Spatial analysis in XML/GML/SVG based WebGIS

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Outline

1. Introduction
   - XML/GML/SVG based WebGIS
   - Load-balancing spatial analysis

2. GML/SVG based spatial information representation

3. Spatial operators and Spatial Extended SQL

4. Implementation and Case studies

5. Conclusions
1. Introduction

- WebGIS is an inevitable trend.

- The problems of spatial information integration and sharing in the web environment.

- XML/GML/SVG based WebGIS
  - GML: coding, storing and transmitting standard of multiple spatial data on the server side.
  - SVG: representing tool for displaying and interacting with spatial data on the browser side.
1. Introduction (cont.)

◆ Spatial analysis: vital for GIS.
  - XML/GML/SVG based WebGIS also needs spatial analysis.

◆ Currently, lots of XML/GML/SVG based WebGISs: visualization only, no spatial analysis functions.
  - When performing spatial analysis task, we always need to install corresponding GIS software on our computer, and carry out the tasks in stand-alone or Local Area Network (LAN) environment.
1. Introduction (cont.)

Some of the WebGISs carry out all the spatial analysis tasks on the server side and then send the result to the browser side for visualization.

- Servers become bottleneck when too many concurrent users
- High network transmission overload
1. Introduction (cont.)

- Load-balancing based spatial analysis for XML/GML/SVG based WebGIS
  - carry out spatial query operation on server side or browser side based on the network communication cost vs. the computational cost.
  - Three issues:
    - GML (server)/SVG (browser) based spatial information representation
    - spatial query language for server side (GML) and browser side (SVG)
    - load-balancing middleware
2. GML/SVG based spatial information representation

- **Spatial dataset**: hierarchical structure (map - layer - spatial object)
  - GML: as a XML-based coding standard for geographic feature.
  - SVG: XML-based publishing tool of 2D graphics

- **GML/SVG based spatial representation models** which take the characteristics of spatial dataset (such as hierarchical structure) into account have to be developed.
2. GML/SVG based spatial information representation (cont.)

- **Spatial data modeling**
  - The process of abstracting the real world and representing the relevant objects in a computer recognizable form.
  - GML/SVG are these kinds of forms.

- We can use the theory of spatial data modeling to design GML/SVG based spatial information representation models.
2. GML/SVG based spatial information representation (cont.)

Three models in spatial data modeling

Three steps:
- choosing a **conceptual model** which can abstract the real world most appropriately;
- choosing an appropriate **data structure** to represent the conceptual model;
- designing a **file format**, or the appropriate method to record or store the data structure.
2. GML/SVG based spatial information representation (cont.)

Spatial conceptual model extended from OGC's Geometry Object Model
2. GML/SVG based spatial information representation (cont.)

Spatial Data Structure
2. GML/SVG based spatial information representation (cont.)

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</table>
2. GML/SVG based spatial information representation (cont.)

SVG Based Spatial Information Representation Model (File Format)
2. GML/SVG based spatial information representation (cont.)

Some Examples in the paper
3. Spatial operators and Spatial Extended SQL

SQL like Spatial query languages can be used for spatial analysis:

- These SQL like languages introduce spatial data types (e.g., point, line and polygon) and spatial operators, allow users to inquire spatial features, primarily in terms of spatial relationships and metric constraints.
3. Spatial operators and Spatial Extended SQL (cont.)

A map represented by GML/SVG can be viewed as a database, the layers as tables of the database, the attributes of spatial objects in the layer as columns of corresponding table, spatial objects as the records of corresponding table.

SQL like languages can be used to support spatial analysis on GML/SVG.
3. Spatial operators and Spatial Extended SQL (cont.)

**Our Spatial Extended SQL:**

- **Data types:** Point, Linestring, Polygon, Multipoint, Multiline, Multipolygon and Multigeometry
- **Spatial Operators:**
  - attribute access: GeometryType, Centroid, Length, Area, and Envelope
  - spatial topological: Disjoint, Touch, Crosses, Within, Overlap and Contain
  - spatial order: East, East_South, South, West_South, West, West_North, North and East_North
3. Spatial operators and Spatial Extended SQL (cont.)

Spatial operators (cont.):
- spatial metric: Max_Distance, Min_Distance and Average_Distance
- Geometrical operators: Buffer, Intersection, Union and Difference.

Integrate the above spatial operators to the original SELECT clause of SQL
3. Spatial operators and Spatial Extended SQL (cont.)

Some spatial query examples in the paper
3. Spatial operators and Spatial Extended SQL (cont.)

_workflow of spatial analysis_

Step 1: Define the goal and evaluation criteria
Step 2: Represent the needed spatial data
Step 3: Carry out spatial query and analysis with GIS tools
Step 4: Result appraisal
- satisfied
- dissatisfied
Step 5: Result explanation
End

_workflow of spatial analysis in XML/GML/SVG based WebGIS_

Step 1: Define the goal and evaluation criteria
Step 2: Represent the needed data in GML
Step 3: Use SESQL to carry out spatial analysis
Step 4: Result appraisal
- satisfied
- dissatisfied
Step 5: Result explanation
End

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4. Implementation and Case Studies

- **Spatial operators:**
  - algorithms of computational geometry
  - Java 2D API

- **Spatial Extended SQL compiler**
  - syntax, sentence, and semantic analysis

- **Server side:** Java servlets

- **Browser side:** Java applets, embedded in HTML; Use DOM to access SVG document and invoke the Java applets.
4. Implementation and Case Studies (cont.)

Case 1: how the cultivated lands along the railway and highway change between 1987 and 1999.

- needed spatial data: railway, highway, district map, and different years’ statistics on land use
- “Buffer”, “Union”, “Within” operators
4. Implementation and Case Studies (cont.)

Case 2: what has happened to cultivated lands with the increasing of the road density (railway, highway, and province-level road)

needed spatial data: railway, highway, province-level road, district map, and different years’ statistics on land use

“intersection”, “length”, “area”
5. Conclusions and Future Work

**Conclusions:**

- Spatial data modeling can be used in designing GML/SVG based spatial information representation models.
- The proposed Spatial Extended SQL can be used to support spatial analysis on GML (server side)/SVG (browser side).
- The proposed method can be used to carried out our spatial analysis in Web environment.
5. Conclusions and Future Work (cont.)

Future work
- Load-balancing middleware
- Completeness of the spatial operators for spatial analysis task
- The performance of spatial operators and spatial extended SQL
- Some more real use cases.
Thank you!