SUPPLEMENTARY INFORMATION FOR:

Understanding coupling dynamics of public transportation networks

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1 Smartcard data

1.1 Data format

Every day, averagely 7 million public transportation transactions are recorded by the SHENZHENTONG smartcard data, consisting of approximately 3 million bus boarding records and 4 million subway records (entering and exiting a station are recorded separately). The bus smartcard data are entry-only records without boarding stops (Type 31 in Table S1) while the subway smartcard data record both entry and exit information (Type 21 and 22 in Table S2).

Table S1. Example of a bus trip record.

Record ID	User ID	Type	Time	Line	Car plate
4429954	20000xxx	31	2016-08-15 14:02:17	No.97	BN1160

Table S2. Example of a subway trip record.

| Record ID	User ID	Type	Time	Line	Station
4116221	20000xxx	21	2016-08-15 13:04:36	Line 3	Shaibu
3543129	20000xxx	22	2016-08-15 13:16:32	Line 1	Science Museum

1.2 Temporal features

Temporal distribution of daily number of trips during the week is shown in Fig. S1. Temporal distribution of average number of trips in each hour is shown in Fig. S2. As shown in Fig. S1, both bus trips and subway trips made during weekdays show no great fluctuation on day-to-day amounts. Trips made on weekend are generally less than weekdays and the bus trips dramatically decreased

on Sunday due to the massive reduction of long-distance bus commuters from suburban areas. Trips on weekdays show prominent peaks during morning and evening peak hours. Moderate peaks are also observed on Saturday while no salient peak is observed on Sunday (Fig. S2).
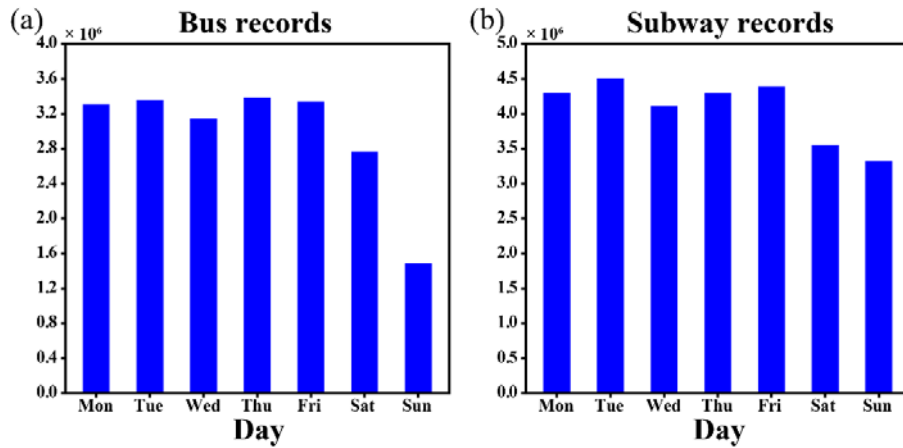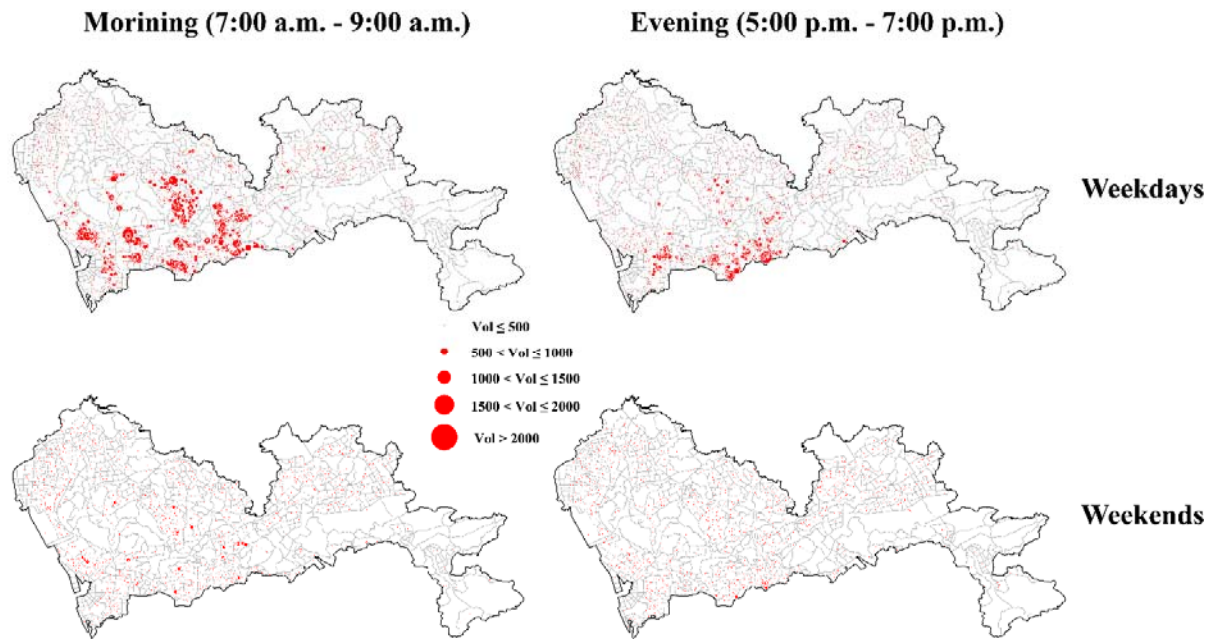

Figure S1. Temporal distribution of daily number of trips. (a) Bus trips; (b) Subway trips (an entry and an exit are considered as one trip).
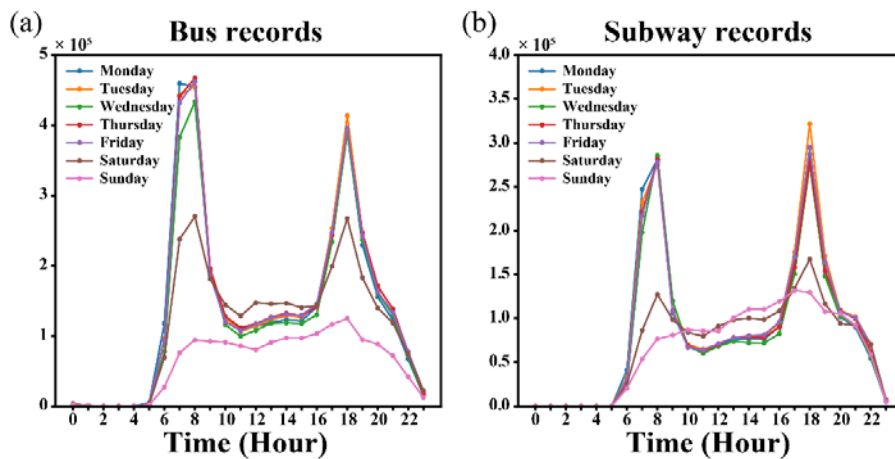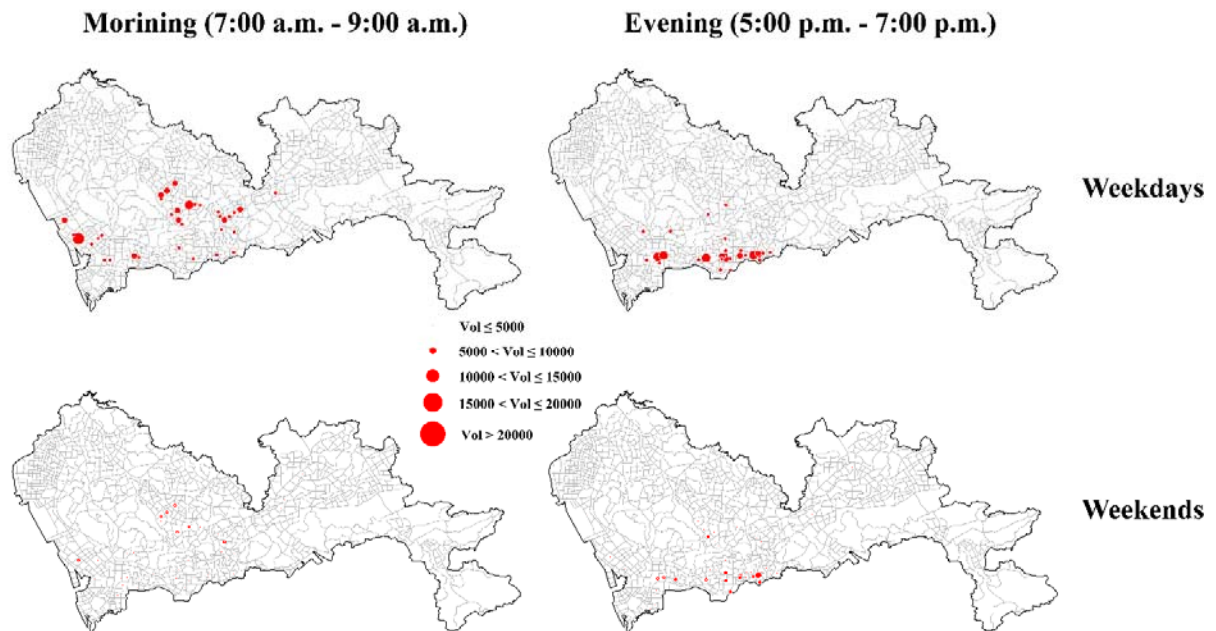

Figure S2. Temporal distribution of average number of trips in each hour. (a) Bus trips; (b) Subway trips (an entry and an exit are considered as one trip).

1.3 Spatial features

The average passenger volumes generated at each bus stop and subway station during morning and evening rush hours are shown in Fig. S3 and Fig. S4. A great number of bus passengers come from suburban areas in the morning while the majority of bus passengers is observed in the city center in the evening (Fig. S3). A similar pattern is observed for subway passengers in Fig. S4.

Morining (7:00 a.m. - 9:00 a.m.)　　Evening (5:00 p.m. - 7:00 p.m.)

Weekdays

Vol ≤ 500
500 < Vol ≤ 1000
1000 < Vol ≤ 1500
1500 < Vol ≤ 2000
Vol > 2000

Weekends

Figure S3. Spatial distribution of trip production of bus passengers in morning and evening rush hours for weekdays and weekends.

Morining (7:00 a.m. - 9:00 a.m.)　　Evening (5:00 p.m. - 7:00 p.m.)

Weekdays

Vol ≤ 5000
5000 < Vol ≤ 10000
10000 < Vol ≤ 15000
15000 < Vol ≤ 20000
Vol > 20000

Weekends

Figure S4. Spatial distribution of trip production of subway passengers in morning and evening rush hours for weekdays and weekends.

2 Destination zones

In this study, we use 124 transfer zones as the destination zones to generate the studied SDNs. The studied destination zones are displayed in Fig. S5. Most studied destination zones are distributed in downtown areas while some are in suburban areas.
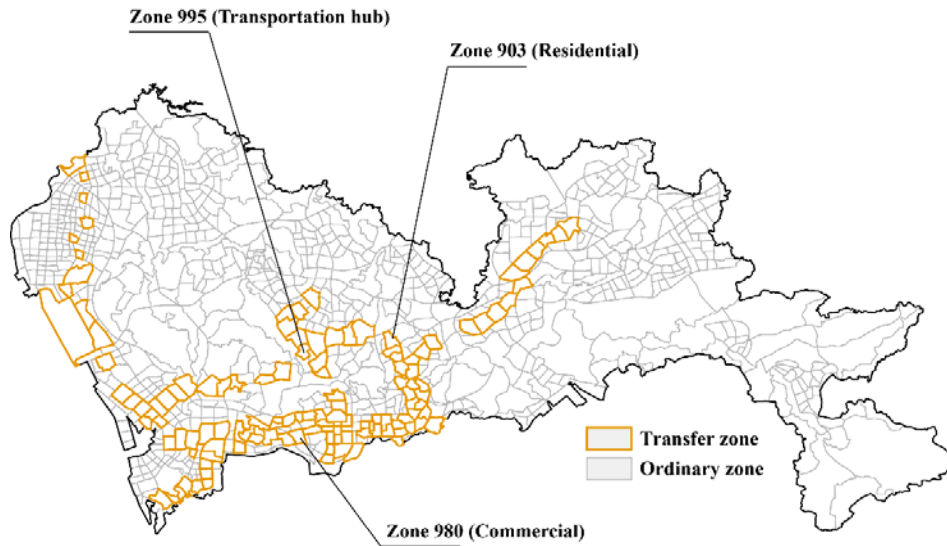

Figure S5. The spatial distribution of transfer zones and ordinary zones.

3 Public transportation systems

The spatial distribution of bus stops and subway stations of Shenzhen are displayed in Fig. S6. A total of 815 bus lines and 6 subway lines are operated on the studied multiplex public transportation network with 9,114 bus stops and 132 subway stations.
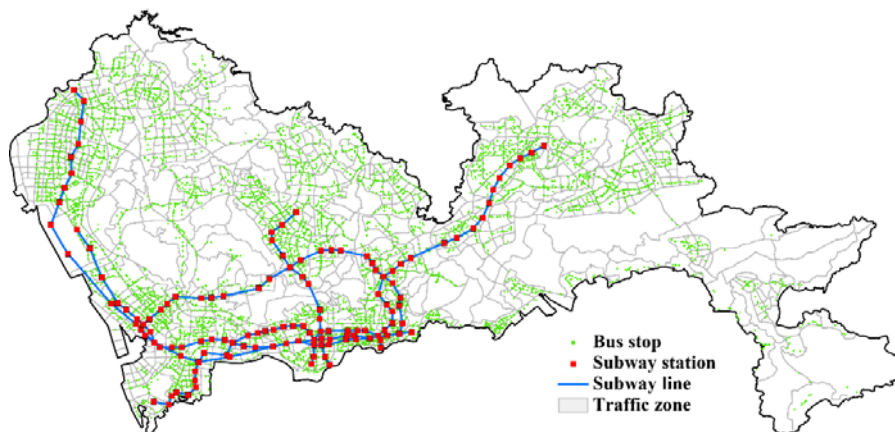

Figure S6. The spatial distribution of bus stops and subway stations of Shenzhen.

4 Bus GPS data

4.1 Data format

The time that a bus arrived at each bus stop was inferred by matching the GPS coordinates of the bus to the stops along the operating route. This generates the timetable of the bus. The data format of the timetable is shown in Table S3.

Table S3. Example of a bus timetable.

Line	Car plate	Time window	Record time	Timestamp	Station
3380	B86xxx	6	2016-08-08 06:19:13	22753	Haishangtianyuan

4.2 Temporal features of bus speed

As shown in Fig. S7. The average operating speed of each section of this bus line is calculated through the average travel time between two stops. We can see that the travel speeds on some sections are greatly lowered by traffic congestion during morning and evening rush hours.
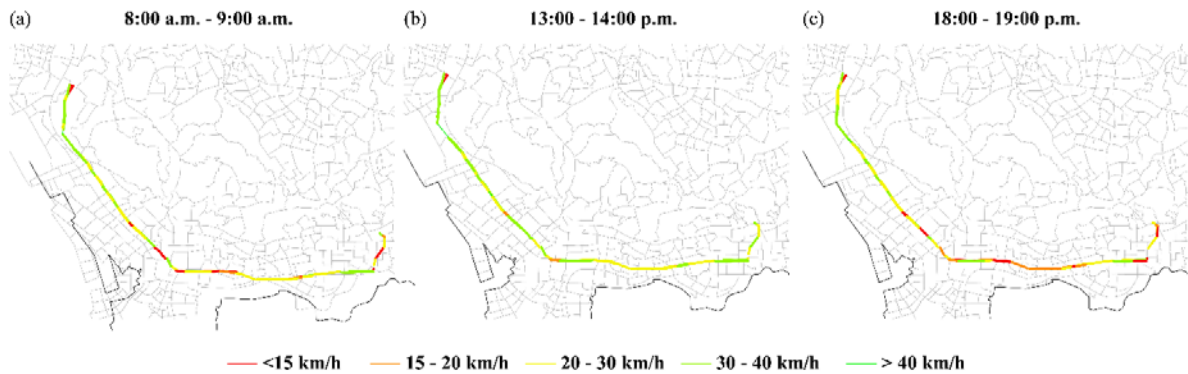
Figure S7. The average operating speed of each section of a bus line. (a) 8:00-9:00 a.m.; (b) 13:00-14:00 p.m. and (c) 18:00-19:00 p.m.