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(54) **DETECTING AND MEASURING EXPOSURE TO MEDIA CONTENT ITEMS**

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(51) **Int. Cl.**
H04H 60/33 (2008.01)

(52) **U.S. Cl.** **455/2.01**; 725/9; 725/19

(58) **Field of Classification Search** 455/2.01; 725/9, 14, 18, 19

See application file for complete search history.

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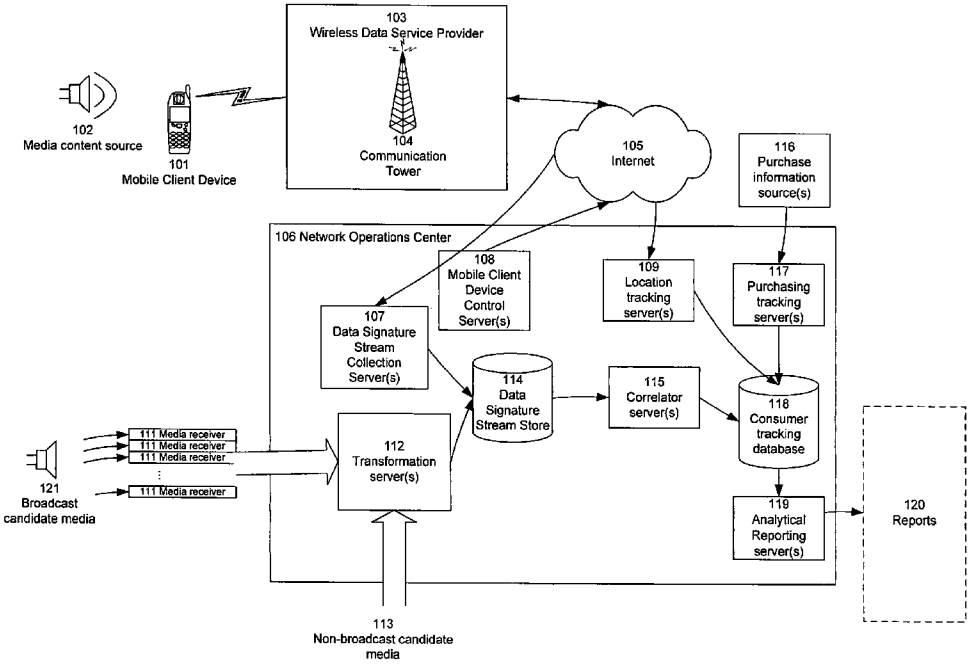
(57) **ABSTRACT**

User exposure to media items is detected and measured. A mobile client device carried by a user digitally samples the audio environment of the user on a regular basis. These samples are transformed into a stream of data signatures and compared with reference media items to detect user exposure to the reference items. Purchase behavior following exposure to selected media content items can be detected and tracked as well, so as to gauge effectiveness of media items such as advertisements.

16 Claims, 4 Drawing Sheets



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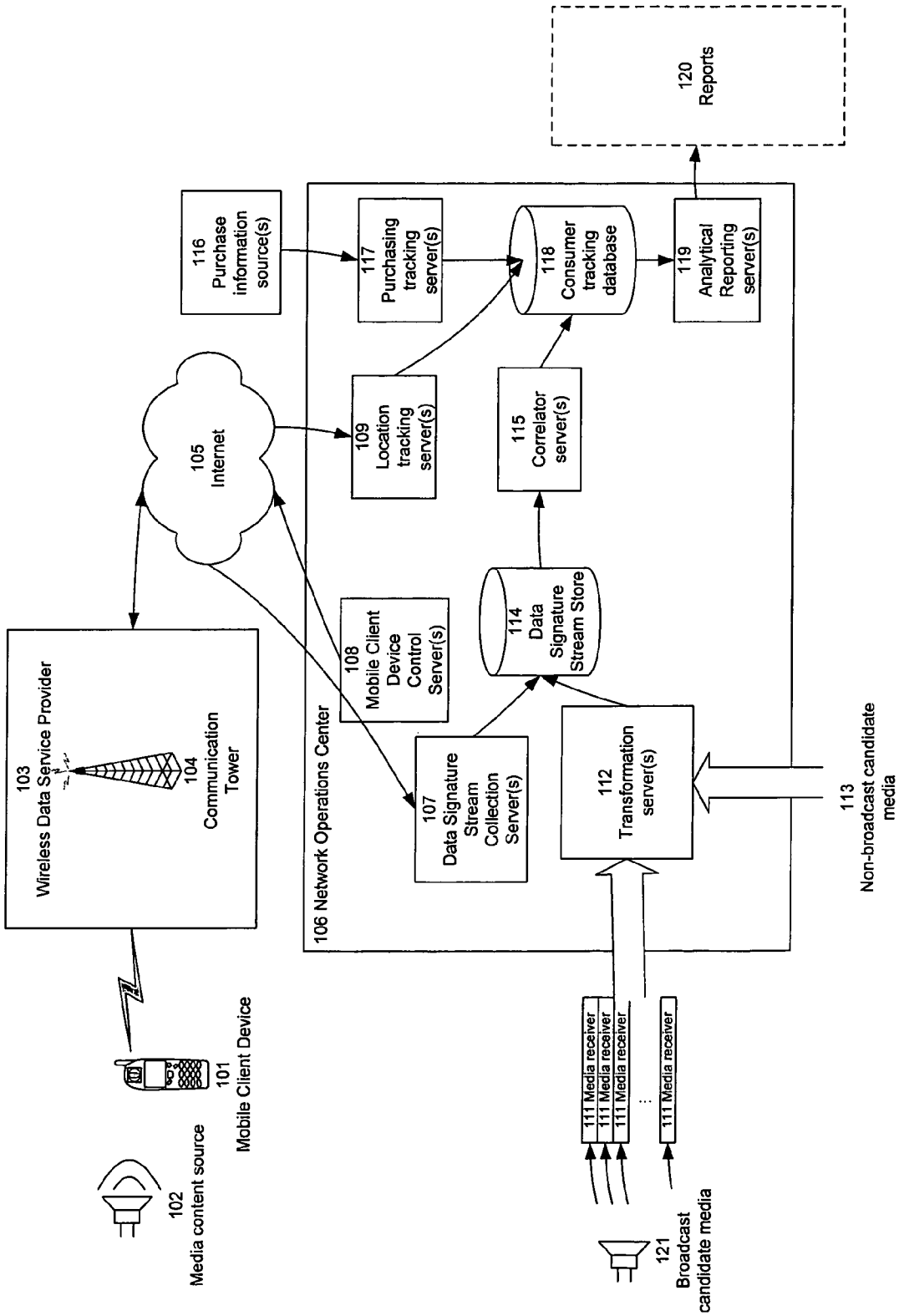
120 Reports
116 Purchase information source(s)
117 Purchasing tracking server(s)
118 Consumer tracking database
119 Analytical Reporting server(s)
105 Internet
109 Location tracking server(s)
115 Correlator server(s)
108 Mobile Client Device Control Server(s)
114 Data Signature Stream Store
106 Network Operations Center
103 Wireless Data Service Provider
104 Communication Tower
107 Data Signature Stream Collection Server(s)
112 Transformation server(s)
113 Non-broadcast candidate media
111 Media receiver
111 Media receiver
111 Media receiver
111 Media receiver
102 Media content source
101 Mobile Client Device
121 Broadcast candidate media

FIG. 1

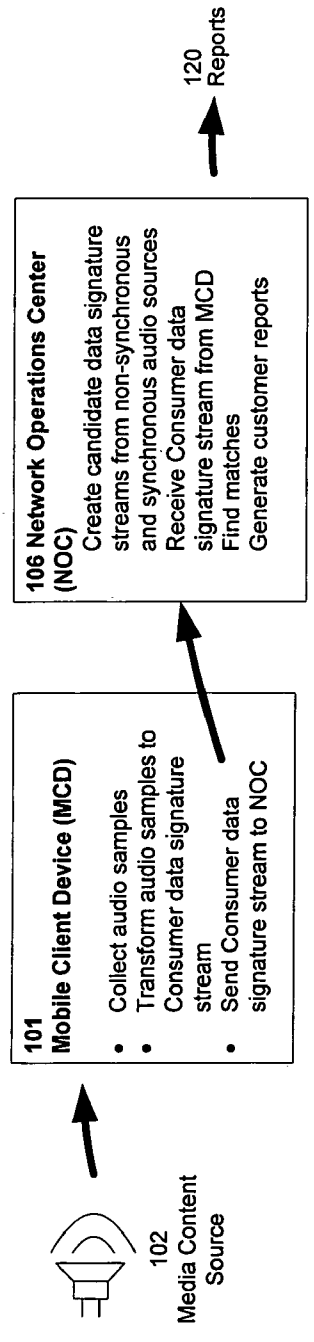

FIG. 2A

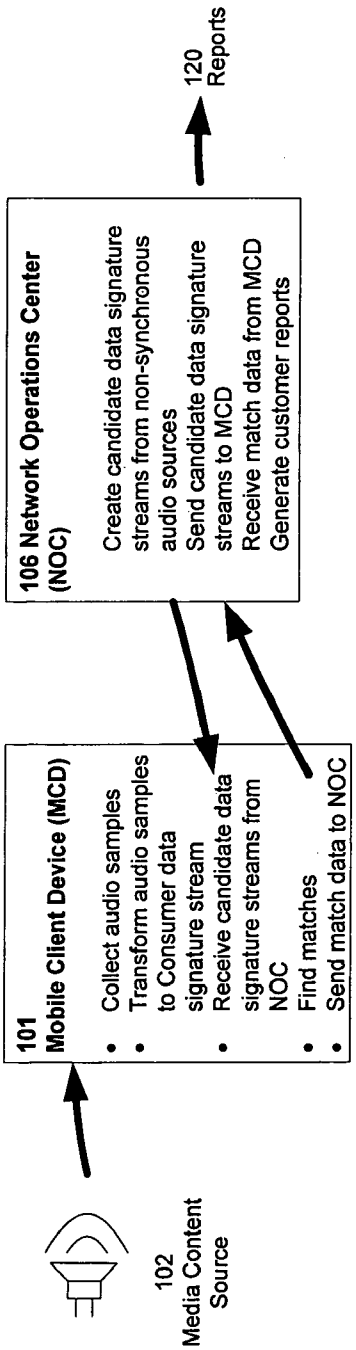

FIG. 2B

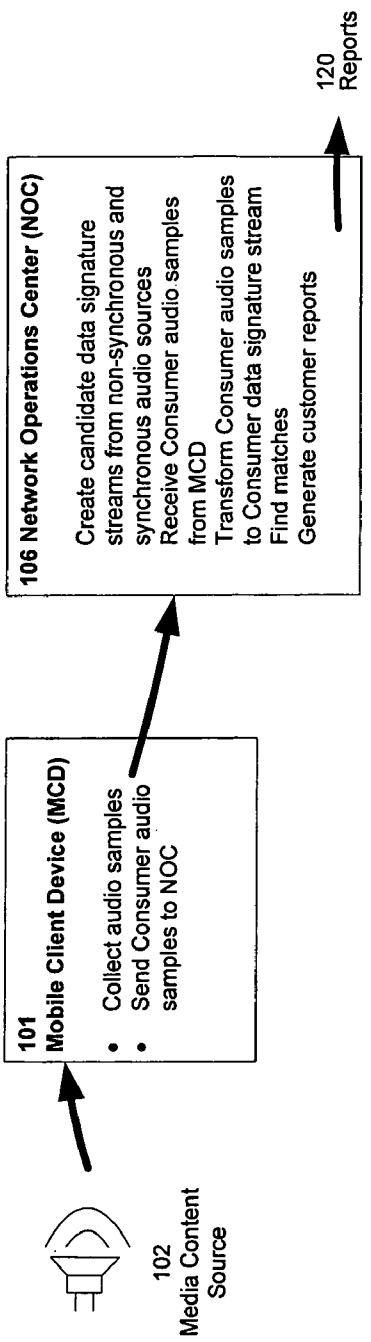

FIG. 2C

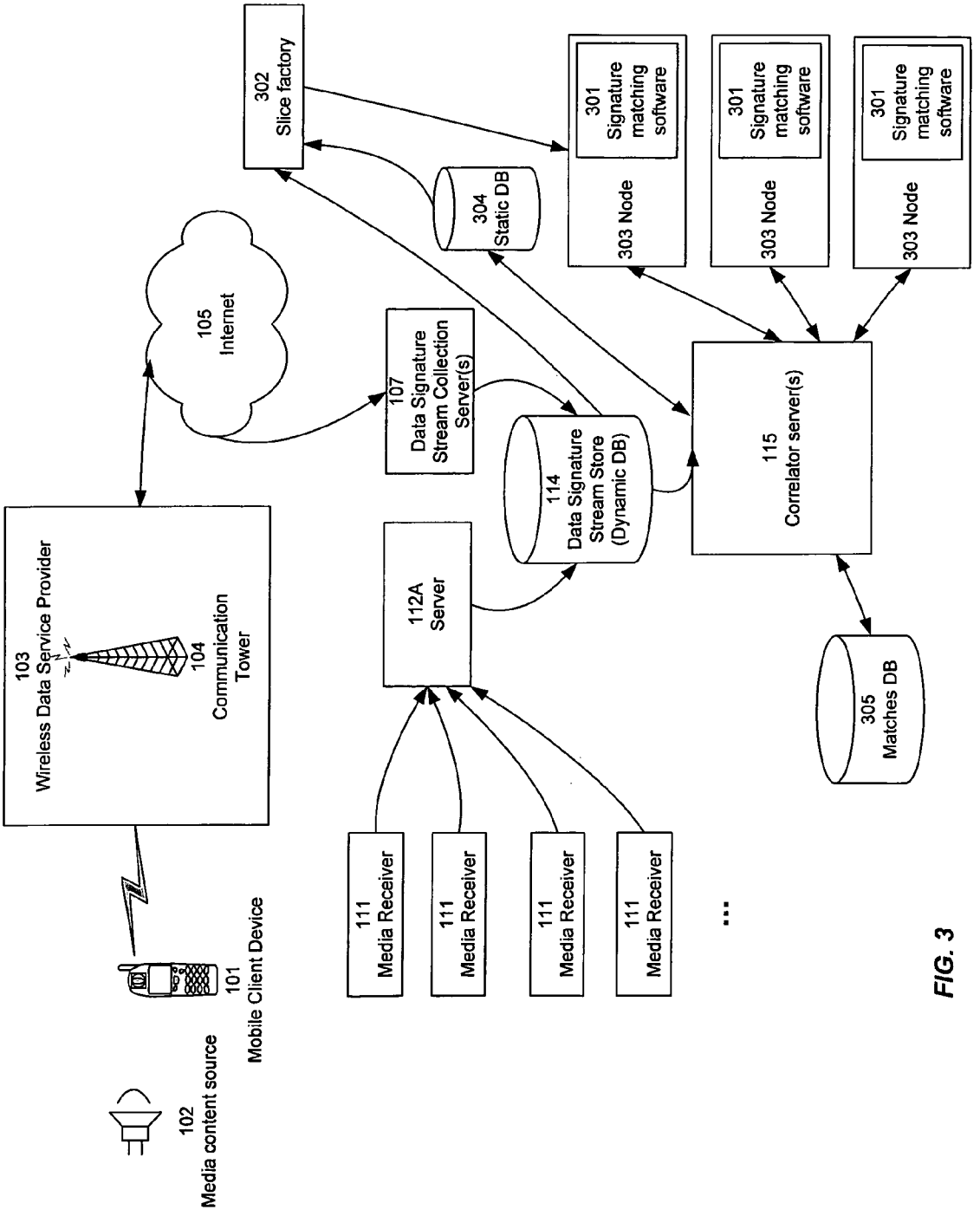
302
Slice factory
301
Signature matching software
303 Node
304
Static DB
105
Internet
107
Data Signature Stream Collection Server(s)
114
Data Signature Stream Store (Dynamic DB)
115
Correlator server(s)
103
Wireless Data Service Provider
104
Communication Tower
112A
Server
305
Matches DB
111
Media Receiver
101
Mobile Client Device
102
Media content source

FIG. 3

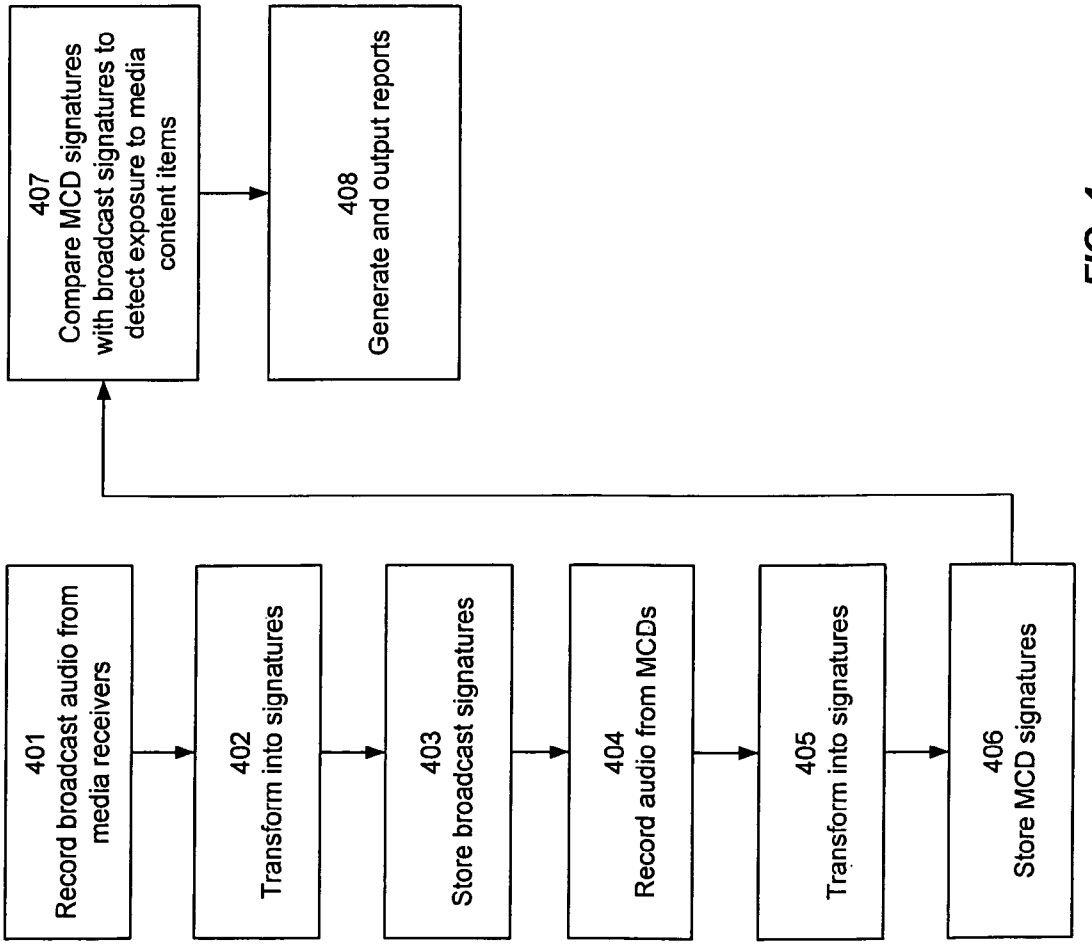
401
Record broadcast audio from media receivers
402
Transform into signatures
403
Store broadcast signatures
404
Record audio from MCDs
405
Transform into signatures
406
Store MCD signatures
407
Compare MCD signatures with broadcast signatures to detect exposure to media content items
408
Generate and output reports

FIG. 4

DETECTING AND MEASURING EXPOSURE TO MEDIA CONTENT ITEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority from U.S. Provisional patent application Ser. No. 60/606,229, for "Measuring Media Consumption and Purchase Behavior Using Client-Device Audio Sampling, Client-Device Location Tracking, and Individual Purchase Information to Derive Marketing Effectiveness," filed Aug. 31, 2004, the disclosure of which is incorporated herein by reference.

The present application further claims priority from U.S. Provisional patent application Ser. No. 60/655,305, for "Personal Music Preference Determination Based on Listening Behavior," filed Feb. 22, 2005, the disclosure of which is incorporated herein by reference.

FIELD OF THE INVENTION

The present invention relates generally to tracking of media consumption, and more particularly to detecting and measuring exposure to media items without requiring user action or knowledge.

BACKGROUND OF THE INVENTION

Producers and distributors of media content, as well as advertisers, are very interested in accurately measuring the size of their audiences. Such measurements ideally indicate the number of people that are exposed to, or that consume, the media content. There is also considerable interest in the demographics and other characteristics of media consumers.

Existing audience measurement techniques overlook many types of media consumption, consumer exposure to purchased music (on CD or mp3), video games, and movies. Initial sales data is available, but usage data is not. In other words, there may be information as to how many copies of a CD were purchased, but there is no information as to how often each consumer has listened to the CD (i.e., how often the consumer was exposed to the media item).

In addition, television viewing and radio listening are typically measured independently from each other and independently of other media consumption. Thus, there is no easy way to determine overall exposure to (consumption of) a particular content item such as an advertisement across various media, nor to obtain an overview of aggregate exposure to various media items and types of media items.

Another disadvantage of conventional media measurement techniques is that the effectiveness of advertising is typically measured in very broad terms. In particular, the effectiveness of advertising targeted at a particular demographic market segment is not easily determined, nor is it easy for advertisers to obtain quick feedback to confirm that their advertising has reached its intended target market.

Yet another disadvantage of conventional media measurement techniques is that such techniques are typically associated with the playback device (such as a particular television set, radio, or the like) and not directly associated with the consumer him- or herself (the viewer of the television set, listener to the radio, or the like). In addition, conventional measurement techniques do not provide a mechanism for tracking exposure both inside the home and outside the home (for example at a bar, or a friend's house, or the like).

Yet another disadvantage of conventional media measurement techniques is that they require active participation by the consumer and can often be quite burdensome. For example, in a "Nielsen family", users must interact with the measuring device (or fill out a paper diary) to identify which family members are watching the television at any given time. Such requirements result in inaccuracy, lowered and/or unreliable participation, skewed results, and the like.

Finally, existing media measurement techniques do not correlate user exposure to media items with store visits or purchases.

What is needed, therefore, is a media measurement technique that addresses the above-described limitations of the prior art.

What is further needed is a media measurement technique that reliably tracks user exposure to media content, regardless of how the content is delivered to the user. What is further needed is a technique that does so without unduly burdening the user and without requiring action on his part.

SUMMARY OF THE INVENTION

The system of the present invention detects and identifies user exposure to audible media. A mobile client device ("MCD") carried by a user digitally samples the audio environment of the consumer on a regular basis. These samples are transformed into a stream of data signatures and transmitted to a network operations center ("NOC").

At the NOC, the user's exposure to media content items is tracked and recorded, and can later be aggregated with information about other users so as to provide effective statistical reporting as to overall media exposure and consumption. The system can also record specific characteristics of the consumer and of the circumstances of his or her exposure to the media content item. For example, the location at which the media was encountered, the activity the user was engaging in, and the like. Media exposure information can also be correlated with purchase information so as to make inferences as to the relationship between advertisements and purchasing behavior.

Using the recorded media exposure information and related tracking data, the present invention, in one embodiment, employs collaborative filtering or other cohort behavior analysis to identify fine-grained psychographic classifications of users and to measure the effectiveness of marketing on various groups. The resulting aggregated reports and interpretations facilitate better targeting of marketing resources so that they tend to reach users who have a high propensity to buy.

MCD **101** may be built into a consumer device with some other utility to the user; examples include a mobile phone, PDA, wristwatch, or the like. In alternative embodiments, MCD **101** can take any other form, such as a standalone device that is carried by or attached to the user. Embedding the functionality of the present invention in a device such as a mobile phone or wristwatch makes it more convenient for a user to carry MCD **101**, and also encourages the user to keep MCD **101** in their possession at all times. MCD **101** operates passively and requires no user input.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate several embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. **1** is a block diagram depicting an overall architecture for implementing the present invention according to one embodiment.

FIGS. **2**A through **2**C are block diagrams depicting alternative methodologies for practicing the present invention.

FIG. **3** is a block diagram depicting a conceptual architecture for implementing the present invention according to one embodiment.

FIG. **4** is a flowchart depicting a method for practicing the present invention according to one embodiment.

One skilled in the art will recognize that these Figures are merely examples of the operation of the invention according to one embodiment, and that other architectures and modes of operation can be used without departing from the essential characteristics of the invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

For purposes of the following description, the terms "user", "consumer", and "individual" are synonymous and are used interchangeably. The terms "consumption" and "exposure" are also synonymous and are used interchangeably.

The present invention is now described more fully with reference to the accompanying Figures, in which several embodiments of the invention are shown. The present invention may be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather these embodiments are provided so that this disclosure will be complete and will fully convey the invention to those skilled in the art.

Referring now to FIG. **1**, there is shown a block diagram depicting an overall architecture for implementing the present invention according to one embodiment. Referring also to FIG. **3**, there is shown a block diagram depicting a conceptual architecture for implementing the present invention according to one embodiment. Referring also to FIG. **4**, there is shown a flowchart depicting a method for implementing the present invention according to one embodiment.

According to one embodiment of the present invention, media receivers **111** receive broadcast audio; this audio (or a sample of it) is recorded **401** and transformed into signatures **402**. These signatures are stored **403** along with appropriate indexing mechanisms to facilitate retrieval and comparison. Mobile client devices **101** detect user exposure to media content sources **102**, for example by picking up audio at a microphone of a cell phone. This audio is recorded **404** and transformed into signatures **405**. These signatures are also stored **406**. At a Network Operations Center (NOC) **106**, the MCD signatures are compared **407** with signatures derived from the broadcast audio, so as to detect and identify media items to which the user has been exposed. In this manner, the present invention is able to determine, with great specificity, which media items a user has been exposed to, and the particulars of such exposure (including number of repetitions, location of exposure, correlation to buying behavior, and the like). GPS or other location data can also be used in analyzing the media exposure. From this correlation and analysis, reports are generated **408** and output. The present invention thus provides a mechanism for determining degrees of penetration and effectiveness for media content items such as advertisements. In addition, since users carry MCDs with them, the system of the present invention is able to detect exposure at any location, include within the home and outside the home.

Media content source **102** is any source to which a user may be exposed. Examples include television, radio, CDs, movies, public address announcements, and the like. According to the techniques described herein, the present invention tracks user exposure to various media content items that may come from any number of sources **102**.

Mobile client device (MCD) **101** is a device capable of detecting and receiving audio from source **102**. Any number of MCDs **101** can be provided; for example, in one embodiment each user being tracked has an MCD **101**. In one embodiment, each MCD **101** is a device (or a component of a device) carried by a user (consumer). For example, MCD **101** may be built into a consumer device with some other utility to the user, such as a mobile phone, personal digital assistant (PDA), wristwatch, handheld computer, or the like. In one embodiment, MCD **101** includes a GPRS platform for transmitting data, and runs an operating system such as Microsoft Windows Mobile or J2ME. In alternative embodiments, MCD **101** can take any other form, such as a standalone device that is carried by or attached to the user. Embedding the functionality of the present invention in a device such as a mobile phone or wristwatch makes it more convenient for a user to carry MCD **101**, and also encourages the user to keep MCD **101** in his or her possession at all times.

Although the description provided herein makes use of the term "MCD", it will be recognized by one skilled in the art that the detection devices need not be mobile; in other words, the present invention can be implemented using stationary devices that perform essentially the same function as described herein.

In one embodiment, MCD **101** makes use of already-present components (such as a microphone in a cell phone) to implement the operations described herein.

MCD **101** operates passively and requires no user input. In one embodiment, MCD **101** digitally samples the audio environment of the user on a regular basis; in another embodiment, MCD **101** performs such sampling when it detects that meaningful audio has been received at MCD **101**. MCD **101** transforms the audio samples to a data signature stream that can be digitally transmitted and/or stored. The audio content items received by MCD **101** are referred to herein as target media items.

In one embodiment, signature transformation is performed at MCD **101**. Since the signature transformation results in a compressed representation of the audio data, performing the transformation at MCD **101** reduces the quantity of data to be transmitted to NOC **106**, thus reducing bandwidth requirements and system load.

For example, in one embodiment, the MCD **101** samples 10 seconds of audio data per 30 seconds received. Such a ratio is particularly effective for detecting exposure to commercials (advertisements), since many such commercials are 30 seconds long. MCD **101** creates a raw audio file (such as a .WAV file) from the sampled data, and performs a signature transformation to generate a signature file from the raw audio file. In one embodiment, the system of the present invention uses a signature transformation algorithm such as Shazam, described in Wang et al. and available from Shazam Entertainment Ltd., of London, England. This algorithm is also described in Avery Li-chun Wang, "An Industrial-Strength Audio Search Algorithm," October 2003, and Avery Li-Chun Wang and Julius O. Smith, III, WIPO publication WO0211123A3, 7 Feb. 2002, "Method for Search in an Audio Database." The signature transformation algorithm generates a 4 k file that is spooled (temporarily stored) at MCD **101**. In one embodiment, MCD **101** erases the raw audio file once the signature file has been created; in another embodiment, raw audio is saved for some period of time for testing purposes.

In one embodiment, some information is lost during the transformation, so that the transformation is a one-way pro-

cess; raw data cannot be reconstructed from the transformed data signature. Transmitting transformed data, as opposed to raw data, thus provides a measure of privacy and confidentiality.

Any of a number of signature algorithms can used. In one embodiment, the system of the present invention uses a signature transformation algorithm that meets design constraints of MCD **101** (processing power, battery life, available memory) and the transmission channel (bandwidth, availability, and the like). For example, the system may be configured to skip or postpone uploads if the network is unavailable. The transformation algorithm retains enough data to facilitate high-accuracy determinations of what media the user is listening to.

In one embodiment, MCD **101** places itself into a quiescent ("sleeping") state to lessen battery drain when the detected audio level drops below a threshold. During this sleeping state, MCD **101** periodically "wakes up" and determines if the audio level is sufficient to resume sampling.

In another embodiment, MCD **101** continually samples for N seconds every M seconds (such as 10 seconds every 30 seconds) and then processes the audio content to make a judgment via frequency analysis/power levels as to its useful audio content before passing it on to the audio fingerprint process. If the audio content is judged to be not sufficient relevant given current power levels, then the sample is discarded so as to save processing and transmission time and thus conserving battery usage.

In another embodiment, MCD **101** does not do any transforming; rather it merely sends raw data.

MCD **101** transmits data to data signature stream collection server(s) **107** at Network Operations Center (NOC) **106**. In one embodiment, this transmission takes place via wireless data service provider **103** which operates communication towers **104** that receive signals from MCD **101** and relay the sampled audio data via the Internet **105** to one or more data signature stream collection servers **107** running at NOC **106**. One skilled in the art will recognize that this data transmission can take place using any known wireless (or wired) communication method, and that such transmission can take place in real-time, or in a batched mode at periodic intervals, or in response to NOC **106** queries to MCD **101**. In one embodiment, such transmission can take place via GPRS, TCP/IP, or other mechanisms, or any combination thereof. In one embodiment, the user "docks" or connects MCD **101** to a computer or other device (not shown) in order to transmit data to NOC **106**.

In one embodiment, signature files are transmitted to data signature stream collection server(s) **107** on a periodic basis (for example, every five minutes). However, if a connection cannot be made, or if power at MCD **101** is low, transfers of signature files can be delayed as long as is necessary. In one embodiment, individual MCDs **101** are capable of spooling (temporarily storing) some quantity of signature data so as to account for temporary inability to transmit to server(s) **107**. If a prolonged period of time takes place when data cannot be transferred, so that an MCD **101** cannot spool additional incoming data, MCD **101** can temporarily stop collecting data. Alternatively, MCD **101** can discard old data in favor of new data. In one embodiment, once data has been transferred to server **107**, MCD **101** clears its local storage (spool) in order to make room for new data.

In one embodiment, MCD **101** does not perform any transfers of target media items when its battery power is less than some threshold amount such as 50%, unless a) it is being charged; or b) its spool space is close to being full. In one embodiment, MCD **101** stops receiving and sampling data from media content sources **102** when its battery power is less than some second threshold amount such as 10%.

In one embodiment, a single data signature stream collection server **107** is used. In another embodiment, a plurality of servers **107** are used, and transmissions of data from MCDs **101** are directed to an appropriate server **107** for receipt, based on current load, geographic location, and/or other factors.

At NOC **106**, data signature stream collection server **107** receives data from MCD **101** and stores it in data signature stream store **114** (also referred to as a dynamic database). Correlator server **115** correlates the data signature stream against a set of data signature streams transformed from candidate media sources **113** to determine which candidate media source, if any, the user is listening to at any given time. In one embodiment, correlator server **115** uses a correlation algorithm as described in Avery Li-chun Wang, "An Industrial-Strength Audio Search Algorithm," October 2003, and Avery Li-Chun Wang and Julius O. Smith, III, WIPO publication WO0211123A3, 7 Feb. 2002, "Method for Search in an Audio Database."

In one embodiment, media receivers monitor media sources for broadcast candidate media content items **121** (also referred to as reference media items). Each media receiver **111** can be implemented, for example, as a personal computer (also referred to as a media monitor) with a number of tuner cards that can pick up broadcasts. In one embodiment, each media receiver **111** includes four tuner cards, each capable of receiving AM, FM, or television audio signals. An example of the type of tuner card that can be used for implementing the present invention is the ASI8712 or ASI8713 eight-tuner broadcast adapter available from AudioScience, Inc. of New Castle, Del. In one embodiment, several media receivers **111** are provided, running in different locations so as to be able to pick up different markets/stations, and also to provide improved reliability and redundancy. Media receivers **111** can be configured, for example, to simultaneously receive 32 channels in parallel, taking audio components audio only, and to convert the received audio into digital form via sampling. In one embodiment, media receivers **111** are located in a location that is remote with respect to NOC **106** (for example, in a location suitable for receiving candidate media **121**); media receivers **111** then transmit signals to NOC **106** via the Internet or by other means. In another embodiment, media receivers **111** are located at NOC **106**.

Transformation server **112** transforms detected candidate media content items **121** to candidate data signature streams, which are then stored at data signature stream store **114** (or at a different stream store, not shown). In one embodiment, only audio is transformed, although one skilled in the art will recognize that the present invention can also be used in connection with video, and that video transforms can thus be applied as well. The transformation converts the raw samples into data files (referred to as signature files or signature streams) that can be compared against other signature files to determine matches.

In addition, in one embodiment, transformation server **112** also transforms candidate media content items from non-broadcast reference media **113** such as audio CDs, video game sound tracks, movie sound tracks, and the like.

In an alternative embodiment, as shown in FIG. **3**, individual media receivers **111** transform audio into signature files, and transmit the signature files to server **112**A.

In one embodiment, servers **112** (or **112**A) and **107** are implemented as a single server for collecting data from both MCDs **101** and media receivers **111**. One skilled in the art will recognize that the present invention can be implemented

using separate dedicated servers for these two functions, or using a single server that performs both functions.

In one embodiment, raw audio files (for example in .WAV format) are stored in addition to signature files. These can be stored at media receivers **111** or at a storage location associated with server **112** or **112**A.

In one embodiment, reference media signature files are broken up into fixed-time increments (such as five-minute increments) for ease of indexing, handling, and comparison. Thus, individual signature files are stored in stream store **114**, each signature file representing five minutes of data for one audio channel. In one embodiment where raw audio is stored, the raw audio files are also broken up into fixed-time increments (such as five-minute increments). As an alternative to fixed-time divisions, some other form of intelligent time-based division can be used; for example, blank areas can be detected and interpreted as indicating breaks between commercials, and files can be divided up according to such commercial breaks.

Accordingly, in one embodiment, media receivers **111** transmit data (either in raw form or in signature form) to server **112** or **112**A on a periodic basis. Data can be transmitted, for example, in five-minute increments, so that one file is transferred in each transmission. Alternatively, a number of files can be collected at receivers **111** and then transmitted to server **112** or **112**A in batch form. In one embodiment, media receivers **111** retain raw audio files for some period of time (such as 3-5 days) and then discard them. In one embodiment, server **112** or **112**A retains signature files for some period of time (such as 30 days) and then discards them. By retaining signature files, the present invention enables detection of user exposure to time-shifted media content items. For example, if a user is watching a television show at a time other than the broadcast time (for example, if the show was recorded on a TiVo or other video recording device), the present invention is able to detect such activity and can report that the show was recorded and at what time it was watched.

Candidate media sources can include any type of media that has an audio component detectable by MCD **101**. Examples include television (broadcast, cable, satellite, etc.), radio (broadcast, cable and satellite, etc.), recorded music (CD, mp3, etc.), videogame audio, audio track of a DVD and other media sources.

In an alternative embodiment, the present invention can detect user exposure to visual media such as billboards, for example by determining, based on a GPS reading on a user's location, that the user is driving past a billboard. Such media exposure events can be tracked and correlated with purchases in the same manner as exposure to audio media items, as described herein. In one embodiment, such exposure can be tracked along with exposure to audio media items, so as to obtain a complete overview of the effectiveness of an advertising campaign that includes billboard, radio advertisements, and the like.

On a periodic basis (for example, every three hours), server **112** or **112**A sends signature data from stream store **114** to correlator server **115** (which may include a single server or any number of servers). In one embodiment, server **115** makes a periodic request for data from server **112** or **112**A, and from data signature stream collection server(s) **107**. In one embodiment, in response to the request, server **112** or **112**A sends signature files representing media items collected by receivers **111**, as well as data from MCDs **101** collected by data signature stream collection server(s) **107**.

Correlator server **115** identifies user exposure to candidate media items including broadcast items and non-broadcast items. In one embodiment, time stamps stored with the data signatures in stream store **114** aid in the correlation.

In one embodiment, location information is collected by location tracking server **109** and used to assist in the correlation. For example, correlator server **115** can recognize that there is a lower probability of TV viewing while moving. Some behaviors that can be inferred using location information include: driving in a car (using speed range and route tracking against a road map), riding in a bus (using bus routes with frequent stops), visits to retail locations (using coordinates of retail establishments), presence at home, and presence at the workplace. Some locations influence the correlation algorithm. For example, radio and CDs in the database are checked before television if the user is moving; television is checked first while the user is at home.

Additional useful correlations and analyses can also be performed, for example to ascertain particular listening behaviors. For example, purchasing tracking server **117** can collect purchase information from sources **116** for use in assisting correlation server **115**. In one embodiment, this is accomplished by tracking the use of a particular credit card that is in the possession of the user.

The present invention is also able to track exposure to entertainment (such as movies), whether such exposure takes place in a movie theater, at home, or elsewhere. Exposure to promotional advertisements can be correlated with exposure to movies and the like. The present invention can also help to determine which promotional channels are most effective in reaching users and which channels are less effective.

For example, in one embodiment, advertisements are given a unique ID. In addition, advertisements are assigned one or more attributes describing the goods or services being advertised at some level of specificity ranging from narrow ("Ford Mustang") to more broad ("Ford") to even more broad ("automobile"). A Ford Mustang advertisement will have all three of these attributes. Attributes may also describe the target audience, such as "professional."

Tallies are kept for each attribute during a sliding window of time, for example 30 days. Purchase information can be acquired from the use of a credit card issued to panel members, through retailer reporting, through survey, or from other sources.

When a user makes a purchase of an item being tracked, related tallies for that user over some period of time (such as the past 30 days) is examined. With a sufficiently large set of users, correlations are made between purchase behavior and media exposure. This is done, for example, by comparing the media exposure of the purchaser of product A with the media exposure of the purchaser of competing product B.

The tracking methods provided by the present invention facilitate measurement of the effectiveness of advertisements in attracting consumers who otherwise would purchase competing brands, as well as attracting consumers who otherwise would not buy the product or product type at all. In addition, the present invention is able to measure the effect an advertisement has on consumption of brands other than the advertised brand.

Using the correlation between purchase behavior and media exposure may show, for example, that people exposed to Ford Mustang commercials have a higher propensity to buy Ford Thunderbirds if they are not exposed to many non-Ford automobile ads.

Given the raw data of purchase behavior and attribute exposure tallies, database queries can be performed to reveal causal relationships and to test advertising hypotheses.

Other sources of data that can be used and stored include an RFID tag, GPS tracking information, and/or a barcode on

MCD **101**, so as to assist in location tracking. In one embodiment, Bluetooth transceivers can be installed in certain locations, and location tracking is performed by detection of unique Bluetooth transceiver codes.

From these various types of data, patterns can be deduced. For example, the system of the present invention can determine that a user watches news at home and listens to music in the car, or can infer purchasing behavior such as a pattern where the user visits a movie theater after listening to an ad for one of the movies playing at that theater.

In one embodiment, correlator server **115** interacts with additional components, as shown in FIG. **3**, to correlate data from MCDs **101** with data from media receivers **111**. For example, a series of nodes **303** can be provided for storing signature data. In one embodiment, any number (for example 14) of 4 GB nodes **303** can be provided, each running at a separate computer; alternatively, other arrangements and node sizes can be provided. Slice factory **302** controls the distribution of data from stream store **114** among nodes **303**. In one embodiment, a utility server (not shown) controls the operation of slice factory **302**.

In one embodiment, nodes **303** run signature matching software **301**, such as for example the SongMon function of software provided by Shazam Entertainment Ltd. and described more fully in Wang et al. In another embodiment, this software **301** is located at correlator server **115**. Software **301** identifies matches, returning a tag indicating what media content item from media receivers **111** matches a media content item picked up by an MCD **101**. Additional information, such as time codes, specifics as to which media receiver **111** and/or channel matched, and the like, can also be returned. Match data is stored, for example in matches database **305** for further analysis and reporting.

In one embodiment, signature matching software **301** runs through candidate data twice. A preliminary run provides quick estimates of matches and can be run on demand. A production run, performed at regular intervals such as once every three hours, provides more accurate matches.

In one embodiment, slice factory **302** and/or utility server (not shown) run signature matching software **301** to aggregate and index signature files from stream store **114** using a hash methodology. From this processed data, a disk image containing indexed signature file data for a particular length of time (such as 18 hours) is formed; this disk image is then stored at each of nodes **303**.

In one embodiment, each node **303** contains an identical image with identical data so as to improve throughput by processing data at multiple nodes **303** operating in parallel with one another. In one embodiment, for example, each node **303** processes a maximum of approximately 50 MCDs so as not to become overloaded. Correlator server **115** dispatches MCD files to available nodes **303** based on load and other factors.

In one embodiment, each node processes approximately 18 hours of a large number of channels (for example 70 channels, totaling over 1,000 hours of content) in rolling update fashion. Target media items are compared with these reference media items so as to determine whether the user has been exposed to the media represented by the reference media items.

At periodic intervals (for example, every three hours), the aggregation and indexing is re-run so as to delete the oldest three hours and add the newest three hours, thus maintaining a set amount of data (for example, 18 hours' worth) at all times. In one embodiment, 32 channels of data are stored.

In one embodiment, a binary representation of the reference media signature data is stored in each node **303**. Nodes **303** compare the signature data from MCDs **101** against this reference data set. In one embodiment, multiple nodes **303** are utilized to improve matching throughput.

In one embodiment, correlator server(s) **115** sends samples from stream store **114** to an appropriate node **303** based on load and other factors. The present invention is scalable in two dimensions: additional numbers of MCDs **101** can be handled by adding more nodes vertically. Greater amounts of data can be stored by adding more nodes horizontally, or by providing nodes having higher storage capacities.

In one embodiment, data from MCDs **101** includes additional information about the circumstances and conditions of the media exposure, including for example time, day, battery level, telephone number, GPS data, and the like; all of this information can be stored at stream store **114** and used in analysis, matching, and/or reporting.

In one embodiment, certain candidate signatures are stored in static database **304**. For example, if an advertiser would like to determine how many users have been exposed to a particular advertisement, a signature for that advertisement is stored in static database **304**. The signature need not be collected via media receivers **111**, but can be provided by direct input or via correlator servers **115**. This stored signature can then be compared with signatures received from MCDs **101**. In one embodiment, these candidate signatures are also passed to nodes **303** to facilitate comparison with incoming signatures from MCDs **101**. In one embodiment, the content in static database **304** ("static content") is combined with the content collected as described above ("dynamic content") to create the reference data set loaded into each node **303**. In another embodiment, static content is processed to generate a reference data set; this reference data set is then loaded into a node **303** that is separate from the dynamic content for analysis of matches against the static content only.

In one embodiment, these candidate signatures are not aged using a sliding window as described above for data collected from media receivers **111**. In another embodiment, these candidates are aged but at a different rate than other data.

In yet another embodiment, data in static database **304** can be compared against data from media receivers **111**. In this manner, an advertiser can determine whether his or her advertisement ran and was detected by a media receiver **111**, regardless of whether it was picked up by an MCD **101**.

Referring again to FIG. **1**, there are shown additional components that can be used in generating reports on media exposure and consumption. A time-based history of user exposure to media items is stored in consumer tracking database **118**. Location information is also stored, if available.

Analytical reporting server **119** uses consumer tracking data from database **118** to generate reports **120**. Reports can include, for example:

advertisement play rates;

program ratings;

metrics of marketing effectiveness;

psychographic classifications;

and the like.

In one embodiment, reports are generated using standard relational-database queries. Results of these queries can be place in tabular or graphical format for presentation.

After all correlations are complete, live media source data signatures may be discarded.

Using the above-described techniques, the system of the present invention is able to measure media consumption both in and out of the home.

Alternate Configurations

One skilled in the art will recognize that the transformation and matching steps can be performed in many different ways and at different components within the overall system. FIGS. **2**A through **2**C provide examples of different configurations for performing these functions. These Figures also provide a description of the overall method of operation of the present invention according to various embodiments. The term "candidate data signature stream" is equivalent to reference media items; the term "consumer data signature stream" is equivalent to target media items.

Referring now to FIG. **2**A, there is shown a configuration where transformation takes place at MCD **101** and matching takes place at NOC **106**. As described above, MCD **101** collects audio samples, transforms them to a signature stream, and transmits the signature stream to NOC **106**. NOC **106** identifies matches between signature stream received from MCD **101** and candidate streams derived from candidate media **113** and **121**. Although FIG. **2**A depicts the candidate data signature data stream being created at NOC **106**; however, one skilled in the art will recognize that the candidate signature data stream can instead be generated at media receivers **111** and/or provided directly to NOC **106** from some other source.

Referring now to FIG. **2**B, there is shown a configuration where transformation and matching both take place at MCD **101**. Here, MCD **101** collects audio samples and transforms them to a signature stream. NOC **106** generates candidate data signature streams from candidate media, and transmits these candidate streams to MCD **101**. Alternatively, the candidate signature data stream can instead be generated at media receivers **111** and/or provided to NOC **106** from some other source; NOC **106** then sends them to MCD **101**. MCD **101** then identifies matches between the signature stream generated from incoming audio data and the candidate data signature streams received from NOC **106**. MCD **101** then sends match data to NOC **106**. This configuration is particularly useful when the number of candidate audio sources is relatively small and known in advance. For example, such a configuration can be used for monitoring a user's exposure to a limited and expected set of advertisements. In such a situation, this configuration reduces the amount of data that is continually transmitted from MCD **101** to NOC **106**; once the set of candidates is provided to MCD **101**, only match data need be transmitted, which typically requires less bandwidth than transmission of signatures from MCD **101** to NOC **106**. Such a configuration is also a more distributed processing paradigm that can serve to reduce processor load at NOC **106**, since NOC **106** need not perform matching operations for a large number of MCDs; rather MCD **101**s do their own matching.

Referring now to FIG. **2**C, there is shown a configuration where transformation and matching both take place at NOC **106**. Here, MCD **101** collects audio samples and transmits the raw data to NCC **106**. NOC **106** transforms the raw data to a signature stream; alternatively, the candidate signature data stream can instead be generated at media receivers **111** and/or provided directly to NOC **106** from some other source. NOC **106** then identifies matches between the signature stream and the candidate data signature streams. This configuration reduces the processing load on MCD **101**.

In any of these configurations, NOC **106** can optionally inform MCD **101** to only sample audio at specific time periods. In this way, MCD **101** sample period may be limited to commercial time periods, or other periods of interest.

In an alternative embodiment, MCD **101** stores feature-extracted samples. When MCD **101** detects (hears) an advertisement or other sought-for audio, it reports back to NOC **106** that it heard the item. In one variation of this embodiment, MCD **101** does not need to transmit any transformed audio back to NOC **106**, but simply reports and identifies the item that was heard. In another variation of this embodiment, MCD **101** transmits additional information about the detected audio, such as time and place where it was detected. In yet another variation, MCD **101** transmits the transformed audio (or some subset of it) to NOC **106**, so that additional information can be derived from the detected audio.

In another alternative embodiment, the invention operates at a variable sample rate depending on the amount of usage that is detected. A default, lower sample rate is used when the usage pattern is continuous and/or relatively stable. A higher sample rate is used when changes in usage pattern are detected. In one variation of this embodiment, MCD **101** switches automatically between these rates in response to changing conditions. Any number of different sample rates, or continuous variation within a defined range, can be used.

Data Signature Algorithm

In one embodiment, the present invention performs audio data signature transformation according to any of a number of well-known algorithms. Preferably, an algorithm is used that meets the processing power, memory size, battery life, and bandwidth constraints of MCD **101**, and also meets a minimum accuracy requirement. The audio data signature transformation algorithm finds matching audio streams in broadcast audio signals, known to be transmitted at a certain time, and asynchronous audio signals such as music tracks and video game sound tracks.

The algorithm can be based in the time-domain, based in the frequency-domain, or based in a hybrid of the two.

In one embodiment, the audio data signature transformation algorithm correlates a consumer data signature stream (target media items) against a potentially large number of candidate data signature streams (reference media items). Once a match is found, it can be presumed the match continues for some period of time. In one embodiment, only the candidate data signature stream is correlated against until there is no longer a match. In other words, when a match is found, it is "locked on to" and no other candidate data signature streams are considered until the match fails.

In one embodiment, the system of the present invention uses a signature transformation algorithm as described in Avery Li-chun Wang, "An Industrial-Strength Audio Search Algorithm," October 2003, and Avery Li-Chun Wang and Julius O. Smith, III, WIPO publication WO0211123A3, 7 Feb. 2002, "Method for Search in an Audio Database."

In one embodiment, the parameters of the audio acquisition (sampling rate, sampling duty cycle, quiescent time between sampling periods, volume, filter parameters, and the like), and even the algorithm in use, can be adjusted dynamically by MCD **101** and/or by NOC **106**. These adjustments may be a function of location information downloaded to MCD **101** from NOC **106** in advance or in near real-time based on current location. These adjustments are performed, for example, to increase matching accuracy, minimize data transmission, minimize MCD **101** battery drain, and for other system performance optimizations. For example, if uploading of data signatures can be carried out close to real-time, and NOC **106** has "locked on" to a matching signal, MCD **101** may be instructed to lower its sampling duty cycle or to suspend sampling for some period of time.

The audio sampling can be continuous or periodic; in one embodiment, 10 seconds are sampled every 30 seconds.

Location Information

In one embodiment, location of MCD **101** is determined by built-in or added-in GPS, by triangulation with wireless data provider transceiver sites, by closest tower identification, by wireless data network registration (Bluetooth, WiFi/802.11), or by other means. Location data can be analyzed and compared with location databases to determine entry into a store or other location, time spent in the location, speed of travel, presence at a public venue (movie theater, concert hall, stadium), and other attributes that may be of commercial value when combined with media consumption. For example, in one embodiment, location information is used to detect when a user takes a car for a test drive by tracking the entry into a car dealership, an average wait time, and a circuit of automobile-speed motion ending back at the dealership.

Purchase Tracking Credit Card

In one embodiment, the present invention provides a mechanism for correlating exposure to media items with purchases. Users are given credit cards to be used for making purchases. Purchase behavior, at least to the resolution of store and amount, is available from the partner affinity card issuer. Other methods for collecting this data may include use of an RFID tag and/or a barcode on MCD **101**. For example, many merchants, most notably grocery stores with affinity cards, store detailed purchase history information about their customers. The media measurement system can access this data in order to provide purchase information to the system of the present invention. In one embodiment, a bar code or other identifying indicia can be provided on MCD **101** itself, so that the user can simply hand the device to the grocery store clerk for "swiping"; alternatively, MCD **101** can be detected via RFID or other mechanisms, and the code detected thereby can be linked to the user's affinity program record.

User Compliance

In one embodiment, MCD **101** includes sensors to help determine if it is in the possession of a person. Sensors may include: vibration, state of the Hosting Device (on/off, usage, key presses, etc.), temperature (to detect whether MCD **101** is being carried, since it will be proximate to or in contact with the person's body), and others. Information from these sensors is processed to assist in determining whether a user is carrying MCD **101** as needed for accurate results. If data is received at a time period when evidence indicates the device is not being carried, the received data may be discarded or treated as having a lower degree of reliability, or it may be otherwise flagged.

In the above description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the invention. It will be apparent, however, to one skilled in the art that the invention can be practiced without these specific details. In other instances, structures and devices are shown in block diagram form in order to avoid obscuring the invention.

In particular, one skilled in the art will recognize that other architectures and analysis and processing techniques and mechanisms may be used, and that the present invention can be implemented using mechanisms other than those described above.

Reference in the specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the invention. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment.

Some portions of the detailed description are presented in terms of algorithms and symbolic representations of operations on data bits within a computer memory. These algorithmic descriptions and representations are the means used by those skilled in the data processing arts to most effectively convey the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities. Usually, though not necessarily, these quantities take the form of electrical or magnetic signals capable of being stored, transferred, combined, compared, and otherwise manipulated. It has proven convenient at times, principally for reasons of common usage, to refer to these signals as bits, values, elements, symbols, characters, terms, numbers, or the like.

It should be borne in mind, however, that all of these and similar terms are to be associated with the appropriate physical quantities and are merely convenient labels applied to these quantities. Unless specifically stated otherwise as apparent from the discussion, it is appreciated that throughout the description, discussions utilizing terms such as "processing" or "computing" or "calculating" or "determining" or "displaying" or the like, refer to the action and processes of a computer system, or similar electronic computing device, that manipulates and transforms data represented as physical (electronic) quantities within the computer system's registers and memories into other data similarly represented as physical quantities within the computer system memories or registers or other such information storage, transmission or display devices.

The present invention also relates to an apparatus for performing the operations herein. This apparatus may be specially constructed for the required purposes, or it may comprise a general-purpose computer selectively activated or reconfigured by a computer program stored in the computer. Such a computer program may be stored in a computer readable storage medium, such as, but is not limited to, any type of disk including floppy disks, optical disks, CD-ROMs, and magnetic-optical disks, read-only memories (ROMs), random access memories (RAMs), EPROMs, EEPROMs, magnetic or optical cards, or any type of media suitable for storing electronic instructions, and each coupled to a computer system bus.

The algorithms and modules presented herein are not inherently related to any particular computer or other apparatus. Various general-purpose systems may be used with programs in accordance with the teachings herein, or it may prove convenient to construct more specialized apparatuses to perform the method steps. The required structure for a variety of these systems will appear from the description below. In addition, the present invention is not described with reference to any particular programming language. It will be appreciated that a variety of programming languages may be used to implement the teachings of the invention as described herein. Furthermore, as will be apparent to one of ordinary skill in the relevant art, the modules, features, attributes, methodologies, and other aspects of the invention can be implemented as software, hardware, firmware or any combination of the three. Of course, wherever a component of the present invention is implemented as software, the component can be implemented as a standalone program, as part of a larger program, as a plurality of separate programs, as a statically or dynamically linked library, as a kernel loadable module, as a device driver, and/or in every and any other way known now or in the future to those of skill in the art of

computer programming. Additionally, the present invention is in no way limited to implementation in any specific operating system or environment.

It will be understood by those skilled in the relevant art that the above-described implementations are merely exemplary, and many changes can be made without departing from the true spirit and scope of the present invention. Therefore, it is intended by the appended claims to cover all such changes and modifications that come within the true spirit and scope of this invention.

What is claimed is:

1. A system for detecting user exposure to media items, comprising:

a server, for receiving a plurality of reference media items from at least one media receiver;

at least one stream collection server, for receiving a representation of at least one target media item from at least one client device;

a stream store, coupled to the server and to the at least one stream collection server, for storing a representation of at least a subset of the received reference media items and for storing a representation of the at least one target media item;

a correlator server, coupled to the stream store, for identifying one of the reference media items as corresponding to the target media item;

an output device, coupled to the correlator server, for generating output signaling user exposure to the identified reference media item; and

a location tracking server for detecting a location for the client device;

wherein the correlator server correlates the detected location with a location of at least one geographically identifiable sponsor of a reference media item.

2. The system of claim **1**, wherein the location tracking server detects the location via at least one selected from the group consisting of:

GPS tracking;

RFID tracking;

Bluetooth tracking.

3. A system for detecting user exposure to media items, comprising:

a server, for receiving a plurality of reference media items from at least one media receiver;

at least one stream collection server, for receiving a representation of at least one target media item from at least one client device;

a stream store, coupled to the server and to the at least one stream collection server, for storing a representation of at least a subset of the received reference media items and for storing a representation of the at least one target media item;

a correlator server, coupled to the stream store, for identifying one of the reference media items as corresponding to the target media item; and

an output device, coupled to the correlator server, for generating output signaling user exposure to the identified reference media item;

wherein the plurality of reference media items comprises at least one broadcast, and wherein the representation of at least one target media item indicates user exposure at a time other than the time of the broadcast.

4. A system for detecting user exposure to media items, comprising:

a server, for receiving a plurality of reference media items from at least one media receiver;

at least one stream collection server, for receiving a representation of at least one target media item from at least one client device;

a stream store, coupled to the server and to the at least one stream collection server, for storing a representation of at least a subset of the received reference media items and for storing a representation of the at least one target media item;

a correlator server, coupled to the stream store, for identifying one of the reference media items as corresponding to the target media item;

an output device, coupled to the correlator server, for generating output signaling user exposure to the identified reference media item; and

a purchasing tracking server, for receiving consumer purchasing information;

wherein the output device generates a report correlating user purchasing information with user exposure to the identified reference media item.

5. The system of claim **4**, wherein the purchasing tracking server receives at least one indication of user use of a credit card.

6. A system for detecting user exposure to media items, comprising:

a server, for receiving a plurality of reference media items from at least one media receiver;

a plurality of stream collection servers for receiving a representation of at least one target media item from at least one client device;

a stream store, coupled to the server and to the stream collection servers, for storing a representation of at least a subset of the received reference media items and for storing a representation of the at least one target media item;

a correlator server, coupled to the stream store, for identifying one of the reference media items as corresponding to the target media item;

an output device, coupled to the correlator server, for generating output signaling user exposure to the identified reference media item; and

a stream collection server selector, for selecting, based on at least one of load and geographic proximity to the client device, one of the plurality of data signature stream collection servers to receive the representation of at least one target media item.

7. A method for detecting user exposure to media items, comprising:

receiving a plurality of reference media items from at least one media source;

for at least one client device:

selecting, based on at least one of load and geographic proximity to the client device, one of a plurality of data signature stream collection servers; and

at the selected data signature stream collection server, receiving, from the client device:

a representation of at least one target media item; and

an indication as to whether the client device is in the physical possession of a person at a time of exposure to the target media item; and

responsive to an indication that the client device is in the physical possession of a person at the time of exposure to the target media item:

identifying one of the reference media items as corresponding to the target media item; and

generating output signaling user exposure to the identified reference media item.

8. The method of claim 7, further comprising:

responsive to an indication that the client device is not in the physical possession of a person at the time of exposure to the target media item, ignoring the representation of the at least one target media item from the client device.

9. The method of claim 7, further comprising:

responsive to an indication that the client device is not in the physical possession of a person at the time of exposure to the target media item:

identifying one of the reference media items as corresponding to the target media item; and

generating output signaling user exposure to the identified reference media item, wherein the output is flagged as having reduced reliability.

10. The method of claim 7, wherein the indication as to whether the client device is in the physical possession of a person is provided based on output of at least one sensor associated with the client device.

11. The method of claim 10, wherein the at least one sensor detects at least one selected from the group consisting of:

vibration of the client device;

key presses on the client device;

temperature of the client device; and

movement of the client device.

12. A system for detecting user exposure to media items, comprising:

a server, for receiving a plurality of reference media items from at least one media receiver;

at least one stream collection server, for, receiving, from at least one client device:

a representation of at least one target media item from at least one client device;

an indication as to whether the client device is in the physical possession of a person at a time of exposure to the target media item; and

a stream store, coupled to the server and to the at least one stream collection server, for:

storing a representation of at least a subset of the received reference media items; and

responsive to an indication that the client device is in the physical possession of a person at the time of exposure to the target media item, storing a representation of the target media item;

a correlator server, coupled to the stream store, for, for each stored representation of a target media item, identifying one of the reference media items as corresponding to the target media item; and

an output device, coupled to the correlator server, for, for each identified reference media item, generating output signaling user exposure to the identified reference media item.

13. The system of claim 12, wherein the stream store:

responsive to an indication that the client device is not in the physical possession of a person at the time of exposure to the target media item, ignores the representation of the target media item.

14. The system of claim 12, wherein, responsive to an indication that the client device is not in the physical possession of a person at the time of exposure to the target media item:

the stream store stores a representation of the target media item and an indication of reduced reliability of the stored representation;

the correlator server identifies one of the reference media items as corresponding to the target media item; and

the output device, generates output signaling user exposure to the identified reference media item and indicates reduced reliability of the indication of user exposure.

15. The system of claim 12, wherein the indication as to whether the client device is in the physical possession of a person is provided based on output of at least one sensor associated with the client device.

16. The system of claim 15, wherein the at least one sensor detects at least one selected from the group consisting of:

vibration of the client device;

key presses on the client device;

temperature of the client device; and

movement of the client device.

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