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BEHAVIORAL URBAN INFORMATICS, LOGISTICS, & TRANSPORT LAB (BUILT@NYU) **C²SMART University Transportation Center, New York University**

--- 2017 Research Brief ---

With the end of the year upon us, it is time to reflect on my lab's research accomplishments this past year. This year has been quite an exciting new chapter for our transportation group at NYU. Because of the new C²SMART University Transportation Center, we have been spending some time putting together the infrastructure and administration to manage it. In addition to the UTC, I was also awarded the NSF CAREER grant at the beginning of the year. Because of these awards, this year we have been focusing on three research projects:

- City-scalable Destination Recommender System for On-demand Senior Mobility (C2SMART)
- Urban Transport Network Design with Privacy-Aware Agent Learning (NSF CAREER CMMI-1652735)
- Stable matching of service tours to design cooperative policies for transport infrastructure systems (NSF CMMI-1634973)

Our collaborator from the Luxembourg Institute of Socio-Economic Research, Dr. Tai-Yu Ma, stayed with our lab as a visiting scholar over the summer. He helped us test our recent dynamic fleet optimization models in new scenarios involving the use of transit networks.

BUILT participated in two summer research programs once again: the Summer Undergraduate Research Program at NYU, and the [ARISE program](#), which supports high school students interested in STEM research.

Research Highlights

Our research agenda this year continued our mission of finding innovative solutions to make use of data and information in managing urban transport systems, divided into three thrust areas: learning/inference, systems evaluation, and dynamic optimization. All our products are open source. Prototypes of our algorithms can be found either online at <https://github.com/BUILTNYU> or by request. A recap of our research products in 2016 is available [here](#). Key findings in the three areas are presented.

Transport system learning and informatics

One of the biggest discoveries we published this year deals with a modeling framework to learn network parameters, such as travel times or the effects of congestion, using machine learning techniques that rely on network relationships in addition to only statistical characterizations. For example, state of the art machine learning techniques may be able to predict a change in travel patterns in a network, but it is hard to be precise enough to attribute those changes in travel patterns to specific links. Network estimation techniques may be able to quantify this effect but encounter a lot of noise due to the need to make an extra step of estimating population variables before being able to estimate link parameters. Our approach, based on multi-agent inverse optimization, makes use of the information from the route choice made by each agent from sample data alone to quantify the effects from each link in the network. This discovery has many applications. It can reduce the computational load for city-level traffic monitoring for city agencies. It can be used to calibrate decision-support models for managing multimodal networks (like bike-share systems, feeder services, or park-and-ride infrastructure). It provides a way to apply more advanced route choice models in networks that can account for diverse population that impose various social/congestion externalities on each other. This can be important for companies like Google and Sidewalk Labs that have large amounts of data and seek to understand the population dynamics better with it.

Another topic that we have recently begun working on is privacy control in data sharing. It is one of the main obstacles for successful smart cities because users and private operators are reluctant to share their data with the public (rightly so). For a private operator, an adversary with access to route information can easily reverse engineer from the data to identify various parameters, constraints, and policies used by the operator. We have developed a



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privacy control mechanism to share transport operator data in a more anonymous manner. This work will provide more support for public-private partnerships that involve making some level of private data publicly accessible, which can include many upcoming last mile operations and Mobility-as-a-Service.

Multimodal flexible transit service evaluation

Two major discoveries were made this year in this area. The first was published in Transportation Research Part B. It presents a new model framework to evaluate transportation systems that account for three sets of actors: the public agency, the private transport operators, and the travelers. The framework makes use of two-sided markets in a smart cities context, by treating the public agency and its transport infrastructure as the platform, the operators and their routes as the sellers, and the travelers as the buyers. We model such a market equilibrium as a dynamic day-to-day system. It serves as an all-in-one type of tool for comparing a vast range of transport systems. This work can readily be adapted to commercial software like MATSIM that already make use of day-to-day adjustments to help evaluate the role of transport operators more organically.

The second discovery in this area is currently published in arXiv as a working paper. The work takes the two-sided market a step further and presents a computational model that can converge to a stable space for matching travelers to operator routes and making trade-offs between different cost allocation schemes or policies. This tool has great potential as it is not simulation-based like the prior study; it can analytically evaluate the market equilibrium that accounts for rational behavior from both travelers and operators. This type of work will be increasing important in the transportation field as systems move away from traffic and highway design and toward Mobility-as-a-Service in an urban context. Companies like Lyft, DiDi, or Ford Chariot can use this type of modeling to help deployment planning. For example, they can help decide between allowing a vehicle to deviate from a fixed route, to have transfers at certain hubs, to allow for fare discounts, to require passengers to reserve a trip more than one hour in advance or to walk more than one city block to meet a vehicle, etc. No analytical modeling framework, besides this one, can currently handle these questions together.

Anticipatory network optimization

The work with my former PhD student Hamid Sayarshad on idle vehicle relocation was recently published. We discovered a new algorithm to relocate, reposition, or rebalance vehicles in dynamic operations to anticipate future costs using queueing theory. This has major benefit to many on-demand services out there because typically most of operating costs are due to rebalancing. Granted, the experiments conducted in the paper are only based on simulation. However, the potential has led us to implement the algorithm in our joint work with Dr. Tai-Yu Ma on relocating idle vehicles to allow them to either drop off passengers directly or at a nearby transit station with a promise of another vehicle picking them up at another station. That work has been accepted for presentation in Austria next year. We are also looking to investigate this algorithm further next year in a collaboration with a local industry partner.

Looking Ahead

In 2018, we expect to continue our work in the focus areas above. We are looking for more opportunities to work more closely with public agencies and industry partners to apply our discoveries and operationalize them. Along this effort, I plan to explore development of a “Network of Living Labs” through C2SMART such that new transportation technologies can make use of our resources (as an arm of the US DOT) to test and certify their performances.



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Lastly, BUILT will once again be present at the TRB reception from NYU Tandon School of Engineering and C2SMART, which will be hosted at the Marriott Marquis Independence E (M4) on Sunday, January 7th, 5-7PM. We hope to see friends and colleagues there!

Sincerely,

Joseph Chow, Ph.D., P.E.

[Assistant Professor, Department of Civil & Urban Engineering](#)

[Deputy Director, C²SMART University Transportation Center](#)

[BUILT@NYU](#)

New York University

BUILT Lab members active in 2017

PhD student researchers

[Susan Jia Xu](#), [Jinkai Zhou](#), [Yueshuai Brian He](#), [Saeid Rasulkhani](#), [Gyugeun Yoon](#), [Ted Pantelidis](#)

MS student researchers

[Daniel Fay](#) (now a Data Scientist at WSP), [Assel Dmitriyeva](#), [Nick Caros](#), [Heba Omholt](#) (now an intern at Philip Habib & Associates and an Eisenhower Fellow)

Undergraduate student researchers

[Ziyi Ma](#), [Xuebo Lai](#), Gisselle Barrera (WTS Scholarship recipient), Elsa Kong (Langan/DJM Memorial Scholarship recipient), Isaiah Mwamba

New Research Products in 2017

Journal publications:

Xu, S. J., Nourinejad, M., **Lai, X.**, **Chow, J.Y.J.**, 2017. [Network learning via multi-agent inverse transportation problems](#). *Transportation Science*, SI: TRISTAN IX, accepted.

Sayarshad, H.R., **Chow, J.Y.J.**, 2017. [Non-myopic relocation of idle mobility-on-demand vehicles as a dynamic location-allocation-queueing problem](#). *Transportation Research Part E* 106, 60-77.

Ma, Z., **Urbanek, M.**, **Pardo, M.A.**, **Chow, J.Y.J.**, **Lai, X.**, 2017. [Spatial welfare effects of shared taxi operating policies for first mile airport access](#). *International Journal of Transportation Science and Technology* 6(4), 301-315.

Djavadian, S., **Chow, J.Y.J.**, 2017. [An agent-based day-to-day adjustment process for modeling ‘Mobility as a Service’ for a two-sided flexible transport market](#). *Transportation Research Part B*, 104, 36-57.

Guo, Q.W., **Chow, J.Y.J.**, **Schonfeld, P.**, 2017. [Stochastic dynamic switching in fixed and flexible transit services as market entry-exit real options](#). *Transportation Research Part C*, SI: ISTTT 22, in press, doi: 10.1016/j.trc.2017.08.008.

Mendes, L.M., **Bennassar, M.R.**, **Chow, J.Y.J.**, 2017. [Comparison of Light Rail Streetcar Against Shared Autonomous Vehicle Fleet for Brooklyn–Queens Connector in New York City](#). *Transportation Research Record* 2650, 142-151.

Conference proceedings:

Xu, S. J., **Chow, J. Y. J.**, 2018. A longitudinal study of bike infrastructure impact on bike-share system performance. Proc. 97th Annual Meeting of the Transportation Research Board, Washington DC.



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- Rasulkhani, S., Chow, J.Y.J.**, 2018. Route-cost-assignment with joint user and operator behavior as a many-to-one stable matching assignment game. Proc. 97th Annual Meeting of the Transportation Research Board, Washington DC.
- Ma, T.Y., **Chow, J.Y.J., Rasulkhani, S.**, 2018. An integrated dynamic ridesharing dispatch and idle vehicle repositioning strategy on a bimodal transport network. Proc. Transport Research Arena 2018, Vienna, Austria.
- He, Y., Chow, J.Y.J.**, Nourinejad, M., 2017. A privacy design problem for sharing transport service tour data, Proc. IEEE ITS Conference, Yokohama, Japan.
- Guo, Q.W., **Chow, J.Y.J.**, Schonfeld, P., 2017. Stochastic dynamic switching in fixed and flexible transit services as market entry-exit real options. In: Proc. ISTTT 22, Transportation Research Procedia 23C, 380-399.

Working papers:

Rasulkhani, S., Chow, J.Y.J., [Route-cost-assignment with joint user and operator behavior as a many-to-one stable matching assignment game](https://arxiv.org/abs/1711.11230), arXiv preprint, <https://arxiv.org/abs/1711.11230>.

Invited Talks:

- “Urban Freight Systems Analysis”, Chung-Ang University, Seoul, South Korea, Oct 14, 2017.
- “Models to operate and evaluate mobility-as-a-service”, University of Minnesota, Sept 6, 2017.
- “Evaluating and Optimizing Smart Transit Operational Strategies”, Ford, Dearborn, MI, Jan 19, 2017.

Conference Presentations:

- “[Real Options Switching Strategies in Dynamic Transport Service Operations](#)”, INFORMS, Houston, TX, Oct 23, 2017.
- “An Algorithm for Preserving the Privacy of Sharing Transport Service Route Data”, INFORMS, Houston, TX, Oct 23, 2017.
- “Pass Programs and Loyalty Programs for Transit Agencies”, INFORMS, Houston, TX, Oct 24, 2017.
- “Matching Assignment Game for Mobility as a Service Transportation Assignment”, INFORMS, Houston, TX, Oct 25, 2017.
- “Data-driven spatial-temporal dynamic equilibrium matching models of welfare effects from New York City taxi and Uber markets”, 21st IFORS Triennial Conference, Quebec City, Canada, July 17, 2017.

Ongoing Guest Editorials:

- [Special Issue in Transportation Research Part C](#), with Feixiong Liao, Harry Timmermans, Song Gao, on “Emerging Mobility Services: Supplier Strategies, Traveler Responses and Network Impacts”
- [Special Issue in IEEE ITS Magazine](#), with Xiaopeng Li, Monica Menendez, Sean Qian, Xiaobo Qu, on “Emerging Mobility Systems”

Media coverage:

- Woyke, E., 2017. The startup behind NYC’s plan to replace phone booths with 7500 connected kiosks. *MIT Technology Review*, July 18. <https://www.technologyreview.com/s/608281/the-startup-behind-nycs-plan-to-replace-phone-booths-with-7500-connected-kiosks/>
- Zimmer, A., 2017. How NYC’s small eco-footprint is threatened by rise of new economy. *DNAinfo*, July 5, 2017. <https://www.dnainfo.com/new-york/20170705/red-hook/eco-footprint-new-economy-app-based-rides-package-deliveries>
- BestMile, 2017. BestMile to Collaborate with NYU on the design of next-generation urban transportation systems. <https://bestmile.com/2017/05/30/bestmile-to-collaborate-with-nyu/>
- Miller, S., 2017. Instead of building de Blasio’s streetcar, what if we had self-driving Uber vans? *The Village Voice*, January 24, 2017, <http://www.villagevoice.com/news/instead-of-building-de-blasio-s-streetcar-what-if-we-had-self-driving-uber-vans-9602278>