Design and Implementation of Advanced Traffic Monitoring System based on Integration of Data Stream Management System and Spatial DBMS

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Abstract  The real-time traffic data is generated continuous and unbounded stream data type while intelligent transport system (ITS) needs to provide various and high quality services by combining with spatial information. Traditional database techniques in ITS has shortage for processing dynamic real-time stream data and static spatial data simultaneously. In this paper, we design and implement an advanced traffic monitoring system (ATMS) with the integration of existed data stream management system (DSMS) and spatial DBMS using IntraMap. Besides, the developed ATMS can deal with the stream data of DSMS, the trajectory data of relational DBMS, and the spatial data of SDBMS concurrently. The implemented ATMS supports historical and one time query, continuous query and combined query. Application programmer can develop various intelligent services such as moving trajectory tracking, k-nearest neighbor (KNN) query and dynamic intelligent navigation by using components of the ATMS.

Keywords : Traffic Monitoring System, Data Stream Management System, Spatial DBMS, Intelligent Transportation System

1. Introduction

Intelligent transportation system (ITS) [1] applies innovative and advanced technologies such as information processing, sensor network, mobile communications, GPS and auto-control to make transportation systems more efficient and customers service-oriented. Recent developments in network and sensor device technologies enable us to easily obtain real time traffic information by which the advanced traffic monitoring system (ATMS) can be developed to provide real time traffic monitoring[22].

ATMS need to handle stream data and spatial data concurrently because continuous and unbounded stream data of traffic information are arrived from the sensor network and many applications use the spatial data to implement map services. Data stream management system (DSMS) [2,3] efficiently handles data stream and executes query whenever new data stream arrives, while it cannot manages the spatial data. While, spatial database management system (SDBMS)[4] can deal with large volume of static and spatial data storage and query but can not process continuous and unbounded data stream. The existing traffic monitoring prototype system [5,6,7,8] combined with DSMS and SDBMS only involves in stream processing on regular areas and is based on specially developed data stream management systems.

Since the objective of DSMS is real-time processing a large number of arriving data stream from sensors and, on the other hand, that of SDBMS is handling the large volume of stored spatial data in database[23], it is difficult to combine DSMS and SDBMS. In this paper, we design and implement a
GIS based ATMS with the integration of existed DSMS and SDBMS using IntraMap [9]. Our developed ATMS can deal with the stream data of DSMS, the trajectory data of relational DBMS, and the spatial data of SDBMS concurrently. And also the implemented ATMS supports three kinds of query: historical one time query, continuous query and combine query. Historical one time query is only involved in the static and historical data that stored in relational DBMS or SDBMS. The continuous query is related with time–varying data stream that process by DSMS. The combine query is processed based on integration of stream data, relational data and spatial data. These queries can serve for various intelligent services such as moving trajectory tracking, k–nearest neighbor (KNN) query and dynamic intelligent navigation.

The remained contents are organized as follows. Related works of SDBMS and DSMS are reviewed in section 2. In section 3, the data types and query models of ATMS are presented. Section 4 highlights the system architecture, proposes data integrating and query execution methods. Then, we show the execution examples and performance evaluation of the implemented ATMS. Finally, section 5 gives the conclusion of this paper.

2. Related works

SDBMS supports spatial data models, abstract data types (ADTs) and query language. It plays an important role for efficient spatial data management in many GIS applications. Several commercial SDBMS have developed and widely used, such as ESRI [10], Arc/View in Canada, ERDAS IMAGINE, MapInfo [11] in America, GEOMania [12] GDK and KSIC’s IntraMap in Korea, SuperMap [13] in China. ERDAS Imagine is a GIS product developed by ERDAS, provides the most comprehensive interoperable geospatial solutions available. Arc/View is the world’s most popular desktop GIS and mapping software. With Arc/View you can create intelligent, dynamic maps using data from virtually any source and across most popular computing platforms. Arc/View provides data visualization, query, analysis, and integration capabilities along with the ability to create and edit geographic data. MapInfo support address geocoding, site selection, mapping customer/competitor locations, problem notification, emergency response coordination, data visualization and analysis. MapInfo datasets in native (TAB) format and in interchange (MIF/MID) format are supported for reading and writing. Update of existing files is not currently supported. SuperMap is developed by SuperMap company in Beijing of China, with most functions of GIS software. IntraMap is a high–end geographic information software that supports GIS data management and spatial query tools in both C/S and internet environment, developed by KSIC (Korea geoSpatial Information & Communication Co., Ltd.). It supports visualization, edit data, decision–making, geo-processing, and so on. The biggest advantage of KSIC’s products is that spatial data can in accordance with attribute data across Microsoft Access database.

DSMS [14,15] can process huge and fast data streams from multiple sources, enable real time response in despite of unpredicted system loads. It requires an integrated model on both persistent relations and time–varying data streams to support continuous queries. New processing paradigms and methods have been proposed and implemented in several stream processing systems to achieve the similar objectives. However, they can only handle streaming point locations naively while do not have adequate support to take account of the spatial and temporal information simultaneously.

Here we present some stream processing systems. CarTel [5] is a mobile sensor computing system designed to collect, process, deliver and visualize mobile sensor data. It provides a simple query–oriented programming interface and manages intermittent and variable network connectivity. CarTel is powerful in processing mobile sensor data, but is weakness to combine queries involved in SDBMS and DSMS. STREAM [16] is a general–purpose DSMS that supports a declarative query language and is designed to handle high–volume data streams with large numbers of complex continuous queries. PLACE [6] is a query processor for handling real time spatio–temporal data streams in regular region with a scalable location–aware database server, but it is helpless in the irregular spatio–temporal queries. Nile [17], a query processing engine for data streams, extends the query processor engine of an object–relational database management system, Predator [18], to process continuous queries over data streams. But Nile can’t support spatio–temporal queries. KOREDstream [19] is a prototype DSMS developed by the Database Lab of Inha University in Korea who corporately studied spatial DBMS and SDBMS with us.