Modeling Herd Trajectory Data Warehouse

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***Abstract*— Studding the movement of animals and their behavior become an important subject. Indeed, such study can generate useful information used next to assist the decision makers involved in different domains such as agriculture, security, health care and business.**

We present in this work a trajectory model related to the displacement of the herd, which allows the generation of trajectory data that is going to be stored into trajectory data warehouse.

The animals in the herd change continuously their location, so the collected information varies over the space and the time. To facilitate their study we present the herd by a point so we focus on the moving points. Such supposition facilitates the modeling of the trajectory.

***Keywords*— Trajectory DataWarehouse (TrDW), modeling, herd, displacement, movement, animal, Star schema.**

I. INTRODUCTION

The information, related to the study of a moving object during its displacement, is almost of time very useful in various domains, we can mention as example the agriculture. We noticed that the world endure a strong exploitation of natural resources. In many countries, the situation related to the ecological system is characterized by a significant degradation which can reach, in certain case, an irreversible stage. By modeling the movement we can get more information about the animals' behavior, we can also predict their future movement. By this way, we can intervene to protect the environment by, for example, changing the direction of the displacement.

Concerning the security, if we don't take the necessary precautions, there is a risk to lose a big number of animals, because of the roads. In fact, a lot of animals are killed each year because of the vehicle's speed. So, by modeling the displacement we can intervene in real time to alert the shepherd or to take it into consideration before the construction of a road to put enough alerts for the drivers.

As mobile objects, we have a herd of animals. It can be composed by domestic animals (sheep, goats, camels, lambs, etc.) that follow a shepherd. In this case, the different information is going to be sent through wireless technology such as GPS. It can be composed also by wild animals (hors, pigs, gazelles, birds, etc.). They move without a supervisor. In this case, sensors are attached to individual animals. The signals are captured by satellites. In both case, we can get real-time information about each animal. The problem of the new technology is: it cannot give information that evaluates continuously, we suppose then that the values of attributes are constant between two successive update. To store the different information, we used a Data Warehouse (DW). This choice is because of the expensive of the computation of the data bases rending online processing inapplicable. The traditional Data Warehouse (DW) and Spatial Data Warehouse (SDW) cannot deal with the spatiotemporal data this why we used a Trajectory Data Warehouse (TrDW) which takes into consideration the continuous evolution of the current position in function of the time.

The data stored into TrDW allows anticipate the future movement of our herd by utilizing the linear interpolation. This last allows trace the trajectory. Despite, it is not quite the reality but it can serve as an approximation. The linear interpolation is very helpful, by starting from the present move; we study the animals' behavior and we can then predict the future one.

In this paper, we focus on modeling the trajectory of the animals. It is a way to structure and organize the data to be understandable by the decision makers. In addition, it gives information about the trajectory as well as its components, so it serves to have ideas about the external factors that influence the path. We propose, then, on one hand, two ways to model the trajectory data, the first one is based on ER model and the second is based on Spaccapietra model. On the other hand, we propose TrDW model allowing the storage of the data into special DW. The purpose is facilitating the making decision in different domains.

To achieve the goals fixed above, we propose to organize this paper as follow:

In section two, we present the different works existing in the literature and giving information about the problem of grazing, the moving objects and the evolution of DW.

In section 3, we present the trajectory data which corresponds in our case to a spatio-temporal movement because we take into account the space XY and the time T. In section 4, we present two models allowing modeling the trajectory data. The first one is based on the Entity-Relation (ER) model and the second is based on the Spaccapietra model. In section 5, we present the TrDW as a way to store the collected Trajectory Data (TrD) and we propose the use of star schema.

II. RELATED WORK

The problem related to the degradation of vegetation becomes very important and crucial. Many works in the literature put the accent on this issue and as example [1] which addresses the problem of degradation in the steppes in Alger which causes the change of the ecosystem (from steppe to semi-desert). This degradation is mainly due to the agricultural practices and livestock. Those latest are considered as the main responsible for the degradation of vegetation cover and accelerated erosion of soils that are noticed by agro-pastoralists. Among the proposed solutions, these practices have to be changed. Concerning [2], the authors addresse the case of pathways degradation in Tunisia and especially in El Hamma Gabes, while putting emphasis on the effect of overgrazing and purporting to be the principal causes of this phenomenon. Overgrazing is considered as the reduction of vegetation cover of perennial species and it results, according to [3], the loss of species which is the result of livestock and the initiation of erosion. This deterioration is exacerbated by the stocking density which is considered three times higher than the normal. The degradation and the overgrazing are increasing day by day especially in recent years which are characterized by their drought. And according to experts (ecologists and phyto-pastoralists) the problem of degradation and regression of rangelands is worsening (desertified areas would be 17% after 25 years and 49% in the case of intensification of current practices). According to [4], the authors present the problems encountered at the SIERRA MADRE OCCIDENTALE (northwestern Mexico). This area met strong exploitation of mountains which generated degradation by areal erosion and loss of pasture quality. A cause is the overgrazing, which has expanded at the expense of forests. In fact, in this area of livestock, breeding is regarded as the main activity and despite the declining population, the number of herds remains high which causes a worsening of the grazing pressure near the villages.

In fact, to properly consider the condition of vegetation in a state, the authors in [5] require making several observations and obtaining data relating to crimes of overgrazing and according to studies, they concluded that overgrazing has an impact on vegetation either qualitative or quantitative scale. Indeed, qualitatively, good palatable species are eaten before they had time to train volunteer for future seasons and then they disappear completely, leaving room for non-palatable species such as Asphodelus microcarpus.

To overcome the problem of the degradation of vegetation, it is important to study the animals' behavior to have enough information to be able to intervene, and as example of such study we propos [6].The authors focused on domestic animals and they deeply studied the different forms took by the animals during their movement, their rest or their grazing. In the follow there are some examples of forms:

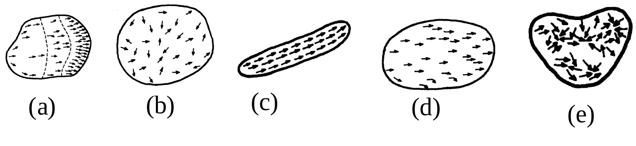


Fig.1 (a) Mobile with front, (b) Stationary circular, (c) Elongated shape with files, (d) Ovoid form without file, (e) Aggregated form

Fig.1 (a) and (b) present the two kinds of forms noticed during grazing. Indeed, mobile with front is noticed when the most of the herb graze and move and, concerning stationary circular form, the animals don't move and they graze the surface around them, without departing from the same group.

Fig.1 (c) and (d) present the forms noticed during a movement. Indeed, elongated shape with files is noticed when the most of animals move without grazing in one direction forming parallel files. The second one is ovoid form without file. The animals move and graze in the sometime.

Last but not least, Fig.1 (e) presents the form that we noticed during a rest. Indeed, aggregated form is found specially when the most of animals stop grazing and stay to ruminate.

In the rest of this work, we will suppose that the animals move together (we do not care about those whose moves away from the herd). In this case, we consider them as points so their movement is studied as movement of points. About the speed and to facilitate the modeling thereafter, it corresponds to the speed of the animals of the front. We move then, to present the studies focusing on the moving objects.

The authors in [7] give a description of moving objects through an abstraction. In fact, we can use a point or even a region to model a moving object and each model has its characteristics, for example, for a moving point, it corresponds to the change of position of an entity and this variation is done in function of the time and presented in 3D space as a curve. Related to a moving region, it focuses on the change of the size of a region. And the result of the presentation of a moving point in 3D space is polyline and for a region is a polyhedral. In order to present the movement, the authors use linear functions which give approximately finite descriptions but such functions are not enough to represent moving real, so, as solution they propose the use of quadratic polynomials.

Concerning the work [8], it is interested on the repetitive nature of some moving objects. Such nature is detected through the follow of the moving object and storing the collected information into databases. Concerning the temporal aspect, it is presented through an instant and duration. The instant corresponds to a timestamp, and in a data base, it has a discrete representation. Concerning the duration, it describes a directed distance between two instant values. For an interval, it is described by its two end points, and they use a relative time intervals.

In this work, the movement is divided into sever small slices having temporal function. So to present the whole movement, we must order the disjoint slices in function of the time

The algorithm, which is presented in this paper and corresponds to repetitive movements, is composed by three steps:

- Creation of an array of integers from the flat representation of a moving object.
- Detection of repetition within the array of integer.
- Construction of a periodic moving object tree.

The purpose of this work [9] is to describe and discuss an approach to modeling moving and evolving spatial objects based on the use of abstract data types. This abstraction is presented by point region and line. It contains also a description of spatiotemporal types and operations. And to explain the conceptions, the authors give some queries to demonstrate that the data types existing in this work can be embedded into any DBMS and the operations can be used in queries.

In [10], an algebra related to moving objects (moving points and moving regions) is proposed. This algebra is implemented into SECONDO which an extensible DBMS environment. The design could be implemented in a similar way in other object-relational or extensible systems.

SECONDO is a DBMS prototyping environment particularly geared for extension by algebra modules for non-standard applications.

The different information generated by the moving animals is going to be stored into TrDW which takes into consideration the continuous aspect of time and space. In fact traditional data warehouse and spatial data warehouse cannot deal with such information.

In the following we introduce different works presenting the evolution of the data warehouse.

Concerning the traditional data warehouse, it is defined in [11] as a "subject-oriented, integrated, time varying, non-volatile collection of data that is used primarily in organizational decision making".

Many works focus on presenting the data warehouse. According to [12], DW is considered as a collection of decision support technologies playing crucial rules, facilitating, then, the task of decision making, especially for knowledge worker such as the executive the manager, and analyst. For the data, they are modeled by a multidimensional way to allow the complex analyses and visualization.

A DW, according to [13], collects the information from operational data sources and puts them into one central repository. This work focuses on how drive the information from the sources. In fact, this is done through extract-transform-load (ETL) process which is a complex process because of the huge number of transformation. This work treats a particular topic that of lineage tracing which consists of loading the data trough a graph of general transformations.

[14] DW is dynamic entities that evolve over time. It is composed by set of materialized views defined over remote base relations to answer queries. This work exposes the problem of new queries which necessities the materialization of new views and this needs extra space and proposes as solution the re-implementation of the DW through the exploitation of new queries.

With the appearance of spatial data, the traditional data warehouse are not suitable with such information hence the appearance of spatial data warehouse.

To deal with spatial data, the authors in [15] use SDW which is considered as the appropriate way. It is not easy the use of spatial Datawarehouse because of the complexity of the relation which exists between spatial data also the complexity of analaysis and computation. This article presents a way to construct a SDW. Indeed, to deal with spatial data, they present three strategies: Data Center Strategy, Distributed Strategy, and Distributed Duplicate Data Strategy.

Then to facilitate the access to SDW from different user, the authors propose the use of multi-level storage method of spatial information. This method is based on data marts, department SDW and global SDW.

Because of the huge amount of data generated by the sensors existing around the earth, we need the use of SDW. The work as presented in [16] is based on GIF which shows its capacity to link information in a spatial context in order to draw the conclusion from the relationships existing between the different phenomena. The phenomena is divided into two types, we find then the discrete ones which are related to the spatial data, and continuous ones which refers to the continuous data in the time and space. In conventional multidimensional structures we use discrete data; the dimensions have discrete hierarchical levels. Concerning continuous data both time and space are treated other way. We use samples which are measured and stored because we cannot measure continuous phenomena. And concerning the cube there are two kinds. The first one is the discrete basic cube formed by a list of dimensions Db, a list of the lowest levels of each dimension Lb, and finally, a set of cells data Rd. And for the second type which is the continuous basic cube, it is derived from discrete basic cube through the interpolation functions.

In this work [17], the authors present the SDW which is the result of the combination of DW and SDBs to deal with huge amount of data including spatial location. They propose the use of MultiDimER to present the users' requirements for SDW. In a MultiDimER, we have spatial levels. They are used to keep information about spatial characteristics and they are captured by its geometry. Concerning the spatial hierarchy, we use by default *within* topological relationship to indicate that the geometry of a child member is included in the geometry of a parent member

For fact relationships, they are considered spatial if there at least two leaf level which are spatial.

A (spatial) fact relationship may include thematic or spatial measures which are represented by geometry or calculated through spatial operators. The former are usually numeric values that allow performing quantitative analysis.

The authors propose, in [18], extending the traditional set-grouping hierarchy into multi-dimensional data space and to use spatial index tree as the hierarchy on spatial dimension. In fact, this helps to construct SDW and manipulate then the spatial data. This becomes more and more important nowadays with the spread of new technology allowing recording geo-spatial information and DW cannot deal with such kind of data, it uses text strings to describe location data which limited capacity in spatial analysis. Geocoding technique translates the location information such as street, address, etc., into two-dimensional point data.

Concerning the moving objects which change always their location in function of time and space, the spatial data warehouse cannot be used, and as solution we present the trajectory data warehouse which deals with trajectory data.

The work, in [19], introduces the notion of trajectory data (TrD) and proposes then the use of TrDW to storage such data that traditional DW cannot deal with. Indeed, TrDW serves to transform the trajectory raws, which are extracted through sensing and positioning technologies, into useful information. The authors propose an architecture which is composed by: trajectory reconstruction that allows transforming the sampled positions collected through GPSs into trajectory data, TrDW feeding which is done through the use of ETL process. It permits to get the identifiers as well as the portions of trajectories that satisfy the range constraints and the aggregation.

The authors study through this work [20], the human movements' behavior. Such study becomes easier thanks to the use of new technologies (mobile phones, GPSs, etc.) and through it, they present a definition of trajectory which is considered as the basic form of mobility data related to the moving object and which generates a sequence of time-stamped location. This specific kind of movement data serves to construct TrDW which is defined as spatio-temporal data cube. The representation of the movement is done through arcs which are lines or curves.

To exploit the data storage into TrDW, we use mining tasks such as trajectory mining, trajectory clustering and trajectory classification and location prediction.

The trajectory pattern mining visualizes a set of trajectories having some property (visiting the same sequence of places with similar travel times). Trajectory clustering focuses on a group of objects by exploring and analyzing the huge amount of data generated and finally trajectory classification and location prediction which allows predicting the next location of the moving object basing on its past trajectory.

This work [21] introduces the cycle life of a TrDW which is composed by the following steps:

- Trajectory reconstruction process: it generates trajectories from raw time-stamped location data. It takes into consideration that raw points arrive in bulk sets so to add them to an existing trajectory or not. Trajectory reconstruction has parameters: Temporal gap between, trajectories which corresponds to the *maximum allowed time interval between two consecutive time-stamped positions of the same trajectory for a single moving object*, Spatial gap between trajectories which corresponds to *the maximum allowed distance in 2D plane between two consecutive time-stamped positions of the same trajectory*. Maximum speed which corresponds to maximum allowed speed of the moving object. Maximum noise duration corresponds to the maximum duration of a noisy part of a trajectory. Tolerance distance which corresponds to *the maximum distance between two consecutive time-stamped positions of the same object*
- ETL procedure: it constructs data cubes with aggregate information. It serves to feed TrDW from MOD. The problem at this level is not related to the loading of dimensions but it concerns fact table which necessities to fill in the measures with appropriate numeric values which are computed before in an exact way.
- OLAP and DM.

The work, in [22], focuses on modeling a trajectory that is able to storage aggregation about trajectories. It gives a definition of a Trajectory which is considered as a finite set of observations and each observation is defined by its identifier **id** has as location **x**, **y** at time **t.** The authors propose the use of linear local interpolation in order to reconstruct the trajectory from its sampling which supposes that the movement between two successive points is done with constant speed in a straight way. The authors present in [23] the notion of trajectory which is considered as a finite set of observations called sampling. The record of those points is based on the actual continuous trajectory.

Related to TrDW, the fact presents the trajectory, the measures then correspond to the number of trajectories, their average, maximum/minimum speed, and the covered distance. Some of these measures must be update ones there is new observations, other ones, require having all the observations before making the update. Concerning the dimensions, there is the spatial dimensions, temporal dimension and "presence" that returns the number of distinct trajectories.

In [18], the authors propose the use of interpolation linear function to deal with continuous data warehouse. In fact, the data collected through the sensor is discrete, it is read at different points in time and at different intervals; so, to give the user the illusion that he is navigating continuously the authors apply spatial and temporal interpolation methods. Such method gives information about the continuous phenomenon at any time basing on the sample points which means that there is data values at every point in space and time.

Spatial talking, there are different ways to present a moving object. As it is mentioned in [24], it can be done as a point, a line or a region. In fact, it is an abstraction for modeling the structure of the geometric entities in space and their relation also.

III. TRAJECTORY DATA

In this section, we introduce the trajectory data. In fact, it is a spatiotemporal concept since it reflects the evolution of the position of an object traveling in space during a given time interval. It is defined in [25] as: "*The user defined record of the evolution of the position (perceived as point) of an object that is moving in space during a given time interval in order to achieve a given goal*".

This definition considers that the trajectory is related to the notion of an object presented by a point, ignoring the fact that the mobility can be done by a region such as the movement of clouds. In addition, according to this definition, a moving object must have a goal which is not always the case. Therefore, there are some movements such as the fire, the field of pollution, the land plates or dust, which doesn't have an aim. Other objects can have more than one goal which changes during the movement.

This definition is appropriate to our case. In fact, the herd is treated as a point that changes continuously its position in function of time to achieve a goal which is eating and drinking. Its dimensional space is composed, then, by two dimensions one presents the space (X-Y space) and one presents the time (T) which makes the trajectory a spatiotemporal trajectory (X-Y-T).

This type of trajectory has two facets: geometric and semantic. Concerning the geometric facet, it is about the different positions of our herd during its displacement. They are recorded to keep information about the lifespan of the moving animals which decomposed by many segments each one is delimited by two points the begin and the end. The different information collected at this level about each point is going to be interpreted in the semantic facet.

IV. MODELING HERD TRAJECTORY DATA

In this section, we are going to introduce two different ways to model the trajectory of the herd. The goal is giving a clear representation of the trajectory of the herd as well as its components and the elements that are linked to facilitate the show of different relations existing which makes the schema of the trajectory more understandable and easier to change after.

A. Entity-Relation model

As presented in [26], this model is considered as the most advantageous one. It reflects a natural view of the real world which is modeled through entities and relationships. The entities present the trajectory and its components and the relationships present the type of relations that can exist between the entities.

Fig.2 presents the ER model corresponding to the trajectory of the herd. It visualizes the relation between the different elements related to the replacement. In fact a trajectory is composed by a set of paths. Each path is defined by its begin and its end and the same thing concern the trajectory which has as a begin the begin of the first path and as end the end of the last path. Talking about the begin, it gives information about the start position thanks to B_X and B_Y and start time thanks to B_T. Concerning the end, it gives information about the final position thanks to E_X and E_Y and the final time B_Y. B_T and E_T are used to calculate the duration of the trajectory, the path and the stop. In fact, it is important to present the stop as an independent element because the animals in the herd can do different activities during any stop such as eating, drinking, or resting. And as presented in Fig.2, stop can correspond to the begin of a move or even its end so it delimits a path.

The move happens generally close to the water especially during dry seasons and in grazing to allow the animal eating. The animal can find during their displacement some hazards which may be natural (sea, river, lake, mountain or desert) or artificial (road, complex, or railway).

Concerning the herd, it follows one specific trajectory. It is composed by a set of animals from different kind, and it can be supervised by a shepherd in case of domestic animals or not if it is about wild animals.

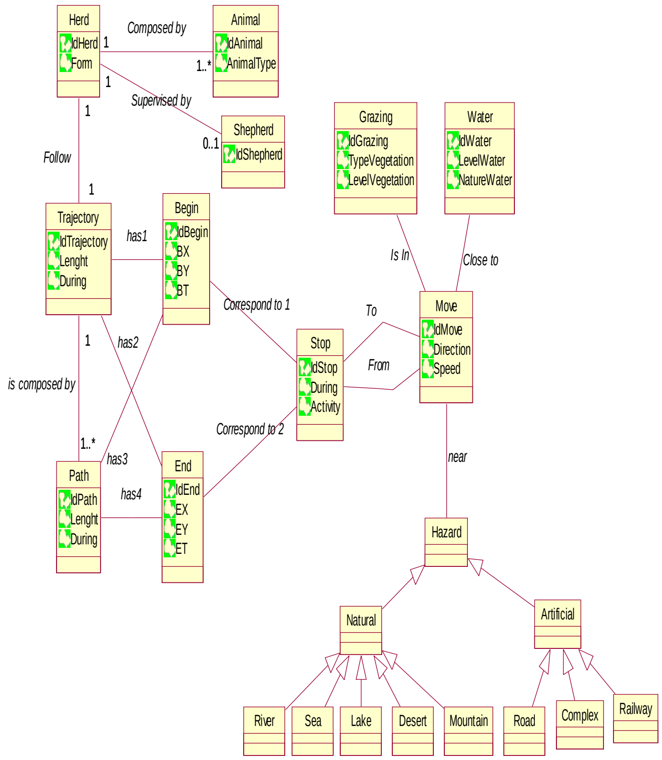


Fig. 2 The ER model related to herd trajectory

B. Spaccapietra et al model

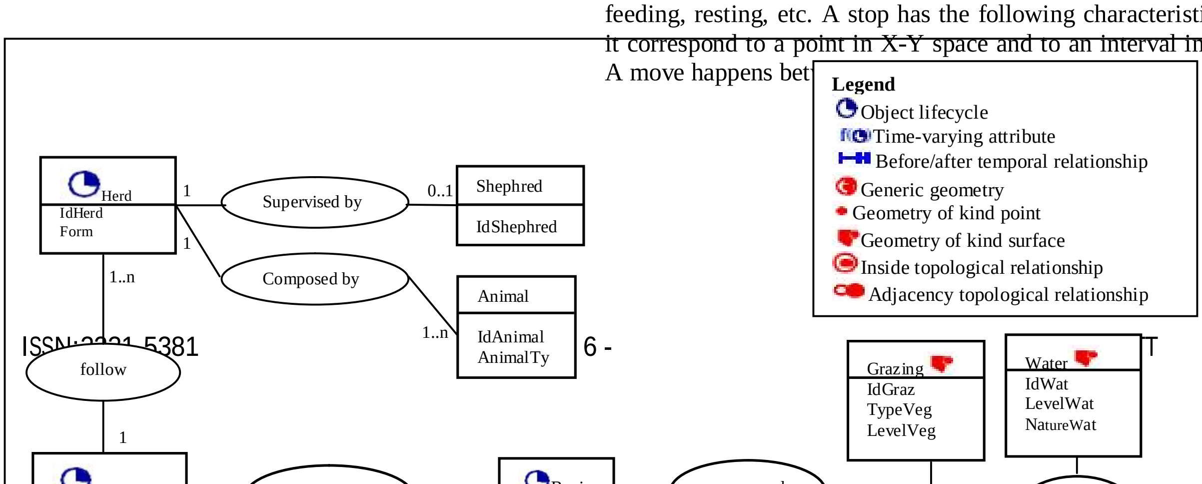
The ER model is useful to present the entities as well as the relations, but it cannot present their characteristics (spatial and temporal aspects). In this case, we propose the use of Spaccapietra et al model as presented in [25]. Fig.3 presents this model as adapted to our case. Indeed, a spatiotemporal trajectory, in our case, is a set of paths having different directions, lengths, and during. It has a lifecycle presented by a time interval, since it has a begin and an end.

Differently to was presented in [25], the begin and the end do not coincide. Temporally talking: $t_B = t_E + d_S$, ie the time corresponding to a begin equals to the sum of the time corresponding to the end of the previous path and the during of a stop. They are presented by two different points. Also, the begin of the trajectory corresponds to the begin of the first path and its end corresponds to the end of the last path.

Fig. 3 The herd trajectory data

A moving object (the herd) does not move during the entire trajectory. It can take stop(s). Therefore, a stop can correspond to the begin or the end of a path. For the shepherd, in fact, he does not exist all the time. It depends on the herd's nature wild or domestic.

An animal can do different activities during a stop such as feeding, resting, etc. A stop has the following characteristics: it correspond to a point in X-Y space and to an interval in T. A move happens bet



temporal interval and a spatial interval also which make it having a lifecycle.

V. DELING TrDW

In this section, we present our TrDW model. Indeed, recording all the information creates the need to use powerful tools that transform the huge amount of data to useful knowledge. We use in this case the TrDW, because it is the only tool which can deal with trajectory data.

So to present the data, we use the star schema. It is very popular concerning data warehousing, because of it is performance, especially, on very large queries. However, it is easy to understand because it is composed by a large table "fact" surrounded by other tables "dimension". It is the simplest data warehouse schema. It is often used to model STDW, because it optimizes performance by keeping queries simple and providing fast response time.
Its power is because it reduces the number of tables in the database, the number of relationship existing and the number of joins required in user query.
Fig.4 presents the star schema related to the trajectory of the herd. It is composed by the fact table "Trajectory" and its dimensions.

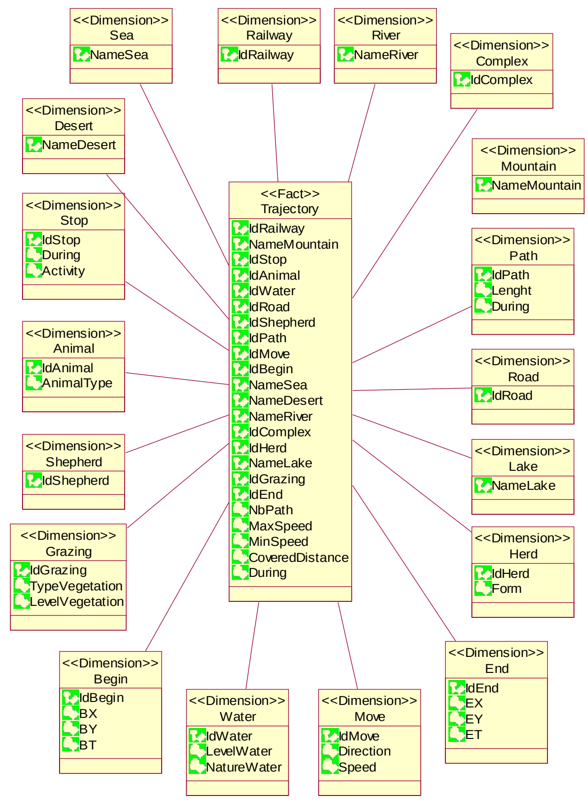


Fig. 4 The star schema

The fact table contains as primary key, the primary keys of the dimensions. Concerning the measures, they are:

- NbPath: it corresponds to the number of paths constituting the trajectory
- MaxSpeed: it corresponds to the maximum speed of the herd. We take into consideration the speed of animals in the front.

- MinSpeed: it corresponds to the minimum speed of the herd. It is calculated basing on the speed of animals in the front.
- CoveredDistance: it corresponds to the covered distance which is the distance traveled by the animals during their displacement.
- During: it corresponds to the duration of the trajectory. It is calculated thanks to the duration of paths.

Concerning the dimension tables, they present a set of attributes which are used to describe the information as well as to specify how the data existing in the fact table must be summarized in order to provide useful information; those attributes must be update as soon as a single observation arrives.

The spatial and temporal aspects are taken into consideration thanks to the two dimensions begin and end. The first one has as attributes B_X and B_T which give information about the start location and BT which gives information of the start date. The second one has as attributes E_X and E_Y which give information about the end location and E_T which gives information of the end date.

VI. CONCLUSION

The overgrazing is considered as a menace, it is a threat to plant species, and it can cause in the most of time their loss. So we must take precautions and this is done through the study of the movement of animals. In our case, and to facilitate their study, we considered the animals as points, and we focused, then, on collecting information from those moving objects.

So to determine their behavior, we followed them during sever time and we record it in order to extract a suitable model allowing taking the best decisions. We proposed, then, two different models allowing the presentation of the trajectory data. The first one is based on ER model which helps to visualize the different entities corresponding to the trajectory and its different components as well as the relation that can exist between them. This model although it is clear, it neglects certain sides treated by the second model based on Spaccapietra et al. This model put into consideration the evolution in spatial and time. The different TrD are stored into TrDW, which is a special DW related to the moving object that evolutes in space and time and we used the star schema to model it.

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REFERENCES

[1] A. Daoudi, N. Benterki, and S. Terranti, *La lutte contre la désertification des parcours steppiques : l'approche du développement agro-pastoral intègre*, isda 2010, Montpellier, pp. 28-30, 2010.

[2] A. Romdhane, and G. Fay, *Dégradation des parcours et problèmes de l'eau dans la région d'El Hamma Gabès (Sud tunisien)*, In Ferchichi A. (comp.). Réhabilitation des pâturages et des parcours en milieux méditerranéens = Rangeland and pasture rehabilitation in Mediterranean areas . Zaragoza (Spain) : CIHEAM-IAMZ, pp : 259-263 : 1 table. 9 ref. Summary (En). (Cahiers Options Méditerranéennes ; v. 62). 11. Réunion du Sous-Réseau Ressources Fourragères Méditerranéennes du Réseau Coopératif Interrégional FAO-CIHEAM de Recherche et Développement sur les Pâturages et les Cultures Fourragères, Djerba (Tunisia), 2002.

[3] A. Noureddine, A. Ferchichi, and N. Manel, *Sauvegarde du patrimoine phylogénétique pastoral et possibilités de son utilisation pour la réhabilitation des parcours dégradés*, revus des régions Arides Tunisie, 1991.

[4] L . DesCroix , D. Viramontes, E. Anaya, J. Poulenard , and J. L. G. Barrios, *L'impact du surpâturage et du déboisement sur l'érosion des sols dans la Sierra Madre Occidentale*, Bulletin du réseau Erosion n°20, (IRD), pp. 218-231, 2000.

[5] C. Kouider, and A. B. Mohamed, *Approche préliminaire d'étude d'impact du surpâturage dans les Monts de Tessala (Wilaya de Sidi Bel Abbes)*, Colloque international « Développement durable des productions animales : enjeux, évaluation et perspectives », Alger, 2008

[6] E. Lécrivain, A. Leroy, I. Savini, and J, P. Deffontaines, *Les formes de troupeau au pâturage*, E. Landais, (éd.) Études & Recherches n° 27, pp. 237-263, 1992.

[7] R.H. Güting, M.H. Böhlen, M. Erwig, C.S. Jensen., N. A. Lorentzos, E. Nardelli, and M. Schneider. *Spatio-temporal Models and Languages: An Approach Based on Data Types*, Chapter 4 of Spatio-Temporal Databases: The CHOROCHRONOS Approach (eds. T. Sellis et al.), Springer Verlag, LNCS 2520, pp. 97-146, 2003.

[8] T. Behr, V. Teixeira de Almeida, and R.H. Güting, *Representation of periodic moving objects in databases*, 14th ACM Intl. Symp. On Geographic Information Systems, ACM-GIS, pp. 43-50, 2006.

[9] M. Erwig, R. H. Güting, M. Schneider, and M. Vazirgiannis, *Abstract and Discrete Modeling of Spatio-Temporal Data Types*, 6th ACM Symp. On Geographic Information Systems (ACMGIS'98), pp. 131-136, 1998.

[10] V. Teixeira de Almeida, R.H. Güting, and T. Behr, *Querying Moving Objects in SECONDO.* 7th Intl. Conf. on Mobile Data Management (MDM), Nara, Japan, pp. 47-51, 2006.

[11] W.H. Inmon, *Building the Data Warehouse*, John Wiley. 1992.

[12] S. Chaudhuri, and U. Dayal, *An Overview of Data Warehousing and OLAP Technology*, SIGMOD Record 26(1), pp. 65-74. 1997.

[13] Y. Cui, and J. Widom, *Lineage tracing for general data warehouse transformations*, Proceedings of the 27th VLDB Conference, Roma, Italy. 2001.

[14] D. Theodoratos, and T. Sellis, *Dynamic Data Warehouse Design*, Proc. Intl. Conf. on Data Warehousing and Knowledge Discovery, (DaWaK'99), Florence Italy, pp. 1-10, 1999.

[15] Q. Li, and C. Yang, *Data Warehouse of Spatial Information*, Beijing, China. ISDE'99 , Nov.29-Dec.2. 1999.

[16] T. O. Ahmed, *Continuous spatial data warehousing*, In 9th International Arab Conference on Information Technology. 2008

[17] E. Malinowski, and E. Zimányi. *Implementing Spatial Data Warehouse Hierarchies in Object-Relational DBMSs*, In Proceedings of the 9th International Conference on Enterprise Information Systems, ICEIS 2007, Funchal, Madeira, Portugal. INSTICC Press. 2007.

[18] F. Rao, L. Zhang, X. L.Yu, Y. Li, and Y. Chen, *Spatial Hierarchy and OLAP-Favored Search in Spatial Data Warehouse*, DOLAP. 2003.

[19] L. Leonardi, G. Marketos, E. Frentzos, N. Giatrakos, S. Orlando, N. Pelekis, A. Raffaetà, A. Roncato, C. Silvestri, and Y. Theodoridis. *T-Warehouse: Visual OLAP Analysis on Trajectory Data*. Proc. 26th International Conference on Data Engineering (ICDE'10), Los Angeles, USA. 2010.

[20] F. Giannotti and R. Trasarti, *Data Mining and Privacy: The GeoPKDD Paradigm*. In Proceedings of the Fourth SIAM Conference on Mathematics for Industry (MI09), San Francisco, California, pp. 10-18. 2009.

[21] G. Marketos, E. Frentzos, I. Ntoutsi, N. Pelekis, A. Raffaetà and Y. Theodoridis. *Building Real World Trajectory Warehouses*, In Proceedings MobiDE. 2008.

[22] F. Braz, S. Orlando, R. Orsini, A. Raffaeta, A. Roncato, and C. Silvestri, *Designing a Spatio-Temporal Trajectory Data Warehouse*, Convegno XXII Brazilian Symposium on Databases, Poster. 2007.

[23] S. Orlando, R. Orsini, A. Raffaetà, and A. Roncato, *Trajectory Data Warehouses: Design and Implementation Issues*, Journal of Computing Science and Engineering, 1(2), pp. 240-261. 2007.

[24] R. H. Güting, M. H. Böhlen, M. Erwigy, C.S.Jensenz, N. A. Lorentzos, M. Schneider, and M. Vazirgiannis, *A Foundation for Representing and Querying Moving Objects*, ACM Transactions on Database Systems, 25, 1, pp. 1-42. 2000.

[25] S. Spaccapietra, C. Parent, M.L. Damiani, J. Antonio de Macedo,F. Porto and C. Vangenot, *A conceptual view on trajectory*, Data and Knowledge Engineering 65(1) pp. 126-146. 2007.

[26] P.P.S. Chen, *The Entity-Relationship Model —Toward a Unified View of Data*, ACM Transactions on Database Systems, pp. 9-36. 1976.

[29] F.J. Braz, *Trajectory data warehouse: Proposal of design and application to exploit data*, in IX Brazilian Symposium on Geoinformatics, Campos do Jordao, Sao Paulo, Brazil, pp. 61-72. 2007

[30] X. Meng, and Z. Ding, *DSTTMOD: A Discrete Spatio-Temporal Trajectory Based Moving Object Database System*, In Proceedings of 14th International Conference on Database and Expert Systems Applications(DEXA 2003) , Prague, Czech Republic, pp. 444-453. 2003

[31] Y. Bédard, T. Merrett and J. Han, *Fundamentals of spatial data warehousing for geographic knowledge discovery*, Geographic Data Mining and Knowledge Discovery, Taylor & Francis, Vol. Research Monographs in GIS, No. Chap. 3, pp. 53-73. 2001.