LiRA Status Workshop: WP3
Production and Validation

Ekkart Kindler, Shahrzad M. Pour and
Markus Berthold

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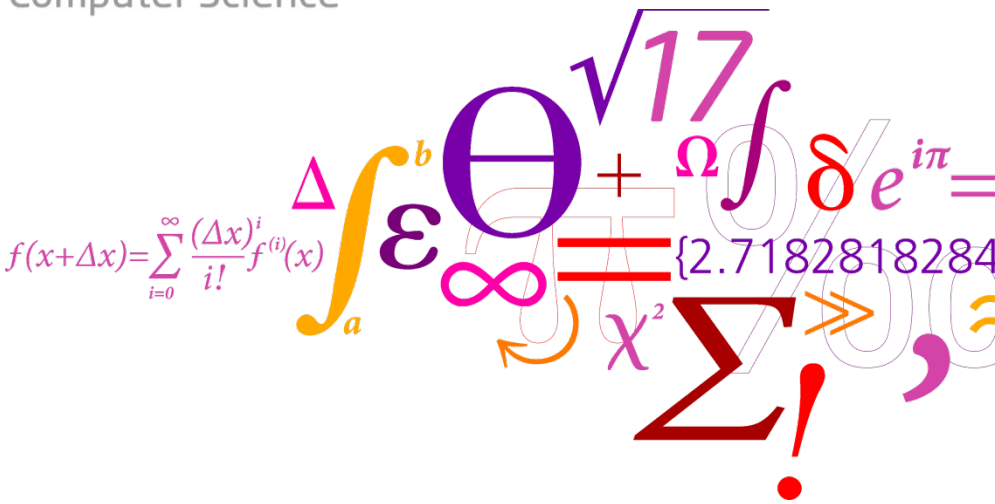

Overview

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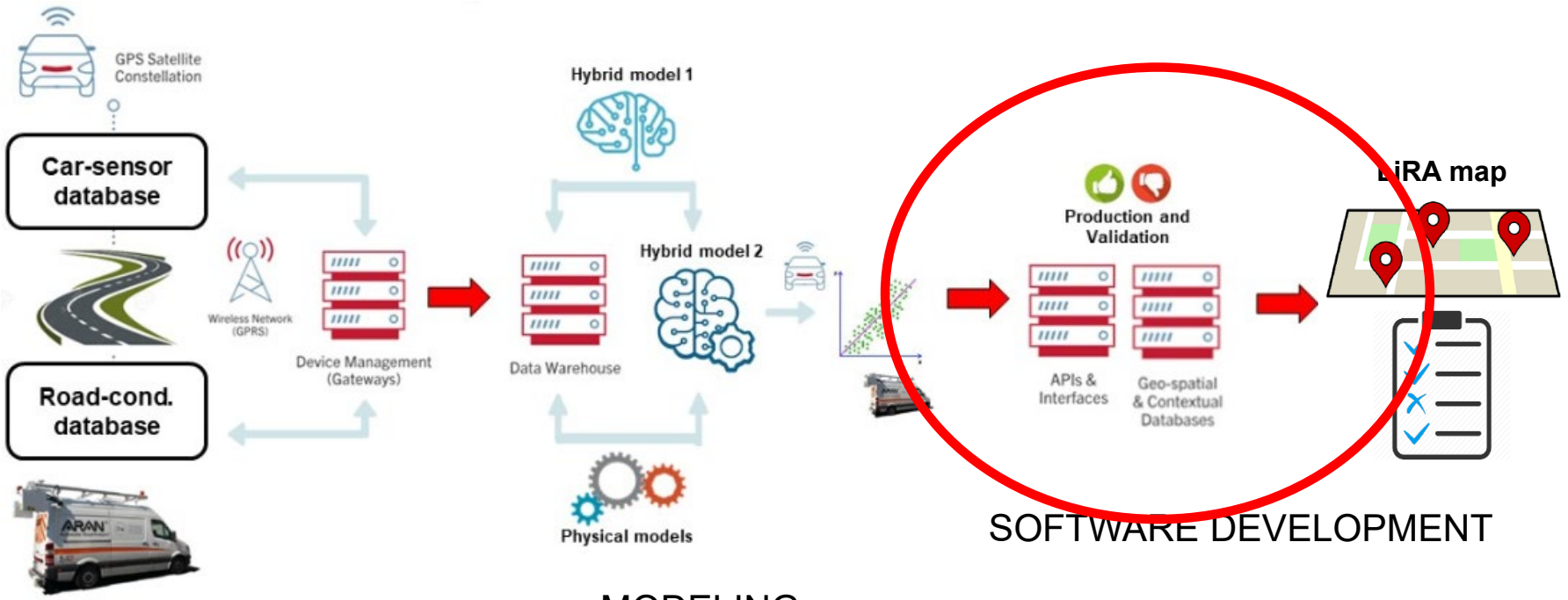
First slide from Kick-off Meeting in February 2019



Changes of Plan

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- Post Doc position for WP3 filled only from Oct. 14, 2019 and for 2 years full-time instead (3 years 2/3 part-time)

- After LiRA SC meeting in September 2019: shift of focus: LiRA Data Warehouse

But work on Production and Validation Tasks still actively pursued

Overview

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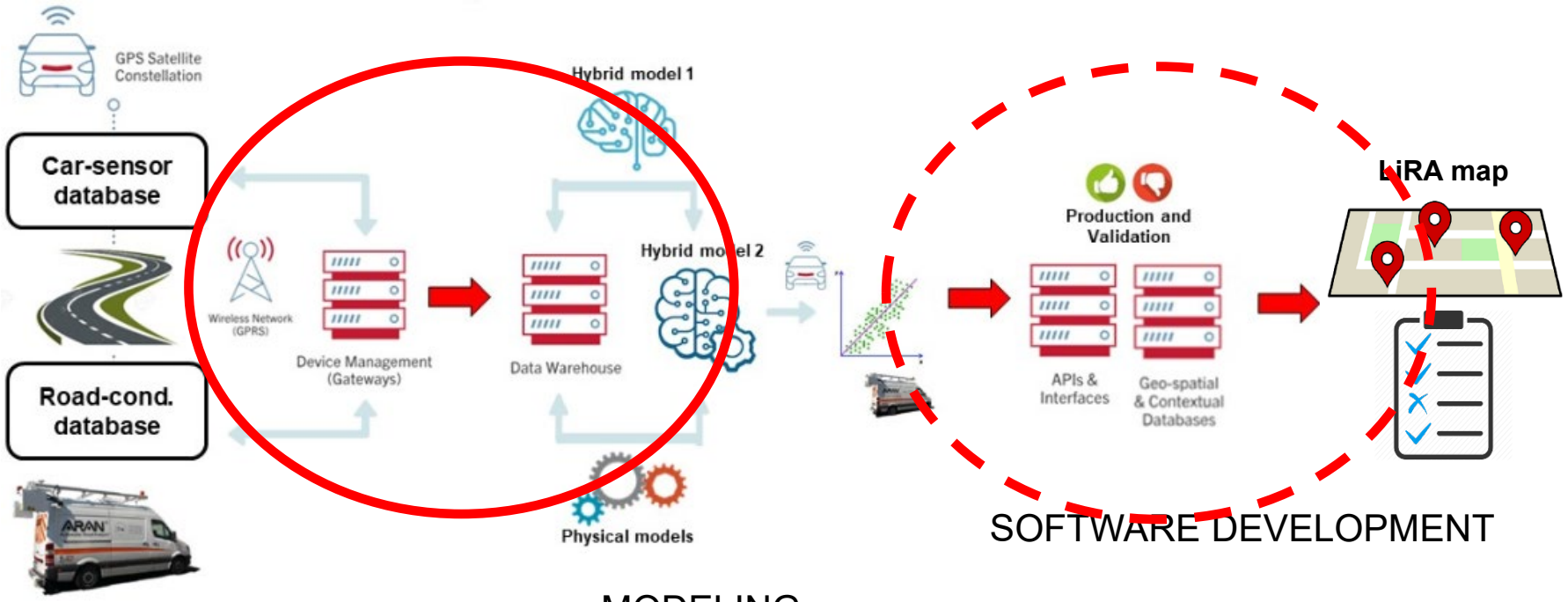

LiRA Data Warehouse:
Concepts, data model, architecture and data collection and processing pipelines

Ekkart Kindler, Shahrzad M. Pour and
Markus Berthold

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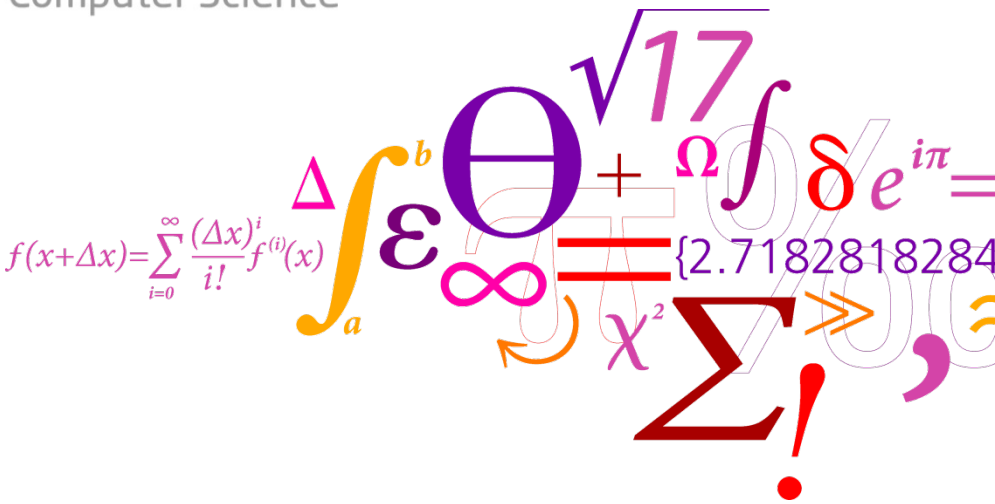

Outline

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- Introduction and overview
- Concepts (domain analysis)
- Design and architecture
- Detailed models
- Data processing pipelines
- Demo

Open Street Map (OSM)

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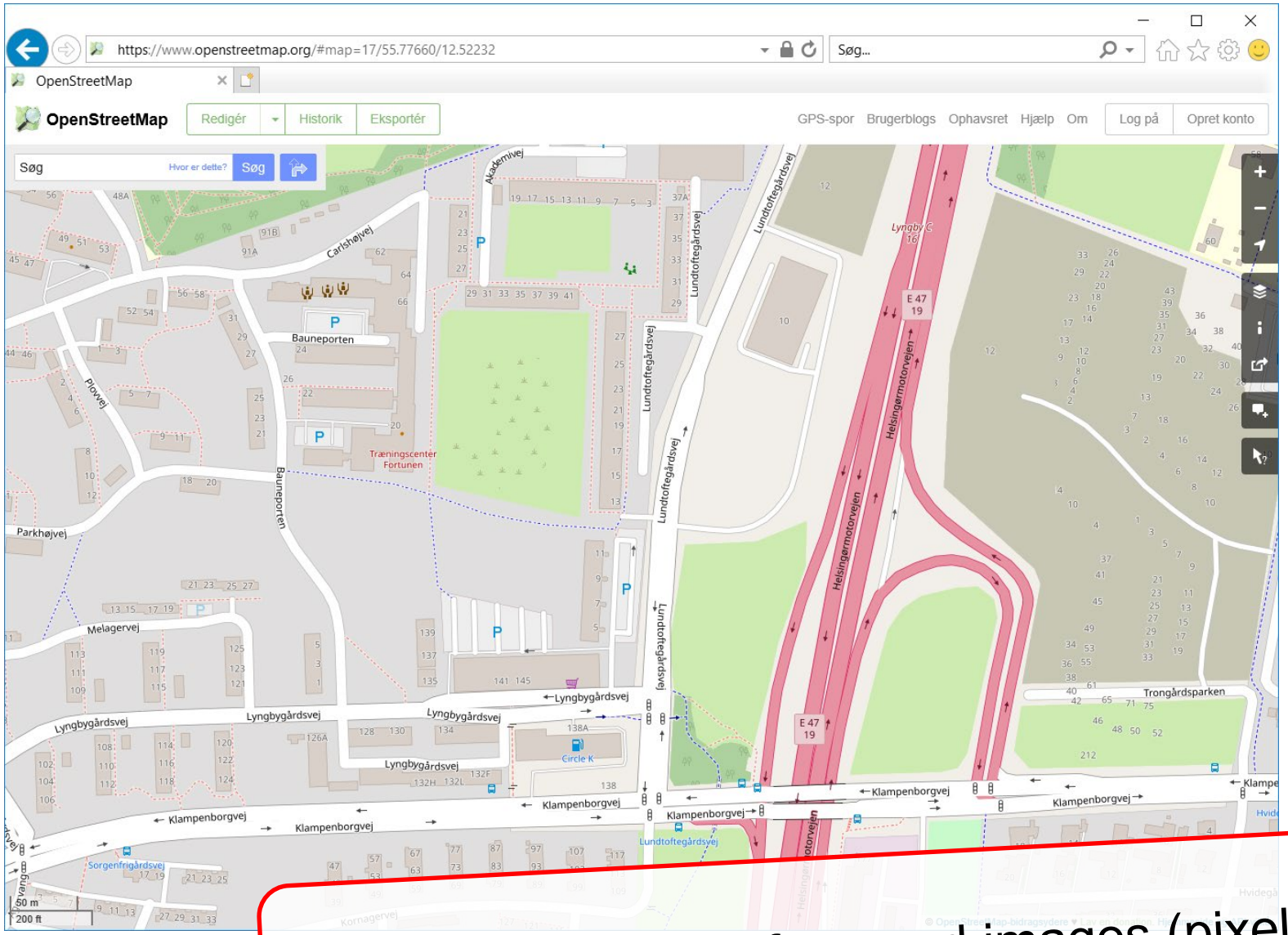

Basically, just geo-referenced images (pixels)!

OSM: Map Data

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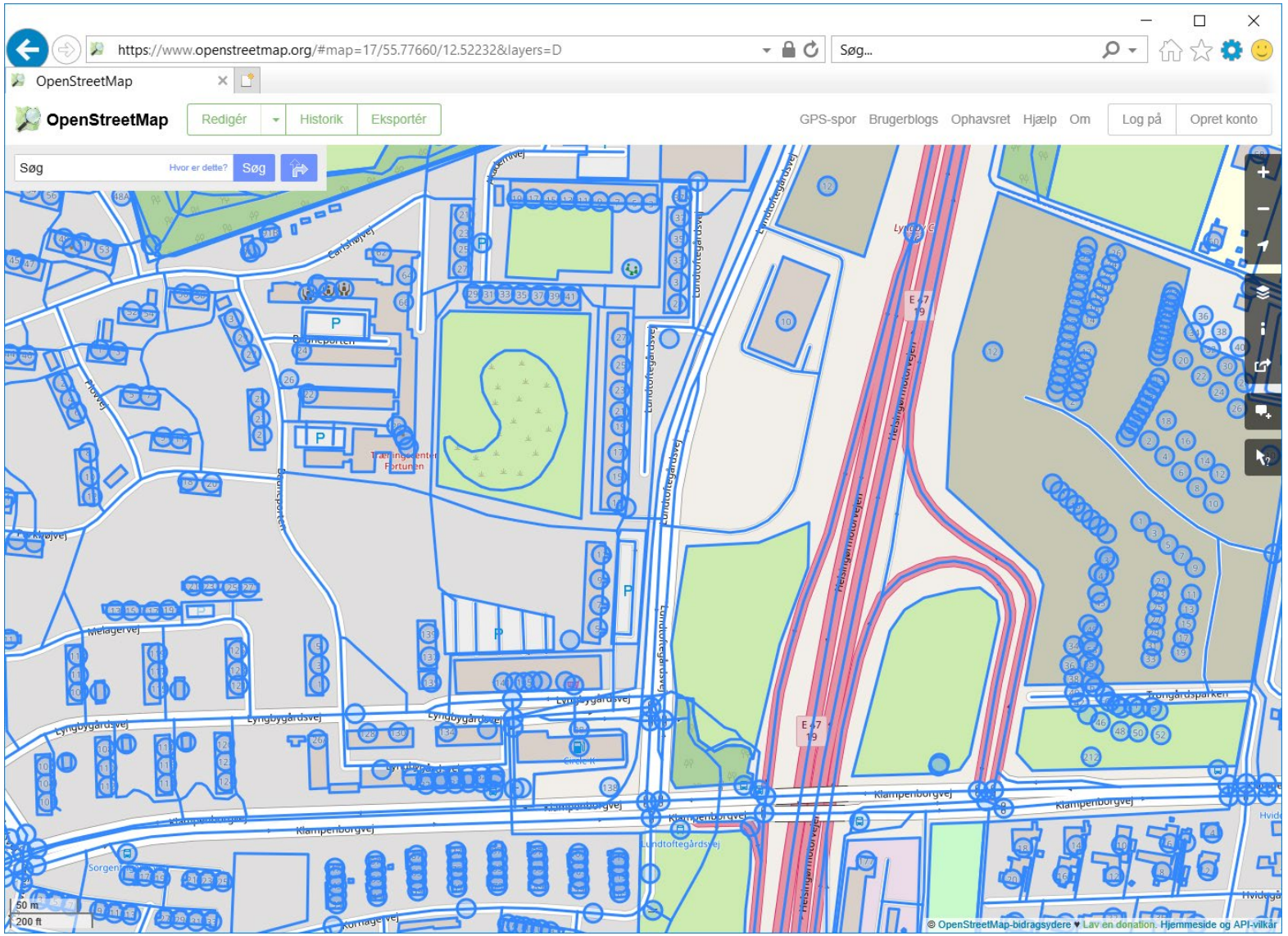

OSM: Way with Tags

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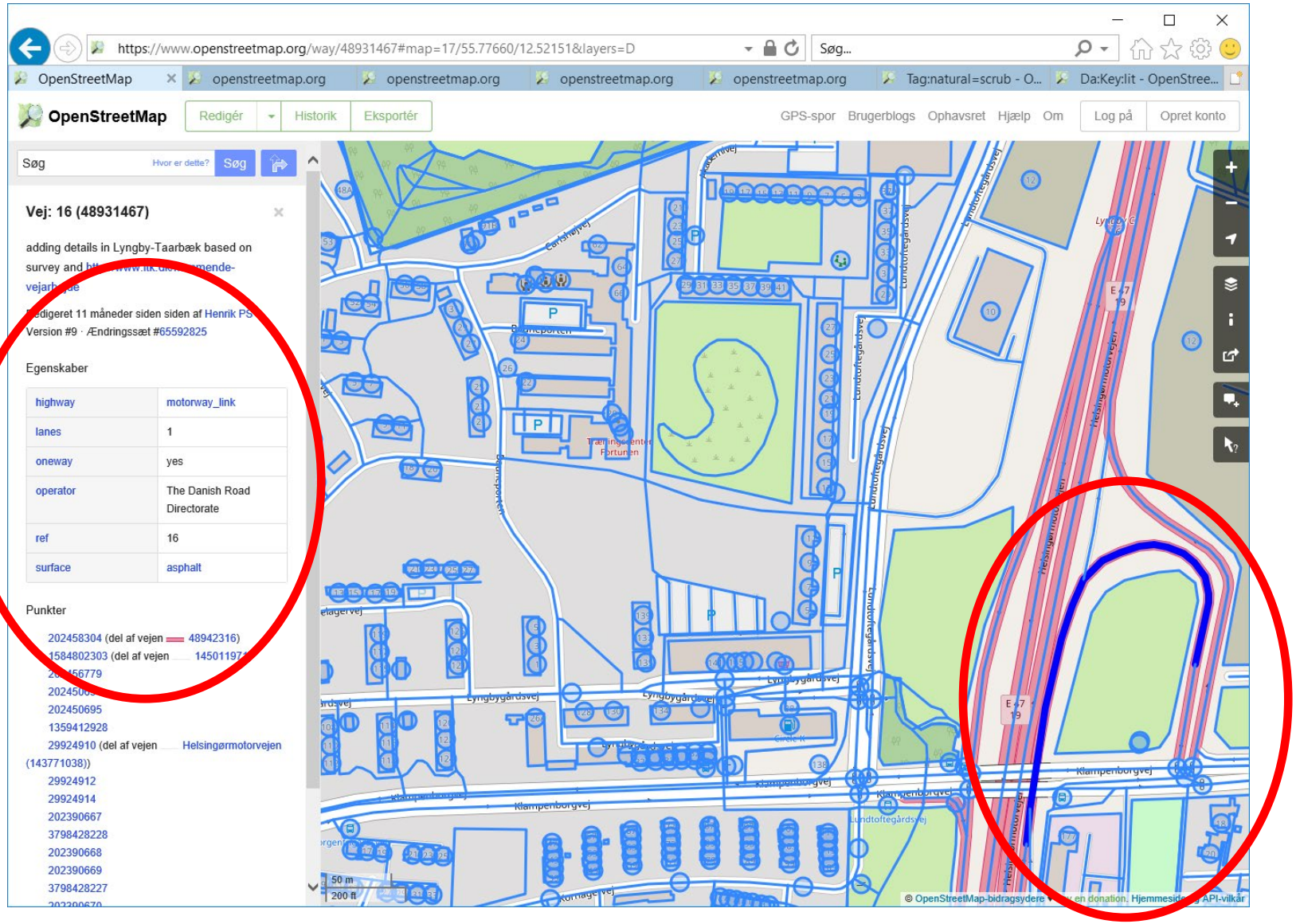

Core Concepts

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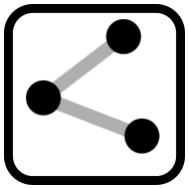
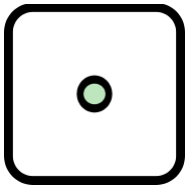
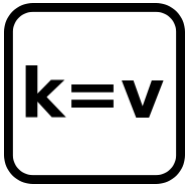
- Way / Section



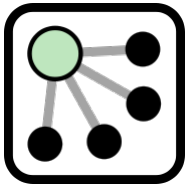
- Node / Point



- Tags / Attributes



- Relations



Car data

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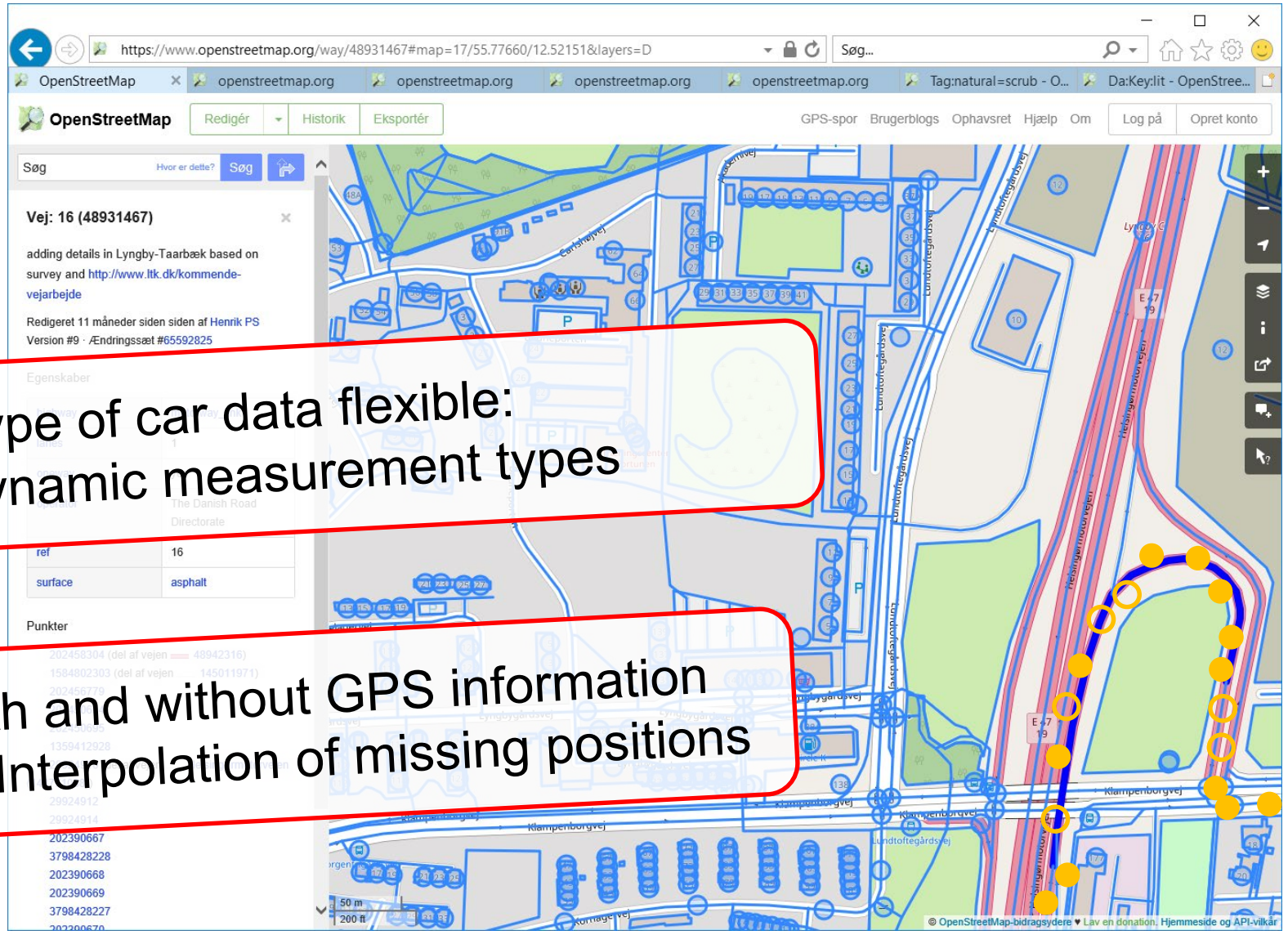

Car data

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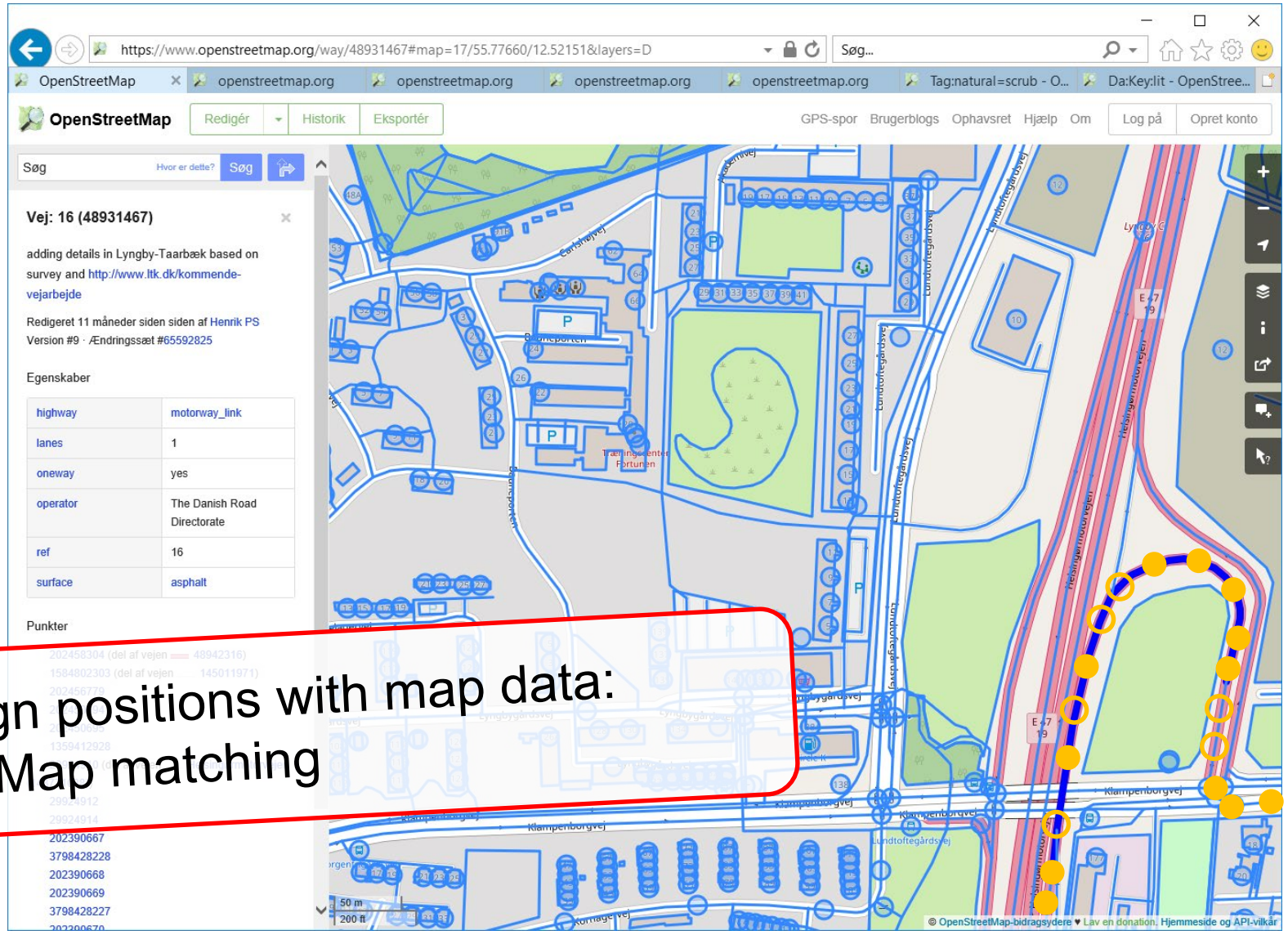

Align positions with map data:
→ Map matching

Road state data

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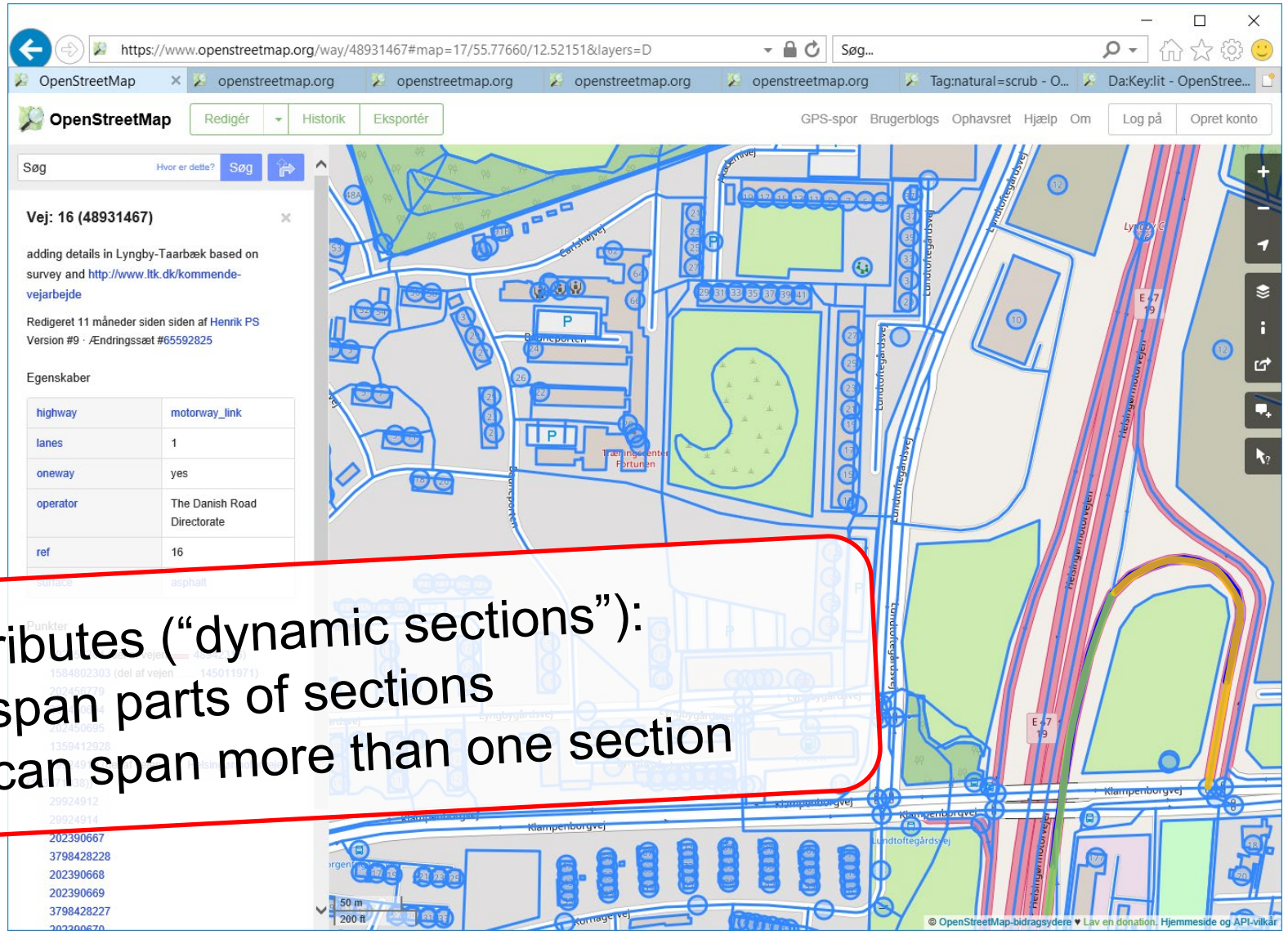

Attributes (“dynamic sections”):

- span parts of sections
- can span more than one section

Data Collection: Steps

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- Collect data raw data from cars (per trip)
- Clean data
- Calculate position for data without positions (Interpolation)
- Map positions to sections

Simplified Data Model

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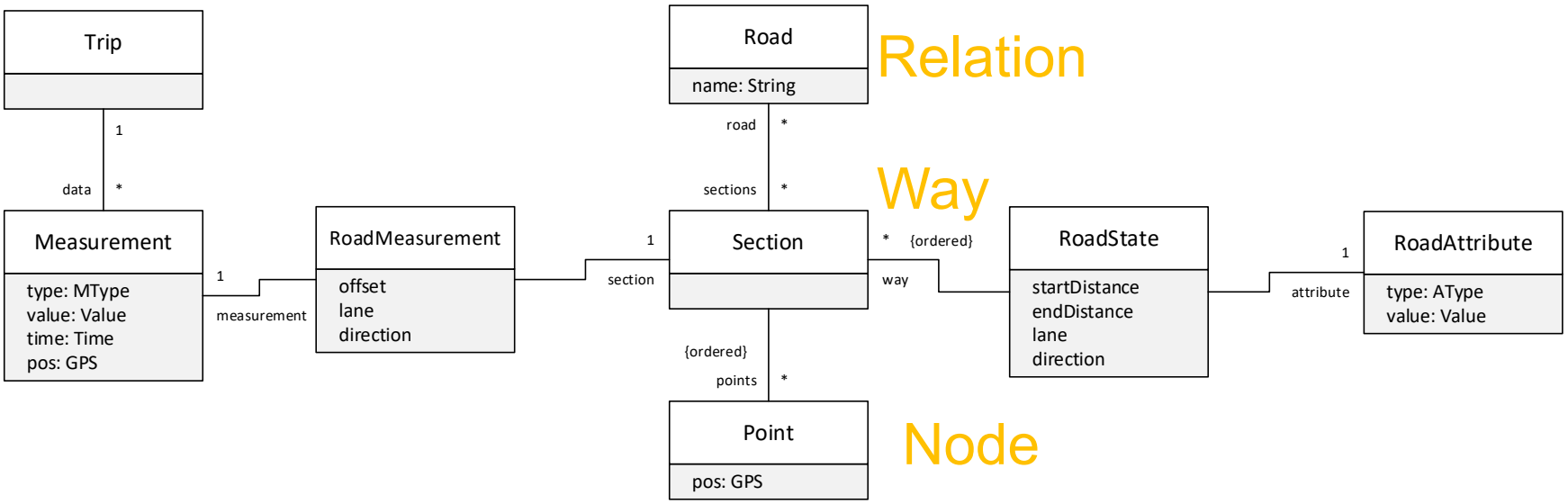
Car Data (from GM) Static road data (OSM, Sweco, …) Dynamic road data …



Outline

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- Introduction and overview
- Concepts (domain analysis)
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Design

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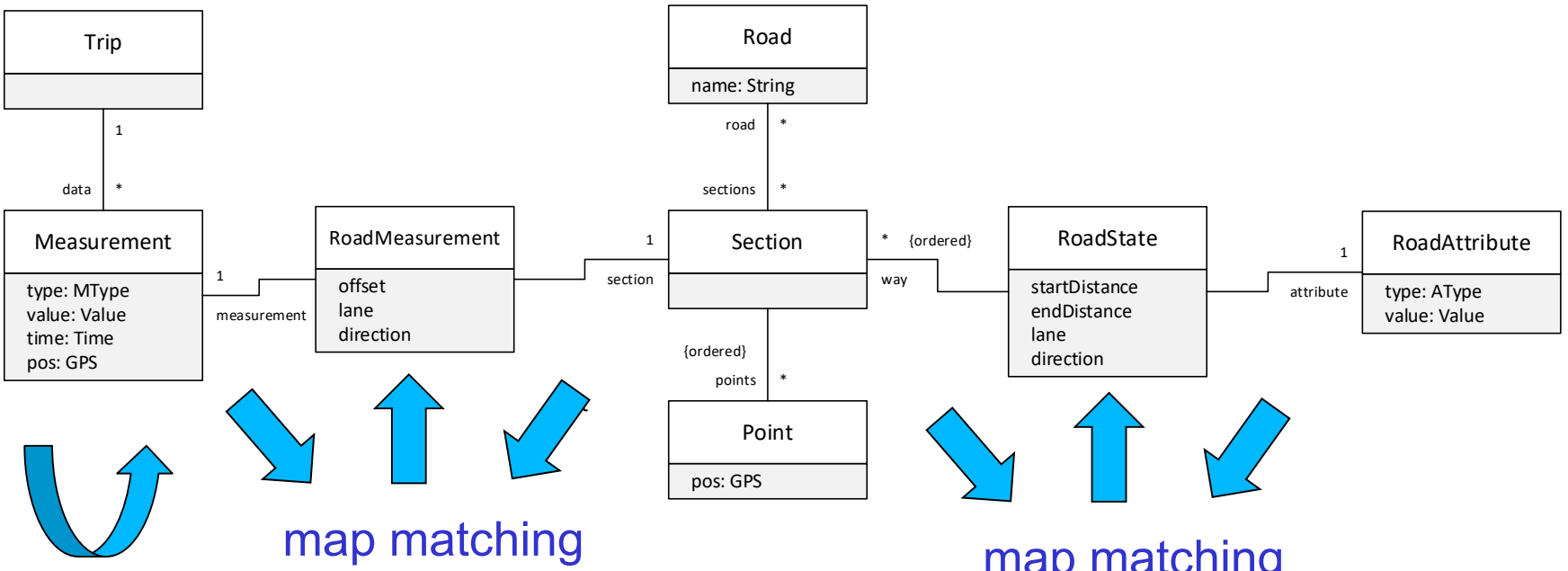
data collection (GM)

Initial data (VD)



- data cleaning
- GPS interpolation

Design

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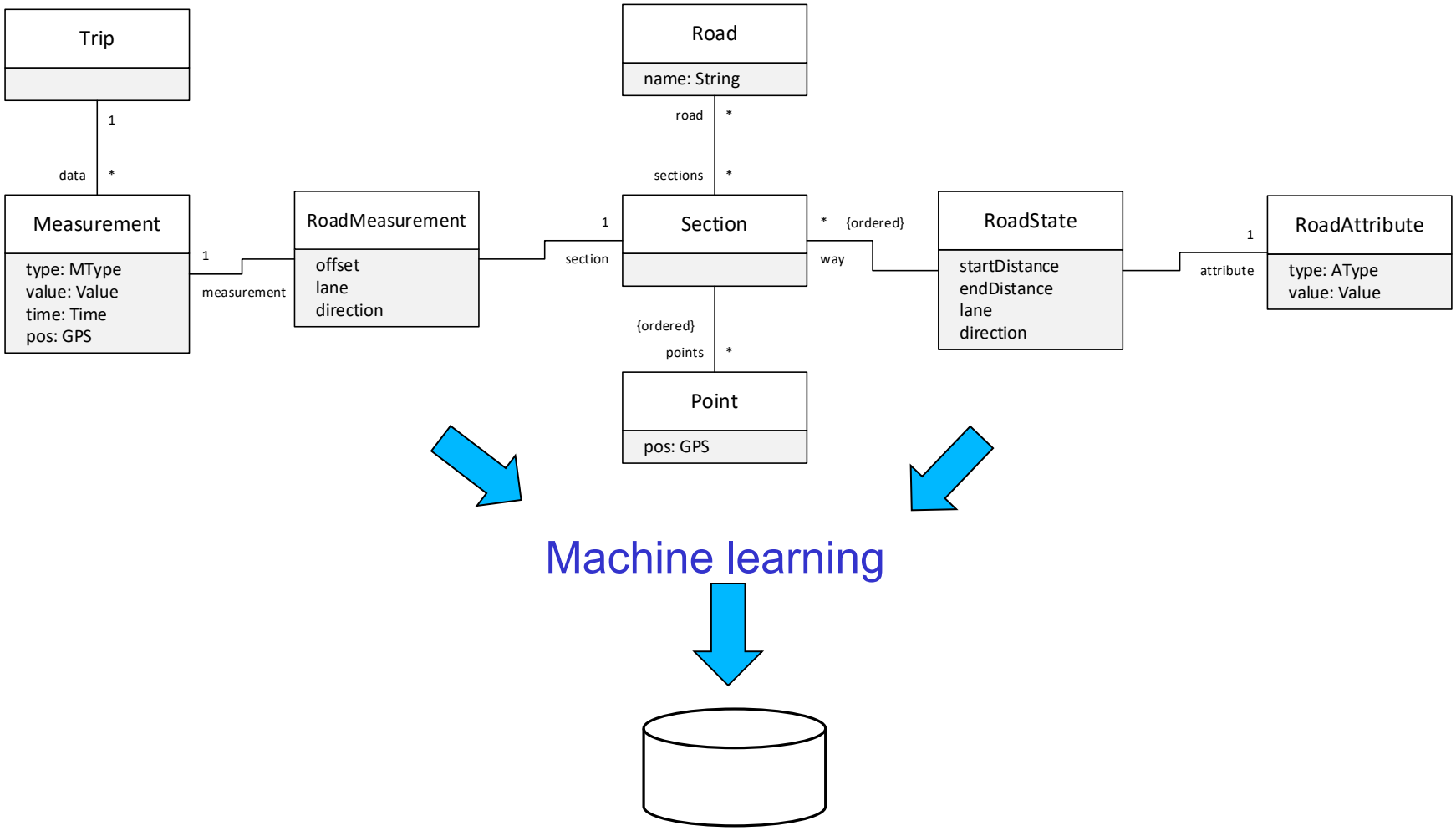

Design

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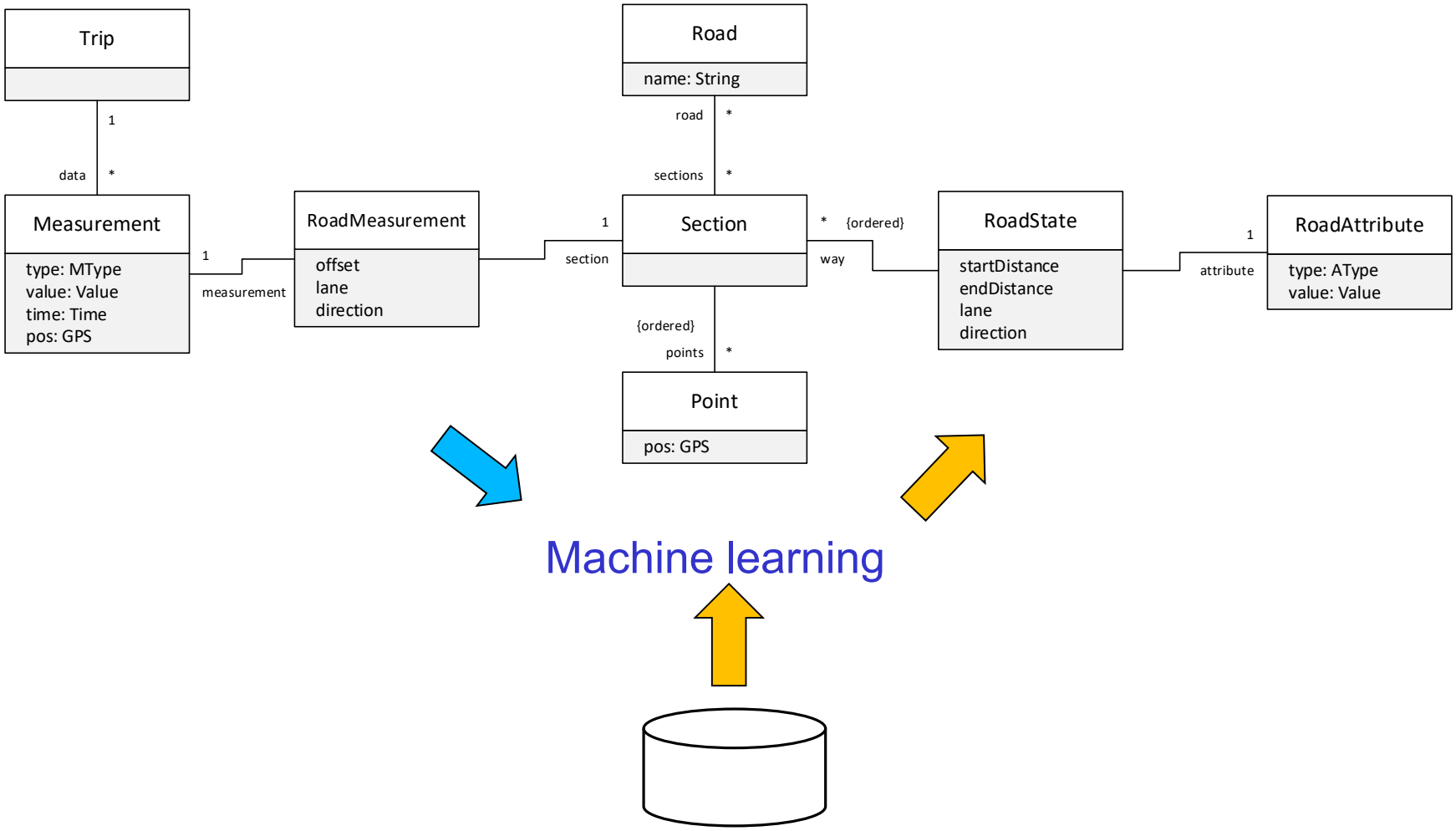

Status and Plan

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- Dec. 2019:
  Initial version on Working paper on
  LiRA Concepts, Design and Architecture of Data Warehouse

- January 2020:
  First internal implementation of minimal version of Data Warehouse (data collection and preprocessing)
- Requirements (Validation and Production): First technology experiments and report (MSc Project January 2020)

IoT Design methodology [1]

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Device:

AutoPi

- Device
  - token Id
- Trip
  - Start and end position
  - Start and end time
  - Device Id
  - List of events
  - Tag (Personal/Business)

Physical entity:

Vehicle

- Event types
  - track position (GPS)
  - accelerometer
  - device events
  - obd
  - rpi
- Event
  - Object Id
  - Timestamp
  - Type
  - Attributes (flat/structured)

Virtual Entity:

Trip

1. (Introduced by Bahga & Madisetti, 2015):

Raw data Domain Model

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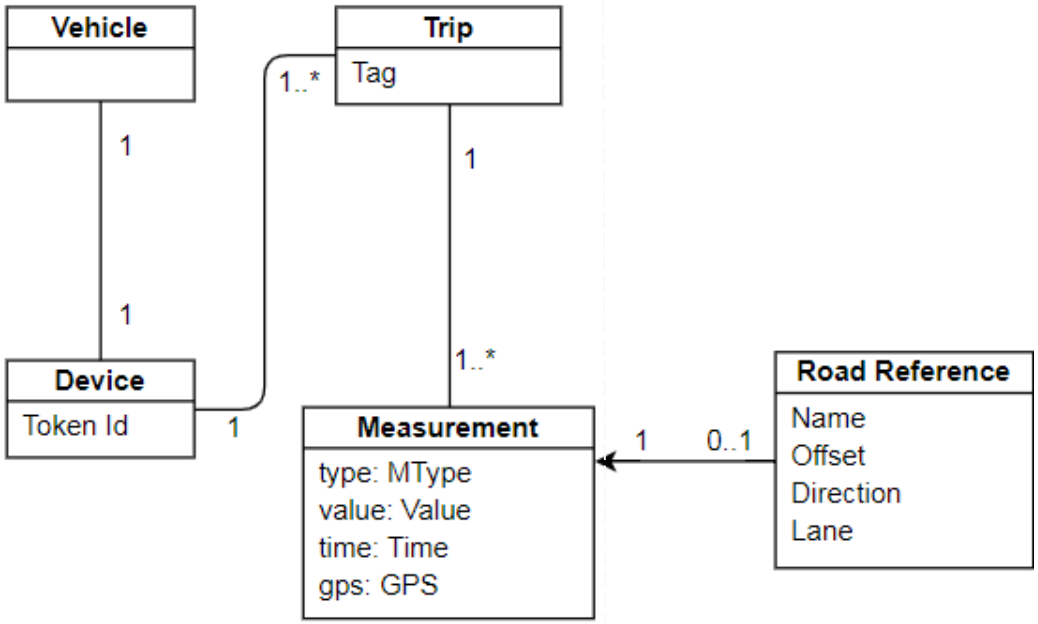

Raw data Pipeline Interface

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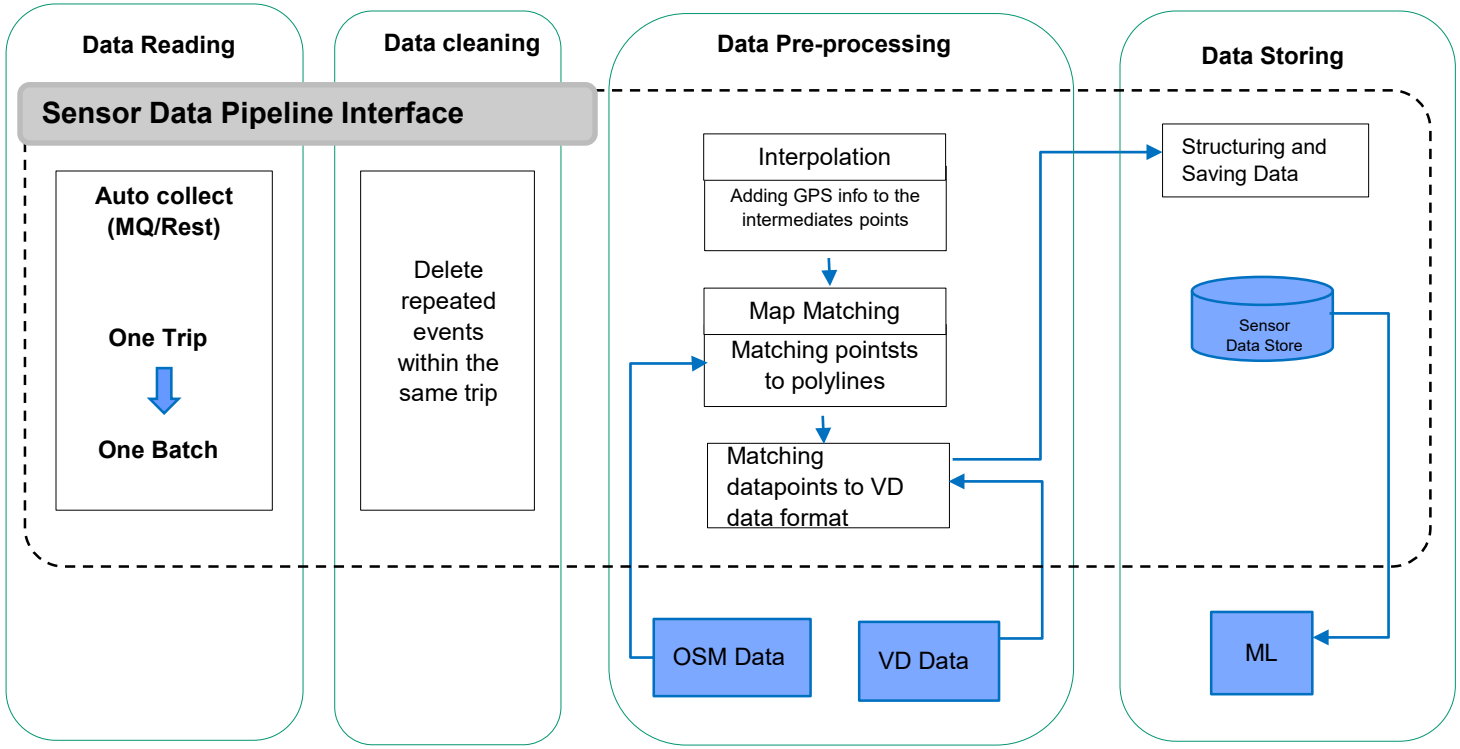

Data Reading

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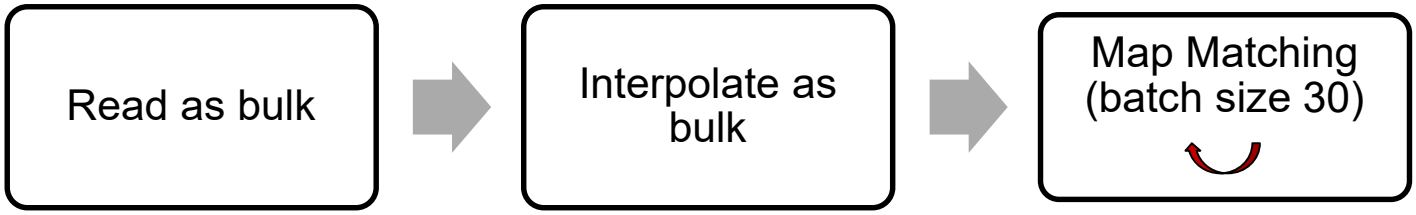
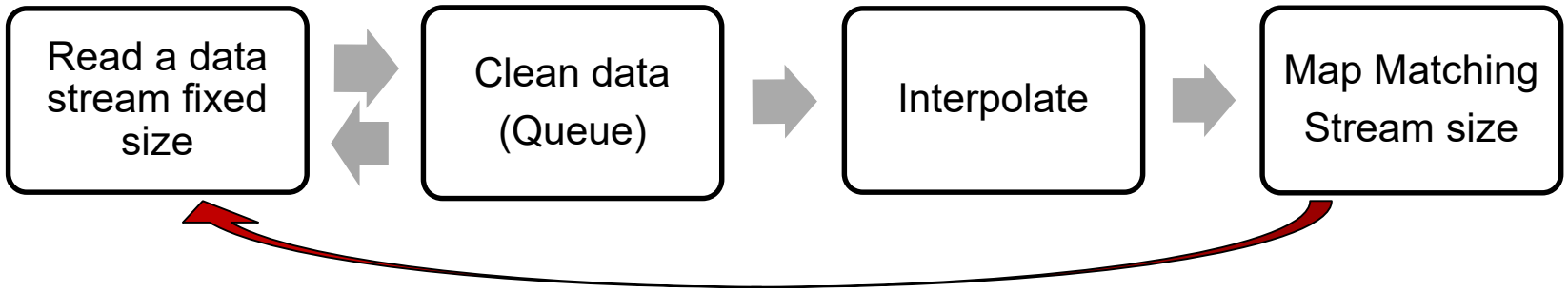
- Batch Streaming
  - JSON input file



- Data Streaming
  - *GreenMobility* Server
  - Read by stream size of fixed number



Data Cleaning

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- Removing the repeated track position events
- Remove events which require extrapolation
- Can be enriched to outlier removal

Pre-Processing: Interpolation

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- each non "track-position" event at a given timestamp needs to be interpolated as a GPS location between other GPS locations obtained by "track-position" events

- Development of three types:
  - Linear
  - Quadratic
  - Cubic splines

$$(x_0, y_0), \ldots, (x_j, y_j), \ldots, (x_k, y_k)$$

$$L(x) := \sum_{j=0}^{k} y_j \ell_j(x)$$

$$\ell_j(x) := \prod_{\substack{0 \le m \le k \\ m \ne j}} \frac{x - x_m}{x_j - x_m} = \frac{(x - x_0)}{(x_j - x_0)} \cdots \frac{(x - x_{j-1})}{(x_j - x_{j-1})} \frac{(x - x_{j+1})}{(x_j - x_{j+1})} \cdots \frac{(x - x_k)}{(x_j - x_k)},$$

Pre-Processing: Map Matching

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- Map-matching is the process of aligning a sequence of observed user positions with the **road** network on a digital map.

- Hidden Markov Model Map matching

  (Paul Newson and John Krumm, 2009)

- Map Matching Service from OSRM library
  - from Open Source Routing Machine(OSRM)
  - It matches/snaps given GPS points to the road network

- Map Matching to **Segments**

haven't been fulfilled yet:

- Require the annotator function from

OSRM library

Data Storing

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- Postgresql database management system

Id
objectId
t
token
ts
tag
lat
lon
message
IsComputed
MapMatched_lat
MapMatched_lon
MapMatched_wayPointName

Road States

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- A Geographic Information System (GIS) :

  facilitating the end user's maintenance planning

  - Domain analysis of Rosy and Vejman
    - Rosy:
      - A pavement management system by Sweco
      - Various layers of information (defect, general traffic)
      - On top of OSM per section
    - Vejman:
      - A pavement management system
      - (general knowledge and road data, operational data)
      - General map (OSM or other topological map) and a lighter version of map
      - Condition Index

- Chosen attributes from Rosy and Vejman:
  - Sectioning
  - Open Street Map (OSM)
  - Condition Index

Domain Model

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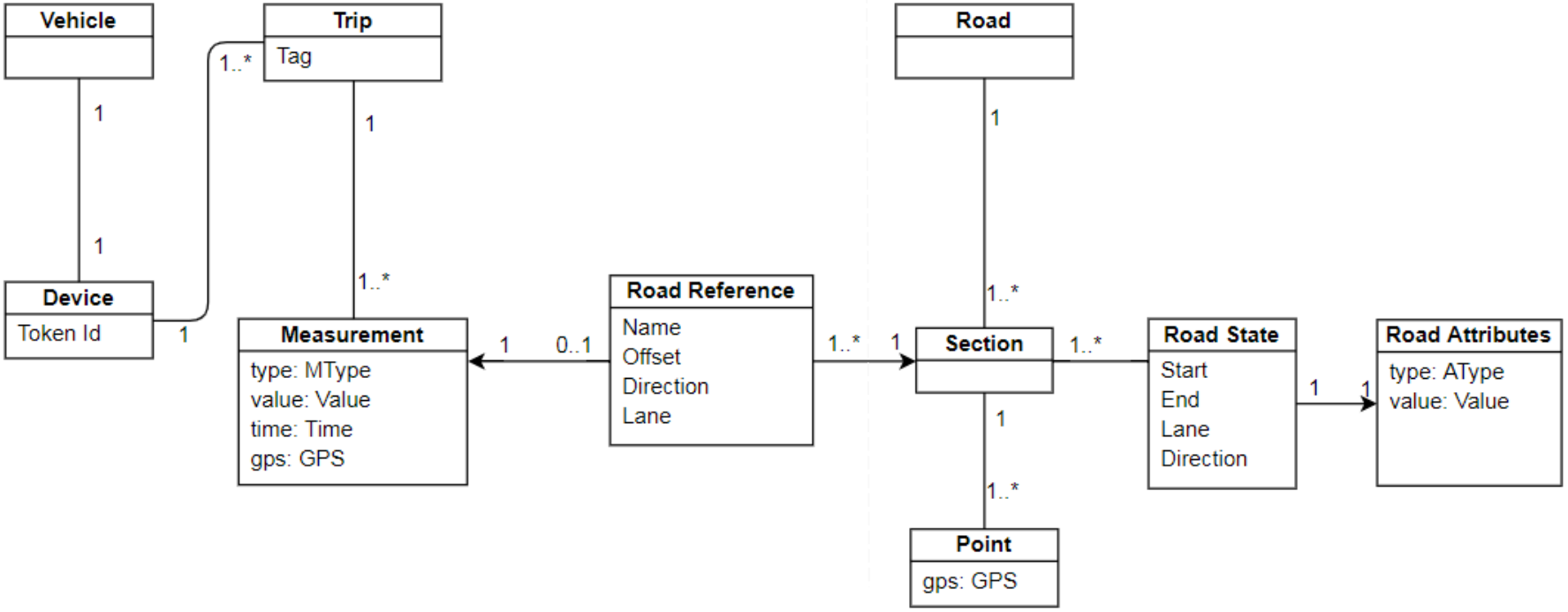
Raw data

Road state



Data Pipeline Interface:

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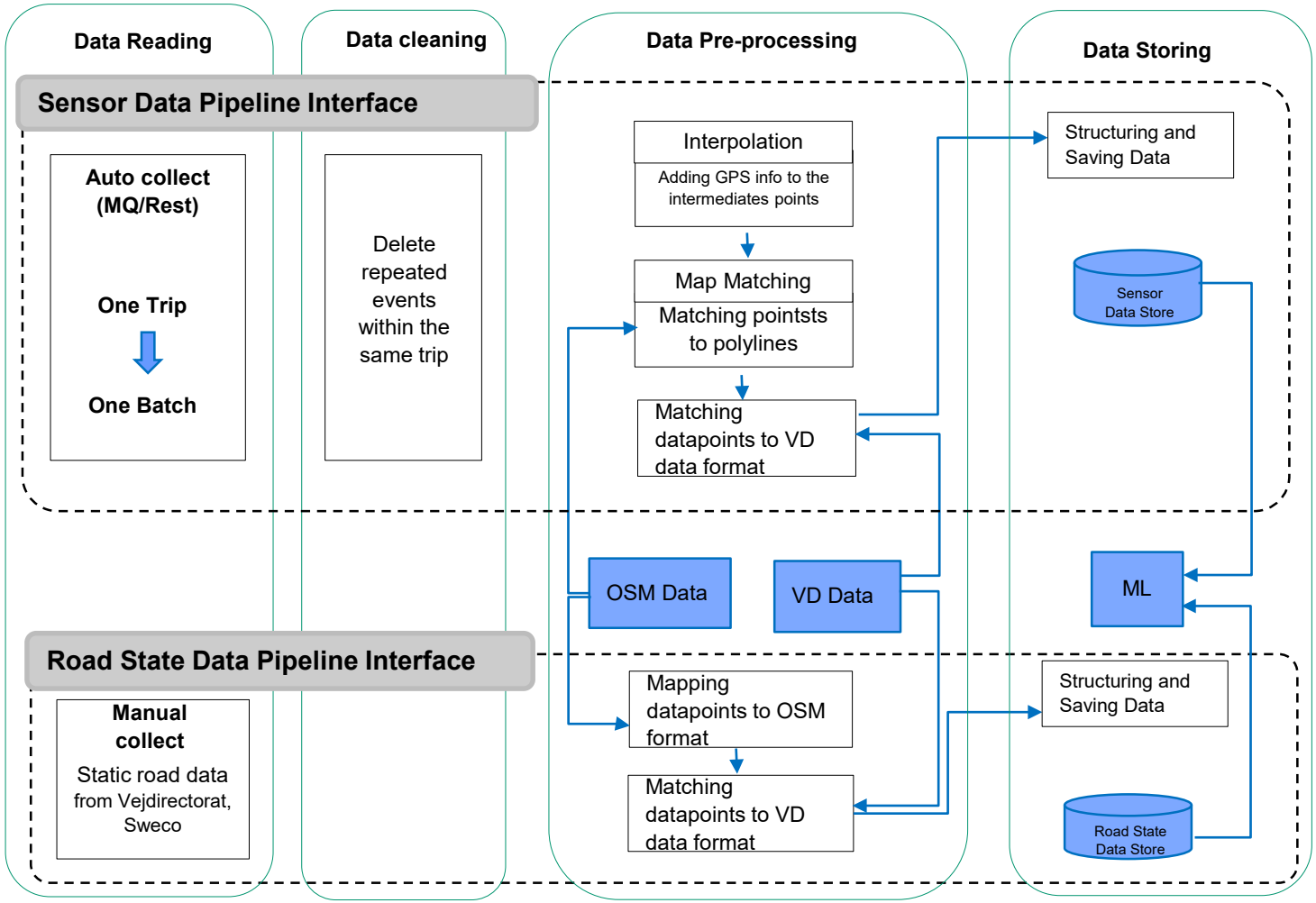

Operational View Specification

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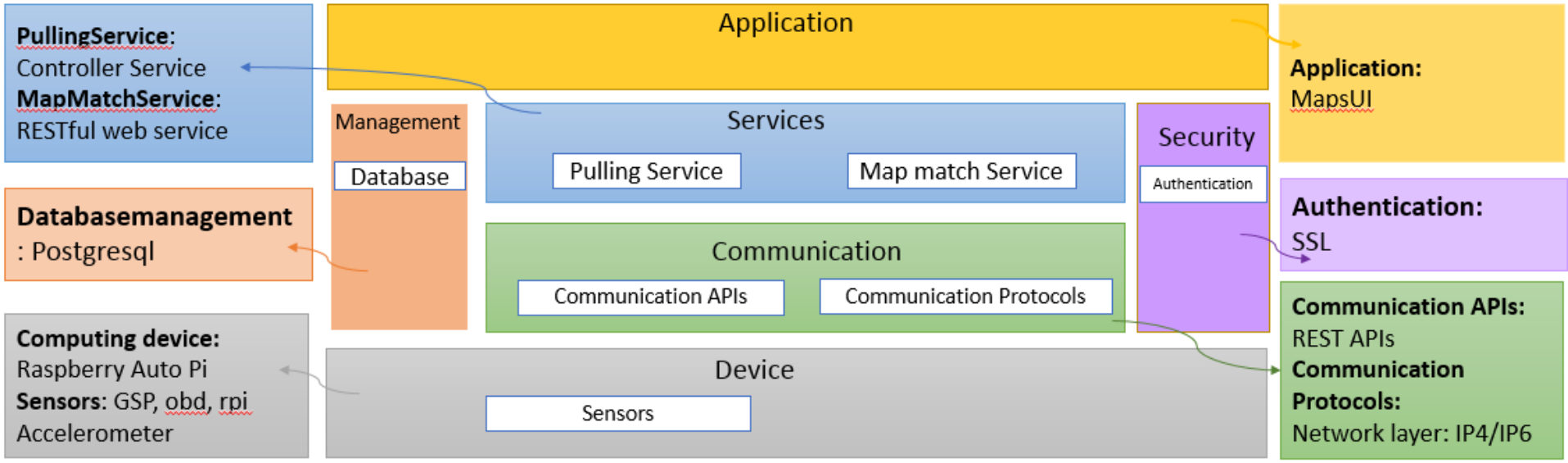

Operational View Specification in LiRA project inspired by the figure of Operational View Specification represented by (Bahga & Madisetti, 2015)

future works

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