



BEUTH HOCHSCHULE FÜR TECHNIK BERLIN
University of Applied Sciences



Linear Referencing with Floating Car Data

Felix Kunde

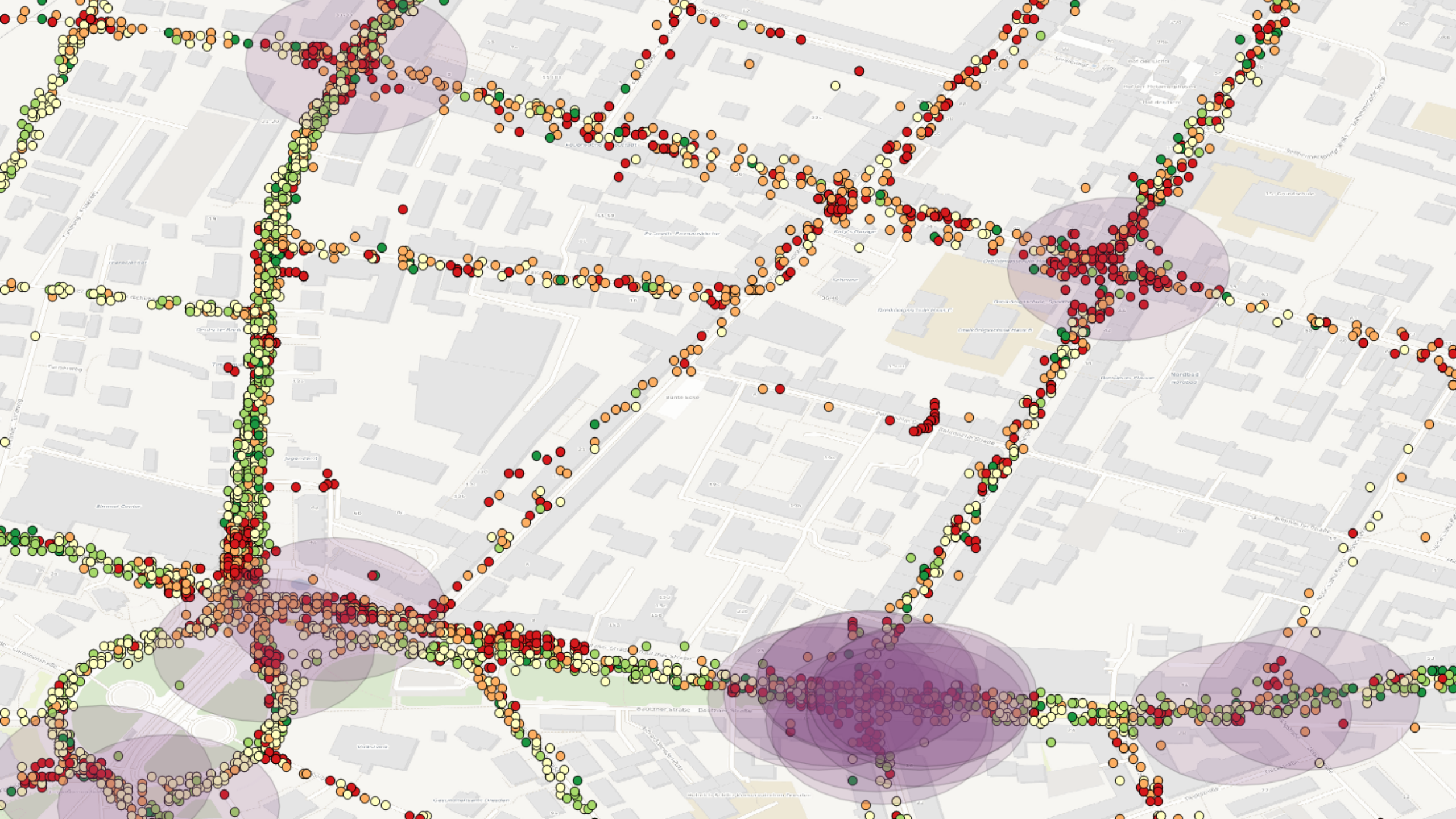
Jérémy Surbier

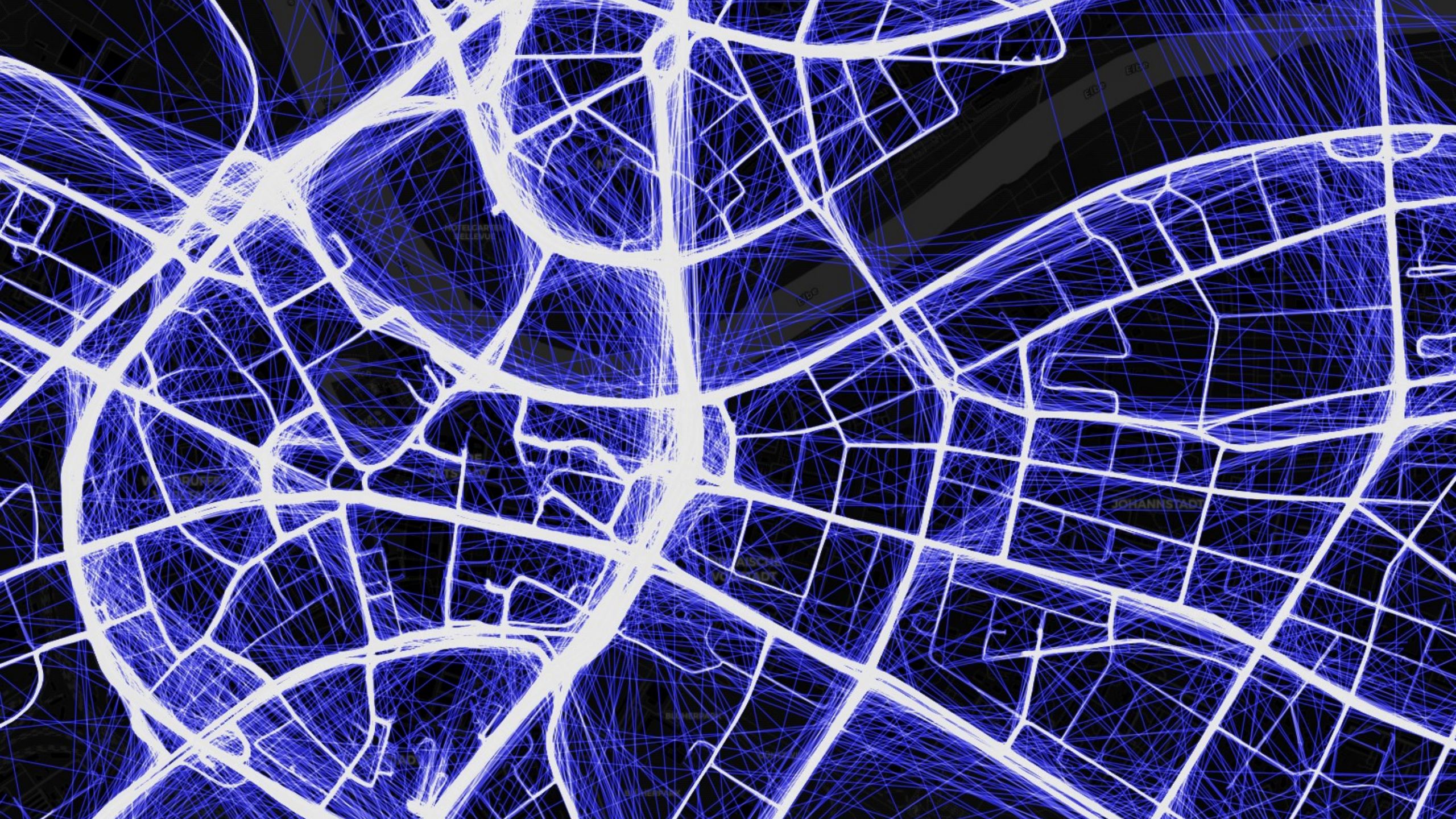
Petra Sauer

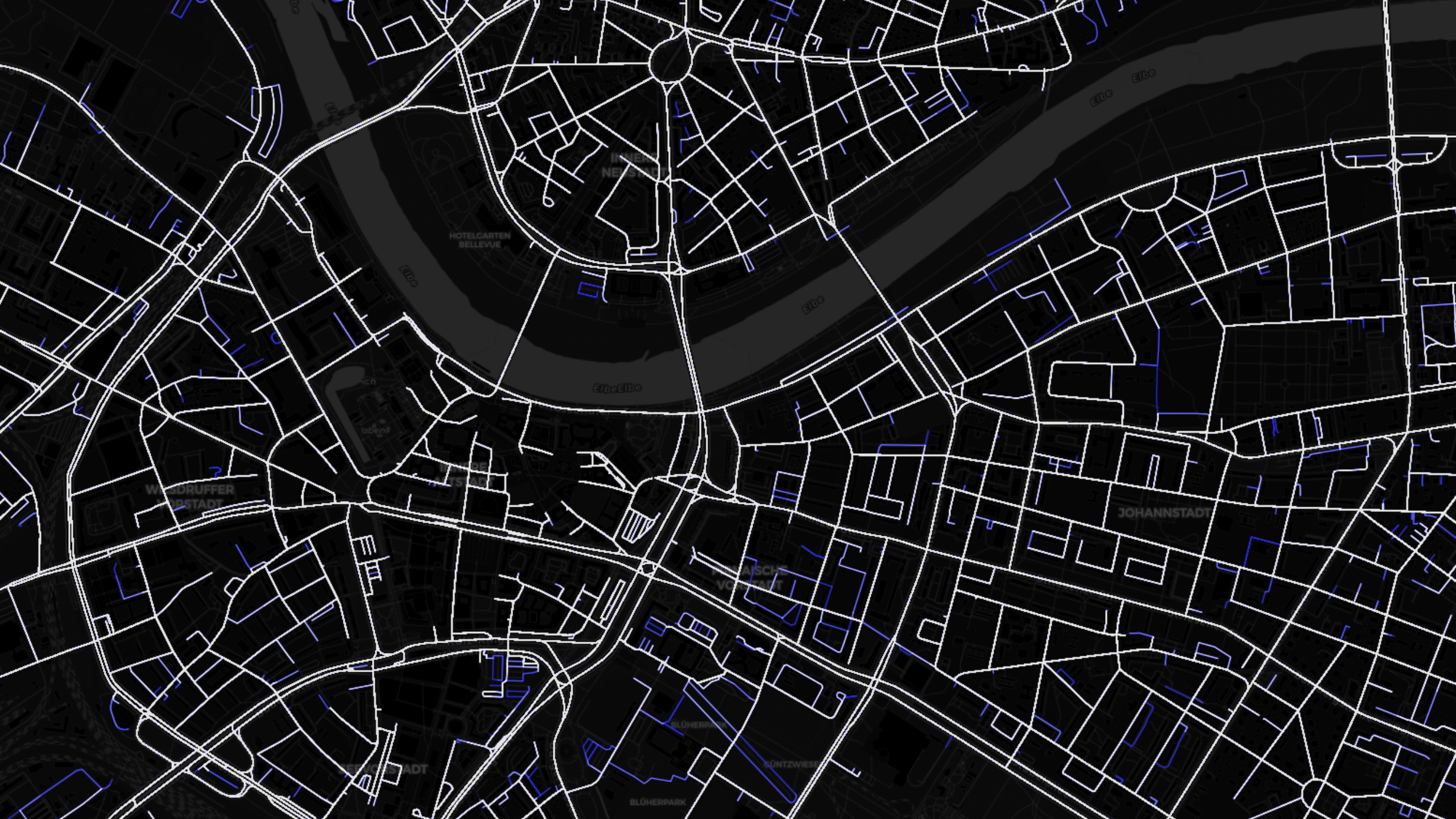




- ITS term: Sensors that „**float**“ with the traffic. Or GPX data.
- Detect traffic where **static sensors** cannot see it. „Installation“ is also way cheaper.
- Important source to estimate **travel times, turn costs, origin-destination** analysis etc.
- Extended **xFCD** = Detect acceleration, breaking, steering, fuel consumption etc.
- Very **sensible** data. Not many open data sets available (e.g. <https://envirocar.org>)







HOTELGARTEN
BELLEVUE

INNER
NEUSTADT

WIEDRUFFER
STADT

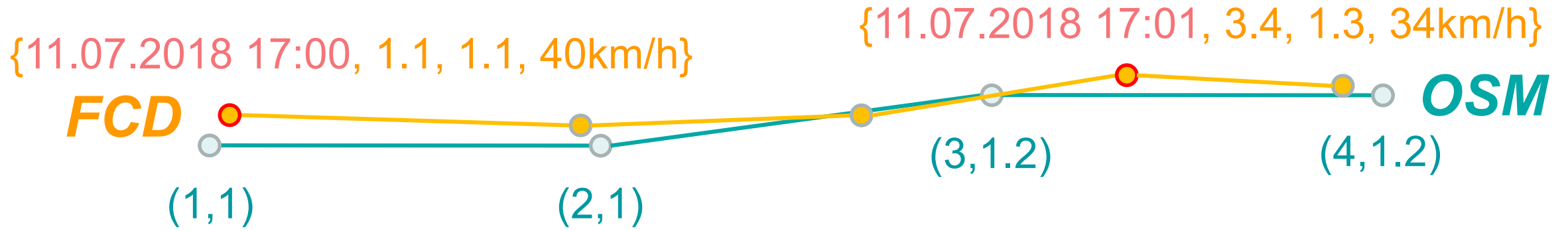
JOHANNSTADT

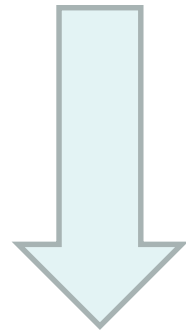
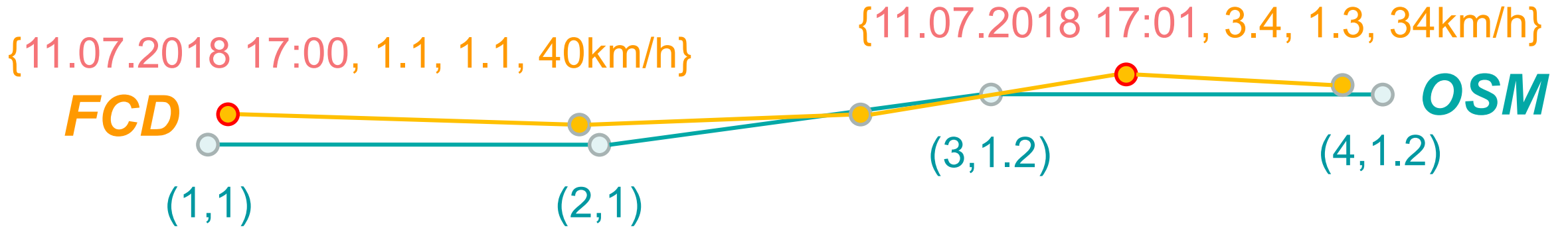
BLÜHERPARK

BLÜHERPARK

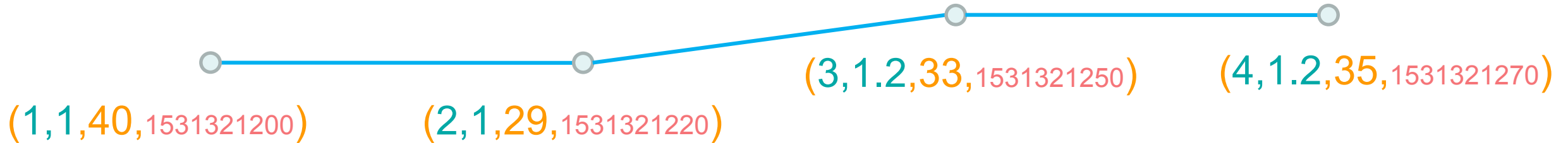
BLÜHERPARK





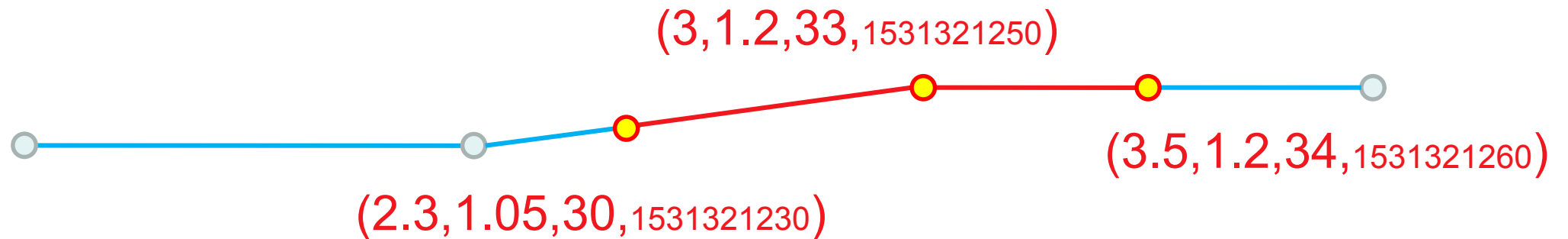


Takes road coordinates from **OpenStreetMap**
 Start and end as in the **FCD**
 Interpolated time and speed **FCD**
 Stored in a **PostGIS database** as **LineStringZM**



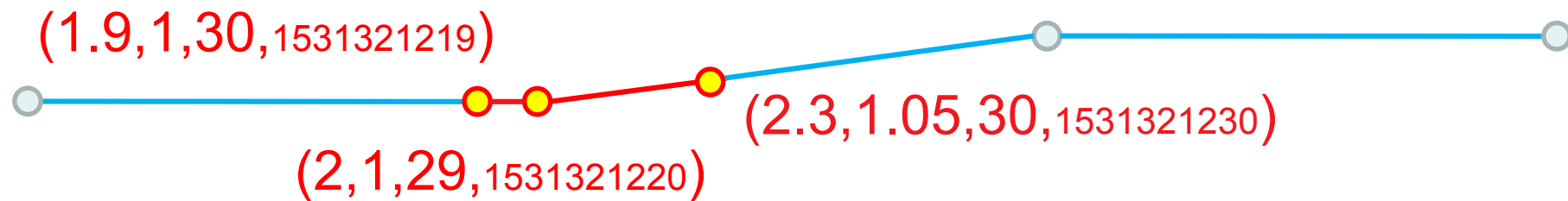


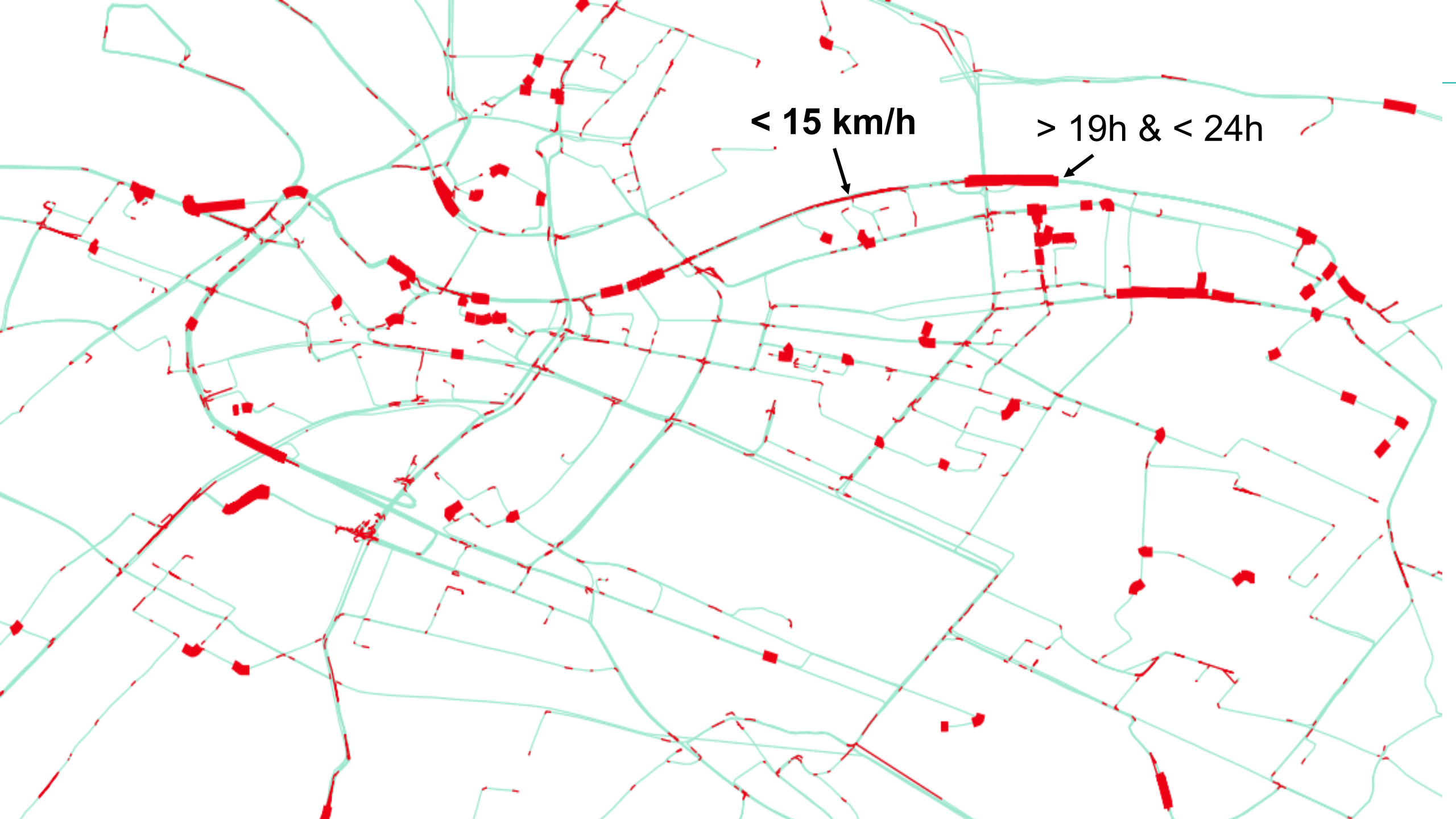
```
SELECT ST_LocateBetween(geom, 1531321230, 1531321260)  
FROM fcd;
```





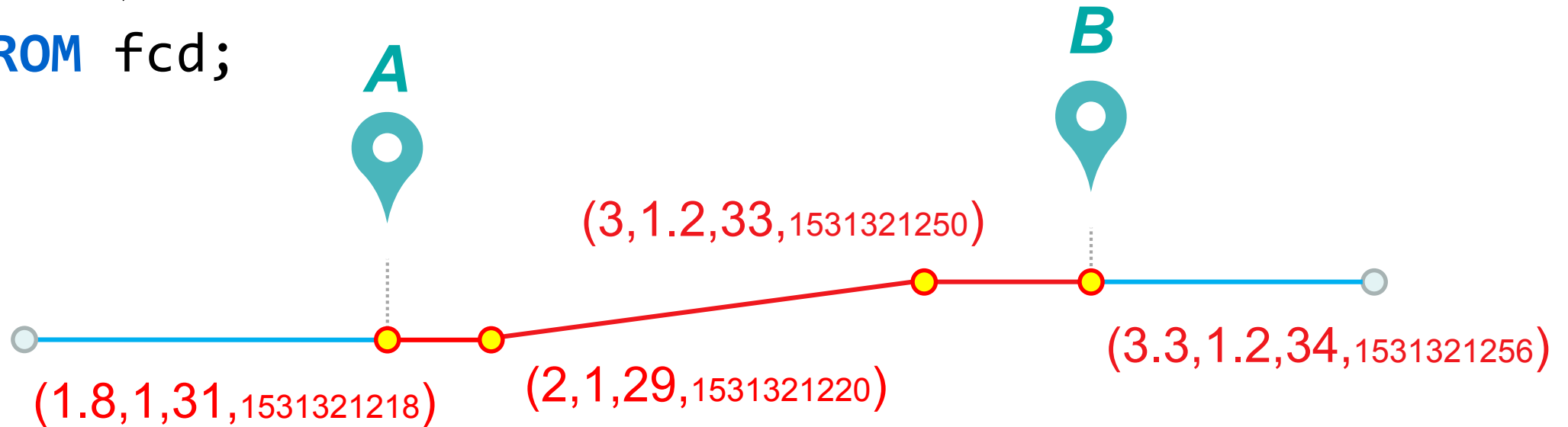
```
SELECT ST_LocateBetweenElevations(geom, 0, 30)
FROM fcd;
```





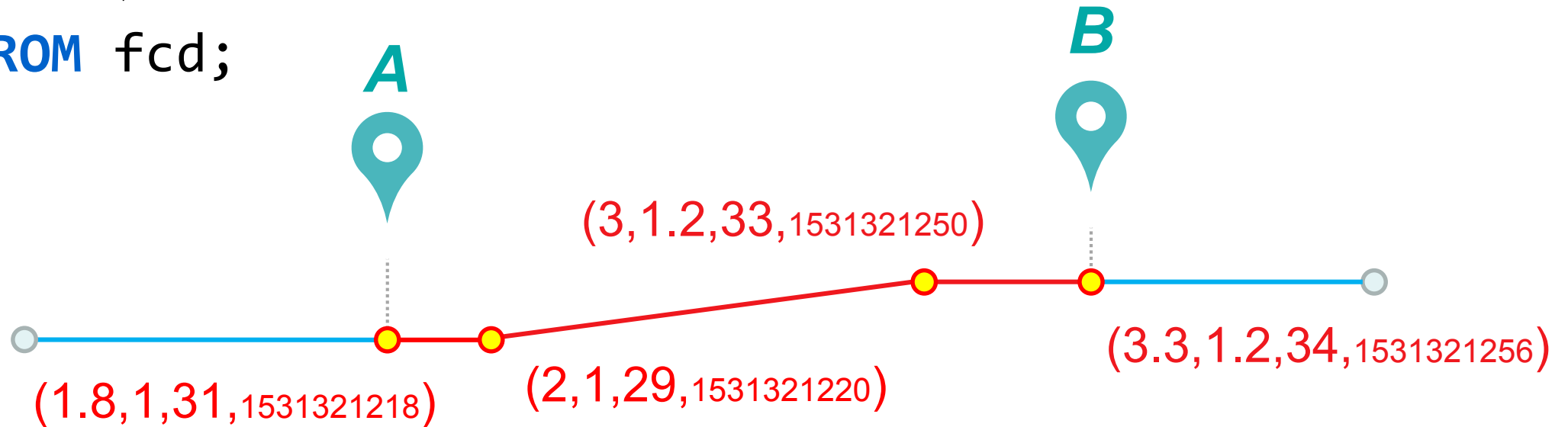


```
SELECT ST_LocateBetween(geom,  
        ST_InterpolatePoint(geom, <point_A>),  
        ST_InterpolatePoint(geom, <point_B>)  
    )  
FROM fcd;
```

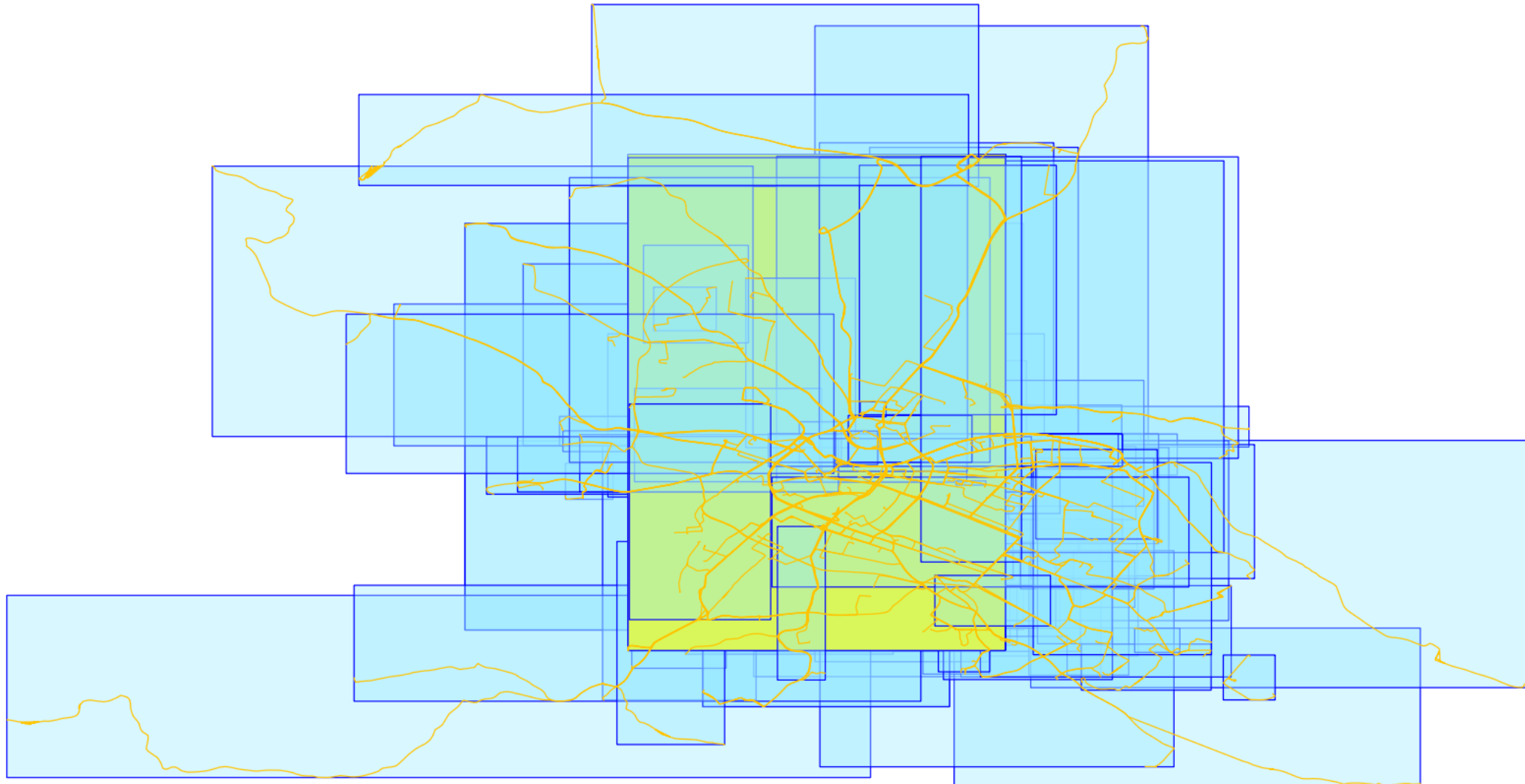




```
SELECT ST_LineSubstring(geom,  
        ST_LineLocatePoint(geom, <point_A>),  
        ST_LineLocatePoint(geom, <point_B>)  
    )  
FROM fcd;
```



- A spatial Index on tracking data has its pitfalls

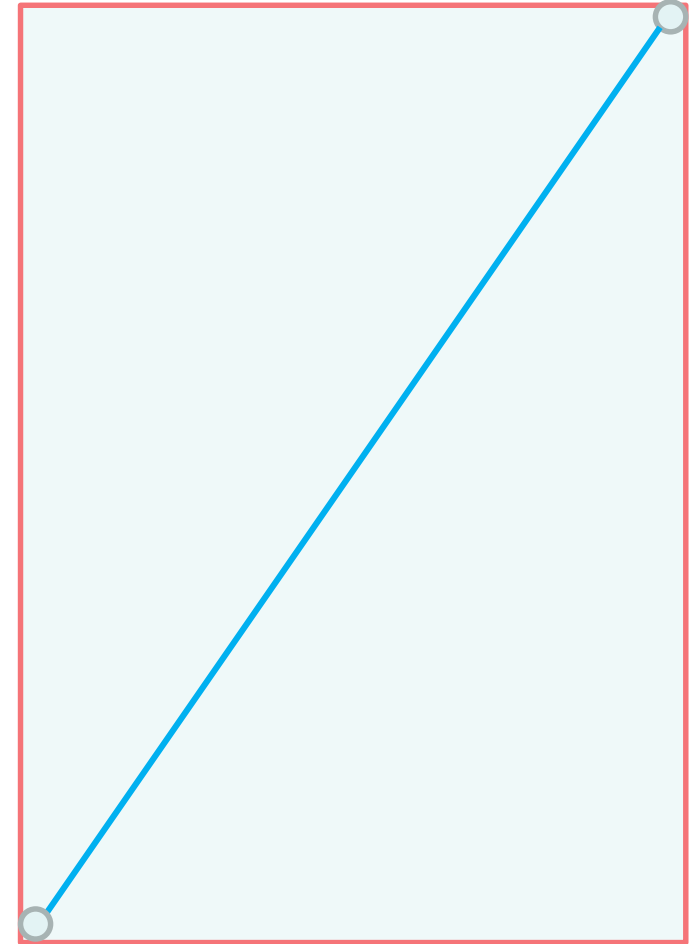




SELECT

-- no need for 4D here
ST_Force2d(geom)

(13.96 51.18 ~~42~~ 1531350000)



(13.58 50.97 ~~39~~ 1531320000)

FROM

matched_tracks;

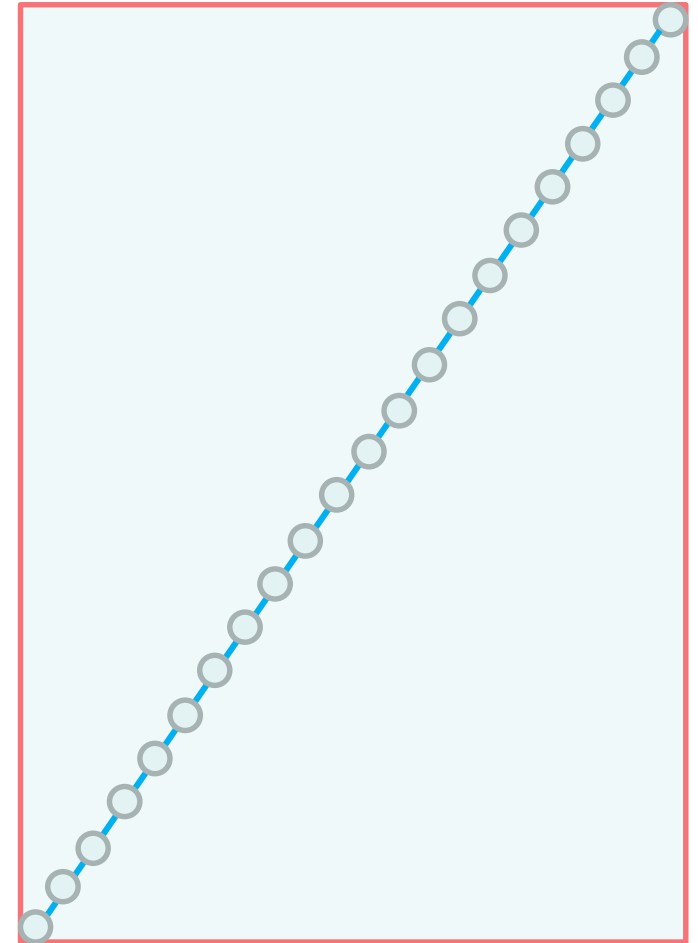


SELECT

```
ST_Segmentize(  
  ST_Force2d(geom),  
  0.0005 -- max_segment_length  
)
```

FROM

```
matched_tracks;
```



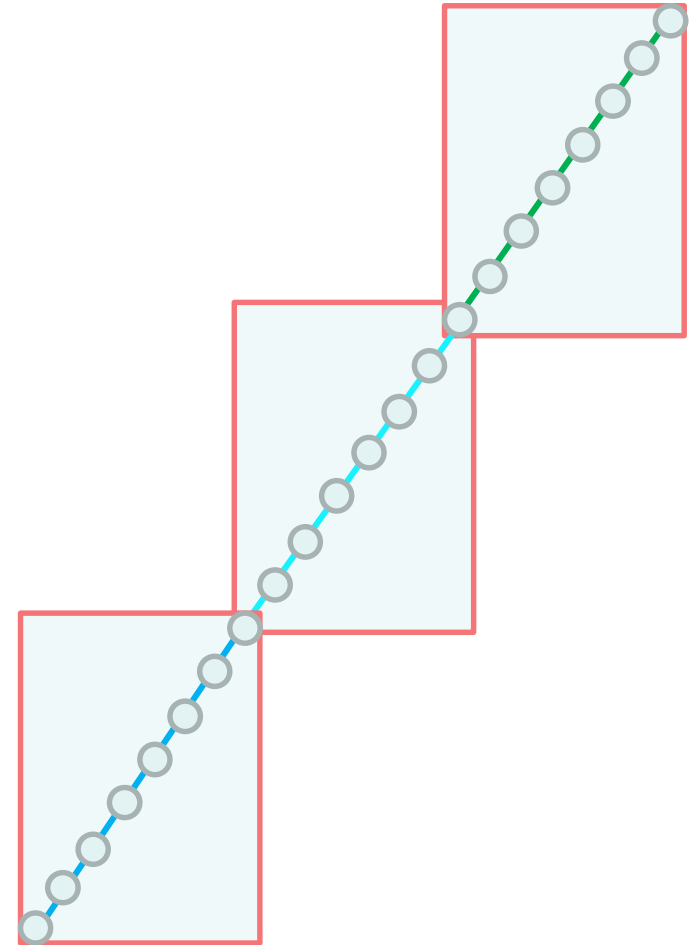


SELECT

```
ST_SubDivide(  
  ST_Segmentize(  
    ST_Force2d(geom),  
    0.0005  
  ),  
  8 -- max_vertices  
)
```

FROM

```
matched_tracks;
```



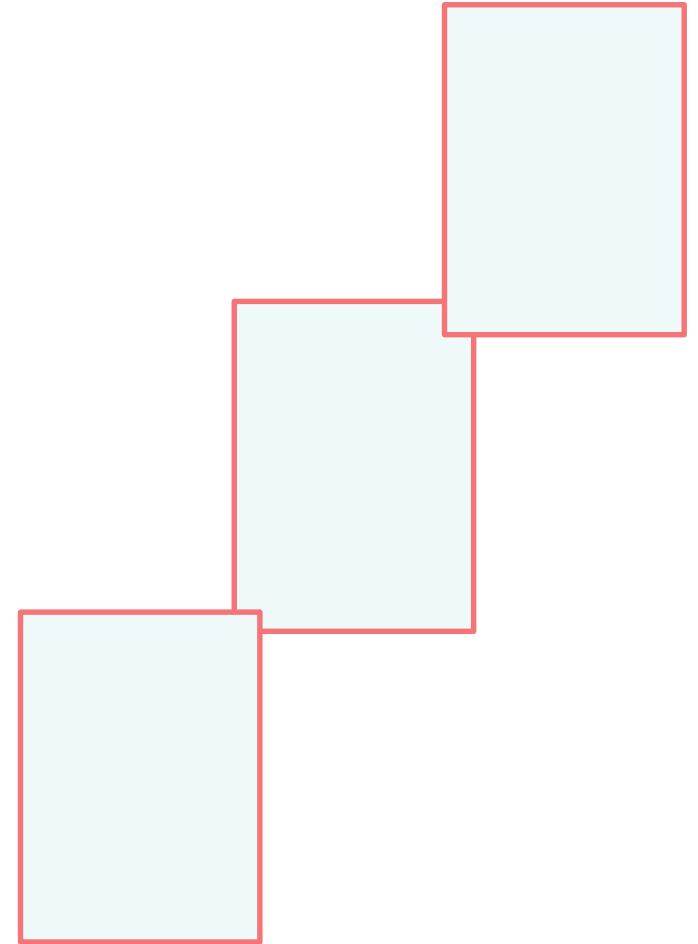


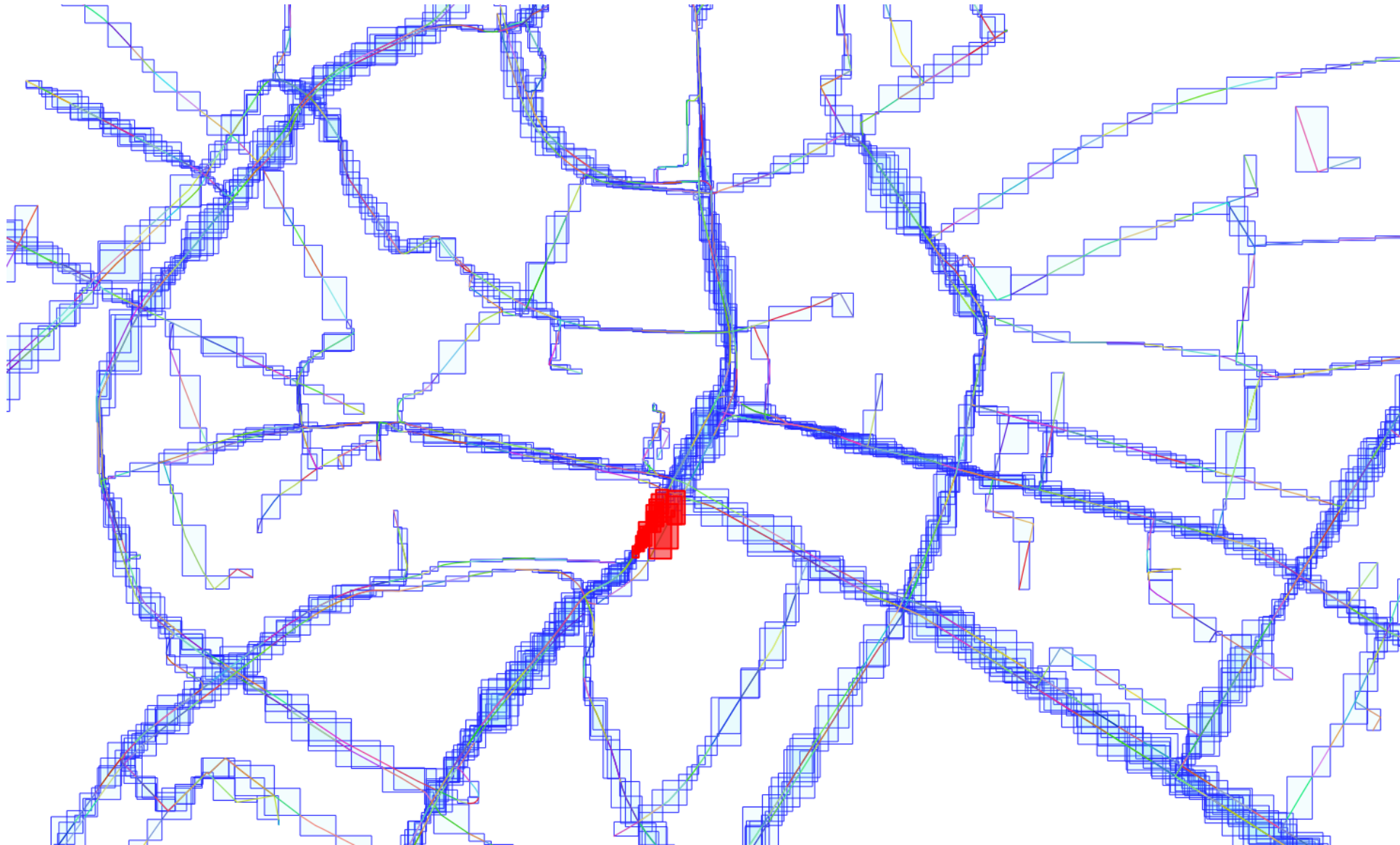
SELECT

```
ST_Envelope( -- box is enough
  ST_SubDivide(
    ST_Segmentize(
      ST_Force2d(geom),
      0.0005
    ),
    8
  )
) AS fcd_segment_bbox
```

FROM

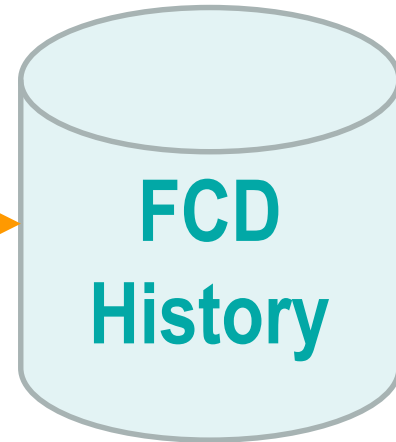
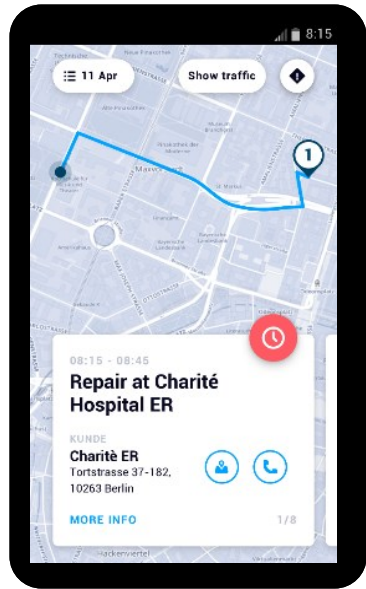
```
matched_tracks;
```







```
WITH find_segments AS (  
  SELECT DISTINCT trip_id  
  FROM matched_tracks_segments  
  WHERE fcd_segment_bbox && <point_A>  
  OR fcd_segment_bbox && <point_B>  
)  
SELECT id, ST_LineSubString(...)  
FROM matched_tracks t  
JOIN find_segments s ON s.trip_id = t.id  
WHERE _ST_DWithin(<point_A>, geom, 0.0005)  
AND _ST_DWithin(<point_B>, geom, 0.0005);
```

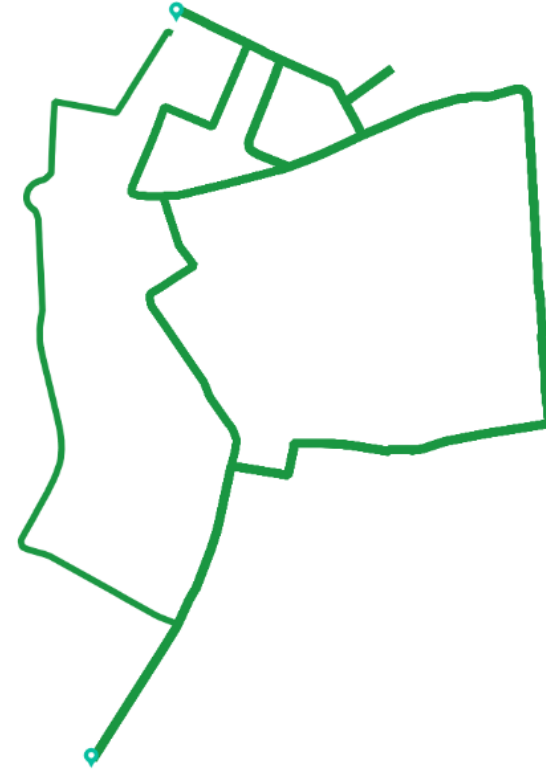
Single trips



Single trips

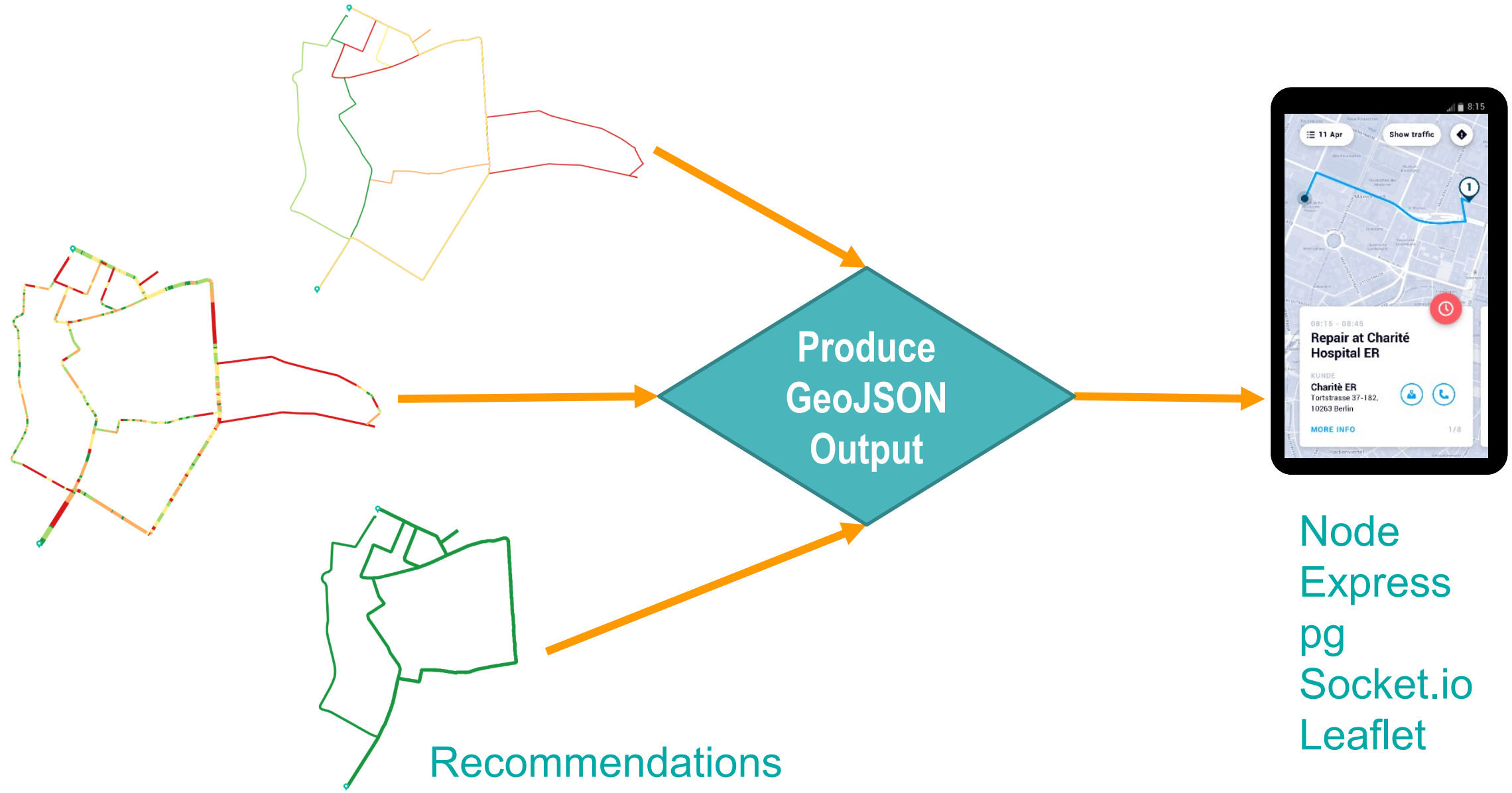


- Dump points
- Make lines with 2 points
- Group by line segment
- Use count to filter outliers



Road segments
with statistics

- Find unique line endings near start
- Recursive query to find line IDs
- Collect geoms and ST_LineMerge

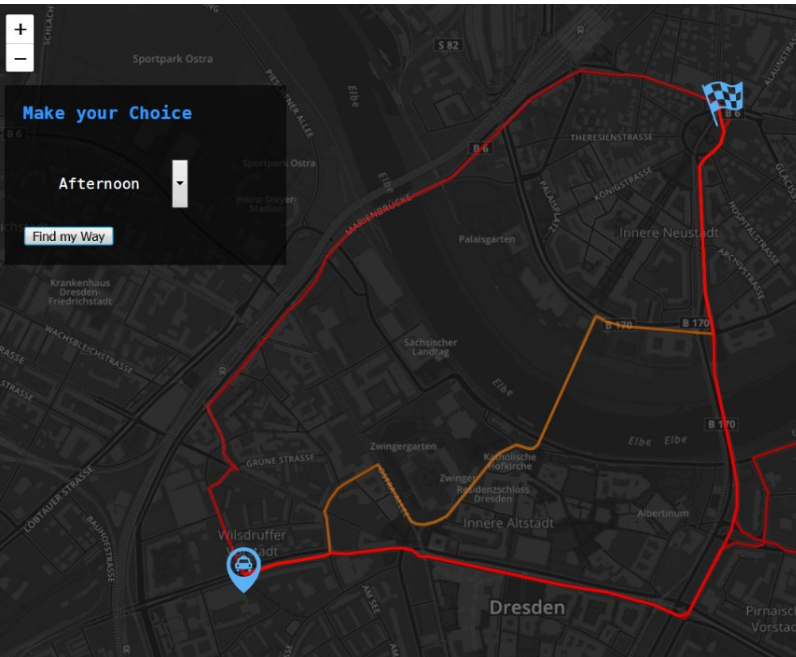




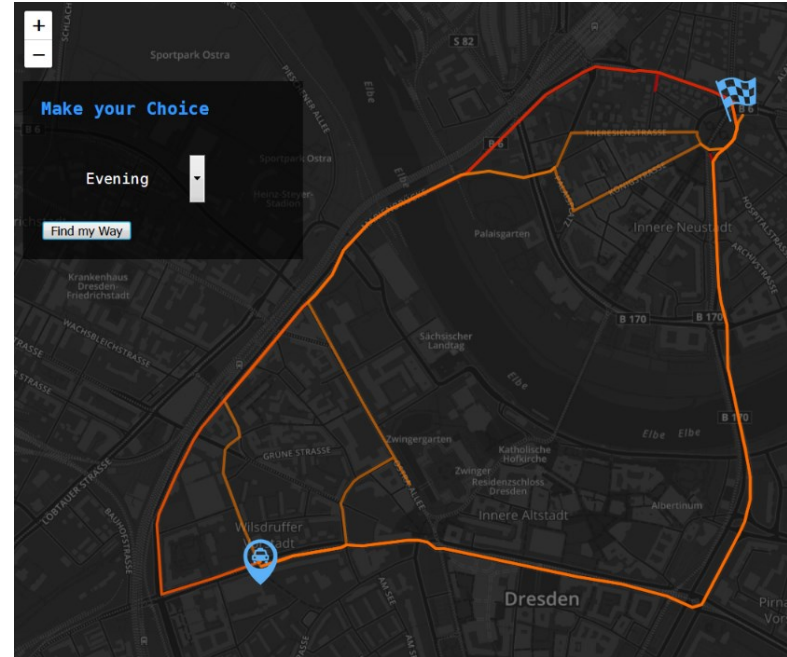
Differences during the day



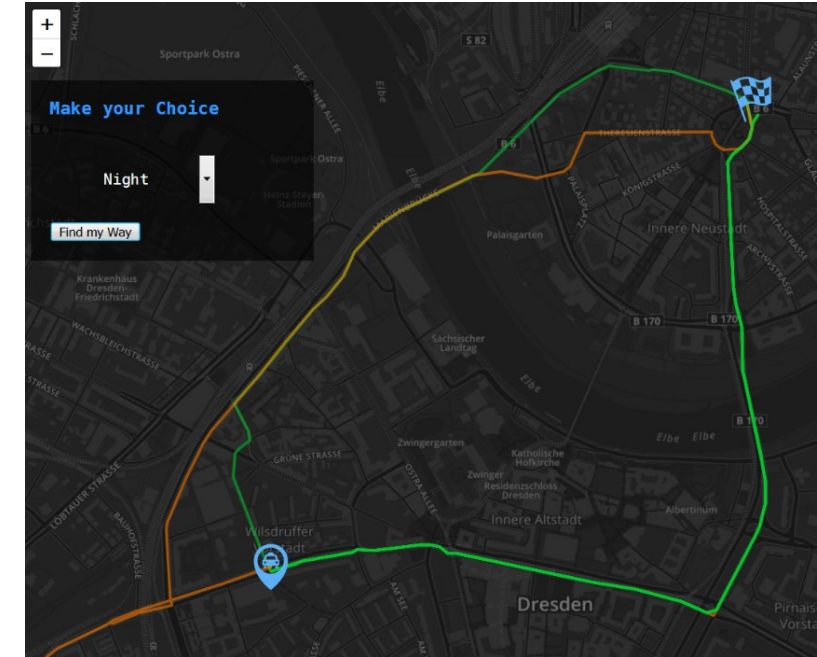
Afternoon (12 - 6 pm)



Evening (6 pm - 12)

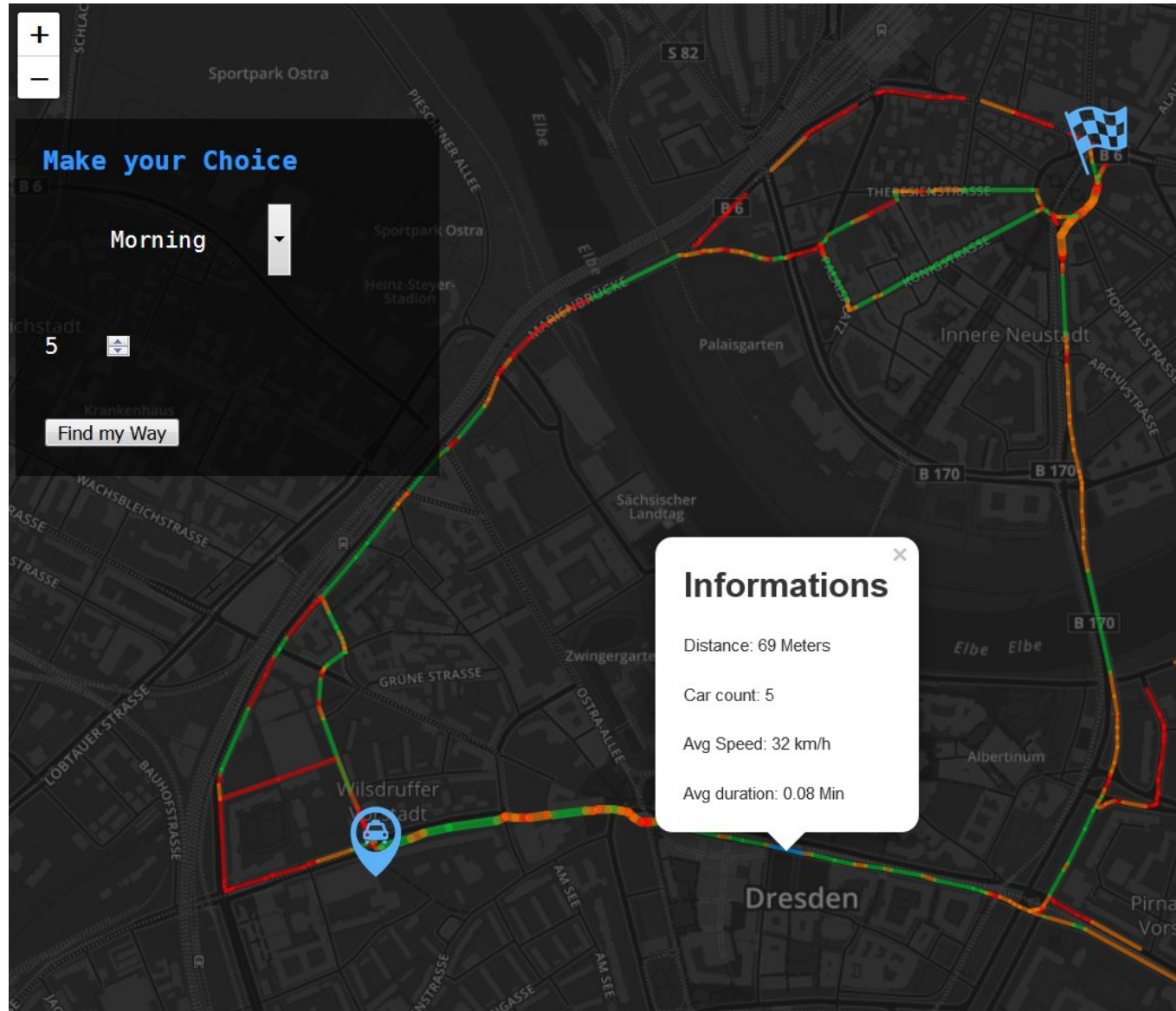


Night (0 – 6 am)



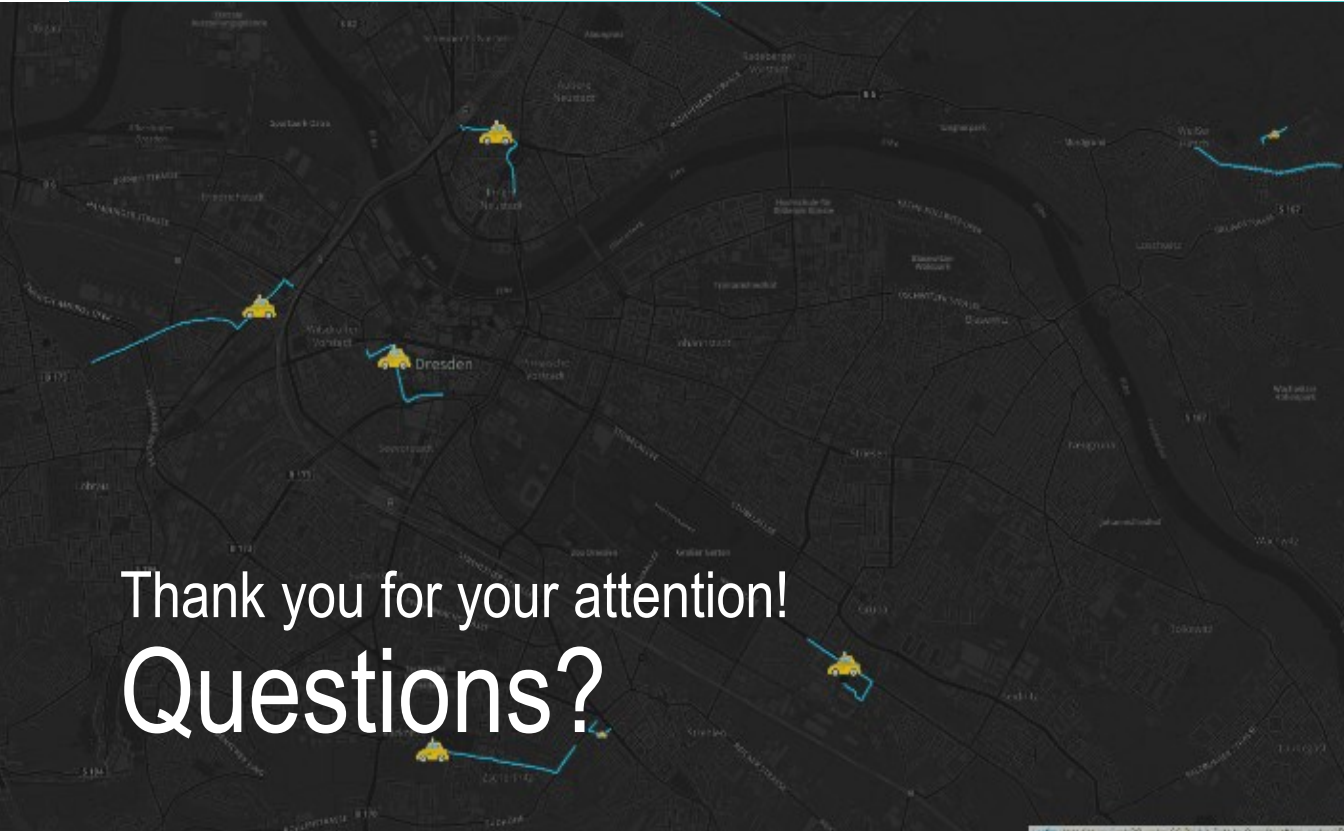
- Shortest way is the best between 6 pm and 6 am
- The higher the density the greater the trip variety
- Even taxis don't take short cuts through residential neighbourhoods

Aggregating trip infos per road segment





- Have trajectory data? Try LineStringM and PostGIS functions
- Spatial lookups on tracks by indexing smaller chunks of the linestring
- Still, too slow for route recommendations (especially on-the-fly aggregates)
- PostGIS 2.5: ST_FilterByM – Removal of stop points (if you cannot use map matching)
- PostGIS 3.0: Idea to have more dimensions for geometry – Interesting for xFCD
- App: github.com/MAGDa-BeuthHS/fcd-miner



Thank you for your attention!
Questions?

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Supported by:



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