STRIDE | Southeastern Transportation Research, Innovation, Development and Education Center

Technology Transfer Final Report

STRIDE Project H3

Smartphone-Based Incentive Framework for Dynamic Network-Level Traffic Congestion Management

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THE STRIDE CENTER

The STRIDE Center is the 2016 USDOT Region 4 (Southeast) University Transportation Center (UTC) housed at the University of Florida Transportation Institute (UFTI). Our mission is to develop novel strategies for Reducing Congestion. The Center has nine partners, representing seven states in the Southeastern U.S. The UFTI and its partners in the STRIDE Center are recognized leaders at state, regional, national, and international levels. The STRIDE Center is focused on assembling and integrating research projects throughout the region in a way that maximizes contributions to solving current and future transportation problems as well as strengthening expertise and developing new technologies. For more information see https://stride.ce.ufl.edu/.

DISCLAIMER

ACKNOWLEDGEMENT OF SPONSORSHIP AND STAKEHOLDERS

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1. Project Overview

By leveraging advances in smartphone-based personalization, big data availability for traffic, and network-level integration through information-based connectivity, this study proposed to manage congestion in real-time in traffic networks, especially during peak period commutes and under debilitating incidents.

Task 1 investigated the role of demand management techniques along with smartphone devices in generating system-level benefits such as reduction in congestion or pollution. This study explored two such techniques: tangible incentives and nudges. Both incentives and nudges were modeled in the context of network-level traffic congestion to be behavior consistent, real-time, and market-based. A reinforcement learning-based approach is employed to design and generate the incentives. A smartphone-based framework is illustrated to disseminate these techniques in the real world.

Task 2 investigated the use of information incentives and designed a correlated routing mechanism that calculates and provides online routing guidance for vehicles with smartphones and/or onboard computing and communication devices. By exploiting information discrepancies between individual vehicles and the Central Planner (CP), the proposed mechanism drives the snapshot equilibrium route choice of a group of vehicles toward a more systematic optimal condition while still preserving the individual's selfish nature. To address the challenge of fast and reliable computation requirements in large-scale real-world problems, this study further developed a robust and distributed solution algorithm by taking advantage of the smartphones and/or onboard computation resources of individual vehicles.

2. Research Goals

In recent years, there has been an explosion of dynamic traffic data from a variety of sources such as public transportation agencies, Google, transportation network companies, and sensors of all types. This study aims to develop smartphone-based frameworks that use real-time incentives, such as monetary rewards, value-based incentives, or travel credits, to influence drivers' routing decisions and improve network-level traffic performance in congested dynamic traffic networks.

3. Findings

Task 1 introduces methods to generate incentives and nudges in response to real-time traffic congestion and mitigate high delays. The solution leverages a ubiquitous smartphone-based framework to present the incentives and nudges to the users. Such a solution is practical in its real-world solution as the models can be trained offline and later implemented online.

Task 2 designs a correlated equilibrium routing mechanism based on information discrepancies that drives the traffic condition to be more systematically efficient while preserving individual vehicles' selfish nature. The simulation experiments show that the proposed routing mechanism in Task 2 can significantly reduce traffic congestion and system travel time by 55% and 3.6% compared to the existing Independent Routing Mechanism and User-oriented Equilibrium Routing Mechanism. Furthermore, the proposed D-AL solution algorithm could quickly solve the routing problem for an online real-time navigation service with the help of smartphones and/or individual vehicles' on-board smart devices.

4. Performance Metrics

Metric	# Completed
OUTPUTS	
Product(s): Number of new or improved tools, technologies, products, methods, practices, and processes created or improved	2
Technical Report: Number of client-based technical reports published	1 STRIDE Final Report
OUTCOMES	
Body of Knowledge: Number of trainings for transportation professionals	1 STRIDE Webinar
Professionals Trained: Number of professionals participating in trainings	10
IMPACTS	
Stakeholders: Number of stakeholders you met with to encourage adoption or implementation of product(s)	3
Adoption/Implementation: Number of incidences outputs of research have been implemented or adopted	0

5. Products

1) A methodology to induce sustainable travel behavior change using incentives and nudges.

The methodology is designed to reduce congestion in real-time by using a reinforcement learning-based framework. Incentives and nudges were modeled in the context of network-level traffic congestion and were found to be behavior consistent, real-time, and market-based. Regional transportation agencies and cities can use this methodology to reduce congestion by incentivizing users to change their behavior.

2) Correlated equilibrium routing mechanism

This mechanism suggests routes that both optimize traffic conditions and benefit the driver. The tool could mitigate traffic congestion and reduce system costs by computing and providing route guidance efficiently for large scales of users.

6. Who benefits/will benefit from your product(s)?

- Transportation researchers and practitioners
- Transit agencies, planners, authorities, drivers, and travelers

7. Body of Knowledge & Professionals Trained

1) STRIDE Webinar: "Smartphone-Based Incentive Framework for Dynamic Network-Level Traffic Congestion Management" presented by Viswa Sri Rupa Anne, Georgia Institute of Technology and Yuqiang Ning, University of Florida; Principle Investigators: Lili Du, Ph.D., University of Florida, and Srinivas Peeta, Ph.D, Georgia Tech on October 26, 2022. Participants in the webinar represented universities, state DOTs, consulting companies, etc. (10 attendees, 26 views on YouTube). Recording: https://youtu.be/fxOMnXkECv8

8. Stakeholder Engagement

MEETING DETAILS		NARRATIVE DESCRIPTION
STRIDE rep.	Srinivas Peeta Viswa Sri Rupa Anne	Rupa Anne has presented the research work on incentives and nudges in the online informs conference in October 2021. The conference has researchers, practitioners, and students from the transportation domain attending. The presentation included details about the mathematical modeling of incentives and nudges and challenges faced in the real-world.
Date of Activity	10/27/2021	
Type of Activity	demonstration	
Location	Online	
Stakeholder(s)	Informs	
STRIDE rep.	Lili Du Yuqiang Ning	Yuqiang Ning presented the findings from Task 2 of the project in the 101st Annual Meeting of the Transportation Research Board. The meeting was attended by researchers, practitioners, and students from the transportation domain.
Date of Activity	01/11/2022	
Type of Activity	demonstration	
Location	Washington, D.C.	
Stakeholder(s)	Transportation Research Board	
STRIDE rep.	Yuqiang Ning	Yuqiang Ning presented the project in the 7th UTC Conference for the Southeastern Region. The conference was attended by researchers, practitioners, and students from the transportation domain.
Date of Activity	03/25/2022	
Type of Activity	demonstration	
Location	Boca Raton, FL	
Stakeholder(s)	University Transportation Centers (UTCs)	
STRIDE rep.	Srinivas Peeta Zhu Qing Yu Wang Einat Tenenboim	Dr. Peeta and post-docs in the research group had an online meeting with Brandon Branham, Assistant City Manager of Peachtree Corners, on 3/18, to discuss the potential use of the incentive mechanism to achieve the local community's sustainability objectives. A research proposal, Fostering Smart and Sustainable Travel through Engaged Communities using Integrated Multidimensional Information-Based Solutions, was developed after the meeting. We proposed to develop a community app tailored to multiple stakeholders, which will include an interface to deliver users' targeted information (e.g., incentives). Residents and other PTC stakeholders can use the smartphone-based incentive framework for transportation needs while fostering the city's sustainability objectives.
Date of Activity	3/18/2021	
Type of Activity	phone meeting	
Location	Online	
Stakeholder(s)	Brandon Branham, Assistant City Manager, City of Peachtree Corners, Georgia	

9. Adoption/Implementation

No adoption yet.

10. Broader Impacts

The demand management techniques in Task 1 and the Correlated equilibrium Routing Mechanism in Task 2 can be used by state/local transportation agencies as new complementary tools in their portfolio to dynamically manage traffic congestion at the network level. It may help transit agencies and planners in understanding the potential of using smartphones and different types of incentives to alleviate traffic congestion.