US 20040103084A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2004/0103084 A1

Megerian (43) Pub. Date: May 27, 2004

(54) DATA MANAGEMENT SYSTEM THAT PROVIDES FLEXIBLE TIME-BASED QUERY CAPABILITY

(75) Inventor: **Mark Gregory Megerian**, Rochester, MN (US)

Correspondence Address:
IBM CORPORATION
ROCHESTER IP LAW DEPT. 917
3605 HIGHWAY 52 NORTH
ROCHESTER, MN 55901-7829 (US)

(73) Assignee: **International Business Machines Corporation**, Armonk, NY

(21) Appl. No.: **10/301,128**

(22) Filed: **Nov. 21, 2002**

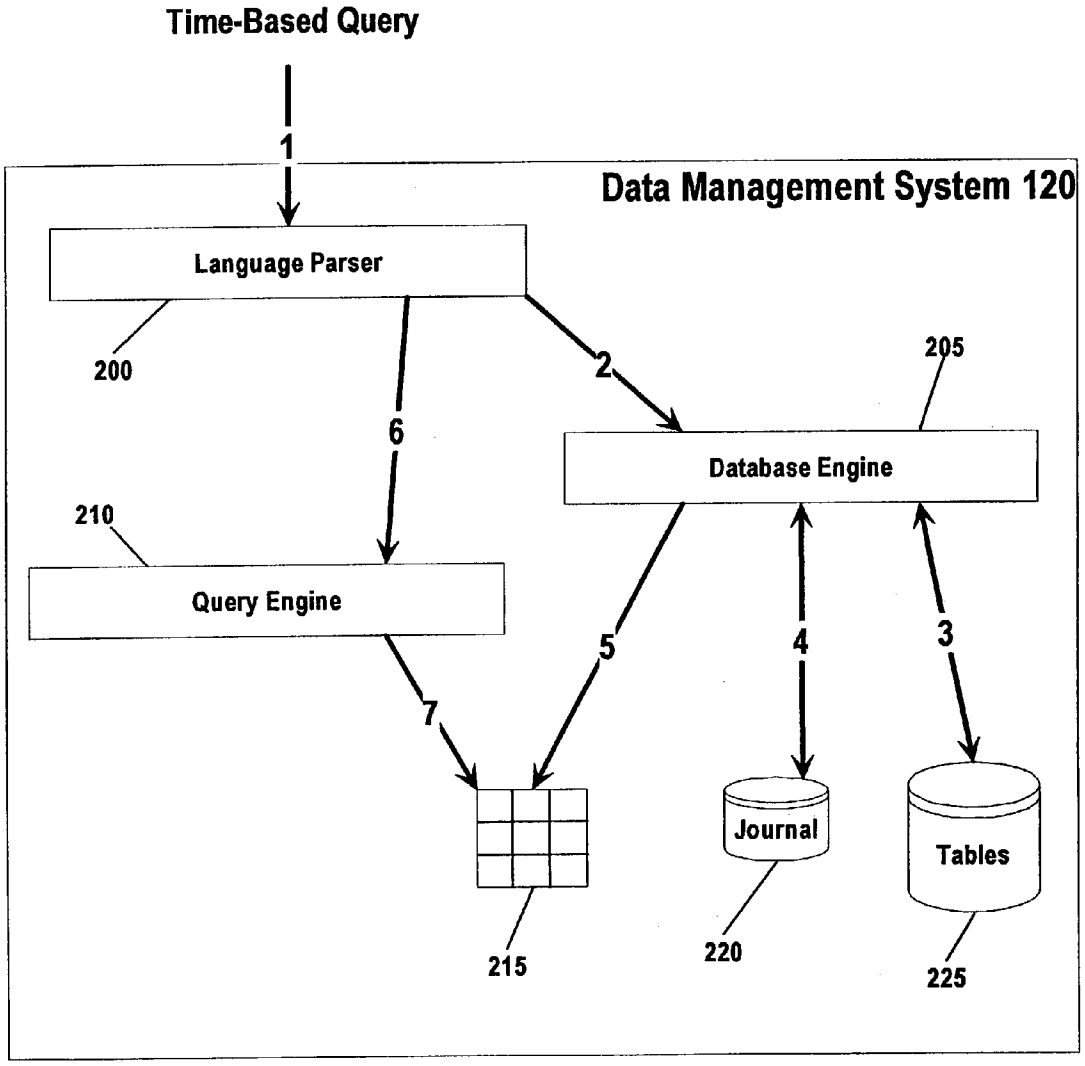
Publication Classification

(51) **Int. Cl.**[7] **G06F 17/30**

(52) **U.S. Cl.** **707/3**

(57) **ABSTRACT**

Disclosed is an apparatus, method, and program product for performing time-based queries using an enhanced conventional (called Unitemporal herein) Data Management System (DMS). A user is able to specify a date and time of day as part of a query, and the disclosed DMS will query stored data and return query results that reflect the data as it appeared on the date and at the time specified in the query. The time-based query capability is accomplished by using database journal information to reconstruct the data as of the specified effective time.



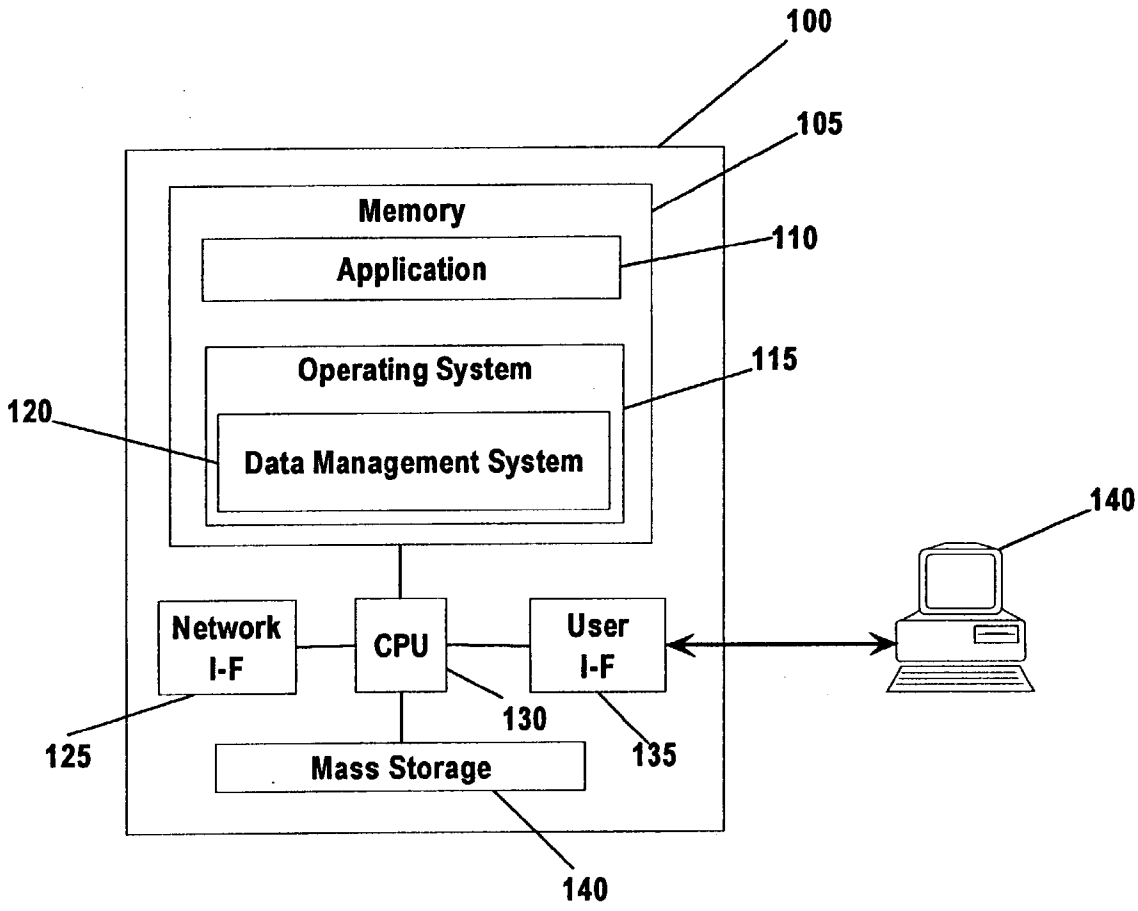

100
105
Memory
Application
110
Operating System
115
120
Data Management System
140
Network I-F
CPU
User I-F
130
125
135
Mass Storage
140

Figure 1

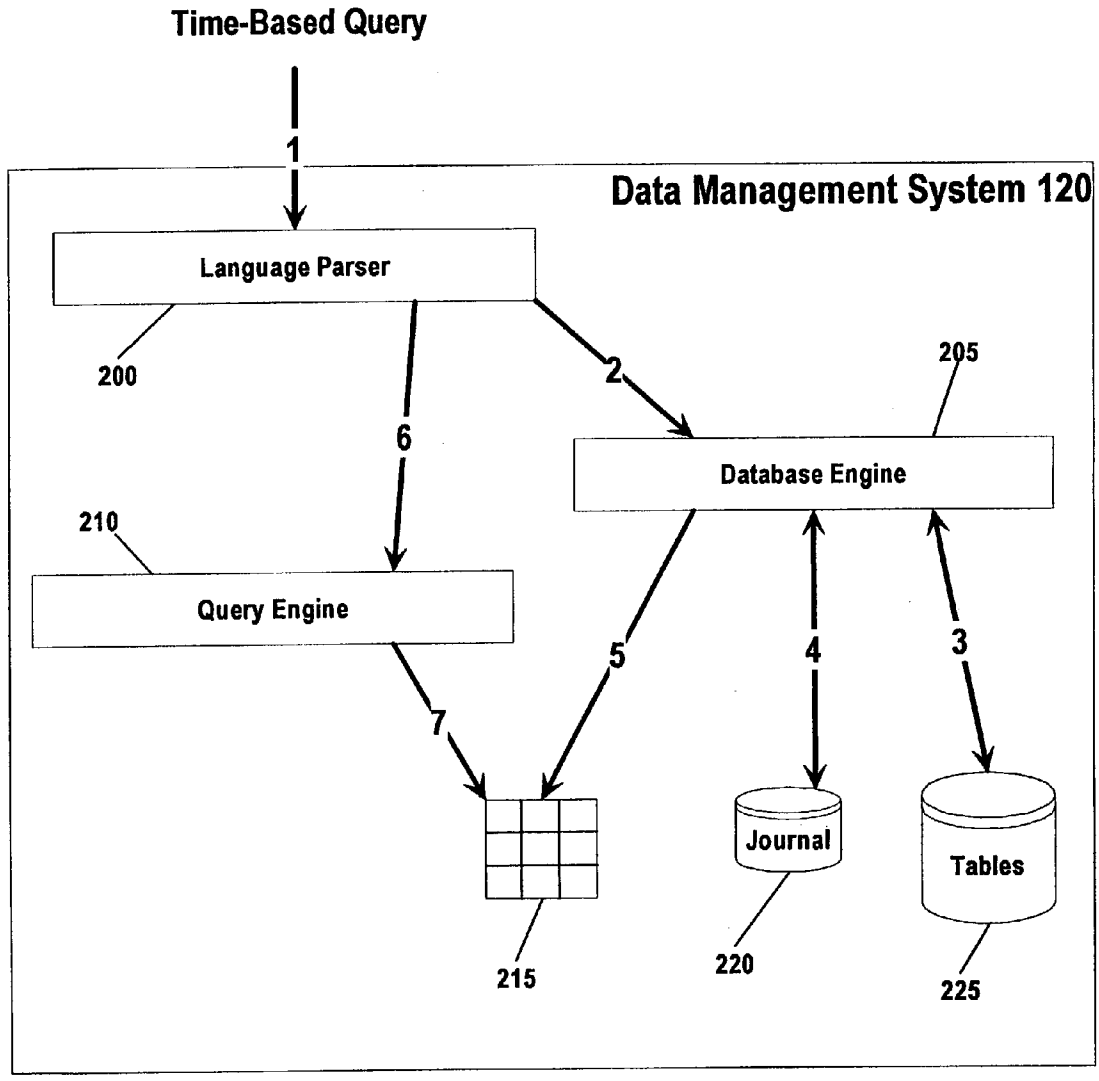

Time-Based Query
1
Data Management System 120
Language Parser
200
2
205
6
Database Engine
210
Query Engine
5
4
3
7
Journal
Tables
215
220
225

Figure 2

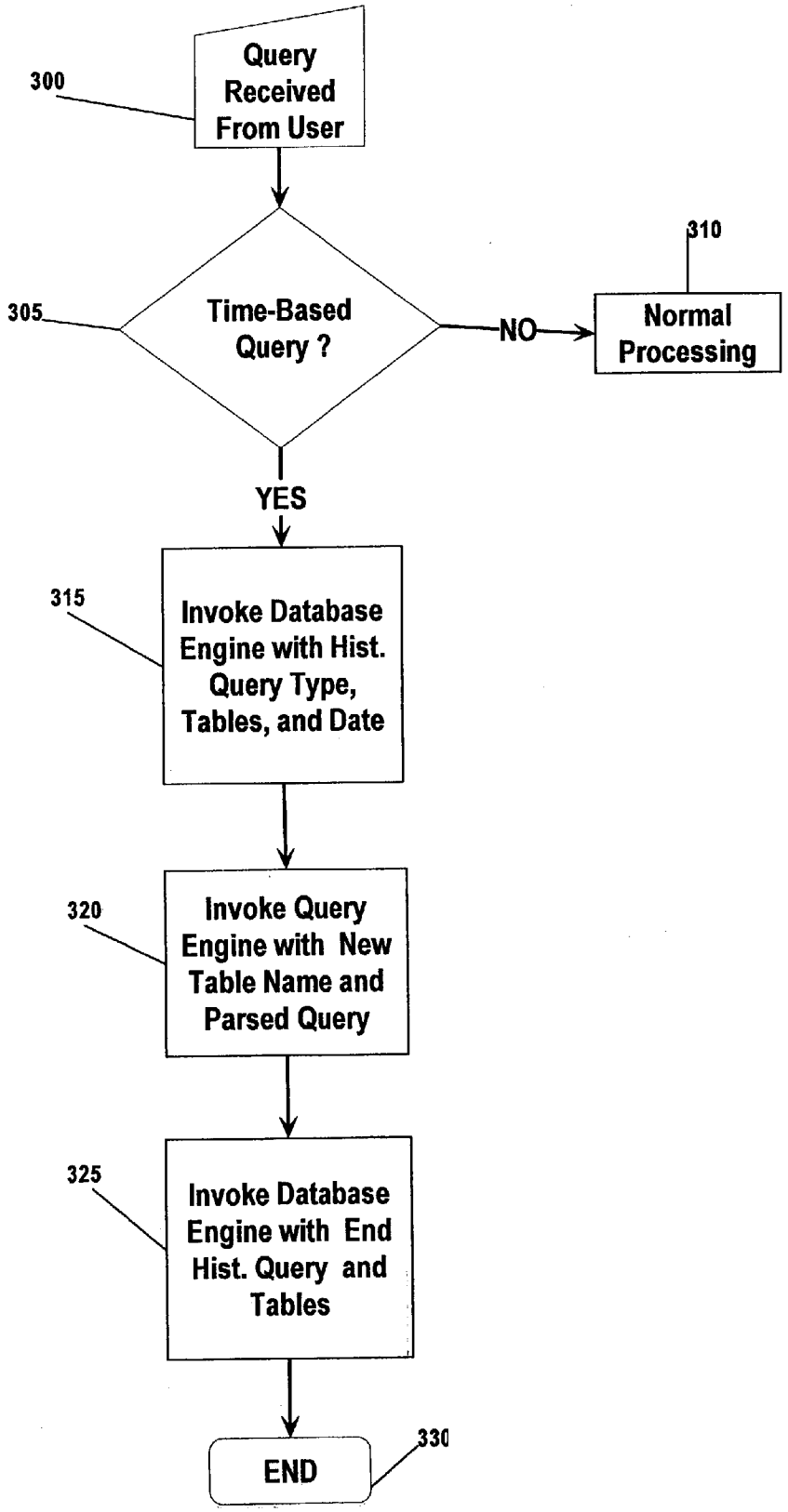

Query Received From User
300
Time-Based Query ?
305
NO
Normal Processing
310
YES
Invoke Database Engine with Hist. Query Type, Tables, and Date
315
Invoke Query Engine with New Table Name and Parsed Query
320
Invoke Database Engine with End Hist. Query and Tables
325
END
330

Figure 3

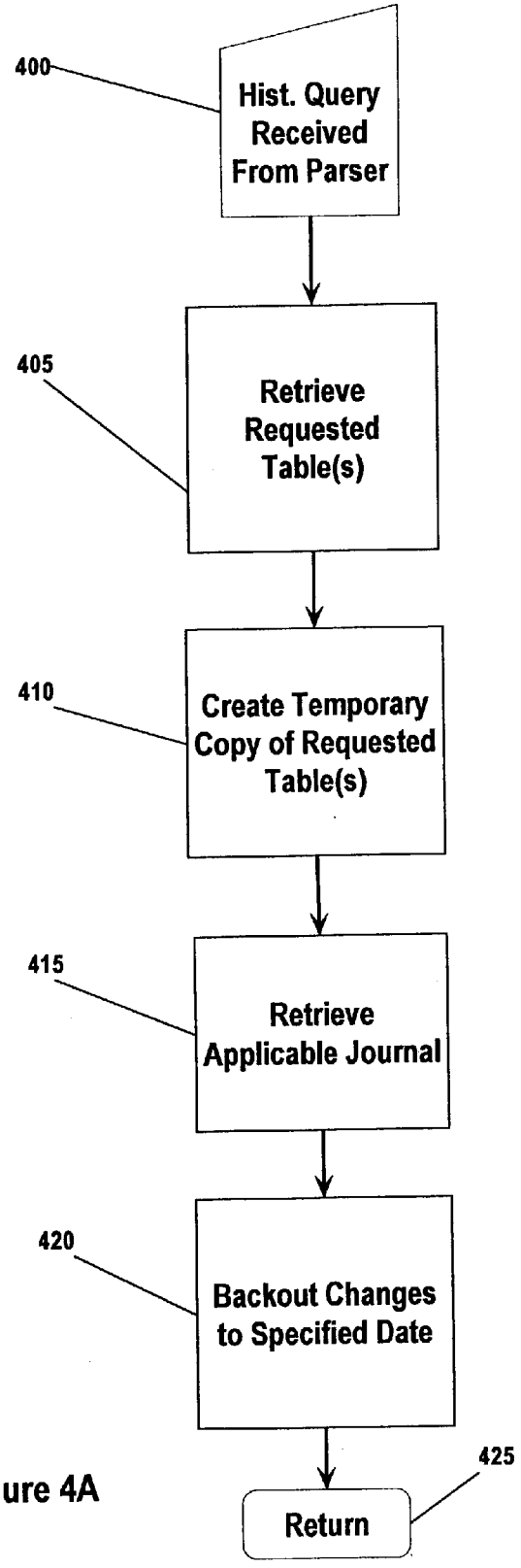


Figure 4A

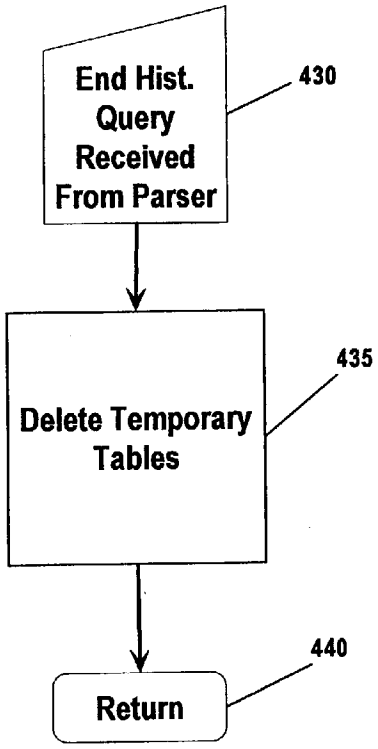


Figure 4B

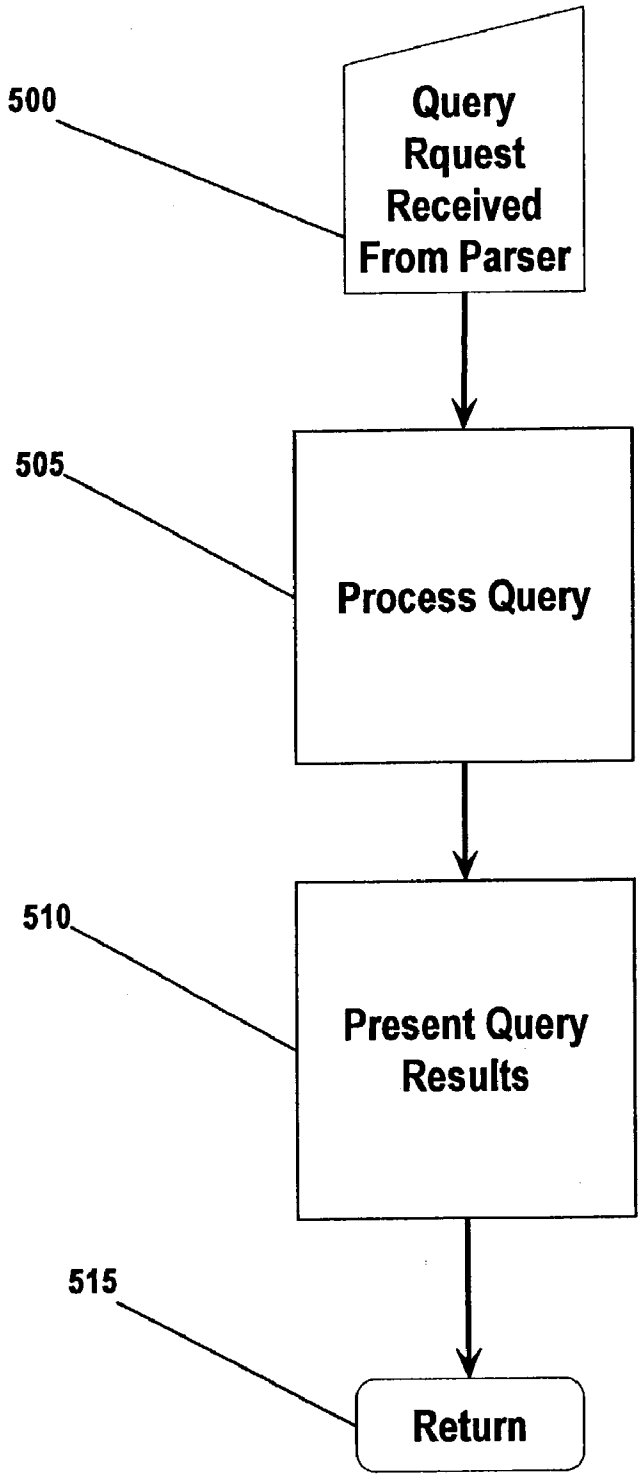

500
Query Rquest Received From Parser
505
Process Query
510
Present Query Results
515
Return

Figure 5

April 25, 2000

Row #	Player Name	Player Team	Goals	Assists	Penalty Mins.	Salary
1	T. Smith	Eagles	10	16	35	.4M
2	S. Jones	Wolves	5	12	120	.4M

Figure 6A

August 1, 2000

Row #	Player Name	Player Team	Goals	Assists	Penalty Mins.	Salary
1	T. Smith	Scorpions	13	20	37	.7M
2	S. Jones	Cougars	3	8	108	.66M
3	L. Nelson	Wolves	67	33	32	1.4M
4	F. Larson	Thunder	15	22	21	.5M

Figure 6B

Current

Row #	Player Name	Player Team	Goals	Assists	Penalty Mins.	Salary
1	T. Smith	Scorpions	17	20	24	.9M
2	S. Jones	Cougars	2	7	108	.66M
3	L. Nelson	Wolves	56	20	32	3.4M
4	F. Larson	Thunder	12	25	27	.75M
5	K. Johnson	Eagles	0	9	78	.8M
6	J. Lundy	Titans	22	28	46	1.5M
7	R. Sims	Wolves	9	14	96	.25M

Figure 6C

Operation	Date	Time	Column	Old Value	New Value	Row #
Insert Row	04/15/2000	08:08:15	Player Name		T. Smith	
Update Row	04/15/2000	08:08:17	Player Team		Eagles	1
Update Row	04/15/2000	08:08:17	Goals		10	1
Update Row	04/15/2000	08:08:17	Assists		16	1
Update Row	04/15/2000	08:08:17	Penalty Mins.		35	1
Update Row	04/15/2000	08:08:17	Salary		.4M	1
Insert Row	04/15/2000	09:03:12	Player Name		S. Jones	
Update Row	04/15/2000	09:03:14	Player Team		Wolves	2
Update Row	04/15/2000	09:03:14	Goals		5	2
Update Row	04/15/2000	09:03:14	Assists		12	2
Update Row	04/15/2000	09:03:14	Penalty Mins.		120	2
Update Row	04/15/2000	09:03:14	Salary		.4M	2
Update Row	05/03/2000	08:17:13	Salary	.4M	.7M	1
Update Row	05/03/2000	18:07:17	Salary	.4M	.66M	2
Insert Row	06/27/2000	15:07:15	Player Name		L. Nelson	
Update Row	06/27/2000	15:07:17	Player Team		Wolves	3
Update Row	06/27/2000	15:07:17	Goals		67	3
Update Row	06/27/2000	15:07:17	Assists		33	3
Update Row	06/27/2000	15:07:17	Penalty Mins.		32	3
Update Row	06/27/2000	15:07:17	Salary		1.4M	3
Insert Row	07/07/2000	10:05:00	Player Name		F. Larson	
Update Row	07/07/2000	10:05:02	Player Team		Thunder	4
Update Row	07/07/2000	10:05:02	Goals		15	4
Update Row	07/07/2000	10:05:02	Assists		22	4
Update Row	07/07/2000	10:05:02	Penalty Mins.		21	4
Update Row	07/07/2000	10:05:02	Salary		.5M	4
Update Row	06/03/2001	08:17:13	Salary	.7M	.9M	1
Update Row	06/05/2001	18:07:17	Salary	1.4M	3.4M	3
Update Row	06/06/2001	18:15:22	Salary	.5M	.75M	4
Insert Row	06/07/2001	16:07:15	Player Name		K. Johnson	
Update Row	06/07/2001	16:07:17	Player Team		Eagles	5
Update Row	06/07/2001	16:07:17	Goals		0	5
Update Row	06/07/2001	16:07:17	Assists		9	5
Update Row	06/07/2001	16:07:17	Penalty Mins.		78	5
Update Row	06/07/2001	16:07:17	Salary		.8M	5
Insert Row	06/23/2001	10:05:00	Player Name		J. Lundy	
Update Row	06/23/2001	10:05:02	Player Team		Titans	6
Update Row	06/23/2001	10:05:02	Goals		22	6
Update Row	06/23/2001	10:05:02	Assists		28	6
Update Row	06/23/2001	10:05:02	Penalty Mins.		46	6
Update Row	06/23/2001	10:05:02	Salary		1.5M	6
Insert Row	07/17/2001	10:05:00	Player Name		R. Sims	
Update Row	07/17/2001	10:05:02	Player Team		Wolves	7
Update Row	07/17/2001	10:05:02	Goals		9	7
Update Row	07/17/2001	10:05:02	Assists		14	7
Update Row	07/17/2001	10:05:02	Penalty Mins.		96	7
Update Row	07/17/2001	10:05:02	Salary		.25M	7

700

Figure 7

DATA MANAGEMENT SYSTEM THAT PROVIDES FLEXIBLE TIME-BASED QUERY CAPABILITY

FIELD OF THE INVENTION

[0001] The present invention relates to Data Management Systems, and in particular, to time-based queries.

BACKGROUND OF THE INVENTION

[0002] Fundamentally speaking, today's computer systems are primarily used for storage, manipulation, and analysis of information. This information, called data, can be anything from complicated financial information to simple baking recipes. It is no surprise, then, that the overall value, or worth, of a computer system depends largely upon how well the computer system stores, manipulates, and analyzes data. This patent pertains to the mechanism used on a computer system to perform these functions. The phrase Data Management System is used herein to refer to this mechanism, although other terms like "database system," or just "database," also apply.

[0003] Data Management Systems (DMS), like many other computer programs, come in various "sizes and flavors." For the purposes of this patent, however, Data Management Systems can be roughly placed into two basic categories: 1) a Conventional (sometimes called Snapshot) DMS, or 2) a Bitemporal DMS. Because it is important in the context of this patent to focus on the temporal characteristics of these two types of data management systems, a conventional DMS is referred to herein as a Unitemporal DMS. As one might guess, a Unitemporal DMS is based upon a single point in time; whereas, a Bitemporal DMS is based upon two points in time.

[0004] A Unitemporal DMS is by far the predominant type of database used in the computer industry today. A key drawback to the Unitemporal DMS approach, however, is its limited recognition of time. In the "eyes" of a Unitemporal DMS there is only one time, and that is the current time. Data can be viewed at any given time, but without explicit steps by the user, the data is subject to change as time moves forward. For example, if a user looks at a particular data item on a Monday, that same data item may be changed or even deleted by Tuesday. Now, it is true the data can be preserved by explicitly saving Monday's data (i.e., a "snapshot" of the data can be taken by the user or a Database Administrator). However, someone must know ahead of time that the data (in Monday's form) will/may be needed at a later time. Otherwise, the user is simply out of luck if the user decides Tuesday that he or she wants Monday's data, and the data was somehow altered in the mean time. It should also be noted that it is virtually impossible to predict what the future may bring in terms of what past view of the data may be needed. So, while snapshots are helpful, they represent only a limited solution.

[0005] A more comprehensive solution to the problem of time-based queries comes in the form of a Bitemporal DMS. Again, as its name suggests, a Bitemporal DMS is specifically designed to operate with two points of time, the current time, like a conventional DMS, and a user specified time. Thus, the user can specifically request to view data in a past form. The problem with this approach, though, is the overhead associated with storing all of this old data. To accomplish this flexibility, it is necessary for the Bitemporal DMS to store and timestamp old versions of the data. It is true that Bitemporal systems can be tuned to track only certain changes, which reduces overhead to some extent. However, this tuning results in a tradeoff between efficiency and flexibility, which means that time-based queries cannot be performed on every data item. It should also be noted that the optimizations in place to provide for time-based queries amount to overhead regardless of whether a time-based query is actually performed. Said another way, the user is exposed to the performance costs associated with the time-based query capability even if the user is not actually performing a time-based query. Because of these drawbacks, Bitemporal systems have yet to gain widespread acceptance within the general computer industry, and are thus mostly relegated to academic pursuits.

[0006] Without a Data Management System that can provide time-based query capability without the overhead associated with Bitemporal Data Management Systems, the industry will continue to be faced with the unpleasant choice between inflexible Unitemporal Data Management Systems and inefficient Bitemporal Data Management Systems.

SUMMARY OF THE INVENTION

[0007] The present invention involves an apparatus, method, and program product for performing time-based queries using a Unitemporal Data Management System. A user is able to specify temporal information as part of a query, and the DMS of the present invention will query stored data and return the results of the query. The returned results are time-specific in that they represent the results that would have been obtained had the query been performed at the time specified in the supplied temporal information.

[0008] The DMS of the preferred embodiment of the present invention performs time-based queries by using database journal information to reconstruct the data so that the results are time-specific according to the supplied temporal information.

[0009] Certain terms and phrases are defined as follows.

Term/Phrase	Definition
Unitemporal Data Management System	A Unitemporal DMS is one that when queried considers only the current time.
Time-Specific Representation	A representation of data values and/or meta data at a specified time.
Past Time-Specific Representation	A representation of data values and/or meta data at a specified time in the past.
Current Time-Specific Representation	A current representation of data values and/or meta data.
Temporal Information	Information that can be used to specify time, time of day or a date for example.
Time-Based Query	A query that specifies temporal information for use in generating a time-specific representation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **FIG. 1** is a block diagram showing the computer system used in the preferred embodiment of the present invention.

[0011] **FIG. 2** is a block diagram showing the Data Management Systems used in the preferred embodiment of the present invention.

[0012] **FIG. 3** is a flow diagram showing the steps used to carry out highlighted processing of the Language Parser of the preferred embodiment.

[0013] **FIGS. 4A and 4B** are flow diagrams showing the steps used to carry out highlighted processing of the Database Engine of the preferred embodiment.

[0014] **FIG. 5** is a flow diagram showing the steps used to carry out highlighted processing of the Query Engine of the preferred embodiment.

[0015] FIGS. **6A-6C** show example tables used herein to explain the preferred embodiment of the present invention.

[0016] **FIG. 7** is an example journal used herein to explain the preferred embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0017] Turning now to the drawings, **FIG. 1A** shows some of the operational components used in the computer system of the preferred embodiment of the present invention. Computer system **100** is an enhanced IBM iSeries computer system, although other computer systems could be used. Depicted components include central processing unit (CPU) **130**, network interface **125**, user interface **135**, mass storage **140**, and memory **105**. CPU **130** is used to execute the programs stored in memory **105**, although it should be understood that at certain times these programs may partially or completely reside in mass storage **140**. Network interface **125** is used to communicate with other computer systems. User interface **135** is used to accept commands and relay information to the one or more users of computer system **100**.

[0018] Operating system **115** contains Data Management System (DMS) **120**. DMS **120**, which is described in forthcoming paragraphs and with reference to FIGS. **2-7**, is integrated into operating system **115**, although non-integrated operating systems could be used in the alternative. Application **110** is an example application program that may be used to access data controlled by DMS **120**.

[0019] As a preliminary matter, it should be understood that while the embodiments of the present invention are being described herein in the context of a complete system, certain program mechanisms, such as DMS **120**, are capable of being distributed in program product form. Of course, a program product can be distributed using different types of signal bearing media, including, but not limited to: recordable-type media such as floppy disks and CD ROMs; and transmission-type media such as digital and analog communications links.

[0020] **FIG. 2** is a block diagram showing some of the internal components of DMS **120** of the preferred embodiment. Each of these components is described in more detail in the forthcoming paragraphs. However, as an overview, Language Parser **200** is responsible for interpreting queries and determining whether a time-based query has been requested. Database Engine **205** uses Tables **225** and Journal **220** to generate Temporary Table **215**. Query Engine **210** uses Temporary Table **215** to generate time-specific query results for the time-based query.

[0021] **FIG. 3** is a flow diagram showing the steps used to carry out highlighted processing of Language Parser **200**. As its name suggests, Language Parser **200** is responsible breaking queries down into known pieces. Different actions are then taken based upon what pieces are identified. As shown, Language Parser **200** receives a query in block **300**. Language Parser **200** first determines whether the query is a time-based query [block **305**]. In the preferred embodiment, a time-based query is identified through use of the HISTORICAL key word, followed by sub-key words DATE and TIME. Thus, in the preferred embodiment, date and time of day are used as temporal information. However, other ways of specifying time could be used. For example, just date, or just time of day could be used; or a running time (e.g., in seconds) from a known start time could be used.

[0022] Returning to block **305** of **FIG. 3**, if the query is not a time-based query, Language Processor **200** continues with its normal processing. Since this processing is not important vis-à-vis the preferred embodiment, its details are not provided here. When Language Parser **200** identifies a time-based query, it also parses out the name of the table(s) that is the subject of the query and the date and time of day specified in the query (referred to herein as the effective time). Language Processor **200** then invokes Database Engine **205** with the database table and the effective time [block **315**].

[0023] **FIG. 4A** is a flow diagram showing the steps used to carry out highlighted processing of Database Engine **205**. Database Engine **205**, recognizing the time-based query, first retrieves the current version of the table(s) specified in the query [block **405**]. Database Engine **205** then makes a temporary copy of the retrieved table [block **410**].

[0024] After making a temporary copy of the retrieved table, Database Engine **205** retrieves the journal associated with the specified table. In the iSeries database implementation, journals are organized based upon libraries. A library is a higher-level construct that includes one or more tables. The journal (shown here as Journal **220**), which is a common construct in the database industry, is essentially a computer system file used to store changes to the database. As such, Journal **220** can be thought of as a record of additions, updates, and deletions to the information (see Tables **225**) contained in the database. A journal is conventionally used for transaction processing and to adjust (i.e., rollback or rollforward) the entire database to a specified date because of a catastrophic failure. In the transaction processing sense, a journal is thus used as a trail of changes that can be reversed if all of the changes required by a given transaction do not occur successfully. In the catastrophic failure sense, a journal is used to bring an old copy of a database up to date (as much as possible) when the current copy is lost or to return the data to a known, prior state if the most recent copy of the data has become unreliable for some reason.

[0025] It should be noted, however, that Database Engine **205** of the preferred embodiment does not use Journal **220** in a conventional manner. Unlike existing journal uses, Database Engine **205** uses Journal **220** to: 1) identify changes to the specified table that were made between the effective time and the current time and then 2) to reverse the identified changes [block **420**]. For example, assume that the current date is Nov. 11, 2002 and the effective date (as specified in the time-based query) is Jul. 8, 2001. Assume also that a change was made to the specified table on Jul. 5, 2001 and again on Jul. 17, 2001. Database Engine **205**

would identify the change made on July 17 as having occurred between the effective date and the current date, but the July 5 change would not be similarly identified. Thus, of these two changes, only the July 17 change would be reversed in Temporary Table **215**.

[**0026**] After Temporary Table **215** has been completely reversed back to its effective date state [block **420**], it amounts to a time-specific representation of the data (i.e., data values and/or meta data) stored therein. In this case, Temporary Table **215** is a past time-specific representation of the data stored therein. Database Engine **205** returns control to Language Parser **200**[block **425**]. Language Parser **200** strips the HISTORICAL keyword and DATE and TIME sub-keywords from the time-based query and invokes Query Engine **210** with the query and Temporary Table **215**[see block **320** of **FIG. 3**].

[**0027**] **FIG. 5** is a flow diagram showing the steps used to carry out highlighted processing of Query Engine **210** of the preferred embodiment. Query Engine **210** receives the query in block **500** and proceeds to execute the query using temporary table **215**. Note here that Query Engine **210** does not need to be specifically adapted to operate within the preferred embodiment. The fact that the specified query is a time-based query is hidden from Query Engine **210** so that Query Engine **210** can process the specified query on the specified table (here Temporary Table **215**) as it would any other query. After the query has been processed, Query Engine **210** presents the results to the user [block **510**] and returns control to Language Processor **220**[block **515**]. Note here that the results presented to the user are a past time-specific representation of at least some of the data values stored within Temporary Table **215**. The results, though, may also include a past time-specific representation of meta data stored within Temporary Table **215**. For example, one or more columns present in a past time specific representation may not be present in a current time-specific representation, and vice versa.

[**0028**] Language Processor **220** regains control in block **325** of **FIG. 3**. Language Processor **220** then again invokes Database Engine **205** with an end of time-based query notification (END_Hist) and the table or tables at issue. Database Engine **205** receives this notification in block **430** of **FIG. 4B**. Database Engine **205** then proceeds to deletes the specified table or tables [block **435**] and return control to Language Parser **22** in block **440**. Language Parser **200** then terminates execution in block **330** of **FIG. 3**.

PROCESSING EXAMPLE

[**0029**] The following example is used to provide additional insight into the inner workings of the preferred embodiment and into the benefits and advantages of the present invention. Consider a hypothetical hockey player named Scott Stanley. Scott is an excellent young prospect. In fact, after a promising year in the Quebec Major-Junior league, Scott was drafted third overall in this year's entry draft by his hometown team, the Worchester Wolves. Scott knows, though, that he will need serious help if he is to successfully navigate the negotiations and other intricacies associated with his first professional contract.

[**0030**] Even though Scott considers himself naive when it comes to understanding all that goes into a big league contract, he does know that he really wants to be a pro hockey player. Therefore, while he certainly wants to be treated fairly, he definitely does not want to be involved in a contract dispute, or worse, a contact hold-out. Therefore, Scott decides that he needs an agent who can get him on the ice at the start of training camp after having signed a fair agreement.

[**0031**] With this philosophy in mind, Scott begins his quest for an agent. Unfortunately, Scott's potential has made him a target for each and every pro agent out there. As one might also expect, Scott is having difficulty determining which agents really agree with Scott's philosophy and which agents are just acting the part in an effort to get Scott's business. Scott is having trouble deciding which way to go, when he receives a call from Ted Jones, an agent Scott interviewed just that morning. Ted tells Scott that he understands Scott's dilemma, and that he (Ted) has prepared a report which will help Scott better understand Ted's track record.

[**0032**] Ted hoped that such a report would convince Scott that Ted was being forthright when espousing the same signing philosophy as Scott. Since Ted didn't know (back in 2000 and 2001) that he would be needing the report, he hadn't saved off copies of his client database for each of those years; and besides, hockey contracts are signed at different times during the Spring and Summer, so it would have been impossible for Ted to guess when to take the snap shots anyway. However, Ted had remembered that his DMS has time-based query capability.

[**0033**] When Ted sat down to create his report, he decided that his first page should show where he started (i.e., with his first two clients). Ted issued his first query to produce an older view of his client database. The time-based query used in the preferred embodiment follows an enhanced version of the iSeries Database Query Language. Ted used the following query.

```
OPNQRYF     FILE((CLIENTS))
            KEYFLD((PlayerName *ASCEND))
            MAPFLD(PlayerName PlayerTeam Goals Assists PenMins
            Salary)
            HISTORICAL('04/25/2000' '01:01:01')
```

[**0034**] However, it should be understood that enhancements to other query languages would be equally effective. Consider, for example, use of the HISTORICAL key word in the well-known Standard Query Language (SQL) format. See the alternative SQL query below.

[**0035**] SELECT Player Name, Player Team, Goals, Assists, Penalty Mins., Salary

[**0036**] FROM Clients

[**0037**] HISTORICAL DATE='Apr. 25, 2000' AND TIME='01:01:01'

[**0038**] ORDER BY Player Name

[**0039**] When Language Parser **200** receives Ted's query, the query is immediately recognized as a time-based query through the presence of the HISTORICAL key word. Language Processor **220** then invokes Database Engine **205**, passing it 1) notification of a time-based query, 2) the name

of the table to be queried ("Clients" in this case), and 3) the effective date and time of day specified in the query ('Apr. 25, 2000' and '01:01:01'). Database Engine **205** responds by first retrieving the "Clients" table and then making a copy of it. The "Clients" table, as initially retrieved by Database Engine **205**, will contain the most up to date data. Database Engine **205** will then retrieve the journal associated with the "Clients" table. The journal (Journal **700**) is shown in **FIG. 7**. (As mentioned earlier, database journals are used for differing purposes. For clarity, only those journal entries which bear on this explanation are shown in Journal **700** of **FIG. 7**.)

[**0040**] After making a copy of the "Clients" table, Database Engine **205** uses Journal **700** to bring the "Clients" table back to the state it was in on Apr. 25, 2000. Database Engine **205** first determines that rows 3-7 were created after Apr. 25, 2000 (see Insert Row operations on Jun. 27, 2000, Jul. 07, 2000, Jun. 07, 2001, Jun. 23, 2001, and Jul. 17, 2001). These rows are then deleted from the "Clients" table, leaving only rows 1 and 2. Database Engine **205** then determines that the salary column of row 1 was changed from 0.7M to 0.9M on Jun. 3, 2001. Database Engine **205** replaces the newer value (0.9M) with the older value (0.7M). Database Engine **205** also determines that the salary column of row 2 was changed from 0.4M to 0.66M on May 03, 2001. Database Engine **205** replaces the newer value (0.66M) with the older value (0.4M). Database Engine **205** also determines that the salary column of row 1 was changed from 0.4M to 0.7M on May 03, 2001. Database Engine **205** replaces the newer value (0.7M) with the older value (0.4M). Control is returned to Language Processor **200**, which in turn strips off the time-based query keywords from Ted's query and invokes Query Engine **210**, passing it the copy of the "Clients" table. Query Engine **210** executes the remaining pieces of Ted's query against the copy of the "Clients" table. The results, which are a past (Apr. 25, 2000) time-specific representation of Ted's client database, are then presented to Ted.

[**0041**] As mentioned, Ted used these results as the first page of his report for Scott. Ted includes the title "Apr. 25, 2000 (see **FIG. 6A**). As shown, Ted started out in 2000 with two clients, Steve Jones, Ted's brother, and Steve's good friend, Tom Smith. Steve, who played for the Eagles at the time, was earning 0.4M per year, while Tom, who played for the Wolves was also earning 0.4M per year. Both players' teams had not made the playoffs that year, and both wanting a fresh start, decided to give Ted a try.

[**0042**] Knowing that he had a good Summer in 2000, Ted decided to have the next page show the database view from Aug. 1, 2000 as his next page. Ted used the following query.

```
OPNQRYF    FILE((CLIENTS))
           KEYFLD((PlayerName *ASCEND))
           MAPFLD(PlayerName PlayerTeam Goals Assists PenMins
           Salary)
           HISTORICAL('08/01/2000' '01:01:01')
```

[**0043**] An alternative SQL query would be.

[**0044**] SELECT Player Name, Player Team, Goals, Assists, Penalty Mins., Salary

[**0045**] FROM Clients

[**0046**] HISTORICAL DATE='Aug. 01, 2000' AND TIME='01:01:01'

[**0047**] ORDER BY Player Name

[**0048**] Language Parser **200** will again immediately recognize Ted's query as a timebased query. Database Engine **205** is again invoked with the required information (e.g., specified table, date, time of day, etc.). After copying the "Clients" table, Journal **700** is used to bring the "Clients" table back to its state at the effective time, in this instance as of Aug. 01, 2001.

[**0049**] When analyzing Journal **700**, Database Engine **205** first determines that rows 5-7 were created after Aug. 01, 2000 (see Insert Row operations on Jun. 07, 2001, Jun. 23, 2001, and Jul. 17, 2001). These rows are then deleted from the "Clients" table, leaving rows 1-4. Database Engine **205** then determines that the salary columns for several rows have changed since Aug. 01, 2000, row 4 from 0.5M to 0.75M on Jun. 06, 2001, row 3 from 1.4M to 3.4M on Jun. 05, 2001, and row 1 from 0.7M to 0.9M on Jun. 03, 2001. Database Engine **205** backs out these changes by replacing the new values with the older values. Database Engine **205** then returns control to Language Processor **200**, which strips off the time-based query keywords from Ted's query and then invokes Query Engine **210**, passing it the copy of the "Clients" table. Query Engine **210** executes the remaining pieces of Ted's query against the copy of the "Clients" table. The results, which are a past (Aug. 01, 2000) time-specific representation of Ted's client database, are then presented to Ted.

[**0050**] As mentioned, Ted used these results as the second page of his report for Scott. Ted includes the title Aug. 1, 2000 (see **FIG. 6B**). As shown, both of his first clients were traded to new teams. Steve Jones, Ted's brother, was traded from the Wolves to the Cougars, where Ted was able to negotiate a new, incentive laden contract worth up to 0.66M. Tom Smith was traded from the Eagles to the Scorpions, where Ted was able to negotiate a new contract worth 0.7M. Because of his success with Steve and Tom, Ted was also able to pick up two new clients, Fred Larson of the Thunder and Larry Nelson, the highly touted young center from the Wolves.

[**0051**] For the last page of his report, Ted decided to generate a current view of his Clients database. To do so, he submits the following standard query.

```
OPNQRYF    FILE((CLIENTS))
           KEYFLD((PlayerName *ASCEND))
           MAPFLD(PlayerName PlayerTeam Goals Assists PenMins
           Salary)
```

[**0052**] An alternative SQL query would be.

[**0053**] SELECT Player Name, Player Team, Goals, Assists, Penalty Mins., Salary

[**0054**] FROM Clients

[**0055**] ORDER BY Player Name

[**0056**] DMS **120** receives this last query and processes it in the standard way. The results, which are a current time-specific representation of Ted's client database, are then

presented to Ted. Ted's last page (see **FIG. 6C**) shows that he has built his representation up to seven players, with the addition of Johnson, Lundy, and Sims. The final page, when shown in the context of the other pages, also shows that Ted negotiated a huge raise for Nelson, from 1.4M to 3.4M, and a nice raise for Larson, from 0.5M to 0.75M.

[**0057**] When Scott reviews Ted's report, he notices that Ted has grown his representation substantially in the last two years, which Scott takes to be a good sign. Scott also notices the nice raises Ted has negotiated over the years, but most importantly, Scott sees that Ted already represents two other Wolves players (Nelson and Sims). Scott is convinced, and agrees to representation by Ted.

[**0058**] Ted, thankful for the time-based query capability of his DMS, adds Scott's information to his Client database. Ted didn't have the foresight to save off the data at different intervals of time and had no idea that the snapshots of data taken on these particular dates would be of any value. But the time-based query capability of his DMS allowed him to generate these reports without having had the prior knowledge of which dates would be useful in the future.

[**0059**] The embodiments and examples set forth herein were presented in order to best explain the present invention and its practical application and to thereby enable those skilled in the art to make and use the invention. However, those skilled in the art will recognize that the foregoing description and examples have been presented for the purposes of illustration and example only. The description as set forth is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the above teaching without departing from the spirit and scope of the following claims.

What is claimed is:

1. A method for performing a time-based query, said method comprising the steps of:

receiving said time-based query, said time-based query comprising temporal information;

applying said time-based query to data stored in a Unitemporal database; and

returning results based on said time-based query, said results being a time-specific representation of said data relative to said temporal information.

2. The method of claim 1 wherein said temporal information comprises a time.

3. The method of claim 1 wherein said temporal information comprises a date.

4. The method of claim 1 wherein said applying step further comprising the substep of:

using a journal to create said time-specific representation of said data prior to said applying step.

5. The method of claim 4 wherein said using step comprises the steps of:

copying said data to create copied data; and

using said journal to reverse changes to said copied data that occurred between and effective time and a current time, said effective time being specified in said temporal information.

6. A method for performing a time-based query, said method comprising the steps of:

receiving said time-based query, said time-based query comprising temporal information;

using a database journal to convert data stored in a database in a current time-specific representation into a past time-specific representation, an effective time of said past time-specific representation being specified in said temporal information; and

applying said time-based query against said past time-specific representation; and

presenting results of said applying step.

7. The method of claim 6 wherein said temporal information comprises a time.

8. The method of claim 6 wherein said temporal information comprises a date.

9. A method for performing a time-based query, said method comprising the steps of:

receiving said time-based query, said time-based query comprising temporal information;

converting data stored in a database in a current time-specific representation into a past time-specific representation, an effective time of said past time-specific representation being specified in said temporal information; and

presenting results, said results being based upon said past time-specific representation.

10. The method of claim 9 wherein said temporal information comprises a time.

11. The method of claim 9 wherein said temporal information comprises a date.

12. A program product, said program product comprising:

signal bearing media; and

a program disposed on said signal bearing media, said program being configured to perform the steps of,

receiving said time-based query, said time-based query comprising temporal information;

applying said time-based query to data stored in a Unitemporal database; and

returning results based on said time-based query, said results being a time-specific representation of said data relative to said temporal information.

13. The program product of claim 12 wherein said temporal information comprises a time.

14. The program product of claim 12 wherein said temporal information comprises a date.

15. The program product of claim 12 wherein said applying step further comprising the substep of:

using a journal to create said time-specific representation of said data prior to said applying step.

16. The program product of claim 15 wherein said using step comprises the steps of:

copying said data to create copied data; and

using said journal to reverse changes to said copied data that occurred between and effective time and a current time, said effective time being specified in said temporal information.

17. A program product for performing a time-based query, said program product comprising:

signal bearing media; and

a program disposed on said signal bearing media, said program being configured to perform the steps of,

receiving said time-based query, said time-based query comprising temporal information;

using a database journal to convert data stored in a database in a current time-specific representation into a past time-specific representation, an effective time of said past time-specific representation being specified in said temporal information; and

applying said time-based query against said past time-specific representation; and

presenting results of said applying step.

18. The program product of claim 17 wherein said temporal information comprises a time.

19. The program product of claim 17 wherein said temporal information comprises a date.

20. A program product for performing a time-based query, said program product comprising:

signal bearing media; and

a program disposed on said signal bearing media, said program being configured to perform the steps of,

receiving said time-based query, said time-based query comprising temporal information;

converting data stored in a database in a current time-specific representation into a past time-specific representation, an effective time of said past time-specific representation being specified in said temporal information; and

presenting results, said results being based upon said past time-specific representation.

21. The program product of claim 20 wherein said temporal information comprises a time.

22. The program product of claim 20 wherein said temporal information comprises a date.

23. An apparatus, said apparatus comprising:

a processor;

memory; and

a program stored in said memory for execution on said processor, said program being configured to perform the steps of,

receiving said time-based query, said time-based query comprising temporal information;

applying said time-based query to data stored in a Unitemporal database; and

returning results based on said time-based query, said results being a time-specific representation of said data relative to said temporal information.

24. The apparatus of claim 23 wherein said temporal information comprises a time.

25. The apparatus of claim 23 wherein said temporal information comprises a date.

26. The apparatus of claim 23 wherein said applying step further comprising the substep of:

using a journal to create said time-specific representation of said data prior to said applying step.

27. The apparatus of claim 26 wherein said using step comprises the steps of:

copying said data to create copied data; and

using said journal to reverse changes to said copied data that occurred between and effective time and a current time, said effective time being specified in said temporal information.

28. An apparatus for performing a time-based query, said program product comprising:

a processor;

memory; and

a program stored in said memory for execution on said processor, said program being configured to perform the steps of,

receiving said time-based query, said time-based query comprising temporal information;

using a database journal to convert data stored in a database in a current time-specific representation into a past time-specific representation, an effective time of said past time-specific representation being specified in said temporal information; and

applying said time-based query against said past time-specific representation; and

presenting results of said applying step.

29. The apparatus of claim 28 wherein said temporal information comprises a time.

30. The apparatus of claim 28 wherein said temporal information comprises a date.

31. An apparatus for performing a time-based query, said program product comprising:

a processor;

memory; and

a program stored in said memory for execution on said processor, said program being configured to perform the steps of,

receiving said time-based query, said time-based query comprising temporal information;

converting data stored in a database in a current time-specific representation into a past time-specific representation, an effective time of said past time-specific representation being specified in said temporal information; and

presenting results, said results being based upon said past time-specific representation.

32. The apparatus of claim 31 wherein said temporal information comprises a time.

33. The apparatus of claim 31 wherein said temporal information comprises a date.

* * * * *