Time dimension in e-goverment GI driven services

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INTRODUCTION AND ABSTRACT

The issue of time dimension in the e-gov geospatial information is discussed in the paper taking advantage by one European co-funded project in which the authors are engaged.

Just for giving a clear example the Civil Protection operators and Public Administrations, engaged in urban planning, resource and environmental management, have often clearly addressed the need of using spatial-temporal processing of GI to support their decision-making specially. Natural disaster monitoring and mitigation is characterized by frequently updated repositories as well as by provision of dynamic data. For these stakeholders being able to access to the most up-to-date information is crucial.. However providing access to harmonized data is only a first step towards providing adequate support to environmental management, which requires development of analysis and spatio-temporal data models functionalities.

The opportunity to deal with this challenges issue is provided by several EU initiatives. In particular the EU project BRISEIDE – (BRIdging SErvices, Information and Data for Europe) allows joining several different experiences, coming from different backgrounds: universities, research centres, SMEs (Small and Medium Enterprises), national agencies –including NMAs (National Mapping Agencies)-, in order to find and propose practical solutions to the issues rising from the use of time -as dimension- within geographic information..

Cartographers' need for representing time along spatial descriptions is hundreds or even thousand years old [Harrower 2004]. Today use of new technologies increases the capability to record spatio-temporal information, for instance through GPS receiver mounted on emergency vehicles or through time-stamped satellite imaging. However being able to fully exploit such a large amount of information is still an open challenge for researchers and, more generally, for the widest community of stakeholders.

It has to be clearly addressed that the above mentioned project is not a research project while aiming to demonstrate how it is possible to compose data and web services with the time dimension for delivering efficient services to final users. Assuming that the delivering of services to final users is essentially based on e-government it clearly appears as the time dimension is directly connected with it. Within this context, temporal aspects play a major role at multiple levels, especially when considering some outstanding applications of geodata that involve dynamic phenomena, such as research on climate change, meteorological forecast, monitoring the impact of natural and anthropic events on the environment, etc. In the perspective of the hugely populated European SDI envisioned by INSPIRE, it's necessary to filter out geographic resources that not only refer to a given spatial location, but also match both the temporal coverage of interest and the temporal resolution suitable to the application purposes. This is the reason why it is important to investigate the connection between the time –as a dimension- and the e-government – as a process - in the framework of using geographic information.

It appeared clear in the early stage that in order to enable public administrators and users to deal with the wide range of capabilities available with the introduction of the time dimension, it is necessary to proceed with an analysis of the key aspects, not only technical, related to the introduction of time as a variable in data and web services.

For these reasons, according to the programme of the project, it has been agreed that a complete analysis should start from data and metadata available aiming to defining data and metadata models which considers time and development of services, including relevant visualization capabilities, which allow proper management of time as a real dimension.

From the analysis performed in the first stage of the project, which will last until 2012, it has been possible to highlight that the temporal dimension is almost not considered in the data and metadata in use nowadays, even if all users involved in the project consortium addressed the need of finding and

retrieving information based on temporal information. If it is needed this is another clear demonstration that the GI community has to reconsider current data models, by taking into account time as one of the main variables.

BRISEIDE: A PROJECT TO EXPLOIT TEMPORAL DIMENSION OF GI INFORMATION

BRISEIDE (BRIdging SErvices, Information and Data for Europe), a Pilot B project co-funded by the ICT Policy Support Programme (or ICT PSP), develops technologies for spatial-temporal analysis as well as data/metadata models building on top of existing Spatial Data Infrastructures (SDI) in order to provide users with a more complete and adequate set of processing tools capable of handling time as a dimension. The shared starting point is that a conspicuous number of environmental analyses simply cannot be performed without being able to consider the evolution, over time, of geographic features.

Examples of these are monitoring the evolution of a sequence of earthquake epicentres, forecasting the path of a storm, monitoring the evolution of wildfire contour, predicting the spread of pollutant across a given area.

In a long term perspective, looking at an information rich European SDI as envisioned by INSPIRE , it is necessary to be able to filter out geographic resources that, not only refer to a given spatial location, but also match both temporal coverages of interest as well as temporal resolution requested by a given process.

Analysis of spatial-temporal data is especially challenging as it requires tools for representation and manipulation of all three aspects of the data: thematic (values of attributes), temporal and spatial. The increased processing speed, storage space, and graphical performances of modern computers offer new opportunities to properly visualize temporal variations of spatially referenced datasets. However, within most GIS systems and, more recently, within most SDIs, time -as a variable- is only partially considered or not taken into account. Furthermore current OGC standards do not provide consistent support for time, with only few standards considering time as a variable (e.g. GML). For this reason BRISEIDE proposes to extend current data/metadata models integrating some elements missing in the typical Geographic information models such as high frequently information data, moving objects, phenomena that evolving during time and forecast.

SOME ISSUES RELATED TO TEMPORAL DIMENSION IN GEOGRAPHIC INFORMATION

Considering that time extension within a geographical dataset increases not only the dimension but also the complexity of the analysis' spatial domain, it is possible to consider three issues rising from management of temporal information in spatial domain. The first is the possibility to retrieve information based on temporal information of the dataset, the second involves the capability to manage temporal information in order to generate analysis and process and, the last requires the capability to simply represent the temporal dimension in a useful and meaningful manner. This involves an extension on the metadata implementation rules. The INSPIRE Metadata Implementation Rules (Version 3, dated 26 October 2007) currently define four elements regarding temporal information:

- The time period covered by the content of the resource (also called the temporal extent of the resource).
- The date of publication of the resource.
- The date of last revision of the resource, if the resource has been revised.
- The date of creation of the resource, if it has not been revised.

However these categories do not allow considering the whole spectrum of temporal information. For this reason one of the first achievements of the project BRISEIDE it is to propose to extend current data/metadata models to be able to benefit from information available at high refresh rate (e.g. from sensors) as well as to be able to analyse evolution of phenomena over time.

The BRISEIDE Metadata profile is intent to provide metadata of dataset collected in the BRISEIDE SDI. The BRISEIDE project is oriented to deal with information related to the disaster management and civil protection and, in particular, with time dimension. The elements presents in the metadata profile allows the discovery of BRISEIDE dataset, in particular using the temporal dimension. The whole of these elements allows to user to identify the resources using the temporal dimension providing information about the resource data, resource updating and resource temporal contain.As far as data visualization is concerned, in many cases a simple visualization is not sufficient and the use of complex diagrams is required in order to visualize results of a given analysis, which

can make the user's comprehension extremely difficult. The issue may be helped by using some of the tools provided by the GeoVisual Analytics (GVA) technique that combines the benefits of data mining and information visualization within a geospatial context. GVA is capable of providing integrated visualization, filtering and reasoning solutions to better support operators looking for design decision support [De Amicis et al. 2009]. Through GVA tools, users can typical acquire visual cues that can help them formulate a set of viable models. The possibility to provide the potential of GVA within web-based 3D geo-browsers is a central issue in the usability of Geographic Information (GI) and for a better understanding of Geographic-dependent phenomena.

TIME AS A VARIABLE WITHIN DATA AND METADATA

It is wise to note that in the second half of 2010, within the activities of the project, about 170 raster, vector, alphanumeric European and national datasets as well as standard web services have been surveyed looking for their time characteristics. The analysis of their properties has shown a certain level of heterogeneity and, sometimes, a serious lack of necessary information. Specially in emergency terms, the use of unsuitable and un-harmonised datasets could cause wrong outcomes by BRISEIDE spatio-temporal services. The analysis on dataset properties has allowed to accurately describe and identify the relevant data sources. In some cases harmonisation has been ensured through dedicated services, required for instance to ensure re-projection between different coordinate reference systems (CRSs) or to perform file format conversion. But in other cases there is the risk of using information not adequately resolute in space or time: detection of small landslides requires remote sensed images with few meters of spatial resolution; monitoring of flooding is possible only with frequent dataset from ground sensors. If metadata doesn't report these properties there is the possibility to obtain unsuitable results.

The relevance of time information used in the management of emergencies is particularly high, as well as the standard used for the metadata. However, the survey carried out in the project has shown the low number of temporal properties related to vector, raster and alphanumeric data sources (see table 1) while metadata are used in almost half of the cases. In particular the time information is not considered like a property of the spatial information, but each spatial data set is considered like a static element till a new update, becoming later a new unrelated item.

	Vector (86)	*Raster (22)*	*Alphanumeric (29)*
Time properties	22 (25.6 %)	10 (45.4 %)	0 (0.0 %)
ISO19115/19119	50 (58.1 %)	9 (40.9 %)	5 (17.2 %)

Table 1: number of BRISEIDE dataset with temporal properties or metadata standard

On the other hand, the survey has reported a good number of standard and advanced geo-spatial services (32), made available from partners as well as several public datasets covering various topics (geology, demography, infrastructures, ecology, etc.). Afterwards these datasets and services will be integrated and enhanced, becoming accessible from partners through a web portal.
The most important achievement of the first project work packages relies on the identification of three relevant temporal dataset properties:

1. the granularity, considered as the temporal resolution (time period between two following measures);
2. the frequency of update, or the time period needed for the availability of new data (sensors acquire field measurements at a certain frequency but they make them available at predefined and different time intervals).
3. the time extensions mean like the temporal validity of the resource.

These properties become even more important for management of fast evolving phenomena, as, for instance, earthquakes. However time properties are only partially considered in INSPIRE and in ISO standards. Some critical aspects have been analysed and reported on this issue:

- INSPIRE considers only the date of creation, publication or last revision as well as the temporal extent of the resource, not of the event itself (I.e. date of creation of the file of administrative boundaries or of the boundaries.

- According to ISO 19115/19119 standards the granularity is only related to raster datasets and the frequency of update is not included in the minimum set of mandatory elements.
- Different levels of precision for time expression (i.e. 12/12/2010 or 12/2010).
- Time expressions do not ever follow ISO standards (ISO 8601 for dates and ISO 19108 for time ranges).

All these issues, related to the management of time as a dimension, demonstrate the need for a major revision of the current standards in order to able to account for time in metadata. The problem has been first highlighted by a review by Dekkers-Craglia, published in 2008, and subsequently handled by researchers through of the use of new classes within ISO elements or through the introduction of non-standard languages.

It should be noted that the main aim of BRISEIDE is the development of spatio-temporal value-added services in order to better monitor and manage the emergencies and not the proposal for a revision of current standard. For this reason it has been decided to adopt a solution that uses existing ISO elements (resolution and maintenance as well as update frequency) for a wider expression of granularity and frequency of update, avoiding in this way the problems arising from the implementation of catalogue services foreseen in the project.

Nevertheless the problem of the temporal metadata standard in GI still remains. The growing use of interoperable web services, of dataset constantly updated (e.g. sensors datasets) and relative OGC standard protocols (SWE, Sensor Web Enablement) creates an increasing need for spatio-temporal e-government services beyond the risk management domain (i.e. administrative boundaries, land use, cadastral parcels, street addresses, urban planning, etc.).

THE IMPORTANCE OF TIME AS A DIMENSION FOR NEAR REAL-TIME SERVICES FOR THE E-GOVERNMENT

First it should be considered that time dimension of e-governance and e-government has been studied mainly focusing on dependencies of given effects on the effectiveness of e-government policies and decisions in function of the time required to deploy e-government measures. This clearly yields a dependency from those specific technical and administrative tools deployed by a public authority to meet the expected progresses expected from the e-government system already set up. Therefore it may be considered that the time has been often considered as a characteristic for evaluating the effectiveness of the policy and measures for achieving e-government final services.

It is well known [HEEKS and others] that a substantial number, or even the majority of e-government policies, especially in areas assigned to further development, fail either totally or partially because of on-the-ground real situation (known as 'design-reality gaps') affects e-government projects since they deeply involve the situation present in the specific administrative and organisational environment where they act.

Time plays several relevant roles: time qualifies available data, time is characterizing the collection and the processing of data, time plays a role in terms of effectiveness of actions generated by the e-government services, time within administrative environment has its own characteristics and it may depend on obsolete rules and procedures.

GI has some peculiar aspects within the data framework used for e-government. Geo information has been only slightly integrated in e-government services [Salvemini and others] and mainly treated as dependency to an already existent information or considered relevant because of the need of giving services at the right moment where they are needed.

Type of time	Type of data	Type of e-government service
T 1	time as component of alpha-numeric data	Data processing
T 2	time as component of data series	Data base processing
T 3	time as specific component of the geospatial information (x,y,z,t)	Geospatial data base processing
T 4	time as characteristic of the service delivering	Monitoring and controlling

Table 2: Time components in e-government services

The table represents a first attempt to discuss the various types of data containing time dimension and types of services which may be developed on the mentioned data. The different types of data may be merged.

Time is part of the process of acquiring, treating and using data. From this point of view standards

and orchestration of services can be used in order to manage the time dimension, this involves the need to extend the existing GI standard and services to these purposes.

Time has also to be considered as part of the process of how public administrations are taking decisions. This specific time dimension may often be longer than the timespan occurred for processing data in a robust interoperable ICT infrastructure such as it should be INSPIRE. Time may depend on internal organization of the administrative and decision-making structure, on its degree of confidence of the results of the services which originated the data, and on how the data presented are understandable and shareable with other administrative entities as well as with the communities of final users.

The ITC services considered by BRISEIDE have a relevant role in providing end-user services deployed by the mandated public administrations (therefore to be considered as e-gov services) to citizens in situations where the time frame is relevant. In fact the final service and its assessment under emergency situations, has to be provided on time and where it is needed with lower approximations whenever highest it is the need of intervention.For instance, in case of wildfires, how long in advance should the evacuation order be given? A very similar situation may be present in a flood emergency. Earthquakes generally generate a more complex situation since their sudden occurrence, in context where they have been largely foreseen, as for instance in the case of the 2009 quake in L'Aquila, Italy, has demonstrated the impotence of public bodies to set up adequate mitigating countermeasures.

CONCLUSION

BRISEIDE is an EU project with the aim to develop some services specially focused on Spatio-Temporal dimension. However some relevant issues related to further research agenda items are addressed and they need to be investigated in the future.

First of all it is important to explore how the services resulting from the "bridging" (in terms of interoperability) of process may be effectively used by public administrations as well as final users, in emergency situations and to satisfy near-real time request under emergency circumstances.

The fact it is expected that, in the future, greater attention will be paid to time as key dimension when producing metadata and ad-hoc spatial information as these only represent the visible "tip of the iceberg". It has still to be investigated and demonstrated analytically how services may be integrated within public administrations to improve efficiency and control for the benefits of the final users.

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