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(54) **ASSIGNING PLAN VOLATILITY SCORES TO CONTROL REOPTIMIZATION FREQUENCY AND NUMBER OF STORED REOPTIMIZATION PLANS**

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(57) **ABSTRACT**

Methods, systems, and computer program products are provided for improving the processing of database queries. Some embodiments include generating volatility scores for various plans for executing similar database queries. Different embodiments may utilize: database statistics, the variable values being selected for, and/or historical run time data, to generate the plan volatility scores. In some embodiments, the volatility scores are used to determine whether to generate a new plan for a query, whether to prune an existing plan, and/or how many different plans to store for a query.

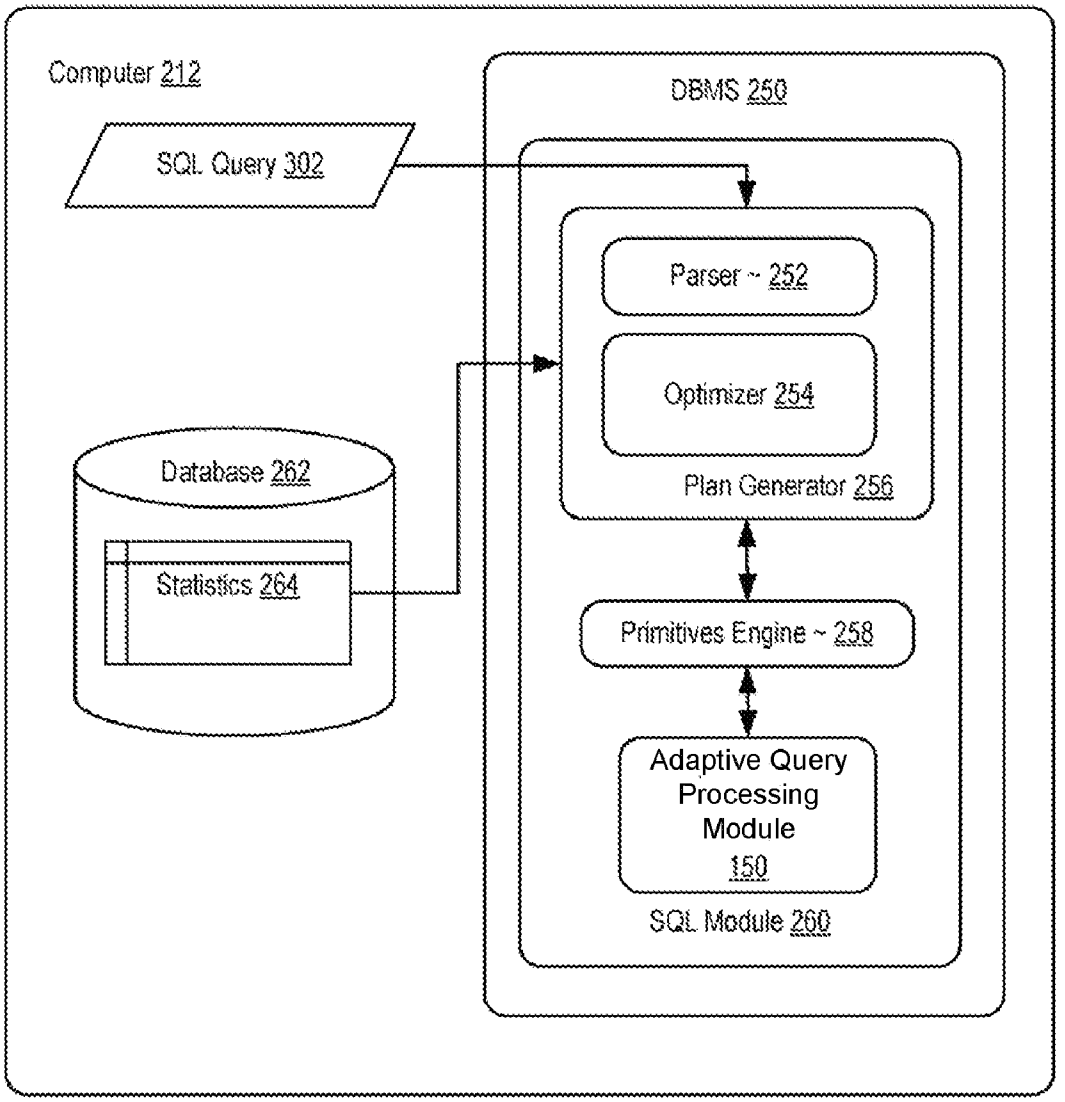


FIG 1

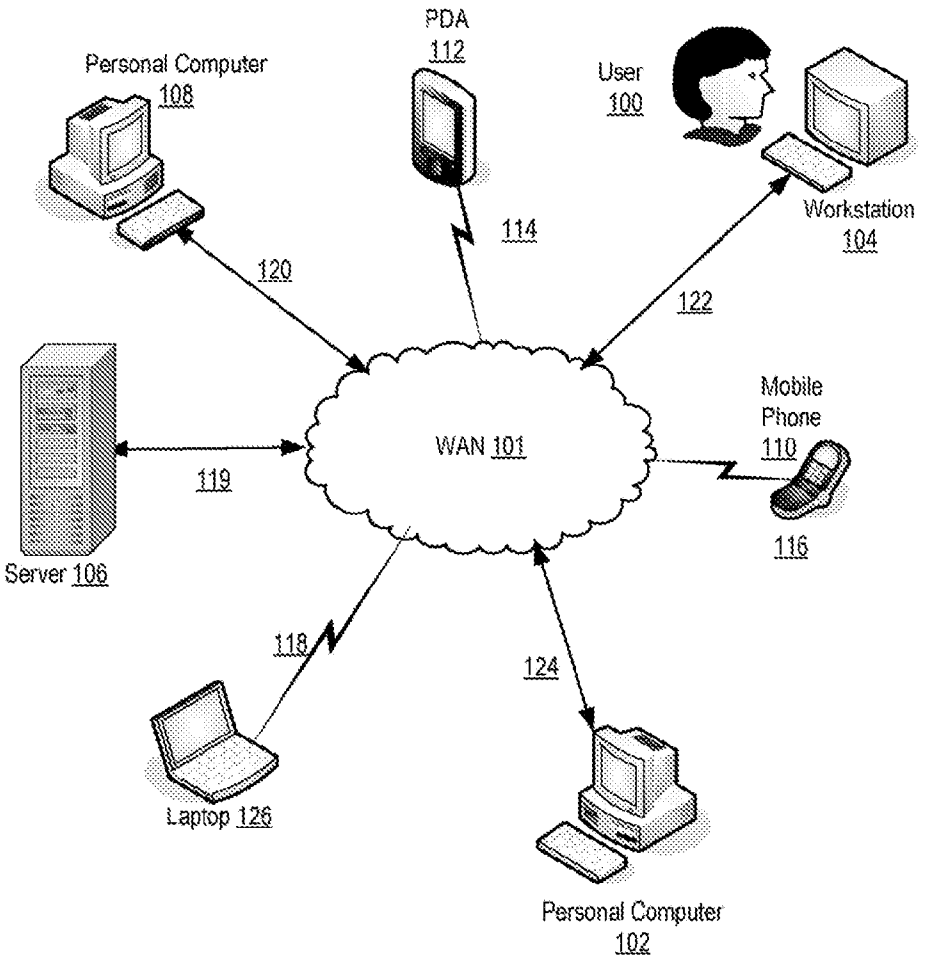

PDA
112
Personal Computer
108
User
100
Workstation
104
114
120
122
Mobile
Phone
110
WAN 101
119
Server 106
116
118
124
Laptop 126
Personal Computer
102

FIG 2

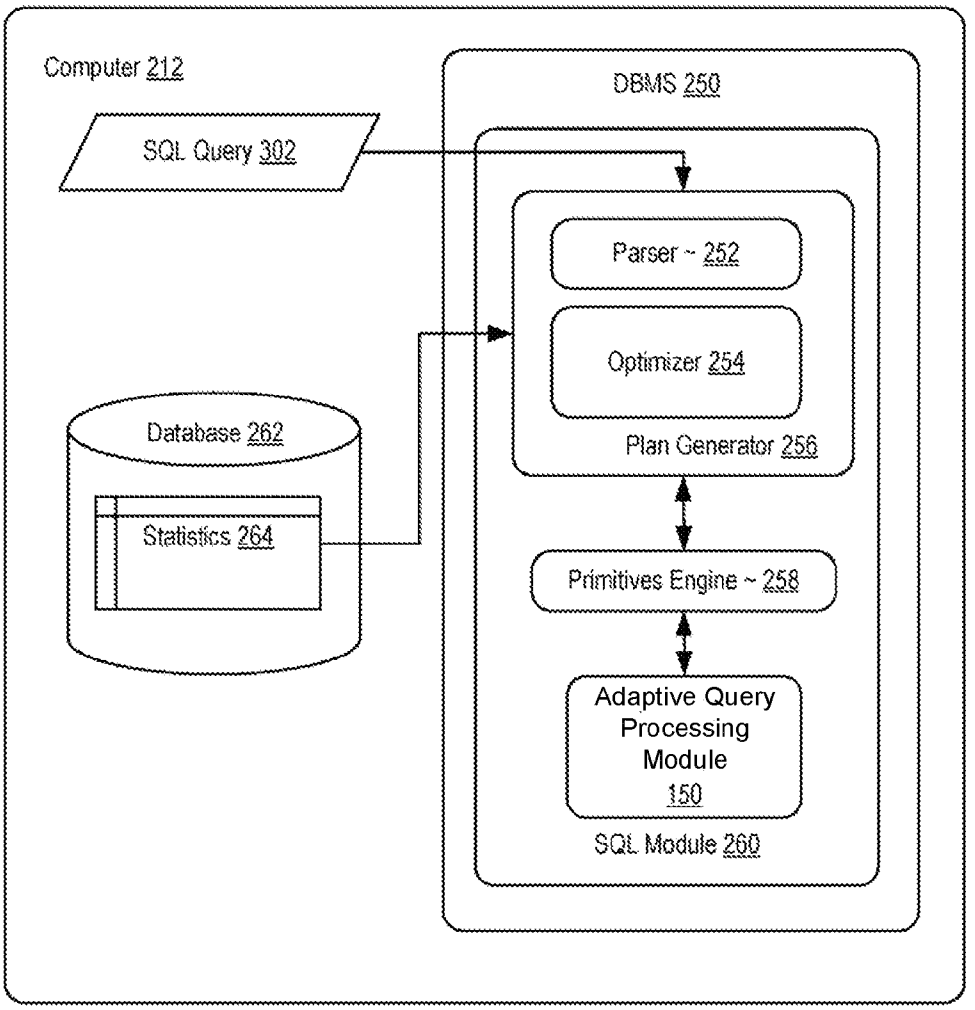

Computer 212
DBMS 250
SQL Query 302
Parser ~ 252
Optimizer 254
Plan Generator 256
Database 262
Statistics 264
Primitives Engine ~ 258
Adaptive Query Processing Module 150
SQL Module 260

FIG 3

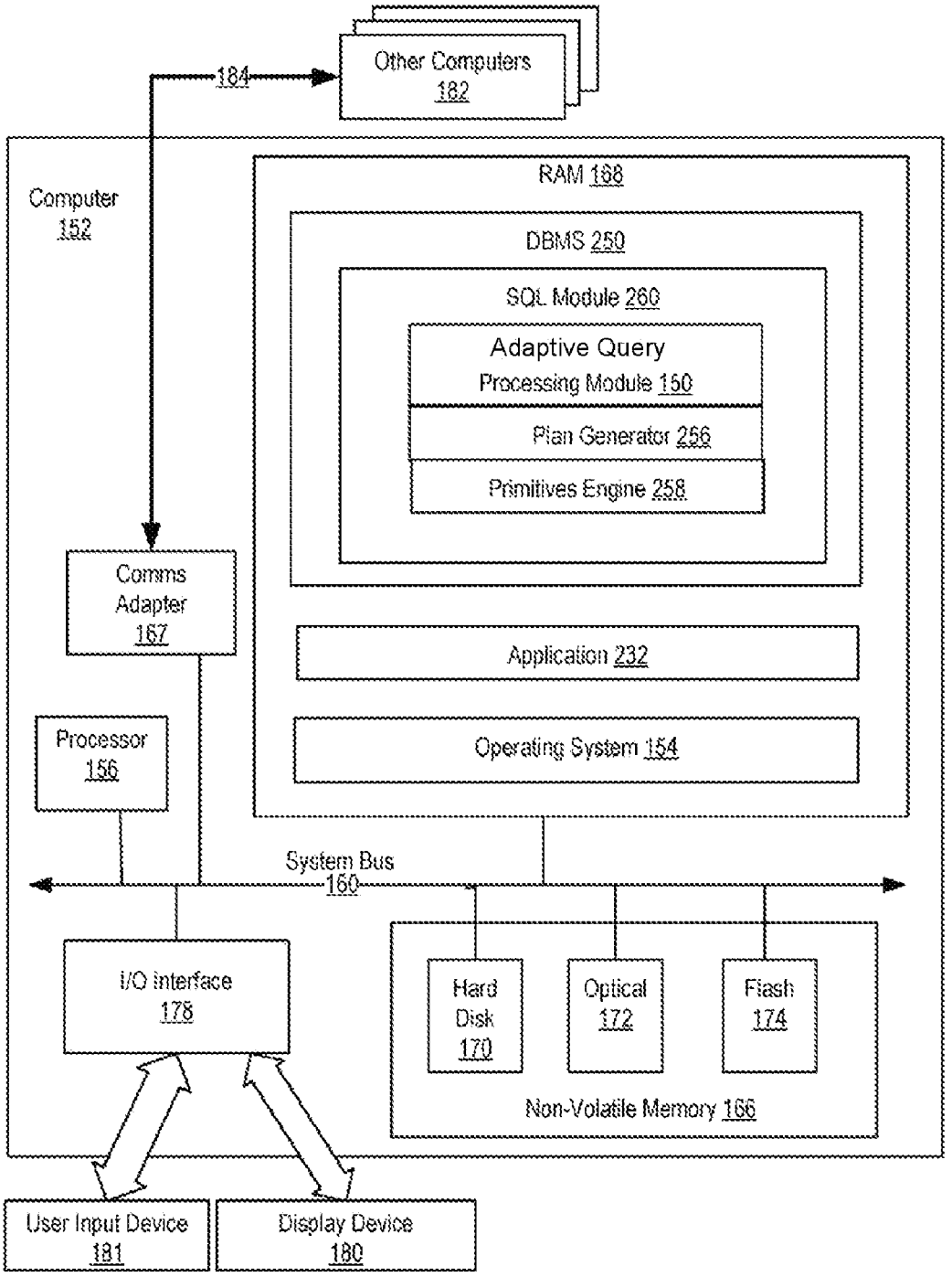

Other Computers
182
184
Computer
152
RAM 168
DBMS 250
SQL Module 260
Adaptive Query
Processing Module 150
Plan Generator 256
Primitives Engine 258
Comms
Adapter
167
Application 232
Processor
156
Operating System 154
System Bus
160
I/O Interface
178
Hard
Disk
170
Optical
172
Flash
174
Non-Volatile Memory 166
User Input Device
181
Display Device
180

FIG 4

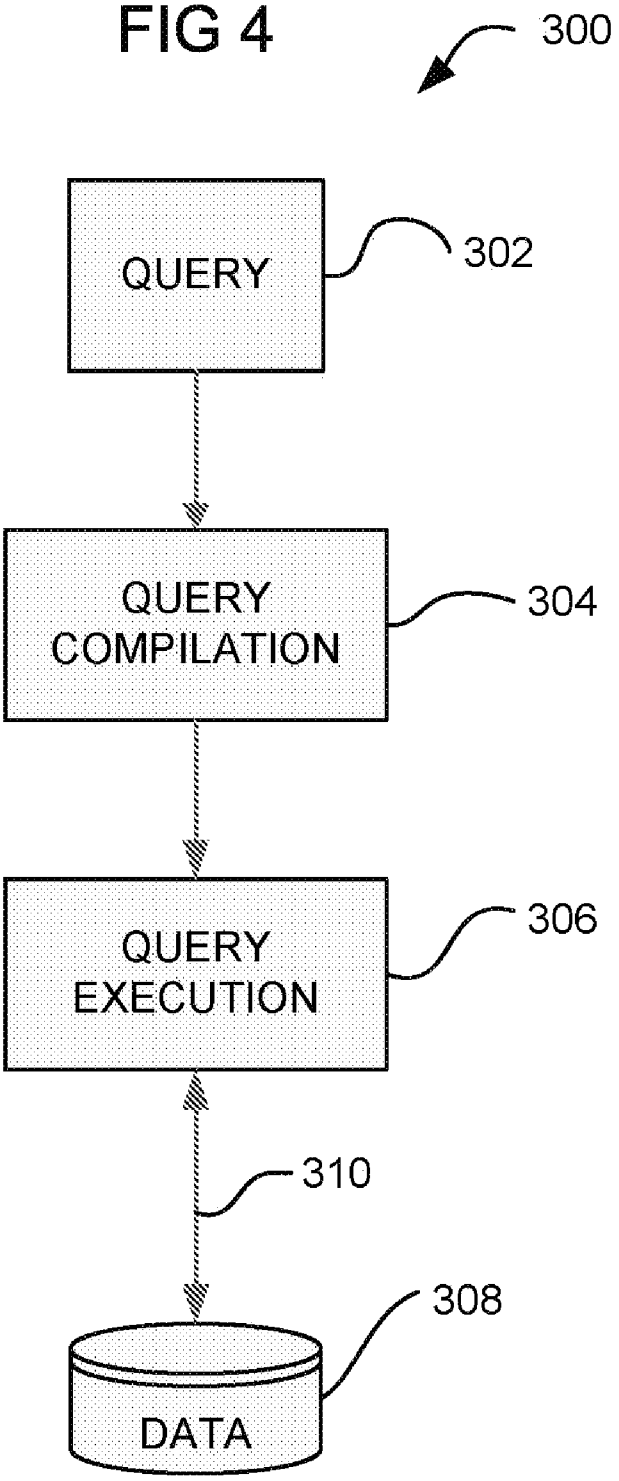

300
QUERY
302
QUERY COMPILATION
304
QUERY EXECUTION
306
310
308
DATA

FIG 5

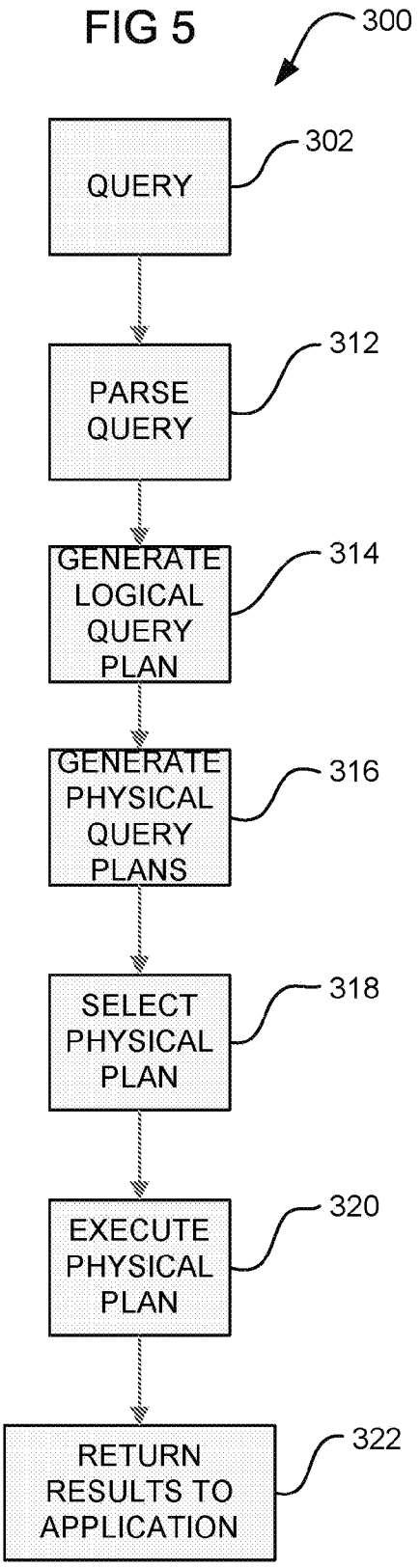
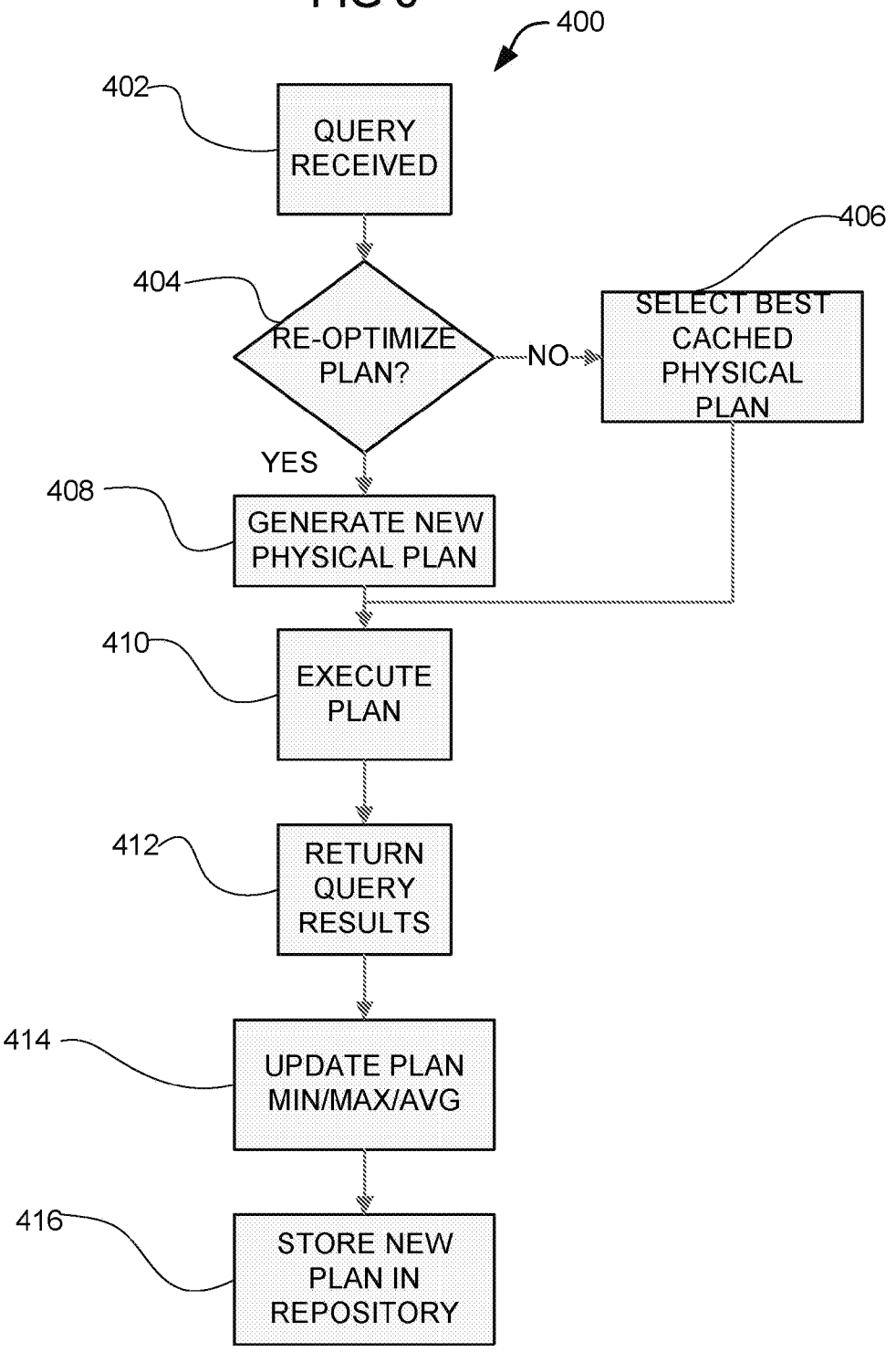

300
QUERY
302
PARSE QUERY
312
GENERATE LOGICAL QUERY PLAN
314
GENERATE PHYSICAL QUERY PLANS
316
SELECT PHYSICAL PLAN
318
EXECUTE PHYSICAL PLAN
320
RETURN RESULTS TO APPLICATION
322

FIG 6


400
402
QUERY RECEIVED
404
RE-OPTIMIZE PLAN?
NO
406
SELECT BEST CACHED PHYSICAL PLAN
YES
408
GENERATE NEW PHYSICAL PLAN
410
EXECUTE PLAN
412
RETURN QUERY RESULTS
414
UPDATE PLAN MIN/MAX/AVG
416
STORE NEW PLAN IN REPOSITORY

# ASSIGNING PLAN VOLATILITY SCORES TO CONTROL REOPTIMIZATION FREQUENCY AND NUMBER OF STORED REOPTIMIZATION PLANS

## BACKGROUND

**[0001]** 1. Technical Field

**[0002]** The field of the invention is data processing, or, more specifically, methods, apparatus, and products for monitoring and managing database queries for improving performance.

**[0003]** 2. Description of Related Art

**[0004]** The development of the EDVAC computer system of 1948 is often cited as the beginning of the computer era. Since that time, computer systems have evolved into extremely complicated devices. Today's computers are much more sophisticated than early systems such as the EDVAC. Computer systems typically include a combination of hardware and software components, application programs, operating systems, processors, buses, memory, input/output devices, and so on. As advances in semiconductor processing and computer architecture push the performance of the computer higher and higher, more sophisticated computer software has evolved to take advantage of the higher performance of the hardware, resulting in computer systems today that are much more powerful than just a few years ago.

**[0005]** Information stored on a computer system is often organized in a structure called a database. A database is a grouping of related structures called 'tables,' which in turn are organized in rows of individual data elements. The rows are often referred to as 'records,' and the individual data elements are referred to as 'fields.' In this specification generally, therefore, an aggregation of fields is referred to as a 'data structure' or a 'record,' and an aggregation of records is referred to as a 'table.' An aggregation of related tables is called a 'database.'

**[0006]** A computer system typically operates according to computer program instructions in computer programs. A computer program that supports access to information in a database is typically called a database management system or a 'DBMS.' A DBMS is responsible for helping other computer programs access, manipulate, and save information in a database.

**[0007]** A DBMS typically supports access and management tools to aid users, developers, and other programs in accessing information in a database. One such tool is the structured query language, 'SQL.' SQL is query language for requesting information from a database. Although there is a standard of the American National Standards Institute ('ANSI') for SQL, as a practical matter, most versions of SQL tend to include many extensions. Here is an example of a database query expressed in SQL:

**[0008]** select * from stores, transactions

**[0009]** where stores.location="Minnesota"

**[0010]** and stores.storeID=transactions.storeID

**[0011]** This SQL query accesses information in a database by selecting records from two tables of the database, one table named 'stores' and another table named 'transactions.' The records selected are those having value "Minnesota" in their store location fields and transactions for the stores in Minnesota. In retrieving the data for this SQL query, an SQL engine will first retrieve records from the stores table and then retrieve records from the transaction table. Records that satisfy the query requirements then are merged in a 'join.'

**[0012]** In many systems, the SQL queries are parsed, a logical plan created, and at least one, often multiple physical plans created for executing the logical plan to execute the SQL query. The multiple physical plans arrive at the same correct output, but can take greatly varying times to arrive at that output, depending on which plan is selected for execution. The best plan to execute is usually the plan having the lowest/cheapest expected cost, typically selected by the query optimizer.

**[0013]** In database query processing, the algorithms used by the query optimizer to implement the query are based on the 'best' plan that the optimizer selects using statistics over the underlying tables and columns. This is called the cost based model and is the defacto standard for databases.

**[0014]** One problem with this mechanism is that the chosen plan is selected based on the lowest expected cost. However, in practice, this selection process sometimes chooses a very inferior plan primarily because the available statistics fail to match reality during this execution. The resulting long running queries can be a major source of user frustration, troubleshooting, and support costs.

**[0015]** The problems of long running queries can be addressed by optimizing query plans and the problem of long running query optimizations can be addressed by storing optimized plans in a cache for re-use in the appropriate situations, should they arise again. Previously optimized plans can be re-optimized in an attempt to obtain better query processing times. However, this should not be done indiscriminately as this also uses resources. In addition, all previously optimized plans cannot be stored indiscriminately and forever, as this also requires the use of too many resources.

**[0016]** Improved methods for deciding how often to force re-optimization of a query and how many different plans to store for a query would be advantageous.

## SUMMARY

**[0017]** Methods, systems, and computer program products are provided for managing a database (DB) query system having a DB query plan repository, where the DB query plan repository can store more than one DB query plan for each DB query. One such method includes steps which, for each DB query plan for a DB query, determine a volatility score for the DB query plan, and for each DB query, determine a number of DB query plans to store for the DB query at least in part as a function of the DB query plan volatility score. In some embodiments, the DB query plan volatility score is determined at least in part as a function of a value contained in the DB query. The DB query plan volatility score may be determined at least in part as a function of a DB table statistic in some methods. The DB table statistic can be selected from at least one of the group of skew, cardinality, selectivity, clusteredness, and combinations thereof, depending on the embodiment.

**[0018]** In some embodiments, the DB query plan volatility score is determined at least in part as a function of actual run time data for the DB query plan. The actual run time data can be selected from at least one of minimum run time, maximum run time, and average run time. Some DB queries involve at least one index, in which the plan volatility score is determined at least in part as a function of the number of indices involved in the query. A DB query may involve at least one table, in which the plan volatility score is determined at least in part as a function of the number of tables involved in the query.

**[0019]** Some methods according to the present invention include displaying the plan volatility scores, and may include accepting user input to set a plan volatility score. In some methods, plan re-optimization is determined at least in part as a function of the plan volatility score and a threshold, where the threshold can be manipulated by the user. The number of plans stored can be determined at least in part by user input in some embodiments.

**[0020]** Some embodiments of the present invention assign a volatility score to each of the DB query plans. The volatility score can provide a numerical indication of how changes in the Host Variable Values (HVVs) affect the optimized plan. The volatility score can be used to determine how many individual plans should be stored for a given query in the plan cache. The volatility score can be used in conjunction with other plan scores to determine whether a plan should stay in a pseudo open mode or whether the plan should be re-optimized more frequently. In a pseudo-open mode the plan is essentially ready to run, and may have a cursor serving as an entry point into the query.

**[0021]** One practical application of the volatility score may be seen when working with commonly run customer queries over very large database (VLDB) queries. In one example, a very large join network with many tables having skewed data and correlated data is involved in the query. The best or "good enough" plan can be highly dependent upon the host variable values. Therefore, the volatility score along with another plan score can be used to urge more numerous optimized plans to be saved for the query.

**[0022]** In some embodiments, the SQL Query engine maintains a volatility score for every plan in the plan cache. The volatility score is externalized in some embodiments. Externalizing the score can allow users to force the optimizer to store more optimized plans for a given query. This can also be used to signal the optimizer to perform optimizations more often and/or to perform deeper optimizations, depending on the embodiment.

**[0023]** In one example of the invention, for each query, the optimizer determines the volatility of the underlying databases and the columns referenced. The volatility may be at least in part a function of factors such as data skew, correlation effect (e.g. month and month-name referenced in the same query), as well as how often the plan has been seen with differing host variable values. The volatility score may also take into account the maximum, minimum, and average execution time and/or the maximum, minimum, and average optimization time.

**[0024]** In some embodiments, when a query is in pseudo open mode, the optimizer can determine whether the host variable values have changed in such a way that would warrant a re-optimization or using a secondary plan stored in the plan repository. This determination can be based at least in part on the plan volatility score and/or database statistics, depending on the embodiment. When a query is not in pseudo open mode and is attempting to be matched to an existing plan, the optimizer may use the volatility score along with another plan score and the host variable values (and sub-combinations thereof) to determine whether another version of the optimized plan should be maintained.

**[0025]** Some embodiments of the present invention also include a system for processing database queries, the system including a computer processor and a computer memory operatively coupled to the computer processor. The computer memory can have disposed within it computer program instructions capable of executing the various methods described in the present application. Also provided is a computer program product for processing database queries, the computer program product disposed in a computer readable signal bearing medium. The computer program product includes computer program instructions capable of executing the various methods described in the present application.

**[0026]** The foregoing and other features and aspects of the invention will be apparent from the following more particular descriptions of exemplary embodiments of the invention as illustrated in the accompanying drawings, wherein like reference numbers generally represent like parts of exemplary embodiments of the invention.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0027]** FIG. **1** is a network diagram of a system for processing database queries according to embodiments of the present invention.

**[0028]** FIG. **2** is a block diagram of an exemplary system for processing database queries in accordance with the present invention according to embodiments of the present invention.

**[0029]** FIG. **3** is a block diagram of automated computing machinery comprising a computer useful in processing database queries in accordance with the present invention.

**[0030]** FIG. **4** is a high level flow chart of a method for processing database queries.

**[0031]** FIG. **5** is a more detailed view of the method of FIG. **4**, showing the results of SQL handling when multiple plans may be generated but not necessarily including plan storage.

**[0032]** FIG. **6** is a high level flow chart of a method according to some embodiments of the invention.

## DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

**[0033]** FIG. **1** depicts an exemplary data processing system capable of processing database queries for query processing according to embodiments of the present invention. The system of FIG. **1** includes a number of computers connected for data communications in networks. Each of the computers of the system of FIG. **1** may have installed upon it a database management system capable of processing database queries in accordance with the present invention. The data processing system of FIG. **1** includes wide area network ("WAN") **101**. The network connection aspect of the architecture of FIG. **1** is only for explanation, not for limitation. In fact, systems for processing database queries according to embodiments of the present invention may be connected as LANs, WANs, intranets, internets, the Internet, webs, the World Wide Web itself, or other connections as will occur to those of skill in the art. Such networks are media that may be used to provide data communications connections between various devices and computers connected together within an overall data processing system.

**[0034]** In the example of FIG. **1**, several exemplary devices including a PDA **112**, a computer workstation **104**, a mobile phone **110**, personal computer **102**, a laptop **126**, a server **106**, and another personal computer **108** are connected to WAN **101**. The network-enabled mobile phone **110** connects to WAN **101** through wireless link **116**, the PDA **112** connects to network **101** through wireless link **114** and the laptop **126** connects to the network **101** through a wireless link **118**. In the example of FIG. **1**, the personal computer **108** connects

through a wireline connection **120** to WAN **101**, the computer workstation **104** connects through a wireline connection **122** to WAN **101**, the personal computer **108** connects through a wireline connection **124** to WAN **101**, and the server **106** connects through a wireline connection **119** to WAN **101**. In the system of FIG. **1**, exemplary devices **120**, **108**, **112**, **104**, **106**, **110**, **126**, and **102** support a database management system capable of processing database queries and interacting with a user **100**.

**[0035]** The arrangement of servers and other devices making up the exemplary system illustrated in FIG. **1** are for explanation, not for limitation. Data processing systems useful according to various embodiments of the present invention may include additional servers, routers, other devices, and peer-to-peer architectures, not shown in FIG. **1**, as will occur to those of skill in the art. Networks in such data processing systems may support many data communications protocols, including for example TCP (Transmission Control Protocol), IP (Internet Protocol), HTTP (HyperText Transfer Protocol), WAP (Wireless Access Protocol), HDTP (Handheld Device Transport Protocol), and others as will occur to those of skill in the art. Various embodiments of the present invention may be implemented on a variety of hardware platforms in addition to those illustrated in FIG. **1**

**[0036]** FIG. **2** is a block diagram of an exemplary system for processing database queries in accordance with the present invention according to embodiments of the present invention. The system of FIG. **2** includes a computer **212** having installed upon it a database management system ('DBMS') **250**. DBMS **250** administers access to the contents of the database **262**. The DBMS **250** includes an SQL module **260**. The SQL module is implemented as computer program instructions that execute a SQL query **302**.

**[0037]** The exemplary SQL module **260** of FIG. **2** also includes an exemplary plan generator **256**. Each SQL query is carried out by a sequence of database operations specified as a plan. The plan generator of FIG. **2** is implemented as computer program instructions that create a plan for a SQL query. A plan is a description of database functions for execution of an SQL query. Taking the following SQL query as an example:

**[0038]** select * from stores, transactions

**[0039]** where stores.storeID=transactions.storeID,

plan generator **256** may generate the following exemplary plan for this SQL query:

**[0040]** tablescan stores

**[0041]** join to

**[0042]** index access of transactions

**[0043]** This plan represents database functions to scan through the stores table and, for each stores record, join all transactions records for the store. The transactions for a store are identified through the storeID field acting as a foreign key. The fact that a selection of transactions records is carried out for each store record in the stores table identifies the join function as iterative.

**[0044]** The exemplary plan generator **256** of FIG. **2** includes a parser **252** for parsing the SQL query. Parser **252** is implemented as computer program instructions that parse the SQL query. A SQL query is presented to SQL module **260** in text form, the parameters of an SQL command. Parser **252** retrieves the elements of the SQL query from the text form of the query and places them in a data structure more useful for data processing of an SQL query by an SQL module.

**[0045]** The exemplary plan generator **256** also includes an optimizer **254** implemented as computer program instructions that optimize the plan in dependence upon database management statistics **264**. Optimizer **254** optimizes the execution of SQL queries against DBMS **250**. Optimizer **254** is implemented as computer program instructions that optimize execution of a SQL query in dependence upon database management statistics **264**. Database statistics are typically implemented as metadata of a table, such as, for example, metadata of tables of database **262** or metadata of database indexes. Database statistics may include, for example:

**[0046]** histogram statistics: a histogram range and a count of values in the range,

**[0047]** frequency statistics: a frequency of occurrence of a value in a column, and

**[0048]** cardinality statistics: a count of the number of different values in a column.

**[0049]** These three database statistics are presented for explanation only, not for limitation. Such database statistics can be used together with the values in a particular query to decide which physical plan to use and whether a new plan should be generated.

**[0050]** The exemplary SQL module **260** of FIG. **2** also includes a primitives engine **258** implemented as computer program instructions that execute primitive query functions in dependence upon the plan. A 'primitive query function,' or simply a 'primitive,' is a software function that carries out actual operations on a database, retrieving records from tables, inserting records into tables, deleting records from tables, updating records in tables, and so on. Primitives correspond to parts of a plan and are identified in the plan. Examples of primitives include the following database instructions:

**[0051]** retrieve the next three records from the stores table into hash table H1

**[0052]** retrieve one record from the transactions table into hash table H2

**[0053]** join the results of the previous two operations

**[0054]** store the result of the join in table T1

**[0055]** The SQL module **260** of FIG. **2** also includes an adaptive query processing module **150**. The adaptive query processing module **150** of FIG. **2** is capable of processing database queries according to the present invention. The adaptive query processing module **150** includes computer program instructions capable of identifying poorly performing queries; substituting an alternate plan to execute the query; and executing the query using the alternate plan.

**[0056]** FIG. **3** is a block diagram of automated computing machinery comprising a computer **152** useful in processing database queries in accordance with the present invention according to embodiments of the present invention. The computer **152** of FIG. **3** includes at least one computer processor **156** or 'CPU' as well as random access memory **168** ("RAM"). Stored in RAM **168** is database management system **250**. The database management system **250** of FIG. **3** includes an SQL module **260**, which in turn includes a plan generator **256** and a primitives engine **258**.

**[0057]** The SQL module **260** of FIG. **3** also includes an adaptive query processing module **150**. The adaptive query processing module **150** was described with respect to FIG. **2**. Also stored in RAM **168** is an application **232**, a computer program that uses the DBMS **250** to access data stored in a database. Also stored in RAM **168** is an operating system **154**. Operating systems useful in computers according to embodi-

ments of the present invention include Unix, Linux, Microsoft NT$_{TM}$, i5OS, and many others as will occur to those of skill in the art. Operating system **154**, DBMS **250**, and application **154** in the example of FIG. **3** are shown in RAM **168**, but many components of such software typically are stored in non-volatile memory **166** also.

**[0058]** The computer **152** of FIG. **3** includes non-volatile computer memory **166** coupled through a system bus **160** to processor **156** and to other components of the computer. Non-volatile computer memory **166** may be implemented as a hard disk drive **170**, optical disk drive **172**, electrically erasable programmable read-only memory space (so-called 'EEPROM' or 'Flash' memory) **174**, RAM drives (not shown), or as any other kind of computer memory as will occur to those of skill in the art.

**[0059]** The exemplary computer **152** of FIG. **3** includes a communications adapter **167** for implementing connections for data communications **184**, including connections through networks, to other computers **182**, including servers, clients, and others as will occur to those of skill in the art. Communications adapters implement the hardware level of connections for data communications through which local devices and remote devices or servers send data communications directly to one another and through networks. Examples of communications adapters useful according to embodiments of the present invention include modems for wired dial-up connections, Ethernet (IEEE 802.3) adapters for wired LAN connections, and 802.11b adapters for wireless LAN connections.

**[0060]** The example computer of FIG. **3** includes one or more input/output interface adapters **178**. Input/output interface adapters in computers implement user-oriented input/output through, for example, software drivers and computer hardware for controlling output to display devices **180** such as computer display screens, as well as user input from user input devices **181** such as keyboards and mice.

**[0061]** FIG. **4** illustrates a method **300** for processing an SQL query. A query **302**, for example an SQL query, is received. The query can be compiled as indicated **304**, and executed at **306**. Query execution **306** can both write data to data store **308** and read data from data store **308**, as indicated at **310**.

**[0062]** FIG. **5** is a more detailed view of method **300** of FIG. **4**. Method **300** can include query **302** being parsed in parse query step **312** and a logical query plan generated in step **314**. The results of the logical query plan can be used to generate multiple, logically equivalent physical query plans in step **316**. One of the logical query plans, likely the lowest cost plan, can be selected for execution in step **318**. The selected physical plan can be executed in step **320** and the results of the query returned to the application in step **322**.

**[0063]** FIG. **6** illustrates a method **400** including one embodiment of the invention. Method **400** receives a database query at **402** and parses and processes the query in part, as previously described. In step **404** a decision is made as to whether or not to generate another plan for this query. This decision is part of some embodiments of the present invention, as described further below. Existing plans in the repository (if any) can have volatility scores associated with the plans. The volatility scores can be generated both as a function of the stored plan attributes and as a function of the variables contained in the query, also referred to as the host variable values (HVVs). The HVVs can be numbers, literals, or strings being searched for.

**[0064]** If no new plan is generated in light of the past run time history, the database statistics, or the HVV, then the risk is taken that the plan executed may take much longer to run than expected, for example, 5 minutes instead of 5 seconds. If a new plan is generated every time a query is received, then the cached plans are of little use and the time required to generate the new plans will itself slow down the query processing. Some embodiments provide ways to improve decision making as to whether or not a new plan should be generated.

**[0065]** Volatility scores can be stored which reflect the minimum, maximum, and average run times of previous executions of each plan in the plan cache. When a plan is found in the cache that is otherwise suitable for the query, the past run time data can provide a gauge of the volatility of the plan. For example, a min, max, and average run time which are close in range to each other would indicate a low degree of volatility or low volatility score, as would a max and average run time close to each other.

**[0066]** The database statistics can also be used to generate a volatility score. If the query operates on a certain column, then statistics for that column can be used to generate a volatility score the plan for the HVV being selected for in that column. In one example, if the HVV is found infrequently in the column, then a plan using an index may be beneficial. If the HVV is found frequently in the column, then a full table scan may be beneficial. In another example, if the table column is highly skewed, then the query plan execution is likely to be more volatile, and a plan utilizing an index may be called for. In some embodiments, the clusteredness may be used to affect the volatility score. Clustered data may be clustered together rather than evenly or randomly distributed. Clustered data may suggest a plan using an index and may increase volatility as the execution time may be more dependent on the HVV.

**[0067]** In some embodiments, the plan volatility is compared to a threshold acceptable volatility and a plan generated if the existing plan is more volatility than the threshold. In one example, different thresholds are associated with different query types, with some query types having a low threshold, and a low toleration for plan volatility. Some embodiments allow display of plan volatility to users and also allow user manipulation of plan volatility scores and/or acceptable volatility thresholds.

**[0068]** Some embodiments of the invention provide different plans for queries which differ only in one or more HVVs. Highly volatile plans may be highly variable in run time as a function of the HVV, which may call for different plans for different HVVs.

**[0069]** Step **404** can also be used to validate the existing plans, for example, to make sure that any indices relied on for the plan still exist. If the existing plan is invalid, then a new plan may be generated.

**[0070]** If an existing plan is acceptable, it can be selected in step **406**. If not, a new plan can be generated in step **408**. In step **410**, the plan can be executed, with the query results returned to the user in step **412**.

**[0071]** In step **414**, the run time of this execution of the plan can be used to update the historical data for the executed plan, for example the minimum, maximum, and average run time. This data can also be used to update the volatility score for this plan.

**[0072]** In step **416**, the plan can be stored in the plan repository if new, or the existing plan historical and volatility

attributes updated. In some embodiments, the decision as to whether to store a new plan or even prune an existing plan can be made in step **416**. Some embodiments have a limit on the number of plans to store for a query and a limit may be reached at this point, with the newest plan either not stored or an older plan purged to make room. The plan volatility scores can be used to determine how many plans to store, with high volatility scores suggesting a larger number of otherwise similar plans being stored for the same query. In some embodiments the size of the plan repository can be determined on the fly, in a step similar to step. In other embodiments, such decisions can be made asynchronously, by jobs running in the background.

**[0073]** Exemplary embodiments of the present invention are described largely in the context of a fully functional computer system for processing database queries. Readers of skill in the art will recognize, however, that the present invention also may be embodied in a computer program product disposed on signal bearing media for use with any suitable data processing system. Such signal bearing media may be transmission media or recordable media for machine-readable information, including magnetic media, optical media, or other suitable media. Examples of recordable media include magnetic disks in hard drives or diskettes, compact disks for optical drives, magnetic tape, and others as will occur to those of skill in the art. Examples of transmission media include telephone networks for voice communications and digital data communications networks such as, for example, Ethernets™ and networks that communicate with the Internet Protocol and the World Wide Web as well as wireless transmission media such as, for example, networks implemented according to the IEEE 802.11 family of specifications. Persons skilled in the art will immediately recognize that any computer system having suitable programming means will be capable of executing the steps of the method of the invention as embodied in a program product. Persons skilled in the art will recognize immediately that, although some of the exemplary embodiments described in this specification are oriented to software installed and executing on computer hardware, nevertheless, alternative embodiments implemented as firmware or as hardware are well within the scope of the present invention.

**[0074]** It will be understood from the foregoing description that modifications and changes may be made in various embodiments of the present invention without departing from its true spirit. The descriptions in this specification are for purposes of illustration only and are not to be construed in a limiting sense. The scope of the present invention is limited only by the language of the following claims.

What is claimed is:

**1**. A method for managing a database (DB) query system having a DB query plan repository, where the DB query plan repository can store more than one DB query plan for each DB query, the method comprising:

for each DB query plan for a DB query, determine a volatility score for the DB query plan; and

for each DB query, determine a number of DB query plans to store for the DB query at least in part as a function of the DB query plan volatility score.

**2**. The method of claim **1**, in which the DB query plan volatility score is determined at least in part as a function of a value contained in the DB query.

**3**. The method of claim **2**, in which the DB query plan volatility score is determined at least in part as a function of a DB table statistic.

**4**. The method of claim **3**, in which the DB table statistic is selected from at least one of the group of DB table statistics consisting of skew, cardinality, selectivity, clusteredness, and combinations thereof.

**5**. The method of claim **2**, in which the DB query plan volatility score is determined at least in part as a function of actual run time data for the DB query plan.

**6**. The method of claim **5**, in which the actual run time data is selected from at least one of the group consisting of minimum run time, maximum run time, and average run time.

**7**. The method of claim **2**, in which the DB query involves at least one index, in which the plan volatility score is determined at least in part as a function of the number of indices involved in the query.

**8**. The method of claim **2**, in which the DB query involves at least one table, in which the plan volatility score is determined at least in part as a function of the number of tables involved in the query.

**9**. The method of claim **1**, further comprising displaying the plan volatility scores.

**10**. The method of claim **1**, further comprising re-optimizing or generating a new DB query plan at least in part as a function of the volatility score.

**11**. The method of claim **10**, further comprising accepting user input to set a plan volatility score.

**12**. The method of claim **10** in which the re-optimization is determined at least in part as a function of the plan volatility score and a threshold in which the threshold can be manipulated by the user.

**13**. The method of claim **1** in which the number of plans stored is determined at least in part by user input.

**14**. A system for managing database (DB) queries, the DB system having a DB query plan repository, where the DB query plan repository can store more than one DB query plan for each DB query, the system comprising a computer processor, a computer memory operatively coupled to the computer processor, the computer memory having disposed within it computer program instructions capable of executing a method comprising:

for each DB query plan for a DB query, determine a volatility score for the DB query plan; and

for each DB query, determine a number of DB query plans to store for the DB query at least in part as a function of the DB query plan volatility score.

**15**. The system of claim **14** wherein the computer program instructions further comprise computer program instructions capable of:

determining the DB query plan volatility score at least in part as a function of a value contained in the DB query.

**16**. The system of claim **14** wherein the computer program instructions further comprise computer program instructions capable of:

determining the DB query plan volatility score at least in part as a function of a DB table statistic, in which the DB table statistic is selected from at least one of the group of DB table statistics consisting of skew, cardinality, selectivity, clusteredness, and combinations thereof.

**17**. A computer program product for managing a database (DB) query system having a DB query plan repository, where

the DB query plan repository can store more than one DB query plan for each DB query, the computer program product disposed in a computer readable signal bearing medium, the computer program product comprising computer program instructions capable of executing a method comprising:

for each DB query plan for a DB query, determine a volatility score for the DB query plan; and

for each DB query, determine a number of DB query plans to store for the DB query at least in part as a function of the DB query plan volatility score.

**18**. The computer program product of claim **17** wherein the computer program instructions further comprise computer program instructions capable of:

determining the DB query plan volatility score at least in part as a function of a value contained in the DB query.

**19**. The computer program product of claim **17** wherein the computer program instructions further comprise computer program instructions capable of:

re-optimizing or generating a new DB query plan at least in part as a function of the volatility score.

**20**. The computer program product of claim **17** wherein the computer program instructions further comprise computer program instructions capable of:

determining the DB query plan volatility score at least in part as a function of actual run time data for the DB query plan, and in which the actual run time data is selected from at least one of the group consisting of minimum run time, maximum run time, and average run time.

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