Modeling and querying moving objects in networks

Appeared in "The VLDB Journal", Volume 15 issue 2 - 2006

Ralf Hartmut Güting and Victor Teixeira de Almeida and Zhiming Ding

LG Datenbanksysteme für neue Anwendungen, FernUniversität

November 8, 2006

Presented by Anders Jensen

Motivation

Modeling Networks

Database perspective

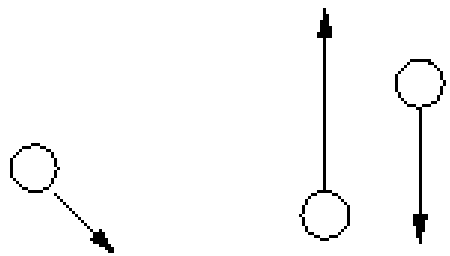
Conclusion

Related Work

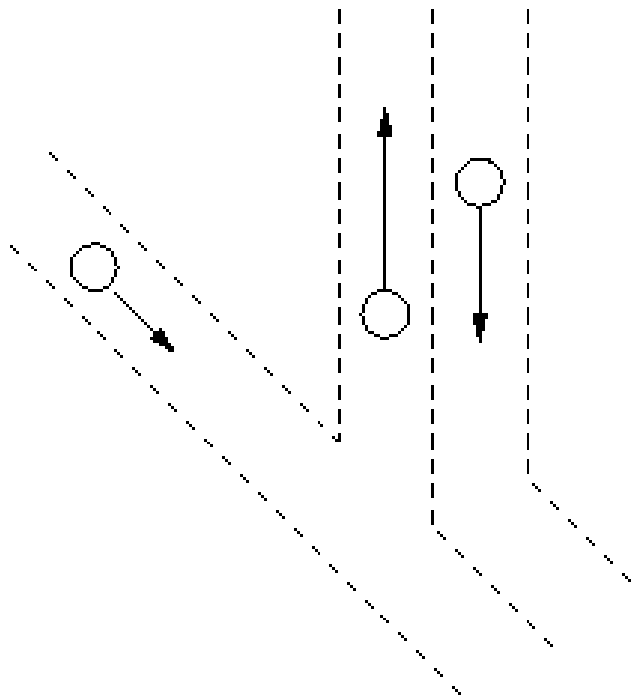
Relation to our project

Strong and weak points

Motivation



Motivation

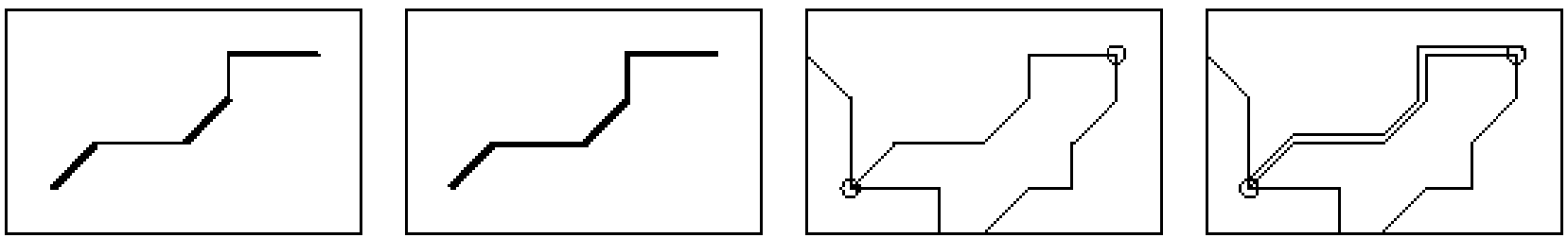


Motivation

- Combine moving object databases with transportation networks
  - Many moving objects move according to networks
  - Leads to efficient storage and indexing
- Be able to ask queries such as:
  - On which road is car X?
  - How many cars have left suburb Y today?
- Main contribution: "Provides a comprehensive data model and query language for moving objects in networks"

Modeling Networks

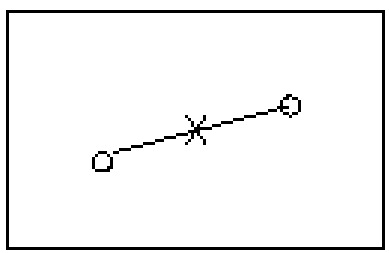
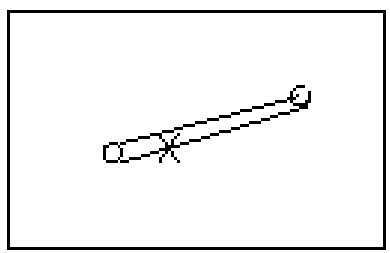
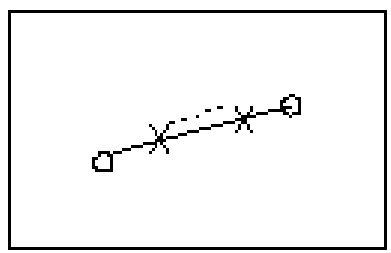
- As routes and junctions, not edges and nodes
- A network is a set of routes and a set of junctions between these routes
- Simple and dual routes



Routes

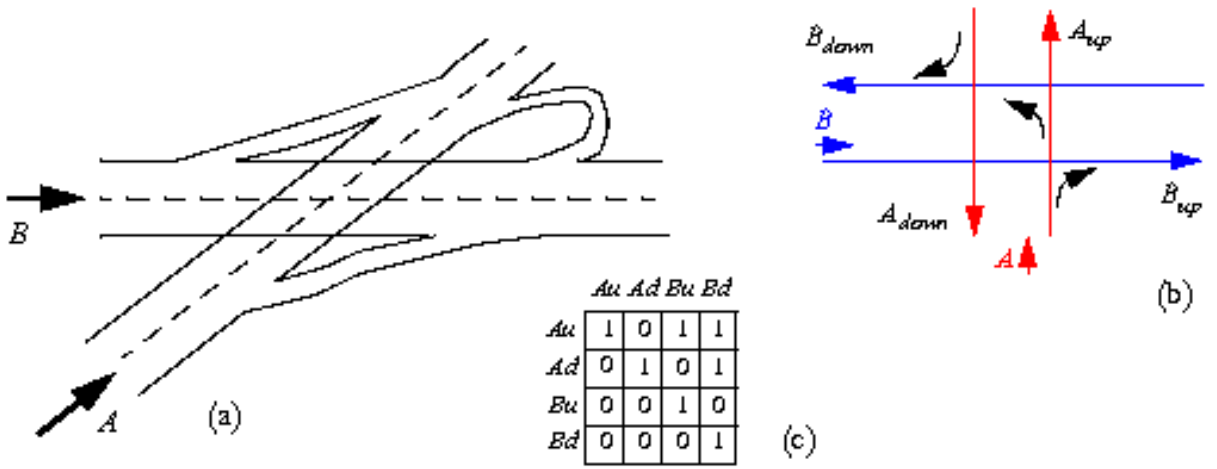
Route=(id,l,c,kind,start), where l=length, c=curve, kind $\in$ {simple/dual} and start $\in$ {smaller/larger}

- Route measure
  - Distance from origin of a specific route
  - *(r,d)*, where r is a route and d is a distance
- Route location
  - Same as measures for routes of type "simple"
  - Additional up/down (direction/side) flag for "dual" routes
  - *(r,d,s)*, where s is side
- Route interval
  - Start measure and end measure for simple routes, start location and end location for dual routes

Junctions

- Triple: *(rm1, rm2, cc)*, rm1 and rm2 are the route measures for the two routes meeting at the junction
- CC: Connectivity code, describes route-to-route connectivity at the junction



	Au	Ad	Bu	Bd
Au	1	0	1	1
Ad	0	1	0	1
Bu	0	0	1	0
Bd	0	0	0	1

(c)

Fig. 1 **a** A physical highway junction, **b** its diagramatical representation, and **c** the transition matrix

- Predicate **connects((r1,s1),(r2,s2),cc)**

A Few Challenges and Their Solutions

- How is connectivity described in junctions of more than two routes? - A connectivity matrix is defined for each pair of routes
- What about roundabouts? - It is a matter of scale, if seen from a large scale it is an ordinary junction of two or more routes, if seen on a small scale it is a circular road
- What if two routes share the same piece of road? - The routes are divided into smaller routes

Spaces

Recall the queries from before:

- On which road is car X?
- How many cars have left suburb Y today?

How is suburb defined in a network?!

- Space: Cities, national parks and natural disaster risk zones
- Network space: Gas stations, motels and congestion
- Network: Roads and junctions

Introduce new data types:

- In (Euclidean) space we have points and lines
- In a network points and lines are constricted

New data types

- Network: As previously described, basically routes and junctions
- GPoint: Tuple, *(network, Loc(network))* where Loc(network) defines a location in the network
- GLine: Tuple, *(network, Reg(network))* where Reg(network) defines a region in the network

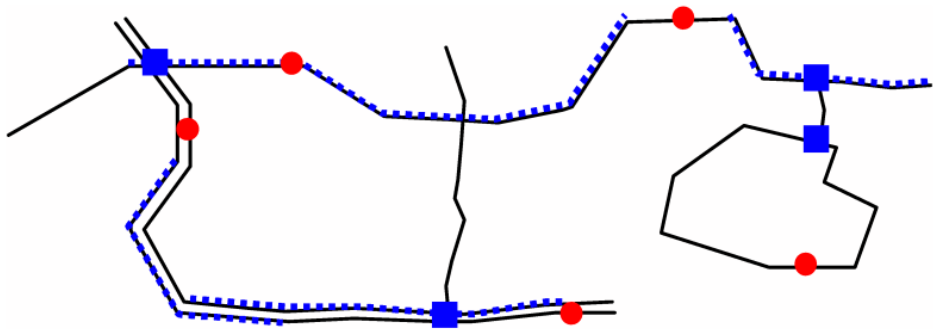


Fig. 4 A simple network example

Example - Operations

- Shortest path:
  - *gpoint (A)* $\times$ *gpoint (B)* $\rightarrow$ *gline* **shortest_path**
  - Computes the shortest path from A to B and returns a gline describing it
- Circle:
  - *gpoint (A)* $\times$ *real (B)* $\rightarrow$ *gline* **circle**
  - Returns the part of the network within B of gpoint A as a gline

Example - Query

- Postman relation: *postman2(name: string, trip: mgpoint, dest: gpoint)*
- HagenerStrasse relation: the route that Hagener Strasse belongs to
- Query: Who will pass Hagener Strasse before he/she can deliver his/her package?

SELECT p.name
FROM postman2 AS p
WHERE shortest_path(current(p.trip), p.dest) intersects HagenerStrasse

Conclusion

- Contributes with a precise and comprehensive data model and query language for moving objects in networks
- Provides a formal model of networks
- Offers abstract data types for network, gpoint/mgpoint and gline/mgline
- Describes an algebra for working with the new data types
- Outlines an implementation strategy

Related Work

- [7] "A foundation for representing and querying moving objects in databases" by R.H. Güting at al.
  Provides a data model and query language for handling time-dependent geometrics. The paper provides the moving point and moving region types and forms the basis for this paper.
- [30] "Data modeling for mobile services in the real world" by C.S. Jensen et al.
  States that modeling real transportation networks is complex. Proposes a number of representations such as the kilometer post representation. This is one of the main motivating papers for this paper.

Our project

- Estimate travel times in transportation networks
- Uses nodes and edges
- GPS-points are map matched to edges (road segments)

Relation to our project

- We should consider using routes instead of edges
- Route measures/locations might be uasble in our project
- While the querying in this paper is interesting, it is outside the scope of our project, we might, however, need to implement some of the operations introduced in this paper

Strong and weak points

Strong points:

- Excellent related work discussion
- Very formal, concise

Weak points:

- Very few figures
- Explanations are missing in many places

Thank you!