Estimating dynamic workplace capacities using public transport smart card data and a household travel Survey

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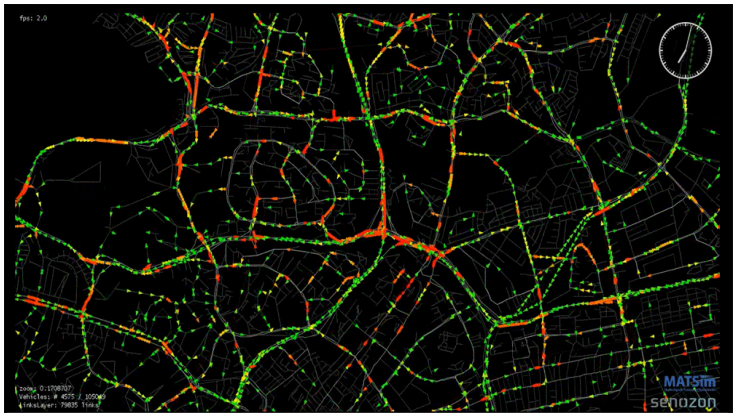
Motivation and requirements

Problem

- Activity based transport simulation requires detailed data on activity locations
- Detailed data on e.g. work locations is often not available and hard to obtain
- Traditional surveys are expensive and tedious



MATSim – Agent-based Transport Simulation

Solution

Modeling of work location based on merge of number of data sources:

- Record of public transport journeys
- Travel diary
- Land-use information

Challenges

- **How to identify working activities between public transport journeys?**
- **How to assign number of work places to each building?**

HITS Singapore

One day travel diary for ~ 1% of Singapore's population

~10'500 Households (~ 38'000 people)
~ 40'000 activities (incl. home)
~15'500 PT consistent activities
- ~ 7600 home
- ~ 6100 work
- ~ 1800 other

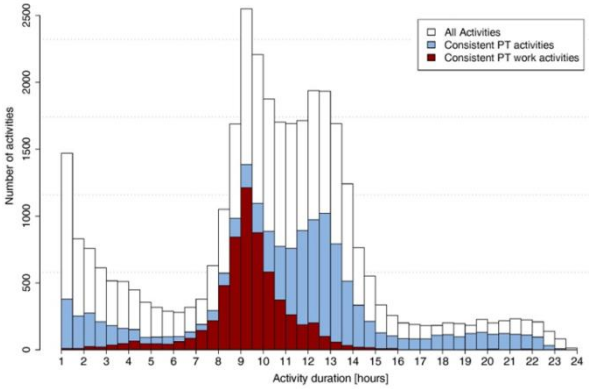
CEPAS smart card in Singapore

JOURNEY_ID	10334624565	10346524565	10346524568	10346524576
CARD_ID	2000232379890	9002933471010	1000700195900	7703533270890
Passenger_Type	Senior Citizen	Adult	Adult	Child/Student
Mode	RTS	Bus	RTS	Bus
Srvc_Num		184		147
Direction		1		0
Bus_Reg_Num		855		156
Origin	STN Bugis	12089	STN City Hall	1211
Destination	STN Bedok	17179	STN Yishun	71109
Date	2011-04-13	2011-04-13	2011-04-13	2011-04-13
Start_Time	12:20:25	12:53:06	18:08:50	22:24:50
Distance	9	2.53	18.8	7.6
Ride_Time	16.4	18.983	32.89	25.733
Fare_Paid	0.86	0.71	1.61	0
Transfer_Num	0	0	0	1

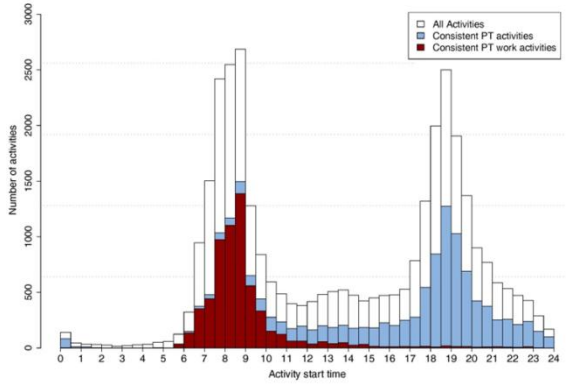
Work trips detection (previous work)

	Model	Parameters	Choices
1.	Rule based model (work, non-work)	• Activity duration	• Work • Other
2.	**Discrete choice MNL model (home, work, other)**	• **Activity duration** • **Activity start time** • **Land-use information**	• **Work** • **Home** • **Other**

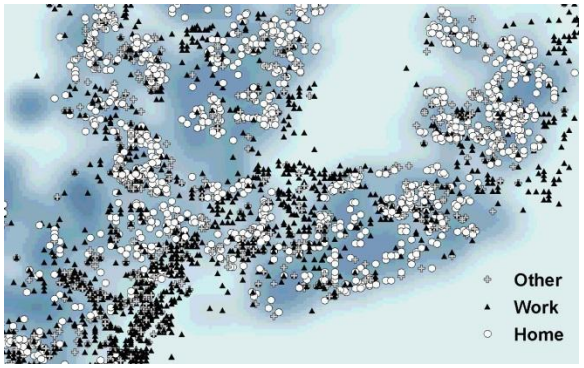
Activity duration



Activity start time



Land-use



Results

Probability for correct choice	Rule-based model	Model with land-use
Mean	0.867*	0.893
Test sample	100%	20%

Chakirov, A. and A. Erath (2012) Activity identification and primary location modelling based on smart card payment data for public transport, paper presented at the 13th International Conference on Travel Behaviour Research (IATBR), Toronto, July 2012.

Distribution problem

Number of **detected work trips** that finish at each stop of Singapore

Distribution problem

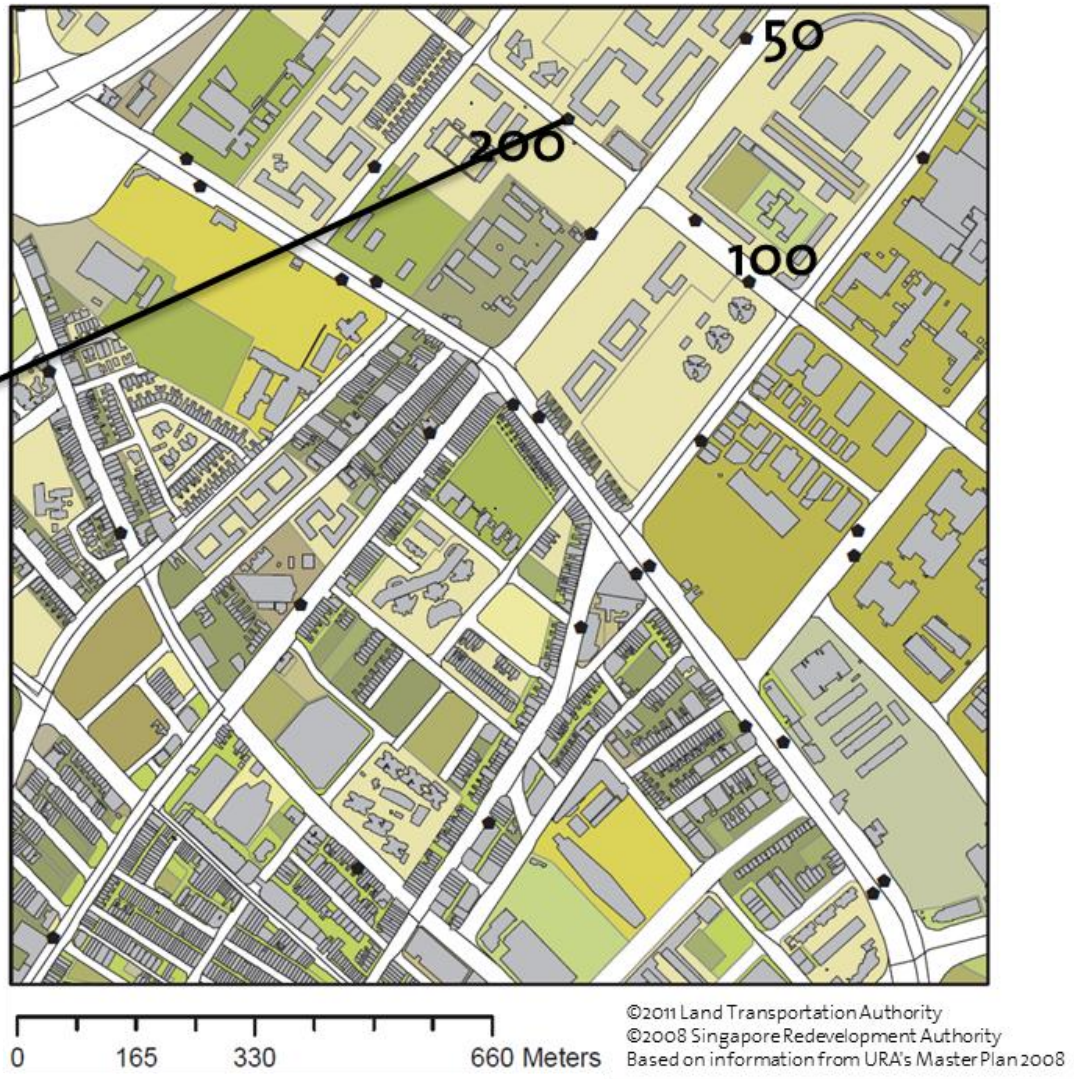
The time when the work activity starts and the duration

- 8:01-17:32
- 9:44-18:15
- 7:54-16:03
...

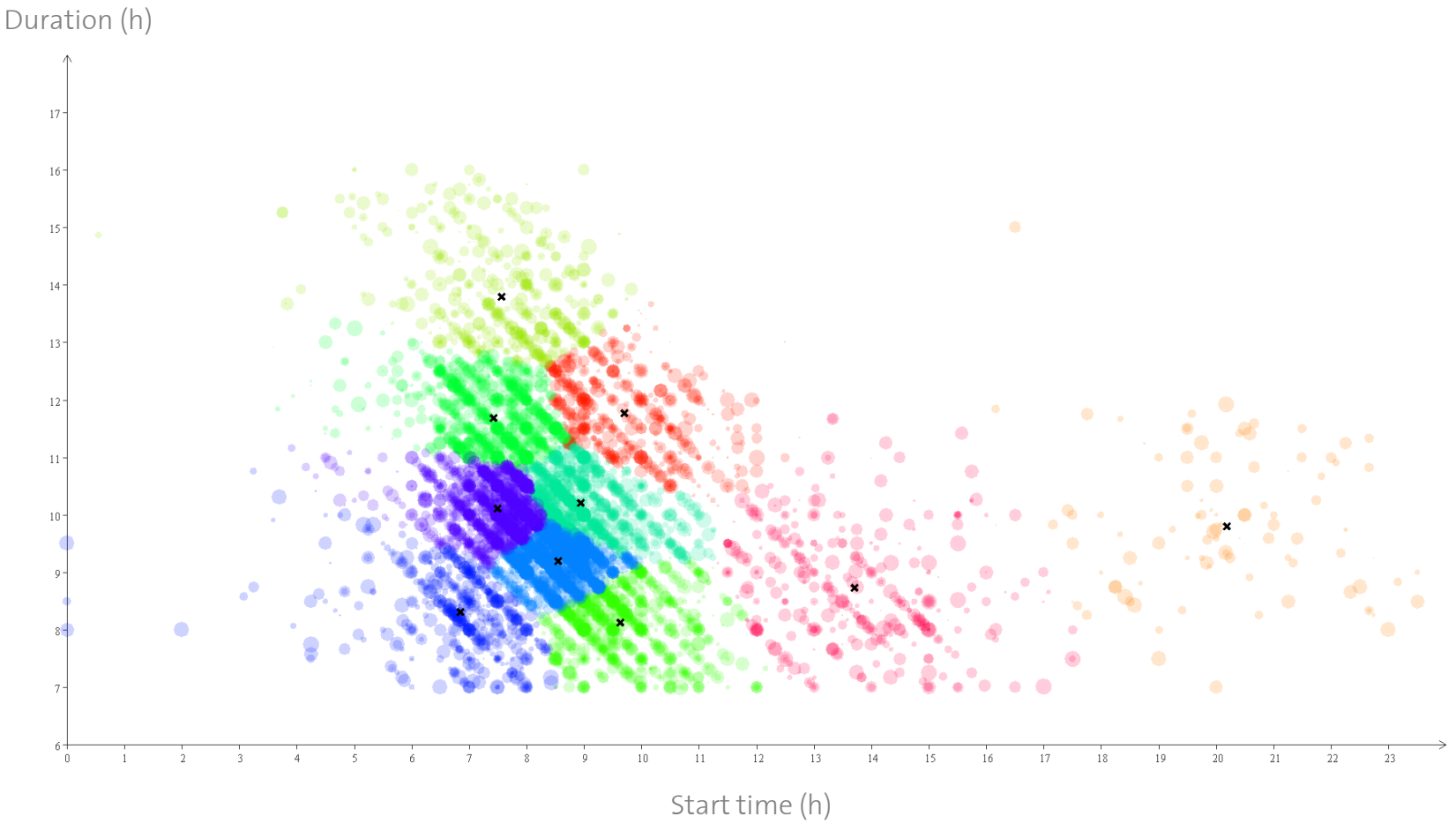
Many work schedules!

Idea:

Define categories



Work schedule information



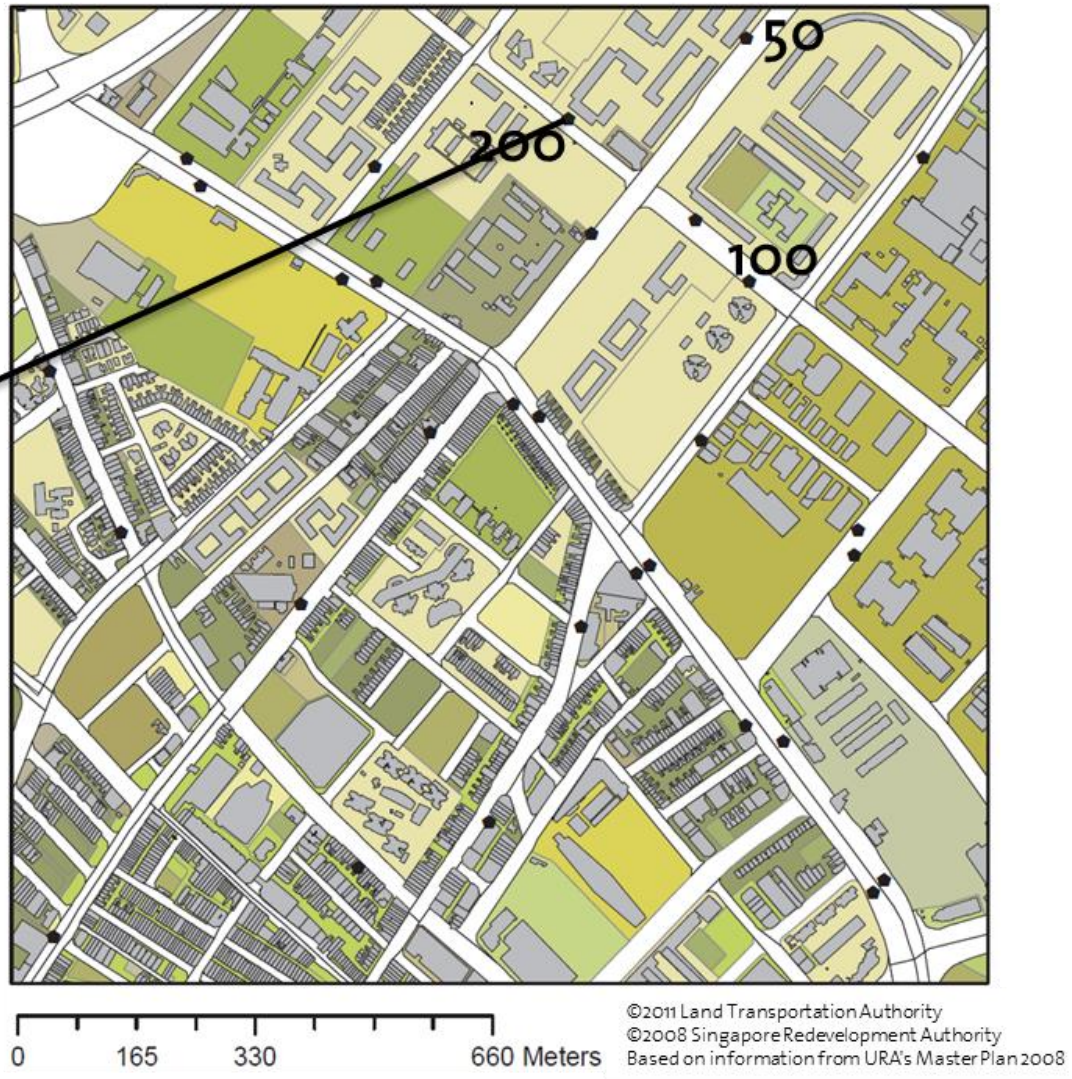
Distribution problem

Count how many people at each category

- 8:00-17:30: **50**
- 9:00-18:00: **75**
- 18:00-03:00: **2**

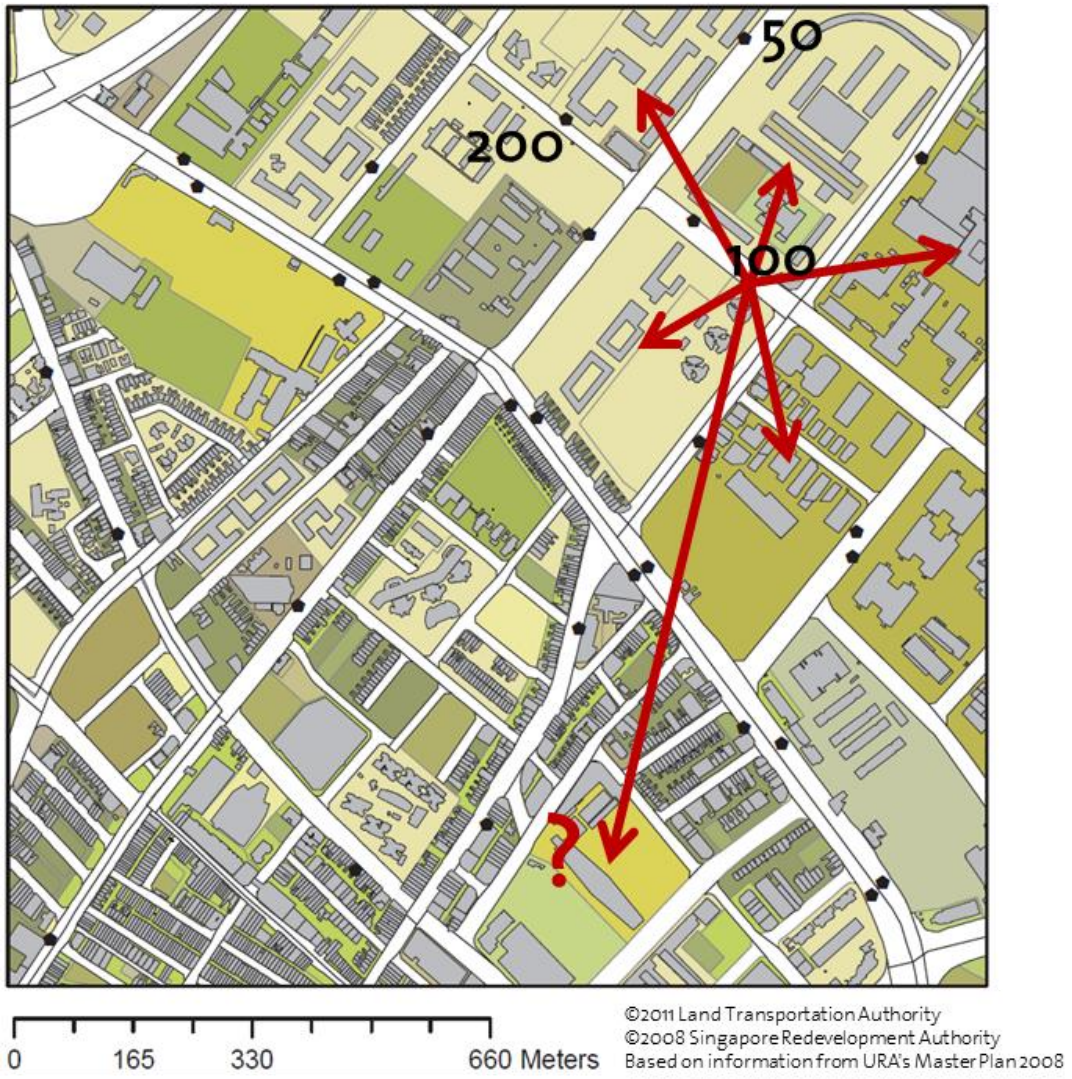
...

Just a few number of work schedules

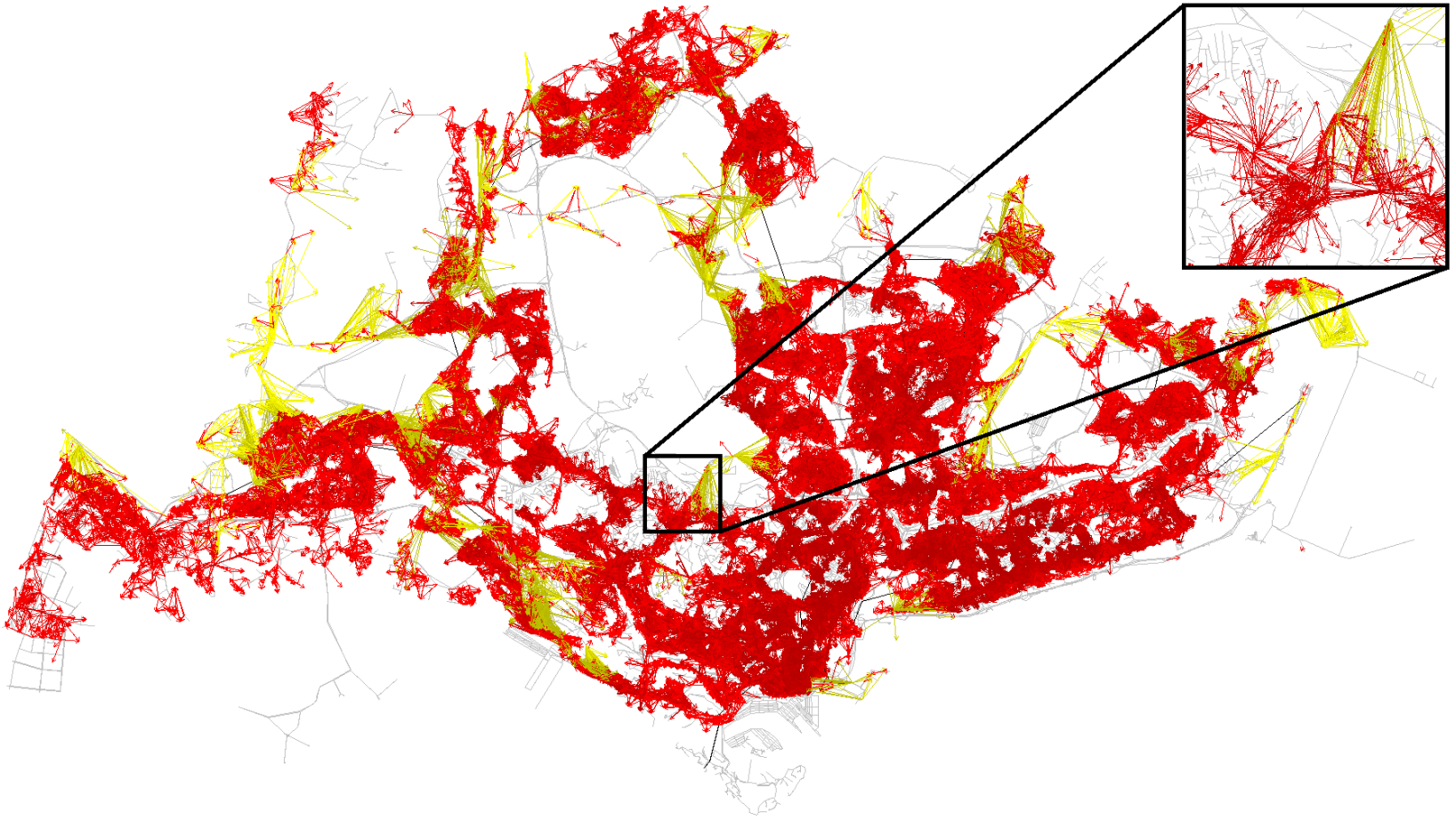


Distribution problem

Which buildings or parcels do the people who alight at a certain stop go to?



Last mile travel times

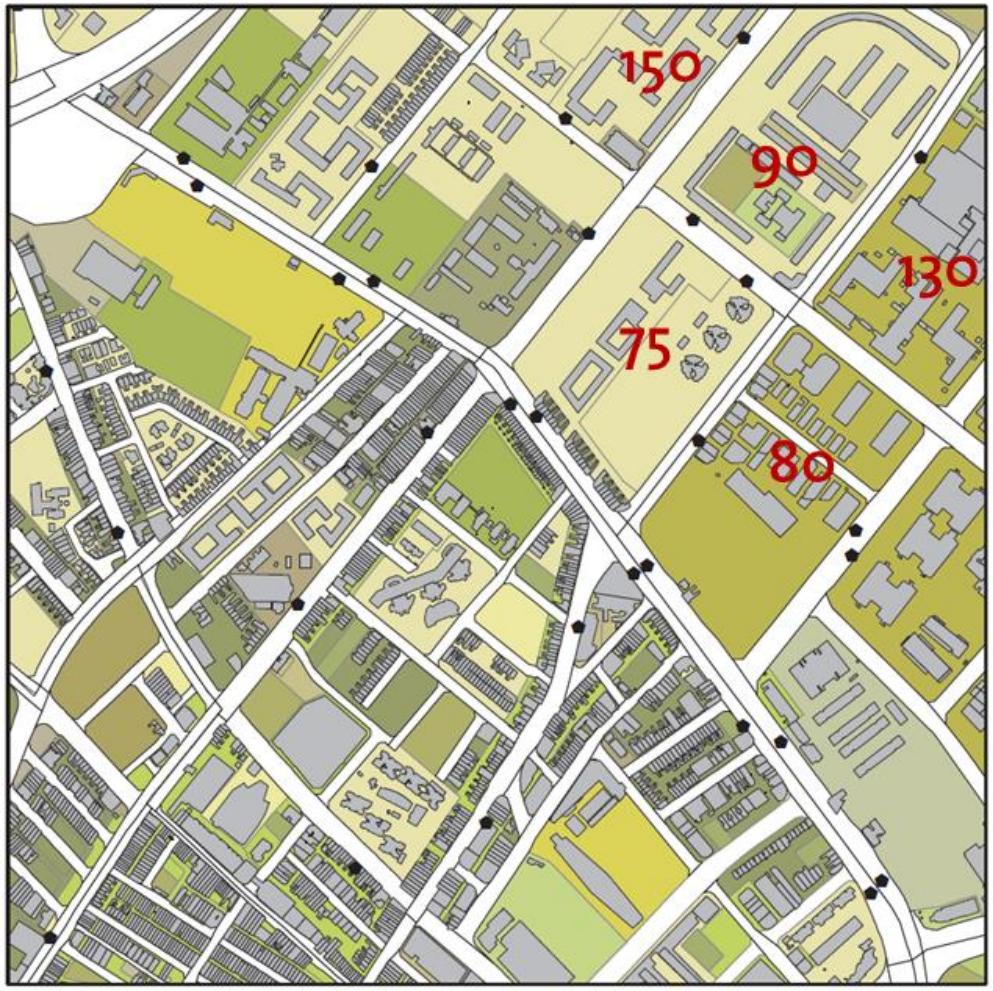


Maximum capacities

Each building has a size. Then there is a **maximum number of workers** that fit in the building

Type	Work space(m^2)
Residential	1.00E+05
Commer. & resident.	250
Commercial	18
Hotel	500
Utility	60
Business Park	10
Bussiness 1	12

-
-
-



Distribution problem

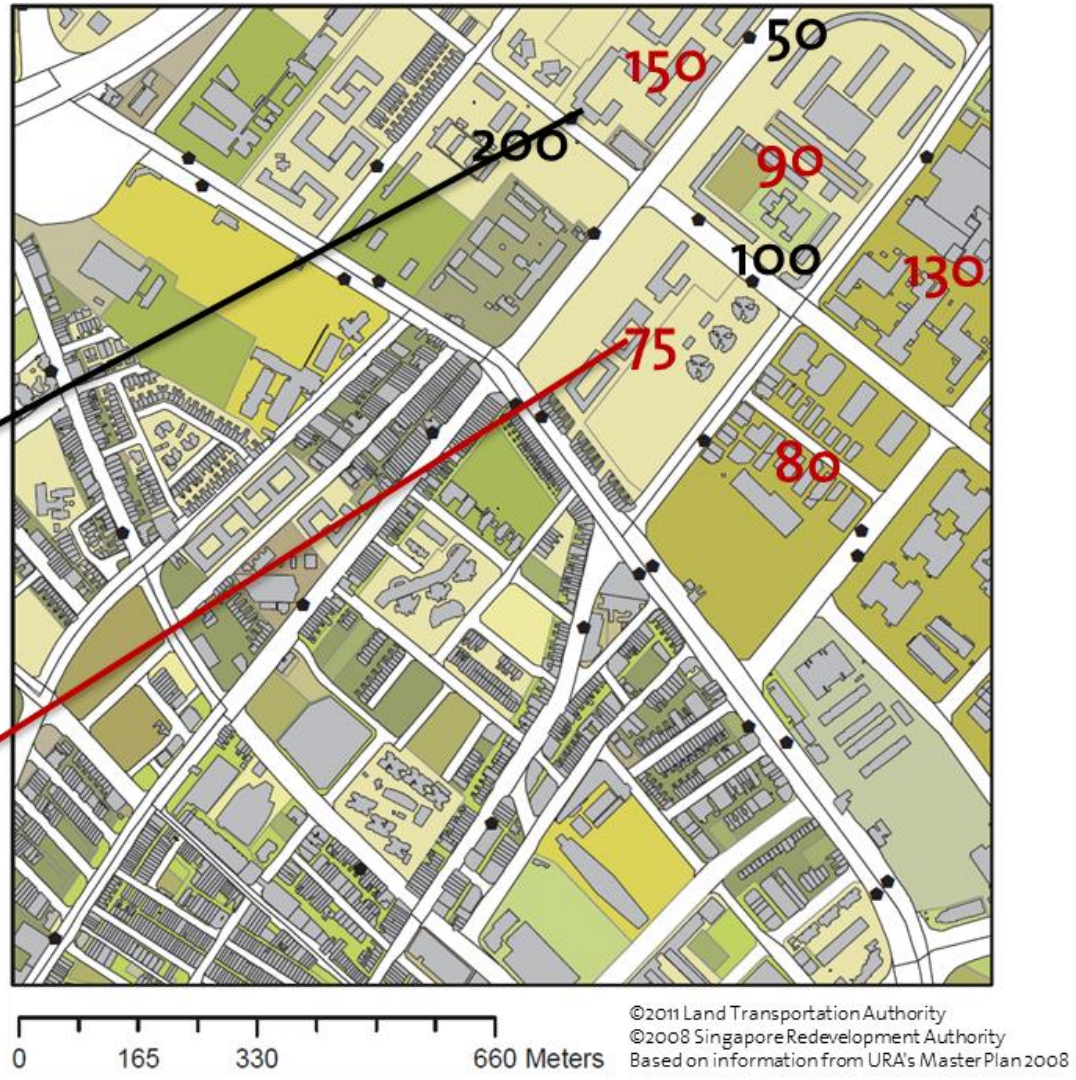
How many people go to each building at each work schedule?

8:00-17:30	9:00-18:00	18:00-03:00			
50	**75**	**2**	…	…	…

Stop $\sum q = \mathbf{200}$

?	?	?	…	…	…

Parcel $\sum x \leq \mathbf{75}$



Distribution to land use parcels.

Minimize last-mile travel time

$$min \sum_{s \in S} \sum_{p \in P} \sum_{w \in W} x_{spw} tt_{sp} \qquad 0 \leq x_{spw}$$

People at each bus stops and at each work schedule can not disappear

$$\sum_{p \in P} x_{spw} = q_{sw} \qquad s \in S, \quad w \in W$$

People in a parcel can't exceed the maximum

$$\sum_{s \in S} \sum_{w \in W} x_{spw} \leq m_p \qquad p \in P$$

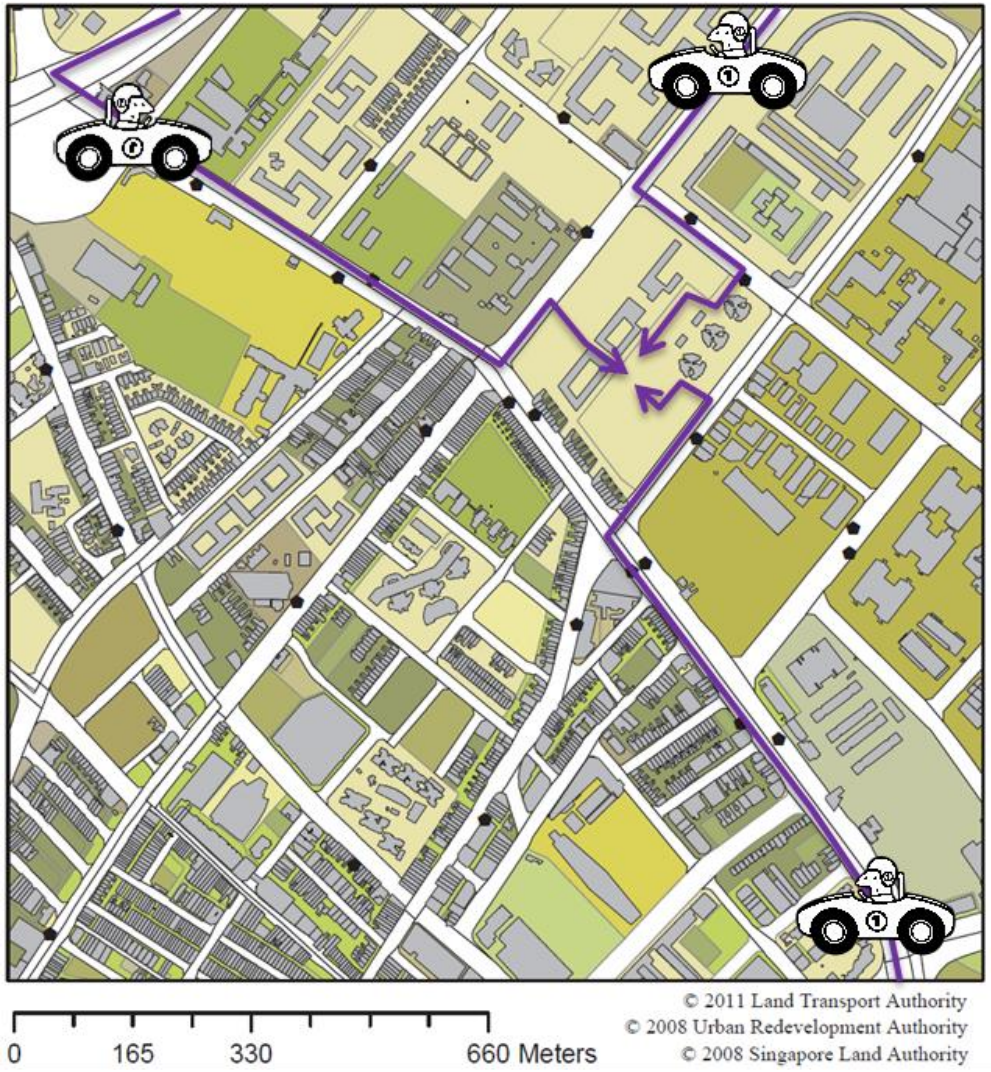
What about car commuters?

Two necessary procedures

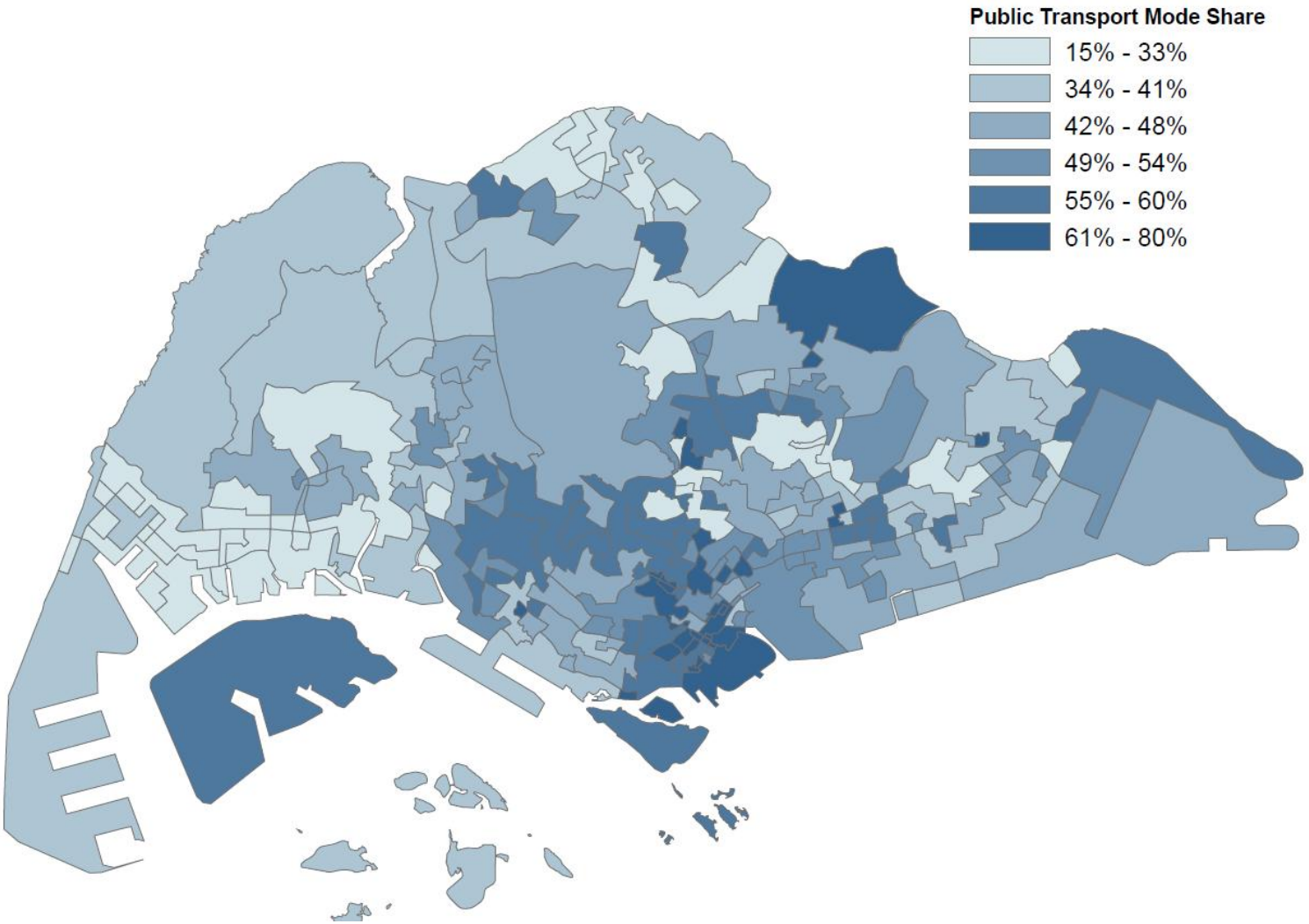
- Deflation of the maximum number of workers
- Inflation of the resulting quantities

Idea:

Use travel diary survey (HITS) for observed mode shares for work trips



Mode share zones (162 zones)



Mode share inflation (proportional)

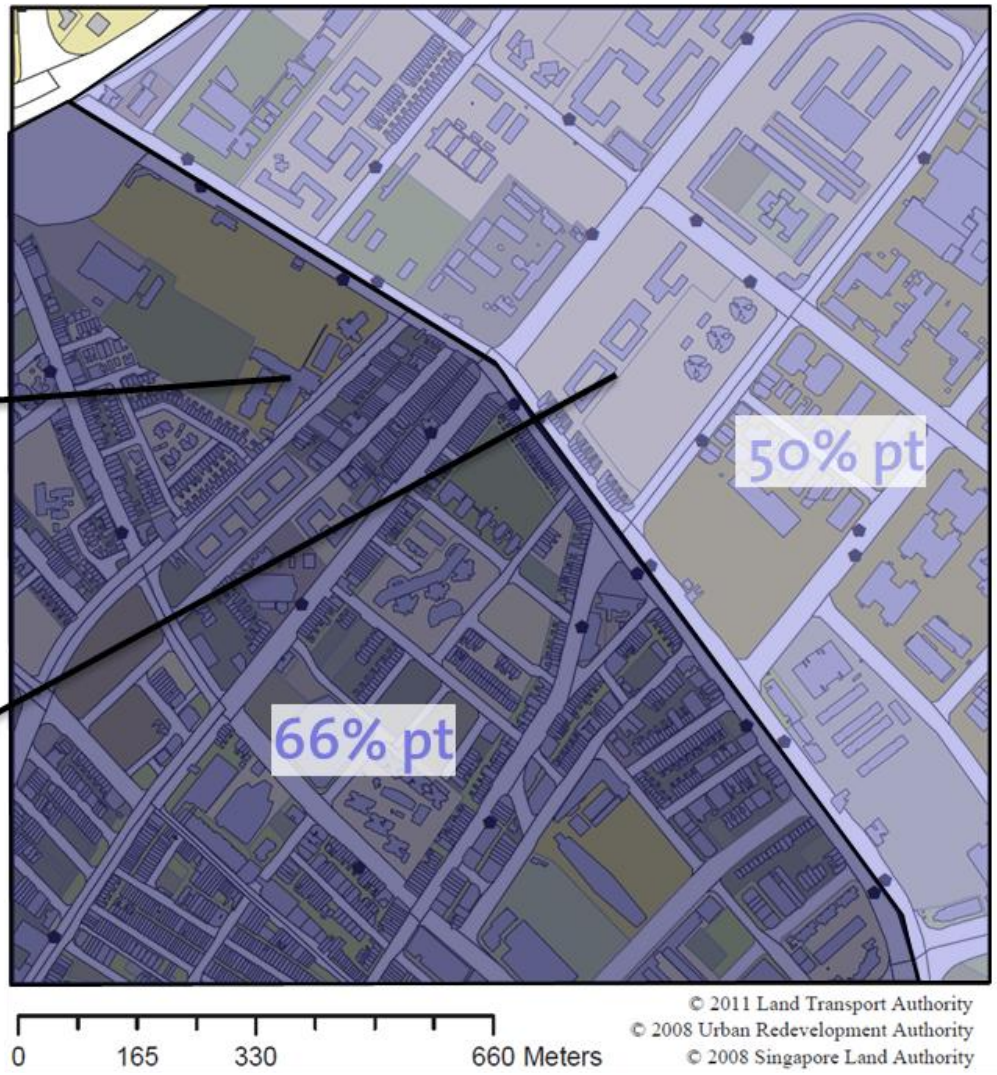
Quantities of different zones must be inflated with different proportions.

20	60	30	…	…	…
30	90	45	…	…	…

66%

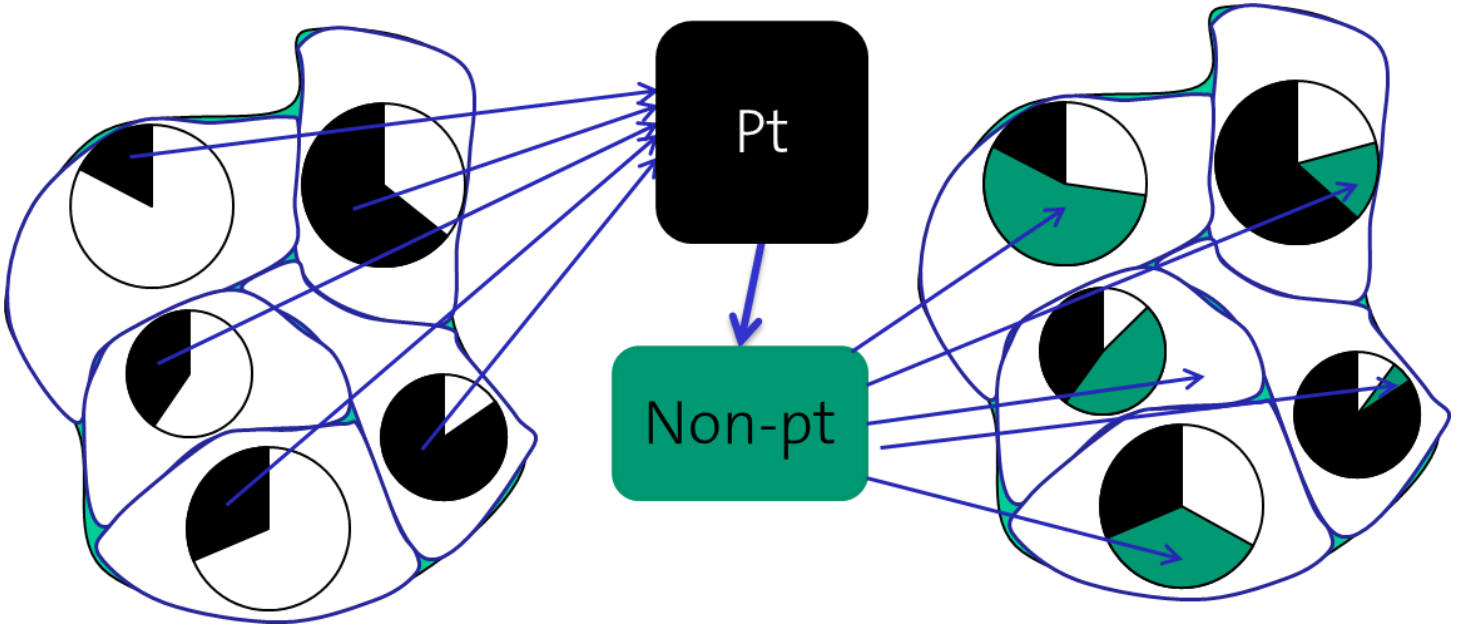
44	12	15	…	…	…
88	24	30	…	…	…

50%

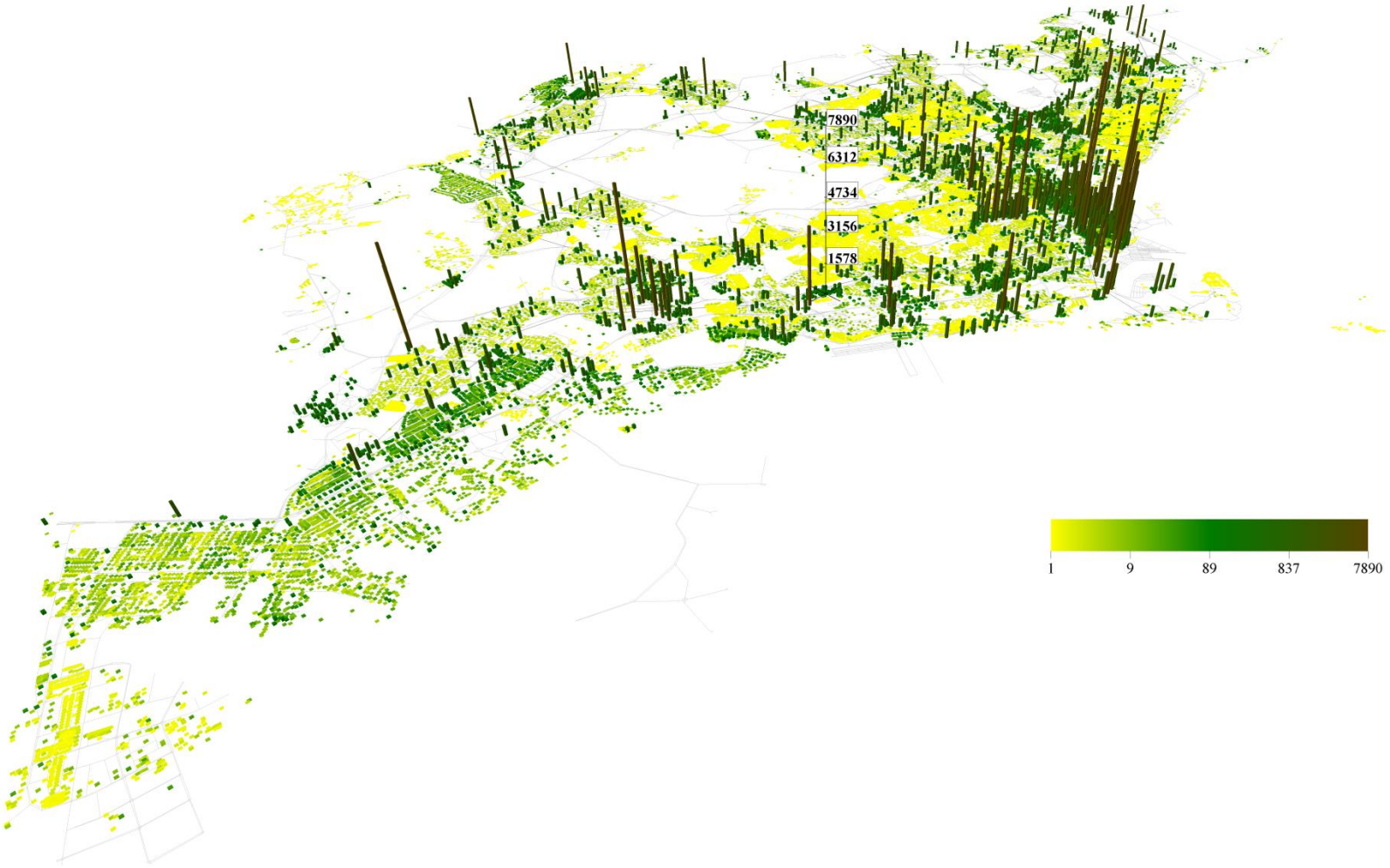


Mode share inflation (pt accessibility-based)

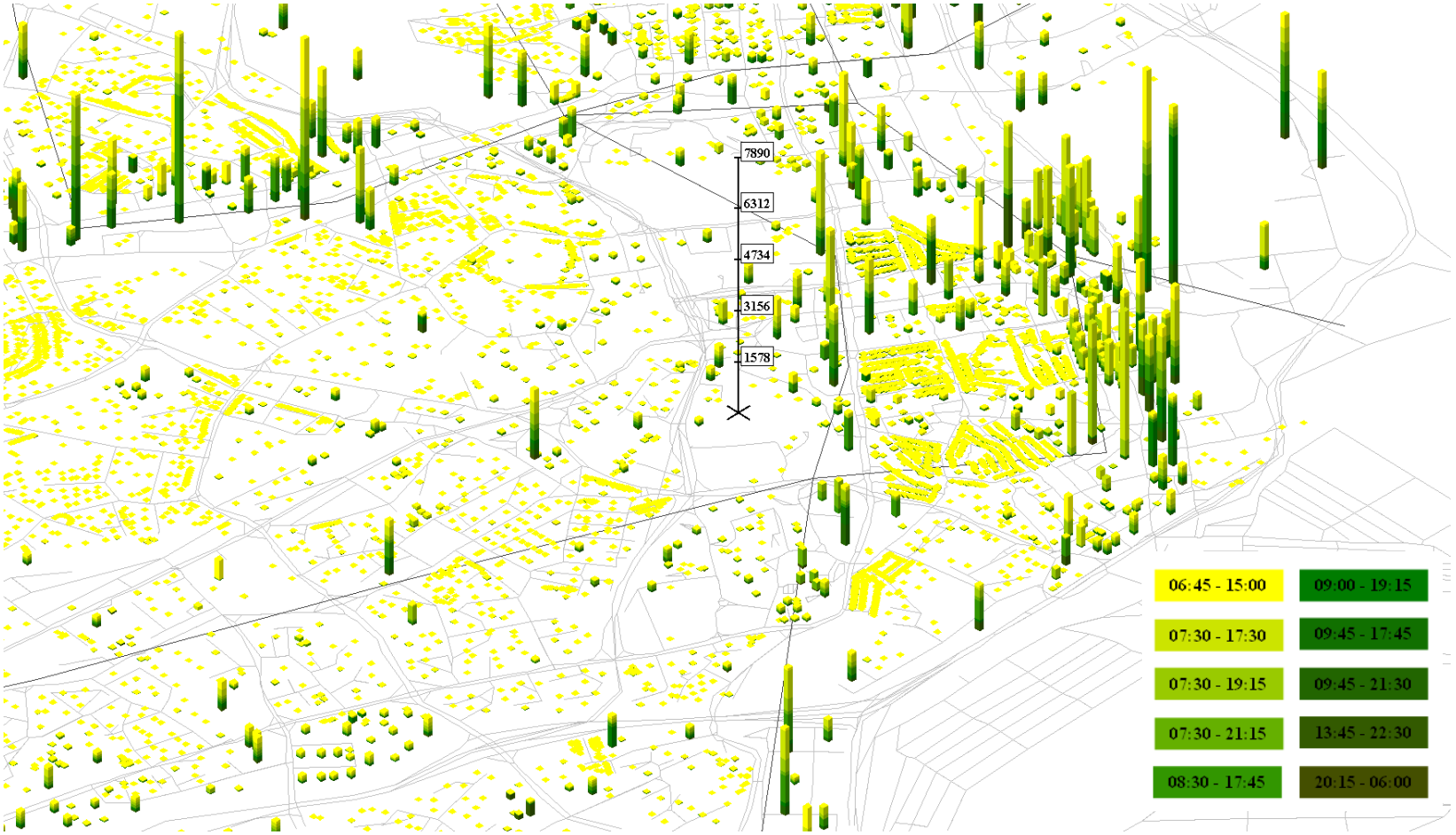
1. The number of public transport (pt) users workers is aggregated for each mode share zone.
2. The number of non-pt commuters of the zone is estimated.
3. The number of non-pt commuters is distributed to the master plan area



Distribution to single buildings



Work schedules and individual buildings



Limitations and Outlook

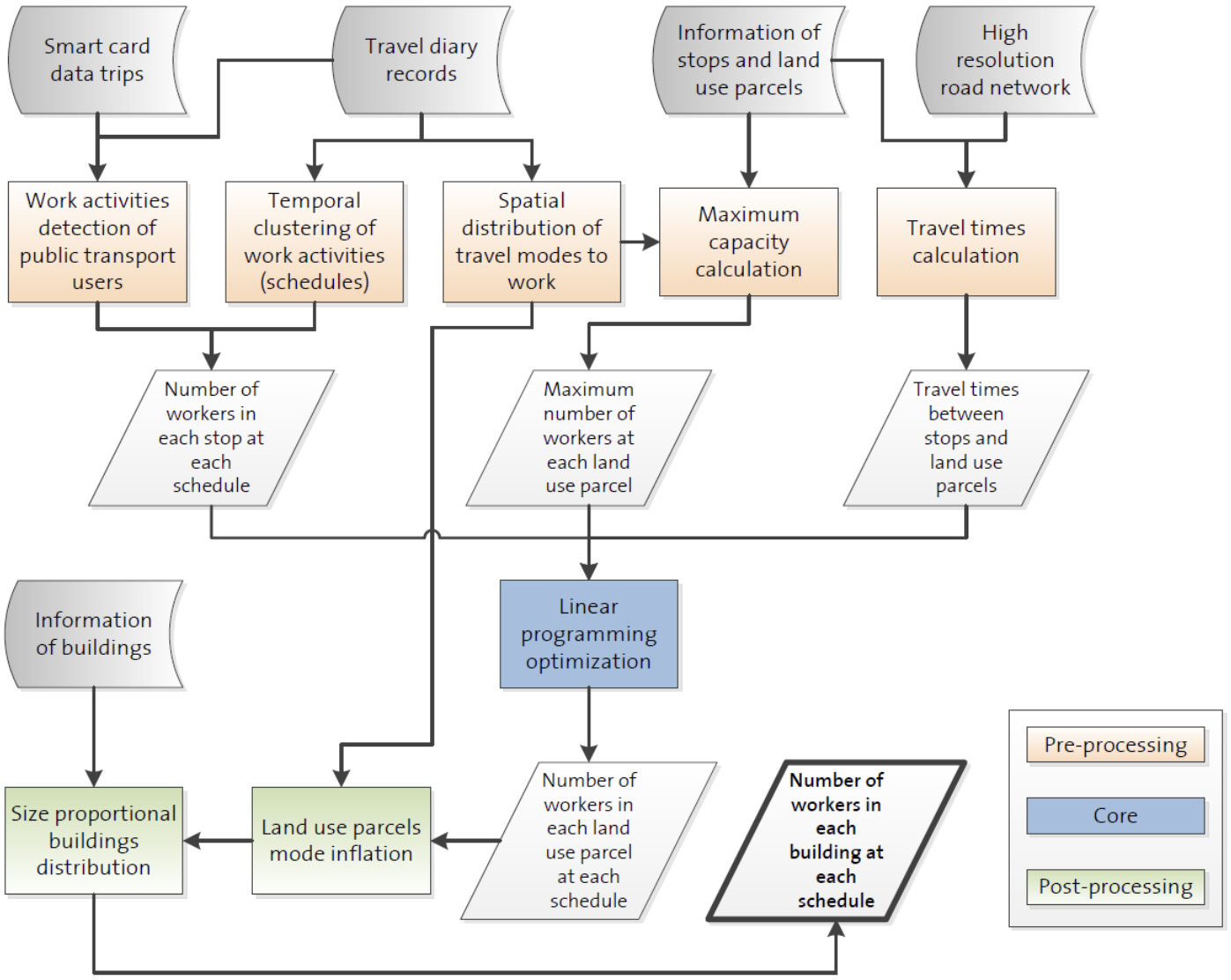
Assumptions

- Constant mode share over different work schedules
- No spatial variation of work space requirements
- Minimization of last-mile travel time only

Outlook – potential projects

- Calculation of walking times with pedestrian network
- Sensitivity analysis
- Application with newer CEPAS dataset

Summary


Smart card data trips
Travel diary records
Information of stops and land use parcels
High resolution road network
Work activities detection of public transport users
Temporal clustering of work activities (schedules)
Spatial distribution of travel modes to work
Maximum capacity calculation
Travel times calculation
Number of workers in each stop at each schedule
Maximum number of workers at each land use parcel
Travel times between stops and land use parcels
Information of buildings
Linear programming optimization
Size proportional buildings distribution
Land use parcels mode inflation
Number of workers in each land use parcel at each schedule
Number of workers in each building at each schedule
Pre-processing
Core
Post-processing