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Systems and methods for preventing database deadlocks during synchronization

Abstract

Embodiments of the present disclosure include techniques for storing and updating data in a database. In one embodiment, data elements are stored in a many to one relationship in different tables. When data updates occur, the records to be updated are divided into batches and sorted. Database transactions to update the batches are performed in parallel. When one transaction accesses a record in the database, the record is locked. Other batches accessing the locked record may wait until the record is unlocked to complete their updates. The present techniques may improve database processing by reducing or eliminating database deadlocks, for example.

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Background/Summary

BACKGROUND

(1) The present disclosure relates generally data management in computer systems, and in particular, to systems and method for preventing database deadlocks during synchronization.

(2) Computer systems require data to produce useful and meaningful results. Data preparation and analytics can involve complex, time consuming preparation of relations, visualizations, and compilations of data. Such data compilations are often stored in interrelated database tables. However, when changes to the data occur, updating the database can be a challenge. In some cases, when multiple different data elements are associated with a common data element, updating the data can lead to deadlocks as the database attempts to change the same data as part of an update to

multiple different other data elements.

(3) The present disclosure addresses these and other challenges and is directed to techniques for preventing database deadlocks.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

(1) FIG. 1 illustrates a system for updating data according to an embodiment.

(2) FIG. 2 illustrates a method of updating data according to an embodiment.

(3) FIG. 3 illustrates example database tables according to an embodiment.

(4) FIG. 4A illustrates batch processing of data updates according to an embodiment.

(5) FIG. 4B illustrates a method of batch processing data updates according to an embodiment.

(6) FIG. 5 illustrates hardware of a special purpose computing system configured according to the above disclosure.

DETAILED DESCRIPTION

(7) Described herein are techniques for preventing database deadlocks during synchronization. In the following description, for purposes of explanation, numerous examples and specific details are set forth in order to provide a thorough understanding of some embodiments. Various embodiments as defined by the claims may include some or all of the features in these examples alone or in combination with other features described below and may further include modifications and equivalents of the features and concepts described herein.

(8) FIG. 1 illustrates a computer system **100** for updating data according to an embodiment.

Features and advantages of the present disclosure include techniques for updating data in a database with prevents database deadlocks, for example. Computer system **100** may comprise multiple computers, such as a cloud computer system (e.g., a data center) or an on-premise network of computers, for example. Each computer may comprise one or more processors and various forms of memory for executing software performing the techniques described herein.

(9) In this example, computer system **100** includes an application **101** and a database **102**.

Application **101** may be an application backend server, which implements functionality of application **101** in response to commands from a frontend user interface, for example. Database **102** stores data. In this example, data elements are stored in tables **130-134**. Data elements may be stored in data records in tables **130-134**.

(10) Features and advantages of the present disclosure may be advantageously used to stored data linked in a hierarchy. For example, application **101** may allow a user to link data elements **110-117** in a hierarchy. Here, data element **112** is a child of data element **111**, which is a child of root data element **110**. Similarly, data element **116** is a child of data element **115**, which is a child of data element **114**, which is a child of data element **113**, which is a child of root data element **110**. Data element **117** is a child of root data element **110**. As the data changes, the hierarchy may change. For example, a modification (illustrated by arrow **190**) of data element **114** to **114'** may result in a change in the hierarchy. In this case, data element **115'** is now a child of data element **114'**.

Example data elements may be dimensions and values (e.g., aggregated values) described in more detail below.

(11) As mentioned above, data elements are stored in database **102** in tables **130-134**, which are linked to form the hierarchy. In this illustrative example, table **134** is linked to tables **130** and **131**, table **131** is linked to table **132**, and table **132** is linked to table **133**. In various embodiments, one or more tables have a many to one relationship with another table. For example, table **131** may have a many to one relationship (N:1) with table **132**. Accordingly, multiple records in table **131** are associated with one record in table **132**, where data elements are stored as records in the tables of the database. For tables with a many to one relationship, groups of data elements in one table

(e.g., table **131**) may be associated with a same data element stored in another table (e.g., table **132**). Embodiments of the present disclosure may advantageously update data elements in table **132** when modifications are made to a hierarchy changing an association between the groups of first data elements (e.g., in table **131**) and corresponding same second data elements (e.g., in table **132**). Such changes in a hierarchy may require different data elements in table **131** to be associated with data elements in table **132**, for example. Associations between data elements across the tables may change as a result of a change in the hierarchy, and updating the database with such changes can be challenging where tables have one or more many to one relationships.

(12) When a modification of the hierarchy is made that changes an association between groups of data elements in one table and a corresponding same data element in another table, the system may determine which same data elements have a changed association with the groups of data elements. For example, if the hierarchy changes such that a path in the hierarchy has different members, including a member in table **132**, then data elements in table **132** may need to be updated. In one embodiment, updates may be performed using batch processing **120**, which is shown here in database **102**, for example. Data elements in table **132** having the changed association, and hence need to be updated, may be divided into batches **121a-n**, which comprise subsets of the data elements in table **132** having the changed association, for example. Advantageously, the subsets of data elements in the batches may be sorted. As illustrated below, sorting prior to updating may help prevent database deadlocks, for example. After sorting, the batches of subsets of data elements having changed associations are updated by performing database transactions (T1–Tn) **140a-n** in parallel.

(13) For instance, a plurality of transactions may be illustrated by looking at two database transactions. When an update occurs and the batches are sorted, a first database transaction (T1) **140a** may be performed on a first batch **121a** having a first subset the second data elements having the changed association and a second database transaction (T2) **140b** may be performed on a second batch **121n** having a first subset the second data elements having the changed association (where “n” is an integer representing the total number of batches). Even though the batches are executed in parallel, the batches may not perform their functions at the same time if there is an update on the same database record. One of transactions T1 and T2 may be issued first (e.g., by a few milliseconds). Here, T1 may execute first, causing T2 to wait, putting T2 on hold. The first database transaction T1 may sequentially lock rows of a table comprising the data elements it is attempting to update (e.g., a first subset of the second data elements having the changed association in batch **121a**). In some embodiments, the lock may cause other transactions, such as T2, to wait, for example. Next, the first database transaction T1 sequentially updates each row comprising the subset of the second data elements having the changed association with the new data values, for example. When T1 is finished updating the elements of the batch, it may unlock the rows of the table. The wait (or hold) command on T2 is removed, and T2 is executed. T2 sequentially locks rows comprising the second subset the second data elements having the changed association in the second batch and sequentially updates each row comprising the second subset of the second data elements having the changed association with the new data values. In some embodiments, additional transactions may be placed on hold if such transactions also are updating data in the same table as T1 and T2. Accordingly, additional database transactions may be sequentially executed as each of the other transactions unlocks the table after performing their updates. This technique may advantageously prevent database deadlocks, which can increase database processing time. Accordingly, the present techniques allow databases to run faster and more efficiently.

(14) FIG. 2 illustrates a method of updating data according to an embodiment. At **201**, a plurality of data elements is stored in a database. The database comprises a plurality of tables linked to form a hierarchy. The plurality of data elements may comprise a plurality of first data elements and a plurality of second data elements, for example. The plurality of first data elements is stored in a plurality of first records in a first table of the database. Groups of the plurality of first data elements

are associated with the same second data elements of the plurality of second data elements stored in a plurality of second records in a second table of the database. When multiple data elements of one table are associated with the same data elements of another table, the tables are said to have a many to one relationship (N:1). Accordingly, the first table and the second table have a many to one relationship where multiple records in the first table are associated with one record in the second table. At **202**, a modification of the hierarchy is received on a first computer system changing an association between the groups of the plurality of first data elements and corresponding same second data elements. As illustrated in the examples below, the modification may be a change of dimension which changes the association of a data element, such as a comment thread, to a data value. At **203**, the system determines which second data elements have a changed association with the groups of the plurality of first data elements. Using the example above, the system may determine which dimensions have a changed association to comment threads. Such dimensions may be updated in one or more tables of the database, for example. At **204**, the second data elements having the changed association are divided into a plurality of batches. The batches comprise subsets of the second data elements having the changed association. At **205**, the subsets in each batch are sorted. At **206**, the subsets of the second data elements having the changed association in each batch are updated in the database by performing a plurality of parallel database transactions.

(15) FIG. 3 illustrates example database tables according to an example embodiment. A commenting feature in a data analytics software system, such as SAP® Analytics Cloud, allows users to add/delete/view comments. There may be different flavors of commenting, such as story comments, datapoint comments, and dimension related comments. Datapoint comments can be added on any datapoint of a table in a story. This requires the commenting service to store the comment context with respect to the dimension members contributing to the datapoint. If the same datapoint is viewed in another story, which is built on the same data model, then the same comments should appear on this datapoint as well.

(16) For these reasons, lifecycle of comment management becomes challenging because the comment context should synchronize with the ongoing addition/deletion of dimension members, or changes to the hierarchy of members in the underlying model. These changes impact the datapoint. Additionally, if comment context is not synchronized, modified comments cannot be viewed due to the context mismatch.

(17) Hence there are dimension update events being triggered from by an analytics application, such as from an analytics backend server **391**. A commenting system **392** listens to such events. Once an event is received for a particular dimension indicating a modification, a request is sent to a commenting service **393** to get the comment context which involves the given dimension. The comment context is then regenerated for the comments. The regenerated context is then sent back to the commenting service **393** via a series of batch requests with a maximum number (e.g., 500) of comment context each to update it back into a comment database **390**.

(18) Commenting service **393** may be a cloud microservice with multiple instances running. Accordingly, each batch of comment context update requests may be processed by different service instances at the same time. There can also be cases of other commenting operations like add, copy etc., which may be triggered at the same time. These requests translate to database operations to be performed on same set of commenting tables. There can be cases of particular table records to be updated by each of these transactions which will end with blocking queries leading to long running deadlocks and high CPU utilization for database **390**.

(19) In order to understand the complexity of the problem, consider the entities involved in commenting and their relations with each other. Referring again to FIG. 3, in this example, comments are coupled together in threads and linked to dimension members so that as dimensions change (e.g., in response to a user selecting different data to analyze across multiple possible dimensions), the comments and comment threads associated with the data values changes.

Accordingly, the database may comprise comments table **301**, threads table **302**, coordinates table **303**, dimension context table **304**, dimension member table **305**, and cached leaves table **306**. As illustrated in FIG. 3, the Dimension Member table **305** has common entries across different comment threads. Accordingly, if a member of a dimension was part of datapoint 1 and 2. Then comments associated with both these datapoint points will have a common entry for that memberId in the DimensionMember table. A distinguishing entry may be for 3 entries in Coordinate table **303** with 3 different threadId.

(20) For example, if User A adds a comment (test-comment1) on a datapoint which involves the following coordinates (Thread T1, comment C1):

(21) TABLE-US-00001 DimensionId MemberId Description Product PD21 Alcohol Location CT2 San Francisco Account GM1 Gross Margin

(22) Additionally, User B may add a comment (test-comment2) on a datapoint which involves the following coordinates (Thread T2, comment C2):

(23) TABLE-US-00002 DimensionId MemberId Description Product PD26 Juices Location CT2 San Francisco Account GM1 Gross Margin

(24) Further, User C may add a comment (test-comment3) on a datapoint which involves the following coordinates (Thread T3, comment C3):

(25) TABLE-US-00003 DimensionId MemberId Description Product PD30 Carbonated Drinks Location CT2 San Francisco Account GM1 Gross Margin

(26) Accordingly, commenting database tables **301-306** are be populated as follows:

(27) Thread table **302** associates threads (e.g., thread identifications (IDs)) and data models:

(28) TABLE-US-00004 Threadid cubeid T1 Model1 T2 Modell T3 Model1

(29) Comment table **301** associates comments (e.g., comment IDs) and threads (e.g., thread IDs) and users (creator IDs):

(30) TABLE-US-00005 commentid threadid commenttext creatorid C1 T1 test-comment1 userA C2 T2 test-coment2 userB C3 T3 test-coment3 userC

(31) Coordinate table **303** associates threads (thread IDs) and dimensions members (dimension member IDs):

(32) TABLE-US-00006 threadid dimensionmemberid T1 DM1 T1 DM2 T1 DM3 T2 DM4 T2 DM2 T2 DM3 T3 DM5 T3 DM2 T3 DM3

(33) DimensionContext table **304** associates threads, dimensions, context, and cache IDs.

(34) TABLE-US-00007 dimensioncontextid threadid dimensionid context cacheid DC1 T1 Product {member: Ch1 {values: [PD21]}} DC2 T1 Location {member: Ch2 {values: [CT2]}} DC3 T1 Account {member: Ch3 {values: [GM1]}} DC4 T2 Product {member: Ch4 {values: [PD26]}} DC5 T2 Location {member: Ch2 {values: [CT2]}} DC6 T2 Product {member: Ch3 {values: [GM1]}} DC7 T3 Product {member: Ch5 {values: [PD30]}} DC8 T3 Location {member: Ch2 {values: [CT2]}} DC9 T3 Product {member: Ch3 {values: [GM1]}}

(35) DimensionMember table **305** associates dimension members, dimensions, members, and cache IDs.

(36) TABLE-US-00008 dimensionmemberid dimensionid memberid cacheid DM1 Product PD21 Ch1 DM2 Location CT2 Ch2 DM3 Account GM1 Ch3 DM4 Product PD26 Ch4 DM5 Product PD30 Ch5

(37) CachedLeaves table **306** associates cache IDs with leaves (groups of members).

(38) TABLE-US-00009 cacheid leaves Ch1 [PD1, PD2, PD3, PD4] Ch2 [CT5, CT6] Ch3 [GM1] Ch4 [PD11, PD12, PD13] Ch5 [PD5, PD6]

(39) FIG. 4A illustrates batch processing of data updates according to an embodiment. From the above data entries, it can be seen that for two different threads T1 and T2, the dimensionmemberId DM2 and DM3 are common and comment context is distinguished by DM1 and DM4. When an update occurs for a dimension say Product, all the comment threads that involve Product dimension need to be updated with new context in terms of leaves for the members on which comments were

placed. If there are new entries to be added into the leaves column for a given member, this will call for an update to the DimensionMember table for the corresponding memberIds. The request to update is triggered in parallel batches as mentioned above. Each batch will have a database transaction to be performed.

(40) For above example, FIG. 4A illustrates two transactions, T1 and T2, being performed in parallel. Each request sends a list of memberIds to be added/updated into the DimensionMember Table. Transaction T1, List of memberIds to be updated, is shown at **401** and transaction T2, list of memberIds to be updated is shown at **402**. Advantageously, because the rows are sorted, both transactions will attempt to update the row, but for one of them the row will be locked. If the rows were unsorted, each transaction may start at different rows, but run into a deadlock when each transaction attempts to access a row locked by the other (e.g., if T1's batch were [PD30,PD26, . . .] and T2's batch were [PD26,PD30], then T1 would lock PD30 and T2 would lock PD26, resulting in a deadlock). Here, each batch is sorted by the given list of members before processing them for updates.

(41) Steps in resolved query processing in above Transaction for given list of members proceeds as follows:

(42) At time t0, sort both lists of dimension members.

(43) At time t1, Transaction T1 locks the row with membered PD21 and updates the values to the row.

(44) At time t1, Transaction T2 waits for T1 to release the lock on PD21.

(45) At time t2, Transaction T1 locks the row with membered PD26 and updates the values to the row.

(46) At time t2, Transaction T1 locks the row with membered PD30 and updates the values to the row.

(47) At time t2, Transaction T1 is committed, and all the row locks acquired by T1 are released.

(48) At time t3, Transaction T2 locks the row with membered PD26 and updates the values to the row. At time t3, Transaction T2 locks the row with memberId PD21 and updates the values to the row. At time t3, Transaction T2 locks the row with memberId PD26 and updates the values to the row. As the lock is release by T1, T2 will be able to acquire locks on each of the row that needs the update and commits the transaction.

(49) At time t3, Transaction T2 locks the row with memberId PD30 and update the values to the row.

(50) At time t3, Transaction T2 is committed, and all the row locks acquired by T2 are released.

(51) As mentioned above, when a transaction modifies a row in a database, it acquires a row lock on that row to prevent other transactions from modifying it at the same time. The row lock exists until the transaction commits or rolls back. These are row level locks and hence they will be locked one after the other.

(52) The above techniques produce a performance improvement with respect overall database query performance. Millions of rows may be processed in quickly (e.g., microseconds) even with multiple similar concurrent requests, for example. With multiple background jobs getting triggered in parallel, the database may be able to easily scale and complete the database transactions without any database locks or race conditions, for example. The techniques disclosed herein may avoid long waiting blocking queries and thus improve the query timings, for example.

(53) FIG. 4B illustrates a method of batch processing data updates according to an embodiment. At **410**, batches of updates are generated and sorted. At **411** and **415**, database transactions attempt to access and update the records in each batch in the sorted order. In this example, batch B1 locks the first row before batch Bn is able to do so. Accordingly, batch Bn and any other batches that attempt to access the same row are placed in a wait state. At **411**, B1 sequentially locks the rows. The rows are updated at **412**. When the database rows in B1 are updated, the updates are committed to the database at **413**. At **414**, the rows are unlocked. Accordingly, Bn is able to come out of the wait

state and sequentially lock rows at **415**, update the rows at **416**, and commit the updates to the database at **417**. The rows Bn locked are unlocked at **418**.

(54) FIG. 5 illustrates hardware of a special purpose computing system **500** configured according to the above disclosure. The following hardware description is merely one example. It is to be understood that a variety of computers topologies may be used to implement the above-described techniques. An example computer system **510** is illustrated in FIG. 5. Computer system **510** includes a bus **505** or other communication mechanism for communicating information, and one or more processor(s) **501** coupled with bus **505** for processing information. Computer system **510** also includes memory **502** coupled to bus **505** for storing information and instructions to be executed by processor **501**, including information and instructions for performing some of the techniques described above, for example. Memory **502** may also be used for storing programs executed by processor(s) **501**. Possible implementations of memory **502** may be, but are not limited to, random access memory (RAM), read only memory (ROM), or both. A storage device **503** is also provided for storing information and instructions. Common forms of storage devices include, for example, a hard drive, a magnetic disk, an optical disk, a CD-ROM, a DVD, solid state disk, a flash or other non-volatile memory, a USB memory card, or any other electronic storage medium from which a computer can read. Storage device **503** may include source code, binary code, or software files for performing the techniques above, for example. Storage device **503** and memory **502** are both examples of non-transitory computer readable storage mediums (aka, storage media).

(55) In some systems, computer system **510** may be coupled via bus **505** to a display **512** for displaying information to a computer user. An input device **511** such as a keyboard, touchscreen, and/or mouse is coupled to bus **505** for communicating information and command selections from the user to processor **501**. The combination of these components allows the user to communicate with the system. In some systems, bus **505** represents multiple specialized buses for coupling various components of the computer together, for example.

(56) Computer system **510** also includes a network interface **504** coupled with bus **505**. Network interface **504** may provide two-way data communication between computer system **510** and a local network **520**. Network **520** may represent one or multiple networking technologies, such as Ethernet, local wireless networks (e.g., WiFi), or cellular networks, for example. The network interface **504** may be a wireless or wired connection, for example. Computer system **510** can send and receive information through the network interface **504** across a wired or wireless local area network, an Intranet, or a cellular network to the Internet **530**, for example. In some embodiments, a frontend (e.g., a browser), for example, may access data and features on backend software systems that may reside on multiple different hardware servers on-prem **531** or across the network **530** (e.g., an Extranet or the Internet) on servers **532-534**. One or more of servers **532-534** may also reside in a cloud computing environment, for example.

Further Examples

(57) Each of the following non-limiting features in the following examples may stand on its own or may be combined in various permutations or combinations with one or more of the other features in the examples below. In various embodiments, the present disclosure may be implemented as a system, method, or computer readable medium.

(58) Embodiments of the present disclosure may include systems, methods, or computer readable media. In one embodiment, the present disclosure includes computer system comprising: at least one processor and at least one non-transitory computer readable medium (e.g., memory) storing computer executable instructions that, when executed by the at least one processor, cause the computer system to perform a method as described herein and in the following examples. In another embodiment, the present disclosure includes a non-transitory computer-readable medium storing computer-executable instructions that, when executed by at least one processor, perform a method as described herein and in the following examples.

(59) In some embodiments, the present disclosure includes a method of batch processing database

records comprising: storing a plurality of data elements in a database comprising a plurality of tables linked to form a hierarchy, the plurality of data elements comprising a plurality of first data elements and a plurality of second data elements, wherein the plurality of first data elements is stored in a plurality of first records in a first table of the database, and wherein groups of the plurality of first data elements are associated with same second data elements of the plurality of second data elements stored in a plurality of second records in a second table of the database, and wherein the first table and the second table have a many to one relationship where multiple records in the first table are associated with one record in the second table; receiving, on a first computer system, a modification of the hierarchy changing an association between the groups of the plurality of first data elements and corresponding same second data elements; determining, on the first computer system, the second data elements having a changed association with the groups of the plurality of first data elements; dividing, on the first computer system, the second data elements having the changed association into a plurality of batches comprising subsets of the second data elements having the changed association; sorting the subsets of the second data elements having the changed association in each batch; updating, in the database, the subsets of the second data elements having the changed association in each batch by performing a plurality of parallel database transactions.

(60) In some embodiments, updating comprises: performing, on the database, a first database transaction on a first batch having a first subset the second data elements having the changed association, the first database transaction comprising sequentially locking rows comprising the first subset of the second data elements having the changed association in the first batch and sequentially updating each row comprising the first subset of the second data elements having the changed association; and performing, on the database after the first database transaction, a second database transaction on a second batch having a second subset the second data elements having the changed association, the second database transaction comprising sequentially locking rows comprising the second subset the second data elements having the changed association in the second batch and sequentially updating each row comprising the second subset of the second data elements having the changed association.

(61) In some embodiments, the method further comprising, prior to performing the second database transaction: after sequentially updating each row, committing updates to the database for the first subset of the second data elements having the changed association; and unlocking the rows comprising the first subset of the second data elements having the changed association.

(62) In some embodiments, during said first database transaction, the second database transaction attempts to access a particular row locked by the first database transactions, and in response thereto, the second database transaction enters a wait state to prevent a database deadlock.

(63) In some embodiments, the first data elements are comments associated with a plurality of dimensions, and wherein the second data elements are dimensions.

(64) In some embodiments, the database comprises: a thread table storing threads associated with the comments stored in a comments table; a dimension member table storing dimensions; and a coordinates table associating dimensions in the dimensions table with a plurality of threads in thread table.

(65) In some embodiments, the database further comprising a cached leaves table comprising a plurality of associated dimensions.

(66) In some embodiments, the dimensions are dimension identifications:

(67) In some embodiments, the first computer system is a backend application server.

(68) The above description illustrates various embodiments along with examples of how aspects of some embodiments may be implemented. The above examples and embodiments should not be deemed to be the only embodiments, and are presented to illustrate the flexibility and advantages of some embodiments as defined by the following claims. Based on the above disclosure and the

following claims, other arrangements, embodiments, implementations, and equivalents may be employed without departing from the scope hereof as defined by the claims.

Claims

1. A method of batch processing database records comprising: storing a plurality of data elements in a database comprising a plurality of tables linked to form a hierarchy, the plurality of data elements comprising a plurality of first data elements and a plurality of second data elements, wherein the plurality of tables comprises a comments table, a dimension member table, a coordinates table, and a thread table, and wherein the plurality of first data elements are comments stored in a plurality of first records in the comments table of the database, and wherein groups of the plurality of first data elements are associated with same second data elements of the plurality of second data elements, wherein the second data elements are dimensions stored in a plurality of second records in the dimension member table of the database, and wherein the thread table stores threads associated with the comments stored in the comments table, and wherein the coordinates table associate dimensions in the dimension member table with a plurality of threads in the thread table, and wherein the comments table and the dimension member table have a many to one relationship where multiple records in the comments table are associated with one record in the dimension member table; receiving, on a first computer system, a modification of the hierarchy changing an association between the groups of the plurality of first data elements and corresponding same second data elements; determining, on the first computer system, the second data elements having a changed association with the groups of the plurality of first data elements; dividing, on the first computer system, the second data elements having the changed association into a plurality of batches comprising subsets of the second data elements having the changed association; sorting the subsets of the second data elements having the changed association in each batch; and updating, in the database, the subsets of the second data elements having the changed association in each batch by performing a plurality of parallel database transactions, including: performing a first database transaction on a first batch having a first subset the second data elements having the changed association, the first database transaction comprising sequentially locking rows comprising the first subset of the second data elements having the changed association in the first batch and sequentially updating each row comprising the first subset of the second data elements having the changed association, wherein, during the first database transaction, a second database transaction attempts to access a particular row locked by the first database transactions, and in response thereto, the second database transaction enters a wait state to prevent a database deadlock; and performing, after the first database transaction, the second database transaction on a second batch having a second subset the second data elements having the changed association, the second database transaction comprising sequentially locking rows comprising the second subset the second data elements having the changed association in the second batch and sequentially updating each row comprising the second subset of the second data elements having the changed association.
2. The method of claim 1, further comprising, prior to performing the second database transaction: after sequentially updating each row, committing updates to the database for the first subset of the second data elements having the changed association; and unlocking the rows comprising the first subset of the second data elements having the changed association.
3. The method of claim 1, the database further comprising a cached leaves table comprising a plurality of associated dimensions.
4. The method of claim 1, wherein the dimensions are dimension identifications.
5. The method of claim 1, wherein the first computer system is a backend application server.
6. A computer system comprising: at least one processor; at least one non-transitory computer readable medium storing computer executable instructions that, when executed by the at least one

processor, cause the computer system to perform a method comprising: storing a plurality of data elements in a database comprising a plurality of tables linked to form a hierarchy, the plurality of data elements comprising a plurality of first data elements and a plurality of second data elements, wherein the plurality of tables comprises a comments table, a dimension member table, a coordinates table, and a thread table, and wherein the plurality of first data elements are comments stored in a plurality of first records in the comments table of the database, and wherein groups of the plurality of first data elements are associated with same second data elements of the plurality of second data elements, wherein the second data elements are dimensions stored in a plurality of second records in the dimension member table of the database, and wherein the thread table stores threads associated with the comments stored in the comments table, and wherein the coordinates table associate dimensions in the dimension member table with a plurality of threads in the thread table, and wherein the comments table and the dimension member table have a many to one relationship where multiple records in the comments table are associated with one record in the dimension member table; receiving, on a first computer system, a modification of the hierarchy changing an association between the groups of the plurality of first data elements and corresponding same second data elements; determining, on the first computer system, the second data elements having a changed association with the groups of the plurality of first data elements; dividing, on the first computer system, the second data elements having the changed association into a plurality of batches comprising subsets of the second data elements having the changed association; sorting the subsets of the second data elements having the changed association in each batch; and updating, in the database, the subsets of the second data elements having the changed association in each batch by performing a plurality of parallel database transactions, including: performing a first database transaction on a first batch having a first subset the second data elements having the changed association, the first database transaction comprising sequentially locking rows comprising the first subset of the second data elements having the changed association in the first batch and sequentially updating each row comprising the first subset of the second data elements having the changed association, wherein, during the first database transaction, a second database transaction attempts to access a particular row locked by the first database transactions, and in response thereto, the second database transaction enters a wait state to prevent a database deadlock; and performing, after the first database transaction, the second database transaction on a second batch having a second subset the second data elements having the changed association, the second database transaction comprising sequentially locking rows comprising the second subset the second data elements having the changed association in the second batch and sequentially updating each row comprising the second subset of the second data elements having the changed association.

7. The computer system of claim 6, further comprising, prior to performing the second database transaction: after sequentially updating each row, committing updates to the database for the first subset of the second data elements having the changed association; and unlocking the rows comprising the first subset of the second data elements having the changed association.

8. The computer system of claim 6, the database further comprising a cached leaves table comprising a plurality of associated dimensions.

9. The computer system of claim 6, wherein the dimensions are dimension identifications.

10. The computer system of claim 6, wherein the first computer system is a backend application server.

11. A non-transitory computer-readable medium storing computer-executable instructions that, when executed by at least one processor, perform a method of moving data, the method comprising: storing a plurality of data elements in a database comprising a plurality of tables linked to form a hierarchy, the plurality of data elements comprising a plurality of first data elements and a plurality of second data elements, wherein the plurality of tables comprises a comments table, a dimension member table, a coordinates table, and a thread table, and wherein the plurality of first

data elements are comments stored in a plurality of first records in the comments table of the database, and wherein groups of the plurality of first data elements are associated with same second data elements of the plurality of second data elements, wherein the second data elements are dimensions stored in a plurality of second records in the dimension member table of the database, and wherein the thread table stores threads associated with the comments stored in the comments table, and wherein the coordinates table associate dimensions in the dimension member table with a plurality of threads in the thread table, and wherein the comments table and the dimension member table have a many to one relationship where multiple records in the comments table are associated with one record in the dimension member table; receiving, on a first computer system, a modification of the hierarchy changing an association between the groups of the plurality of first data elements and corresponding same second data elements; determining, on the first computer system, the second data elements having a changed association with the groups of the plurality of first data elements; dividing, on the first computer system, the second data elements having the changed association into a plurality of batches comprising subsets of the second data elements having the changed association; sorting the subsets of the second data elements having the changed association in each batch; and updating, in the database, the subsets of the second data elements having the changed association in each batch by performing a plurality of parallel database transactions including performing a first database transaction on a first batch having a first subset the second data elements having the changed association, the first database transaction comprising sequentially locking rows comprising the first subset of the second data elements having the changed association in the first batch and sequentially updating each row comprising the first subset of the second data elements having the changed association, and performing a second database transaction after the first database transaction, on a second batch having a second subset the second data elements having the changed association, the second database transaction comprising sequentially locking rows comprising the second subset the second data elements having the changed association in the second batch and sequentially updating each row comprising the second subset of the second data elements having the changed association, wherein, during said first database transaction, the second database transaction attempts to access a particular row locked by the first database transactions, and in response thereto, the second database transaction enters a wait state to prevent a database deadlock.

12. The non-transitory computer-readable medium of claim 11, further comprising, prior to performing the second database transaction: after sequentially updating each row, committing updates to the database for the first subset of the second data elements having the changed association; and unlocking the rows comprising the first subset of the second data elements having the changed association.

13. The non-transitory computer-readable medium of claim 11, the database further comprising a cached leaves table comprising a plurality of associated dimensions.

14. The non-transitory computer-readable medium of claim 11, wherein the dimensions are dimension identifications.

15. The non-transitory computer-readable medium of claim 11, the first computer system is a backend application server.
