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(54) SQL ENHANCEMENTS TO SUPPORT TEXT QUERIES ON SPEECH RECOGNITION RESULTS OF AUDIO DATA

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(51) **Int. Cl.**
G01L 11/00 (2006.01)

(52) **U.S. Cl.** **704/270.1**
(58) **Field of Classification Search** .... None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,233,544 B1 *	5/2001	Alshawi	....	704/2
6,601,073 B1 *	7/2003	Robare	....	340/995.1

* cited by examiner

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(57) **ABSTRACT**

A system, method, computer program product, and application program interface for indexing data relating to results of speech recognition in a database management system provides the capability to perform simple and efficient searches on audio speech data with reduced development effort. An application program interface for indexing data relating to results of speech recognition in a database management system comprises an indextype operable to support text queries on speech recognition results, an interface operable to provide interaction with an index of the indextype, and a format adapter interface a format adapter that the index creation activity will invoke to extract relevant information from a proprietary speech recognition format.

27 Claims, 9 Drawing Sheets

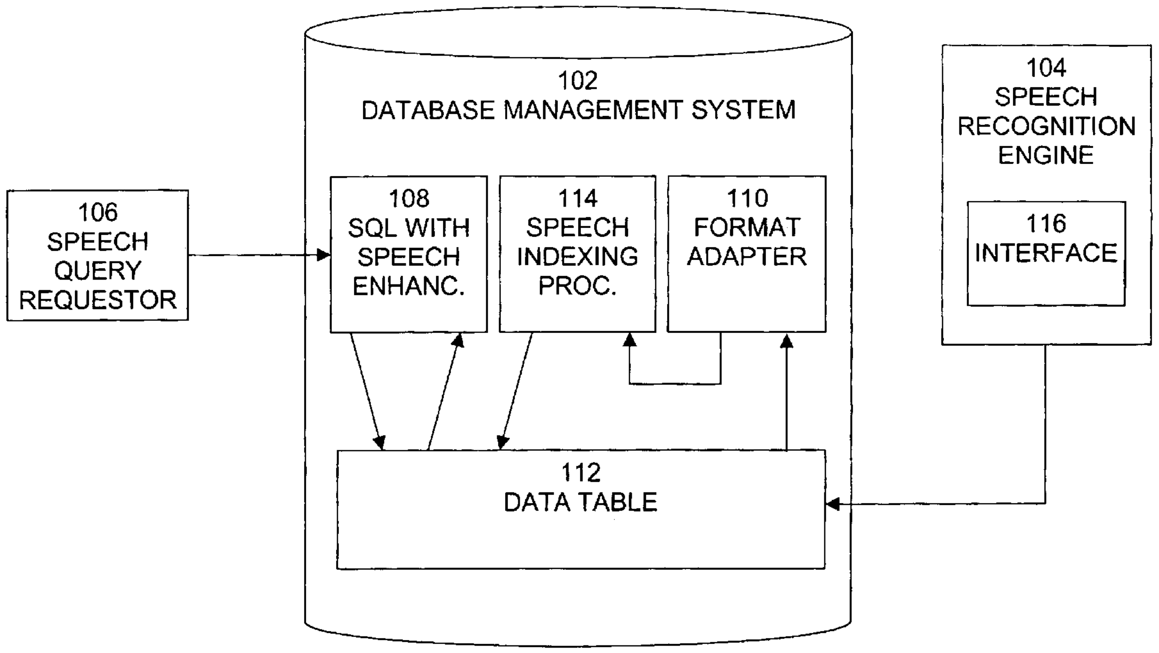


Fig. 1

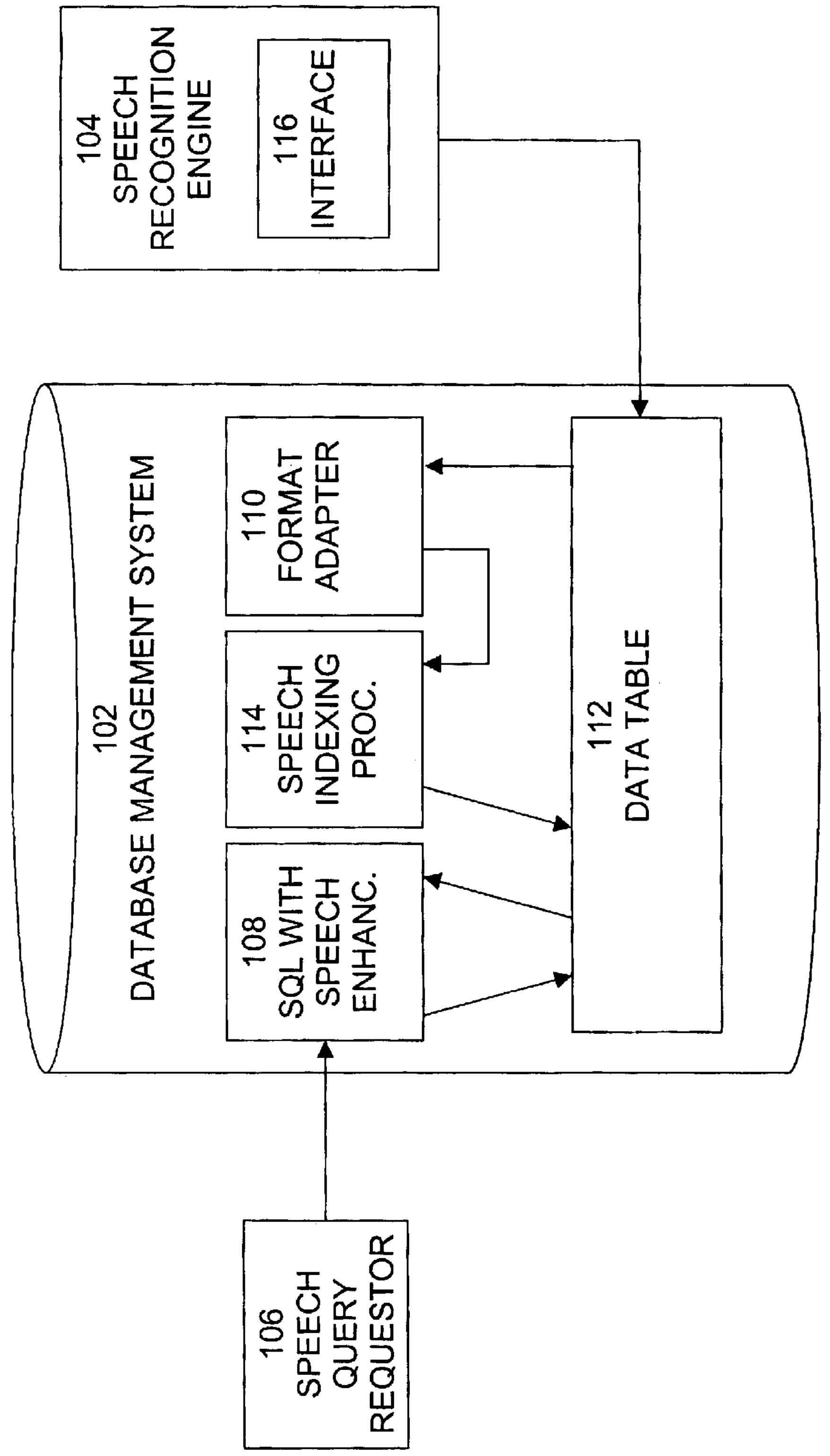

104 SPEECH RECOGNITION ENGINE
116 INTERFACE
102 DATABASE MANAGEMENT SYSTEM
110 FORMAT ADAPTER
114 SPEECH INDEXING PROC.
108 SQL WITH SPEECH ENHANC.
112 DATA TABLE
106 SPEECH QUERY REQUESTOR

Fig. 2

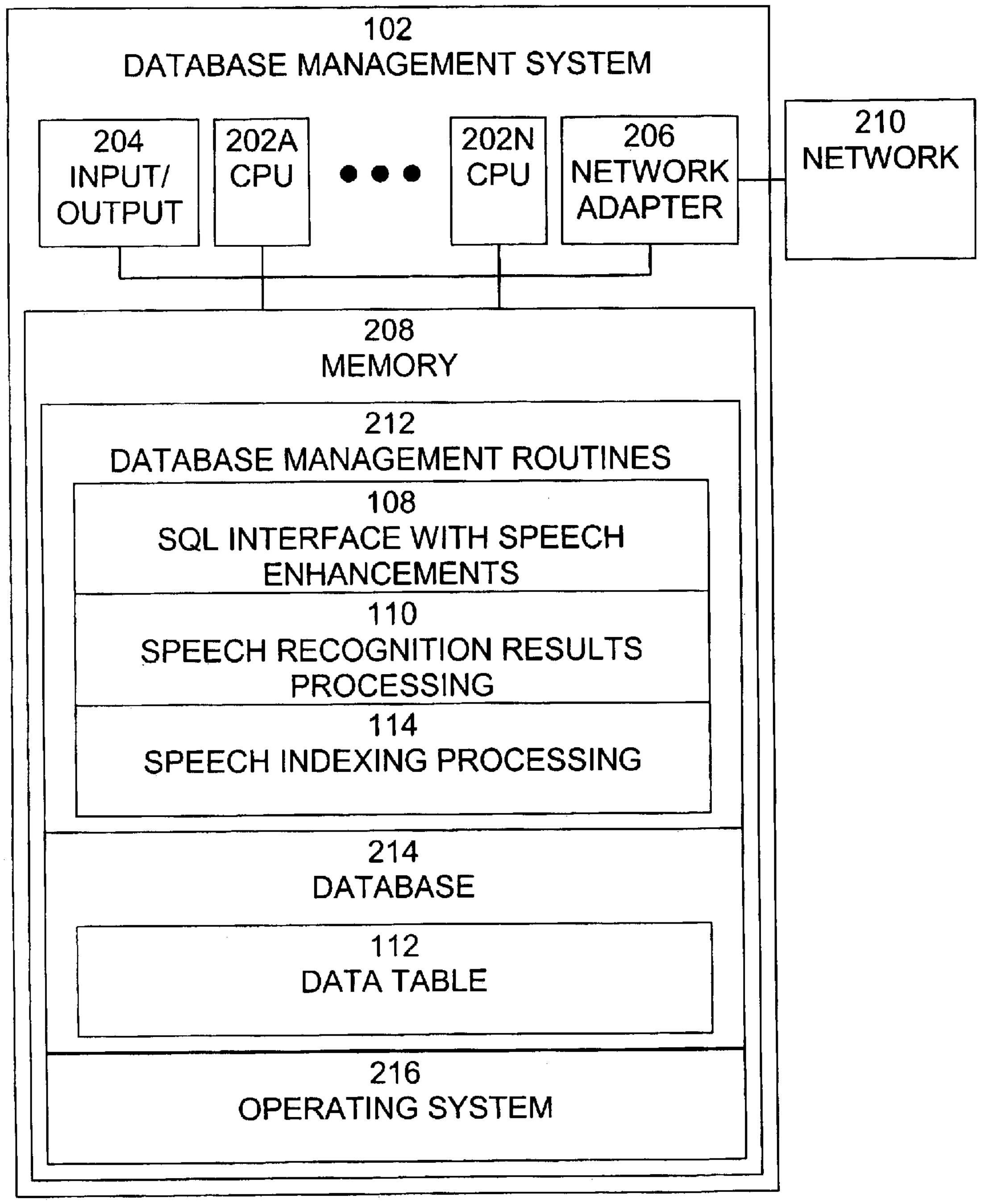

102
DATABASE MANAGEMENT SYSTEM
204
INPUT/
OUTPUT
202A
CPU
202N
CPU
206
NETWORK
ADAPTER
210
NETWORK
208
MEMORY
212
DATABASE MANAGEMENT ROUTINES
108
SQL INTERFACE WITH SPEECH
ENHANCEMENTS
110
SPEECH RECOGNITION RESULTS
PROCESSING
114
SPEECH INDEXING PROCESSING
214
DATABASE
112
DATA TABLE
216
OPERATING SYSTEM

Fig. 3

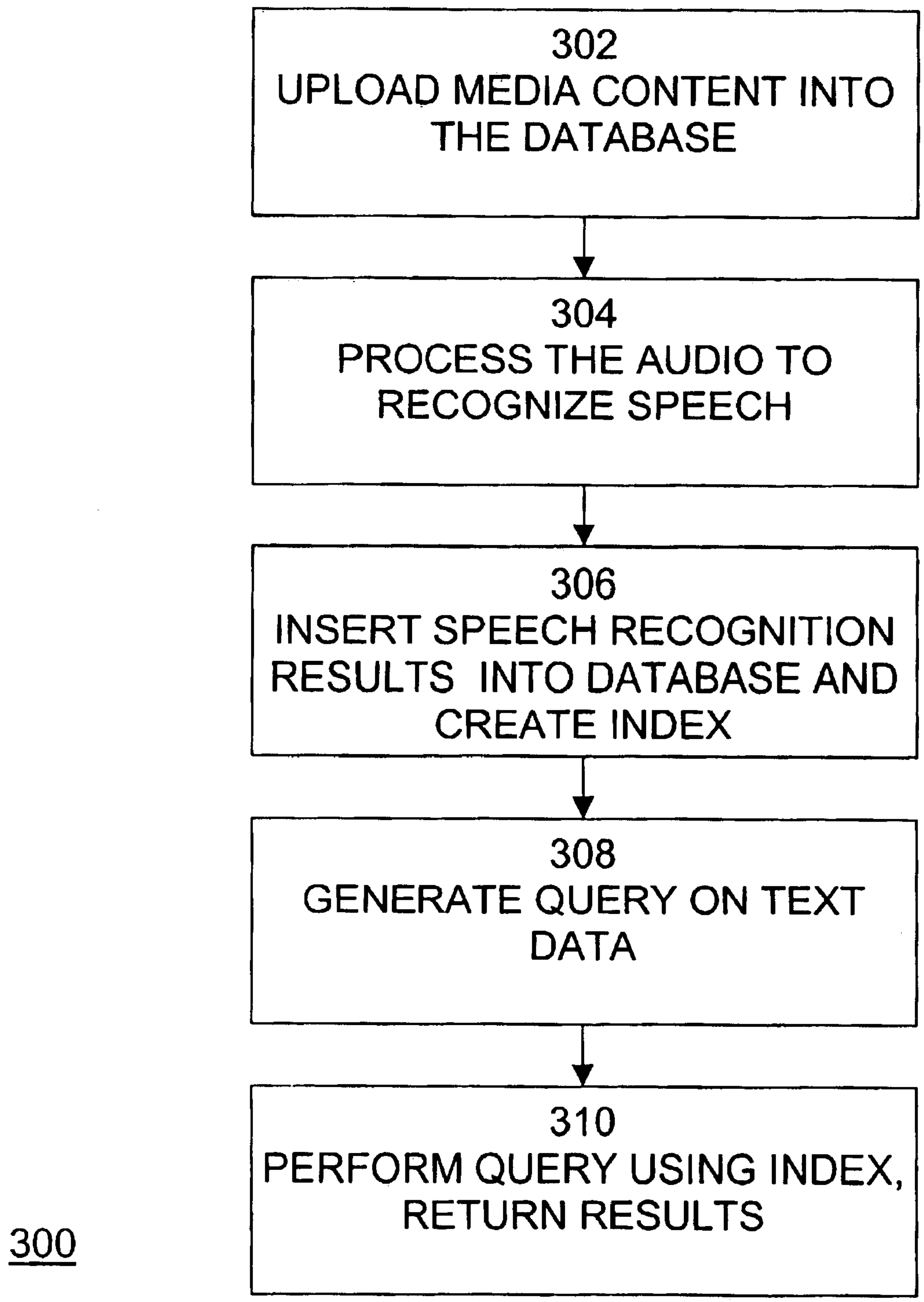
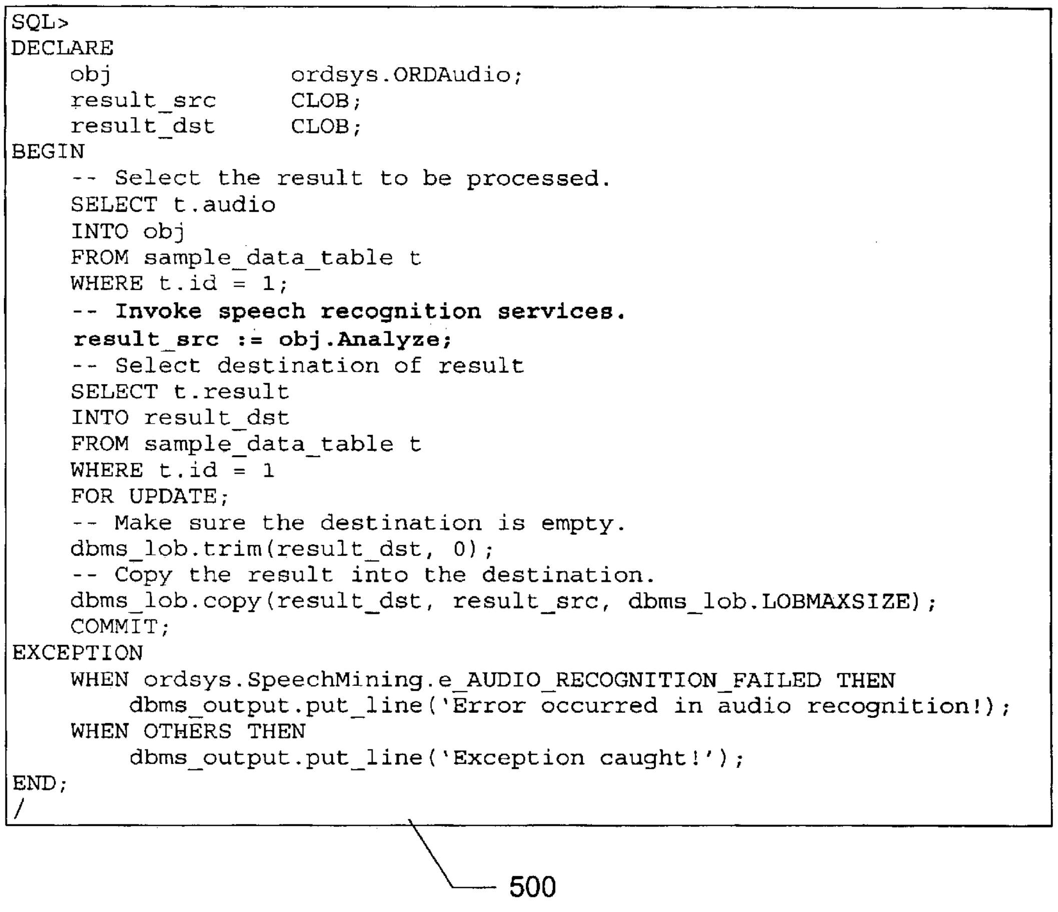

302
UPLOAD MEDIA CONTENT INTO THE DATABASE
304
PROCESS THE AUDIO TO RECOGNIZE SPEECH
306
INSERT SPEECH RECOGNITION RESULTS INTO DATABASE AND CREATE INDEX
308
GENERATE QUERY ON TEXT DATA
310
PERFORM QUERY USING INDEX, RETURN RESULTS
300

Fig. 4

112 DATA TABLE		
402 ID(NUMBER)	404 AUDIO(ORDSYS.ORDAUDIO)	406 RESULT(CLOB)

Fig. 5



```
SQL>
DECLARE
    obj             ordsys.ORDAudio;
    result_src      CLOB;
    result_dst      CLOB;
BEGIN
    -- Select the result to be processed.
    SELECT t.audio
    INTO obj
    FROM sample_data_table t
    WHERE t.id = 1;
    -- Invoke speech recognition services.
    result_src := obj.Analyze;
    -- Select destination of result
    SELECT t.result
    INTO result_dst
    FROM sample_data_table t
    WHERE t.id = 1
    FOR UPDATE;
    -- Make sure the destination is empty.
    dbms_lob.trim(result_dst, 0);
    -- Copy the result into the destination.
    dbms_lob.copy(result_dst, result_src, dbms_lob.LOBMAXSIZE);
    COMMIT;
EXCEPTION
    WHEN ordsys.SpeechMining.e_AUDIO_RECOGNITION_FAILED THEN
        dbms_output.put_line('Error occurred in audio recognition!);
    WHEN OTHERS THEN
        dbms_output.put_line('Exception caught!');
END;
/
```

Fig. 6

```
SQL> CREATE INDEX aud_idx ON sample_data_table(result)
         INDEXTYPE IS ordsys.ORDSpeechIndex;
```

600

Fig. 7

```
SQL> CREATE INDEX aud_idx ON sample_data_table(result)
         INDEXTYPE IS ordsys.ORDSpeechIndex
         PARAMETERS('preferences_string');
```

700

Fig. 8

```
SQL> SELECT id, ordsys.SpeechScore(1)
     FROM sample_data_table
     WHERE ordsys.SpeechContains(result,
                                 'some text query',
                                 1)> 0;
```

800

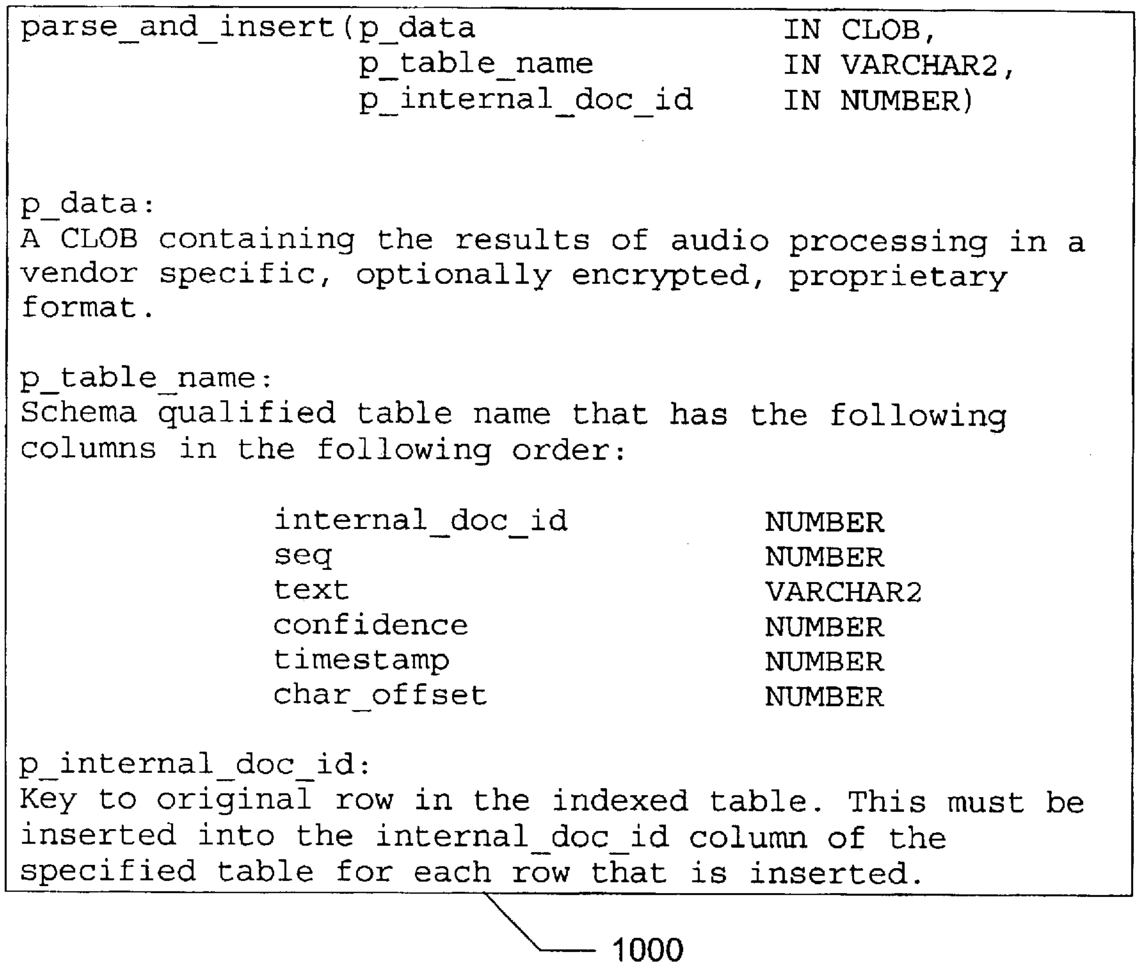
Fig. 9

```
SQL>
DECLARE
    ct_pairs  ordsys.ORDConfidenceTimestampTable;
    media_id  NUMBER;
    conf      NUMBER;
    ts        NUMBER;

    CURSOR c1 IS
    SELECT t.id, ordsys.SpeechConfidenceTimestamp(1)
    FROM sample_data_table t
    WHERE ordsys.SpeechContains(t.result,
                                'some text query',
                                1) > 0;
BEGIN
    OPEN c1;
    -- Outer loop iterates over matched rows.
    LOOP
    FETCH c1 INTO media_id, ct_pairs;
    EXIT WHEN c1%NOTFOUND;
        -- Inner loop iterates over confidence/timestamp pairs
        -- within a matched row.
        FOR cntr IN 1..ct_pairs.COUNT LOOP
            conf := ct_pairs(cntr).confidence;
            ts   := ct_pairs(cntr).timestamp;
         -- display and/or manipulate confidence/timestamp values
            -- ...
        END LOOP;
    END LOOP;
    CLOSE c1;
END;
/
```

900

Fig. 10



```
parse_and_insert(p_data                    IN CLOB,
                 p_table_name              IN VARCHAR2,
                 p_internal_doc_id         IN NUMBER)


p_data:
A CLOB containing the results of audio processing in a
vendor specific, optionally encrypted, proprietary
format.

p_table_name:
Schema qualified table name that has the following
columns in the following order:

             internal_doc_id             NUMBER
             seq                         NUMBER
             text                        VARCHAR2
             confidence                  NUMBER
             timestamp                   NUMBER
             char_offset                 NUMBER

p_internal_doc_id:
Key to original row in the indexed table. This must be
inserted into the internal_doc_id column of the
specified table for each row that is inserted.
```

Fig. 11

```
parse_and_insert(p_data                 IN     CLOB,
                 p_table_name           IN     VARCHAR2,
                 p_internal_doc_id      IN     NUMBER)
VARIABLES
    sequence_number   INTEGER := 1;
    character_offset  INTEGER := 1;
BEGIN
    IF (p_data == NULL) THEN RETURN;
    IF (p_data.length() == 0) THEN RETURN;
    WHILE (we haven't reached the end of p_data)
    BEGIN
        Extract the next first choice
            <text, confidence, timestamp> tuple;
        INSERT INTO p_table_name
            VALUES(p_internal_doc_id,
                   sequence_number,
                   text,
                   confidence,
                   timestamp,
                   character_offset);
        // Update variables for the next iteration;
        sequence_number := sequence_number + 1;
        // +1 is for a space char
        character_offset := character_offset + text.length() + 1;
    END;
END;
```

1100

SQL ENHANCEMENTS TO SUPPORT TEXT QUERIES ON SPEECH RECOGNITION RESULTS OF AUDIO DATA

CROSS-REFERENCE TO RELATED APPLICATIONS

The benefit under 35 U.S.C. § 119(e) of provisional application Ser. No. 60/419,520, filed October 21, 2002, is hereby claimed.

FIELD OF THE INVENTION

The present invention relates to a system, method, computer program product, and application program interface for indexing data relating to results of speech recognition in a database management system.

BACKGROUND OF THE INVENTION

Speech recognition technology provides the capability to design computer systems that can recognize spoken words. Speech recognition systems accept audio speech data, which are digitized audio speech signals, and output textual information. A number of speech recognition systems are available on the market. The most powerful can recognize thousands of words. However, they generally require an extended training session during which the computer system becomes accustomed to a particular voice and accent. Such systems are said to be speaker dependent. More recently speech recognition systems have been developed that can recognize speech without being trained using a particular voice and accent. Such systems may recognize the speech of most or any speakers, and are said to be speaker independent.

Audio speech data may be treated like any other data and stored and organized in a database. In the case of textual or numeric data, searches may be readily performed on the data by a database management system for the database. However, unlike textual or numeric data, there is no simple and efficient way to search audio speech data. Prior systems required developers who wished to search audio speech data had to develop complex software procedures in order to perform the searching. For example, to perform a typical search, a user will want to know which audio or video assets satisfy given text query search criteria, the time offsets within each matched media asset where matches occurred, and the user may want to know the speech recognition confidence of each match. Conventionally, this required development of software to perform several iterations of extracting the relevant text, time offset, and confidence data from the speech recognition results, build appropriate B-tree indices on this extracted data, and associate time offsets and confidence values. with their corresponding text data. In addition, procedures would have to be developed that would use the index and search through the text data for matched rows, and then search through the matched rows for time offsets into the media asset where matches occurred.

What is needed is a technique by which simple and efficient searches may be performed on audio speech data and which provides reduced development effort.

SUMMARY OF THE INVENTION

The present invention provides the capability to perform simple and efficient searches on audio speech data with reduced development effort. According to one embodiment of the present invention, an application program interface for indexing data relating to results of speech recognition in a database management system comprises an indextype operable to support text queries on speech recognition results, an interface operable to provide interaction with an index of the

indextype, and a format adapter interface operable to invoke a format adapter for converting speech recognition results having a first format to a second format.

The format adapter may be operable to parse the speech recognition results in the first format, extract from the speech recognition results text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result, and generate speech recognition results in the second format using the extracted text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result.

The indextype may comprise the text data representing the recognized speech, the information relating to a confidence in each speech recognition result, and the timestamp information indicating a location of each portion of a speech recognition result. The interface may be operable to provide interaction comprising performing a query of the text data representing the recognized speech. The query of the text data representing the recognized speech relates to the confidence information and/or the timestamp information. The results of the query may indicate time offsets within each matched media asset where matches occurred and speech recognition confidence of each match occurrence within a matched media asset.

BRIEF DESCRIPTION OF THE DRAWINGS

The details of the present invention, both as to its structure and operation, can best be understood by referring to the accompanying drawings, in which like reference numbers and designations refer to like elements.

FIG. **1** is an exemplary dataflow diagram of speech indexing processing performed in the present invention.

FIG. **2** is a block diagram of an exemplary implementation of a database management system, in which the present invention may be implemented.

FIG. **3** is an exemplary flow diagram of a process of operation of the present invention.

FIG. **4** is an exemplary format of data table that may be used in the present invention.

FIG. **5** is an exemplary code sample of how an application would invoke speech recognition on a particular row and populate the result column.

FIG. **6** is an example of an SQL command to build an index on the result column.

FIG. **7** is an example of an SQL command to create and pass preferences as arguments to index creation.

FIG. **8** is an example of a simple query on the data table, which makes use of the index.

FIG. **9** is an example of a query that retrieves confidence and timestamps for each occurrence within a matched audio asset row.

FIG. **10** is an example of an interface to a format adapter shown in FIG. **1**, which is a proprietary format understanding procedure that extracts the information required for creating an index of the required indextype from a proprietary audio processing result format of a speech recognition engine.

FIG. **11** is an algorithmic description of an exemplary implementation of the proprietary format understanding procedure.

DETAILED DESCRIPTION OF THE INVENTION

An exemplary dataflow diagram of speech indexing processing performed in the present invention is shown in FIG.

1. Included in FIG. **1** are database management system (DBMS) **102**, speech recognition engine **104**, and speech query requestor **106**. Speech query requester **106** may be any database client, tool, or application that wants to issue text queries on audio speech data.

Database management system (DBMS) **102** provides the capability to store, organize, modify, and extract information from one or more databases included in DBMS **102**. From a technical standpoint, DBMSs can differ widely. The terms relational, network, flat, and hierarchical all refer to the way a DBMS organizes information internally. The internal organization can affect how quickly and flexibly you can extract information.

Each database included in DBMS **102** includes a collection of information organized in such a way that computer software can select and retrieve desired pieces of data. Traditional databases are organized by fields, records, and files. A field is a single piece of information; a record is one complete set of fields; and a file is a collection of records. An alternative concept in database design is known as Hypertext. In a Hypertext database, any object, whether it be a piece of text, a picture, or a film, can be linked to any other object. Hypertext databases are particularly useful for organizing large amounts of disparate information, but they are not designed for numerical analysis.

Typically, a database includes not only data, but also low-level database management functions, which perform accesses to the database and store or retrieve data from the database. Such functions are often termed queries and are performed by using a database query language, such as Structured Query Language (SQL). SQL is a standardized query language for requesting information from a database. Historically, SQL has been a popular query language for database management systems running on minicomputers and mainframes. Increasingly, however, SQL is being supported by personal computer database systems because it supports distributed databases (databases that are spread out over several computer systems). This enables several users on a local-area network to access the same database simultaneously.

Most full-scale database systems are relational database systems. Small database systems, however, use other designs that provide less flexibility in posing queries. Relational databases are powerful because they require few assumptions about how data is related or how it will be extracted from the database. As a result, the same database can be viewed in many different ways. An important feature of relational systems is that a single database can be spread across several tables. This differs from flat-file databases, in which each database is self-contained in a single table.

DBMS **102** may also include one or more database applications, which are software that implements a particular set of functions that utilize one or more databases. Examples of database applications include:

computerized library systems

automated teller machines

flight reservation systems

computerized parts inventory systems

Typically, a database application, includes data entry functions and data reporting functions. Data entry functions provide the capability to enter data into a database. Data entry may be performed manually, by data entry personnel, automatically, by data entry processing software that receives data from connected sources of data, or by a combination of manual and automated data entry techniques. Data reporting functions provide the capability to select and retrieve data from a database and to process and format that data for other uses. Typically, retrieved data is used to display information to a user, but retrieved data may

also be used for other functions, such as account settlement, automated ordering, numerical machine control, etc.

DBMS **102** includes speech enhancements **108**, format adapter **110**, data table **112** and speech indexing processing **114**. Speech enhancements **108** are extensions to the standard query language of DBMS **102**. For example, where DBMS **102** uses SQL, speech enhancements include extensions to the command set of SQL, an indextype, and its associated operators and types to empower applications with sophisticated text querying capabilities on audio data.

Speech recognition engine **104** provides speech recognition processing functionality to DBMS **102**. Speech recognition engine **104** is typically configured as a server communicatively connected to DBMS **102**. Preferably, speech recognition engine **104** provides large vocabulary continuous speech recognition (LVCSR) services to DBMS **102**. Essentially, speech recognition engine **104** receives data that represents digitized speech, processes the data to recognize the speech, and outputs text data that represents the speech, which is the speech recognition result. The speech recognition results are placed in the CLOB (Character Large Object) result column in the data table **112** the procedure that invoked the speech recognition processing. This procedure places the result in a CLOB column in data table **112** next to the audio data. When a Create Index command is issued on this CLOB column, Speech Indexing processing **114** is invoked, which in turn invokes format adapter **110**. Typically, the speech recognition result is arranged in a proprietary format. Format adapter **110** adapts the format of the speech recognition result generated by speech recognition engine **104** to the format used for speech indexing. Format adapter **110** parses the speech recognition result and extracts the required information. In particular, format adapter **110** extracts text, confidence, and timestamp tuples from each speech recognition result.

Speech indexing processing **114** receives the text, confidence, and timestamp tuples extracted from the proprietary format of each speech recognition result by format adapter **110**, stores the extracted information in its own internal data structures and creates an index of the required indextype based on the extracted data. When an index of the required indextype is created or updated, speech indexing processing **114** is invoked for each new or updated row in data table **112**. The row data, which are extracted from the speech recognition results, along with a table name and key to the original row in the indexed table, are provided as parameters. The routine must process the speech recognition result to extract <text, timestamp, confidence> and insert this data, along with some additional computed data (character offset and sequence number), and the key supplied as a parameter to the procedure into a that is part of an index internal data structure. Speech indexing processing **114** then inserts the extracted tuples of information into index data structures that are stored independently from the table upon which the index is built.

An example of an interface **1100** to format adapter **110** and speech indexing processing **114** is shown in FIG. **10** An example of an implementation of format adapter **110** is shown in FIG. **11**.

A block diagram of an exemplary implementation of a DBMS **102**, in which the present invention may be implemented, is shown in FIG. **2**. DBMS **102** is typically a programmed general-purpose computer system, such as a personal computer, workstation, server system, and minicomputer or mainframe computer. DBMS **102** includes one or more processors (CPUs) **202**A–**202**N, input/output circuitry **204**, network adapter **206**, and memory **208**. CPUs **202**A–**202**N execute program instructions in order to carry out the functions of the present invention. Typically, CPUs **202**A–**202**N are one or more microprocessors, such as an INTEL PENTIUM® processor. FIG. **2** illustrates an embodiment in which DBMS **102** is implemented as a single multi-processor computer system, in which multiple processors **202**A–**202**N share system resources, such as memory **208**, input/output circuitry **204**, and network adapter **206**. However, the present invention also contemplates embodiments in which DBMS **102** is implemented as a plurality of networked computer systems, which may be single-processor computer systems, multi-processor computer systems, or a mix thereof.

Input/output circuitry **204** provides the capability to input data to, or output data from, DBMS **102**. For example, input/output circuitry may include input devices, such as keyboards, mice, touchpads, trackballs, scanners, etc., output devices, such as video adapters, monitors, printers, etc., and input/output devices, such as, modems, etc. Network adapter **206** interfaces DBMS **102** with network **210**. Network **210** may include one or more standard local area networks (LAN) or wide area networks (WAN), such as Ethernet, Token Ring, the Internet, or a private or proprietary LAN/WAN.

Memory **208** stores program instructions that are executed by, and data that are used and processed by, CPU **202** to perform the functions of DBMS **102**. Memory **208** may include electronic memory devices, such as random-access memory (RAM), read-only memory (ROM), programmable read-only memory (PROM), electrically erasable programmable read-only memory (EEPROM), flash memory, etc., and electromechanical memory, such as magnetic disk drives, tape drives, optical disk drives, etc., which may use an integrated drive electronics (IDE) interface, or a variation or enhancement thereof, such as enhanced IDE (EIDE) or ultra direct memory access (UDMA), or a small computer system interface (SCSI) based interface, or a variation or enhancement thereof, such as fast-SCSI, wide-SCSI, fast and wide-SCSI, etc, or a fiber channel-arbitrated loop (FC-AL) interface.

In the example shown in FIG. **2**, memory **208** includes database management routines **212**, database **214**, and operating system **216**. Database management routines **212** include software routines that provide the database management functionality of DBMS **102**. Database management routines **212** include SQL interface with speech enhancements **108**, format adapter **110**, and speech indexing processing **114**. SQL interface **108** accepts database queries using the SQL database query language, converts the queries to a series of database access commands, calls database processing routines to perform the series of database access commands, and returns the results of the query to the source of the query. For example, in an embodiment in which DBMS **102** is a proprietary DBMS, such as the ORACLE® DBMS, SQL interface **108** may support one or more particular versions of SQL or extensions to SQL, such as the ORACLE® PL/SQL extension to SQL. Speech enhancements are extension to the standard query language of DBMS **102**. For example, where DBMS **102** uses SQL, speech enhancements include extensions to the command set of SQL, an indextype, and its associated operators and types to empower applications with sophisticated text querying capabilities on audio data.

Format adapter **110** processes the speech recognition result from speech recognition engine **104**. Typically, the speech recognition result is arranged in a proprietary format. Format adapter **110** adapts the format of the speech recognition result generated by speech recognition engine **104** to the format used for speech indexing. Format adapter **110** parses the speech recognition result and extracts the required information. In particular, format adapter **110** extracts text, confidence, and timestamp tuples from each speech recognition result.

Speech indexing processing **114** receives. the text, confidence, and timestamp tuples extracted from the proprietary format of each speech recognition result by format adapter **110**, stores the extracted information in its own internal data structures and creates an index of the required indextype based on the extracted data. When an index of the required indextype is created or updated, speech indexing processing **114** is invoked for each new or updated row in data table **112**. The row data, which are extracted from the speech recognition results, along with a table name and key to the original row in the indexed table, are provided as parameters. The routine must process the speech recognition result to extract <text, timestamp, confidence> and insert this data, along with some additional computed data (character offset and sequence number), and the key supplied as a parameter to the procedure into a that is part of an index internal data structure. Speech indexing processing **114** then inserts the extracted tuples of information into index data structures that are stored independently from the table upon which the index is built. Database **214** includes a collection of information organized in such a way that computer software can select, store, and retrieve desired pieces of data. Typically, database **214** includes a plurality of data tables, such as data table **112**. Data table **112** is arranged to store audio speech data that has been or is to be processed by speech recognition engine **104**, shown in FIG. **1**, speech recognition processing results output by speech recognition engine **104**. Preferably, indexing information is kept in internal data structures, not in the same data table that stores the media data and speech recognition results. Typically, a user of the system would store media assets in data table **112**.

In addition, as shown in FIG. **2**, the present invention contemplates implementation on a system or systems that provide multi-processor, multi-tasking, multi-process, and/or multi-thread computing, as well as implementation on systems that provide only single processor, single thread computing. Multi-processor computing involves performing computing using more than one processor. Multi-tasking computing involves performing computing using more than one operating system task. A task is an operating system concept that refers to the combination of a program being executed and bookkeeping information used by the operating system. Whenever a program is executed, the operating system creates a new task for it. The task is like an envelope for the program in that it identifies the program with a task number and attaches other bookkeeping information to it. Many operating systems, including UNIX®, OS/2®, and WINDOWS®, are capable of running many tasks at the same time and are called multitasking operating systems. Multi-tasking is the ability of an operating system to execute more than one executable at the same time. Each executable is running in its own address space, meaning that the executables have no way to share any of their memory. This has advantages, because it is impossible for any program to damage the execution of any of the other programs running on the system. However, the programs have no way to exchange any information except through the operating system (or by reading files stored on the file system). Multi-process computing is similar to multi-tasking computing, as the terms task and process are often used interchangeably, although some operating systems make a distinction between the two.

An exemplary flow diagram of a typical process **300** of operation of a database management system incorporating the present invention is shown in FIG. **3**. It is best viewed in conjunction with FIG. **1**. Process **300** begins with step **302**, in which media content is uploaded into a database table in DBMS **102**, such as data table. In particular, media content includes audio speech data, which are digitized audio speech signals. In step **304**, a speech recognition processing requestor **106**, such as an application, that wants to process audio data with speech recognition engine **104** invokes the appropriate speech recognition. This causes the speech recognition engine **104**, which is waiting for speech processing requests to receive a request for speech recognition. The received requests are processed by interface **116** of speech recognition engine **104**. Speech recognition engine **104** processes the speech data in this request in order to recognize the speech and generate text data representing the recognized speech.

In step **308**, format adapter **110** adapts the format of the speech recognition result generated by speech recognition engine **104** to the format used for speech indexing. Format adapter **110** parses the speech recognition result and extracts the required information. In particular, format adapter **110** extracts text, confidence, and timestamp tuples from each speech recognition result. Then, speech indexing processing **114** receives the text, confidence, and timestamp tuples extracted from the proprietary format of each speech recognition result by format adapter **110**, inserts the extracted data in to data table **112** and creates an index of the required indextype based on the inserted data. In one embodiment shown in FIG. **1**, the extracted text, confidence, and timestamp tuples from format adapter **110** are passed directly to speech indexing processing **114** for index creation. In other embodiments, the extracted text, confidence, and timestamp tuples from format adapter **110** may be stored before being passed o speech indexing processing **114** for index creation. When an index of the required indextype is created or updated, speech indexing processing **114** is invoked for each new or updated row in data table **112**. The row data, which are extracted from the speech recognition results, along with a table name and are provided as parameters. This routine must process the data to extract <text, timestamp, confidence> tuples and insert them into data table **112**. Speech indexing processing **114** then inserts the extracted tuples of information into index data structures associated.

In step **308**, speech query requestor **206** generates a query on the text data included in data table **112** and transmits the query to DBMS **102**. The generated query utilizes speech enhancements **108** to the query language used by DBMS **102**. In step **310**, DBMS **102** performs the query by accessing data table **112** and, using the index, retrieves the specified information, and returning the results of the query to speech query requester **106**.

Following is an exemplary description of a sample usage scenario that will demonstrate the power and ease of use of the speech indexing functionality provided by the present invention.

Imagine a scenario in which a customer wants to do the following:

1. Upload media content including audio into DBMS **102**.
2. Process the audio by sending data to a previously started speech recognition engine **104** and store the results in DBMS **102**.
3. Create an index on the speech recognition results that will allow for sophisticated text querying capabilities.
4. Query the data to retrieve matched rows along with time offset and speech recognition confidence pairs for each occurrence within a matched row.

The customer stores media content including audio in data table **112** in DBMS **102**. An exemplary format of data table **112** is shown in FIG. **4**. Data table **112** includes id column **402**, audio data column **404**, and result column **406**. For each row of data in data table **112**, id column **402** includes a unique identifier if the data in the row, audio data column **404** includes the actual audio data, and result column **406** includes the speech recognition results. An example **500** of how an application would invoke speech recognition on a particular row and populate the result column **406** is shown in FIG. **5**.

After the application has processed each audio asset in data table **112** and populated the result column **406**, it is now

ready to build an index on the result column, for example, using an SQL command **600**, such as that shown in FIG. **6**. For enhanced text queries that need to take into account customized preferences, such as lexer and wordlist preferences, the application can create preferences using the and pass those preferences as arguments to index creation, for example, using an SQL command **700**, such as that shown in FIG. **7**.

An example **800** of a simple query on the data table **112** is shown in FIG. **8**. An example **900** of a more sophisticated query that that retrieves confidence and timestamps for each occurrence within a matched audio asset row is shown in FIG. **9**. In this example, the SpeechContains operator matches those rows that satisfy the input query while the ancillary operator SpeechConfidenceTimestamp returns the corresponding collection of confidence/timestamp pairs for each returned row.

Format adapter **110** must be provided to adapt the format of the speech recognition result generated by speech recognition engine **104** to the format used for speech indexing. The formatting procedure must extract the information required for creating an index of the required indextype from the proprietary audio processing result format of speech recognition engine **104**. In one embodiment, when an index of the required indextype is created or updated, format adapter **110** is invoked for each new or updated row in the indexed table. The row data, which are processing results of SpcechMining, along with a table name and key to the original row in the indexed table, are provided as parameters. This routine must process the data to extract <text, timestamp, confidence> tuples. An example of the interface **100** to format adapter **110** is shown in FIG. **10**. An example of the processing **1100** performed by format adapter **110** is shown in FIG. **11**.

APPENDIX A

OPERATOR: SpeechContains

Signature

```
SpeechContains(indexed_column CLOB,
          query_string VARCHAR2,
          [reference_label NUMBER])
     RETURN NUMBER;
```

Description

Use the SpeechContains operator in the WHERE clause of a SELECT statement to specify the query expression for a SpeechIndexing query. SpeechContains returns a relevance score for every row selected. You obtain this score with the SpeechScore operator. Additionally, SpeechConfidenceTimestamp returns tuples of speech recognition confidences and time offsets for the matches in the selected row.

Parameters

indexed_column: Specify the CLOB column to be searched on. This column must have an ordsys.ORDSpeechIndex index associated with it.
query_string: Specify the query that defines your search in indexed_column. Oracle Text query operators can be used in this query string.
reference_label: Optionally specify the label that associates the SpeechScore and SpeechConfidenceTimestamp generated by the SpeechContains operator.

Returns

For each row selected, SpeechContains returns a number between 0 and 100 that indicates how relevant the document row is to the query. The number 0 means that Oracle found no matches in the row.

Example

The following example searches for all documents in the SpeechMining_result column that contain the word 'oracle'. The score for each row is selected with the SpeechScore operator using a label of 1:

```
SELECT ordsys.SpeechScore(1), title
FROM audionews
```

APPENDIX A-continued

WHERE ordsys.SpeechContains(SpeechMining__result,
'oracle', 1) > 0;

OPERATOR: SpeechScore

Signature

SpeechScore(reference__label IN NUMBER) RETURN NUMBER;

Description

Use the SpeechScore operator in a SELECT statement to return the score values produced by SpeechContains in an SpeechIndexing query.

Parameters

reference__label: An integer that refers to the corresponding invocation of SpeechContains. If there are multiple invocations of SpeechContains in the same query, this parameter is used to maintain the reference.

Notes

The SpeechScore operator can be used in a SELECT, ORDER BY, or GROUP BY clause.

Returns

This operator returns a NUMBER.

Example

See the example for SpeechContains

OPERATOR: SpeechConfidenceTimestamp

Signature

```
SpeechConfidenceTimestamp(reference__label IN NUMBER)
    RETURN ordsys.ORDConfidenceTimestampTable;
```

Description

Use the SpeechCoinfidenceTimestamp operator in a SELECT statement to return a collection of confidence and timestamp pairs produced by SpeechContains in an SpeechIndexing query.

Parameters

reference__label: An integer that refers to the corresponding invocation of SpeechContains. If there are multiple invocations of SpeechContains in the same query, this parameter is used to maintain the reference.

Notes

The SpeechConfidenceTimestamp operator can be used in a SELECT clause.

Returns

This operator returns a table of type ordsys.ORDConfidenceTimestampTable (defined below).

INDEXTYPE: ORDSpeechIndex

Description

This indextype allows a user to create an audio index on a CLOB column that contains the results of SpeechMining.

Parameters

parameter__string: Can be used to pass in Oracle Text preferences to the underlying Oracle Text index. Note that datastore preferences are disallowed.

The types below are used to retrieve speech recognition confidence and timestamp values from the query into PL/SQL variables.

OBJECT ORDConfidenceTimestampTuple

```
CREATE TYPE ORDConfidenceTimestampTuple
    AS OBJECT (confidence NUMBER, timestamp NUMBER);
```

OBJECT ORDConfidenceTimestampTable

```
CREATE TYPE ORDConfidenceTimestampTable
    AS TABLE OF ORDConfidenceTimestampTuple;
```

What is claimed is:

1. A method for indexing data relating to results of speech recognition in a database management system, comprising the steps of:

receiving speech recognition results at the database management system, the speech recognition results having a first format;

converting the first format of the speech recognition results to a second format; and

generating an index of the speech recognition results in the database management system.

2. The method of claim 1, wherein the converting step comprises the steps of:

parsing the speech recognition results in the first format;

extracting from the speech recognition results text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result; and

generate speech recognition results in the second format using the extracted text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result.

3. The method of claim 2, wherein the second format is a standardized format.

4. The method of claim 3, wherein the first format is a proprietary format.

5. The method of claim 2, wherein the generating step comprises the steps of:

generating an index using the extracted speech recognition results, including the text data representing the recognized speech, the information relating to a confidence in each speech recognition result, and the timestamp information indicating a location of each portion of a speech recognition result in the database management system; and

storing the extracted information.

6. The method of claim 5, wherein the second format is a standardized format.

7. The method of claim 6, wherein the first format is a proprietary format.

8. A system for indexing data relating to results of speech recognition in a database management system comprising:

a processor operable to execute computer program instructions;

a memory operable to store computer program instructions executable by the processor; and

computer program instructions stored in the memory and executable to perform the steps of:

receiving speech recognition results at the database management system, the speech recognition results having a first format;

converting the first format of the speech recognition results to a second format; and

generating an index of the speech recognition results in the database management system.

9. The system of claim 8, wherein the converting step comprises the steps of:

parsing the speech recognition results in the first format;

extracting from the speech recognition results text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result; and

generate speech recognition results in the second format using the extracted text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result.

10. The system of claim **9**, wherein the second format is a standardized format.

11. The system of claim **10**, wherein the first format is a proprietary format.

12. The system of claim **9**, wherein the generating step comprises the steps of:

generating an index using the extracted speech recognition results, including the text data representing the recognized speech, the information relating to a confidence in each speech recognition result, and the timestamp information indicating a location of each portion of a speech recognition result in the database management system; and

storing the extracted information.

13. The system of claim **12**, wherein the second format is a standardized format.

14. The system of claim **13**, wherein the first format is a proprietary format.

15. A computer program product for indexing data relating to results of speech recognition in a database management system comprising:

a computer readable medium;

computer program instructions, recorded on the computer readable medium, executable by a processor, for performing the steps of

receiving speech recognition results at the database management system, the speech recognition results having a first format;

converting the first format of the speech recognition results to a second format;

generating an index of the speech recognition results in the database management system.

16. The computer program product of claim **15**, wherein the converting step comprises the steps of:

parsing the speech recognition results in the first format; extracting from the speech recognition results text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result; and

generate speech recognition results in the second format using the extracted text data representing the recognized speech, information relating to a confidence in each speech recognition result, and tirnestamp information indicating a location of each portion of a speech recognition result.

17. The computer program product of claim **16**, wherein the second format is a standardized format.

18. The computer program product of claim **17**, wherein the first format is a proprietary format.

19. The computer program product of claim **16**, wherein the generating step comprises the steps of:

generating an index using the extracted speech recognition results, including the text data representing the recognized speech, the information relating to a confidence in each speech recognition result, and the timestamp information indicating a location of each portion of a speech recognition result in the database management system; and

storing the extracted information.

20. The computer program product of claim **19**, wherein the second format is a standardized format.

21. The computer program product of claim **20**, wherein the first format is a proprietary format.

22. An application program interface for indexing data relating to results of speech recognition in a database management system comprising:

an indextype operable to support text queries on speech recognition results;

an interface operable to provide interaction with an index of the indextype; and

a format adapter interface operable to invoke a format adapter for converting speech recognition results having a first format to a second format.

23. The application program interface of claim **22**, wherein the format adapter is operable to parse the speech recognition results in the first format, extract from the speech recognition results text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result, and generate speech recognition results in the second format using the extracted text data representing the recognized speech, information relating to a confidence in each speech recognition result, and timestamp information indicating a location of each portion of a speech recognition result.

24. The application program interface of claim **23**, wherein the indextype comprises the text data representing the recognized speech, the information relating to a confidence in each speech recognition result, and the timestamp information indicating a location of each portion of a speech recognition result in the database management system.

25. The application program interface of claim **24**, wherein the interface is operable to provide interaction comprising performing a query of the text data representing the recognized speech.

26. The application program interface of claim **25**, wherein the query of the text data representing the recognized speech relates to the confidence information and/or the timestamp information.

27. The application program interface of claim **26**, wherein results of the query indicate time offsets within each matched media asset where matches occurred and speech recognition confidence of each match occurrence within a matched media asset.

* * * * *