Multidimensional Database Representation of Real-time, Volatile, and Multi-behavioral Environments

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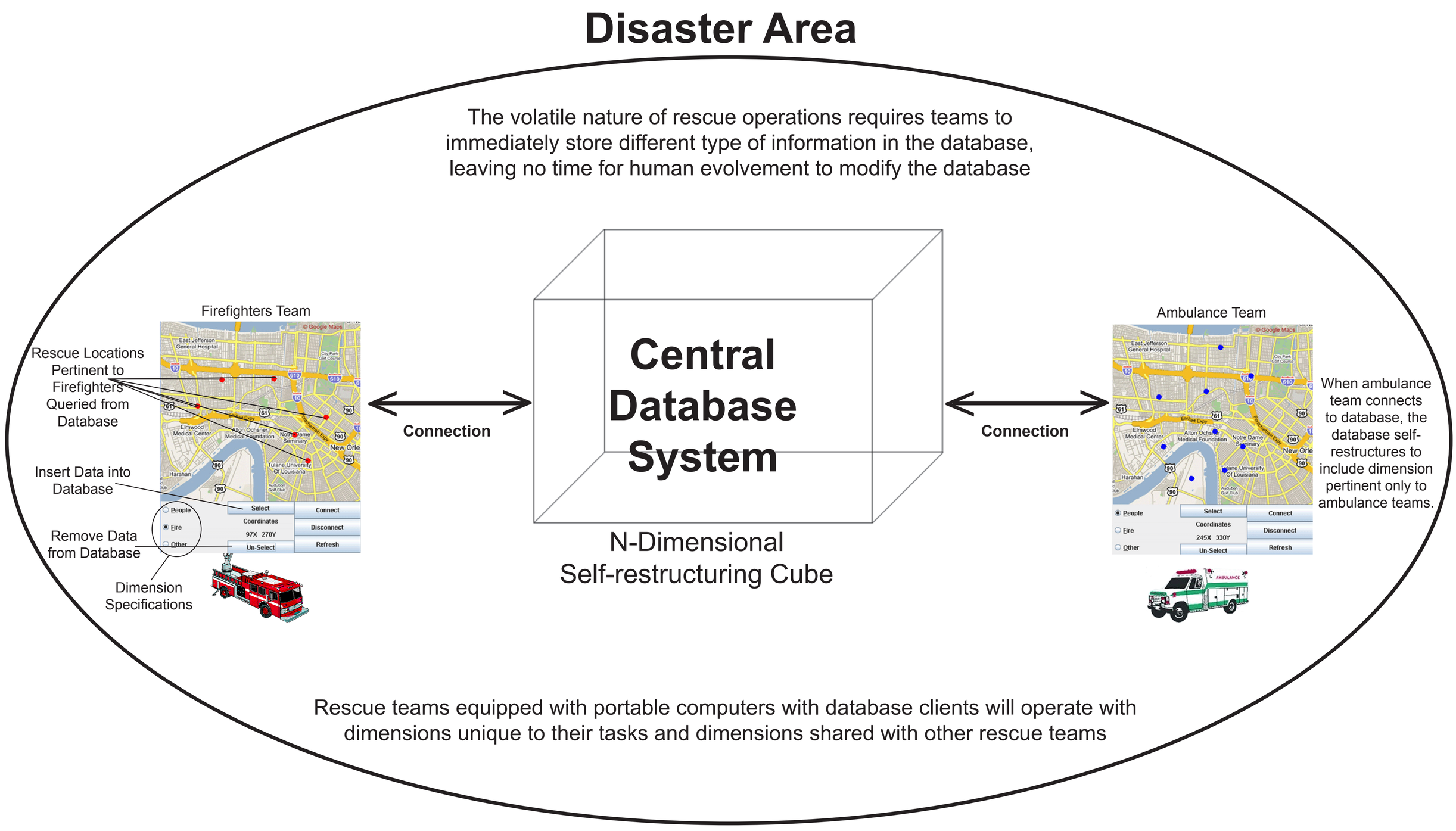
Introduction

The goal of this research is to create a database architecture that utilizes best features of relational and multidimensional database models, and employs a flexible structure to adequately self-manage its data model in real-time, volatile, and multi-behavioral environments. Relational and multidimensional systems primarily address data management needs of environments in which characteristics are well known at database design and modeling stage. Steady nature of such environments tolerates need of human involvement to make modifications of the database structure. However, highly dynamic environments would require an ability to autonomously change database structure in real time by the database itself.

A multidimensional organization is fundamental for the proposed database design. Dimensional structure is a robust and adaptable mechanism to express objects, complex real-world characteristics, and relationships. The ability to simplify mapping between real-world objects and database structure substantially reduces complexity of Structured Query Language (SQL) statements, used in communication with relational databases.

This project addresses foundations of the proposed database organization, explains the database architecture, discusses methods of manipulation of the data model, and demonstrates an implementation. Motivated applications for the database architecture also are presented.



"You can do all the planning in the world, **but if you can't communicate with one another,** then you're going to have some issues." ~ Mike Zezeski, of the Maryland State Highway Department

Background

The field of database systems has been an important development area in software engineering for the past 30 years. Relational Database Management Systems (RDBMS) became predominant for many business management applications. Relational databases use relations (tables with columns and rows), attributes (named columns of relations), and tuples (rows of relations) to organize data. The databases have a relatively easy structure to understand and use. Relational databases are capable of handling enormous volumes of data, while providing high performance for processing of data updating. However, organization properties of relational database become disadvantages in dynamic environments. Relational data structures could not directly model after real-world characteristics, because the structures are oriented for dealing with data semantics, consistency, and redundancy problems. Therefore, relational databases require human involvement for conceptual, logical, and physical design phases before real world objects could be mapped to their respective data models. Another considerable obstacle for applying relational databases in dynamic environments is the need for client software to adjust SQL statements to fit changing database structure on the fly.

Multidimensional databases, a core component of On-Line Analytical Processing (OLAP) systems, address some of the weaknesses of relational databases. These database systems implement cube database structures that associate variables based on dimensional coordinates. Dimensions represent intuitive and direct form of characteristics of real-world objects. The databases hide as much complex syntax as possible from users and provide consistent response times for all queries. Multidimensional databases still

have difficultly adapting to real-time processes, because they do not have a flexible mechanism to dynamically change dimensionality of the database. A new multidimensional structure (cube) must be constructed to support addition and removal of dimensions whenever characteristics change in the environment.

Considering the advantages and disadvantages of relational and multidimensional databases, this project's goal is to find a database architecture that would include best of both database models and serve dynamic environments effectively

Motivated Applications

The proposed database can be adapted to systems, whose characteristics are erratic and can change rapidly, such as search-and-rescue operations. Emergency management systems have needs for databases. In case of natural disasters, rescue delegations have little time to prepare and must operate in chaotic conditions. Coordination efforts between rescue forces are complex tasks. To increase efficiency, teams will interact with a database to retrieve necessary data collected by all types of teams (police, firefighters, army, etc.). The volatile nature of rescue operations requires teams to immediately store different type of information in the database, leaving no time for human evolvement to modify the database structure. Employing the proposed database, rescue teams equipped with portable computers with database clients will operate with dimensions unique to teams' tasks and dimensions shared with other rescue teams. Such electronic coordination could be vital important in international rescue efforts, in which often languages are barriers between different international teams.

References

Connolly, Thomas and Carolyn Begg. Database Systems. Harlow: Pearson Educational Limited, 2002.

Bagnall, Brian. Core Lego Mindstorms Programming: Unleash the Power of the Java Platform. Upper Saddle River: Prentice Hall PTR, 2002.

Delaney, Kalen. Inside Microsoft SQL Server 2000. Redmont: Microsoft Press, 2001.

Horstmann, Cay S. and Gary Cornell. Core Java 2 Volume II – Advanced Features. Palo Alto: Sun Microsystems, Inc., 2002.

Jones, Tim M. AI Application Programming. Hingham: Charles River Media, Inc., 2003.

Rafanelli, Maurizio. Multidimensional Databases: Problems and Solutions. Hershey: Idea Group Publishing, 2003.

Russel, Stuart and Peter Norvig. Artificial Intelligence: A Modern Approach. Upper Saddle River: Pearson Education, Inc, 2003.

Sedgewick, Robert. Algorithms in C++: Fundamentals, Data Structures, Sorting, Searching. Boston: Addison-Wesley Publishing Company, Inc., 1998.

Sedgewick, Robert. Algorithms in C: Graph Algorithms. Boston: Addison-Wesley Publishing Company, Inc., 2002.

Thomsen, Erik, George Spofford, and Dick Chase. Microsoft OLAP Solutions. New York: John Wiley & Sons, Inc, 1999.