Towards Real Time Metadata for Network-Based Geographic Databases

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TOWARDS REAL-TIME METADATA FOR SENSOR-BASED NETWORKS AND GEOGRAPHIC DATABASES

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KEY WORDS: Metadata, Sensor database, SpatioTemporal, Data Quality, GIS

ABSTRACT:

Nowadays, the geographic metadata are defined by ISO standards and their particular goal is to assist the data exchange between different users and to provide the data quality information. However, these metadata are defined for static data processed by traditional applications. Such metadata do not take into consideration the qualification of dynamic data resulting from mobile and agile objects or from real-time measurements managed in "on-line" applications, such as industrial or natural phenomenon management. Moreover, the sensor networks linked to databases are increasingly used in many fields, in particular in the disaster management systems. The real-time management of spatiotemporal data resulting from these sensors requires a definition of real-time metadata, especially for quality assessment in a decision support context during a critical situation. This papers sets out the issues of real-time spatiotemporal data and metadata to help to design quality assessment of spatiotemporal data. .

1. INTRODUCTION

In Geographic Information Systems more and more data coming from sensors are used especially in applications for environmental surveillance (volcano, tsunami, earthquakes...). These kinds of applications are used to support the Geographic Information Systems (GIS), especially during critic event, like the detection of volcano eruption. In this context, the metadata (data about data) is a useful element in decision making-process, being a technique to inform on data quality.

The Geographic Metadata are defined by ISO standards (ISO19115), their purpose is to assist the data exchange between users and to provide quality information. Actually, quality is evaluated by several criteria (accuracy, completeness, etc.); such criteria are defined for static data processed by traditional applications and do not take into consideration the qualification of dynamic data. The scope of this paper is to analyze the outcomes of sensor-based geographic databases and their real-time issues especially for quality assessment.

This paper includes three sections. The first section presents an overview that explains the particularities of real-time databases. A description of a related example is presented. The second section presents several concepts related to our topic: real-time databases, metadata especially concerning GIS, and the recent data and sensor network structures. Finally, in the third section, we introduce the RTSTMD (Real-Time SpatioTemporal Metadata) by a definition of Real-Time SpatioTemporal Data (RTSTD) and their characteristics. In this section we present a real-time spatiotemporal data model and a formalization of sensor objects.

2. OVERVIEW

The sensor networks linked to databases are increasingly used in disaster management, the prevention of natural disasters, navigation, etc. In this context, quality control is important for decision-making process. It is significant to remind that the quality information does not represent the most detailed or the most precise information, but rather it represents the information that meets the user's requirements. We often confuse the quality definition with that of excellence or perfection (Guptill, 1995). Actually, quality is overall managed in Geographic Information Systems (GIS) by the metadata.

In fact, user's requirements are variable and depend of each application. Nowadays, in several sensor network applications such as natural phenomena surveillance, navigation or traffic monitoring where sensors are used, quality is restricted to the acquisition system. The real-time management of spatiotemporal data resulting from sensors requires a definition and analysis of data quality, the accuracy and also a definition of quality communication techniques. This quality can be evaluated using metadata. With this perspective, the real-time management of dynamic information dedicated to metadata represents a critical point.

In this subject, we consider several questions that need to be answered. Which information is necessary to consider in the real-time spatiotemporal metadata? Which are those that contribute to define data quality? In a real-time context: how to identify metadata from data? How to generate, to extract and to communicate these metadata to the user? At which intervals these metadata should be communicated?

The purpose of this paper is not to answer to all these questions, otherwise we present several ideas and possible solutions that could hep to resolve the real-time spatiotemporal issues.

Next, we describe a related example and we present the particularities of real-time databases.

2.1 An example of a related application: Volcano monitoring

The Popocatepetl is a Mexican volcano, at 60 kilometres from Mexico City and at 45 kilometres from Puebla. It extends on three Mexican states, where each one has its own disaster management policy. In order to prevent natural disasters, the volcano was placed under the surveillance of Cenapred (Cenapred, 2006), the Mexico's National Center for Disaster Prevention. The Cenapred use a group of sensors distributed on 25 stations (seismographs, clinometers, etc.) allowing to qualify and quantify the volcano activity. This data are collected within a centralized database. Actually, the system is based on the Earthworm specifications, defined by the USGS (USGS, 2006).

The experts (chemists, physicists, decision-makers) admit that the most recent data are for them the most interesting, except data acquired in specific phases of activity. The quality indicators on the gathered data would allow better decision-making. Then, the difficulty is to identify the necessary information and to allow their real-time processing.

2.2 Real-Time Databases, sensors and monitoring

The aim of the surveillance systems is to minimize the damage caused by natural disaster, supervising and analyzing environmental data in real-time. A critic situation can be avoided or minimized providing alarms. Therefore, the natural disaster management requires increasingly real-time information. This information must be complete, reliable, understandable, reusable, shared out, and obtained by specific time constraints (Brewer and al., 2002; Hodgkinson and al., 1991; Hoo Jung and al., 2006).

For example, in the surveillance applications implying sensor networks and requiring the data management in real-time, like volcano activity, we generally find a several heterogeneous sensors, measuring different parameters: temperature, pressure, etc. Whereas certain sensors are entirely periodic (seismographs), others send updates only when threshold of measurement is exceeded or when a variation of a value is noted. Other policies combine these different operating modes.

Historically, the sensors are represented by their sensor ID (Identifier). With the new technologies that allow the update of positioning information, it becomes useful to refer the sensors according to their spatial information (GPS, triangulations). Data collected by a sensor are nowadays referred according to the sensor itself and a time-stamp.

Therefore, it is possible to represent a generic model of data, measures and sensors (Figure 1). The sensors can be classified in several categories by their mobility. Generally, the fixed and agile sensors are the most used in natural phenomena management systems.

The purpose of sensor spatial referencing implies the association of a spatial component to multidimensional data, then, data become spatial and temporal.

Once the sensors have completed their measurements, the problem of data storage appears. Although, several research works recommend the storage in sensors or in intermediate sensors, we observe that the majority of the sensor networks send the data towards an in-memory database, centralized (Eiman and al., 2004), and briefly explained in section 3.3.

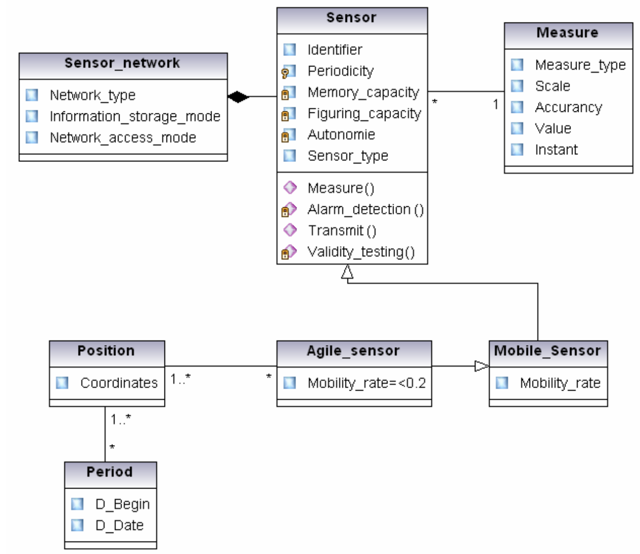

Figure 1. Model of data, sensors and measures (Noel et al., 2005)

The data replication could be carried out towards other databases or data warehouses that are situated outside the network and on disk, as illustrated in Figure 2.

In fact, the analysis of collected data uses in priority the most recent data. Therefore the analysis is carried out principally in memory, whereas measurements have just arrived at the central system.

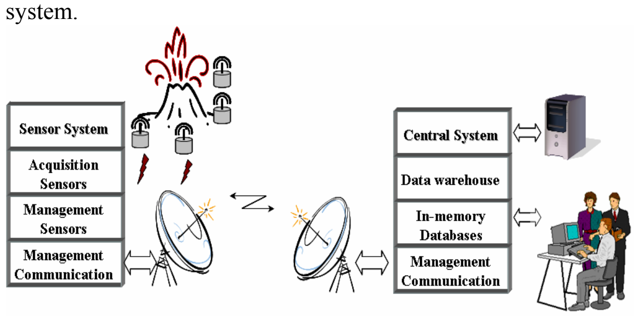

Figure 2. Example of sensor network and central system (Noel et al., 2005)

In crisis situations, the users want to dispose complementary information in particular on the quality of the received data. In this context, the real-time metadata management becomes critical. Therefore, it is necessary to define metadata and also the temporality and granularity of their extraction, their evaluation and their storage.

3. RELATED WORK

Currently, disaster management and natural phenomena surveillance require increasingly real-time information coming form different sources (weather agencies, geologists, the agency itself.).

Real-time is a relative aspect. We can state that the real-time represents according to the user the availability of immediate information. The real-time characteristics are essential for the dynamic applications which cannot be satisfied in differed-time (monitoring systems, motorways, navigation, etc). However, a real-time system can be defined as application where the respect of temporal constraints is as important as the results of these (Ramamritham, 1993).

Concerning real-time natural phenomena surveillance, each phenomenon is specific and their parameters are particular. However, in practice, the sources availability, the execution time and the storage capacity are significant. Moreover, the monitoring activity in real-time, in particular during crises, requires a quick system response and the absence of any source can produce undesirable effects.

Information required in monitoring systems depends directly on the user needs and the application kind. In a real-time context, this information can be defined by metadata, according to the analysis of the quality criteria, data modelling and metadata structuring. All these aspects are important to our work. Next, we present the relation between the real-time spatiotemporal data and the geographical metadata.

3.1 Geographical Metadata and Standards

Metadata are "data about data". Metadata describe the contents, quality and other data characteristics (FGDC, 2000; ADAE, 2006), as the general system description, the geographical extent, the data quality, etc. The data quality is defined itself by several criteria (Servigne and al., 2006) as the accuracy, completeness, etc.

The whole information contained in metadata, must be accessible. All users must be able to reach and share metadata information, in order to make easier the access to information. Generally, each application defines a metadata classification according to their requirements. But actually, it exist a standard that represents the structure of the spatial metadata: The ISO 19115 standard (ISO19115, 2006).

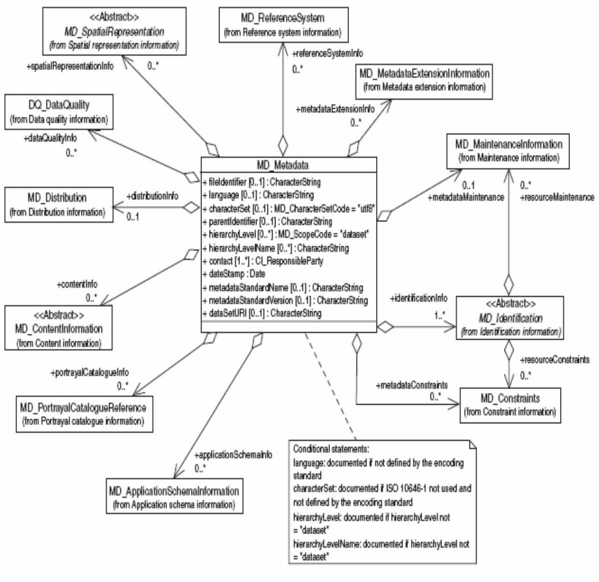

Figure 3. Metadata classes model, Standard ISO19115 (ISO/FDIS 2003)

The ISO19115 standard is the international reference on geographical information concerning the metadata exchange. This standard makes it possible to create metadata models; each model is created differently, since standard or mandatory and other particular elements.

The ISO19115 standard provides a model of metadata elements (Figure 3). The metadata model must allow as possible an exhaustive description of all the information concerning geographical data.

The metadata elements are defined by their type, their relations and the associated conditions. In order to make easier the information access, the standard elements, in this standard, were classified in four groups:

* Thematic (What)	* Spatial (Where)
* Temporal (When)	* Contact (Who)

Metadata elements presented above (Figure 3) are provided by data producers during data delivery and they are also supposed to meet the global user requirements. However, sometimes the users are facing some problems like the difficulty to update and manage a large dataset. In a real-time context, the access delay is critical, in particular in disaster management applications and generally these quality criteria do not take into consideration the dynamic particularities of the real-time data.

An important aspect of this metadata classification is the data quality. Data quality has been an active domain in the geographic information systems research. This research field was developed in particular by the growth of data exchanges and the use of SIG as a tool of decision-making process (Goodchild, 1995; Veregin, 1999).

Actually, spatial data quality is described according to several criteria (Servigne and al., 2006): lineage, geometric accuracy, semantic accuracy, the completeness, logic consistency, temporal accuracy, the semantic consistency and finally the "specific quality" in order to complete the aspects not covered by the other criteria.

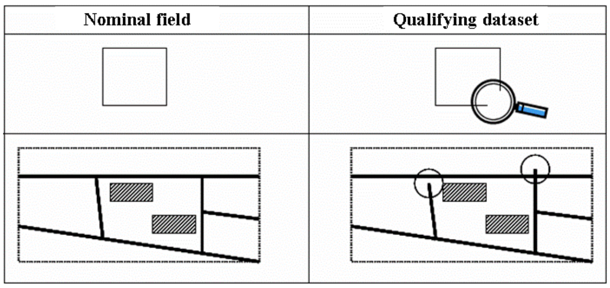

Figure 4. Example of Logic consistency: Polygon contour verification. (Servigne et al., 2006)

Quality evaluation by these criteria makes possible to represent data performance according to data quality elements and the use of metadata as a method to communicate quality.

3.2 Real-time SpatioTemporal Metadata

Actually, there exist a few works and any official standard proposed to modelling and structuring sensor data (OGC 2006).

However, we identified some particular research works exposing the problematic of geographic metadata in a real-time context. These works are interested in the management of oceanic data or data concerning natural phenomenon, etc. (Charpentier, 2005; PIRATA, 2006; TAO, 2006; MMI, 2006). The special requirements of these works are: to standardize a data format for metadata, the definition of protocols and procedures for metadata exchange, definition of a metadata database. This database requires a centralized storage and their availability in real-time. The must important difficulty, in terms of the large quantity of information, is to carry out real-time metadata transmission and documentation by limiting the equipment resources. An analysis of the real-time data infrastructures is then unavoidable.

3.3 Data and sensor networks structure

In a real-time context, it is important to consider sensor capacities of storage and transmission, sensor localisation and sensor measures types which depend on sensor types. For the networks composed by microsensors, the continuous data transmission is generally unrealizable, considering transmission cost. Several studies shown in this context that local data aggregations before a data transfer is generally more economic (Intanagonwiwat, 2001; Ratnsamy, 2002).

Responding information cost, several studies are focused on the data localisation. (Eiman and al., 2004) identify two types of approaches:

The **local approaches** propose to preserve the maximum data at local side. This approach minimizes the transmission cost of the updates. However, for data query it becomes often necessary to transmit the query through different elements on the network, thus increasing the cost of the query. More over in systems asking to preserve an historical of data collected, it becomes necessary to transmit data in certain way.

The **external approaches** propose to centralize data in a database outside the sensor network. In this case, the transmission cost of the updates is obviously higher. However, this approach makes it possible to minimize the requesting cost. In decision-making support or phenomenon analysis systems, data centralization should be suitable for a data collection.

Between these two approaches there are several ones that offer data replication systems between several nodes in the network. However different problems may occur. By the using of data spatial localisation techniques and the centred storage of data makes possible to define replication nodes where it is possible to reach data. As a result, it is possible to have a proposed solution between the two approaches.

In natural phenomena management, the use of sensor network makes it possible to obtain data about the observed system even in an unstable environment (difficult meteorology, risk of ground falls…). According to these conditions, another element to be taken into consideration is the risk of a sensor failure, particularly in crisis situations. Consequently it is not recommended to preserve data into sensors. Even, it is better to preserve data in a centralized database outside the network and located in a safe environment.

All these characteristics are to be considered to metadata management in real-time.

4. REAL-TIME SPATIOTEMPORAL METADATA

Generally, metadata are defined according to their using context and their contents. In our work, we define the Real-time SpatioTemporal Metadata as being "data about data that meet the user's requirements through a period of time for a particular localization at specific time (date)”.

According to the metadata functions, we consider that certain metadata correspond to the fundamental information to describe any RTST (Real-time SpatioTemporal) application. In the same way, we consider another metadata that corresponds to the particular application requirements. We propose, then in the section 4.1 two categories of metadata: **generic metadata** and **specific metadata**.

In a real-time context, suitable the dynamic nature and using of real-time data, it is often difficult to make a distinction between data and metadata. These problems were underlined in some recent studies, in particular in the oceanographic field (MMI, 2006; Charpentier, 2005). To support the identification of data and metadata we propose in section 4.2 a Real-time SpatioTemporal Data model. With this model it is possible to determinate the rules and conditions of eligibility (data or metadata) according to semantic constraints, data dynamicity, etc.

Following this identification, we propose in section 4.3, a metadata classification: **static metadata** and **dynamic metadata**. These categories correspond to the data dynamicity characteristic that can be transmitted to metadata according to the using context.

Moreover, we observe that the ST (SpatioTemporal) data in a real-time information system pass though several real-time processes.. The impact of these processes in particular on data quality is not harmless. In Section 4.4, we distinguish among these processes: the **real-time acquisition**, **real-time processing** and their **real-time use**. We consider that each process has an influence on the data properties, in particular on their quality. Furthermore, it is important to our work to define metadata of these processes in order to provide quality information.

Finally, in section 4.5, we analyze the real-time use of metadata. As we indicated before, the purpose of metadata is to provide useful information for improve data processing by the user. These metadata must be updated and available. In a real-time context, the using mode is rather important. We commonly distinguish the real-time use and the offline use. Each one of these has advantages and disadvantages according to the application. For our work, we take into consideration the critical context (disaster management, natural phenomena, etc) of applications.

4.1 Metadata: Specific and Generic

One of the difficulties previously raised relates the mass of information to be managed in metadata; this difficulty becomes crucial in a real-time context. Therefore, this means necessary to define a metadata classification in order to establish the generic metadata which appears essential and which represents the core of the real-time applications. The others specific metadata, correspond to the specialized information depending each application.

In Geographical Information Systems, we can appreciate two information levels: the generic level, which describes common information in different kinds of applications and the specific level, which describes particular information according each application. In this context, we propose to define a metadata group for each one of these levels.

Generic metadata describe the minimum information necessary for the identification and definition of a dataset. These metadata represent the core elements for the identification of a Real-time SpatioTemporal application.

Specific metadata describe the particular information of each system, according to each application and their characteristics. These optional metadata can be added according to user requirements.

This classification is carried out considering the level of user data access (generic and specific) in order to save time and system resources.

4.2 Metadata and Real-Time SpatioTemporal data

To better understand the characteristics of real-time spatiotemporal data, we propose a data model that allows to:

- Evaluate the relations between the ST data and RT (Real-time) context.
- Facilitate the identification of information that concerns data and of those that concerns metadata.
- Be used as support to the development of metadata identification rules according to data evolution and of their application context.

4.2.1 Real-time SpatioTemporal Data model: In this data model (Figure 5) we present a structure of the real-time spatiotemporal data as well as the interaction of their static and dynamic characteristics.

The data collected by a sensor (fixed, agile or mobile) are referred according to their position and their acquisition date. In current applications (NOAA, 2006; Volcano, 2006; Parrend, 2005), we have several sensor networks in the same observation environment, but also we have the possibility to acquire data in different positions (mobile and agile sensors) and several measurements carried out by the same sensor (RDI Sensor, this sensor contains at the same time: a pressure sensor, a magnetic compass, a temperature gauge sensor).

In a disaster management environment, for example, there are several observation stations (Weather stations, boats, buoys, etc.) that are responsible to supervise the phenomena around the world (Volcanoes, Tsunamis, Seismic, Pollution, etc). One or more elements (i.e. Temperature, Pressure, CO2, etc) of each phenomenon could determinate their evolution. The evolution of these phenomena is carried out according to the acquired measurements, in a real-time context, these measurements represent a value on a given date, but they are valid just for a specific period of time.

In this model, we underline the static and dynamic aspects of the acquisition system, as well as their relations.

Static aspects: Observation Station, Observing phenomena, Measured element, Measure series, Fixed sensor

Dynamic aspects: Position, Measure, Agile Sensor, Mobile Sensor.

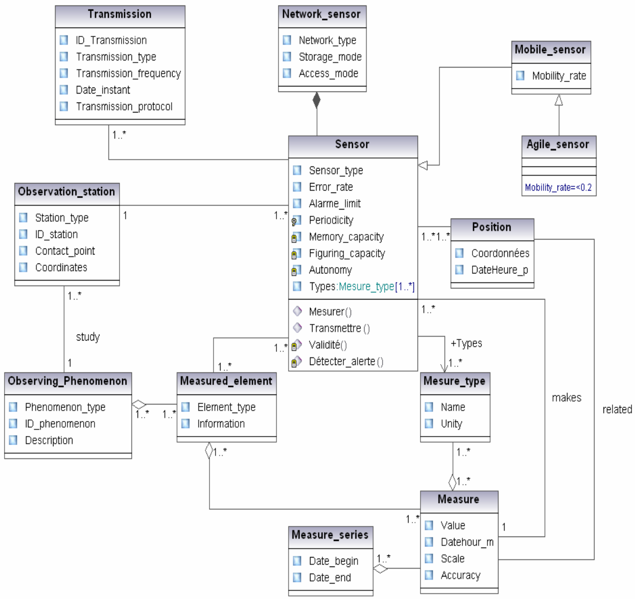

Figure 5. Real-time SpatioTemporal Data model

4.2.2 Sensor Object Formalization: Within sensor networks, the principal objects are sensors, measures or information collected. We propose in this formalisation the connection between the three types of sensors (fixed, agile or mobile) and their measurements.

We call *id* the object identifier; it is unique and does not change in time. Each object represented in the database is identified. The *IdS*, represents the sensor identifier. The spatial position is called *P*, this position is associated to geographic coordinates or cartographic systems. Most of the time, the position is obtained by a satellite position system. To these located objects there are several sets of thematic attributes associated. The values of this attributes are fixed or variable in time. The attributes where the value changes are M^j. For each M^j a value M^j_I is given in a moment D_i. The instants D_i are ordered ($D_i < D_{i+1}$). The M^j_I values are constantly or variably provided by the sensor. The fixed attributes are called B^k . Their value do not changes in time.

We present next, the formalisation of the objects resulting from fixed, agile and mobile sensors.

⇒ **Fixed Sensor**

$$FSO \; : id, idS, P, \{T_i\{M_i^j\}\}, \{B_k\} \qquad (1)$$

$$T_p \leq T_i \rightarrow P = fixed$$

Where:

D_i = Date and time at moment *i* with $Di \leq D_{i+1}$
D_p = Date and time at the beginning of position *P*

For the objects coming from fixed sensors, the position is fixed, and values that change in time are M^j. We can define these objects with a identifier, a position in a delay of time or for each instant of time T_i a value M^j is communicated. Their static attributes are also represented.

⇒ **Agile Sensor**

$$ASO \; : id, idS\{D_t\{D_{i,}\{M_i^j\}\}\}, \{B^k\} \qquad (2)$$

$$D_t^p \leq D_i \quad et \quad D_t^p \leq D_t^{p+\Delta p}$$

Where:

D_i = Date and time at moment i with $Di \leq D_{i+1}$

D_t^p = Date and time at moment t at the beginning of position P

B^k = Fixed value attribute

For the objects coming from agile sensors, the sensor position does not change in the same proportion as the M^j attributes. We propose to formalize these objects with an identifier and a temporal position series collected by this sensor. In this temporal series, another temporal series of values M^j to each $M^j{}_I$ is defined. This temporal series contains all the measures collected in this position by the sensor.

⇒ **Mobile Sensor**

$$MSO: id, idS, \{P_i, D_i, \{M_i^j\}\}, B^k \quad (3)$$
$$D_i^p = D_i$$

Where:

D_i = Date and time at moment i with $Di \leq D_{i+1}$

D_i^p = Date and time at moment i at the beginning of the sensor position p

For the objects resulting from mobile sensors, the sensor position is susceptible to change with each data acquisition. We can formalize these objects with an identifier, a temporal series or for each instant of time D_i a position P_i is communicated and a value $M^j{}_I$ to each M^j is defined.

4.2.3 Real-Time SpatioTemporal data or Metadata?: Following the proposition and analysis of data model (Figure 5), we continue the study of metadata in order to define the rules to differentiate data of metadata. We consider that there are two aspects to be taken with consideration: the great data dynamicity and data semantics.

The data semantic is principally characterized according to their use by a final user. According the application or the application context, a data can or can not characterize a phenomenon. The final user, describing the final objective and the context of their application, can allow the identification of information that concerns data of those that concerns metadata.

The dynamicity and the semantics of data are related aspects in a real-time context. According to the dynamicity, we have a considerable variation of value in time. We have the mobility of a sensor as useful example. If the sensor position varies constantly, that is an example of a mobile sensor; this information will be inevitably considerer as a data. In fact the position is a measure and it is part of the measured elements like the others elements measured by the sensor. On the other hand, as the fixed sensor the position is stable information. It could be considerer like a complementary data over the sensor measurements. Then, the position could be determinate like a metadata.

Information acquired in real-time and with strong dynamicity (high frequency of modification or transmission) is data and cannot be regarded as metadata. The dynamicity and the using context establish the conditions to differentiate data element from metadata.

4.3 Static and Dynamic Metadata

We consider in our data model the importance to expose the constant evolution of the values in certain information. Certain data can make evolve the contents of the metadata.

We propose initially two types of metadata which can improve the real-time spatiotemporal processing: **static metadata** and **dynamic metadata**. This classification is carried out according to the evolution of data in time.

The first category, **static metadata**, is metadata generally found in the traditional applications as the spatial domain. These metadata describe data gathered which do not evolve regularly during the development of the application, for example: project identification, station information, contact organization, etc. The static metadata does not change during the measurement time.

The second category, **dynamic metadata**, is described according to the dynamic data behaviour. This type of metadata represents variable information in time. For example, the data quality can be affected during the real-time transmission; it depends in particular on the quality of service. Another related example is the sensor position. If this sensor is fixed, in particular in natural phenomena management, the position can be regarded as a static metadata. We can remember that information with a high dynamicity it can not be considerer like a metadata. All the difficulty is then to determine the definition of "high dynamicity". If the sensor is mobile, the position is a data and not a metadata. If the sensor is agile, the sensor position can be regarded as data or a dynamic metadata according to their processing and the frequency of their position changes.

We consider that a real-time spatiotemporal metadata can be dynamic. We think information which contributes to inform a dynamic metadata it is not part of measure series, but the value of this metadata is likely evaluated in time et during a measure series.

4.4 Metadata and real-time process

Data in a real-time context are given from different processes through an information system. We distinguish, among these processes, real-time acquisition, real-time transformation and real-time use. Indeed, real-time execution of these processes changes the properties of the data and of course their quality.

Consequently, we consider important to represent the information of each one of these processes in metadata. These metadata make it possible to known data status in each real-time data processing. Principally, the metadata are coming from the application and their characteristics in acquisition, processing and use in a real-time context.

4.5 Real-time SpatioTemporal Metadata Use

In the spatial domain, there are differed and real-time services (NOAA, 2006; TAO, 2006), like transport applications (navigation), management resources (oil resources protection), regional planning (management of constructions, topography, prevention), earth, (cartography, meteorology) and civil security (catastrophes, management of dangerous transport). In these current examples, “time” is an important aspect of information use and it is determinant to the quality information.

In critical applications, the need for a quick response of the system is very important and the absence of any information can generate irrevocable effects. On the other hand, in offline applications, the user has more time to recover the measured data according to his concern and to carry out a data "post processing".

Currently, metadata is used in order to improve data management and also to archive information considered relevant. In a real-time context, the relevance of information is very relative in particular by the continual evolution data, the diversity of applications and also the user requirements.

For the analysis of the real-time and differed-time processing, we chose the critical real-time information systems (Disaster management, Meteorology, Seismic, etc.). The characteristics of these systems make possible to evaluate the advantages and the disadvantages of these aspects.

RTSTMD and Real-time processing: In critical applications, the necessity of quickly responses is very important. The user seeks in the real-time processing, the "immediate" information availability. That is means that the processing, the filtering and the checking of the data are generally carried out in the sensors themselves or at least not in the processing stations (local approaches, Section 3.3).

The real-time characteristics are crucial for the dynamic applications; generally the differed-time behaviour is not enough to their data processing (Seism, Navigation, Traffic management, etc.). We consider that the real-time advantages are more that a simple gain of time, it makes possible decision making in a critical situation.

In applications like disaster management, the use of information in real-time is essential for the information availability. But also, real-time could be the detriment of quality and accuracy of information. Nevertheless, many users and scientific professionals choose the real-time mode when it is possible.

4.5.1 RTSTMD and Differed-time processing: The differed-time processing presents a time delay by their processing, because when data are gathered, they will be prepared for post-processing and for data evaluation and visualization.

The several differed-time functionalities, like the historical data, the authorization control, allow us to save time and accuracy. We have the possibility with this kind of processing to detect invalid values in a qualitative way (physical limits, comparisons of values, etc.) and also in a quantitative way (according to the results).

In critical applications, the presence of differed-time processing does not represent an option. Among other applications, the important factor in decision-making is time and the immediately reaction towards the unforeseen events. But, this processing can help determine the causes of an event.

We estimate that the differed-time processing allows the information synthesizing, the comparison of data according to its environment and their use in order to prevent catastrophes.

Comparing these information uses, we consider that there are two important factors: their application context and their quality. In a rather simple way, the need of rapidity and immediate responses could generate a propagation of certain uncertainties and the decrease of quality information. On the other hand, our study shows that the application context is rather important. We have studied applications which need rapidity rather accuracy and others which require fast and such accurate information. Consequently, we consider that the information use is directly related to the user requirements and the characteristics of their application.

5. CONCLUSIONS

In first place, the objective of this article is to present the particularities of the spatiotemporal metadata in a real-time context. Indeed, if the geographic metadata are classify today by ISO standards, these metadata are defined for the static data exploited in traditional applications. These metadata do not take into consideration dynamic data issues of mobile or agile objects or of real-time measurements. Therefore, it is important to our work to provide real-time additional information in order to help the users in the decision-making process.

The analysis that we present above, makes possible to specify the problematic of real-time spatiotemporal metadata. In this paper, we state the difficulty to identify data from metadata and their importance in the real-time systems. As a result, we propose a Real-time SpatioTemporal data model in order to identify and bring the first rules to determine the difference between them. Also, the analysis of our data model makes possible to propose several classifications of different kinds of metadata. These classifications are defined according to the level of user data access, the real-time processes and the features of the dynamicity and semantics.

In order to formalize sensor (fixed, agile, and mobile) behaviour, we propose a mathematic representation of the functions and sensor characteristics. This formalization allows identifying the limits, properties and behaviour of a sensor.

Finally, the study that we present, concerns metadata in order to define the information quality in the acquisition process and the real-time data use. In the same way, the difference between the real-time and the differed-time processing, the valuation and the extraction by query or in real-time must be carried out.

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