Intensification of the supply chain by the storing of trajectories data

Zina Nakhla[1] and Jalel Akaichi [2]

[1]ISG, Institut supérieur de gestion, Tunis

Zinanakhla@yahoo.fr

[2]ISG, Institut supérieur de gestion, Tunis

Jalel.akaichi@isg.rnu.tn

ABSTRACT

To improve the profitability and the quality of services, and to confront the difficult competition, companies are in search of the effective approaches to improve their professions in general, and the management of the supply chain in particular which plays an essential role for reduction of cost, the improvement of the quality of services, and increase of the productivity. This work aims to improve the performance of supply chain by the conception of trajectories data warehouse intended to collect the data relative to the mobile objects. The information stored in the data warehouse will be analyzed to extract knowledge which we use to a decision-making and leading to strengthen the management of the supply chain.

KEYWORDS

Supply chain, Mobile objects, Trajectory data warehouse

1. INTRODUCTION

The economic context is complex and unstable, companies are confronted to competition and demanding customers. The objective of any company is to produce and to deliver for the precise deadlines, to reduced costs, and satisfy the high levels of service required by the customers. That is why, today the supply chain and its management is an important concept in the companies, which is defines by Mentezer [9] as the systematic, strategic coordination and the tactical management of the actions in the departments of a particular organization, and it aims to improving the performance of every organization.

To realize their objective, companies are in search of the new approaches to improve the global performance of the supply chain which is considered as a leading key to the evolution and the optimization of the management of company. Indeed the logistics can contribute strongly to the performance of company by control the spending, optimize the physical flows and the information flows, reduce the financial impact of the consumption of products, limit the wasting and to insure the traceability of products and services. The logistics so becomes a strategic instrument of improvement and development the performance of companies. The supply chain is a system characterized by the mobility between the various processes of the chain as well as in the processes. The logistics is the art to coordinate and to manage the movements of products and information from the origin point to the destination. The mobility in the supply chain amounts by the function of transport. The transport is a tool of coordination between the actors of the chain, the role of transport is to manage simultaneously the flow of information and the physical flow. The mobile objects in the supply chain present the means of transportation, and they have an influence on the functioning of the supply chain. The mobile object bring a correct information, where and

DOI : 10.5121/ijmvsc.2010.1101

when necessities, to reduce the uncertainty, increase the visibility of products and increase the global efficiency of the supply chain.

The decisions-making in the supply chain requires taking into account various elements which participate in the functioning of the chain such as products, customers, suppliers... But the decisions taking do not take into account data relative to the mobile objects, while they can contribute to optimize the management of the supply chain. The mobile objects are load with some role such as control of the interactions, the traceability of flows and to reduce the uncertainty by the contribution of the relevant information.

The objective of our work consists to improve the performance of the supply chain by the conception of a trajectories data warehouse. This last one is intended to collect data relative to mobile objects. These data will be collect and analyzed to serve in intensification of the management of supply chain by optimizing the various stages of the logistic process such as synchronization of the data between the various processes of the chain, the management of the physical flows and the management of information flows. The decision-making in the company based on trajectories objects, becomes more and more agile, adaptable and strong.

The purposes of this work can be summarized in the following stages:

- Definition of the mobility in the supply chain and modeling their trajectory.
- Conceive the model of Trajectory Data Warehouse (TDW) of supply chain.
- Querying the TDW for the supply chain.

This article is structured as follows: the second section presents the running scenario of storing data relative to the mobile objects in the supply chain. The third section presents the mobile objects. The fourth section presents a related work of the supply chain and its management, we present the main recent research works treating the mobility in supply chain. The fifth section investigates the trajectories data. The sixth section describes the conception of the trajectory data warehouses. The seventh section presents the querying of the TDW. And finally a conclusion which presents the key points to be held of our contribution as well as the perspectives related to this work.

2. RUNNING SCENARIO

In this section, we introduce a running scenario, involving TDW, which observes mobile object in the supply chain. Those latter collect and sent various data met in their trajectories, to a centralized TDW, in order to be analyzed and mined. Data are collected and sent thanks to mobile devices such as sensors, cell phones, PDAs … and GPS technologies.

The supply chain consist of processes that exchanging flows (physical, informatical, financial). The mobile objects are used to insure the functions of transfer, sending and reception products. These functions are indispensable for the functioning of chain. We can distinguish two types of mobility in the supply chain, external and internal. The mobility extern corresponds to the movement of various products between the processes of the chain (transformation, distribution …), as well as between the suppliers or the consumers of supply chain. This movement is insured by the means of transportation which choose according to needs and address's location. While the internal mobility, consists in the movement of products and equipments in the process of the chain by using wagons.

In the supply chain, the analyses of trajectories of mobile objects help to make the best decisions and to satisfy needs and requirements of customers. This analysis can insure the best follow-up and controls the transport process, the productivity, take measures to avoid any problems all during the transportation, and facilitate the management of objects by the precision of adequate means of transportation and the trajectory. It is necessary to store the

trajectories data, as well as the characteristics of the mobile objects in a TDW. These data are sent to TDW by using the mobile devices as sensors, mobile phones, PDAs, RFID and GPS technologies. The various collected data are analyzed to loosen the necessary information for the decision-making. Analyzing trajectories data helps to get better knowledge not only about the work of mobile objects but also about their trajectories' characteristic in which they move. This information can be divided into two categories that related to the mobile objects (type of object, the localization of the object,…) and other related to trajectory (the destination, duration of trajectory, stops of trajectory, the state of trajectory in movement or in stop, natural characteristic of trajectory,…).

3. RELATED WORKS

The speed transmission of the information plays an important role in the supply chain which characterized by the mobility, because it reduce the uncertainty by the contribution of the relevant information and to insure the flexibility in the decision-making, and to contribute to the performance of the supply chain and her actors. The mobility of supply chain does not take into account the trajectory data in a decision-making context. The management of the mobile Supply Chain (mSCM) is treated in the article [4][5][12] which consists to the use of the mobile devices to help in the driving the activities of supply chain and help companies to reduce the costs. The mSCM consists of integrating the mobile devices (PDA, phone…), which insure the flexibility for functioning in a wireless environment. The work of [6] presents a system of coordination in the mobile supply chain in real-time based of Intelligent Wireless Web (IWW), for the improvement of the mobile communication and the real-time coordination of the supply chain. The IWW uses the capacities of wireless networks and exploits the progresses of technologies. The IWW insures the delivery of information in real-time in supply chain, and will save the time and will improve the efficiency.

The article of [1][10][11] presents the important role of the technology Radio Frequency IDentification (RFID) for the collection of data. It is the technology which generates the data relative to the mobile objects which are useful for the decision-making. The RFID is labels which are very useful in the supply chain. These labels have the power to insure an ideal followed of the track of equipments along the supply chain. The article [7] develops a system of Mobile Construction RFID-based of the Management of Dynamic Supply Chain (M-ConRDSCM). The M-ConRDSCM system improves the acquisition of data by using RFID, and also presents an instructor for the control. This system used to improve the efficiency and the profitability of the control project, improve the communication and increase the flexibility in times of delivery of project and the time of answer.

The management of event for mobile supply chain consists in controlling networks of the chain by observing specific events, alerting decision-makers in the case of problem and having good solutions. In this context, the work [12] which presents an approach of simulation for the management of event of supply chain (SCEM) based on Auto-id and the mobile technologies for example, RFID, the sensors… These technologies can used to plan unexpected events like the break or the delays of the network of supply chain. These technologies can lead the major problems and supply a useful alert.

The data collected from different devise sensors is very useful in decision-making. That's why the system of decision in the supply chain is treated by several works [17][2] [3] to offer a decision-maker a support to have a view of the whole activity in the company. The management of the supply chain requires the use a support of the decision systems which can be used to support the grip of complex decisions and the resolution of problems. The systems of decision-making improve the capacity of management data sophisticated with the access to the internal and external data. The work of [18], develop a system of decision-making called DEcision support for Supply Chains through Object Modeling (DESSCOM) which

allows the strategic, tactical and operational decision-making in supply chains. DESSCOM has two major components: the DESSCOM-Model, an infrastructure of modeling including a library of generic objects conceived to model elements of supply chain and dynamic interactions. And the DESSCOM-Workbench is a workbench of decision; it can potentially include methods of solution algorithmic with simulation powerful for the decision-making of the supply chain. And by using the models DESSCOM-Model, any given supply chain can be quickly created at any desirable level of abstraction. For the analysis of these collected data, it is necessary to use tools which transform the data in real sources of knowledge. In the article of Levray and Mathieu [1] present the methods of integration of Data warehouse and Data mining for optimization and the analysis of the supply chain. These methods base on the principle of accumulation of data called the Technology of Group (GT), which consists in grouping the data and the resources according to different characteristics such as the function of manufacturing, the materials and the productivity. In what follows table we are going to present the main works which treated the decision system in the supply chain and the mobility of the supply chain.

Table1. Summary of some research related to mobile supply chain and decisional system

	Data mining	Decision nel system	Data warehouse	Mobility	Sensor technologies	Data warehousing a trajectory data
Shim, Merrill (2002) [17]	*		*			
Biswas et Narahari, (2002). [18]		*				
Levray et Mathieu GT (2009) [1]	*		*		*	
Oleska et al, (2007) [26]	*					
Stefanovica et al, SCI(2006)[3]	*	*	*			
Wang, Lin, Lin, (2007)[7]					*	
Soroor, Tarokh, Shemshadi, (2009)[6]				*		
Eng,mSCM (2006)[4]				*		
Vural, Sengül et al, (2006)[2]		*				
Teuteberg et Ickerott, (2007)[12]				*	*	
Jiang, Hu, Wang, (2009)[5]				*		
Cheng, Wang, (2008)[27]				*	*	

The works of presented researches treated the mobility of the supply chain, the collection of relative data by using sensors' technologies (RFID, PDA), they treated the decisions in the chain by storing data and extraction data for the analysis. But these works do not considerate the storing and the analysis of data relative to the mobile objects in the chain and their trajectory, while the treatment of the mobility of the supply chain in a decision-making context is necessary for the improvement of the decision-making.

The concept of the mobility in the supply chain was treated by some works, but not the trajectory of the mobile objects. The treatment of trajectory information of mobile objects in the supply chain is very important, for the reduction of the uncertainty and the improvement efficiency of the chain by the analysis of trajectory. The solution is to store the trajectory

data in the TDW which is a recent concept relative to trajectory of mobile objects. Where our contribution to strengthen the supply chain by storing the trajectory data and the analyzed afterward.

4. MOBILE OBJECT

Due to the development of localization systems and wireless networks, new applications based on mobile sources generate a huge amount of data. The development of the mobile technologies, such as cellular telephones, GPS, PDA and recently the RFID (Radio Frequency Identification) opened the way to the applications exploiting the location. There is a wide variety of applications which manipulate the objects which change its spatial characteristics during the time. Mobile sources often called mobile objects are spatial objects of which the shape and/or the localization change continuously during the time. According to Wan and Zeitouni [19] a mobile object is an object which the location changes constantly in the time. The movement of an object in the time and the space allows obtaining a continuity of movement. This continuity of movements [21] presents the trajectory of a mobile object which is constituted by infinite points, for which we have to define a finished representation. The work of Pfoser [25] distinguish three types of movement:

- Unconstrained movement such as floods, hurricanes or forest fire, etc.
- Constrained movement such as pedestrian
- Constrained movement by the network

Several applications were interested to study the movement of mobile objects as the evolution of traffic [22], the migration of birds [8], and applications which treated the location of mobile objects (such as the management of vehicle, the management of boats…). And other application which uses the mobile objects for the control and the forecast of price.

These applications generated new problem which concern the management of mobile objects. Most of the existing works are focused on the modeling of mobile objects and the methods of access to the data which concern these objects. In the literature, most of works were concentrated on the mobile objects in the field of databases [23][24] [28][29] [30][31] and few works were interested in the domain of data warehouse [20] [32]where the exploitation of history of stored mobile objects and the analyzed in a decision-making purpose.

5. MODELLING TRAJECTORY DATA

The trajectory data include for example data of people in movement, natural phenomena as tsunamis, as well as cells of body. The analysis of trajectory data, for example, pulls the behavioral models of people. The models can be useful in the understanding of the broadcasting of some diseases, incentive of the appropriate measures to protect populations and prevent the new broadcasting of the disease, or in the controlling animal to increase chances of survival for endangered species.

In our context of the supply chain, the trajectory data include data about distance, duration, location, stops… of trajectory. The analysis of the trajectories of the means of transportation in the chain makes the best decisions and satisfies needs and requirements of the customers. This analysis can insure the best follow-up and the controls of the transport process and facilitate the management of objects by the precision of adequate means of transportation and trajectory.

The modeling of trajectory depends on these different types; the work of Spaccapietra [8] distinguishes three types of trajectory:

- The metaphoric trajectories: in this type of trajectory, the object moves in an abstracted space (the example: the movement of high school at the university). Trajectories can be described by defining an attribute varying time (for example the level of study) for the mobile object (the student).

- Innocent geographical trajectories: this type of trajectory is a particular case of the first type of trajectory. The geographical trajectories can be described by using an attribute varying of time (for example. I went from Gabes to Beja then to Tunis).

- The spatiotemporal trajectories: this type of trajectory is used to show the position of the mobile object which is geometrically represented as a point. In the spatiotemporal trajectories, a trajectory has two faces: a geometrical facet and a semantic facet. The geometrical facet is represented as a continuous function of an interval of given time [Tbegin, Tend] in a geographical space. The semantic facet includes two types of the semantic characteristics of trajectories, the first type is specific in the requirements of the application and the second includes standard semantics and uses the components of trajectory as: stops, movements, begin and the end of trajectory.

In our work, and for the need of our application, we interest in the type of spatiotemporal trajectory. The trajectory consists of movements and stops, also a mobile object in the supply chain can set either the status, in movement, or in stop for different reasons such as breakdown or arrive in the destination. The figure below (eg, Figure1) presents the various statutes which can take a mobile object in the supply chain.

Movement: every mobile object move in its trajectory. Every movement is characterized by a time of the beginning and a time of the end. The beginning of a movement indicates the end of a stop and the end of a movement indicates the beginning of a stop, thus the interval of time of a movement is bounded by two consecutive stops.

Stop: a stop is an important part of a trajectory. We can distinguish the stop in three types:

- A strategic stop: for the delivery of the transported products, when arrived in the destination.
- A private stop: to have a break …
- An unforeseen stop: when there is a breakdown or a bad climate.

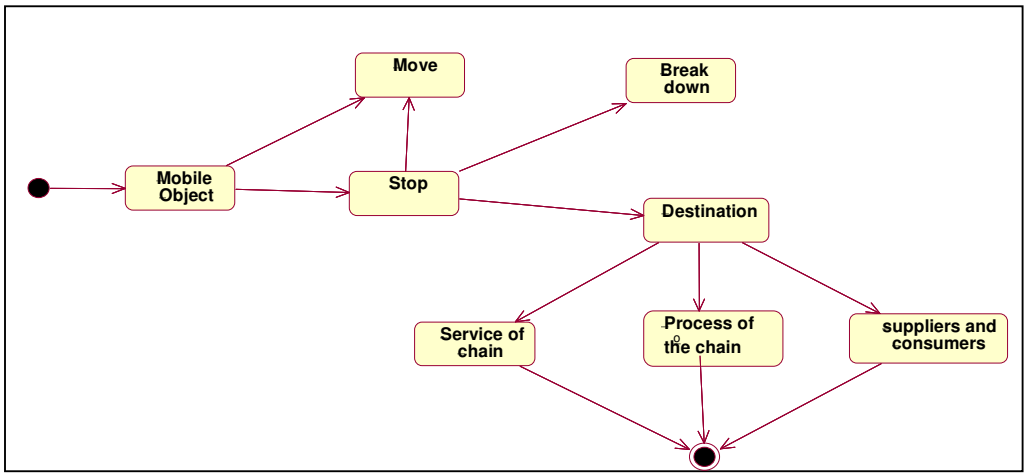

Figure 1. The statuses of the mobile objects in the supply chain

The model of trajectory data is presented by a class diagram of UML, which models the trajectories data of the mobile objects in the supply chain and is the best agreed to represent the requirements of the applications. The figure (eg, Figure2) presents the class diagram.

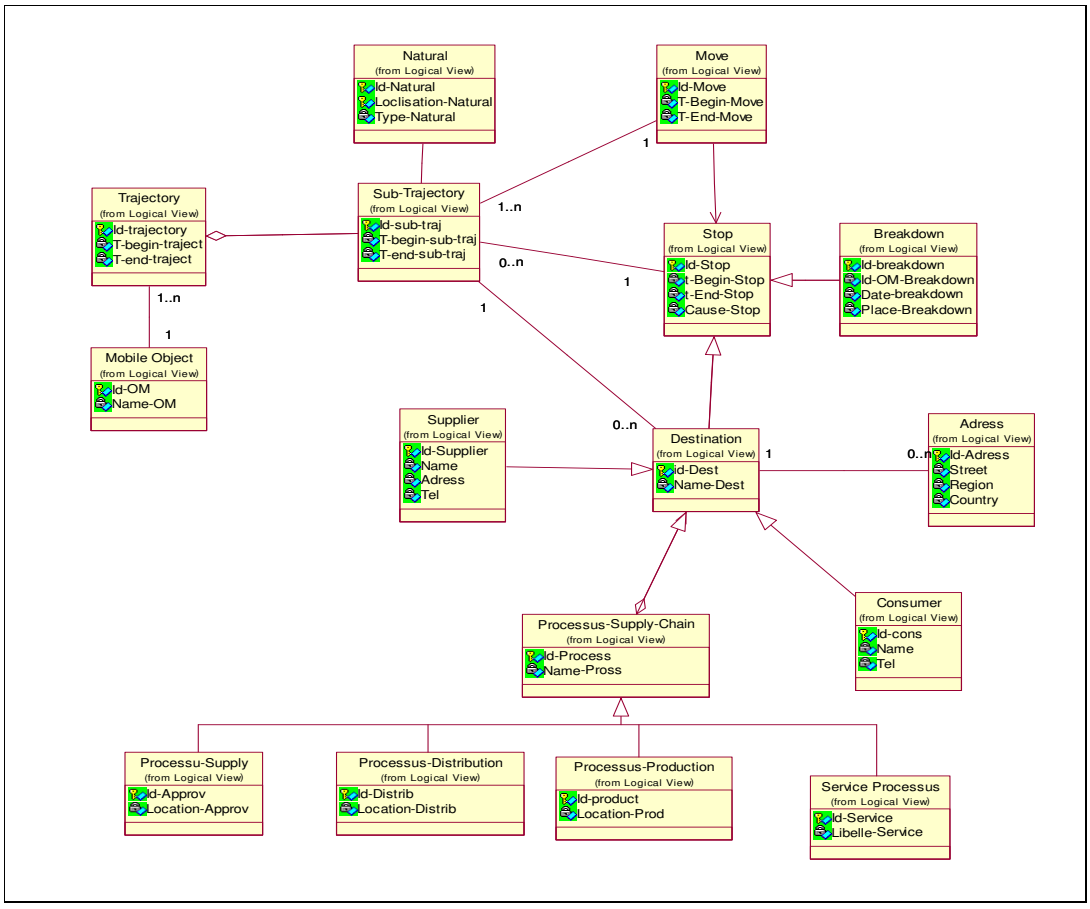

Figure 2. Diagram of class for the conception of the trajectories data of the mobile objects in the
supply chain

To analyze the trajectory of these objects, it is necessary to register the trajectories data which are according to the status of the mobile object (in movement, in stop, at begin, in the end), as well as the characteristics of the mobile objects.

6. THE CONCEPTION OF TDW OF SUPPLY CHAIN

The development of new technologies of mobile devices engenders the storage of a big volume of data which concerns the trajectories of mobile objects. This volume of data must be stored in a multidimensional model to be analysis. The model of the classic data warehouse is not adapted to the storage of the information relative to the mobile objects. These applications need to join spatial and temporal types of data, what requires a spatiotemporal data warehouse, but this data warehouse is not sufficient for the treatment of the trajectories of mobile objects. It is necessary to use a data warehouse which able to resolve the problem of storage the trajectories data. The model of storage defined as a TDW aims to store the trajectories data in a multidimensional way. The creation of the trajectory data warehouse is to manage the characteristics of spatiotemporal data and the associated dimensions. Besides, the TDW must be able to work in an environment, where the observations of trajectory data are received in a continuous way. The analysis of trajectories will help the decision-makers to observe the movement of trajectories of the mobile objects in the supply chain. The modeling of our TDW requires the precision of contents of supply chain and to organize according to the expected results and the statues of the mobile object. We used the multidimensional modeling of the TDW, which is the star schema. The TDW model of supply chain could have the following dimensions: localization (spatial dimension), time (temporal dimension), destination, sub trajectory, stop, movement, mobile object and natural.

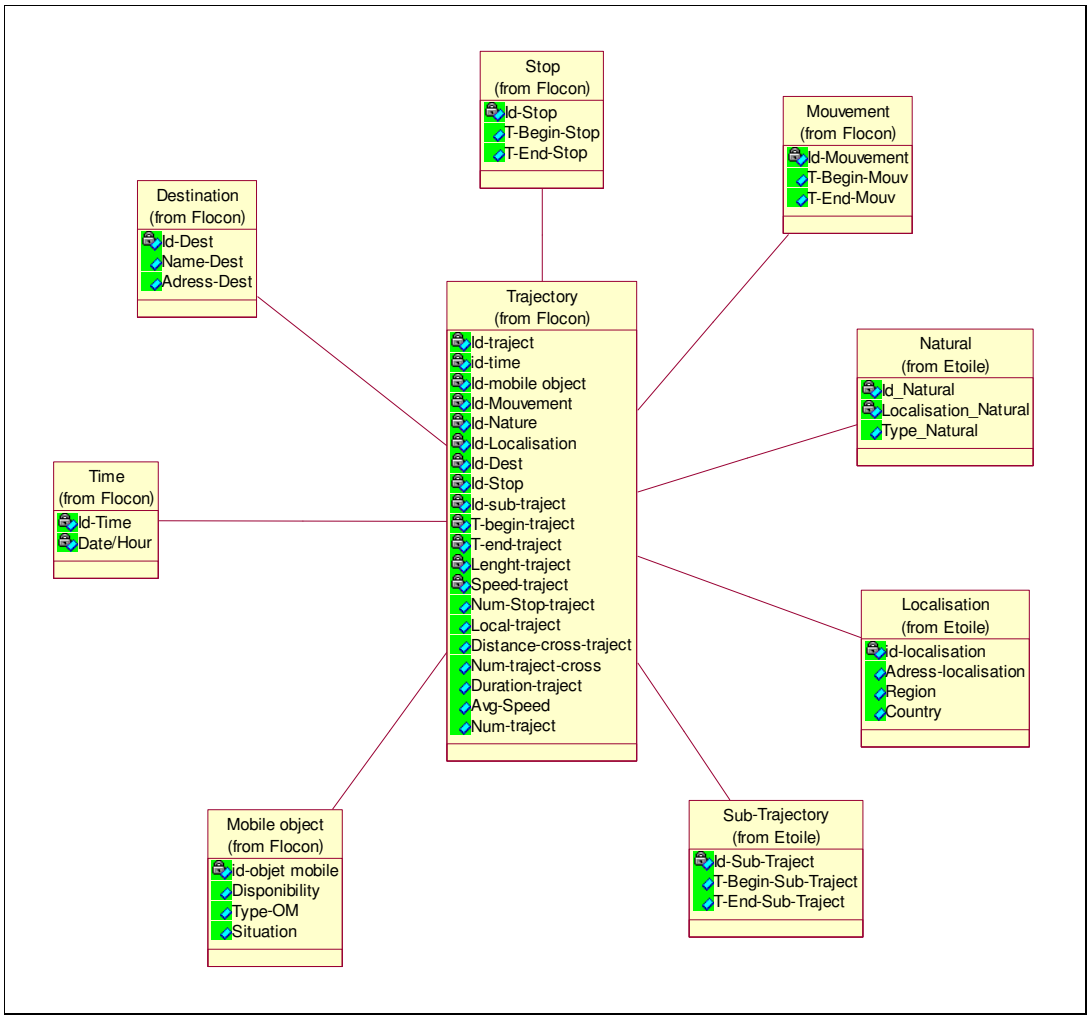

Figure 3. The star schema

Mobile object: the mobile objects insure the movement of the goods between the various services of the chain; these objects also transfer the data to the decision-making. The type of mobile object can be either a vehicle for the external transport, or a wagon for the internal transport.

Trajectory: the trajectory is the road crossed by a mobile object. Every trajectory is characterized by a time of begins and of the end. The end of the trajectory presents the arrived to the destination. A trajectory can consist of one or several sub-trajectories (eg, Figure 4). Trajectory =∑ sub- trajectory

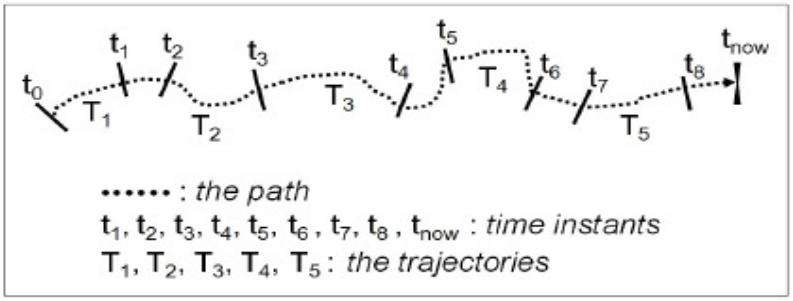

Figure 4. The road of a mobile object consisted of a set of sub-trajectories [8]

Sub-trajectory: every sub-trajectory consists of a set of movement. The sub-trajectory limited by two successive stops. Sub-trajectory =∑ Movement

Movement: every movement of mobile object in a trajectory has an identifier and characterized by time and location of movement.

Stop: stops in a trajectory are identified and characterized by time and location of the stop. A stop can be for several reasons either for reason of breakdown, or in case when the mobile object arrived at its destination.

Destination: the destination of the trajectory can be the consumers, the suppliers or the processes of the chain, or the services of the supply chain.

Natural: the natural present the natural characteristic for each trajectory (urban, mountain, desert…).

7. QUERYING THE TDW

In this section, we analyse the trajectories data relative to the mobile objects according to spatial dimensions (for example the location of the mobile object) and spatiotemporal dimensions (for example the change of the position of mobile object at time and in space). Furthermore, the analysis of trajectory has to respect the conditions as: the destination, characteristic of trajectories, climate …

Several research works treat the problem of querying the mobile objects in the data warehouses. In the work of Wolfson [13] proposes a model to specify the uncertain position of a mobile object by using the requests based on mathematical formulae, these requests specify the current position and the future position of a mobile object. The work [14] proposes a query language for the Mobile Object Spatial Temporal (MOST) called the Logical model Temporal Future (FTL). This model queried for future values concerning the dynamic attributes. The authors distinguish three types of questions: immediate, continuous and persistent. The article of Mouza and Rigaux [15] proposes a query language based on regular expressions, intended for the obtaining of a model called "mobility patterns". However, this language is only adapted for the trajectory data and does not connect the trajectory with its environment, so the classes of querying of this model are limited.

The work of Guting [16] present a query language for the mobile object in the networks. It can define two type of data gpoint and gline for the network representation and it define various type of operation: temporal operation, no temporal operation, operation of movement operation, specific operation of network and auxiliary operation.

The querying of data relative to the mobile objects of the supply chain stored in the TDW is an important stage to deduct the knowledge necessary for the decision-making. These querying are classified under two categories:

- Querying for the mobile object: These querying serve to specify the data relative to the mobile objects (the localization of the mobile object at the moment determined, the details concerning the mobile objects for the period determined, the mobile objects available on the use, the places visited by the object…). This data improve the management of mobile objects in the company.

- Querying for the trajectory of the mobile objects: These querying concern the trajectories of the mobile objects and these characteristics (the stop of a trajectory, the duration, the length of trajectory, trajectories crossed…). This data improve the management of the movement of mobile object, thus improve the functioning of transport service.

These two categories of querying offer to the decision-makers a global view on the mobility in a supply chain. The data extracted from these querying serve to strengthen the supply chain by the improvement of the taken decisions which will take into account trajectory data.

The current decisions in supply chains based on discreet data, while the chain is characterized by the mobility. The data contents on the mobile objects and the movements of these objects in the chain are necessary to improve decision-making. The schema of data warehouse and the queering proposed give to the decision-makers a global view to the mobility in the chain by specifying the behavior of the mobile object and the characteristic of its trajectory such as the number of stops in a trajectory, the location of trajectories, the distance crossed and the duration of trajectories …

These data trajectories allow the decision-makers to make decisions which take into account the mobility in the supply chain. This decision can reduce cost relative to transport, improve the traceability of transported, unforeseen products, the ability to adapt quickly of event, control of the interactions and reduce the uncertainty of the information relative to the mobile objects, what engenders afterward the optimization of the various features of the supply chain in particular and the company in generally.

8. CONCLUSION

In the current context of competitive, companies collect the data which used to the improvement of the decision-making. This is facilitated by the implementation of the new technologies of information. Among the important information for decision, that related to the movements of mobile objects. The development of the techniques of follow-up of location of mobile objects and the collection of data relative to the movement of these objects leads to an abundance of data relative to the mobile objects and raises the question to exploit them for the support the decision-making. Indeed, the history of the mobile objects can deliver precious information if we apply it a multidimensional analysis.

In our work we treat the case of the supply chain, which is a system characterized by the mobility between the various processes of the chain as well as within the processes. It is the system which coordinates and manages the movements of products and information. The mobile objects in the supply chain are vehicles and wagons, which insure the transport. Our work studies the problem of the storing and the analysis of data relative to the mobile objects in a supply chain. This data are stored in TDW which supports an important volume of information relative to the trajectories of the mobile objects. The objective of our work consists of improving the performance of the supply chain. We propose an abstract model of trajectory data and an abstract model for the trajectory data warehouse which supports the trajectory data in a supply chain. The data warehouse is analyzed to extract knowledge which

is used as a support to the decision-making to strengthen the management of the supply chain.

We did not take into account in the querying the future information as the future place of the mobile object, thus this type of question can be treated in future works.

ACKNOWLEDGEMENTS

The autors would like to think their professors at the Institut Superieur de Gestion for being ever-present with their help and support and many thanks to their colleagues at the Institut Superieur de Gestion. They also would like to think their families for their support.

REFERENCES

[1] Levray, R., Mathieu, R. (2009). 'Data warehousing and mining in supply chain'. Encyclopedia of Data Warehousing and Mining p 586-591.

[2] Vural, E., Sengül, O., Davis, S., Günther, H.(2006). 'Business Intelligence for supply chain management system'. Issues in Information Systems, Volume VII, No. 2.

[3] Stefanovica, N., Radenkovicb, B., Stefanovicc, D. (2006).' Supply chain intelligence'. Information Systems Division.

[4] Eng, T.Y.(2006). 'Mobile supply chain management: Challenges for implementation'. Technovation 26 (2006) 682–686.

[5] Jiang, G., Hu, B., Wang, Y. (2009). 'Agent-based simulation of competitive and collaborative mechanisms for mobile service chains'. Information Sciences 180 (2010) 225–240

[6] Soroor, J., Tarokh, M. J., Shemshadi, A.(2009).' Initiating a state of the art system for real-time supply chain coordination'. European Journal of Operational Research 196 (2009) 635–650.

[7] Wang, L.C., Lin, Y.C., Lin, P.H.(2007).'Dynamic mobile RFID-based supply chain control and management system in construction'. Advanced Engineering Informatics 21 (2007) 377–390.

[8] Spaccapietra, S., Parent, C., Damiani, M.L., de Macedo, J.A., Porto, F., Vangenot, C.(2007).'A Conceptual View on Trajectories'. Technical Report, Ecole Polythecnique Federal de Lausanne, April 2007.

[9] Mentzer, J.,T. (2001).'Supply Chain Management'. Library of congress cataloging in publication data.

[10] Saygin, C., Sarangapani, J,. Grasmann, S.E.(2007).'A système approach to viable RFID implementation in the supply chain'. Trends supply chain design and management p 3-28.

[11] Gaukler, G.M., Seifert, R.W.(2007).'Applications of RFID in supply chain'. Trends supply chain design and management p 29-48.

[12] Teuteberg, F., Ickerott, I. (2007). 'Mobile supply chain events management using Auto-Id and sensor technologies'. Trends supply chain design and management p 93-125.

[13] Wolfson O., Chamberlain S., Dao S., Jiang L., Mendez G. (1998). 'Cost and Imprecision in Modeling the Position of Moving Objects'. In: Proceedings of ICDE 1998.

[14] Sistla, P., Wolfson, O, Chamberlain, S., Dao, S.(1997). 'Modeling and Querying Moving Objects'.

[15] Mouza, C., and Rigaux, P.(2005). 'Mobility patterns'. Geoinformatica, 9(23):297–319, 2005.

[16] Guting, R.H., Almeida, V.T., Ding, Z.(2004). ' Modeling and Querying Moving Objects in network'. Technical Report 308, Fernuniversitat Hagen, Fachbereich Informatik.

[17] Shim, J., P., Warkentin, M., James, F., Daniel, J., Sharda, R., Carlsson, C.(2002). 'Past, present, and future of decision support technology'. Decision Support Systems.

[18] Biswas, S., Narahari, Y.(2002). 'Object oriented modeling and decision support for supply chains'. European Journal of Operational Research.

[19] Wan, T., Zeitouni, K.(2006). 'Vers un entrepôt d'objets mobiles contraints par le réseau'.

[20] Wan, T., Zeitouni, K. (2005). 'Modélisation d'objet mobile dans un entrepôt de données'. Edition Cépaduès.

[21] Mouza, C., and Rigaux, P.(2005). 'Mobility patterns'. Geoinformatica, 9(23):297–319, 2005.

[22] Brakatsoulas, S., Pfoser, D., Tryfona, N. (2004). 'Modeling, Storing and Mining Moving Object Databases'. Proceedings of the International Database Engineering and Applications Symposium Pages: 68 – 77.

[23] Meng, X., Ding, Z.(2003). 'DSTTMOD: A Discrete Spatio-Temporal Trajectory Based Moving Object Databases System'. LNCS 2736, (Springer verlag).

[24] Guting, R.H, Almeida, V.T., Ding, Z.(2004). ' Modeling and Querying Moving Objects in network'. Technical Report 308, Fernuniversitat Hagen, Fachbereich Informatik.

[25] Pfoser,D.(2002). 'Indexing the Trajectories of Moving Objects'. Bulletin of the IEEE Computer Society Technical Committee on Data Engineering.

[26] Oleskow, J., Fertesch, M., Golinska, P., Mauszewska, K.(2007). 'data mining as a suitable tool for efficient supply chain integration'. information technologies in environmental engineering. third International ICSC Symposuim P 321-325

[27] Cheng, B., Wang, C. (2008). 'Outsourcer selection and order tracking in a supply chain by mobile agents'. Computers & Industrial Engineering 55 (2008) 406–422.

[28] P. Rigaux, M. Scholl, L. Segoufin, S. Grumbach. Building a Constrained-Based Spatial Database System: Model, Languages and Implementation. Information Systems.

[29] Z.Ding and R.H. Guting. Managing Moving Objects on Dynamic Transportation Networks. Proc of the 16th Intl. Conf. On Scientific and statistical Database Management (SSDBM, Santorini Island, Greece), 2004.

[30] P. Rigaux, M. Scholl, L. Segoufin, S. Grumbach. Building a Constrained-Based Spatial Database System: Model, Languages and Implementation. Information Systems.

[31] O. Wolfson, B. Xu, S. Chamberlain, and L. Jiang. Moving objects databases: Issues and solutions. In SSDBM '98: Proceedings of the 10th International Conference on Scienti¯c and Statistical Database Management, pages 111{122, Washington, DC, USA, 1998. IEEE Computer Society.

[32] D. Pfoser and C. S. Jensen. Indexing of Network Constrained Moving Object. 11th ACM International Symposium on Advances in Geographical Information Systems (ACM-GIS), 2003.