U.S. DEPARTMENT OF ENERGY

SMARTMOBILITY

Systems and Modeling for Accelerated Research in Transportation

Emerging Mobility Services – Understanding and Modeling the Curbside

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NYS Association of MPOs
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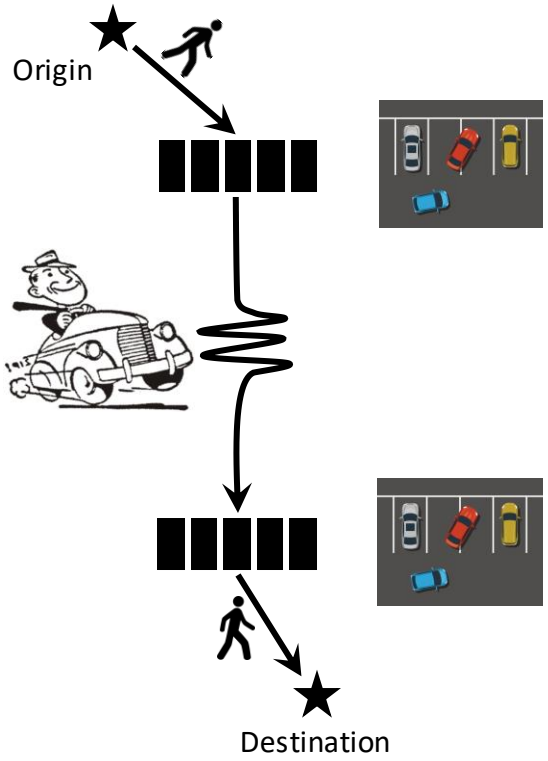
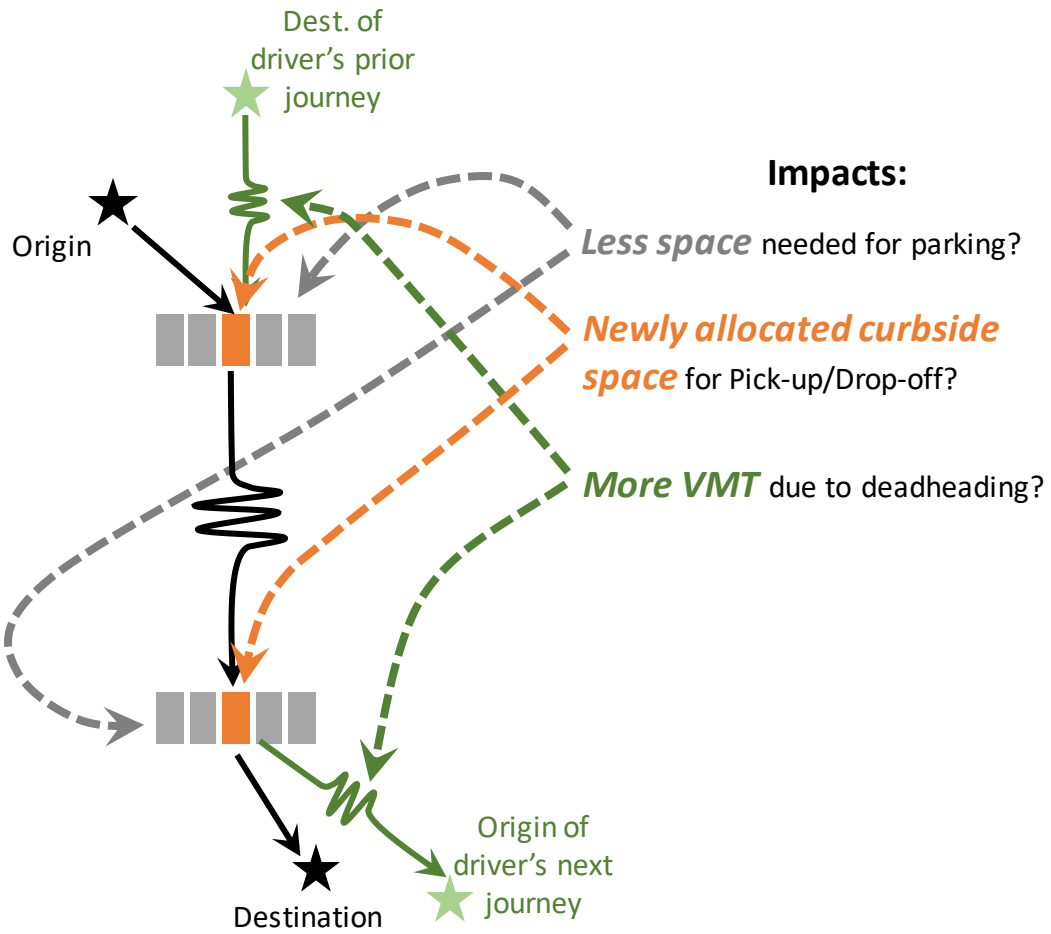
RELEVANCE: New forms of mobility (e.g. Ridehailing, in the example below) impose a unique mix of demands on the network

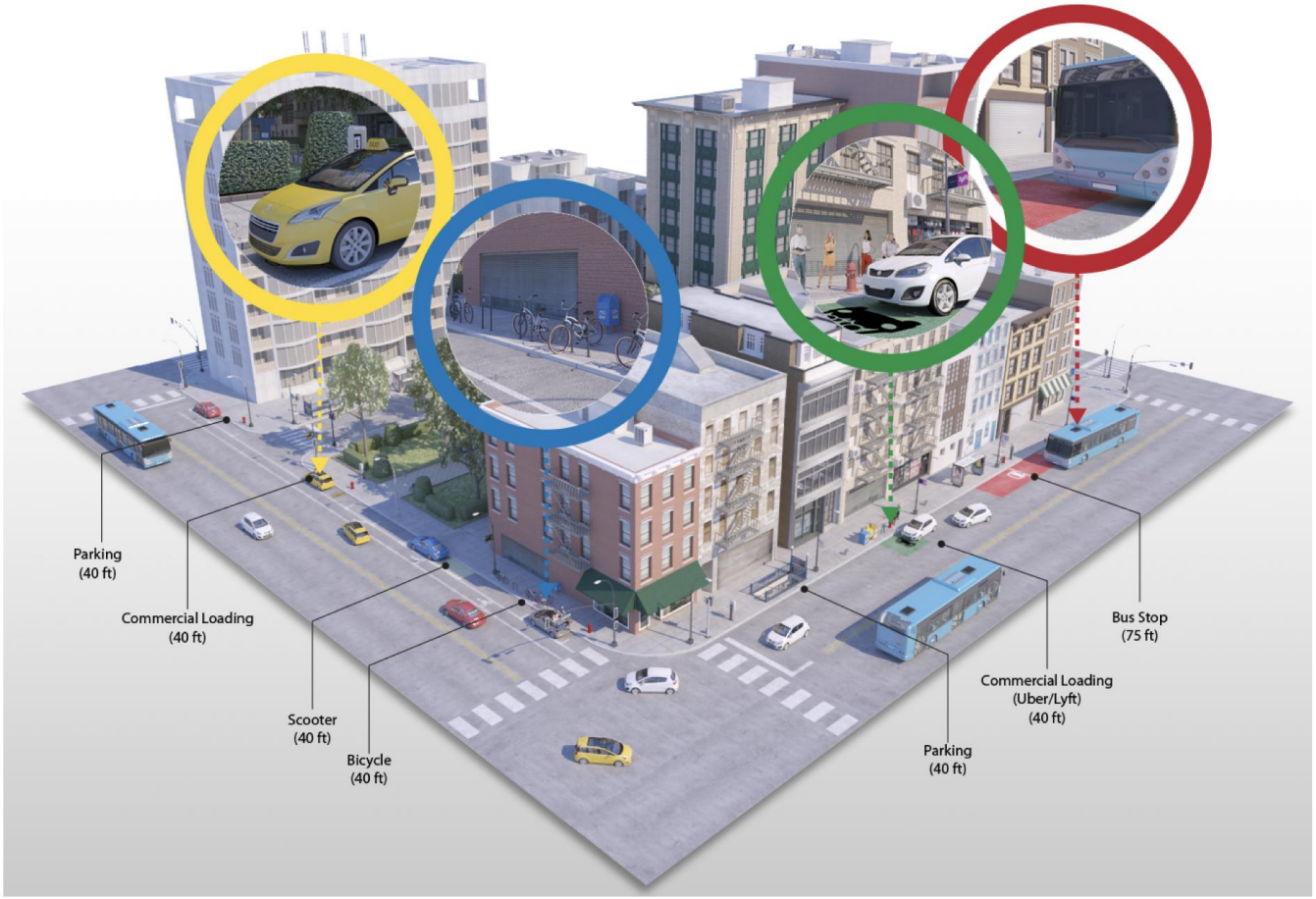
Logistics of a ***Private Car*** journey



Logistics of same journey, by ***Ridehailing***



Some example curbside activities



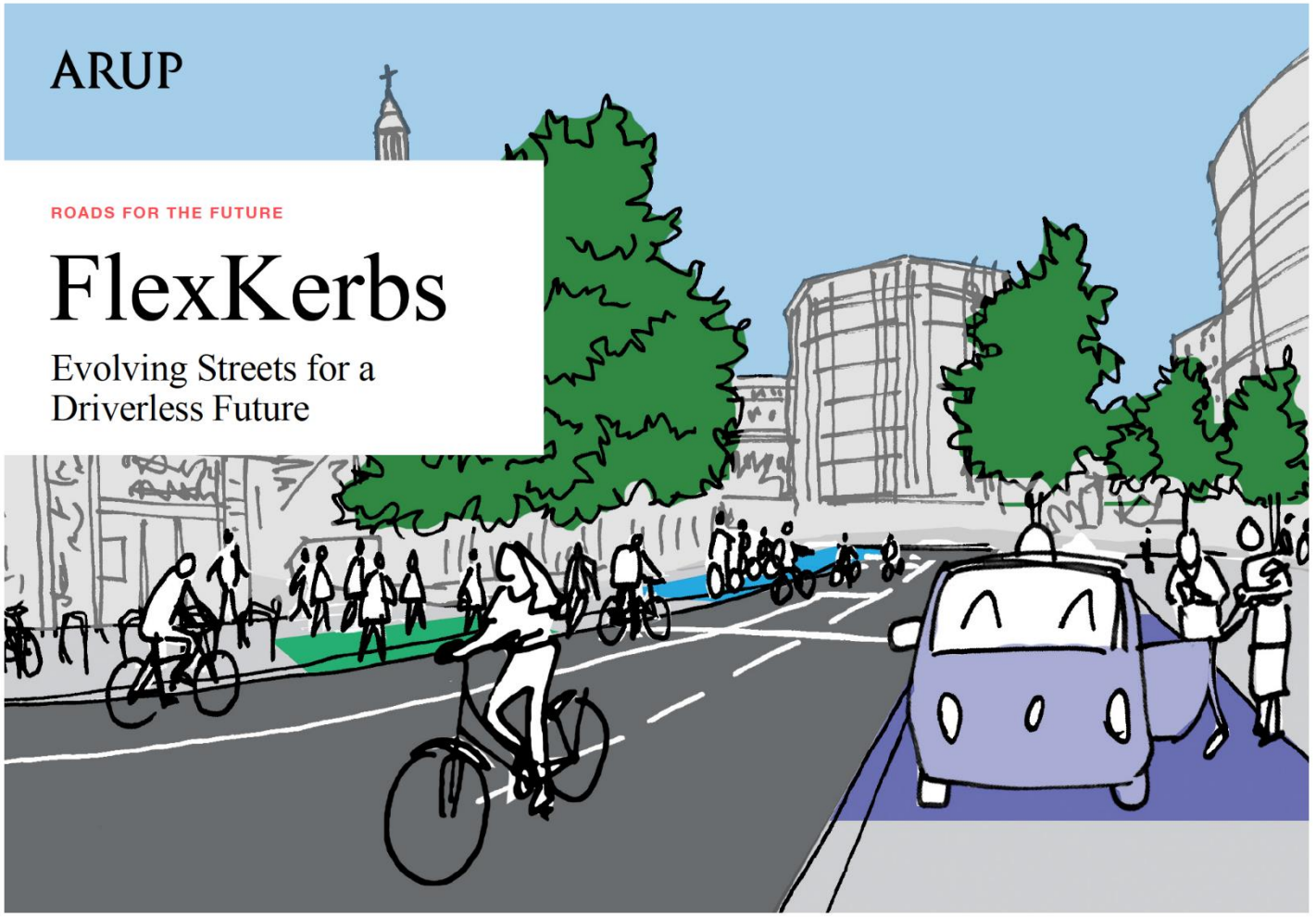
Concept: Alejandro Henao;
Design: Joshua Bauer

RELEVANCE

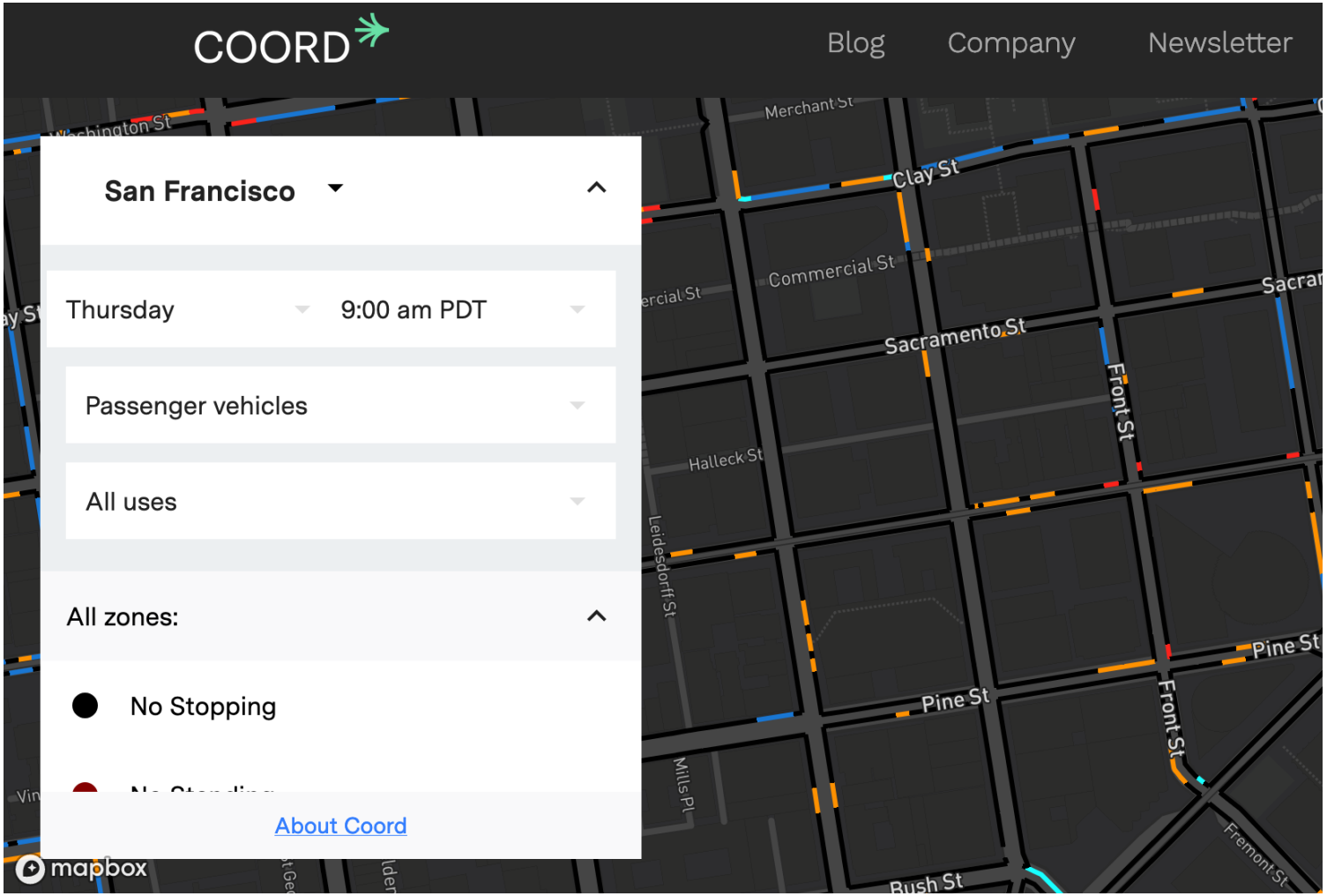
- Municipalities/regions (MPOs) under growing pressure to "tame" increasingly chaotic curbside activity in many cities value of curbspace is basically unknown, so hence highly undervalued…
- …but lack tools to predict impacts (VMT, energy, economic activity, equity, etc.) of policy options or to rationally set prices for occupying the curbside
- Thus Research Need has emerged to allocate space for both traditional (travel lanes, bus stops, on-street parking, commercial loading) and emerging uses (TNC PUDO, more small parcel deliveries, shared-micromobility corrals, etc.), to optimize mobility impacts and energy use

San Francisco Curb Study (Uber and Fehr & Peers, 2018)

EMERGING ECOSYSTEM: ARUP'S "FlexKerbs"



EMERGING ECOSYSTEM: COORD



EMERGING ECOSYSTEM: PRESENTERS AT US DOE BRIEFING EVENT ON 5/23/19

- Fehr and Peers ("Curb Productivity Index"; recently developed Curbspace+ software)
- Costa Samaras (Carnegie Mellon Univ.)
- Miguel Jaller (UC-Davis)
- Wenwen Zhang (Virginia Tech)
- Xiao-Yun Lu (UC-Berkeley)
- David Lipscomb (d.)

- General observation is that policy/research interest has rapidly scaled very recently; faster than the typical 2-3 year research cycle for formal publication, so state-of-practice is outpacing state-of-literature

WHAT'S IN A NAME? (TOPOLOGY):
Focus on the *edges* – the sides of network segments – in addition to the segments/nodes as is more commonly the focus

OVERVIEW OF 'TOPOLOGY' PROJECT

Literature Review

- Review of studies on how practitioners and researchers are attempting to model TNC activity, as well as impacts on land use and urban infrastructure

Practitioner Interviews

- Interview experts (municipal staff, airports, MPO modelers, and TNC operators) with parking, curbside, land use, and "new modes" responsibility. The intent is to understand the state-of-practice and requirements for quantitative methods to be useful.
- STATUS: 11.5 interviews down, 3 to go…

Optimization Framework

Microsimulation Analysis

APPROACH: PRACTITIONER INTERVIEWS

- Interviews to date have been with senior staff at municipal DOTs and 1 US MPO; all central-city municipalities with pop in range ~200K – 1M+; situated in all 4 Census Regions (Midwest, Northeast, South, and West)
- Standardized protocol of questions/topics to be covered and notetaker's report. Audio recorded and machine-transcribed (via www.otter.ai)
- Interviews planned for ~30-45 mins; some have run longer
- We decided to maintain anonymity of interviewees and their employing agencies, to enable free and frank discussion
- Planned submission of a summary research paper later this summer, to next January's TRB conference…whether or not this paper is accepted, we will publish a free-to-download NREL-branded research report

APPROACH: PRACTITIONER INTERVIEWS (MUNICIPAL DOTs)

- Some key themes from practitioner interviews:
  - Fragmented responsibility for managing TNCs (inc. state pre-emption); intra/inter-agency coordination efforts across the board; mixed bag in terms of perceived success
  - Reorganization of "on-street parking" teams into "curbside management" teams
  - Growth in FTEs, new skillsets needed to accommodate new responsibilities
  - Great diversity in both existing and planned parking-management sophistication
  - Approaches for allocating/pricing curbside space mainly ad-hoc (requests, consultations, etc.); "implement-and-revise"; particular focus on special events
  - Some cities proactive (formal pilot projects, etc.), others mainly in responsive mode

APPROACH: PRACTITIONER INTERVIEWS (MUNICIPAL DOTs)

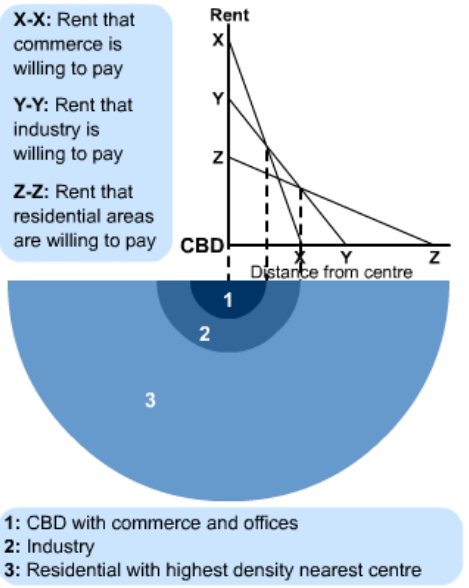
- Some key themes from practitioner interviews:
  - Some cities receiving some data; others report otherwise
  - Most *cities* are experiencing broadly stable parking revenues (but different story at airports, where some are experiencing sustained declines)
  - "Failure" of curbside is not contained at curbside – safety of riders waiting in carriageway, emergency vehicle mobility, throughput of main travel lanes, etc.
  - Both longstanding and new issues enforcing regulation at the curbside
  - Consistent desire for richer, more real-time data streams – and capability to make use of them intelligently for management/operations

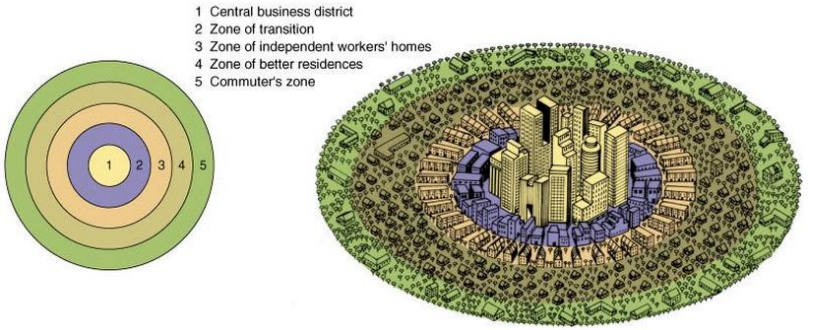
APPROACH: QUANTITATIVE MODELING

- Overarching objective is to simulate the 'market' for curbside space, inspired by earlier models (Bid-Rent theory, described on next slide) that simulate the urban real estate market
- Once the 'market' of interacting supply (curbside space) and demand (for various curbside activities) can be simulated, there is a decision-support tool to:
  - Test alternative geometry configurations (PUDO zones, curbside space for through traffic at intersections, bus lanes, etc.)
  - Test policy options, including pricing strategies
- Aim is to develop generic model forms, that can be implemented by practitioners, at micro or macro (regional=MPO) scales, customized to suit local context

Similarities to Bid-Rent Model of urban land use

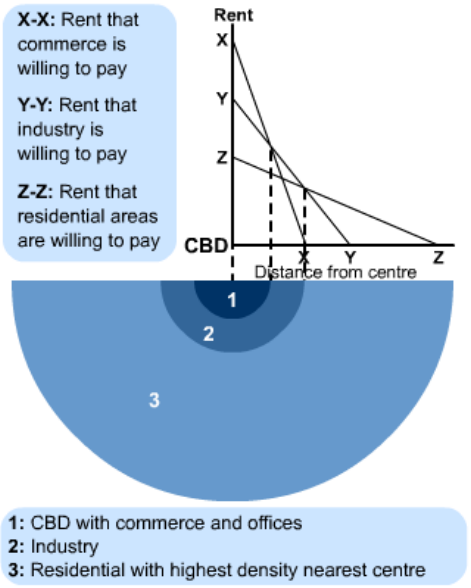
- Bid-Rent theory posits that urban land is used by the type of use that values it the most (i.e. highest Willingness-to-Pay)
- 'Valuation' by each type of land use is represented by its B-R function (i.e. an equation; see top-left diagram)
- Therefore, high-value activities that demand greatest accessibility occupy the CBD, and successively lower-value and less-accessibility-sensitive uses occupy real estate moving outwards towards urban-rural fringe

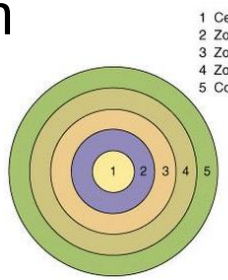


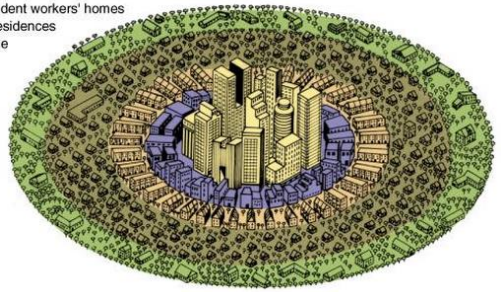


Similarities to Bid-Rent Model of urban land use

- Key ways in which the proposed model extends from classical Bid-Rent Theory:
  - Different types of uses (PUDO, traffic lane, bus stop, etc…..rather than Commerce, Industry, Residential)
  - Rather than all land uses desiring proximity to a single central point, curbside demand is generated by many, many individual buildings in different locations
  - Competition is for linear space along edges of the road network, rather than for urban real estate in a flat (2D) plane







APPROACH: Initial Conceptual Model (Micro-scale)

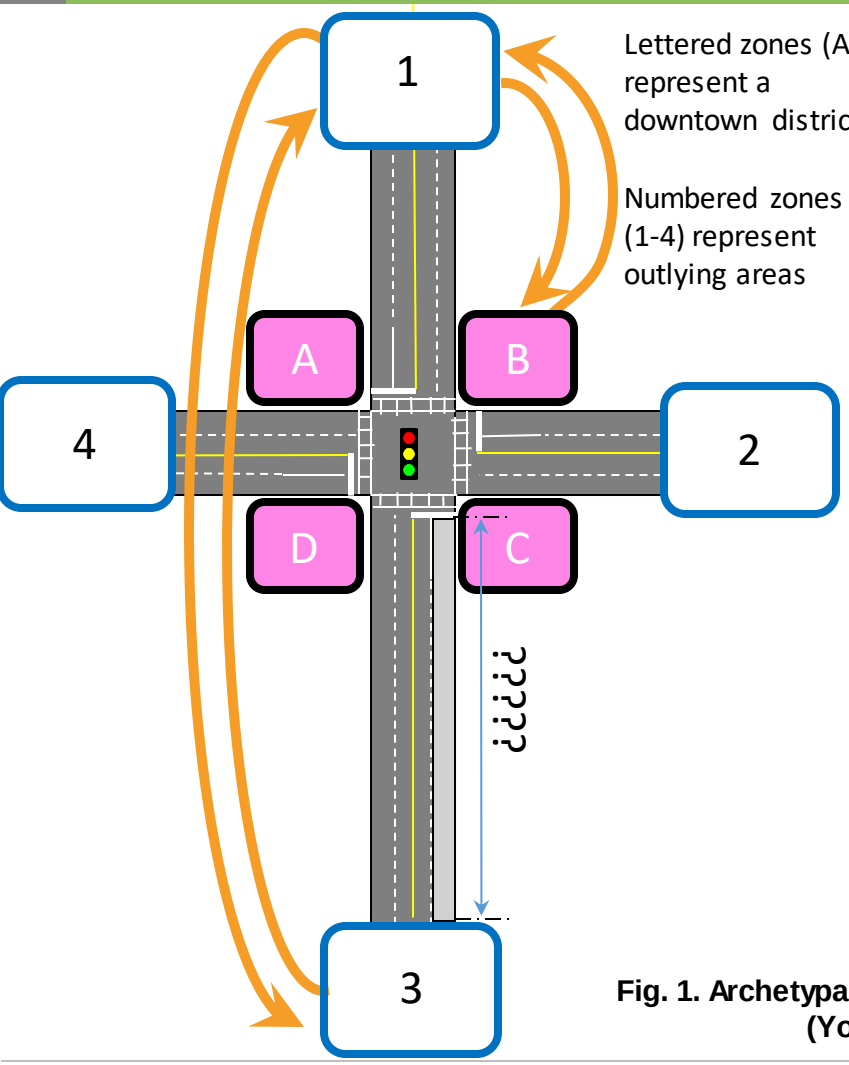


Fig. 1. Archetypal system (You Kong)

- Various modes of transport seek *Mobility* ('through' movements) and/or *Accessibility* (to local land uses), competing for scarce space within the public right-of-way
- This basic system has both outlying and "downtown" zones with an O-D travel demand matrix. Some trips (e.g. from zone 3 to 1) are 'through' and others start or end in zones in the downtown district (e.g. zone 3 to zone C). In this simple-geometry example, a major signalized intersection is at core of the downtown district.
- Curbspace is to be allocated to some combination of: A travel lane, On-street parking, A bus lane, A TNC PUDO zone, A commercial loading zone, or others (sidewalks, scooter/bikeshare), etc.

APPROACH: Initial Conceptual Model (Micro-scale)

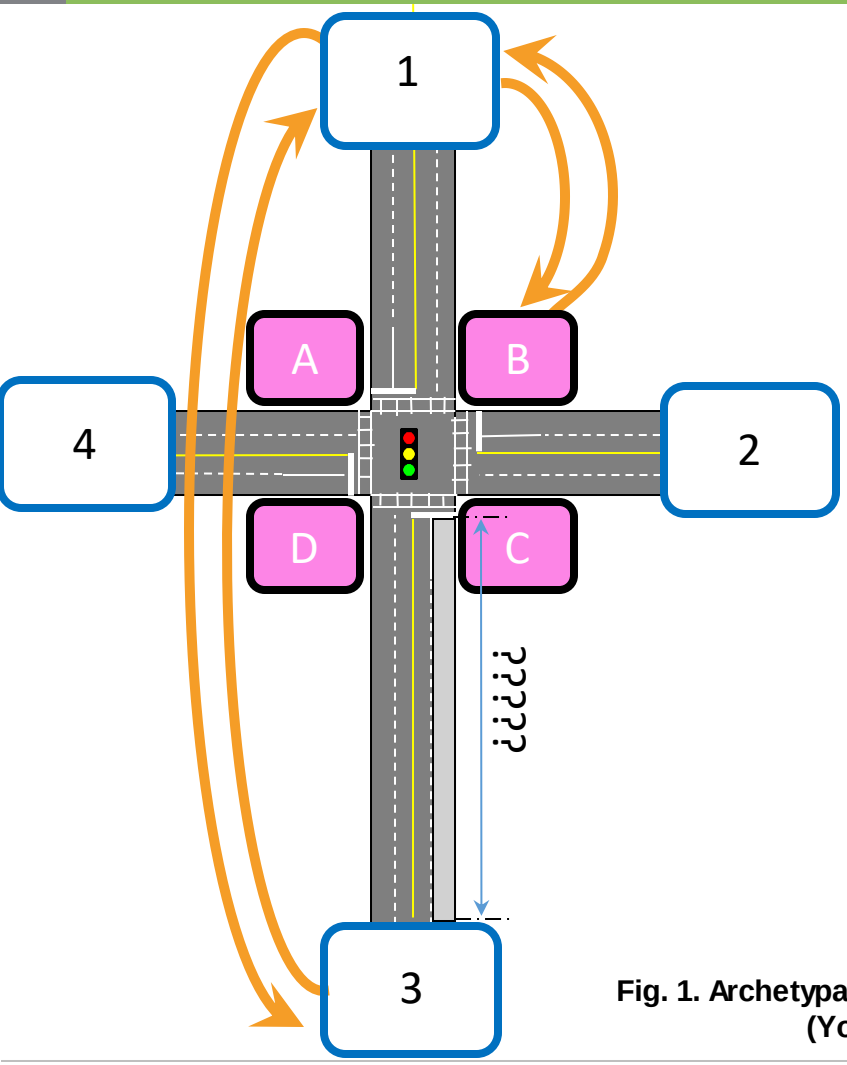


Fig. 1. Archetypal system (You Kong)

- Each linear foot of curbside will provide value to some or all groups of travelers. For example, a curbside TNC PUDO zone immediately adjacent to the intersection provides great value to TNC users accessing Zone C, however at the expense of potentially delays to travelers traveling from Zone 3 to 1.
- Alternatively, allocating **X** linear feet of this curbside (starting at the intersection) to a through lane would reduce delays (and hence costs, via Value of Time) to "through" traffic.
- But this would increase costs for travelers destined to Zone C, whether they are traveling by private car, TNC, or bus – because loading/unloading for all of these competing uses would be displaced away from the Downtown by **X** linear feet

APPROACH: Initial Conceptual Model (Micro-scale)

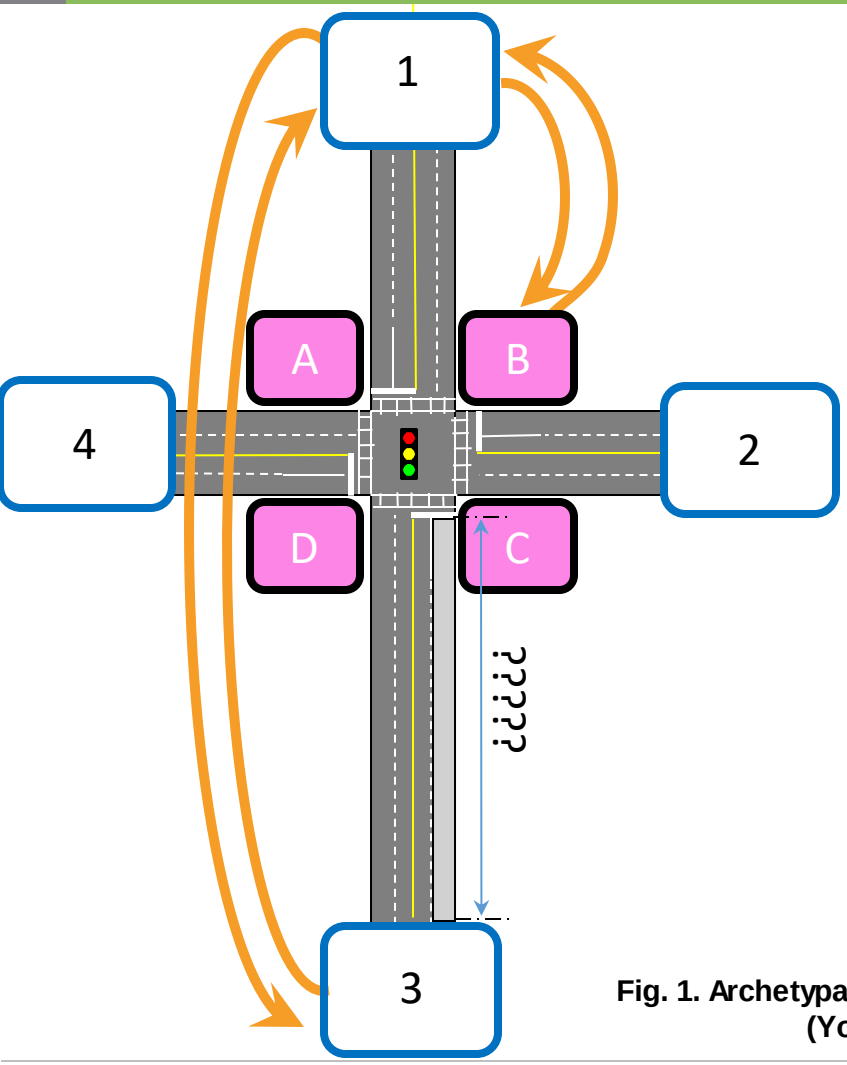


Fig. 1. Archetypal system (You Kong)

- Our current strategy is to get the simplest possible version of this model operational, as proof of concept
- Then, possible directions for refinement/extension:
  - Allow mode choices to be influenced by curbside-allocation policies (by fusing w/a mode choice model)
  - Incorporate larger, more realistic set of competing curbside uses – including urban freight (Amazon…)
  - More complex corridor/grid geometry, including major/minor roads
  - Scale up to macro scale
  - Explicitly model sensitivity to policies for off-street parking/loading
  - Test strategies for pricing the curbside
  - Make curbside dynamic
  - Priority access for the mobility disadvantaged

Example equations used in this “simplest operational version"

- ***Objective Function (to be minimized):*** $C_{delay\_PUDO} + C_{walk\_PUDO} + C_{walk\_Parking} + C_{delay\_through}$

- **Volume-delay function of PUDO zone,** $d_{PUDO} = 200 \cdot (r_{PUDO})^4 \cdot D_{PUDO}$

  - d_{PUDO}: Aggregate delay for PUDO
  - r_{PUDO}: Volume/capacity ratio for PUDO
  - D_{PUDO}: PUDO demand

- **VDF for curbside lane used for “through" travel:** $d_t = 200 \cdot (r_t)^3 \cdot D_t$

  - d_t: Aggregate delay for travel through
  - r_t: Volume/capacity ratio for travel through in lane 1
  - D_t: Travel through demand in lane 1

Example sensitivity tests

TNC PUDO demand (veh/hr)	PUDO service rate (veh/hr)	VOT ($/hr)	Parking demand (veh)	Travel through demand (veh/hr)	Percent of green time in signal cycle	Walking speed (mph)	Optimal number of slots allocated to THROUGH TRAVEL curbside lane	Optimal number of slots allocated to PUDO ZONE
200	30	20	10	1000	40%	2.5	**12**	**14**
400	30	20	10	1000	40%	2.5	**8**	**16**
200	**60**	20	10	1000	40%	2.5	**18**	**11**

SUMMARY

- Prevailing curbside management practices becoming increasingly untenable; need exists to facilitate rational allocation of curbside space for mobility and energy optimization, suitable for testing alternatives

- But -- curbside activity has not traditionally been represented in transportation network modeling in high fidelity…its growing importance leads to our objective to develop capability to incorporate it into transportation modeling practice…

- …because if we cannot model it, we cannot optimize it (for mobility and energy optimization, for economic development impacts, etc.)

Q/A, Feedback, Discussion