Next Generation Activity/Travel Demand Modelling: A Mobility Service Oriented Approach

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Automated Vehicles

- A variety of autonomous vehicles are being road-tested in a number of cities.
  - Individual vehicles.
  - Ridesharing vehicles.
  - Micro-transit / mini-buses / shuttles.
- Many, many claims are being made concerning AV impacts.
  - Many are very dubious!
- Very serious public policy issues exist requiring sound analysis & modelling.

Mobility Services (MS)

- Many new service models & companies are emerging daily:
  - Uber, Lyft, etc.
  - Single customer (taxi, "ride-hailing") service.
  - Multiple customer ridesharing.
  - Micro-transit.
    - Potential first-mile/last-mile solutions.
- Services are being introduced in advance of AV deployment, but clearly most are anticipating this deployment.
- Again, major policy challenges & need for advanced analysis & modelling.
  - Need for "complete mobility solutions" (Mobility-as-a-Service, MaaS) that marry the best of:
    - Public & private operations.
    - AV-based & conventional transit technologies.
    - Generate "win-win" outcomes that improve the public good.

Other New Technologies, Services & Behaviours

- Bicycles:
  - E-bikes
  - Bikeshare services.
- E-scooters.
- …

- E-shopping.
- Work from home (WfH).
- …

Implications for activity/travel modelling

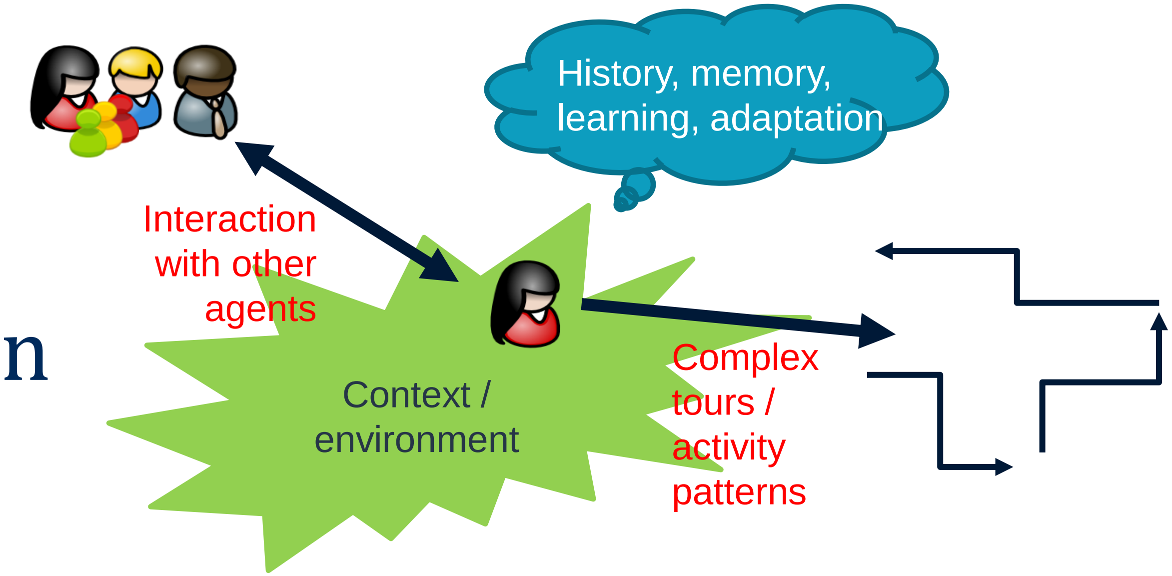
- AVs, MS, etc. are in many respects truly disruptive, and, as such, pose major challenges to even the most cutting-edge of current travel demand models.
- Many "axiomatic /maintained hypotheses" that have existed in our models for decades need to be re-examined and probably replaced.
- Our models need to be much more "fundamental" in their behavioural representations if they are going to respond "appropriately" when confronted with these new technologies & services.
- This means not only accommodating these innovations within the models but improving many elements of the models that are weak/inadequate even when dealing with conventional services & policies.

Can we build an activity/travel demand model system that is sufficiently abstract, fundamental and extensible that it can address a much wider range of technologies, services & policies, both conventional and emerging with improved accuracy, behavioural realism & policy sensitivity?

"Find the beginning, the slight silver key to unlock it, to dig it out. Here then is a maze to begin, to be in."
Michael Ondaatje, "The Collected Works of Billy the Kid: Left-Handed Poems"

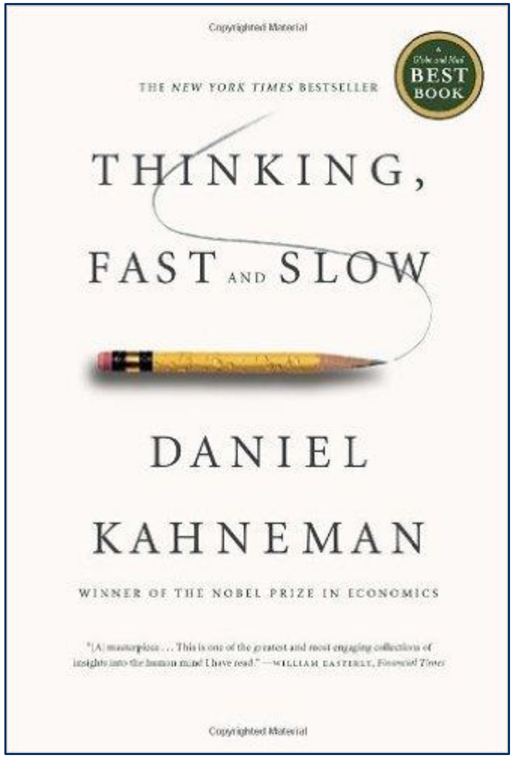
"Anybody building a new travel demand model that does not account for autonomous vehicles is guilty of professional malpractice.
Rick Donnelly, Vice President, WSP, & Technical Fellow, University of Melbourne

Agent-Based Microsimulation



- Agent-based microsimulation (ABM), in which the behaviour of each person & vehicle (agent) in the system is individually modelled is the state of the art of travel demand modelling.
- E.g.: GTAModel is an ABM developed for the GTHA in operational use by most planning agencies in the region.
- ABM is an ideal computational framework for modelling advanced transportation systems & services.

Some propositions for behavioural model building:



- Myopic decision-making:
  - People are “boundedly rational” but not global optimizers.
- Maslow’s Hierarchy of Needs:
  - Projects
  - Utility
- Take the activity-based approach seriously:
  - Activity-scheduling.
- Take human agency seriously.
- Get context & structure right:
  - Decomposition to manage complexity (object-orientation)
  - Model implementations will follow.
  - Model structure should be both behaviourally sound & feasible to implement.
- Build a flexible/extensible framework.
- Computing efficiency is critical (run times matter):
  - Keep it simple, stupid.
  - Detail where needed, not for detail’s sake.
- We must respect data (& computing) constraints, but design for what is needed (and what is coming down the pipe), not what is currently feasible.

AV & MS related modelling components

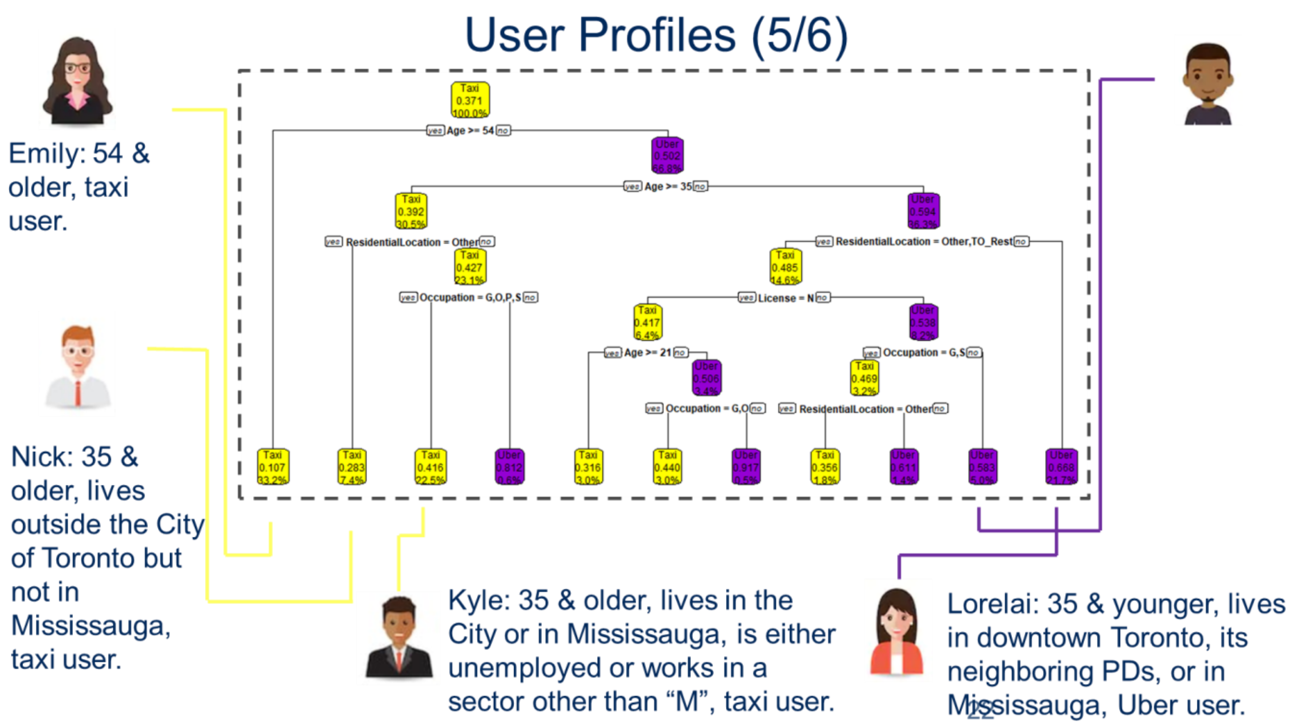
- Mobility tools.
- “Passenger” modes.
- Parking.
- Modeling Mobility Services.
- Vehicles as agents.
- Transportation network modelling.

Modelling mobility tools

- Mobility tools include:
  - Vehicle ownership.
  - Bicycle ownership.
  - Car/bike sharing memberships.
  - Mobility service memberships.
  - Driver's license.
  - Transit passes.
  - …
- Currently auto ownership, possession of a driver's license, etc. are often treated as exogenous model system inputs (or are very simplistically modelled).
- This needs to change as the options proliferate for car and ride sharing, personal ownership versus simply "renting" services as needed, etc.
- How to properly integrate modelling these "medium-term" decisions within day-to-day travel modelling is a challenge.

Modelling “passenger” modes

- “Passenger” modes of travel (intra-household ridesharing, inter-household car-pooling, taxis, etc.) have always been poorly modelled in all operational travel demand models.
- Modelling new mobility services (autonomous or not) require that we significantly improve our ability to model auto-based passenger travel.
- This is particularly critical from a policy perspective, since many of the “societal benefits” of AVs are only likely to be realized if shared-ride services replace a large number of SOV trips (autonomous or otherwise).



Modelling parking

- Parking is usually not explicitly modelled in most operational model systems, except perhaps for the inclusion of very aggregate parking price (and, maybe, in some cases parking supply).
- Autonomous vehicles may fundamentally change the role and nature of parking.
- Many claims re. the benefits of AVs & AV-based MaaS have to do with the elimination of much of current parking demand. This is very much an untested assertion.
- As a result, the demand and supply of parking must be explicitly incorporated within our model systems at an unprecedented level of detail.

Mobility Services (MS)

- We define a *mobility service* (MS) as an entity that provides the means to move from A to B. Examples include:
  - Ride-hailing & ride-sharing companies (Uber, Lyft, etc.).
  - Conventional taxis.
  - Public transit.
  - Demand-responsive transit.
  - Bike-sharing, car-sharing, e-scooter-sharing.
  - ...
- MSs also deal with managing the *vehicle fleets* that are used to deliver the service.

Mobility as a Service (MaaS)

- We define MaaS as a “broker” or a “platform” that provides integrated mobility solutions to trip-makers.
- These solutions may consist of one or more MS components to deliver the door-to-door movement required.
- E.g., morning journey to work:
  - Ridehail Company X picks you up at your door, takes you to a commuter rail station.
  - Commuter rail trip to downtown.
  - E-bike from the egress rail station to your office.
- A MS may also be a MaaS.
- Both MSs & MaaSs may be either private or public sector.

Modelling MS & MaaS

- MS-type services simply do not exist within conventional model systems.
- Even conventional taxi modes are rarely explicitly modelled in any detail.
- Inclusion of the modelling of the supply/performance of such services requires a major extension to and rethink of our overall representation of transportation services within our model systems, including conventional services such as public transit.

High-Level Architecture of Typical Current Activity/Travel Model Systems (e.g., GTAModel)

Person & Household Agent Decisions

Medium/Long-Term "Mobility" Decisions

- Place of work/school
- Auto ownership
- Driver's licence
- Transit pass

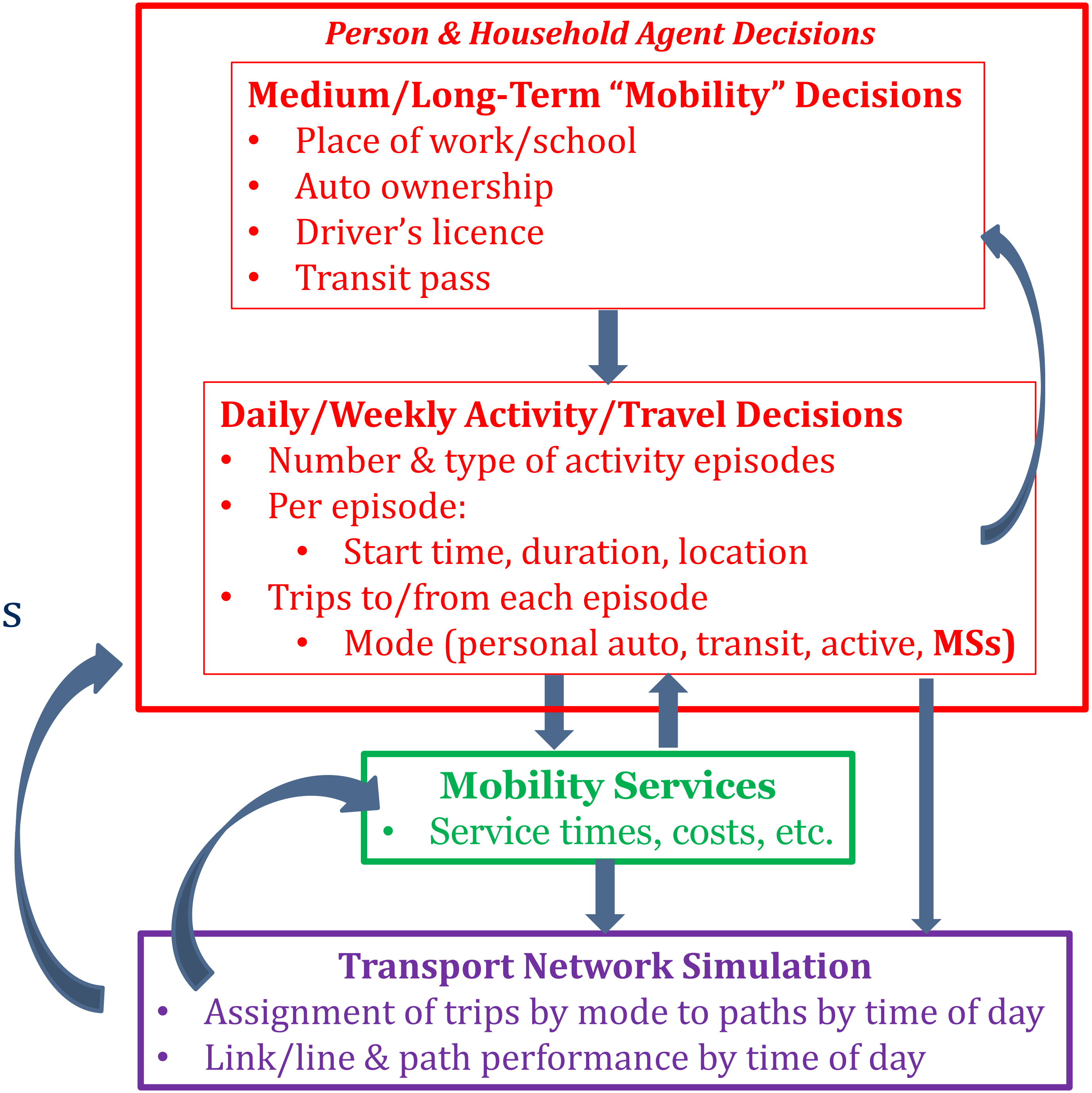
Daily/Weekly Activity/Travel Decisions

- Number & type of activity episodes
- Per episode:
  - Start time, duration, location
- Trips to/from each episode
  - Mode (personal auto, transit, active, **MSs)**

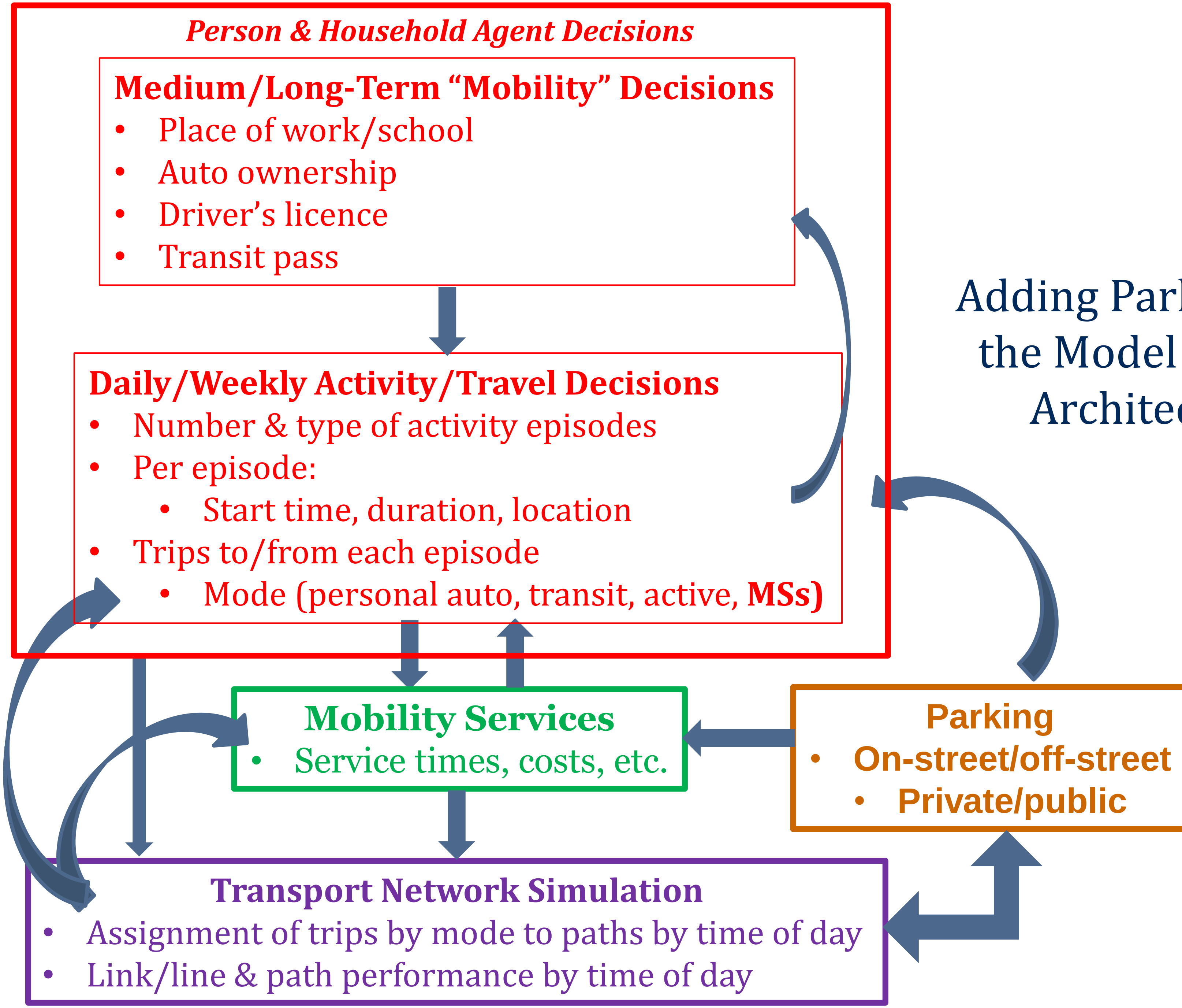
Transport Network Simulation

- Assignment of trips by mode to paths by time of day
- Link/line & path performance by time of day

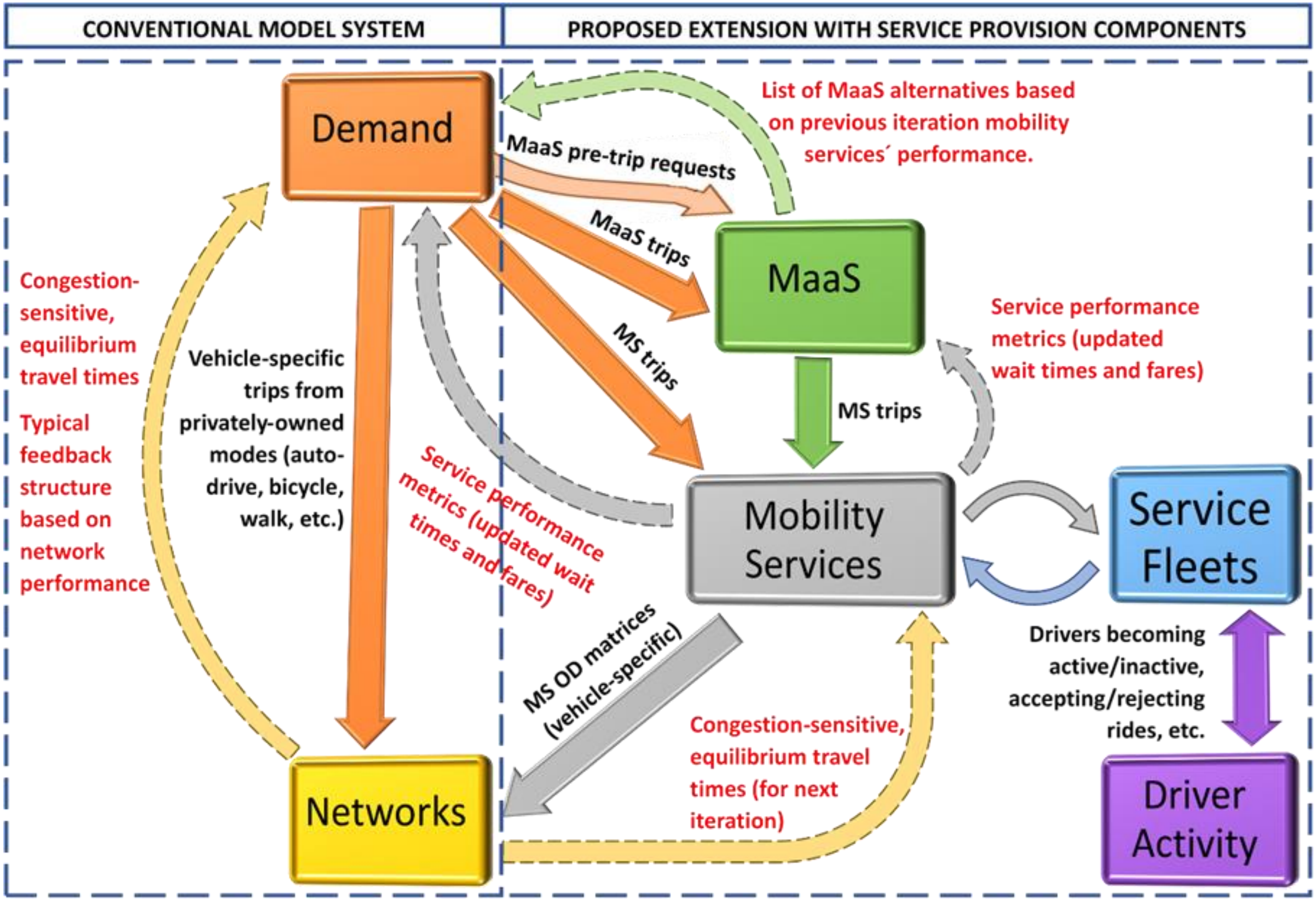
Modified Activity/Travel Model System Architecture Incorporating Mobility Services



Adding Parking into the Model System Architecture



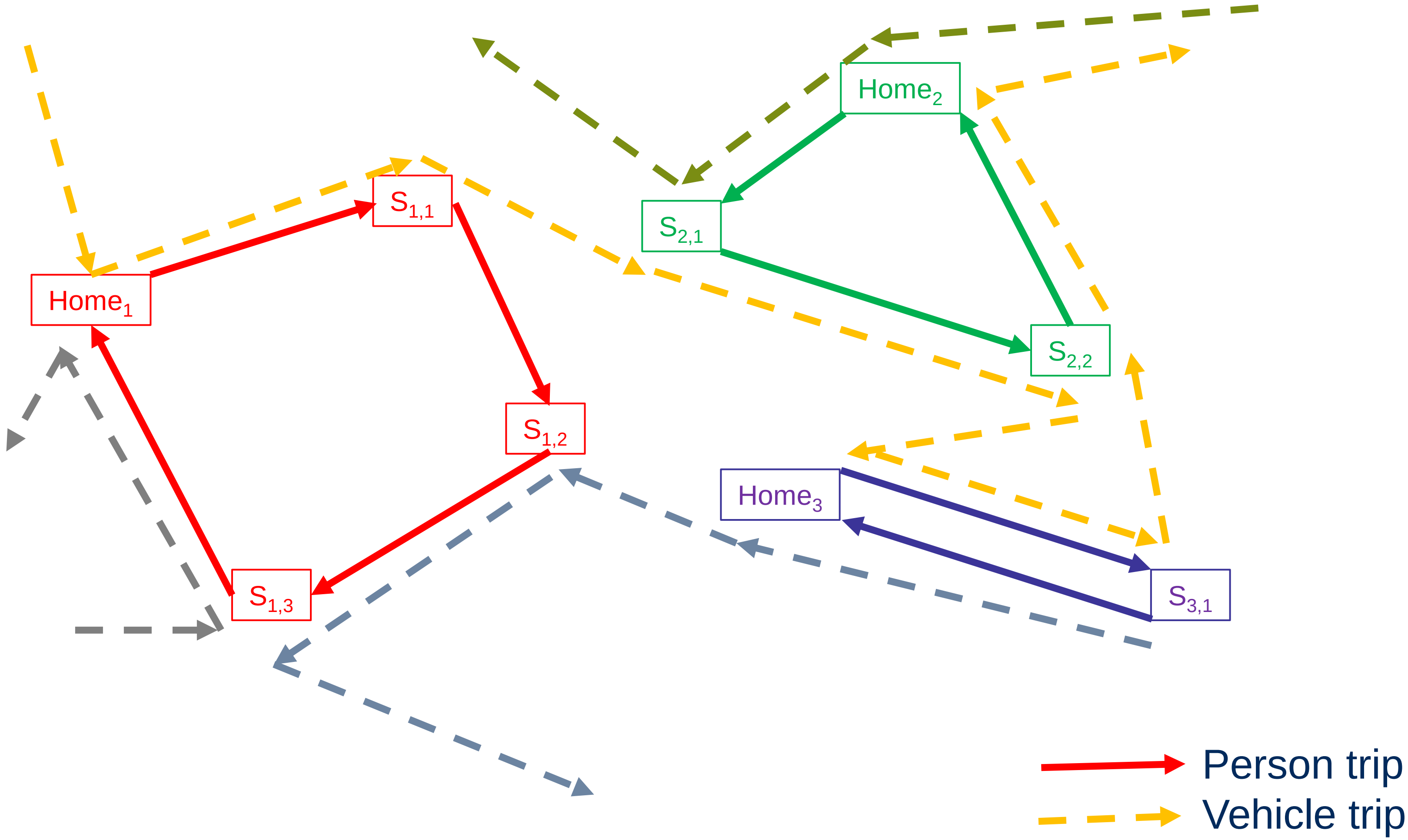
MSs & MaaS within an overall modelling framework



Vehicles as agents

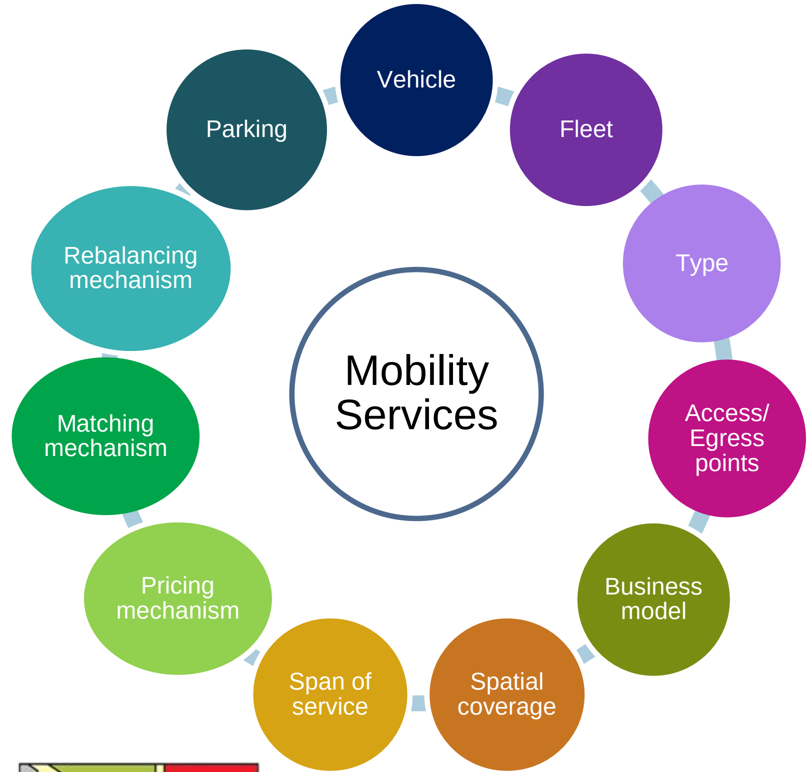
- In current models there is a 1-1 mapping between person movements by car & car movements.
- This will no longer be the case with AVs & MaaS.
- Will need to track vehicle movements & schedules in addition to person movements & schedules.

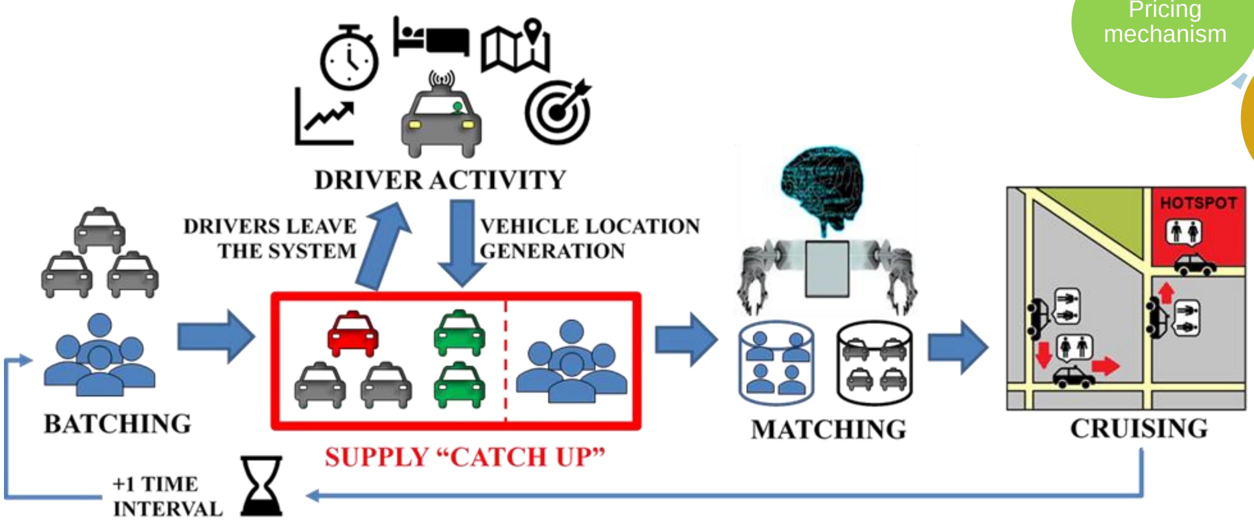
Person & MS Vehicle Movements/Tours



Modelling Mobility Service Provision

- Agent classes:
  - Service providers.
  - Vehicles.
  - Users.
  - MaaS agents.
  - (Drivers).
- Processes:
  - Matching.
  - Rebalancing.
  - Pricing.
  - Driver activities.





Francisco Calderón (2020) *Modelling On-Demand Mobility Services Within Agent-Based Travel Demand Model Systems with a Ridehailing Case Study*, PhD thesis, Toronto: Department of Civil & Mineral Engineering, University of Toronto

Bike Share Toronto
Spencer McNee

Overview:

- Research builds on mobility service framework previously developed in the research group (Calderón & Miller, 2021) to model ride hailing.
- Work uses trip and station data from Bike Share Toronto System.

Goals:

- Expand mobility service framework to include modelling of bike sharing systems.
- Understand Bike Share Toronto system behavior, operation, and rebalancing.
- Understand accessibility offered by Bike Share Toronto.
- Examine system network effects as the number of stations has grown.

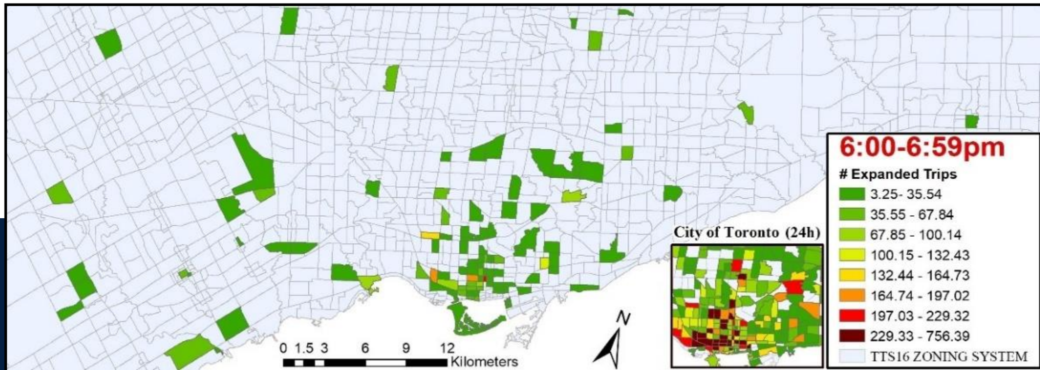
From Trip Assignment to Network Simulation

- Static equilibrium assignment methods (for both road & transit) will no longer be adequate.
- Need a more dynamic, "agent-based" approach.
- May be "meso" in its representation of vehicle & person flows.
- But needs to be "micro" in terms of tracking agents (persons & vehicles) through space & time within the transportation network.
- MATSim is probably currently closest to what is needed, but issues exist.
- Computation time is a major practical issue.

Data

- While AVs & MS are certainly “new”, and while SP surveys help explore “response frontiers”, existing modes & services surely can tell us much about how people will respond to these new services.
- Taxis & public transit are “autonomous” as far as the trip-maker is concerned.
- Taxis, Uber, etc. are mobility services.
- Transit is a form of “ride-sharing”.
- Car-, ride- & bike-sharing services already exist.
- What can we learn from current services & behaviours that help us understand likely MS & AV usage?

2016 Ridehailing Trip Origins (TTS)



Next Steps

- Developing & testing:
  - Next generation activity generation & scheduling models.
  - Mobility tool models.
  - Incorporating parking supply & location choice models.
- Reformulating the demand – network interface to insert MS & MaaS.
  - Implement the Calderón ridehailing model.
  - Working on a bikeshare model.
  - Other MS/MaaS modules …
- Dynamic network assignment?
- New data collection?

- COVID-19 & the emerging “new normal”?

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Questions