SIT-IN: a Real-Life Spatio-Temporal Information System

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1 SIT-IN Overview

The SIT-IN (acronym for Integrated Territorial Information System, in Italian) system integrates a historical database, providing information about the temporal evolution of territorial administrative partitions; the Institute's GIS, providing the cartography of the Italian territory down to the census tract level of detail; a statistical data warehouse, providing spatio-temporal data from a number of different surveys; and finally an address normalizing/geo-matching system, providing information about the limits of census tracts (e.g. portions of streets or the sides of town squares).

SIT-IN has a three-layer/multi-tier architecture.

Layer 3. The data level is composed of a few RDB instances. In particular, on top of the spatial database, the spatial data engine allows efficient access and manipulation of geographical data.

Layer 2. This layer consists of various application servers, particularly: (i) a Java server, handling the communications to and from the databases; (ii) an *Internet Map Server*, allowing cartography serving on the Web; (iii) a Report Server, dynamically generating HTML pages of statistical tables.

Layer 1. The system-user interaction is enabled by Java applets and "classical" HTTP calls for the dynamic generation of HTML pages.

* Partially supported by CNR-IASI, viale A. Manzoni 30, 00185, Roma, Italy

Proceedings of the 27th VLDB Conference, Roma, Italy, 2001

2 Significance for Database Applications

The system addresses the following deficiencies of current commercial systems:

Dynamic dimension instances. Commercial OLAP systems do not consider dynamic dimensions [2]. The spatial partition of a territory is an example of such a dimension. Consider for instance the administrative subdivision of a country territory into a hierarchy of regions, provinces and towns. There are several factors affecting the dynamics of this hierarchy: a town may be re-assigned to a different province, towns and provinces could be renamed, new towns and provinces can be introduced (typically from part of the territory of other towns and provinces), border "adjustments" could be established by administrative laws.

This dynamic behaviour has of course an influence on any time-dependent data analysis process. In SIT-IN, this was overcome by implementing a general spatio-temporal data model which completely describes the possible mutations in time of the objects of interest, e.g. object birth and destruction, modification of object properties (borders, name, statistics, etc.), and object inclusion in a less detailed object. Our model can be viewed as an extension of "the description of change with respect to states of existence and non-existence for identifiable objects" proposed by the authors of [1]. Figure 1 schematically represents the evolution of an Italian region (Lombardia) after the creation of two new provinces.

From another point of view, this schema is an implementation of a multidimensional model with space acting as a "dynamic dimension" [2].

Spatio-temporal visualization of data. Existing commercial GIS's and DBMS's still do not have enough features to effectively visualize the temporal aspects of spatial data. In fact, GIS's structure data in layers, without providing tools to model the tem-

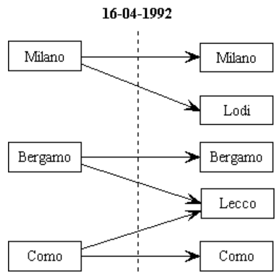

Figure 1: Temporal evolution of Lombardia provinces

poral evolution of a layer; while, DBMS's, although offering specific features for the management of temporal and spatial data, lack primitives and operators for the effective integrated management of the two aspects. In SIT-IN, layers are dynamically generated according to the chosen time stamp, and data referring to territorial objects in a given time are mapped to the appropriate polygon.

3 What will be demonstrated

We will demonstrate what follows.

Spatio-temporal selection. SIT-IN enables its users to perform time-dependent roll-up and drill-down operations, by automatically selecting the correct time-dependent territorial hierarchies.


SAS Output - Microsoft Internet Explorer

POPOLAZIONE RESIDENTE AL 31/12 PER NUMERO

	anno					
	1988	1989	1990	1991	1992	1993
	N	N	N	N	N	N
PROVINCIE						
BERGAMO	920228	924804	931885	932370	917264	924166
BRESCIA	1036112	1039548	1045419	1044699	1050405	1055881
COMO	787942	790789	795729	795756	525102	528292
CREMONA	327846	327536	328027	327784	328867	329895
LECCO	.	.	.	.	298274	299795
LODI	.	.	.	.	185553	187273
MANTOVA	370892	370460	370832	369314	369410	369190
MILANO	3985433	3986838	3992204	3920626	3740608	3734206
PAVIA	498064	496753	496040	490478	490619	491988
SONDRIO	176167	176485	176769	175453	176015	176371
VARESE	796267	798782	802524	796981	800291	803966

Figure 2: A time series on a dynamic dimension: yearly resident population in the Lombardia region from 1988 to 1993.

Visualization of territory evolution. The temporal evolution of the area of interest is dynamically visualized on a set of temporal geographic maps. For each distinct *version* of the territorial partition a different layer is generated and the evolution of objects is highlighted by establishing a 1-1 correspondence between objects and colours. The system determines the "relevant" objects to display by computing the connected components on the evolution graph.

Multidimensional navigation. The spatio-temporal selection is used as the access plane to the navigation through aggregate data. Each dynamic report table refers to the chosen time stamp and set of territorial entities. Dynamic dimensions are effectively managed.

Time series of aggregated data. A time-slice selection of spatial aggregated data can be "extruded" along the time dimension to produce a time series of spatial data which takes into account the heterogeneity of the space dimension. (Figure 2)

Dynamic integration of users' data. Users can dynamically link their own data to the system. As an example of such a mechanism, we implemented a function for dynamic geographic theme building and visualization based on users' data. Figure 3 shows the dynamic thematic map generation obtained from the population density values of the Lombardia provinces in 1991 and 1994.

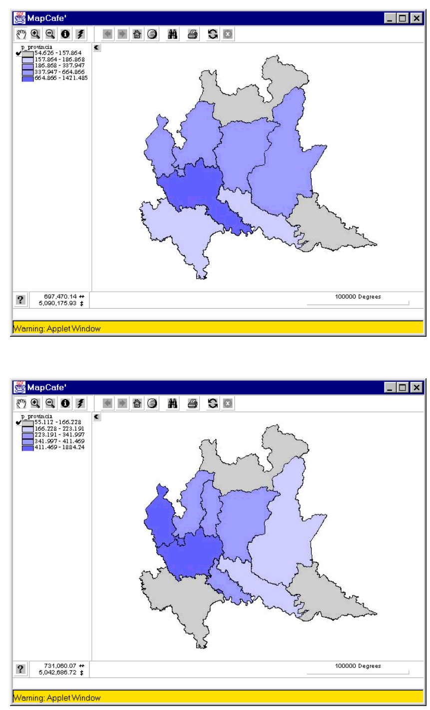

Figure 3: Thematic maps: population densities of the Lombardia provinces in 1991 and 1994.

References

[1] K. Hornsby and M. J. Egenhofer. Identity-based change: A foundation for spatio-temporal knowledge representation. *IJGIS*, 14(3):207–224, 2000.

[2] A. O. Mendelzon and A. A. Vaisman. Temporal queries in olap. In *VLDB 2000*, pages 242–253, 2000.