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UrbComp 2012

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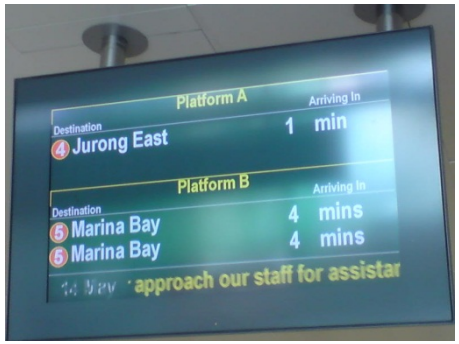
USING SMART CARD DATA TO EXTRACT PASSENGER'S SPATIO-TEMPORAL DENSITY AND TRAIN'S TRAJECTORY OF MRT SYSTEM

Reliability of MRT (Mass Rapid Transit / Subway) System

- Reliability for MRT System
  - Time table
  - Passenger load

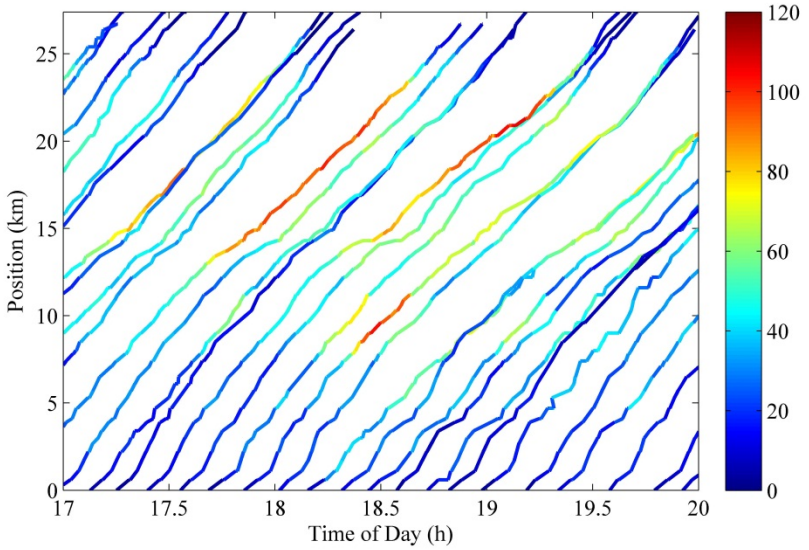


- Disruption Response
  - Where is the demand?
  - How much is the demand?

Reliability from smart card data

- MRT
  - Where is the train?
  - How many passengers are there on the train?

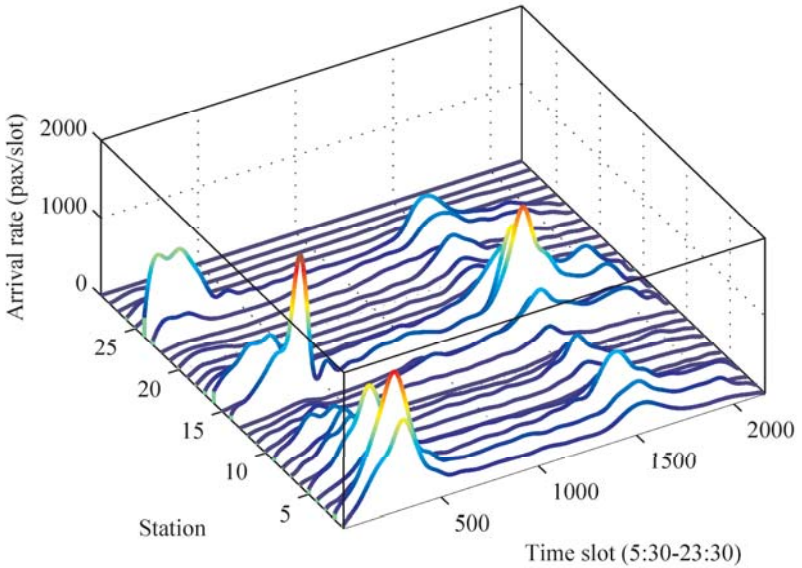
- Different with bus system, the time-location-occupancy (spatio-temporal occupancy) information cannot be extracted directly from smart card data.

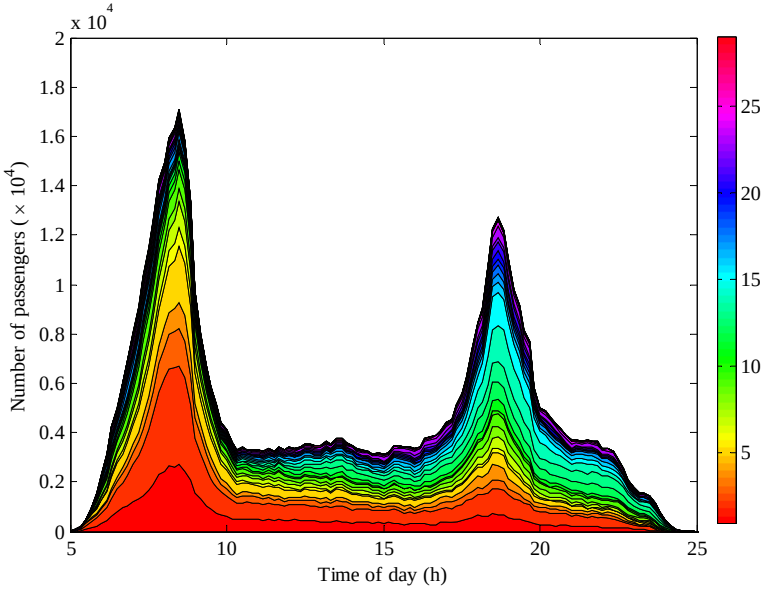


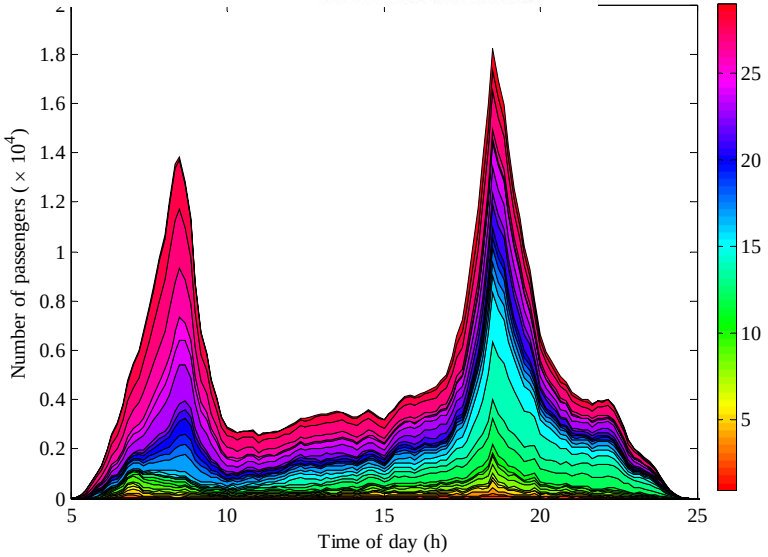
Trajectories of buses extracted from smart card data (one case service)

Demand of MRT system

- Demand Pattern
- Grouped by boarding station







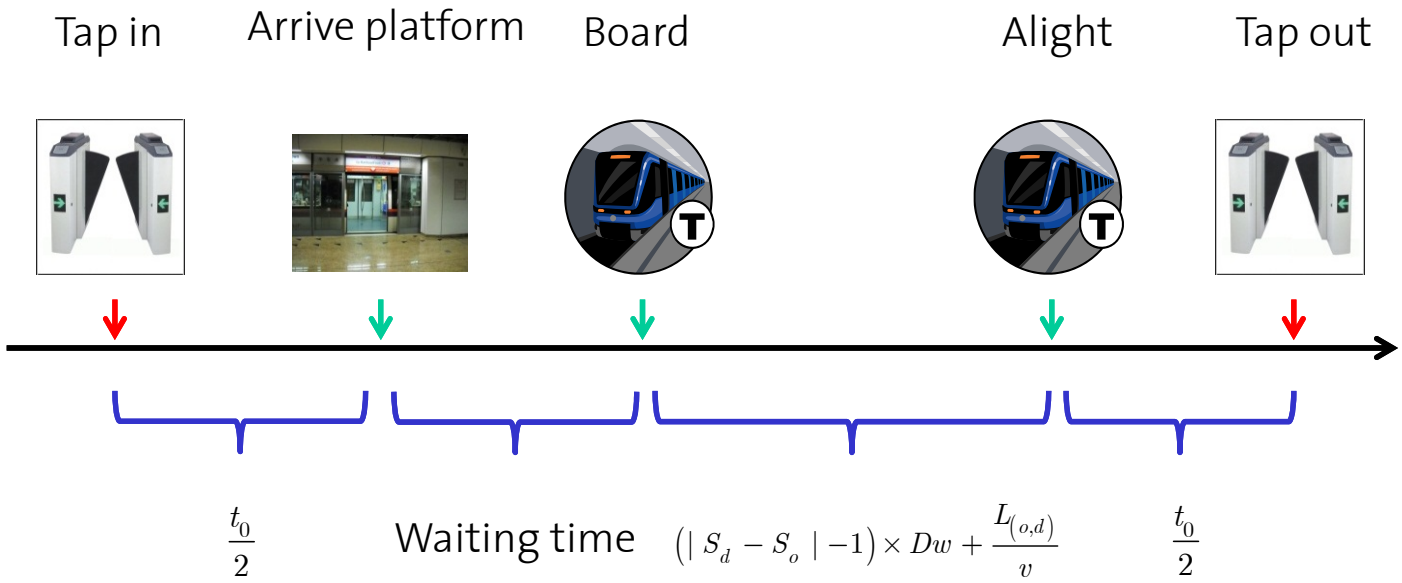
EW1->EW29

EW29->EW1

Question: Where are the passengers (trains) at certain time?

Travel Time Model

- Typical MRT trip(driverless)



↓ Recorded in smart card data

↓ Unknown (not accessible from operators…)

Travel Time

- For the fastest passengers, minimum t_0 and no waiting time

$$T - T_w = t_0 + \left(\mid S_d - S_o \mid -1 \right) \times Dw + \frac{L_{(o,d)}}{v}$$

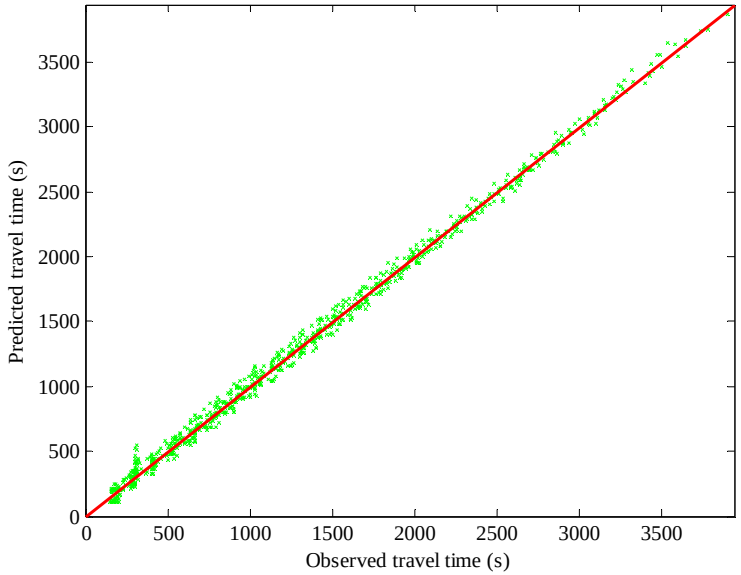
- Parameters t_0, Dw, v

$L_{(o,d)}$ Distance between o and d

Dw Dwell time at each station

v Traveling velocity

$\left(\mid S_d - S_o \mid -1 \right)$ Number of stations with dwell time



Parameters	Value	T-stat	P value
$t_0(s)$	109.75	48.58	0.0000
$Dw(s)$	65.76	61.41	0.0000
$v(m/s)$	21.63	61.82	0.0000
R^2	0.9981		

Estimating Passenger's Location

- For all the stations in $o,\cdots,k,\cdots d$
- $$L\left(k\right)=\left(t-T_a+\left(\mid S_d-S_o\mid -1\right)\times Dw+\frac{t_0}{2}\right)\times v+D\left(d\right)$$
- If the first station can be found, which satisfies

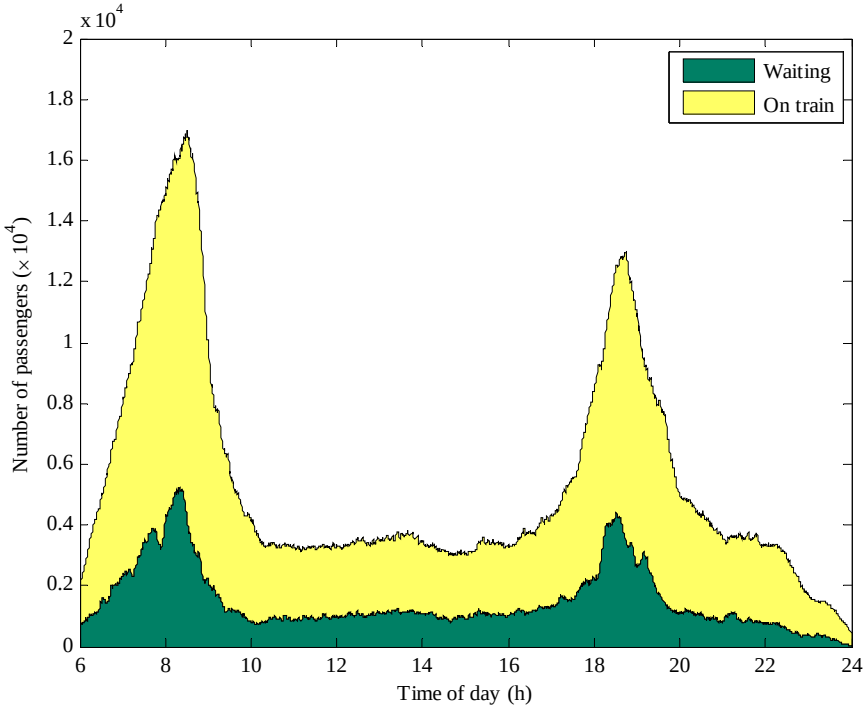
  $$L\left(\ddot{k}\right)-P\left(\ddot{k}\right)\geq 0$$

  - Then the estimated location is $L\left(\ddot{k}\right)$
  - Else, the passenger is not on the train (still waiting for the train)

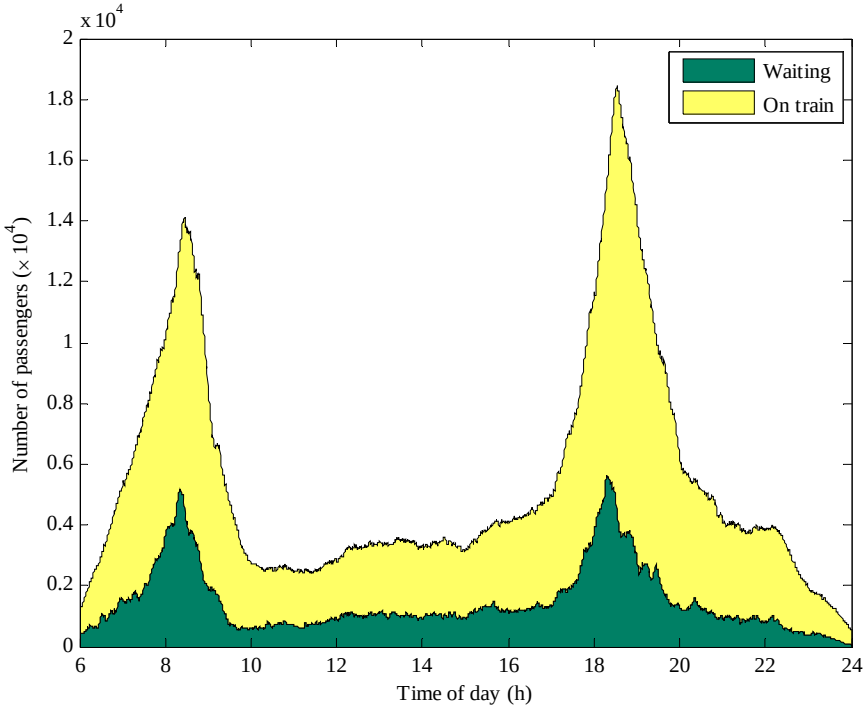
$P\left(\ddot{k}\right)$ Location of station $\ddot{k}$

Station	second	minute	published
2	178.1415	2.97	3
3	130.8763	2.18	2
4	182.8681	3.05	3
5	154.5089	2.58	2
6	159.2354	2.65	2
7	116.6967	1.94	2
8	116.6967	1.94	2
9	121.4232	2.02	2
10	130.8763	2.18	2
11	116.6967	1.94	2
12	116.6967	1.94	2
13	111.9702	1.87	2
14	111.9702	1.87	2
15	121.4232	2.02	2
16	111.9702	1.87	2
17	135.6028	2.26	2
18	121.4232	2.02	2
19	130.8763	2.18	2
20	121.4232	2.02	2
21	116.6967	1.94	2
22	130.8763	2.18	2
23	145.0558	2.42	2
24	230.1333	3.84	4
25	135.6028	2.26	2
26	130.8763	2.18	2
27	149.7824	2.50	2
28	111.9702	1.87	1
29	192.3211	3.21	3
sum	3834.69	63.91	60

- Demand can be identified into 2 groups
  - People who are traveling on the trains
  - People who are waiting for the trains



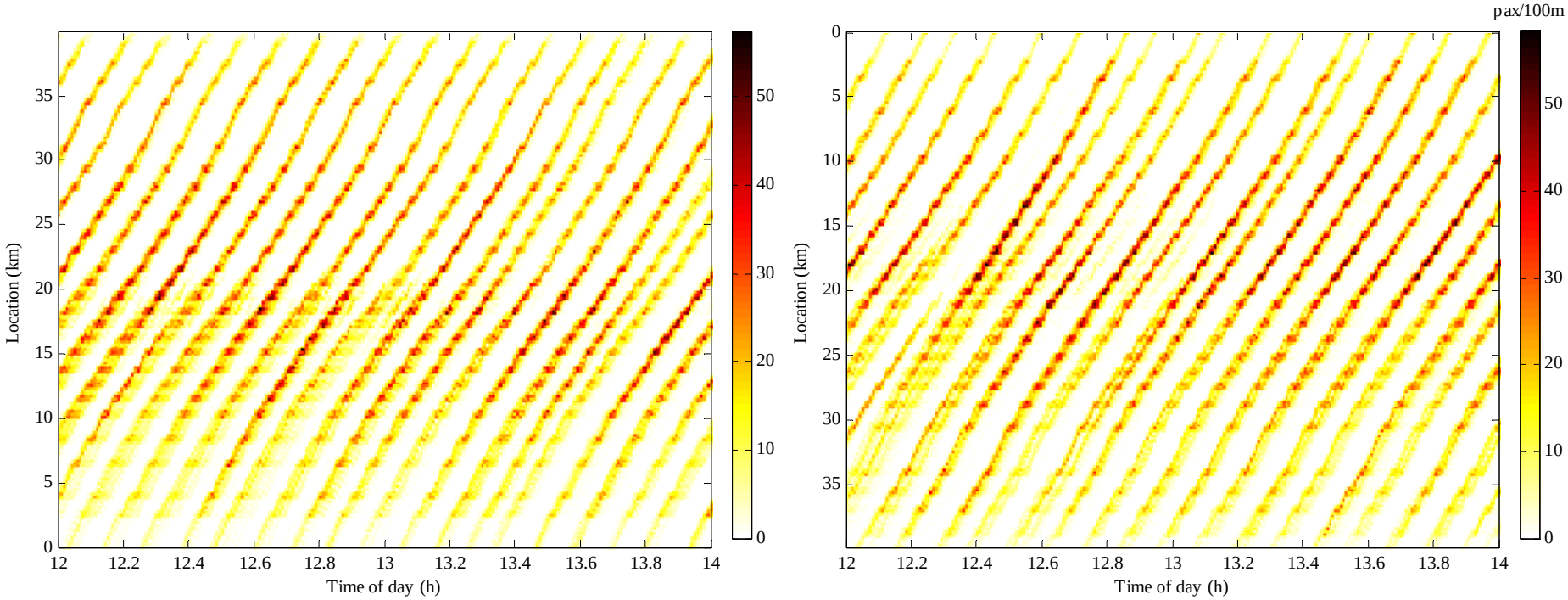
EW1->EW29



EW29->EW1

Spatio-Temporal Density and Trajectories

- Based on the location estimation model, time-location density can be estimated.
- Trajectories can be identified.



EW1->EW29

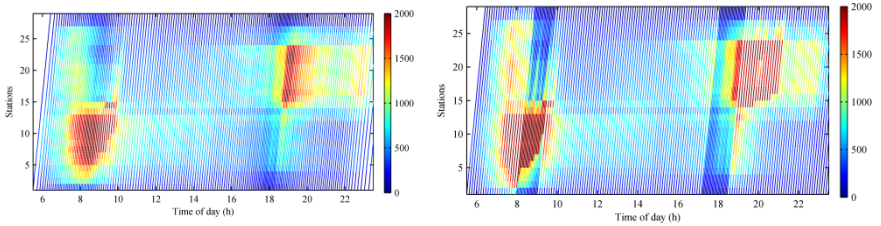
EW29->EW1

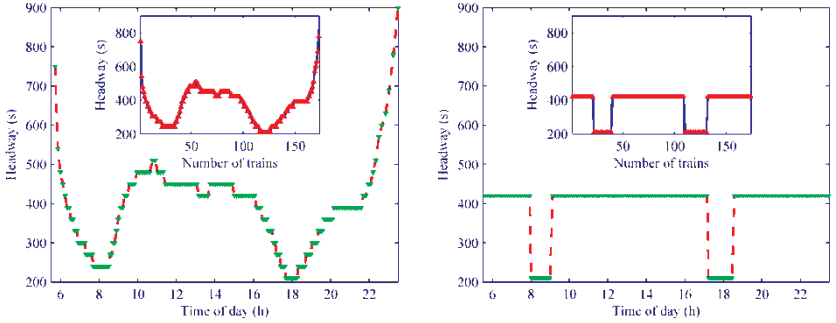
- Questions solved: Where is the train & How much is the demand.

Discussion & Outlook

- An easily applied model to identify demand pattern
- Helpfully, to be applied in disruption response
- Shortcomings:
  - Not real time application: historical smart card data (hopefully, same pattern might be found)
  - Errors for peak hour: difficult to identify trajectories (schedule & timetable)

- Outlook:
  - Combine this model with GTFS (Google Transit Feed) (schedule & timetable)
  - Disruption response (where the train stops, how to transfer the passengers with bus services)
  - Define a more demand responsive timetable for MRT operation (optimization model considering headway)





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THANKS