driven models for energy forecasting across their mixed fleet of electric and internal combustion vehicles under the DOE HD-EMMA grant [106, 107]. This energy-aware perspective informed a suite of novel algorithms for microtransit and paratransit, including offline routing that integrates mandatory driver breaks [108], methods for handling offline VRP (Vehicle Routing Problems) with online bookings [109], rolling horizon temporal decomposition for scalability [110], and online MCTS-based planners for dynamic, stochastic trip requests [111]. This research culminated in the deployed *SmartTransit.ai* platform [112, 16], an AI-driven system that, in pilot testing, showed improved efficiency and an increased number of shared rides [113]. The core optimization logic proved highly generalizable, forming the parallel basis for the ADVISER framework, which won the IJCAI 2022 AI for Social Good Best Paper Award for optimizing vaccination resource distribution in Nigeria [114]. For fixed-route transit, we addressed the critical challenge of service disruptions. This work is a direct application of our foundational research in non-myopic planning, resulting in best paper award for "An Online Approach to Solving Public Transit Stationing and Dispatch Problem", an online decision solver that proactively stations and dispatches reserve buses to mitigate disruptions. Validated with data from WeGo, this approach serves more passengers while reducing inefficient "deadhead" miles [7, 115]. This real-world impact has been highlighted in outlets like *WPLN News* and *GovTech*, showcasing how our AI-driven solutions are making transit more efficient and accessible [116, 117]. This body of work has laid the groundwork for major new initiatives. We are now leading the PATH-TN (Partnership for AI-driven Multimodal Transportation Services Integration in Tennessee Cities) project, a $8.6M USDOT-funded consortium to integrate fixed-route buses, microtransit, and park-and-ride facilities across Tennessee's four largest cities [118]. Further, a new $3.3M DOE grant with CARTA, titled "AI-Powered Autonomy-Aware Neighborhood Mobility Zones," is focusing on redesigning fixed-line services and integrating them with on-demand autonomous vehicles to increase transit usage and improve energy efficiency[119].

3. **Energy Systems**: My research in the energy domain, addresses the dual challenges of decentralization and resilience, with a strong emphasis on the increasingly intertwined nature of energy and mobility systems. Our foundational work began with diagnostics and resilience for the power grid itself. We developed novel formalisms like Temporal Causal Diagrams (TCD) to model and diagnose complex fault propagation in power systems with protection assemblies [82, 120], and created advanced data-driven techniques for anomaly detection, such as using unsupervised Wavelet Convolutional Autoencoders to detect events in high-frequency synchrophasor data [89]. To enable the study of these phenomena, we also developed the Power-Attack toolchain for modeling and simulating cyber-attacks in power systems [72]. Recognizing the need for secure, peer-to-peer energy markets at the grid edge, we developed TRANSAX, which uses a blockchain-based forward-trading market to allow prosumers to manage local resources while solving the conflicting requirements of grid safety, market efficiency, and participant privacy [14, 65, 66, 121, 58, 63, 64, 61, 59, 62, 71, 122, 123]. It enables participants to trade in an energy futures market, which improves efficiency by finding possible matches for energy trades, thereby reducing the load on the distribution system operator. It provides privacy to participants by anonymizing their trading activity using a distributed mixing service while also enforcing constraints that limit trading activity based on safety requirements, such as keeping power flow below line capacity. One of the critical innovations in TRANSAX was developing a novel hybrid solver concept that combines the trustworthiness of distributed ledgers with the efficiency of conventional computational platforms. This work was built upon our foundational research on the RIAPS

decentralized middleware platform [60]. Recently, we have also worked on grid resilience against extreme events. We developed a proactive control framework that uses reinforcement learning to intelligently reconfigure the power grid in anticipation of a wildfire's path [124].

4. **Combined Mobility and Energy Systems**: A major thrust after I received tenure has been the integration of the mobility and energy domains, focusing on the complex optimization problems that arise as transportation electrifies. This work began with foundational data-driven energy forecasting models for mixed fleets of electric and internal combustion vehicles, developed in partnership with CARTA under the DOE HD-EMMA grant [106, 107]. These predictive models provided the necessary groundwork for operational optimization. Building on this, we tackled the challenge of grid-aware operational planning. Our work on optimizing mixed-fleet public transit accounts for dynamic electricity pricing, jointly optimizing charging schedules and trip assignments to minimize costs while respecting vehicle and grid constraints [125]. The most significant integration challenge we have addressed is the Vehicle-to-Building (V2B) problem. We first developed an online decision-making framework using Monte Carlo Tree Search to optimize EV fleet charging under uncertainty, formulating the problem as a Markov Decision Process to handle the large state and action spaces [5]. To improve real-time responsiveness, we created a reinforcement learning-based approach capable of handling heterogeneous agents and optimizing for sparse, long-term rewards like monthly demand charges, using a novel combination of Deep Deterministic Policy Gradient (DDPG) with action masking and MILP-driven policy guidance [6]. This entire research effort is supported by high-fidelity simulation platforms we created to enable the training and validation of these complex control policies. This includes BTE-Sim, a fast simulation environment for public transportation [126], which evolved into E-Transit-Bench for analyzing electric bus fleet operations, and most recently, OPTIMUS, a dedicated discrete event simulator for the V2B challenge [22].

Future Research Outlook

Looking forward, my research agenda will continue to be shaped by the pressing need to design and deploy decision-making frameworks that not only achieve efficiency and resilience in societal-scale CPS, but also guarantee *assurance, robustness, and human trust at scale*. This agenda is supported by my current graduate students collaborating with me on various topics (see Table 3). On the foundational side, my research will advance the science of decision-making under uncertainty and non-stationarity, with a focus on designing *assured and robust online planning algorithms at scale*. This agenda will extend the principles established in our work on Policy-Augmented Monte Carlo Tree Search (PA-MCTS) [26] and Adaptive MCTS (ADA-MCTS) [3] into a unified framework for Augmented Search and utilizing them for developing *Human-Augmented Search*, where we develop interactive protocols that allow human operators to inject constraints, critique partial plans, or adjust reward functions *during* the search process, moving beyond passive oversight to active, real-time guidance and embedding explainability and human-AI teaming directly into these decision frameworks.

On the use-inspired side, we will continue focusing on the integration of mobility and energy sector, with an eye for next set of challenges, especially as we begin to integrate autonomous vehicles for public mobility operations. Building on our deployments with WeGo and CARTA, and extending through major new initiatives like the \$8.6M USDOT-funded PATH-TN project [118] and the \$3.3M DOE-funded work on neighborhood mobility zones [119], we are developing integrated optimization frameworks that jointly coordinate fixed-route transit, paratransit, microtransit, and emerging autonomous vehicle services. A key technical challenge is managing the operational constraints of mixed-autonomy fleets. Our research will advance the AVATAR framework [127], moving beyond traditional time- or distance-based routing to create multi-objective, reliability-aware routing engines. These engines will optimize for metrics critical to autonomous operations, such as route predictability and safety, enabling the seamless integration of AVs into complex, multimodal urban networks.

1. References

[1] Yunuo Zhang, Baiting Luo, Ayan Mukhopadhyay, Gábor Karsai, and Abhishek Dubey. "ESCORT: Efficient Stein-variational and Sliced Consistency-Optimized Temporal Belief Representation for POMDPs". In: *Advances in Neural Information Processing Systems (NeurIPS)*. Proceedings of Machine Learning Research. accepted. 2025.

[2] Nathaniel S. Keplinger, Baiting Luo, Kyle Hollins Wray, Yunuo Zhang, Iliyas Bektas, Aron Laszka, Abhishek Dubey, and Ayan Mukhopadhyay. "NS-Gym: A Comprehensive and Open-Source Simulation Framework for Non-Stationary Markov Decision Processes". In: *Advances in Neural Information Processing Systems (NeurIPS)*. Proceedings of Machine Learning Research. accepted. 2025.

[3] Baiting Luo, Yunuo Zhang, Abhishek Dubey, and Ayan Mukhopadhyay. "Act as You Learn: Adaptive Decision-Making in Non-Stationary Markov Decision Processes". In: *Proceedings of the 23rd International Conference on Autonomous Agents and Multiagent Systems*. AAMAS '24. Auckland, New Zealand: International Foundation for Autonomous Agents and Multiagent Systems, 2024, 1301–1309. ISBN: 9798400704864.

[4] Baiting Luo, Ava Pettet, Aron Laszka, Abhishek Dubey, and Ayan Mukhopadhyay. "Scalable Decision-Making In Stochastic Environments Through Learned Temporal Abstraction". In: *Proceedings of the 13th International Conference on Learning Representations, Singapore*. 2025.

[5] Rishav Sen, Yunuo Zhang, Fangqi Liu, Jose Paolo Talusan, Ava Pettet, Yoshinori Suzue, Ayan Mukhopadhyay, and Abhishek Dubey. "Online Decision-Making Under Uncertainty for Vehicle-to-Building Systems". In: *Proceedings of the ACM/IEEE 16th International Conference on Cyber-Physical Systems (with CPS-IoT Week 2025)*. ICCPS '25. Irvine, CA, USA: Association for Computing Machinery, 2025. ISBN: 9798400714986.

[6] Fangqi Liu, Rishav Sen, Jose Talusan, Ava Pettet, Aaron Kandel, Yoshinori Suzue, Ayan Mukhopadhyay, and Abhishek Dubey. "Reinforcement Learning-based Approach for Vehicle-to-Building Charging with Heterogeneous Agents and Long Term Rewards". In: *Proceedings of the 23rd Conference on Autonomous Agents and MultiAgent Systems, AAMAS 2025, Detroit, Michigan*. AAMAS '25. nominated for best paper. International Conference on Autonomous Agents and Multi-Agent Systems. Detroit, Michigan: International Foundation for Autonomous Agents and Multiagent Systems, 2025.

[7] Jose Paolo Talusan, Chaeeun Han, Ayan Mukhopadhyay, Aron Laszka, Dan Freudberg, and Abhishek Dubey. "An Online Approach to Solving Public Transit Stationing and Dispatch Problem". In: *Proceedings of the ACM/IEEE 15th International Conference on Cyber-Physical Systems (ICCPS)*. ICCPS '24. Hong Kong, China: Association for Computing Machinery, 2024.

[8] Ziyan An, Hendrik Baier, Abhishek Dubey, Ayan Mukhopadhyay, and Meiyi Ma. "Enabling MCTS Explainability for Sequential Planning Through Computation Tree Logic". In: *ECAI 2024 - 27th European Conference on Artificial Intelligence*. Santiago de Compostela, Spain, 2024.

[9] Ziyan An, Xia Wang, Hendrik Baier, Zirong Chen, Abhishek Dubey, Taylor T. Johnson, Jonathan Sprinkle, Ayan Mukhopadhyay, and Meiyi Ma. "Combining LLMs with a Logic-Based Framework to Explain MCTS". In: *Proceedings of the 24th International Conference on Autonomous Agents and Multiagent Systems*. AAMAS '25. Detroit, MI, USA: International Foundation for Autonomous Agents and Multiagent Systems, 2025, 2405–2407. ISBN: 9798400714269.

[10] Abhishek Dubey, Gabor Karsai, and Nagabhushan Mahadevan. "A component model for hard real-time systems: CCM with ARINC-653". In: *Software: Practice and Experience* 41.12 (2011), pp. 1517–1550.

[11] Subhav Pradhan, Abhishek Dubey, Shweta Khare, Saideep Nannapaneni, Aniruddha S. Gokhale, Sankaran Mahadevan, Douglas C. Schmidt, and Martin Lehofer. "CHARIOT: Goal-Driven Orchestration Middleware for Resilient IoT Systems". In: *Transactions of Cyber Physical Systems* 2.3 (2018), 16:1–16:37.

[12] Matthew P. Burruss, Shreyas Ramakrishna, Gabor Karsai, and Abhishek Dubey. "DeepNNCar: A Testbed for Deploying and Testing Middleware Frameworks for Autonomous Robots". In: *IEEE 22nd International Symposium on Real-Time Distributed Computing, ISORC 2019, Valencia, Spain, May 7-9, 2019*. 2019, pp. 87–88.

[13] Charles Hartsell, Shreyas Ramakrishna, Abhishek Dubey, Daniel Stojcsics, Nag Mahadevan, and Gabor Karsai. "ReSonAte: A Runtime Risk Assessment Framework for Autonomous Systems". In: *16th International Symposium on Software Engineering for Adaptive and Self-Managing Systems, SEAMS 2021*. 2021.

[14] Scott Eisele, Taha Eghtesad, Keegan Campanelli, Prakhar Agrawal, Aron Laszka, and Abhishek Dubey. "Safe and Private Forward-Trading Platform for Transactive Microgrids". In: *ACM Transactions of Cyber-Physical Systems* 5.1 (Jan. 2021). ISSN: 2378-962X.

[15] Shreyas Ramakrishna, Baiting Luo, Christopher B. Kuhn, Gabor Karsai, and Abhishek Dubey. "ANTI-CARLA: An Adversarial Testing Framework for Autonomous Vehicles in CARLA". In: *2022 IEEE 25th International Conference on Intelligent Transportation Systems (ITSC)*. 2022, pp. 2620–2627.

[16] Sophie Pavia et al. "Deploying mobility-on-demand for all by optimizing paratransit services". In: *Proceedings of the Thirty-Third International Joint Conference on Artificial Intelligence*. IJCAI '24. Jeju, Korea, 2024. ISBN: 978-1-956792-04-1.

[17] Ayan Mukhopadhyay, Geoffrey Pettet, Mykel J. Kochenderfer, and Abhishek Dubey. "Designing Emergency Response Pipelines : Lessons and Challenges". In: *CoRR* abs/2010.07504 (2020).

[18] Scott Eisele, István Madari, Abhishek Dubey, and Gabor Karsai. "RIAPS: Resilient Information Architecture Platform for Decentralized Smart Systems". In: *20th IEEE International Symposium on Real-Time Distributed Computing, ISORC 2017, Toronto, ON, Canada, May 16-18, 2017*. 2017, pp. 125–132.

[19] Scott Eisele, Taha Eghtesad, Nicholas Troutman, Aron Laszka, and Abhishek Dubey. "Mechanisms for Outsourcing Computation via a Decentralized Market". In: *14TH ACM International Conference on Distributed and Event Based Systems*. 2020.

[20] Scott Eisele, Michael Wilbur, Taha Eghtesad, Kevin Silvergold, Fred Eisele, Ayan Mukhopadhyay, Aron Laszka, and Abhishek Dubey. "Decentralized Computation Market for Stream Processing Applications". In: *2022 IEEE International Conference on Cloud Engineering (IC2E)*. 2022, pp. 36–46.

[21] William Emfinger, Pranav Kumar, Abhishek Dubey, William Otte, Aniruddha Gokhale, and Gabor Karsai. "DREMS: A toolchain and platform for the rapid application development, integration, and deployment of managed distributed real-time embedded systems". In: *IEEE Real-time Systems Symposium*. 2013.

[22] Jose Paolo Talusan, Rishav Sen, Aaron Kandel Ava Pettet, Yoshinori Suzue, Liam Pedersen, Ayan Mukhopadhyay, and Abhishek Dubey. "OPTIMUS: Discrete Event Simulator for Vehicle-to-Building Charging Optimization". In: *2024 IEEE International Conference on Smart Computing (SMARTCOMP)*. June 2024, pp. 223–230.

[23] Ayan Mukhopadhyay, Geoffrey Pettet, Chinmaya Samal, Abhishek Dubey, and Yevgeniy Vorobeychik. "An online decision-theoretic pipeline for responder dispatch". In: *Proceedings of the 10th ACM/IEEE International Conference on Cyber-Physical Systems, ICCPS 2019, Montreal, QC, Canada*. 2019, pp. 185–196.

[24] Geoffrey Pettet, Ayan Mukhopadhyay, Mykel Kochenderfer, and Abhishek Dubey. "Hierarchical Planning for Resource Allocation in Emergency Response Systems". In: *Proceedings of the 12th ACM/IEEE International Conference on Cyber-Physical Systems, ICCPS 2021, Nashville, TN, USA*. 2021.

[25] Amutheezan Sivagnanam, Ava Pettet, Hunter Lee, Ayan Mukhopadhyay, Abhishek Dubey, and Aron Laszka. "Multi-agent reinforcement learning with hierarchical coordination for emergency responder stationing". In: *Proceedings of the 41st International Conference on Machine Learning*. ICML'24. Vienna, Austria: JMLR.org, 2024.

[26] Geoffrey Pettet, Ayan Mukhopadhyay, and Abhishek Dubey. *Decision Making in Non-Stationary Environments with Policy-Augmented Monte Carlo Tree Search*. 2022.

[27] Ava Pettet, Yunuo Zhang, Baiting Luo, Kyle Wray, Hendrik Baier, Aron Laszka, Abhishek Dubey, and Ayan Mukhopadhyay. "Decision Making in Non-Stationary Environments with Policy-Augmented Search". In: *Proceedings of the 23rd International Conference on Autonomous Agents and Multiagent Systems*. AAMAS '24. Auckland, New Zealand: International Foundation for Autonomous Agents and Multiagent Systems, 2024, 2417–2419.

[28] Baiting Luo, Shreyas Ramakrishna, Ava Pettet, Christopher Kuhn, Gabor Karsai, and Ayan Mukhopadhyay. "Dynamic Simplex: Balancing Safety and Performance in Autonomous Cyber Physical Systems". In: *Proceedings of the ACM/IEEE 14th International Conference on Cyber-Physical Systems (with CPS-IoT Week 2023)*. ICCPS '23. San Antonio, TX, USA: Association for Computing Machinery, 2023, pp. 177–186. ISBN: 9798400700361.

[29] Yunuo Zhang, Baiting Luo, Ayan Mukhopadhyay, and Abhishek Dubey. "Observation Adaptation via Annealed Importance Resampling for POMDPs". In: *Proceedings of the 35th International Conference on Automated Planning and Scheduling (ICAPS)*. accepted as oral presentation. AAAI Press, 2025.

[30] Abhishek Dubey, Gabor Karsai, Aniruddha Gokhale, William Emfinger, and Pranav Kumar. "DREMS-OS: An operating system for managed distributed real-time embedded systems". In: *2017 6th International Conference on Space Mission Challenges for Information Technology (SMC-IT)*. IEEE. 2017, pp. 114–119.

[31] Daniel Balasubramanian, Abhishek Dubey, William Otte, Tihamer Levendovszky, Aniruddha S. Gokhale, Pranav Srinivas Kumar, William Emfinger, and Gabor Karsai. "DREMS ML: A wide spectrum architecture design language for distributed computing platforms". In: *Science of Computer Programming* 106 (2015), pp. 3–29.

[32] Tihamer Levendovszky, Abhishek Dubey, William Otte, Daniel Balasubramanian, Alessandro Coglio, Sandor Nyako, William Emfinger, Pranav Srinivas Kumar, Aniruddha S. Gokhale, and Gabor Karsai. "Distributed Real-Time Managed Systems: A Model-Driven Distributed Secure Information Architecture Platform for Managed Embedded Systems". In: *IEEE Software* 31.2 (2014), pp. 62–69.

[33] Gabor Karsai, Daniel Balasubramanian, Abhishek Dubey, and William Otte. "Distributed and Managed: Research Challenges and Opportunities of the Next Generation Cyber-Physical Systems". In: *17th IEEE International Symposium on Object/Component/Service-Oriented Real-Time Distributed Computing, ISORC 2014, Reno, NV, USA, June 10-12, 2014*. 2014, pp. 1–8.

[34] Abhishek Dubey, W. Emfinger, A. Gokhale, G. Karsai, W. R. Otte, J. Parsons, C. Szabo, A. Coglio, E. Smith, and P. Bose. "A software platform for fractionated spacecraft". In: *2012 IEEE Aerospace Conference*. Mar. 2012, pp. 1–20.

[35] William R. Otte, Abhishek Dubey, and Gabor Karsai. "A resilient and secure software platform and architecture for distributed spacecraft". In: *Sensors and Systems for Space Applications VII*. Ed. by Khanh D. Pham and Joseph L. Cox. Vol. 9085. International Society for Optics and Photonics. SPIE, 2014, pp. 121 –130.

[36] Abhishek Dubey, Aniruddha Gokhale, Gabor Karsai, W Otte, and Johnny Willemsen. "A model-driven software component framework for fractionated spacecraft". In: *Proceedings of the 5th International Conference on Spacecraft Formation Flying Missions and Technologies (SFFMT)*. IEEE Munich, Germany. 2013.

[37] Shashank Shekhar, Ajay Chhokra, Hongyang S, Aniruddha Gokhale, Abhishek Dubey, Xenofon Koutsoukos, and Gabor Karsai. "URMILA: Dynamically Trading-off Fog and Edge Resources for Performance and Mobility-Aware IoT Services". In: *Journal of Systems Architecture* (2020). ISSN: 1383-7621.

[38] William Emfinger, Gabor Karsai, Abhishek Dubey, and Aniruddha S. Gokhale. "Analysis, verification, and management toolsuite for cyber-physical applications on time-varying networks". In: *Proceedings of the 4th ACM SIGBED International Workshop on Design, Modeling, and Evaluation of Cyber-Physical Systems, CyPhy 2014, Berlin, Germany, April 14-17, 2014*. 2014, pp. 44–47.

[39] Pranav Srinivas Kumar, Abhishek Dubey, and Gabor Karsai. "Colored Petri Net-based Modeling and Formal Analysis of Component-based Applications". In: *Proceedings of the 11th Workshop on Model-Driven Engineering, Verification and Validation co-located with 17th International Conference on Model Driven Engineering Languages and Systems, MoDeVVa@MODELS 2014, Valencia, Spain, September 30, 2014*. 2014, pp. 79–88.

[40] G. Martins, A. Bhattacharjee, Abhishek Dubey, and X. Koutsoukos. "Performance evaluation of an authentication mechanism in time-triggered networked control systems". In: *2014 7th International Symposium on Resilient Control Systems (ISRCS)*. Aug. 2014, pp. 1–6.

[41] Rajat Mehrotra, Abhishek Dubey, Sherif Abdelwahed, and Asser N. Tantawi. "Power-Aware Modeling and Autonomic Management Framework for Distributed Computing Systems". In: *Handbook of Energy-Aware and Green Computing - Two Volume Set*. CRC Press, 2012, pp. 621–648.

[42] Nilabja Roy, Abhishek Dubey, and Aniruddha S. Gokhale. "Efficient Autoscaling in the Cloud Using Predictive Models for Workload Forecasting". In: *IEEE International Conference on Cloud Computing, CLOUD 2011, Washington, DC, USA, 4-9 July, 2011*. 2011, pp. 500–507.

[43] Nilabja Roy, Abhishek Dubey, Aniruddha S. Gokhale, and Larry W. Dowdy. "A Capacity Planning Process for Performance Assurance of Component-based Distributed Systems". In: *ICPE'11 - Second Joint WOSP/SIPEW International Conference on Performance Engineering, Karlsruhe, Germany, March 14-16, 2011*. 2011, pp. 259–270.

[44] R. Mehrotra, Abhishek Dubey, S. Abdelwahed, and W. Monceaux. "Large Scale Monitoring and Online Analysis in a Distributed Virtualized Environment". In: *2011 Eighth IEEE International Conference and Workshops on Engineering of Autonomic and Autonomous Systems*. Apr. 2011, pp. 1–9.

[45] Rajat Mehrotra, Abhishek Dubey, Jim Kwalkowski, Marc Paterno, Amitoj Singh, Randolph Herber, and Sherif Abdelwahed. *RFDMon: A Real-Time and Fault-Tolerant Distributed System Monitoring Approach*. Tech. rep. Nashville: Vanderbilt University, Oct. 2011.

[46] Rajat Mehrotra, Abhishek Dubey, Sherif Abdelwahed, and Asser N. Tantawi. "Integrated Monitoring and Control for Performance Management of Distributed Enterprise Systems". In: *MASCOTS 2010, 18th Annual IEEE/ACM International Symposium on Modeling, Analysis and Simulation of Computer and Telecommunication Systems, Miami, Florida, USA, August 17-19, 2010*. 2010, pp. 424–426.

[47] Abhishek Dubey, Rajat Mehrotra, Sherif Abdelwahed, and Asser N. Tantawi. "Performance modeling of distributed multi-tier enterprise systems". In: *SIGMETRICS Performance Evaluation Review* 37.2 (2009), pp. 9–11.

[48] Abhishek Dubey, Derek Riley, Sherif Abdelwahed, and Ted Bapty. "Modeling and Analysis of Probabilistic Timed Systems". In: *16th Annual IEEE International Conference and Workshop on the Engineering of Computer Based Systems, ECBS 2009, San Francisco, California, USA, 14-16 April 2009*. 2009, pp. 69–78.

[49] Abhishek Dubey, Gabor Karsai, and Sherif Abdelwahed. "Compensating for Timing Jitter in Computing Systems with General-Purpose Operating Systems". In: *2009 IEEE International Symposium on Object/Component/Service-Oriented Real-Time Distributed Computing, ISORC 2009, Tokyo, Japan, 17-20 March 2009*. 2009, pp. 55–62.

[50] Abhishek Dubey, W. Emfinger, A. Gokhale, P. Kumar, D. McDermet, T. Bapty, and G. Karsai. "Enabling Strong Isolation for Distributed Real-Time Applications in Edge Computing Scenarios". In: *IEEE Aerospace and Electronic Systems Magazine* 34.7 (July 2019), pp. 32–45. ISSN: 1557-959X.

[51] Akshay Dabholkar, Abhishek Dubey, Aniruddha S. Gokhale, Gabor Karsai, and Nagabhushan Mahadevan. "Reliable Distributed Real-Time and Embedded Systems through Safe Middleware Adaptation". In: *IEEE 31st Symposium on Reliable Distributed Systems, SRDS 2012, Irvine, CA, USA, October 8-11, 2012*. 2012, pp. 362–371.

[52] Jaiganesh Balasubramanian, Aniruddha S. Gokhale, Abhishek Dubey, Friedhelm Wolf, Chenyang Lu, Christopher D. Gill, and Douglas C. Schmidt. "Middleware for Resource-Aware Deployment and Configuration of Fault-Tolerant Real-time Systems". In: *16th IEEE Real-Time and Embedded Technology and Applications Symposium, RTAS 2010, Stockholm, Sweden, April 12-15, 2010*. 2010, pp. 69–78.

[53] Saideep Nannapaneni, Abhishek Dubey, and Sankaran Mahadevan. "Automated aircraft separation safety assurance using Bayesian networks". In: *2018 Aviation Technology, Integration, and Operations Conference*. 2018, p. 3199.

[54] Saideep Nannapaneni, Abhishek Dubey, and Sankaran Mahadevan. "Performance evaluation of smart systems under uncertainty". In: *2017 IEEE SmartWorld*. 2017, pp. 1–8.

[55] Saideep Nannapaneni, Sankaran Mahadevan, Subhav Pradhan, and Abhishek Dubey. "Towards Reliability-Based Decision Making in Cyber-Physical Systems". In: *2016 IEEE International Conference on Smart Computing, SMARTCOMP 2016, St Louis, MO, USA, May 18-20, 2016*. 2016, pp. 1–6.

[56] Saideep Nannapaneni, Abhishek Dubey, Sherif Abdelwahed, Sankaran Mahadevan, Sandeep Neema, and Ted Bapty. "Mission-based reliability prediction in component-based systems". In: *International Journal of Prognostics and Health Management* 7.001 (2016).

[57] Saideep Nannapaneni, Abhishek Dubey, Sherif Abdelwahed, Sankaran Mahadevan, and Sandeep Neema. "A Model-Based Approach for Reliability Assessment in Component-Based Systems". In: *PHM 2014 - Proceedings of the Annual Conference of the Prognostics and Health Management Society 2014*. Oct. 2014.

[58] Aron Laszka, Scott Eisele, Abhishek Dubey, Gabor Karsai, and Karla Kvaternik. "TRANSAX: A Blockchain-Based Decentralized Forward-Trading Energy Exchanged for Transactive Microgrids". In: *24th IEEE International Conference on Parallel and Distributed Systems, ICPADS 2018, Singapore, December 11-13, 2018*. 2018, pp. 918–927.

[59] Aron Laszka, Abhishek Dubey, Michael Walker, and Douglas C. Schmidt. "Providing privacy, safety, and security in IoT-based transactive energy systems using distributed ledgers". In: *Proceedings of the Seventh International Conference on the Internet of Things, IOT 2017, Linz, Austria, October 22-25, 2017*. 2017, 13:1–13:8.

[60] Scott Eisele, Purboday Ghosh, Keegan Campanelli, Abhishek Dubey, and Gabor Karsai. "Demo: Transactive Energy Application with RIAPS". In: *IEEE 22nd International Symposium on Real-Time Distributed Computing, ISORC 2019, Valencia, Spain, May 7-9, 2019*. 2019, pp. 85–86.

[61] Scott Eisele, Abhishek Dubey, Gabor Karsai, and Srdjan Lukic. "Transactive energy demo with RIAPS platform". In: *Proceedings of the 8th International Conference on Cyber-Physical Systems, ICCPS 2017, Pittsburgh, Pennsylvania, USA, April 18-20, 2017*. 2017, p. 91.

[62] Jonatan Bergquist, Aron Laszka, Monika Sturm, and Abhishek Dubey. "On the design of communication and transaction anonymity in blockchain-based transactive microgrids". In: *Proceedings of the 1st Workshop on Scalable and Resilient Infrastructures for Distributed Ledgers, SERIAL@Middleware 2017, Las Vegas, NV, USA, December 11-15, 2017*. 2017, 3:1–3:6.

[63] Scott Eisele, Aron Laszka, Anastasia Mavridou, and Abhishek Dubey. "SolidWorx: A Resilient and Trustworthy Transactive Platform for Smart and Connected Communities". In: *IEEE Conference on Internet of Things and Blockchains*. 2018, pp. 1263–1272.

[64] Aron Laszka, Anastasia Mavridou, and Abhishek Dubey. "Resilient and Trustworthy Transactive Platform for Smart and Connected Communities". In: *High Confidence Software and Systems Conference*. 2018.

[65] Scott Eisele, Carlos Barreto, Abhishek Dubey, Xenofon Koutsoukos, Taha Eghtesad, Aron Laszka, and Anastasia Mavridou. "Blockchains for Transactive Energy Systems: Opportunities, Challenges, and Approaches". In: *IEEE Computer* 53.9 (2020), pp. 66–76.

[66] Aron Laszka, Anastasia Mavridou, Scott Eisele, Emmanouela Statchtiari, and Abhishek Dubey. "VeriSolid for TRANSAX: Correct-by-Design Ethereum Smart Contracts for Energy Trading". In: *First International Summer School on Security and Privacy for Blockchains and Distributed Ledger Technologies, BDLT 2019, Vienna, Austria*. Sept. 2019.

[67] Anastasia Mavridou, Aron Laszka, Emmanouela Stachtiari, and Abhishek Dubey. "VeriSolid: Correct-by-Design Smart Contracts for Ethereum". In: *Financial Cryptography and Data Security - 23rd International Conference, FC 2019, Frigate Bay, St. Kitts and Nevis, Revised Selected Papers*. 2019, pp. 446–465.

[68] Carlos Barreto, Taha Eghtesad, Scott Eisele, Aron Laszka, Abhishek Dubey, and Xenofon Koutsoukos. "Cyber-Attacks and Mitigation in Blockchain Based Transactive Energy Systems". In: *3rd IEEE International Conference on Industrial Cyber-Physical Systems (ICPS 2020)*. 2020.

[69] Scott Eisele, Aron Laszka, Doug Schmidt, and Abhishek Dubey. "The Role of Blockchains in Multi-Stakeholder Transactive Energy Systems". In: *Frontiers in Blockchain* 3 (2020), p. 55. ISSN: 2624-7852.

[70] Michael A. Walker, Douglas C. Schmidt, and Abhishek Dubey. "Chapter Six - Testing at scale of IoT blockchain applications". In: *Advances in Computers*. Vol. 115. Oreilly, 2019, pp. 155–179.

[71] Michael A. Walker, Abhishek Dubey, Aron Laszka, and Douglas C. Schmidt. "PlaTIBART: a platform for transactive IoT blockchain applications with repeatable testing". In: *Proceedings of the 4th Workshop on Middleware and Applications for the Internet of Things, M4IoT@Middleware 2017, Las Vegas, NV, USA, December 11, 2017*. 2017, pp. 17–22.

[72] Ajay Chhokra, Carlos Barreto, Abhishek Dubey, Gabor Karsai, and Xenofon Koutsoukos. "Power-Attack: A comprehensive tool-chain for modeling and simulating attacks in power systems". In: *9th Workshop on Modeling and Simulation of Cyber-Physical Energy Systems, MSCPES@CPSIoTWeek*. 2021.

[73] Rishav Sen, Alok Kumar Bharati, Seyedmehdi Khaleghian, Malini Ghosal, Michael Wilbur, Toan Tran, Philip Pugliese, Mina Sartipi, Himanshu Neema, and Abhishek Dubey. "E-Transit-Bench: Simulation Platform for Analyzing Electric Public Transit Bus Fleet Operations". In: *Proceedings of the Thirteenth ACM International Conference on Future Energy Systems*. e-Energy '22. Virtual Event: Association for Computing Machinery, 2022, 532–541. ISBN: 9781450393973.

[74] Nagabhushan Mahadevan, Abhishek Dubey, Daniel Balasubramanian, and Gabor Karsai. "Deliberative, search-based mitigation strategies for model-based software health management". In: *Innovations in Systems and Software Engineering* 9.4 (2013), pp. 293–318.

[75] Abhishek Dubey, Gabor Karsai, and Nagabhushan Mahadevan. "Fault-Adaptivity in Hard Real-Time Component-Based Software Systems". In: *Software Engineering for Self-Adaptive Systems II: International Seminar, Dagstuhl Castle, Germany, October 24-29, 2010 Revised Selected and Invited Papers*. Ed. by Rogério de Lemos, Holger Giese, Hausi A. Müller, and Mary Shaw. Berlin, Heidelberg: Springer Berlin Heidelberg, 2013, pp. 294–323. ISBN: 978-3-642-35813-5.

[76] Nagabhushan Mahadevan, Abhishek Dubey, and Gabor Karsai. "Architecting Health Management into Software Component Assemblies: Lessons Learned from the ARINC-653 Component Mode". In: *15th IEEE International Symposium on Object/Component/Service-Oriented Real-Time Distributed Computing, ISORC 2012, Shenzhen, China, April 11-13, 2012*. 2012, pp. 79–86.

[77] Abhishek Dubey, Nagabhushan Mahadevan, and Gabor Karsai. "A deliberative reasoner for model-based software health management". In: *The Eighth International Conference on Autonomic and Autonomous Systems*. 2012, pp. 86–92.

[78] Abhishek Dubey, Gabor Karsai, and Nagabhushan Mahadevan. *Formalization of a Component Model for Real-time Systems*. Tech. rep. ISIS-12-102. Institute for Software Integrated Systems, Vanderbilt University, Apr. 2012.

[79] Abhishek Dubey, Nagabhushan Mahadevan, and Gabor Karsai. *The Inertial Measurement Unit Example: A Software Health Management Case Study*. Tech. rep. ISIS-12-101. Insitute for Software Integrated Systems, Vanderbilt University, Feb. 2012.

[80] Nagabhushan Mahadevan, Abhishek Dubey, and Gabor Karsai. "Application of software health management techniques". In: *2011 ICSE Symposium on Software Engineering for Adaptive and Self-Managing Systems, SEAMS 2011, Waikiki, Honolulu , HI, USA, May 23-24, 2011*. 2011, pp. 1–10.

[81] Abhishek Dubey, G. Karsai, and N. Mahadevan. "Model-based software health management for real-time systems". In: *2011 Aerospace Conference*. Mar. 2011, pp. 1–18.

[82] Ajay Chhokra, Abhishek Dubey, Nagabhushan Mahadevan, Saqib Hasan, and Gabor Karsai. "Diagnosis in Cyber-Physical Systems with Fault Protection Assemblies". In: *Diagnosability, Security and Safety of Hybrid Dynamic and Cyber-Physical Systems*. Ed. by Moamar Sayed-Mouchaweh. Cham: Springer International Publishing, 2018. Chap. Chapter 8, pp. 201–225. ISBN: 978-3-319-74962-4.

[83] Michael Wilbur, Abhishek Dubey, Bruno Leão, and Shameek Bhattacharjee. "A Decentralized Approach for Real Time Anomaly Detection in Transportation Networks". In: *IEEE International Conference on Smart Computing, SMARTCOMP 2019, Washington, DC, USA*. June 2019, pp. 274–282.

[84] Sanchita Basak, Afiya Aman, Aron Laszka, Abhishek Dubey, and Bruno Leao. "Data-Driven Detection of Anomalies and Cascading Failures in Traffic Networks". In: *Proceedings of the 11th Annual Conference of the Prognostics and Health Management Society (PHM)*. Oct. 2019.

[85] Kaduvettykunnal Sajan, Mohini Bariya, Sanchita Basak, Anurag K. Srivastava, Abhishek Dubey, Alexandra von Meier, and Gautam Biswas. "Realistic Synchrophasor Data Generation for Anomaly Detection and Event Classification". In: *8th Workshop on Modeling and Simulation of Cyber-Physical Energy Systems, MSCPES@CPSIoTWeek*. 2020.

[86] Zhuangwei Kang, Ayan Mukhopadhyay, Aniruddha Gokhale, Shijie Wen, and Abhishek Dubey. "Traffic Anomaly Detection Via Conditional Normalizing Flow". In: *2022 IEEE 25th International Conference on Intelligent Transportation Systems (ITSC)*. 2022, pp. 2563–2570.

[87] Shreyas Ramakrishna, Zahra RahimiNasab, Gabor Karsai, Arvind Easwaran, and Abhishek Dubey. "Efficient Out-of-Distribution Detection Using Latent Space of β-VAE for Cyber-Physical Systems". In: *ACM Trans. Cyber-Phys. Syst.* (2021).

[88] Shreyas Ramakrishna, Zahra Rahiminasab, Arvind Easwaran, and Abhishek Dubey. "Efficient Multi-Class Out-of-Distribution Reasoning for Perception Based Networks: Work-in-Progress". In: *2020 International Conference on Embedded Software (EMSOFT)*. 2020, pp. 40–42.

[89] Jacob Buckelew, Sagnik Basumallik, Vasavi Sivaramakrishnan, Ayan Mukhopadhyay, Anurag K. Srivastava, and Abhishek Dubey. "Synchrophasor Data Event Detection using Unsupervised Wavelet Convolutional Autoencoders". In: *2023 IEEE International Conference on Smart Computing (SMARTCOMP)*. 2023, pp. 326–331.

[90] Ammar Bin Zulqarnain, Jacob Buckelew, Jose Paolo Talusan, Ayan Mukhopadhyay, and Abhishek Dubey. "TRACE: Traffic Response Anomaly Capture Engine for Localization of Traffic Incidents". In: *2025 IEEE International Conference on Smart Computing (SMARTCOMP)*. 2025, pp. 42–49.

[91] Abhishek Dubey, Nagbhushan Mahadevan, and Robert Kereskenyi. "Reflex and healing architecture for software health management". In: *International workshop on software health management. IEEE conference on space mission challenges for information technology*. 2009.

[92] Abhishek Dubey, Gabor Karsai, and Subhav Pradhan. "Resilience at the edge in cyber-physical systems". In: *Second International Conference on Fog and Mobile Edge Computing, FMEC 2017, Valencia, Spain, May 8-11, 2017*. 2017, pp. 139–146.

[93] Subhav M. Pradhan, Abhishek Dubey, Aniruddha S. Gokhale, and Martin Lehofer. "CHARIOT: a domain specific language for extensible cyber-physical systems". In: *Proceedings of the Workshop on Domain-Specific Modeling, DSM@SPLASH 2015, Pittsburgh, PA, USA, October 27, 2015*. 2015, pp. 9–16.

[94] Subhav Pradhan, Abhishek Dubey, Tihamer Levendovszky, Pranav Srinivas Kumar, William Emfinger, Daniel Balasubramanian, William Otte, and Gabor Karsai. "Achieving resilience in distributed software systems via self-reconfiguration". In: *Journal of Systems and Software* 122 (2016), pp. 344–363.

[95] Subhav Pradhan, Abhishek Dubey, and Aniruddha S. Gokhale. "Designing a Resilient Deployment and Reconfiguration Infrastructure for Remotely Managed Cyber-Physical Systems". In: *Software Engineering for Resilient Systems - 8th International Workshop, SERENE 2016, Gothenburg, Sweden, September 5-6, 2016, Proceedings*. 2016, pp. 88–104.

[96] Shreyas Ramakrishna, Charles Hartsell, Matthew P. Burruss, Gabor Karsai, and Abhishek Dubey. "Dynamic-weighted simplex strategy for learning enabled cyber physical systems". In: *Journal of Systems Architecture* 111 (2020), p. 101760. ISSN: 1383-7621.

[97] Shreyas Ramakrishna, Abhishek Dubey, Matthew P. Burruss, Charles Hartsell, Nagabhushan Mahadevan, Saideep Nannapaneni, Aron Laszka, and Gabor Karsai. "Augmenting Learning Components for Safety in Resource Constrained Autonomous Robots". In: *IEEE 22nd International Symposium on Real-Time Distributed Computing, ISORC 2019, Valencia, Spain, May 7-9, 2019*. 2019, pp. 108–117.

[98] Geoffrey Pettet, Saideep Nannapaneni, Benjamin Stadnick, Abhishek Dubey, and Gautam Biswas. "Incident analysis and prediction using clustering and Bayesian network". In: *2017 IEEE SmartWorld*. 2017, pp. 1–8.

[99] Ayan Mukhopadhyay, Yevgeniy Vorobeychik, Abhishek Dubey, and Gautam Biswas. "Prioritized Allocation of Emergency Responders based on a Continuous-Time Incident Prediction Model". In: *Proceedings of the 16th Conference on Autonomous Agents and MultiAgent Systems, AAMAS 2017, São Paulo, Brazil, May 8-12, 2017*. 2017, pp. 168–177.

[100] Geoffrey Pettet, Ayan Mukhopadhyay, Mykel J. Kochenderfer, and Abhishek Dubey. "Hierarchical Planning for Dynamic Resource Allocation in Smart and Connected Communities". In: *ACM Trans. Cyber-Phys. Syst.* 6.4 (Nov. 2022). ISSN: 2378-962X.

[101] H. Purohit, S. Nannapaneni, Abhishek Dubey, P. Karuna, and G. Biswas. "Structured Summarization of Social Web for Smart Emergency Services by Uncertain Concept Graph". In: *2018 IEEE International Science of Smart City Operations and Platforms Engineering in Partnership with Global City Teams Challenge (SCOPE-GCTC)*. Apr. 2018, pp. 30–35.

[102] Geoffrey Pettet, Ayan Mukhopadhyay, Mykel Kochenderfer, Yevgeniy Vorobeychik, and Abhishek Dubey. "On Algorithmic Decision Procedures in Emergency Response Systems in Smart and Connected Communities". In: *Proceedings of the 19th Conference on Autonomous Agents and MultiAgent Systems, AAMAS 2020, Auckland, New Zealand*. 2020.

[103] Nashville Innovation Alliance. *Tech Studio's inaugural grant supports collaboration between Vanderbilt, Metro Nashville government to improve emergency response*. https://engineering.vanderbilt.edu/2025/03/27/tech-studios-inaugural-grant-supports-collaboration-between-vanderbilt-metro-nashville-government-to-improve-emergency-response/. Accessed: September 6, 2025. 2025.

[104] Fangzhou Sun, Abhishek Dubey, Jules White, and Aniruddha Gokhale. "Transit-hub: a smart public transportation decision support system with multi-timescale analytical services". In: *Cluster Computing* 22.Suppl 1 (Jan. 2019), pp. 2239–2254.

[105] Michael Wilbur et al. "Impact of COVID-19 on Public Transit Accessibility and Ridership". In: *Transportation Research Record* 2677.4 (2023), pp. 531–546.

[106] Afiya Ayman, Amutheezan Sivagnanam, Michael Wilbur, Philip Pugliese, Abhishek Dubey, and Aron Laszka. "Data-Driven Prediction and Optimization of Energy Use for Transit Fleets of Electric and ICE Vehicles". In: *ACM Trans. Internet Technol.* 22.1 (2021). ISSN: 1533-5399.

[107] Michael Wilbur, Ayan Mukhopadhyay, Sayyed Vazirizade, Philip Pugliese, Aron Laszka, and Abhishek Dubey. "Energy and Emission Prediction for Mixed-Vehicle Transit Fleets Using Multi-task and Inductive Transfer Learning". In: *Machine Learning and Knowledge Discovery in Databases. Applied Data Science Track: European Conference, ECML PKDD 2021, Bilbao, Spain, September 13–17, 2021, Proceedings, Part IV*. Bilbao, Spain: Springer-Verlag, 2021, 502–517. ISBN: 978-3-030-86513-9.

[108] Agrima Khanna, Fangqi Liu, Samir Gupta, Sophie Pavia, Ayan Mukhopadhyay, and Abhishek Dubey. "PDPTW-DB: MILP-Based Offline Route Planning for PDPTW with Driver Breaks". In: *Proceedings of the 26th International Conference on Distributed Computing and Networking*. ICDCN '25. New York, NY, USA: Association for Computing Machinery, 2025, pp. 73–83. ISBN: 9798400710629.

[109] Amutheezan Sivagnanam, Salah Uddin Kadir, Ayan Mukhopadhyay, Philip Pugliese, Abhishek Dubey, Samitha Samaranayake, and Aron Laszka. "Offline Vehicle Routing Problem with Online Bookings: A Novel Problem Formulation with Applications to Paratransit". In: *31st International Joint Conference on Artificial Intelligence (IJCAI)*. July 2022.

[110] Youngseo Kim, Danushka Edirimanna, Michael Wilbur, Philip Pugliese, Aron Laszka, Abhishek Dubey, and Samitha Samaranayake. "Rolling horizon based temporal decomposition for the offline pickup and delivery problem with time windows". In: *Proceedings of the Thirty-Seventh AAAI Conference on Artificial Intelligence and Thirty-Fifth Conference on Innovative Applications of Artificial Intelligence and Thirteenth Symposium on Educational Advances in Artificial Intelligence*. AAAI'23/IAAI'23/EAAI'23. AAAI Press, 2023. ISBN: 978-1-57735-880-0.

[111] Michael Wilbur, Salah Uddin Kadir, Youngseo Kim, Geoffrey Pettet, Ayan Mukhopadhyay, Philip Pugliese, Samitha Samaranayake, Aron Laszka, and Abhishek Dubey. "An Online Approach to Solve the Dynamic Vehicle Routing Problem with Stochastic Trip Requests for Paratransit Services". In: *ACM/IEEE 13th International Conference on Cyber-Physical Systems (ICCPS)*. 2022, pp. 147–158.

[112] Sophie Pavia et al. "SmartTransit.AI: a dynamic paratransit and microtransit application". In: *Proceedings of the Thirty-Third International Joint Conference on Artificial Intelligence*. IJCAI '24. Jeju, Korea, 2024. ISBN: 978-1-956792-04-1.

[113] Lucas Johnson. *Test project uses AI system to improve transit accessibility in Chattanooga*. https://engineering.vanderbilt.edu/2024/06/18/test-project-uses-ai-system-to-improve-transit-accessibility-in-chattanooga/. Accessed: September 6, 2025. 2024.

[114] Vineet Nair, Kritika Prakash, Michael Wilbur, Aparna Taneja, Corrine Namblard, Oyindamola Adeyemo, Abhishek Dubey, Abiodun Adereni, Milind Tambe, and Ayan Mukhopadhyay. "ADVISER: AI-Driven Vaccination Intervention Optimiser for Increasing Vaccine Uptake in Nigeria". In: *31st International Joint Conference on Artificial Intelligence (IJCAI: AI for Social Good Track)*. July 2022.

[115] Jose Paolo Talusan, Chaeeun Han, David Rogers, Ayan Mukhopadhyay, Aron Laszka, Dan Freudberg, and Abhishek Dubey. "An End-to-End Solution for Public Transit Stationing and Dispatch Problem". In: *ACM Trans. Cyber-Phys. Syst.* (July 2025). Just Accepted. ISSN: 2378-962X.

[116] Cynthia Abrams. *'How do I move more people?': As Nashville aims for major transit funding, data efforts are already happening to improve trips*. https://wpln.org/post/how-do-i-move-more-people-as-nashville-aims-for-major-transit-funding-data-efforts-are-already-happening-to-improve-trips/. Accessed: September 6, 2025. 2024.

[117] Skip Descant. *Chattanooga Transit Agency Developing Improved Operations Technology*. https://www.govtech.com/transportation/chattanooga-transit-agency-developing-improved-operations-technology. Accessed: September 6, 2025. 2024.

[118] Dubey, Abhishek and Mukhopadhyay, Ayan and Talusan, Jose Paolo. *PATH-TN: Partnership for AI-driven Multimodal Transportation Services Integration in Tennessee Cities*. U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA), Advanced Transportation Technology and Innovation (ATTAIN) Program Grant. Total funding: $8,666,053. Prime: Vanderbilt University. Collaborating Institutions: WeGo, Penn State, University of Tennessee at Chattanooga, University of Memphis, Chattanooga Area Regional Transportation Authority, Memphis Area Transit Authority, Knoxville Area Transit, University of Tennessee at Knoxville. 2024.

[119] Chattanooga Area Regional Transportation Authority and Dubey, Abhishek and Mukhopadhyay, Ayan. *AI-Powered Autonomy-Aware Neighborhood Mobility Zones*. U.S. Department of Energy (DOE) Grant. Prime: Chattanooga Area Regional Transportation Authority. Collaborating Institutions: Vanderbilt University (Tech Lead), Cornell University, Penn State, Spark the Firm, Nissan. 2024.

[120] Ajay Chhokra, Abhishek Dubey, Nagabhushan Mahadevan, Gabor Karsai, Daniel Balasubramanian, and Saqib Hasan. "Hierarchical Reasoning about Faults in Cyber-Physical Energy Systems using Temporal Causal Diagrams". In: *International Journal of Prognostics and Health Management* 9.1 (Feb. 2018).

[121] Yue Zhang, Scott Eisele, Abhishek Dubey, Aron Laszka, and Anurag K. Srivastava. "Cyber-Physical Simulation Platform for Security Assessment of Transactive Energy Systems". In: *7th Workshop on Modeling and Simulation of Cyber-Physical Energy Systems, MSCPES@CPSIoTWeek 2019, Montreal, QC, Canada*. 2019, pp. 1–6.

[122] Karla Kvaternik, Aron Laszka, Michael Walker, Douglas C. Schmidt, Monika Sturm, Martin Lehofer, and Abhishek Dubey. "Privacy-Preserving Platform for Transactive Energy Systems". In: *preprint at arxiv*. Vol. abs/1709.09597. 2017.

[123] Himanshu Neema, William Emfinger, and Abhishek Dubey. "A Reusable and Extensible Web-Based Co-Simulation Platform for Transactive Energy Systems". In: *Proceedings of the 3rd International Transactive Energy Systems, Portland, Oregon, USA*. Vol. 12. 2016.

[124] Salah Uddin Kadir, Subir Majumder, Anurag K. Srivastava, Ajay Dev Chhokra, Himanshu Neema, Abhishek Dubey, and Aron Laszka. "Reinforcement-Learning-Based Proactive Control for Enabling Power Grid Resilience to Wildfire". In: *IEEE Transactions on Industrial Informatics* 20.1 (2024), pp. 795–805.

[125] Rishav Sen, Amutheezan Sivagnanam, Aron Laszka, Ayan Mukhopadhyay, and Abhishek Dubey. "Grid-Aware Charging and Operational Optimization for Mixed-Fleet Public Transit". In: *2024 IEEE 27th International Conference on Intelligent Transportation Systems (ITSC)*. 2024.

[126] Rishav Sen, Toan Tran, Seyedmehdi Khaleghian, Philip Pugliese, Mina Sartipi, Himanshu Neema, and Abhishek Dubey. "BTE-Sim: Fast Simulation Environment For Public Transportation". In: *2022 IEEE International Conference on Big Data (Big Data)*. 2022, pp. 2886–2894.

[127] David Rogers, Samir Gupta, Jose Paolo Talusan, Ammar Bin Zulqarnain, Mirza Baig, Arti Ramesh, Natsu Takahashi, Naoki Kojo, and Abhishek Dubey. "AVATAR: Autonomy Aware Routing for On-demand Transit Applications". In: *2025 IEEE International Conference on Smart Computing (SMARTCOMP)*. 2025, pp. 74–81.