Requirements and implementation issues for a topology component in 3D geo-databases

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ABSTRACT

Topology plays an increasing role in 3D geo-applications. However, still different data structures are used for topology in 2D and 3D applications. A dimension-independent approach for topology is needed, which can be used uniformly in different application classes, such as 2D maps or 3D sub-surface models. In this paper, requirements of a topology component and first implementation issues for modeling and managing topological objects in a 3D geo-database are presented.

INTRODUCTION AND RELATED WORK

Work about dimension-independent topology models in the field of 3D geo-modeling (Mallet 1992, 2002) has been extensively discussed by Brisson (1989) and by Lienhardt (Liehnhardt 1988, 1989, 1994). Further contributions to modeling and managing topological data structures has been published by Thomsen et al. (2007). Other significant work in the GIS field has been presented by Molenaar et al. (1994), by Zlatanova (2000), Ellul and Haklay (2006), and by other authors. Nevertheless there is no satisfactory topology data management in existing geo-databases known so far. Even the mature and extensively used spatial algorithms library "JTS Topology Suite" by Vivid Solutions (2003) does not supply a cross-dimensional topology notion.

REQUIREMENTS OF THE TOPOLOGY COMPONENT
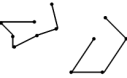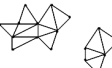
A sustainable topology component has to provide methods for the aggregation of complex topological structures to cells of different dimensions and shapes, a general approach for the topological modeling of 0D, 1D, 2D and 3D objects to achieve compatibility of data structures between the different dimensions. Furthermore, the module should offer the possibility to convert the managed data to standard topological representations such as B-Rep for data export. The topology component has to be able to allocate a hierarchy of different levels of detail (LOD) of topological configurations and the possibility of navigating (i.e. determining routes through adjacencies) on any of these levels. Last but not least, the topology component should provide the possibility for temporal topological database queries (however, this is out of the scope of this extended abstract).

DB4GEO – A GEO-DATABASE PROTOTYPE

DB4GeO is a modular geodatabase server, developed and maintained by the deodatabases working group of Martin Breunig. We intend to implement the topology component on top of the existing code foundation of DB4GeO. More information on the architecture, history and application scenarios

concerning DB4GeO can be found in previous publications of the working group as in Breunig et al. 2009, Bär 2007, Breunig 2001, Balovnev et al. 2004 or Breunig et al. 2004. The inner core of DB4GeO, its geometry, net topology and spatial index library has recently been published as open source software under a GPL-like licence (repository: http://github.com/geodb/db3dcore).

The geometry library of DB4GeO allows the user to model geo-objects from sets of simplicial complexes. The possible geometrical configurations are depicted in figure 1.

**Figure 1:** Classes of simple and complex geo-objects provided by the geometry library.

The left column shows the simplicial complexes of dimensions 0-3. This is the "geometrical building-ground" of DB4GeO. DB4GeO also provides a "geometry element" (Elt) object for every simplicial complex. An Elt object extends a geometry object with information about its directly connected neighbours. A set of connected Elts is combined to a net component (NetComp). A set of disjoint NetComps is combined to a Net.

IMPLEMENTATION ISSUES AND CONNECTION WITH DB4GEO

A lack of functionality inherent to the described geo-object model of DB4GeO is to differentiate (thematically) defined topological units inside a NetComp. So the goal of upcoming development efforts is to construct a new "higher abstraction level" for topological operators that allow the aggregation of geometry elements (of a component) to larger units (topologically defined cells).

Extension of the builder framework

The targeted topological framework shall provide the possibility to create topological cells "on top" of a geometry net component. For example, to construct a consistent triangle net component in DB4GeO, at present a builder object is used. The builder design pattern is used for consistent ID management, realigning of geometry elements and spatial index construction. A builder object "consumes" geometry objects, analyzes their geometrical configuration in space, constructs the appropriate net components and aggregates them in a net. When construction is accomplished, the builder provides the net and all components (see figure 2, left side).
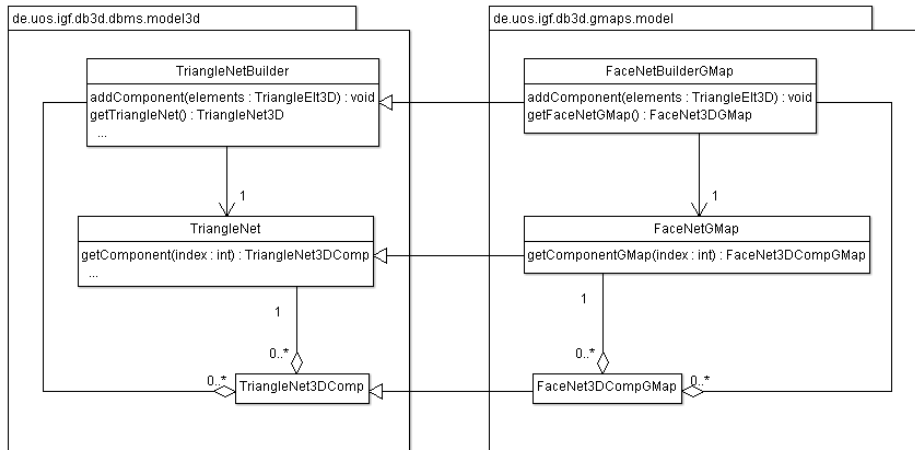
Figure 2: Net builder architecture.

The topology module will build on this structure and extend the triangle net builder with a face net builder (see right side of figure 2). In analogy to the triangle net builder a face net builder will provide access to a face net and all its face net components.

Associations between cells and simple geo-objects (aggregations)

The returned face net component is then a composition of faces, edges and nodes (cells). In this model the topological cells have associations to the primitives of the 3D model of DB4GeO. The relations between the cells are described in CellTuples of the underlying topological model that we use (see figure 3).
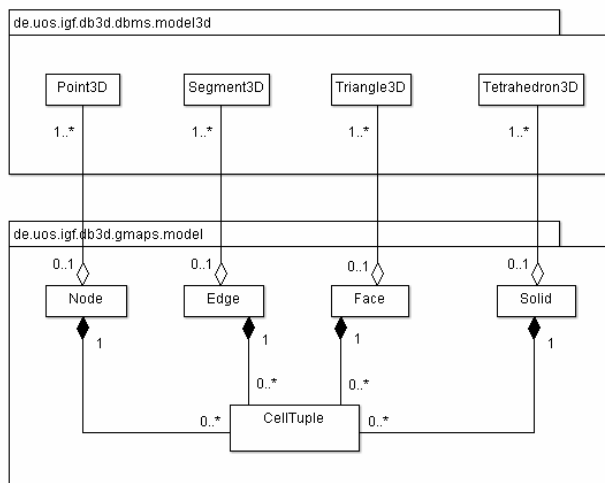
Figure 3: Associations between cells and simple geo-objects.

The notion of celltuples is borrowed from the concept of Generalized Maps (G-Maps) by Lienhardt or Celltuple Structure by Brisson. The viability of this concept for database systems has been discussed in previous papers of our working group (Thomsen et al., 2007, Thomsen et al. 2008). A substantial part of the development will transfer the existing DB4GeO operators from simplicial complexes to operators for general topological cells.

OUTLOOK

The next step will be the implementation and evaluation of the proposed approaches to manage hierarchic cellular complexes in the DB4GeO "G-Maps topology module". In particular, the possibility of efficient navigation on (large data) G-Maps has to be investigated to enable quick scanning operations on the topology of 2D and 3D models. Another crucial issue of development is the implementation of temporal topological operators in the module.

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