Vaite: a Visualization-Assisted Interactive Big Urban Trajectory Data Exploration System

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Outline

- **Introduction**
- System Architecture
  - Three Layer Architecture
- Case Study
  - Data Model
  - Three Real World Cases
- Summary

Introduction --- Background

Urban Trajectory Data

- **<longitude, latitude >, timestamp, trip attributes**
- Heterogeneous: Taxi, Bus, Pedestrian
- Massive
- Valuable



Applications

- Congestion detection [BigData 2017]
- Taxi communities, outlier identification [TKDE 2017, WWW 2017]
- Billboard placement location [KDD 2018]

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Introduction --- Motivation

General urban trajectory data analysis

- Particular analysis procedures for specific trajectory analysis tasks.
- e.g., Traffic Congestion Prediction [BigData 2017],
- Finding significant places [TVCG 2013].
- SQL-like query language
- **Professional Knowledge: Required.**

City manager explore the potential issues of the city ?

Taxi company explore the interesting facts among taxi drivers ?

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Introduction --- Motivation

Interactive data exploration analysis

- Interactively pose ad-hoc visualization queries to identify potential relationships or glean insights.
- **Professional Knowledge: Non-required.**

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Introduction --- Challenges

- **User-friendly Exploratory Analysis**
  a) issue an ad-hoc query should be convenience
  b) the corresponding results should be easy to interpret.

- **Incremental and Interactive Visualization**
  - **The underlying analysis algorithms and visualization techniques to be scalable.**

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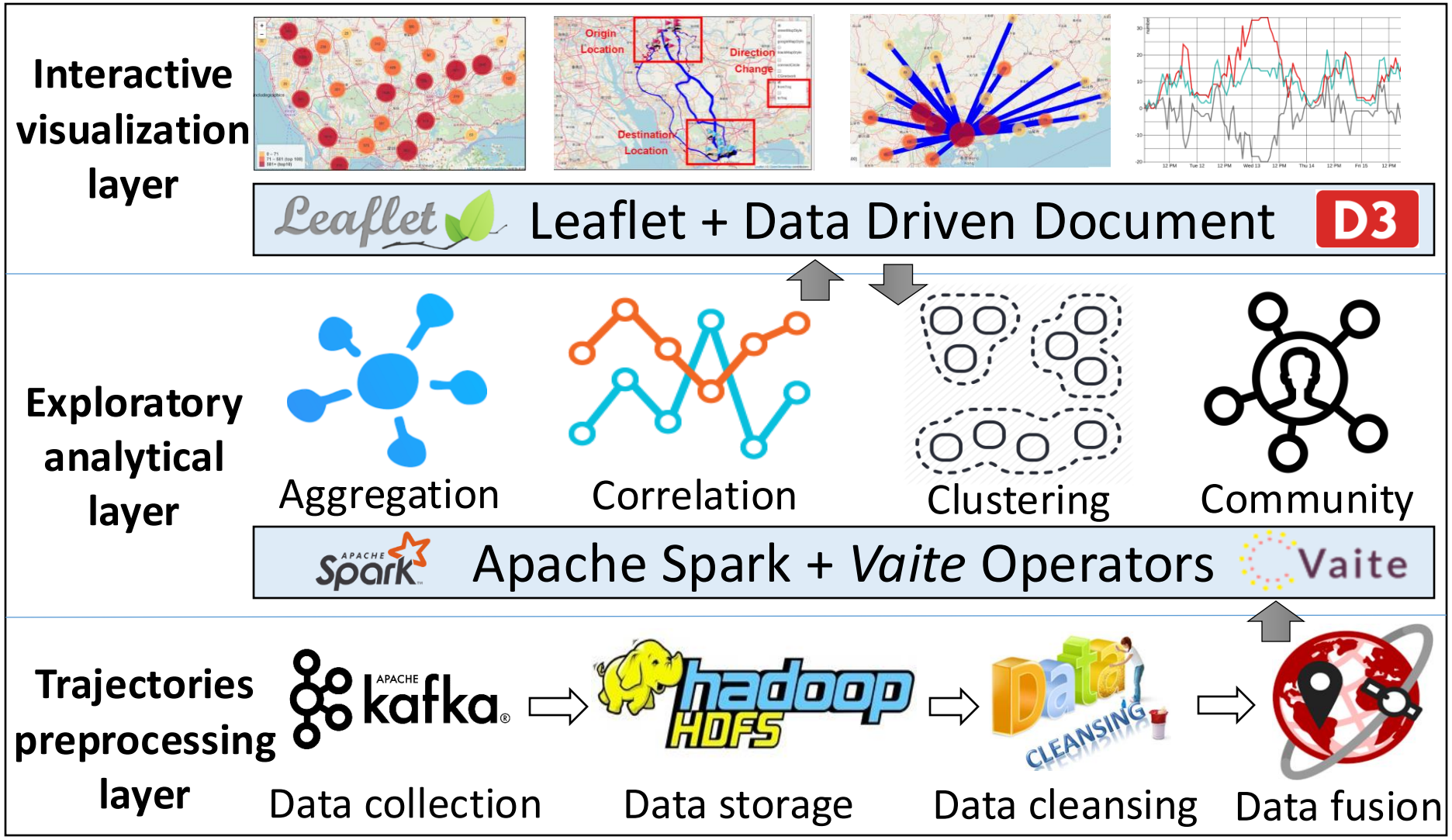
System Overview



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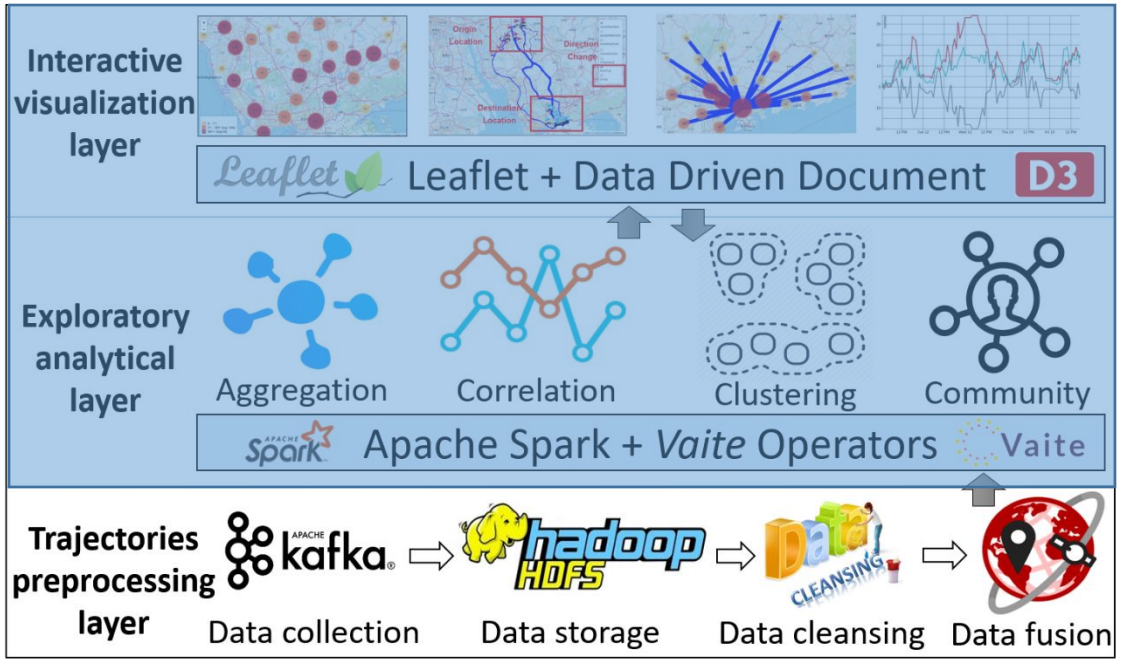
Vaite Framework --- Data preprocessing layer



- Collecting urban trajectories.
- Storing data on HDFS
- Matching road network.
- Cleaning the data errors
  - E.g., value missing, wrong data records

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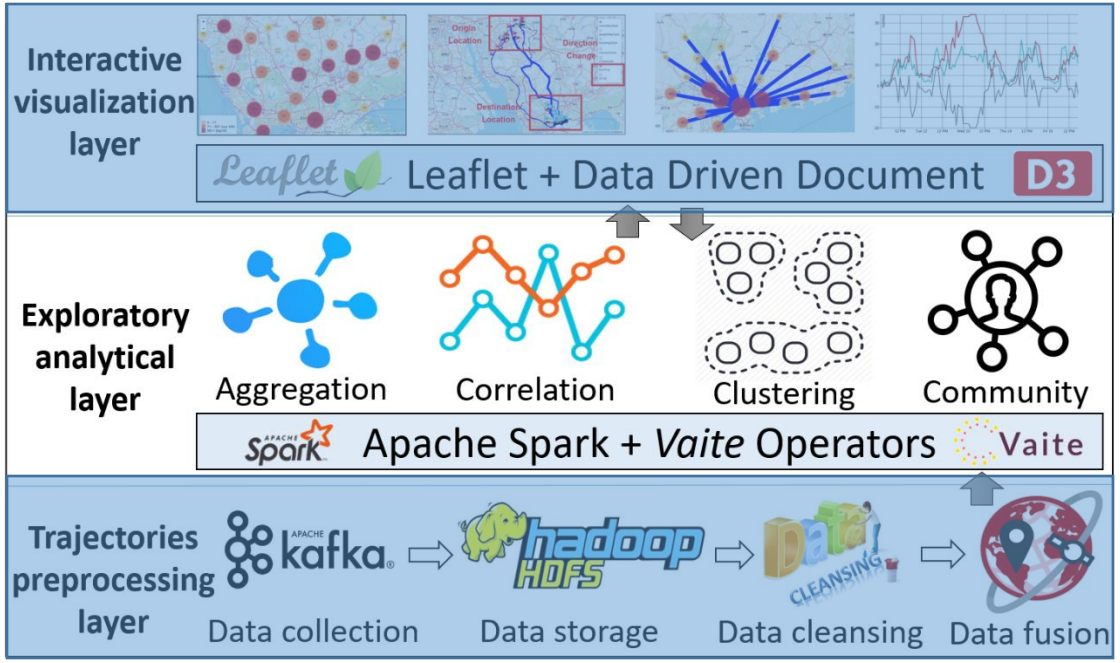
Vaite Framework --- Exploratory analytical layer



- Core Computation Layer
- A suite of atomic operators:
  - *event extractor, sub-traj extractor…*
- A set of analysis models:
  - *clustering, correlation…*

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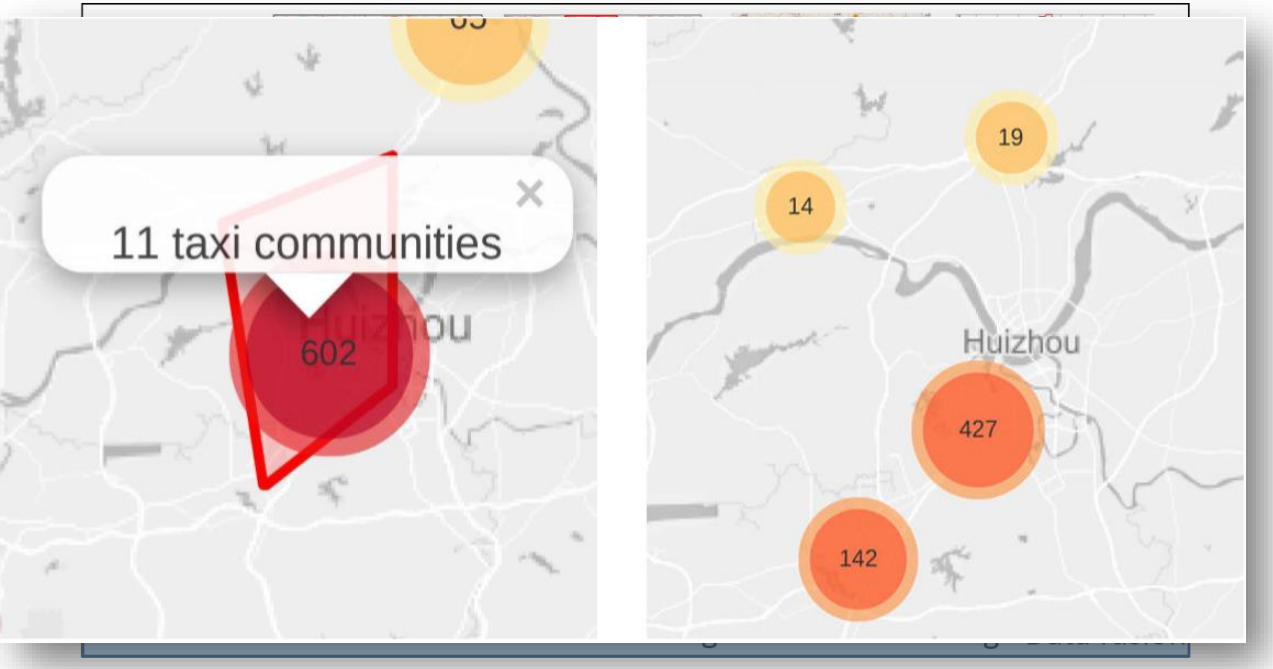
Vaite Framework --- Interactive visualization layer



- Trajectory exploratory visualization tools:
  - Spatial bubble view
    - design for spatial aggregation task.
    - supports a set of aggregation operators,
    - e.g., *Min*, *Max*, *Avg*, *Sum*
  - Trajectory-map view
  - ……
- Interactive action:
  - Convert keyboard/mouse input to analysis operator and pass them to computation engine.

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Case Study --- Data Model

- **Data Source:**
  - Shenzhen Taxi Trajectories Data
- **Data Size:**
  - nearly 6GB/day, nearly 80,000,000 GPS Records.
  - overall Data: one month data
  - in use: one week data(2016_01_25 ~ 2016_01_31)
    - Size: 41.8 G
    - Records: 562,476,072
- **Data Characteristics:**
  - Massive: growing day by day.
  - Noisy: e.g., Value Missing, Wrong Records, GPS Location Floating

```
val schema = StructType(
  StructField("TerminalNumber",StringType,nullable=true)::
    StructField("Longitude",DoubleType,nullable=true)::
    StructField("Latitude",DoubleType,nullable=true)::
    StructField("GPStime",TimestampType,nullable=true)::
    StructField("DeviceNumber",IntegerType,nullable=true)::
    StructField("V",IntegerType,nullable=true)::
    StructField("Direction",IntegerType,nullable=true)::
    StructField("P_State",BooleanType,nullable=true)::
    StructField("WarnCode",IntegerType,nullable=true)::
    StructField("SimId",IntegerType,nullable=true)::
    StructField("S_State",BooleanType,nullable=true)::
    StructField("Color",StringType,nullable=true)::Nil
)
```

```
粤B642ZB,113.960197,22.572617,2016-01-25 00:00:07,1457167,0,315,1,,,0,蓝色,
粤B8NN15,113.807899,22.626801,2016-01-24 23:59:57,1398983,0,0,0,,,0,蓝色,
粤B8MT13,114.035599,22.559999,2016-01-24 23:59:43,1382069,0,0,0,,,0,蓝色,
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粤B1P1R2,113.914497,22.528601,2016-01-25 00:00:06,1653419,0,0,0,,,0,蓝色,
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粤B4NJ18,113.821899,22.650999,2016-01-24 23:59:57,1395340,9,256,0,,,0,蓝色,
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Case Study --- Taxi Community Identification

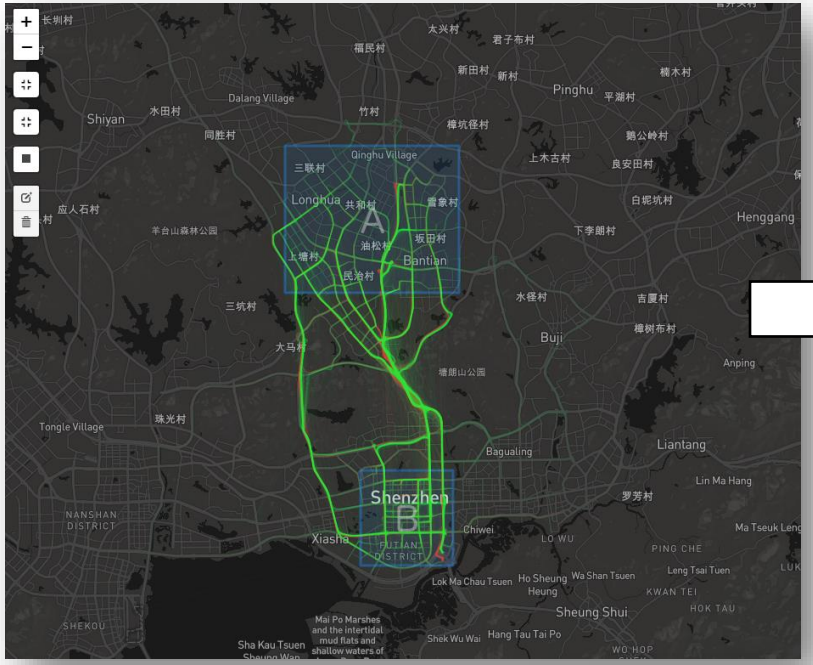
a) Extracting the pick-up events by **event extractor** and Visualizing them by **heat-map**

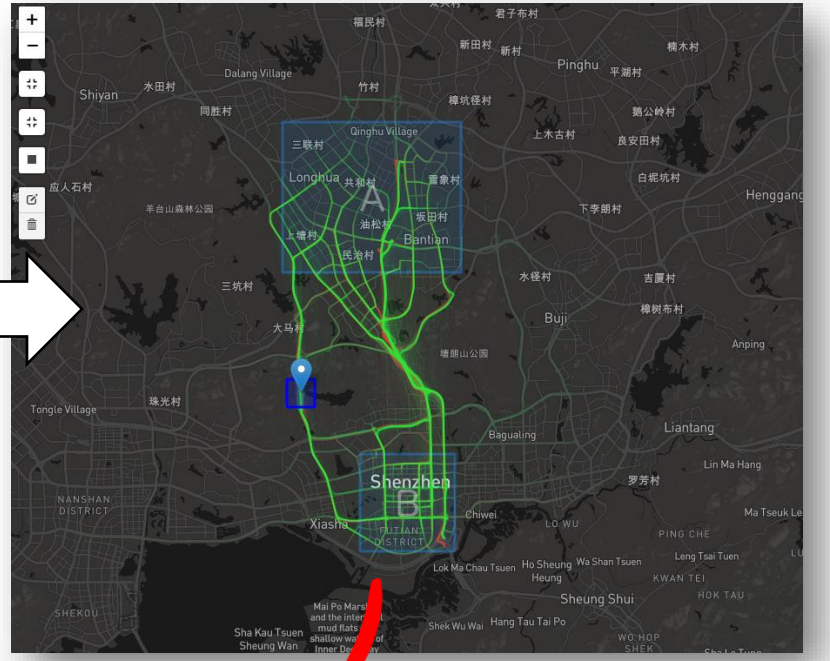
d) Applying **aggregation analysis model** and identifying taxis with top-10 pick-up events

b) **Clustering** pick-up event by spatial features

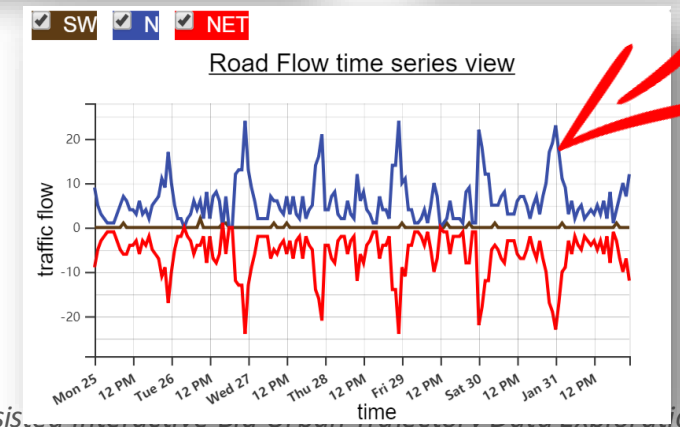
c) Aggregating clustering results and Visualizing them by **spatial bubble view**

Case Study --- Traffic Flow Exploration





Step 1. Selecting two areas on the map (by mouse), extracting and visualizing all sub-trajectories between them (identifying popular paths).



Step 2. Investigating one of popular path between two areas (by mouse), the traffic flow will be visualized.

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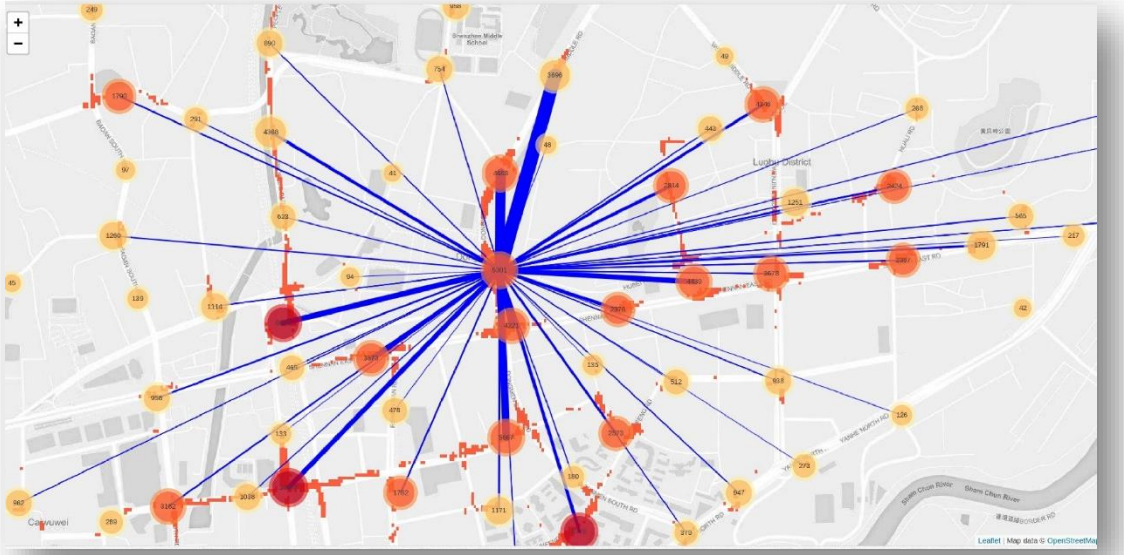
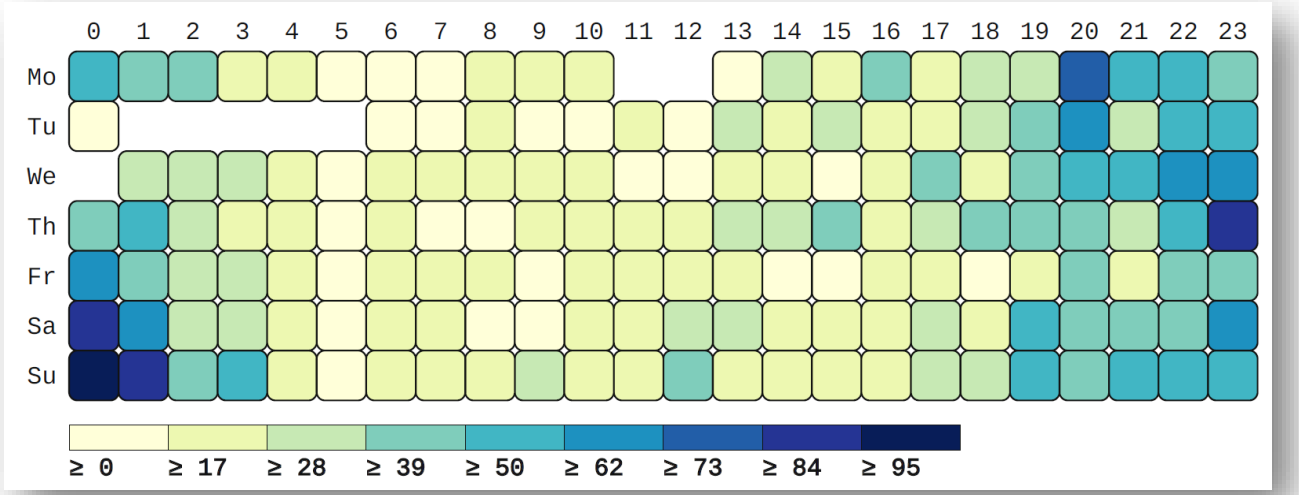
Case Study --- Traffic Congestion Exploration





1. Finding traffic jams locations: **spatial bubble view**
2. Exploring traffic jams correlations: **star topology view**
3. Identifying the traffic jam trend: **pixel based view**

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Summary

- **Interactively:** support ad-hoc exploratory analysis, near real-time computation
- **User friendly:** easy to use, results are easy to interpret
- **Extensible:** customize for users' analysis operator, easy to configure for specific analysis tasks

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Thanks for your listening !
Q&A