



Mobility Data Management & Exploration

Ch. 05.
Moving Object Database
Engines

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Chapter outline

5.1. From Spatial Database Systems to MOD Engines

5.2. A Data Type Model for Trajectory Databases

5.3. Extending the Trajectory Data Type Model with Object Methods and Operators

5.4. On Mobility Data Provenance

4.5. Summary



5.1.

From spatial database
systems to MOD engines

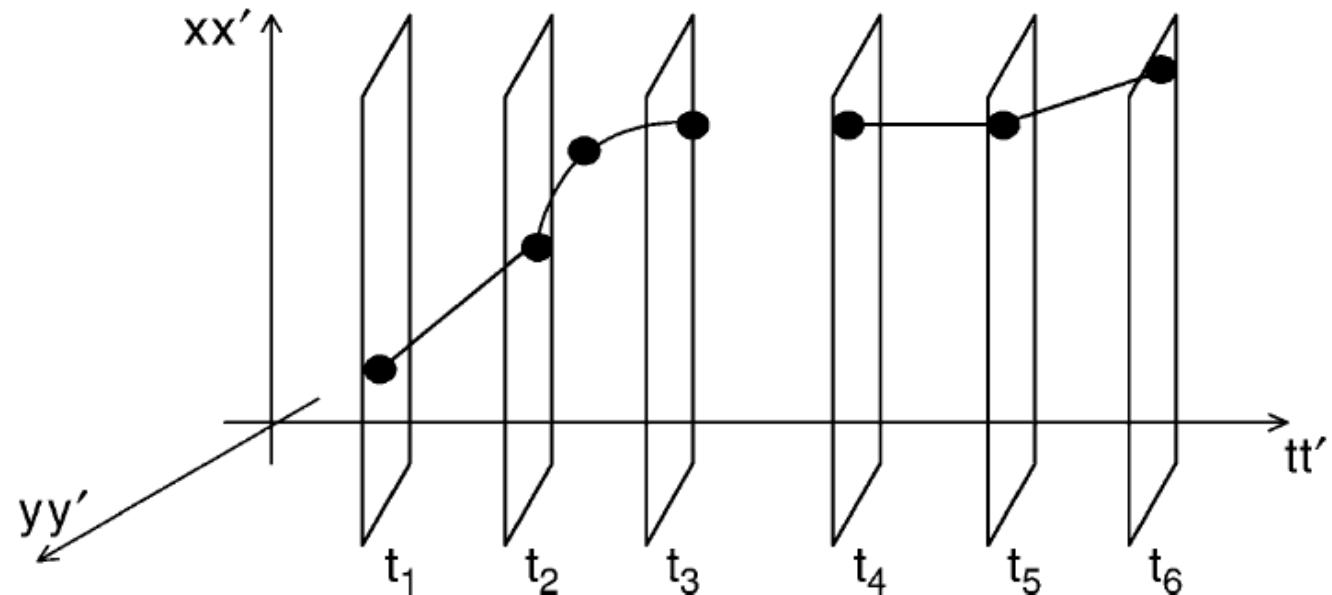
MOD Systems

- From traditional DBMS to **Moving Object Database (MOD) engines**
 - Objective: spatial and temporal dimensions to be considered as first-class citizens.
- Current MOD solutions:
 - Spatial DBMS simulated to work as MODs (e.g. PostGIS) vs.
 - State-of-the-art MODs (Secondo, Hermes, etc.)
- A quick note on the PostGIS solution:
 - PostGIS supports 2D/3D/4D geometry data types
 - Hence, a trajectory can be simulated by a 3D path (= sequence of 3D points)

MOD Systems

- Prototype MOD engines for archival (trajectory) data
 - **SECONDO** (2002-) by Güting et. al. @ Uni. Hagen
 - **HERMES** (2006-) by Pelekis et. al. @ Uni. Piraeus
- Both are based on the 'sliced' representation of trajectories*

* Recall Chap. 3

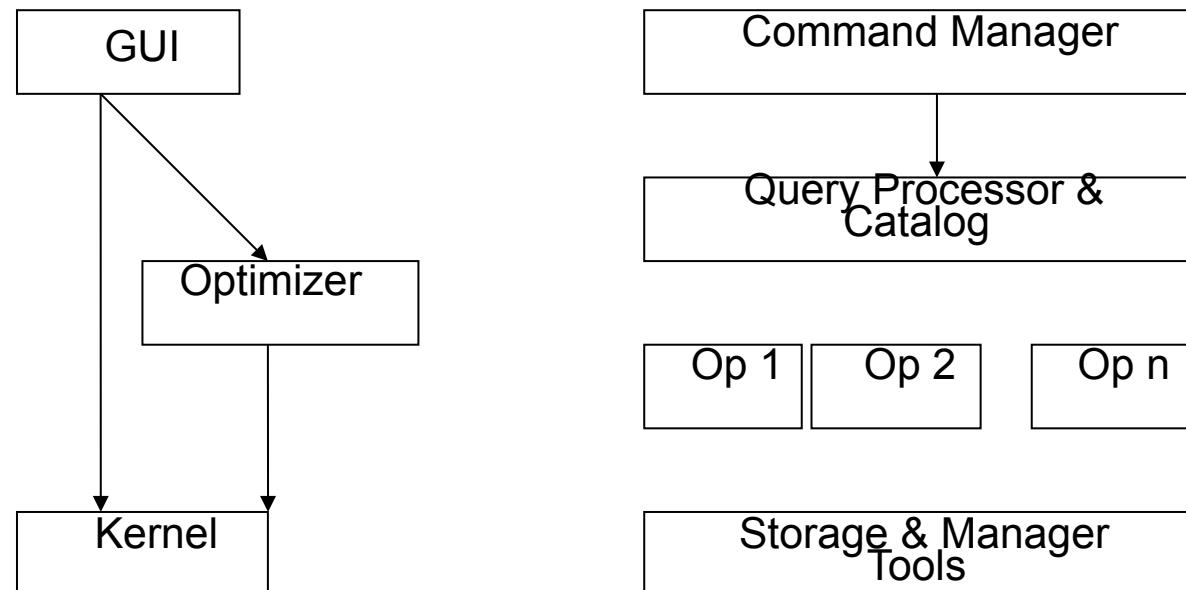


- Data model: from (static) spatial to moving object data types

inside[point region] → bool

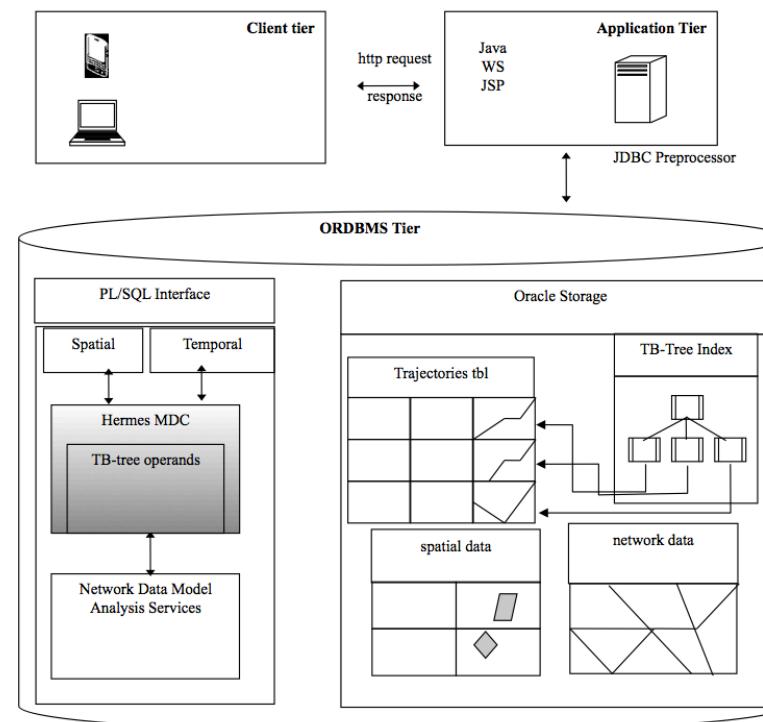
inside[moving point region] → mbool

- Query optimizer: includes optimization of conjunctive queries, selectivity estimation, and implementation of an SQL-like query language

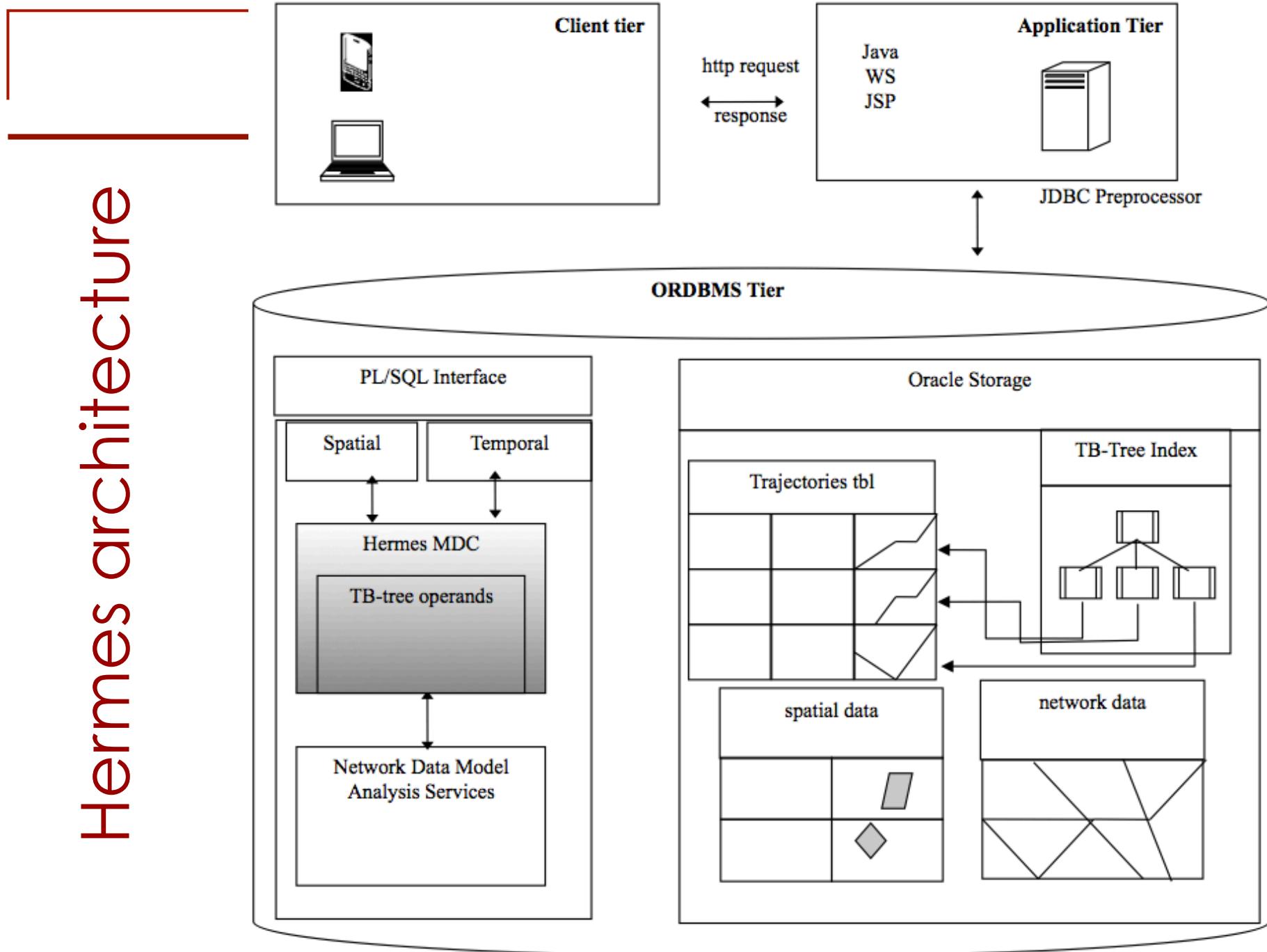


Hermes

- A palette of moving object data types ...
- ... access methods and indexes (3D R-tree, TB-tree)
- ... on top of an extensible DBMS (2 variations)
 - Oracle Spatial
 - PostgreSQL

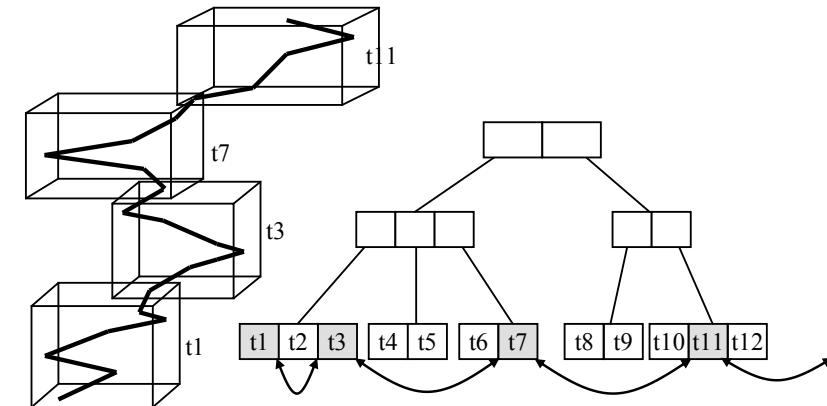
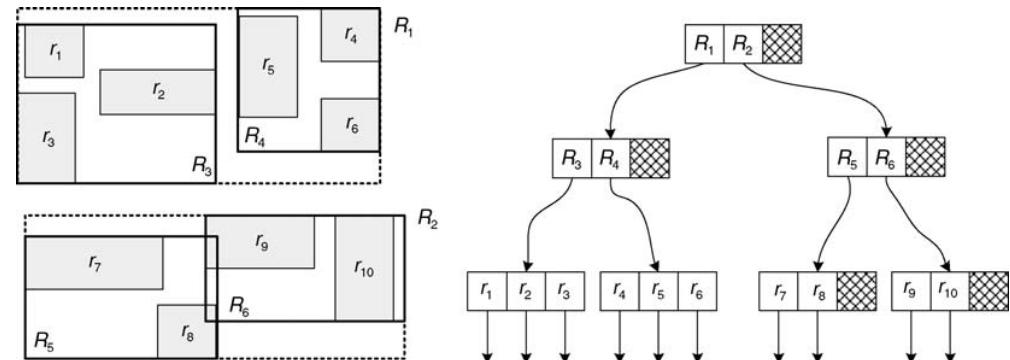
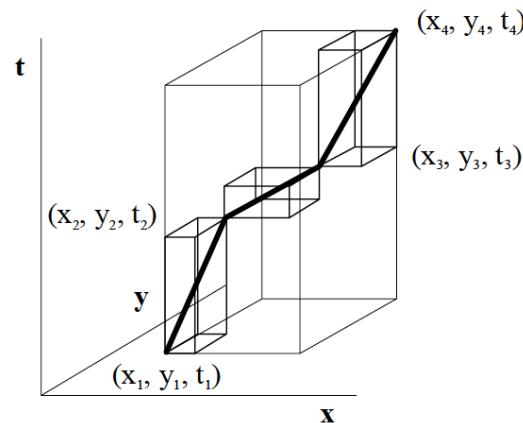


Hermes architecture



Indexing trajectories in Hermes

- Indexing support
 - **3D R-trees** (in PostgreSQL implementation)
 - **TB-trees** (in Oracle implementation)
- Options for indexing a trajectory: single vs. several MBBs

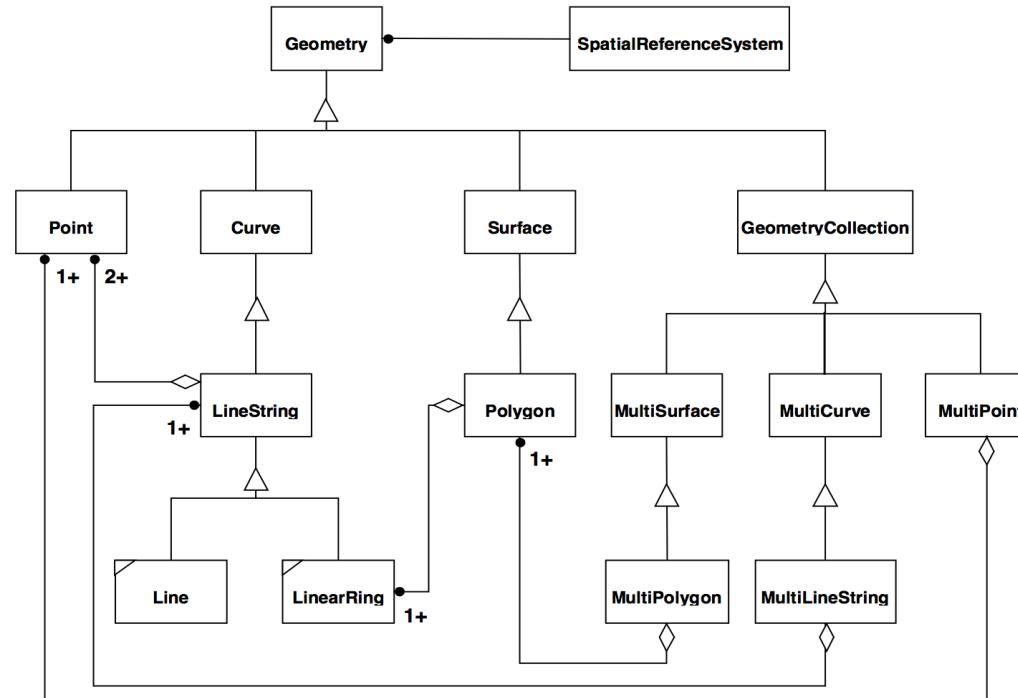


5.2.

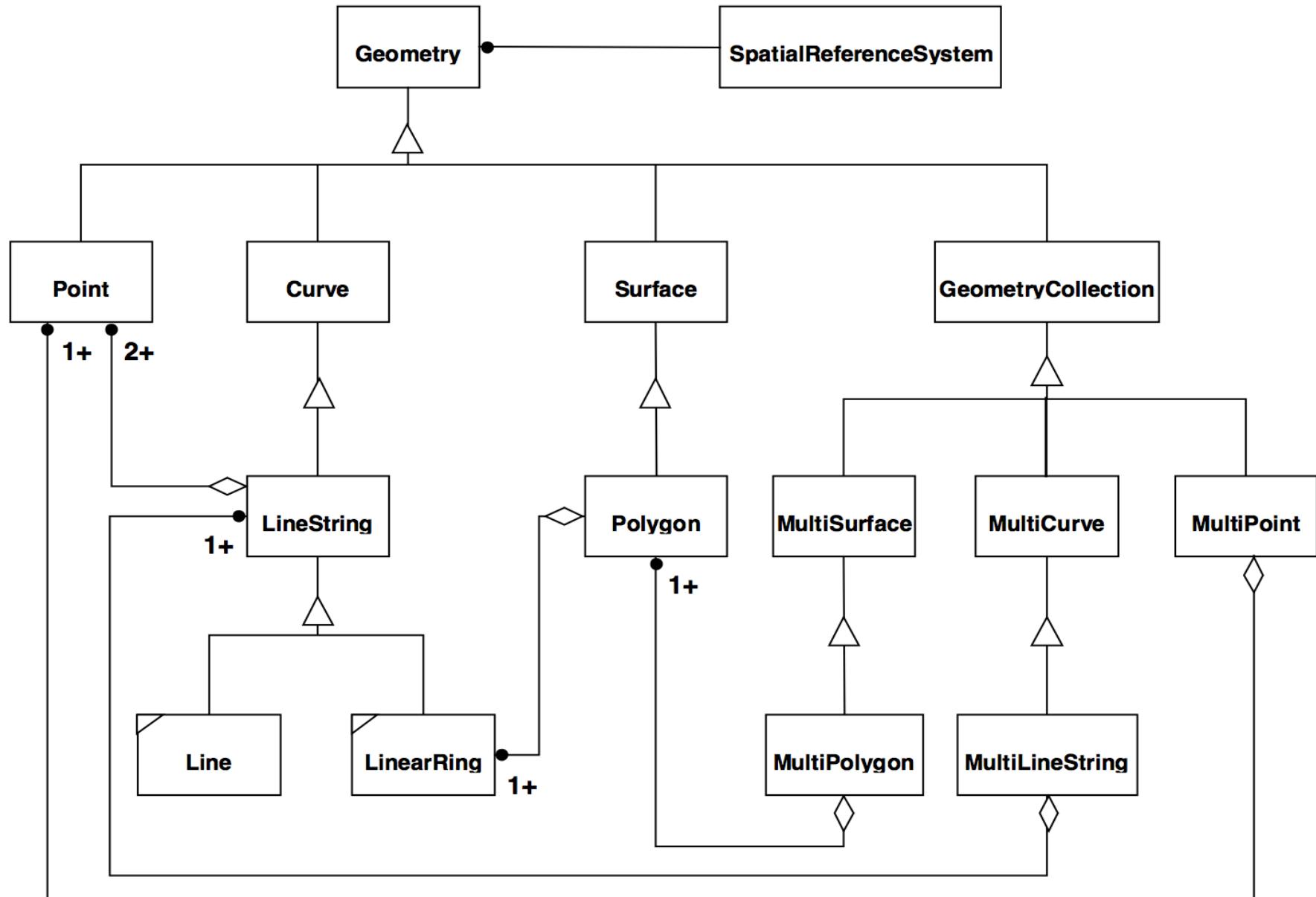
A data type model for
trajectory databases

Temporal and Spatial data types

- Temporal data types: TimeStamp, Period, etc.
 - ODMG model
- Spatial data types: Point, Line, Rectangle, etc.
 - OGIS model (Open Geospatial Consortium)

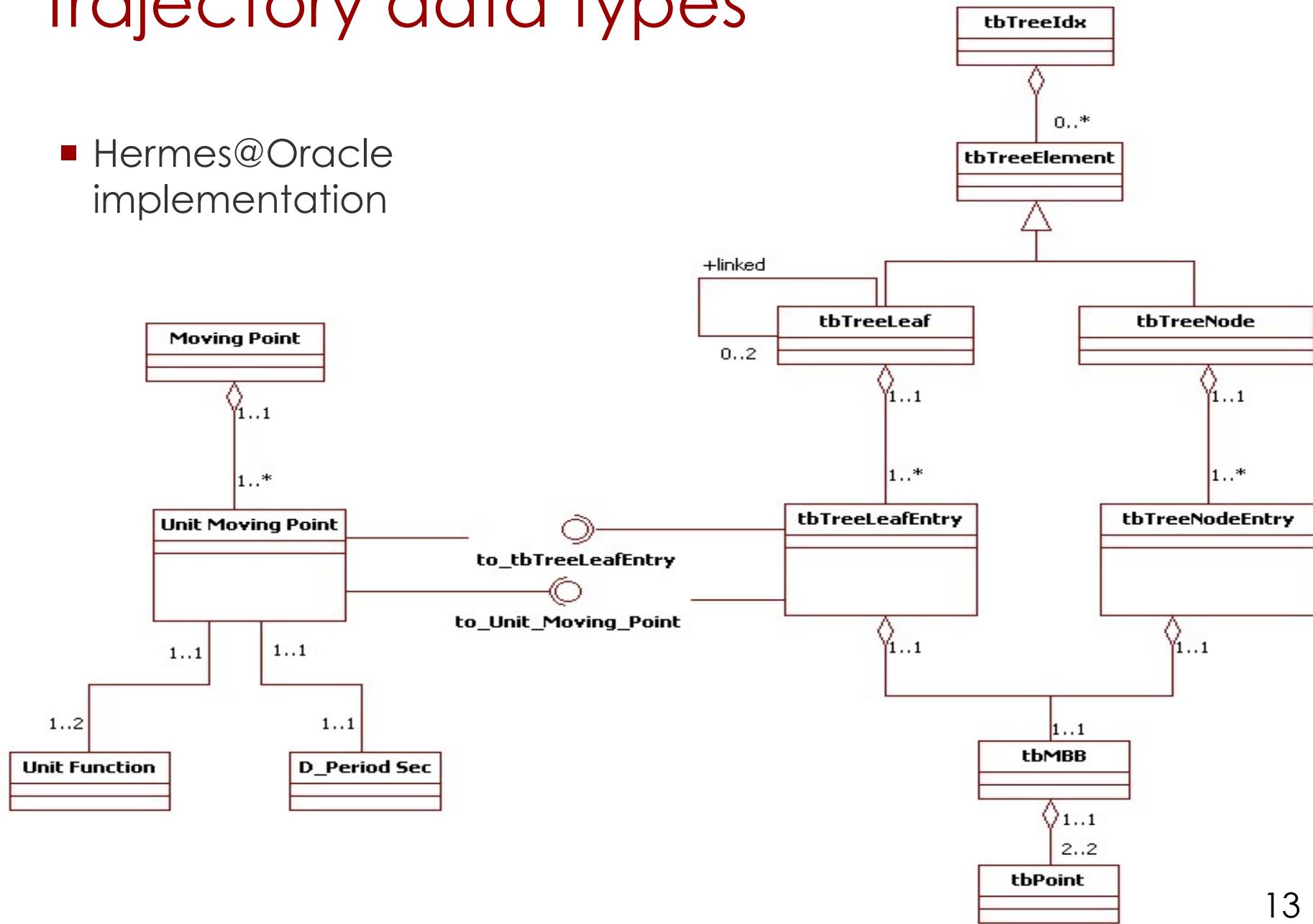


OGIS data model



Trajectory data types

- Hermes@Oracle implementation



5.3.

Extending the trajectory data type model with object methods and operators

MOD methods and operators

- Useful methods in support of the previous data types include
 - **predicates**: topological etc. relationships (intersection, within distance, etc.) over a trajectory
 - **projection methods**: operations that restrict a trajectory with respect to spatial and/or temporal constraints
 - **numeric operations**: functions that calculate a numeric value over a trajectory (e.g. speed)
 - **distance functions**: functions that calculate distance (dissimilarity) between two trajectories
 - **query operators**: popular (timeslice, range, NN, etc.) queries over sets of trajectories

Predicates and projection methods

- Unit_Moving_Point **unit_type** (TimePoint t)
- Geometry **at_instant** (TimePoint t)
- Geometry **f_initial** ()
- Moving_Point **at_period** (TimePeriod dt)
- Geometry **route** ()
- TimePoint **f_enter** (Geometry r)
- MultiPoint **get_enter_leave_points** (Geometry r)
- Moving_Point **f_intersection** (Geometry r)
- boolean **f_within_distance** (number d, Moving_Point mp2, TimePoint t)
- set <Moving_Point> **re_sample**(set <Moving_Point> mps, set <TimePoint> tps)

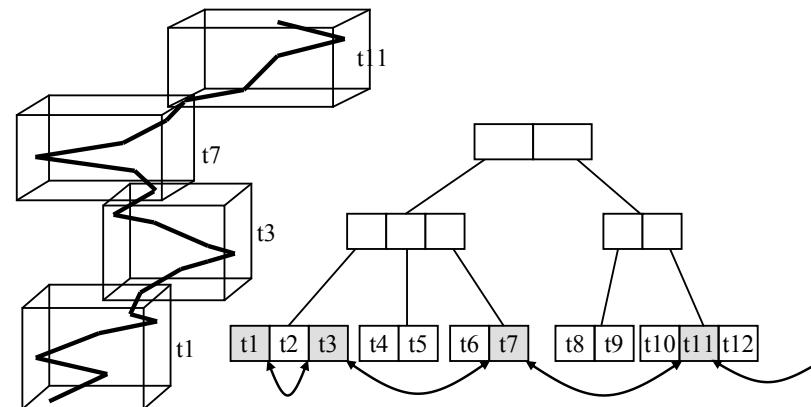


Numeric operations & Distance functions

- number **f_length** (TimePoint t)
- number **f_speed** (TimePoint t)
- number **f_direction** (Moving_Point mp2, TimePoint t)
 - boolean **f_west()**, boolean **f_east()**, boolean **f_north()**, boolean **f_south()**
 - boolean **f_left()**, boolean **f_right()**, boolean **f_above()**, boolean **f_behind()**
- number **GenLIP** (Moving_Point mp2)
- number **GenSTLIP** (Moving_Point mp2)
- number **number_of_times_close**(Moving_Point mp2, number d, number tolerance)

Query operators

- set <Moving_Point> **Range** (Geometry r, TimePeriod dt):
- set <number, Unit_Moving_Point> **IncrPointNN** (Geometry p, TimePeriod dt, number k):
- set <number, Unit_Moving_Point> **IncrTrajectoryNN** (number id, number k):
- set <number> **Topological** (Geometry r, TimePeriod dt, String mask):
 - mask: “Enter”, “Leave”, “Cross”, etc.
- Query operators are processed using the TB-tree index



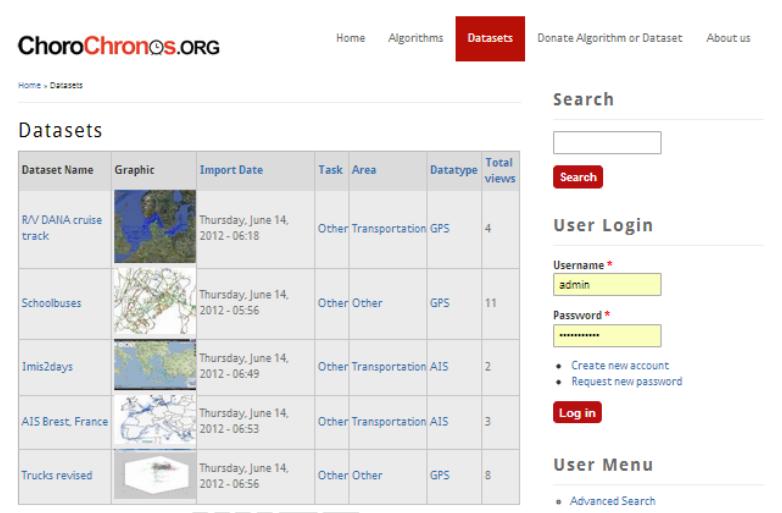
5.4.

On mobility data
provenance

The need for data provenance

- “Scientific research is considered of good provenance when it is documented in detail sufficient to allow reproducibility” !!
- From traditional data provenance ...
 - Workflows to perform scientific experiments and simulation
- ... to **mobility data provenance**, e.g. ChoroChronos.org

- Chorochronos.org
 - includes donated datasets and algorithms
 - supports experimental workflows and MOD queries



The screenshot shows the ChoroChronos.ORG website. At the top, there is a navigation bar with links for Home, Algorithms, Datasets (which is highlighted in red), Donate Algorithm or Dataset, and About us. Below the navigation bar, there is a search bar with a 'Search' button and a user login form with fields for Username (admin) and Password, and buttons for Create new account, Request new password, and Log in. On the left, there is a sidebar with a 'Datasets' section. The main content area displays a table titled 'Datasets' with the following data:

Dataset Name	Graphic	Import Date	Task	Area	Datatype	Total views
R/V DAIIA cruise track		Thursday, June 14, 2012 - 06:18	Other	Transportation	GPS	4
Schoolbuses		Thursday, June 14, 2012 - 05:56	Other	Other	GPS	11
Imis2days		Thursday, June 14, 2012 - 06:49	Other	Transportation	AIS	2
AIS Brest, France		Thursday, June 14, 2012 - 06:53	Other	Transportation	AIS	3
Trucks revised		Thursday, June 14, 2012 - 06:56	Other	Other	GPS	8

ChoroChronos.org interface



ChoroChronOS.ORG

Home Algorithms

Datasets

Donate Algorithm or Dataset

About us

Home > Datasets

Datasets

Dataset Name	Graphic	Import Date	Task	Area	Datatype	Total views
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Search

Search

User Login

Username *

admin

Password *

.....

- Create new account
- Request new password

Log in

User Menu

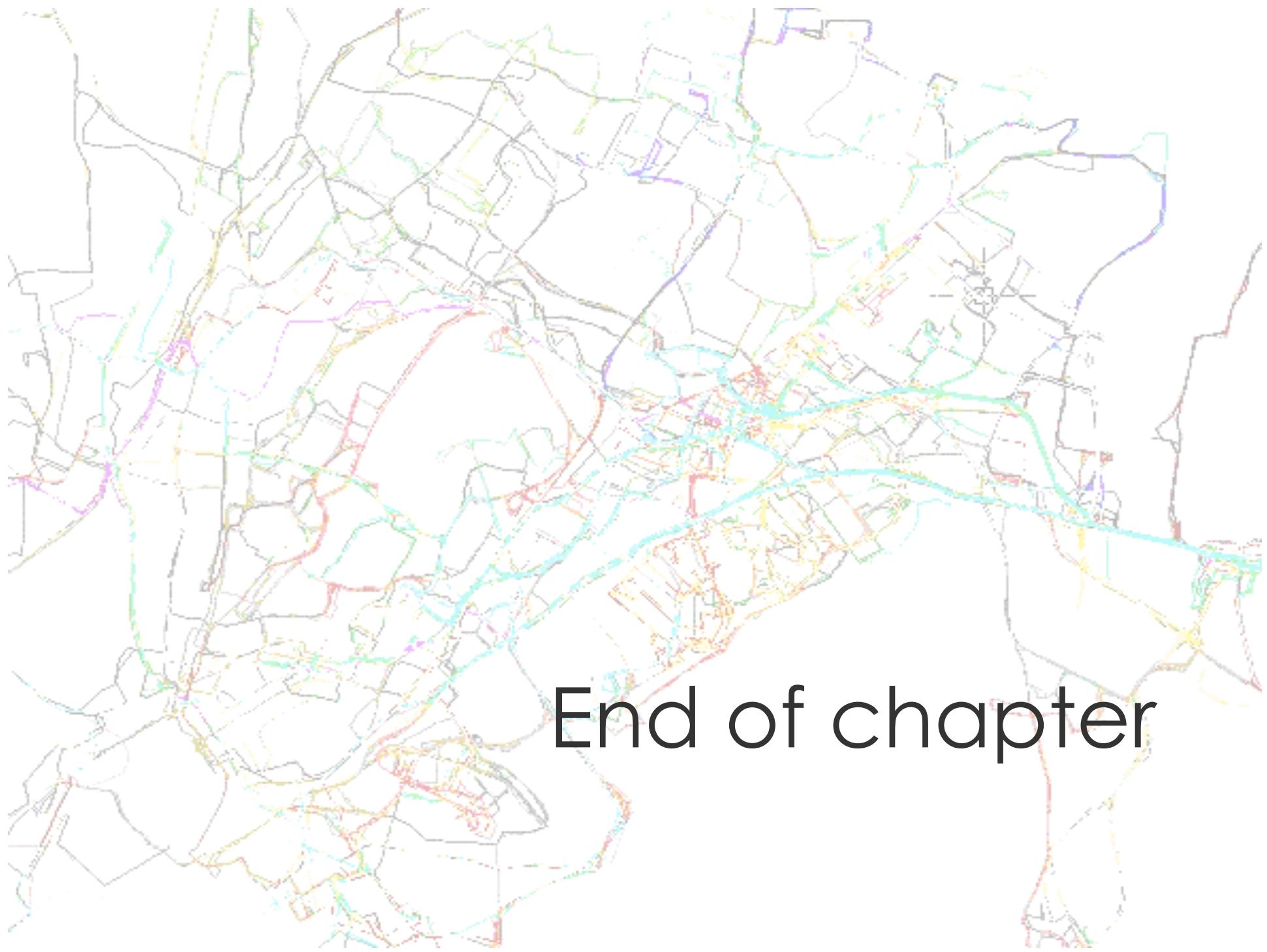
- Advanced Search

5.5. Summary

Summarizing ...

- Models, algorithms and access methods have been materialized in Moving Object Database (MOD) engines
 - SECONDO, Hermes, etc.
- In this chapter, we presented:
 - the trajectory-oriented data types
 - the architecture of selected MOD engines
 - the essential functionality (operators and methods) of such an engine
 - a few ideas on mobility data provenance





End of chapter