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Linden et al.

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(54) **COLLABORATIVE RECOMMENDATIONS USING ITEM-TO-ITEM SIMILARITY MAPPINGS**

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(58) **Field of Search** 705/26, 27, 14; 235/383; 380/24; 455/5.1, 450; 707/3, 102; 709/227

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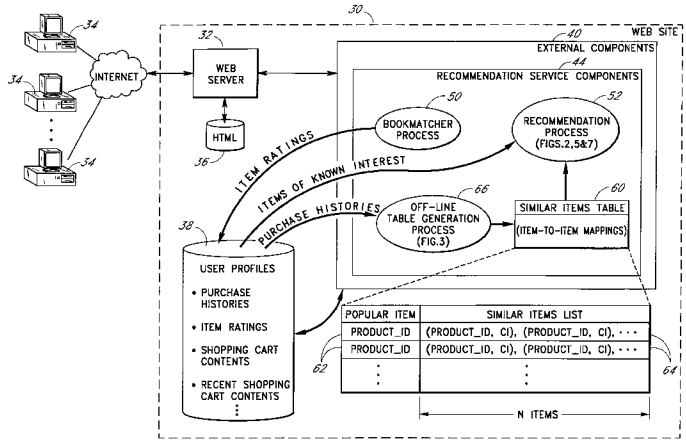
(57) **ABSTRACT**

A recommendations service recommends items to individual users based on a set of items that are known to be of interest to the user, such as a set of items previously purchased by the user. In the disclosed embodiments, the service is used to recommend products to users of a merchant's Web site. The service generates the recommendations using a previously-generated table which maps items to lists of "similar" items. The similarities reflected by the table are based on the collective interests of the community of users. For example, in one embodiment, the similarities are based on correlations between the purchases of items by users (e.g., items A and B are similar because a relatively large portion of the users that purchased item A also bought item B). The table also includes scores which indicate degrees of similarity between individual items. To generate personal recommendations, the service retrieves from the table the similar items lists corresponding to the items known to be of interest to the user. These similar items lists are appropriately combined into a single list, which is then sorted (based on combined similarity scores) and filtered to generate a list of recommended items. Also disclosed are various methods for using the current and/or past contents of a user's electronic shopping cart to generate recommendations. In one embodiment, the user can create multiple shopping carts, and can use the recommendation service to obtain recommendations that are specific to a designated shopping cart. In another embodiment, the recommendations are generated based on the current contents of a user's shopping cart, so that the recommendations tend to correspond to the current shopping task being performed by the user.

49 Claims, 7 Drawing Sheets



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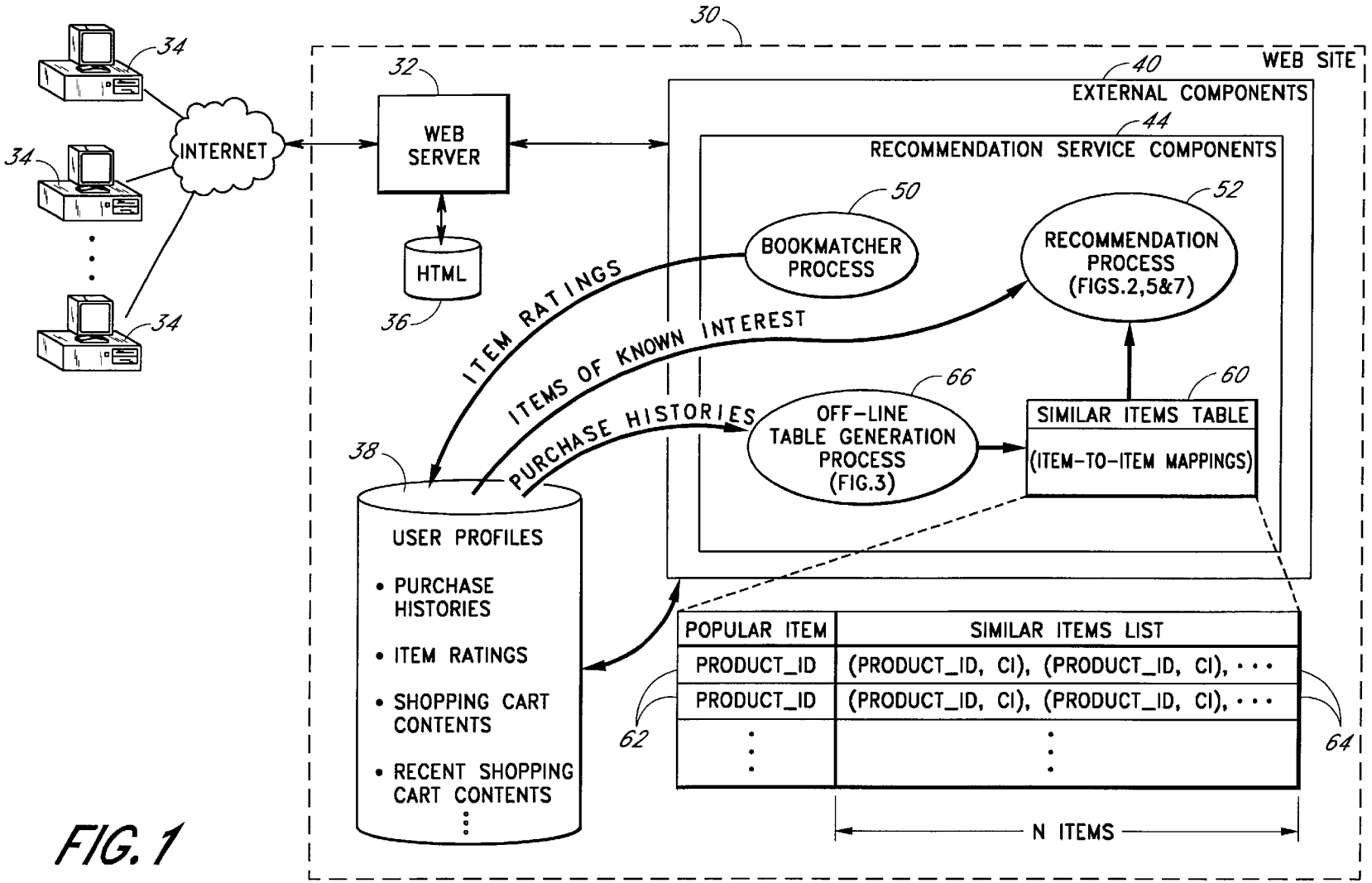
30
WEB SITE
34
34
34
INTERNET
32
WEB SERVER
HTML
36
40
EXTERNAL COMPONENTS
44
RECOMMENDATION SERVICE COMPONENTS
50
BOOKMATCHER PROCESS
52
RECOMMENDATION PROCESS (FIGS.2,5&7)
ITEM RATINGS
ITEMS OF KNOWN INTEREST
PURCHASE HISTORIES
66
OFF-LINE TABLE GENERATION PROCESS (FIG.3)
60
SIMILAR ITEMS TABLE
(ITEM-TO-ITEM MAPPINGS)
38
USER PROFILES
• PURCHASE HISTORIES
• ITEM RATINGS
• SHOPPING CART CONTENTS
• RECENT SHOPPING CART CONTENTS
POPULAR ITEM
SIMILAR ITEMS LIST
PRODUCT_ID
(PRODUCT_ID, CI), (PRODUCT_ID, CI), ...
PRODUCT_ID
(PRODUCT_ID, CI), (PRODUCT_ID, CI), ...
62
64
N ITEMS

FIG. 1

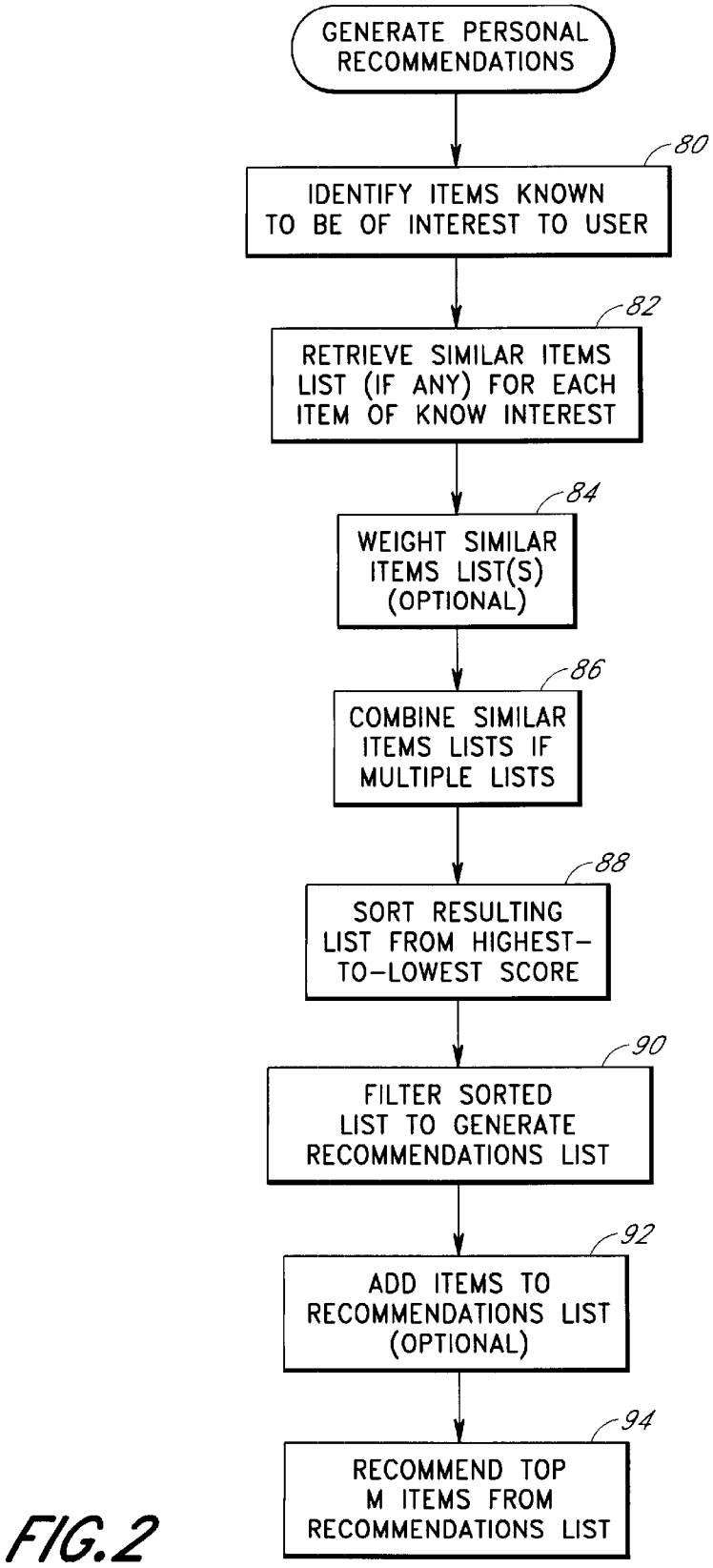
GENERATE PERSONAL RECOMMENDATIONS
80
IDENTIFY ITEMS KNOWN TO BE OF INTEREST TO USER
82
RETRIEVE SIMILAR ITEMS LIST (IF ANY) FOR EACH ITEM OF KNOW INTEREST
84
WEIGHT SIMILAR ITEMS LIST(S) (OPTIONAL)
86
COMBINE SIMILAR ITEMS LISTS IF MULTIPLE LISTS
88
SORT RESULTING LIST FROM HIGHEST-TO-LOWEST SCORE
90
FILTER SORTED LIST TO GENERATE RECOMMENDATIONS LIST
92
ADD ITEMS TO RECOMMENDATIONS LIST (OPTIONAL)
94
RECOMMEND TOP M ITEMS FROM RECOMMENDATIONS LIST

FIG. 2

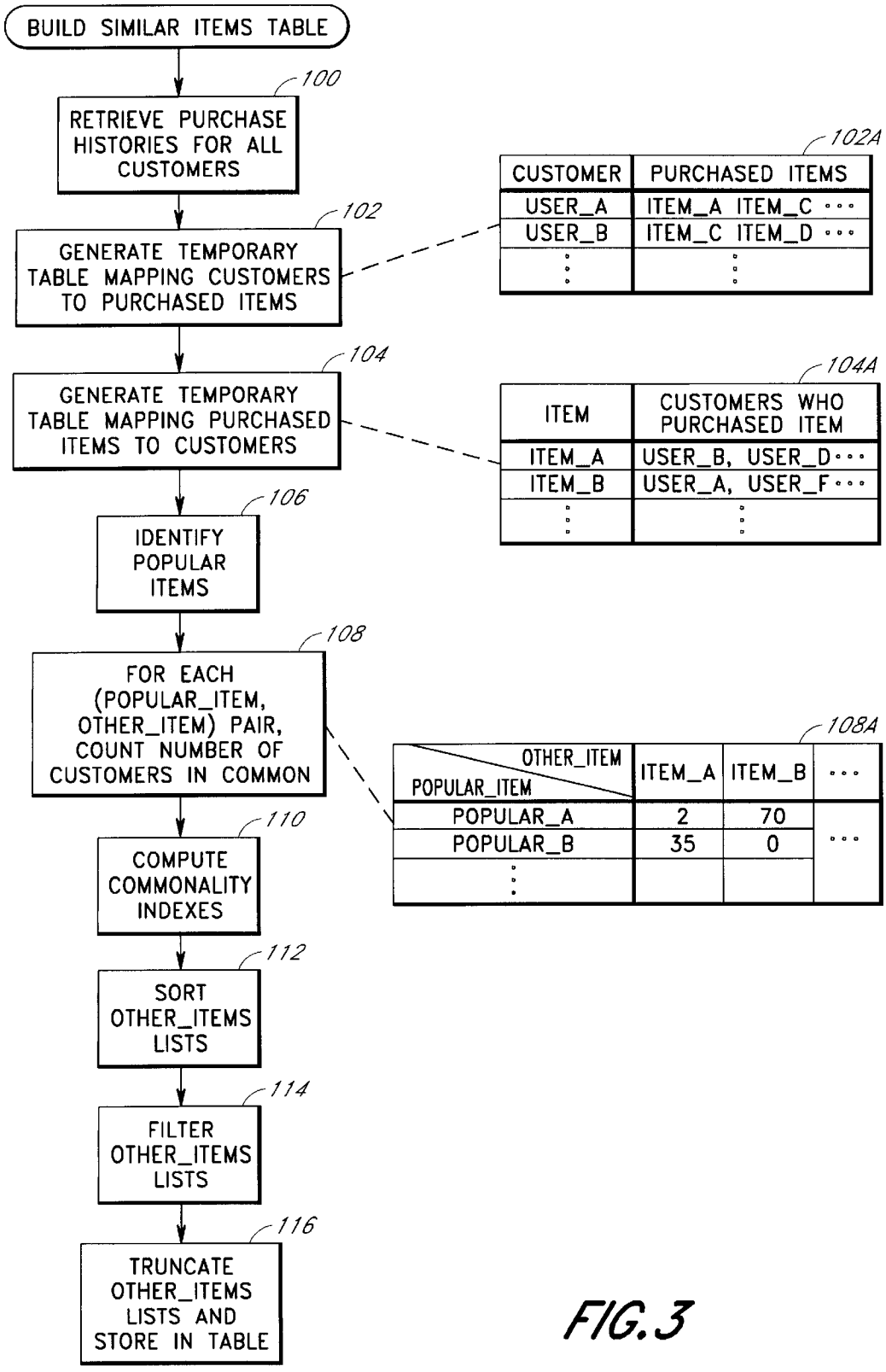
BUILD SIMILAR ITEMS TABLE
100
RETRIEVE PURCHASE HISTORIES FOR ALL CUSTOMERS
102
GENERATE TEMPORARY TABLE MAPPING CUSTOMERS TO PURCHASED ITEMS
102A
CUSTOMER
PURCHASED ITEMS
USER_A
ITEM_A ITEM_C ···
USER_B
ITEM_C ITEM_D ···
104
GENERATE TEMPORARY TABLE MAPPING PURCHASED ITEMS TO CUSTOMERS
104A
ITEM
CUSTOMERS WHO PURCHASED ITEM
ITEM_A
USER_B, USER_D···
ITEM_B
USER_A, USER_F···
106
IDENTIFY POPULAR ITEMS
108
FOR EACH (POPULAR_ITEM, OTHER_ITEM) PAIR, COUNT NUMBER OF CUSTOMERS IN COMMON
108A
OTHER_ITEM
POPULAR_ITEM
ITEM_A
ITEM_B
···
POPULAR_A
2
70
POPULAR_B
35
0
110
COMPUTE COMMONALITY INDEXES
112
SORT OTHER_ITEMS LISTS
114
FILTER OTHER_ITEMS LISTS
116
TRUNCATE OTHER_ITEMS LISTS AND STORE IN TABLE

FIG. 3

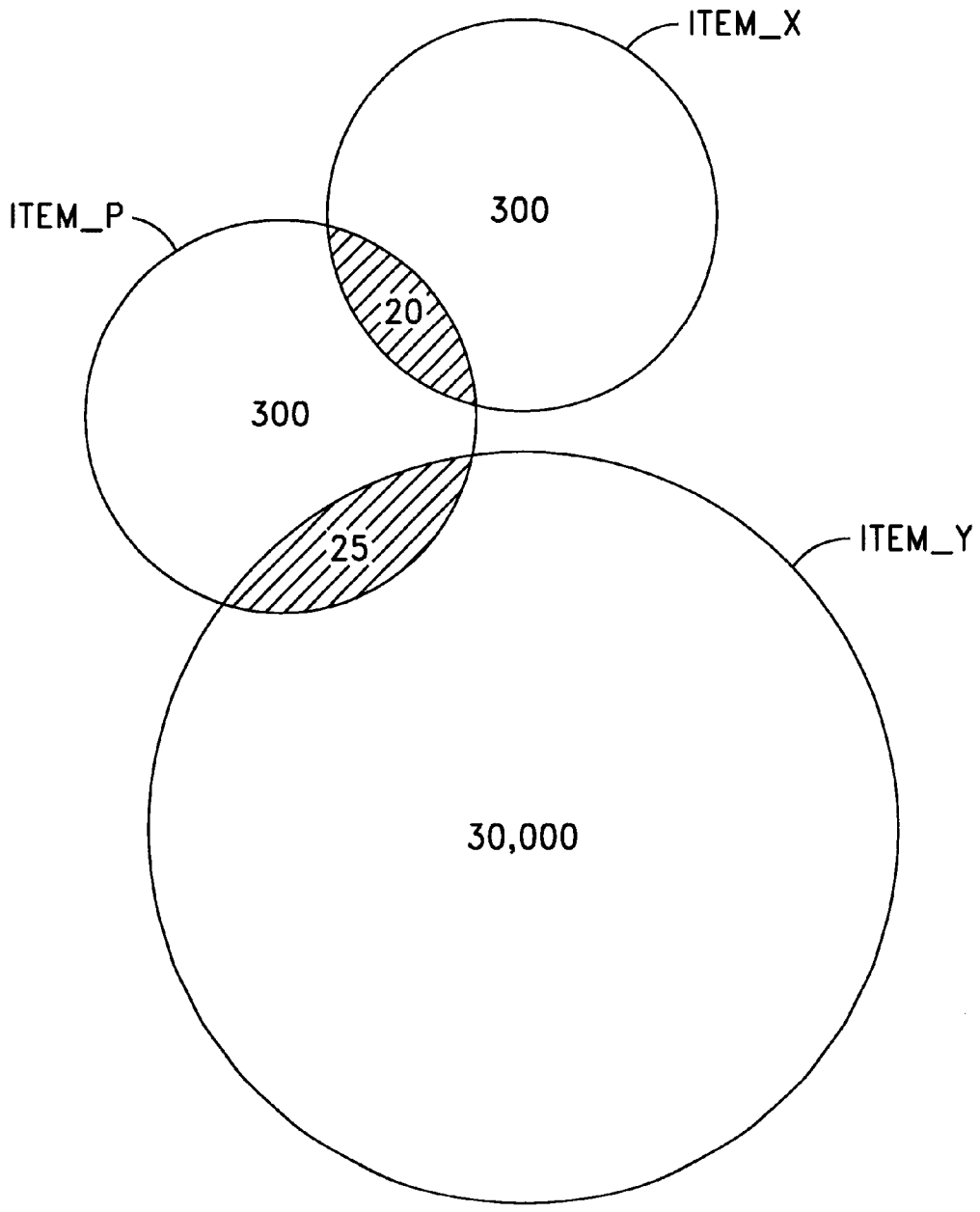

FIG. 4

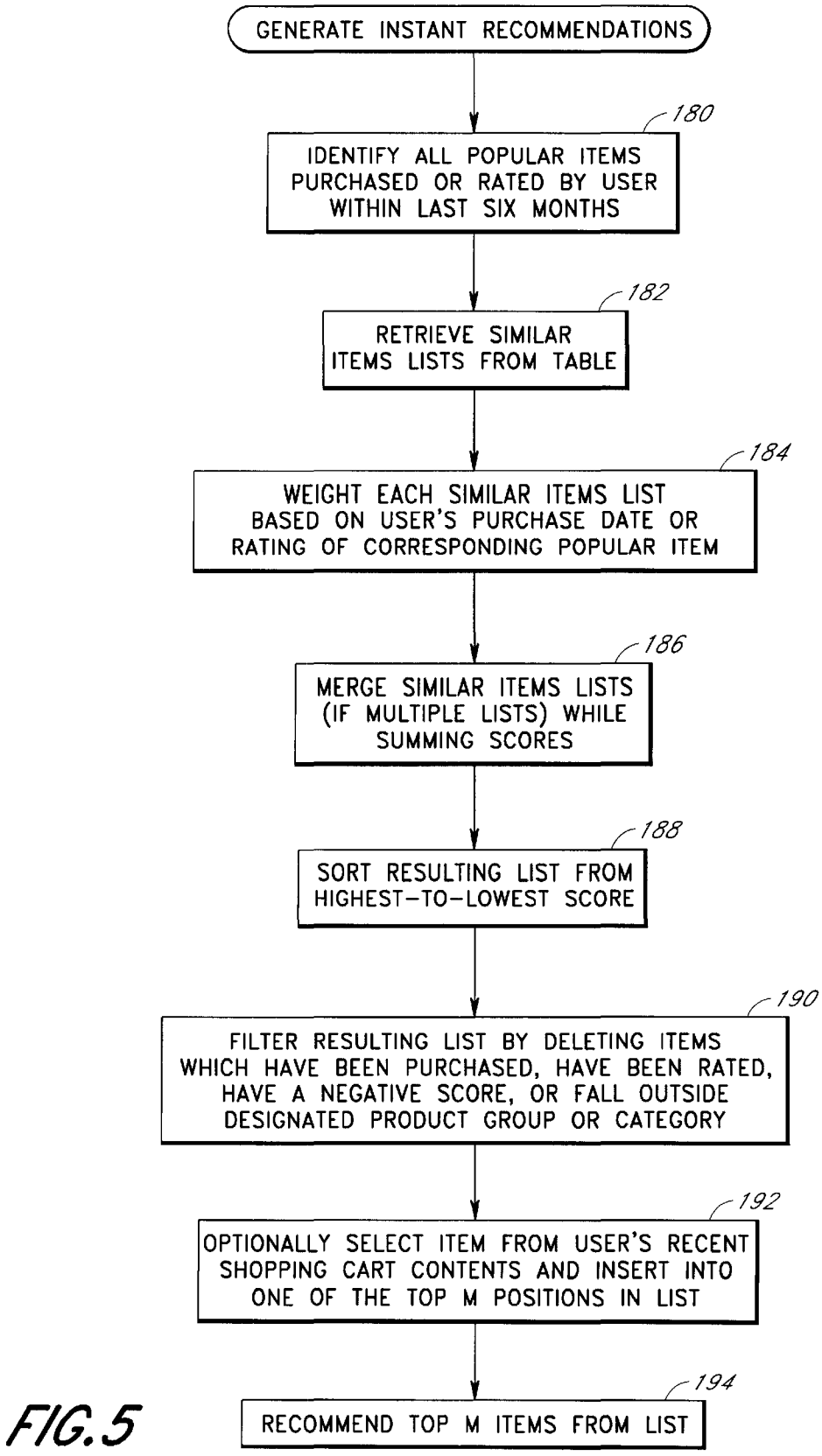
GENERATE INSTANT RECOMMENDATIONS
180
IDENTIFY ALL POPULAR ITEMS PURCHASED OR RATED BY USER WITHIN LAST SIX MONTHS
182
RETRIEVE SIMILAR ITEMS LISTS FROM TABLE
184
WEIGHT EACH SIMILAR ITEMS LIST BASED ON USER'S PURCHASE DATE OR RATING OF CORRESPONDING POPULAR ITEM
186
MERGE SIMILAR ITEMS LISTS (IF MULTIPLE LISTS) WHILE SUMMING SCORES
188
SORT RESULTING LIST FROM HIGHEST-TO-LOWEST SCORE
190
FILTER RESULTING LIST BY DELETING ITEMS WHICH HAVE BEEN PURCHASED, HAVE BEEN RATED, HAVE A NEGATIVE SCORE, OR FALL OUTSIDE DESIGNATED PRODUCT GROUP OR CATEGORY
192
OPTIONALLY SELECT ITEM FROM USER'S RECENT SHOPPING CART CONTENTS AND INSERT INTO ONE OF THE TOP M POSITIONS IN LIST
194
RECOMMEND TOP M ITEMS FROM LIST

FIG. 5

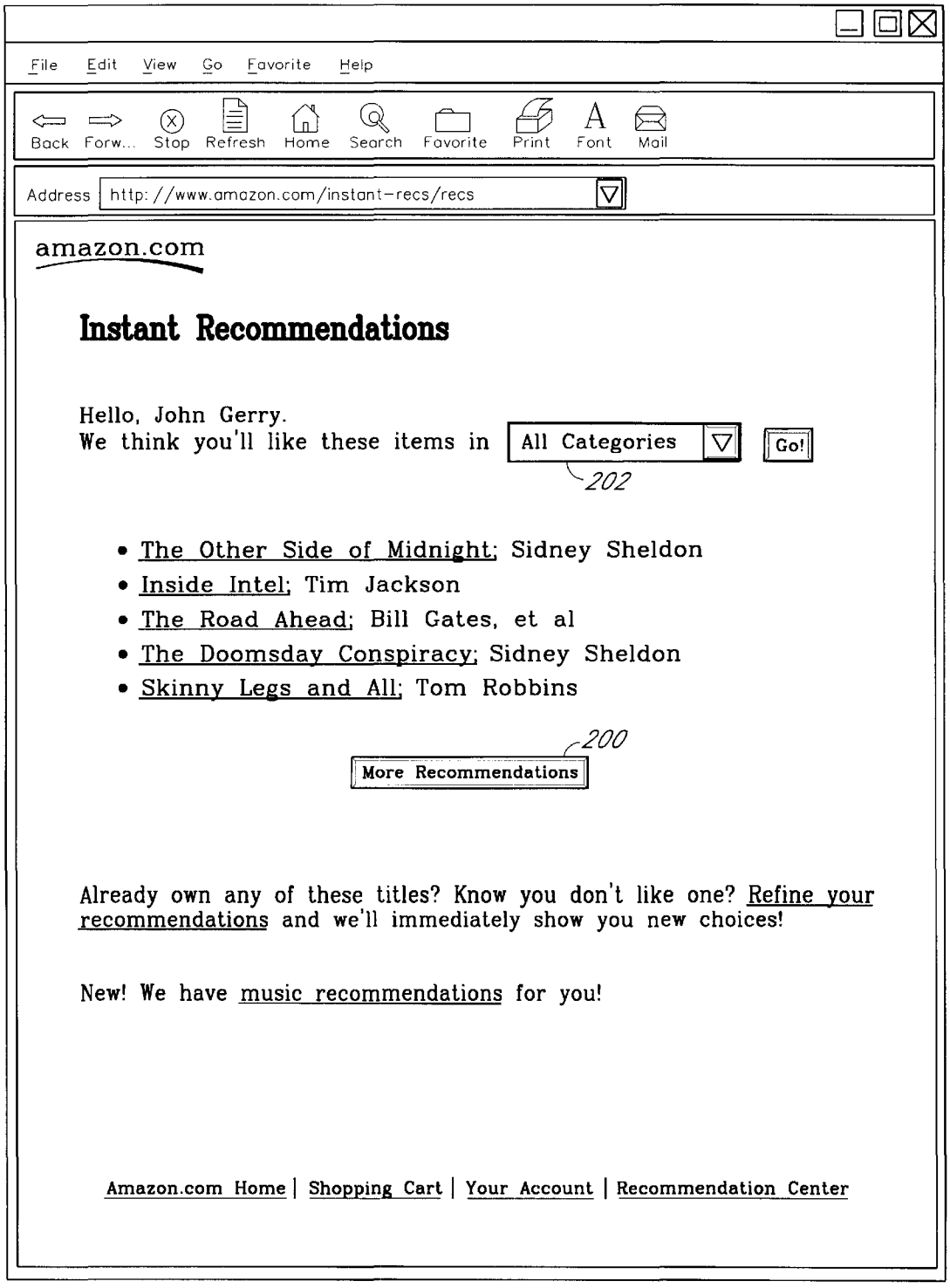
File Edit View Go Favorite Help
Back Forw... Stop Refresh Home Search Favorite Print Font Mail
Address http://www.amazon.com/instant-recs/recs
amazon.com
Instant Recommendations
Hello, John Gerry.
We think you'll like these items in All Categories Go!
202
The Other Side of Midnight; Sidney Sheldon
Inside Intel; Tim Jackson
The Road Ahead; Bill Gates, et al
The Doomsday Conspiracy; Sidney Sheldon
Skinny Legs and All; Tom Robbins
200
More Recommendations
Already own any of these titles? Know you don't like one? Refine your recommendations and we'll immediately show you new choices!
New! We have music recommendations for you!
Amazon.com Home | Shopping Cart | Your Account | Recommendation Center

FIG. 6

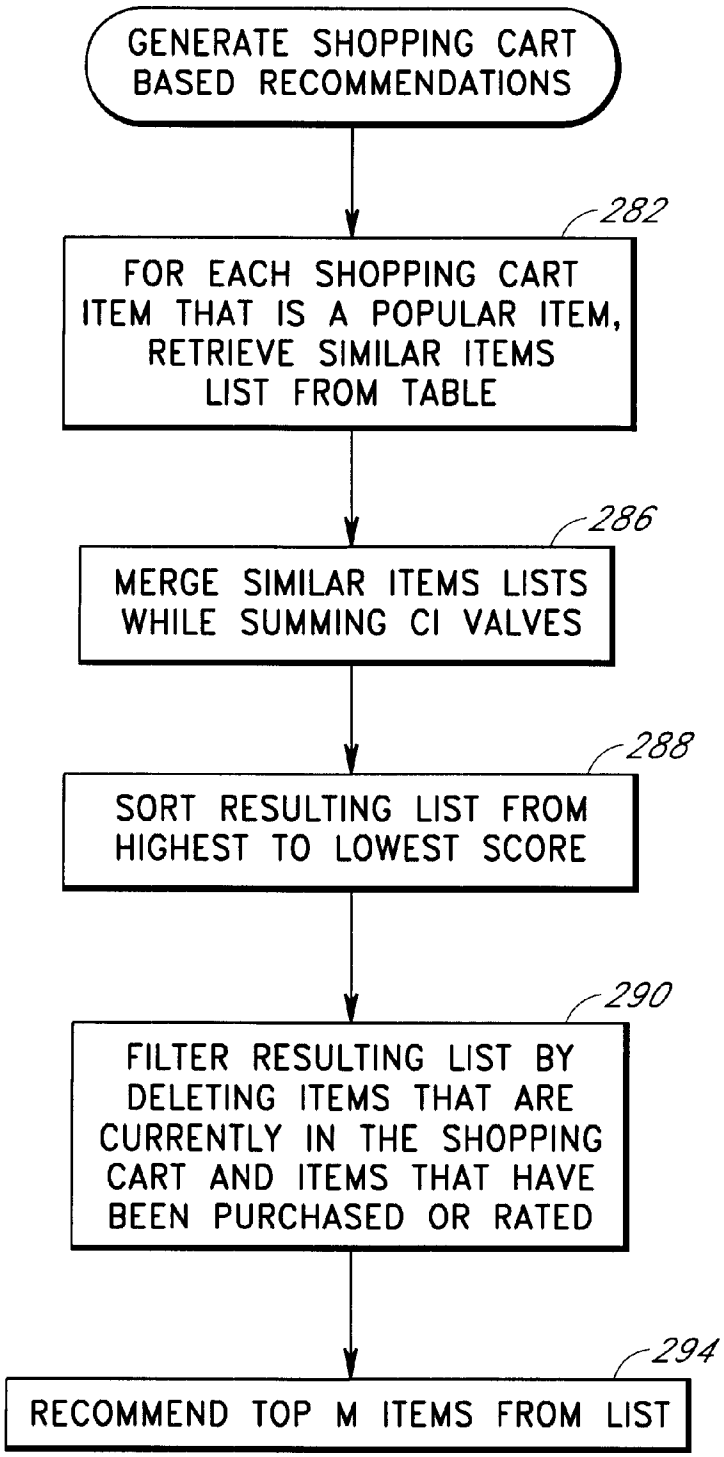
GENERATE SHOPPING CART BASED RECOMMENDATIONS
282
FOR EACH SHOPPING CART ITEM THAT IS A POPULAR ITEM, RETRIEVE SIMILAR ITEMS LIST FROM TABLE
286
MERGE SIMILAR ITEMS LISTS WHILE SUMMING CI VALVES
288
SORT RESULTING LIST FROM HIGHEST TO LOWEST SCORE
290
FILTER RESULTING LIST BY DELETING ITEMS THAT ARE CURRENTLY IN THE SHOPPING CART AND ITEMS THAT HAVE BEEN PURCHASED OR RATED
294
RECOMMEND TOP M ITEMS FROM LIST

FIG. 7

COLLABORATIVE RECOMMENDATIONS USING ITEM-TO-ITEM SIMILARITY MAPPINGS

FIELD OF THE INVENTION

The present invention relates to information filtering and recommendation systems. More specifically, the invention relates to methods for predicting the interests of individual users based on the known interests of a community of users.

BACKGROUND OF THE INVENTION

A recommendation service is a computer-implemented service that recommends items from a database of items. The recommendations are customized to particular users based on information known about the users. One common application for recommendation services involves recommending products to online customers. For example, online merchants commonly provide services for recommending products (books, compact discs, videos, etc.) to customers based on profiles that have been developed for such customers. Recommendation services are also common for recommending Web sites, articles, and other types of informational content to users.

One technique commonly used by recommendation services is known as content-based filtering. Pure content-based systems operate by attempting to identify items which, based on an analysis of item content, are similar to items that are known to be of interest to the user. For example, a content-based Web site recommendation service may operate by parsing the user's favorite Web pages to generate a profile of commonly-occurring terms, and then use this profile to search for other Web pages that include some or all of these terms.

Content-based systems have several significant limitations. For example, content-based methods generally do not provide any mechanism for evaluating the quality or popularity of an item. In addition, content-based methods generally require that the items include some form of content that is amenable to feature extraction algorithms; as a result, content-based systems tend to be poorly suited for recommending movies, music titles, authors, restaurants, and other types of items that have little or no useful, parsable content.

Another common recommendation technique is known as collaborative filtering. In a pure collaborative system, items are recommended to users based on the interests of a community of users, without any analysis of item content. Collaborative systems commonly operate by having the users rate individual items from a list of popular items. Through this process, each user builds a personal profile of ratings data. To generate recommendations for a particular user, the user's profile is initially compared to the profiles of other users to identify one or more "similar users." Items that were rated highly by these similar users (but which have not yet been rated by the user) are then recommended to the user. An important benefit of collaborative filtering is that it overcomes the above-noted deficiencies of content-based filtering.

As with content-based filtering methods, however, existing collaborative filtering techniques have several problems. One problem is that the user is commonly faced with the onerous task of having to rate items in the database to build up a personal ratings profile. This task can be frustrating, particularly if the user is not familiar with many of the items that are presented for rating purposes. Further, because collaborative filtering relies on the existence of other, similar users, collaborative systems tend to be poorly suited for providing recommendations to users that have unusual tastes.

Another problem with collaborative filtering techniques is that an item in the database normally cannot be recommended until the item has been rated. As a result, the operator of a new collaborative recommendation system is commonly faced with a "cold start" problem in which the service cannot be brought online in a useful form until a threshold quantity of ratings data has been collected. In addition, even after the service has been brought online, it may take months or years before a significant quantity of the database items can be recommended.

Another problem with collaborative filtering methods is that the task of comparing user profiles tends to be time consuming —particularly if the number of users is large (e.g., tens or hundreds of thousands). As a result, a tradeoff tends to exist between response time and breadth of analysis. For example, in a recommendation system that generates real-time recommendations in response to requests from users, it may not be feasible to compare the user's ratings profile to those of all other users. A relatively shallow analysis of the available data (leading to poor recommendations) may therefore be performed.

Another problem with both collaborative and content-based systems is that they generally do not reflect the current preferences of the community of users. In the context of a system that recommends products to customers, for example, there is typically no mechanism for favoring items that are currently "hot sellers." In addition, existing systems do not provide a mechanism for recognizing that the user may be searching for a particular type or category of item.

SUMMARY OF THE DISCLOSURE

The present invention addresses these and other problems by providing a computer-implemented service and associated methods for generating personalized recommendations of items based on the collective interests of a community of users. An important benefit of the service is that the recommendations are generated without the need for the user, or any other users, to rate items. Another important benefit is that the recommended items are identified using a previously-generated table or other mapping structure which maps individual items to lists of "similar" items. The item similarities reflected by the table are based at least upon correlations between the interests of users in particular items.

The types of items that can be recommended by the service include, without limitation, books, compact discs ("CDs"), videos, authors, artists, item categories Web sites, and chat groups. The service may be implemented, for example, as part of a Web site, online services network, e-mail notification service, document filtering system, or other type of computer system that explicitly or implicitly recommends items to users. In a preferred embodiment described herein, the service is used to recommend works such as book titles and music titles to users of an online merchant's Web site.

In accordance with one aspect of the invention, the mappings of items to similar items ("item-to-item mappings") are generated periodically, such as once per week, by an off-line process which identifies correlations between known interests of users in particular items. For example, in the embodiment described in detail below, the mappings are generating by periodically analyzing user purchase histories to identify correlations between purchases of items. The similarity between two items is preferably measured by determining the number of users that have an interest in both items relative to the number of users

that have an interest in either item (e.g., items A and B are highly similar because a relatively large portion of the users that bought one of the items also bought the other item). The item-to-item mappings could also incorporate other types of similarities, including content-based similarities extracted by analyzing item descriptions or content.

To generate a set of recommendations for a given user, the service retrieves from the table the similar items lists corresponding to items already known to be of interest to the user, and then appropriately combines these lists to generate a list of recommended items. For example, if there are three items that are known to be of interest to the user (such as three items the user recently purchased), the service may retrieve the similar items lists for these three items from the table and combine these lists. Because the item-to-item mappings are regenerated periodically based on up-to-date sales data, the recommendations tend to reflect the current buying trends of the community.

In accordance with another aspect of the invention, the similar items lists read from the table may be appropriately weighted (prior to being combined) based on indicia of the user's affinity for, or current interest in, the corresponding items of known interest. For example, the similar items list for a book that was purchased in the last week may be weighted more heavily than the similar items list for a book that was purchased four months ago. Weighting a similar items list heavily has the effect of increasing the likelihood that the items in that list will be included in the recommendations that are ultimately presented to the user.

An important aspect of the service is that the relatively computation-intensive task of correlating item interests is performed off-line, and the results of this task (item-to-item mappings) stored in a mapping structure for subsequent look-up. This enables the personal recommendations to be generated rapidly and efficiently (such as in real-time in response to a request by the user), without sacrificing breadth of analysis.

Another feature of the invention involves using the current and/or recent contents of the user's shopping cart as inputs to the recommendation service (or to another type of recommendation service which generates recommendations given a unary listing of items). For example, if the user currently has three items in his or her shopping cart, these three items can be treated as the items of known interest for purposes of generating recommendations, in which case the recommendations may be generated and displayed automatically when the user views the shopping cart contents. Using the current and/or recent shopping cart contents as inputs tends to produce recommendations that are highly correlated to the current short-term interests of the user—even if these short term interest differ significantly from the user's general preferences. For example, if the user is currently searching for books on a particular topic and has added several such books to the shopping cart, this method will more likely produce other books that involve the same or similar topics.

Another feature of the invention involves allowing the user to create multiple shopping carts under a single account (such as shopping carts for different family members), and generating recommendations that are specific to a particular shopping cart. For example, the user can be prompted to select a particular shopping cart (or set of shopping carts), and the recommendations can then be generated based on the items that were purchased from or otherwise placed into the designated shopping cart(s). This feature of the invention allows users to obtain recommendations that correspond to the role or purpose (e.g., work versus pleasure) of a particular shopping cart.

Two specific implementations of the service are disclosed, both of which generate personal recommendations using the same type of table. In the first implementation, the recommendations are based on the items that have recently been rated or purchased by the user. In the second implementation, the recommendations are based on the current shopping cart contents of the user.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the invention will now be described with reference to the drawings summarized below. These drawings and the associated description are provided to illustrate a preferred embodiment of the invention, and not to limit the scope of the invention.

FIG. **1** illustrates a Web site which implements a recommendation service which operates in accordance with the invention, and illustrates the flow of information between components.

FIG. **2** illustrates a sequence of steps that are performed by the recommendation process of FIG. **1** to generate personalized recommendations.

FIG. **3** illustrates a sequence of steps that are performed by the table generation process of FIG. **1** to generate a similar items table, and illustrates temporary data structures generated during the process.

FIG. **4** is a Venn diagram illustrating a hypothetical purchase history profile of three items.

FIG. **5** illustrates one specific implementation of the sequence of steps of FIG. **2**.

FIG. **6** illustrates the general form of a Web pages used to present the recommendations of the FIG. **5** process to the user.

FIG. **7** illustrates another specific implementation of the sequence of steps of FIG. **2**.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The various features and methods of the invention will now be described in the context of a recommendation service, including two specific implementations thereof, that is used to recommend book titles, music titles, video titles, and other types of items to individual users of the Amazon.com Web site. As will be recognized to those skilled in the art, the disclosed methods can also be used to recommend other types of items, including non-physical items. By way of example and not limitation, the disclosed methods can also be used to recommend authors, artists, categories or groups of titles, Web sites, chat groups, movies, television shows, downloadable content, restaurants, and other users.

Throughout the description, reference will be made to various implementation-specific details of the recommendation service, the Amazon.com Web site, and other recommendation services of the Web site. These details are provided in order to fully illustrate preferred embodiments of the invention, and not to limit the scope of the invention. The scope of the invention is set forth in the appended claims.

I. Overview of Web Site and Recommendation Services

The Amazon.com Web site includes functionality for allowing users to search, browse, and make purchases from an online catalog of several million book titles, music titles, video titles, and other types of items. Using a shopping cart feature of the site, users can add and remove items to/from a personal shopping cart which is persistent over multiple sessions. (As used herein, a "shopping cart" is a data structure and associated code which keeps track of items that

have been selected by a user for possible purchase.) For example, a user can modify the contents of the shopping cart over a period of time, such as one week, and then proceed to a check out area of the site to purchase the shopping cart contents.

The user can also create multiple shopping carts within a single account. For example, a user can set up separate shopping carts for work and home, or can set up separate shopping carts for each member of the user's family. A preferred shopping cart scheme for allowing users to set up and use multiple shopping carts is disclosed in U.S. application Ser. No. 09/104,942, filed Jun. 25, 1998, titled METHOD AND SYSTEM FOR ELECTRONIC COMMERCE USING MULTIPLE ROLES, the disclosure of which is hereby incorporated by reference.

The site also implements a variety of different recommendation services for recommending book titles, music titles, and/or video titles to users. One such service, known as BookMatcher™, allows users to interactively rate individual books on a scale of 1–5 to create personal item ratings profiles, and applies collaborative filtering techniques to these profiles to generate personal recommendations. The BookMatcher service is described in detail in U.S. application Ser. No. 09/040,171 filed Mar. 17, 1998, the disclosure of which is hereby incorporated by reference. The site may also include associated services that allow users to rate other types of items, such as CDs and videos. As described below, the ratings data collected by the BookMatcher service and similar services is optionally incorporated into the recommendation processes of the present invention.

Another type of service is a recommendation service which operates in accordance with the invention. The service ("Recommendation Service") is preferably used to recommend book titles, music titles and/or videos titles to users, but could also be used in the context of the same Web site to recommend other types of items, including authors, artists, and groups or categories of titles. Briefly, given a unary listing of items that are "known" to be of interest to a user (e.g., a list of items purchased, rated, and/or viewed by the user), the Recommendation Service generates a list of additional items ("recommendations") that are predicted to be of interest to the user. (As used herein, the term "interest" refers generally to a user's liking of or affinity for an item; the term "known" is used to distinguish items for which the user has implicitly or explicitly indicated some level of interest from items predicted by the Recommendation Service to be of interest.)

The recommendations are generated using a table which maps items to lists of "similar" items ("similar items lists"), without the need for users to rate any items (although ratings data may optionally be used). For example, if there are three items that are known to be of interest to a particular user (such as three items the user recently purchased), the service may retrieve the similar items lists for these three items from the table, and appropriately combine these lists (as described below) to generate the recommendations.

In accordance with one aspect of the invention, the mappings of items to similar items ("item-to-item mappings") are generated periodically, such as once per week, from data which reflects the collective interests of the community of users. More specifically, the item-to-item mappings are generated by an off-line process which identifies correlations between known interests of users in particular items. For example, in the embodiment described in detail below, the mappings are generating by analyzing user purchase histories to identify correlations between purchases of particular items (e.g., items A and B are similar because a relatively large portion of the users that purchased item A also bought item B). The item-to-item mappings could also reflect other types of similarities, including content-based similarities extracted by analyzing item descriptions or content.

An important aspect of the Recommendation Service is that the relatively computation-intensive task of correlating item interests is performed off-line, and the results of this task (item-to-item mappings) are stored in a mapping structure for subsequent look-up. This enables the personal recommendations to be generated rapidly and efficiently (such as in real-time in response to a request by the user), without sacrificing breadth of analysis.

In accordance with another aspect of the invention, the similar items lists read from the table are appropriately weighted (prior to being combined) based on indicia of the user's affinity for or current interest in the corresponding items of known interest. For example, in one embodiment described below, if the item of known interest was previously rated by the user (such as through use of the BookMatcher service), the rating is used to weight the corresponding similar items list. Similarly, the similar items list for a book that was purchased in the last week may be weighted more heavily than the similar items list for a book that was purchased four months ago.

Another feature of the invention involves using the current and/or recent contents of the user's shopping cart as inputs to the Recommendation Service. For example, if the user currently has three items in his or her shopping cart, these three items can be treated as the items of known interest for purposes of generating recommendations, in which case the recommendations may be generated and displayed automatically when the user views the shopping cart contents. If the user has multiple shopping carts, the recommendations are preferably generated based on the contents of the shopping cart implicitly or explicitly designated by the user, such as the shopping cart currently being viewed. This method of generating recommendations can also be used within other types of recommendation systems, including content-based systems and systems that do not use item-to-item mappings.

Using the current and/or recent shopping cart contents as inputs tends to produce recommendations that are highly correlated to the current short-term interests of the user—even if these short term interests are not reflected by the user's purchase history. For example, if the user is currently searching for a father's day gift and has selected several books for prospective purchase, this method will have a tendency to identify other books that are well suited for the gift recipient.

Another feature of the invention involves generating recommendations that are specific to a particular shopping cart. This allows a user who has created multiple shopping carts to conveniently obtain recommendations that are specific to the role or purpose to the particular cart. For example, a user who has created a personal shopping cart for buying books for her children can designate this shopping cart to obtain recommendations of children's books. In one embodiment of this feature, the recommendations are generated based solely upon the current contents of the shopping cart selected for display. In another embodiment, the user may designate one or more shopping carts to be used to generate the recommendations, and the service then uses the items that were purchased from these shopping carts as the items of known interest.

As will be recognized by those skilled in the art, the above-described techniques for using shopping cart contents to generate recommendations can also be incorporated into other types of recommendation systems, including pure content-based systems.

FIG. **1** illustrates the basic components of the Amazon.com Web site **30**, including the components used to implement the Recommendation Service. The arrows in FIG. **1** show the general flow of information that is used by the Recommendation Service. As illustrated by FIG. **1**, the Web site **30** includes a Web server application **32** ("Web server") which processes HTTP (Hypertext Transfer Protocol) requests received over the Internet from user computers **34**. The Web server **34** accesses a database **36** of HTML (Hypertext Markup Language) content which includes product information pages and other browsable information about the various products of the catalog. The "items" that are the subject of the Recommendation Service are the titles (regardless of media format such as hardcover or paperback) that are represented within this database **36**.

The Web site **30** also includes a "user profiles" database **38** which stores account-specific information about users of the site. Because a group of individuals can share an account, a given "user" from the perspective of the Web site may include multiple actual users. As illustrated by FIG. **1**, the data stored for each user may include one or more of the following types of information (among other things) that can be used to generate recommendations in accordance with the invention: (a) the user's purchase history, including dates of purchase, (b) the user's item ratings profile (if any), (c) the current contents of the user's personal shopping cart(s), and (d) a listing of items that were recently (e.g., within the last six months) removed from the shopping cart(s) without being purchased ("recent shopping cart contents"). If a given user has multiple shopping carts, the purchase history for that user may include information about the particular shopping cart used to make each purchase; preserving such information allows the Recommendation Service to be configured to generate recommendations that are specific to a particular shopping cart.

As depicted by FIG. **1**, the Web server **32** communicates with various external components **40** of the site. These external components **40** include, for example, a search engine and associated database (not shown) for enabling users to interactively search the catalog for particular items. Also included within the external components **40** are various order processing modules (not shown) for accepting and processing orders, and for updating the purchase histories of the users.

The external components **40** also include a shopping cart process (not shown) which adds and removes items from the users' personal shopping carts based on the actions of the respective users. (The term "process" is used herein to refer generally to one or more code modules that are executed by a computer system to perform a particular task or set of related tasks.) In one embodiment, the shopping cart process periodically "prunes" the personal shopping cart listings of items that are deemed to be dormant, such as items that have not been purchased or viewed by the particular user for a predetermined period of time (e.g. two weeks). The shopping cart process also preferably generates and maintains the user-specific listings of recent shopping cart contents.

The external components **40** also include recommendation service components **44** that are used to implement the site's various recommendation services. Recommendations generated by the recommendation services are returned to the Web server **32**, which incorporates the recommendations into personalized Web pages transmitted to users.

The recommendation service components **44** include a BookMatcher application **50** which implements the above-described BookMatcher service. Users of the BookMatcher service are provided the opportunity to rate individual book titles from a list of popular titles. The book titles are rated according to the following scale:

1=Bad!

2=Not for me

3=OK

4=Liked it

5=Loved it!

Users can also rate book titles during ordinary browsing of the site. As depicted in FIG. **1**, the BookMatcher application **50** records the ratings within the user's items rating profile. For example, if a user of the BookMatcher service gives the book *Into Thin Air* a score of "5," the BookMatcher application **50** would record the item (by ISBN or other identifier) and the score within the user's item ratings profile. The BookMatcher application **50** uses the users' item ratings profiles to generate personal recommendations, which can be requested by the user by selecting an appropriate hyperlink. As described in detail below, the item ratings profiles are also used by an "Instant Recommendations" implementation of the Recommendation Service.

The recommendation services components **44** also include a recommendation process **52**, a similar items table **60**, and an off-line table generation process **66**, which collectively implement the Recommendation Service. As depicted by the arrows in FIG. **1**, the recommendation process **52** generates personal recommendations based on information stored within the similar items table **60**, and based on the items that are known to be of interest ("items of known interest") to the particular user.

In the embodiments described in detail below, the items of known interest are identified based on information stored in the user's profile, such as by selecting all items purchased by the user or all items in the user's shopping cart. In other embodiments of the invention, other types of methods or sources of information could be used to identify the items of known interest. For example, in a service used to recommend Web sites, the items (Web sites) known to be of interest to a user could be identified by parsing a Web server access log and/or by extracting URLs from the "favorite places" list of the user's Web browser. In a service used to recommend restaurants, the items (restaurants) of known interest could be identified by parsing the user's credit card records to identify restaurants that were visited more than once.

The various processes **50**, **52**, **66** of the recommendation services may run, for example, on one or more Unix or NT based workstations or physical servers (not shown) of the Web site **30**. The similar items table **60** is preferably stored as a B-tree data structure to permit efficient look-up, and may be replicated across multiple machines (together with the associated code of the recommendation process **52**) to accommodate heavy loads.

II. Similar Items Table (FIG. **1**)

The general form and content of the similar items table **60** will now be described with reference to FIG. **1**. As this table can take on many alternative forms, the details of the table are intended to illustrate, and not limit, the scope of the invention.

As indicated above, the similar items table **60** maps items to lists of similar items based at least upon the collective interests of the community of users. The similar items table **60** is preferably generated periodically (e.g., once per week)

by the off-line table generation process **66**. The table generation process **66** generates the table **60** from data that reflects the collective interests of the community of users. In the embodiment described in detail herein, the similar items table is generated exclusively from the purchase histories of the community of users (as depicted in FIG. **1**). In other embodiments, the table **60** may additionally or alternatively be generated from other indicia of user-item interests, including indica based on users viewing activities, shopping cart activities, and item rating profiles. For example, the table **60** could be built exclusively from the present and/or recent shopping cart contents of users. The similar items table **60** could also reflect non-collaborative type item similarities, including content-based similarities derived by comparing item contents or descriptions.

Each entry in the similar items table **60** is preferably in the form of a mapping of a popular item **62** to a corresponding list **64** of similar items ("similar items lists"). As used herein, a "popular" item is an item which satisfies some pre-specified popularity criteria. For example, in the embodiment described herein, an item is treated as popular of it has been purchased by more than **30** customers during the life of the Web site. Using this criteria produces a set of popular items (and thus a recommendation service) which grows over time. The similar items list **64** for a given popular item **62** may include other popular items.

In other embodiments involving sales of products, the table **60** may include entries for most or all of the products of the online merchant, rather than just the popular items. In the embodiment described herein, several different types of items (books, CDs, videos, etc.) are reflected within the same table **60**, although separate tables could alternatively be generated for each type of item.

Each similar items list **64** consists of the N (e.g., 20) items which, based on correlations between purchases of items, are deemed to be the most closely related to the respective popular item **62**. Each item in the similar items list **64** is stored together with a commonality index ("CI") value which indicates the relatedness of that item to the popular item **62**, based on sales of the respective items. A relatively high commonality index for a pair of items ITEM A and ITEM B indicates that a relatively large percentage of users who bought ITEM A also bought ITEM B (and vice versa). A relatively low commonality index for ITEM A and ITEM B indicates that a relatively small percentage of the users who bought ITEM A also bought ITEM B (and vice versa). As described below, the similar items lists are generated, for each popular item, by selecting the N other items that have the highest commonality index values. Using this method, ITEM A may be included in ITEM B's similar items list even though ITEM B in not present in ITEM A's similar items list.

In the embodiment depicted by FIG. **1**, the items are represented within the similar items table **60** using product IDs, such as ISBNs or other identifiers. Alternatively, the items could be represented within the table by title ID, where each title ID corresponds to a given "work" regardless of its media format. In either case, different items which correspond to the same work, such as the hardcover and paperback versions of a given book or the VCR cassette and DVD versions of a given video, are preferably treated as a unit for purposes of generating recommendations.

Although the recommendable items in the described system are in the form of book titles, music titles and videos titles, it will be appreciated that the underlying methods and data structures can be used to recommend a wide range of other types of items. For example, in the system depicted by FIG. **1**, the Recommendation Service could also be used to recommend authors, artists, and categorizations or groups of works.

III. General Process for Generating Recommendations (FIG. **2**)

The general sequence of steps that are performed by the recommendation process **52** to generate a set of personal recommendations will now be described with reference to FIG. **2**. This process, and the more specific implementations of the process depicted by FIGS. **5** and **7** (described below), are intended to illustrate, and not limit, the scope of the invention.

The FIG. **2** process is preferably invoked in real-time in response to an online action of the user. For example, in an Instant Recommendations implementation (FIGS. **5** and **6**) of the service, the recommendations are generated and displayed in real-time (based on the user's purchase history and/or item ratings profile) in response to selection by the user of a corresponding hyperlink, such as a hyperlink which reads "Instant Book Recommendations" or "Instant Music Recommendations." In a shopping cart based implementation (FIG. **7**), the recommendations are generated (based on the user's current and/or recent shopping cart contents) in real-time when the user initiates a display of a shopping cart, and are displayed on the same Web page as the shopping cart contents. The Instant Recommendations and shopping cart based embodiments are described separately below under corresponding headings.

Any of a variety of other methods can be used to initiate the recommendations generation process and to display the recommendations to the user. For example, the recommendations can automatically be generated periodically and sent to the user by e-mail, in which case the e-mail listing may contain hyperlinks to the product information pages of the recommended items. Further, the personal recommendations could be generated in advance of any request or action by the user, and cached by the Web site **30** until requested.

As illustrated by FIG. **2**, the first step (step **80**) of the recommendations-generation process involves identifying a set of items that are of known interest to the user. The "knowledge" of the user's interest can be based on explicit indications of interest (e.g., the user rated the item highly) or implicit indications of interest (e.g., the user added the item to a shopping cart). Items that are not "popular items" within the similar items table **60** can optionally be ignored during this step.

In the embodiment depicted in FIG. **1**, the items of known interest are selected from one or more of the following groups: (a) items in the user's purchase history (optionally limited to those items purchased from a particular shopping cart); (b) items in the user's shopping cart (or a particular shopping cart designated by the user), (c) items rated by the user (optionally with a score that exceeds a certain threshold, such as two), and (d) items in the "recent shopping cart contents" list associated with a given user or shopping cart. In other embodiments, the items of known interest may additionally or alternatively be selected based on the viewing activities of the user. For example, the recommendations process **52** could select items that were viewed by the user for an extended period of time and/or viewed more than once. Further, the user could be prompted to select items of interest from a list of popular items.

For each item of known interest, the service retrieves the corresponding similar items list **64** from the similar items table **60** (step **82**), if such a list exists. If no entries exist in the table **60** for any of the items of known interest, the

process **52** may be terminated; alternatively, the process could attempt to identify additional items of interest, such as by accessing other sources of interest information.

In step **84**, the similar items lists **64** are optionally weighted based on information about the user's affinity for the corresponding items of known interest. For example, a similar items list **64** may be weighted heavily if the user gave the corresponding popular item a rating of "5" on a scale or 1–5, or if the user purchased multiple copies of the item. Weighting a similar items list **64** heavily has the effect of increasing the likelihood that the items in that list we be included in the recommendations that are ultimately presented to the user. In one implementation described below, the user is presumed to have a greater affinity for recently purchased items over earlier purchased items.

The similar items lists **64** are preferably weighted by multiplying the commonality index values of the list by a weighting value. The commonality index values as weighted by any applicable weighting value are referred to herein as "scores." In other embodiments, the recommendations may be generated without weighting the similar items lists **64**.

If multiple similar items lists **64** are retrieved in step **82**, the lists are appropriately combined (step **86**), such as by merging the lists while summing the scores of like items. The resulting list is then sorted (step **88**) in order of highest-to-lowest score. In step **90**, the sorted list is filtered to remove unwanted items. The items removed during the filtering process may include, for example, items that have already been purchased or rated by the user, and items that fall outside any product group (such as music or books), product category (such as non-fiction), or content rating (such as PG or adult) designated by the user. The filtering step could alternatively be performed at a different stage of the process, such as during the retrieval of the similar items lists from the table **60**. The result of step **90** is a list ("recommendations list") of other items to be recommended to the user.

In step **92**, one or more additional items are optionally added to the recommendations list. In one embodiment, the items added in step **92** are selected from the set of items (if any) in the user's "recent shopping cart contents" list. As an important benefit of this step, the recommendations include one or more items that the user previously considered purchasing but did not purchase. The items added in step **92** may additionally or alternatively be selected using another recommendations method, such as a content-based method.

Finally, in step **94**, a list of the top M (e.g., 15) items of the recommendations list are returned to the Web server **32** (FIG. **1**). The Web server incorporates this list into one or more Web pages that are returned to the user, with each recommended item being presented as a hypertextual link to the item's product information page. The recommendations may alternatively be conveyed to the user by email, facsimile, or other transmission method. Further, the recommendations could be presented as advertisements for the recommended items.

IV. Generation of Similar Items Table (FIGS. **3** and **4**)

The table-generation process **66** is preferably executed periodically (e.g., once a week) to generate a similar items table **60** that reflects the most recent purchase history data. The recommendation process **52** uses the most recently generated version of the table **60** to generate recommendations.

FIG. **3** illustrates the sequence of steps that are performed by the table generation process **66** to build the similar items table **60**. The general form of temporary data structures that are generated during the process are shown at the right of the drawing. As will be appreciated by those skilled in the art, any of a variety of alternative methods could be used to generate the table **60**.

As depicted by FIG. **3**, the process initially retrieves the purchase histories for all customers (step **100**). Each purchase history is in the general form of the user ID of a customer together with a list of the product IDs (ISBNs, etc.) of the items (books, CDs, videos, etc.) purchased by that customer. In embodiments which support multiple shopping carts within a given account, each shopping cart could be treated as a separate customer for purposes of generating the table. For example, if a given user (or group of users that share an account) purchased items from two different shopping carts within the same account, these purchases could be treated as the purchases of separate users.

The product IDs may be converted to title IDs during this process, or when the table **60** is later used to generate recommendations, so that different versions of an item (e.g., hardcover and paperback) are represented as a single item. This may be accomplished, for example, by using a separate database which maps product IDs to title IDs. To generate a similar items table that strongly reflects the current tastes of the community, the purchase histories retrieved in step **100** can be limited to a specific time period, such as the last six months.

In steps **102** and **104**, the process generates two temporary tables **102**A and **104**A. The first table **102**A maps individual customers to the items they purchased. The second table **104**A maps items to the customers that purchased such items. To avoid the effects of "ballot stuffing," multiple copies of the same item purchased by a single customer are represented with a single table entry. For example, even if a single customer purchased 4000 copies of one book, the customer will be treated as having purchased only a single copy. In addition, items that were sold to an insignificant number (e.g., <15) of customers are preferably omitted or deleted from the tables **102**A, **104**B.

In step **106**, the process identifies the items that constitute "popular" items. This may be accomplished, for example, by selecting from the item-to-customers table **104**A those items that were purchased by more than a threshold number (e.g., 30) of customers. In the context of the Amazon.com Web site, to resulting set of popular items may contain hundreds of thousands or millions of items.

In step **108**, the process counts, for each (popular_item, other_item) pair, the number of customers that are in common. A pseudocode sequence for performing this step is listed in Table 1. The result of step **108** is a table that indicates, for each (popular_item, other_item) pair, the number of customers the two have in common. For example, in the hypothetical table **108**A of FIG. **3**, POPULAR_A and ITEM_B have seventy customers in common, indicating that seventy customers bought both items.

TABLE 1

```
for each popular_item
  for each customer in customers of item
    for each other_item in items of customer
      increment common-customer-count(popular_time, other_item)
```

In step **110**, the process generates the commonality indexes for each (popular_item, other_item) pair in the table **108**A. As indicated above, the commonality index (CI) values are measures of the similarity between two items, with larger CI values indicating greater degrees of similarity. The commonality indexes are preferably generated such that, for a given popular_item, the respective commonality

indexes of the corresponding other_items take into consideration both (a) the number of customers that are common to both items, and (b) the total number of customers of the other_item. A preferred method for generating the commonality index values is set forth in the equation below.

TABLE 1

```
for each popular_item
  for each customer in customers of item
    for each other_item in items of customer
      increment common-customer-count(popular_item, other_item)
```

FIG. **4** illustrates this method in example form. In the FIG. **4** example, item_P (a popular item) has two "other items," item_X and item_Y. Item_P has been purchased by **300** customers, item_X by 300 customers, and item_Y by 30,000 customers. In addition, item_P and item_X have 20 customers in common, and item_P and item_Y have 25 customers in common. Applying the equation above to the values shown in FIG. **4** produces the following results:

$$CI(item_P, item_X)=20/sqrt(300\times300))=0.0667$$

$$CI(item_P, item_Y)=25/sqrt(300\times30{,}000))=\mathbf{0.0083}$$

Thus, even though items P and Y have more customers in common than items P and X, items P and X are treated as being more similar than items P and Y. This result desirably reflects the fact that the percentage of item_X customers that bought item_P (6.7%) is much greater than the percentage of item_Y customers that bought item_P (0.08%).

Because this equation is symmetrical (i.e., CI(item_A, item_B)=CI(item_B, item_A)), it is not necessary to separately calculate the CI value for every location in the table **108**A. In other embodiments, an asymmetrical method may be used to generate the CI values. For example, the CI value for a (popular_item, other_item) pair could be generated as (customers of popular_item and other_item)/(customers of other_item).

Following step **110** of FIG. **3**, each popular item has a respective "other_items" list which includes all of the other_items from the table **108**A and their associated CI values. In step **112**, each other_items list is sorted from highest-to-lowest commonality index. Using the FIG. **4** values as an example, item_X would be positioned closer to the top of the item_B's list than item_Y, since 0.014907>0.001643.

In step **114**, the sorted other_items lists are filtered by deleting all list entries that have fewer than **3** customers in common. For example, in the other_items list for POPULAR_A in table **108**A, ITEM_A would be deleted since POPULAR_A and ITEM_A have only two customers in common. Deleting such entries tends to reduce statistically poor correlations between item sales.

In step **116**, the sorted other_items lists are truncated to length N to generate the similar items lists, and the similar items lists are stored in a B-tree table structure for efficient look-up

As indicated above, any of a variety of other methods for evaluating similarities between items could be incorporated into the table generation process **66**. For example, the table generation process could compare item contents and/or use previously-assigned product categorizations as additional indicators of item similarities. An important benefit of the FIG. **3** method, however, is that the items need not contain any content that is amenable to feature extraction techniques, and need not be pre-assigned to any categories. For example, the method can be used to generate a similar items table given nothing more than the product IDs of a set of products and user purchase histories with respect to these products.

Another important benefit of the Recommendation Service is that the bulk of the processing (the generation of the similar items table **60**) is performed by an off-line process. Once this table has been generated, personalized recommendations can be generated rapidly and efficiently, without sacrificing breadth of analysis.

V. Instant Recommendations Service (FIGS. **5** and **6**)

A specific implementation of the Recommendation Service, referred to herein as the Instant Recommendations service, will now be described with reference to FIGS. **5** and **6**.

As indicated above, the Instant Recommendations service is invoked by the user by selecting a corresponding hyperlink from a Web page. For example, the user may select an "Instant Book Recommendations" or similar hyperlink to obtain a listing of recommended book titles, or may select a "Instant Music Recommendations" or "Instant Video Recommendations" hyperlink to obtain a listing of recommended music or video titles. As described below, the user can also request that the recommendations be limited to a particular item category, such as "non-fiction," "jazz" or "comedies." The Instant Recommendations service generates the recommendations based exclusively on the purchase history and any item ratings profile of the particular user. The service becomes available to the user (i.e., the appropriate hyperlink is presented to the user) once the user has purchased and/or rated a threshold number (e.g. three) of popular items within the corresponding product group. If the user has established multiple shopping carts, the user may also be presented the option of designating a particular shopping cart to be used in generating the recommendations.

FIG. **5** illustrates the sequence of steps that are performed by the Instant Recommendations service to generate personal recommendations. Steps **180–194** in FIG. **5** correspond, respectively, to steps **80–94** in FIG. **2**. In step **180**, the process **52** identifies all popular items that have been purchased by the user (from a particular shopping cart, if designated) or rated by the user, within the last six months. In step **182**, the process retrieves the similar items lists **64** for these popular items from the similar items table **60**.

In step **184**, the process **52** weights each similar items list based on the duration since the associated popular item was purchased by the user (with recently-purchased items weighted more heavily), or if the popular item was not purchased, the rating given to the popular item by the user. The formula used to generate the weight values to apply to each similar items list is listed in C in Table **2**. In this formula, "is_purchased" is a boolean variable which indicates whether the popular item was purchased, "rating" is the rating value (1–5), if any, assigned to the popular item by the user, "order_date" is the date/time (measured in seconds since 1970) the popular item was purchased, "now" is the current date/time (measured in seconds since 1970), and "6 months" is six months in seconds.

TABLE 2

```
1  Weight = ( (is_purchased ? 5:rating) * 2 - 5)*
2  (1 + (max( (is purchased ? order_date:0)-(now-6 months), 0) )
3  / (6 months))
```

In line 1 of the formula, if the popular item was purchased, the value "5" (the maximum possible rating value) is selected; otherwise, the user's rating of the item is selected. The selected value (which may range from 1–5) is

then multiplied by 2, and 5 is subtracted from the result. The value calculated in line 1 thus ranges from a minimum of −3 (if the item was rated a ("1") to a maximum of 5 (if the item was purchased or was rated a "5").

The value calculated in line 1 is multiplied by the value calculated in lines 2 and 3, which can range from a minimum of 1 (if the item was either not purchased or was purchased at least six months ago) to a maximum of 2 (if order_date= now). Thus, the weight can range from a minimum of −6 to a maximum of 10. Weights of zero and below indicate that the user rated the item a "2" or below. Weights higher than 5 indicate that the user actually purchased the item (although a weight of 5 or less is possible even if the item was purchased), with higher values indicating more recent purchases.

The similar items lists **64** are weighted in step **184** by multiplying the CI values of the list by the corresponding weight value. For example, if the weight value for a given popular item is ten, and the similar items list **64** for the popular item is

(productid_A, 0.10), (productid_B, 0.09), (productid_C, 0.08),

the weighted similar items list would be:

(productid_A, 1.0), (productid_BB, 0.9), (productid_C, 0.8),

The numerical values in the weighted similar items lists are referred to as "scores."

In step **186**, the weighted similar items lists are merged (if multiple lists exist) to form a single list. During this step, the scores of like items are summed. For example, if a given other_item appears in three different similar items lists **64**, the three scores (including any negative scores) are summed to produce a composite score.

In step **188**, the resulting list is sorted from highest-to-lowest score. The effect of the sorting operation is to place the most relevant items at the top of the list. In step **190**, the list is filtered by deleting any items that (1) have already been purchased or rated by the user, (2) have a negative score, or (3) do not fall within the designated product group (e.g., books) or category (e.g., "science fiction," or "jazz").

In step **192** one or more items are optionally selected from the recent shopping cart contents list (if such a list exists) for the user, excluding items that have been rated by the user or which fall outside the designated product group or category. The selected items, if any, are inserted at randomly-selected locations within the top M (e.g., 15) positions in the recommendations list. Finally, in step **194**, the top M items from the recommendations list are returned to the Web server **32**, which incorporates these recommendations into one or more Web pages.

The general form of such a Web page is shown in FIG. **6**, which lists five recommended items. From this page, the user can select a link associated with one of the recommended items to view the product information page for that item. In addition, the user can select a "more recommendations" button **200** to view additional items from the list of M items. Further, the user can select a "refine your recommendations" link to rate or indicate ownership of the recommended items. Indicating ownership of an item causes the item to be added to the user's purchase history listing.

The user can also select a specific category such as "non-fiction" or "romance" from a drop-down menu **202** to request category-specific recommendations. Designating a specific category causes items in all other categories to be filtered out in step **190** (FIG. **5**).

VI. Shopping Cart Based Recommendations (FIG. **7**)

Another specific implementation of the Recommendation Service, referred to herein as shopping cart recommendations, will now be described with reference to FIG. **7**.

The shopping cart recommendations service is preferably invoked automatically when the user displays the contents of a shopping cart that contains more than a threshold number (e.g., 1) of popular items. The service generates the recommendations based exclusively on the current contents of the shopping cart. As a, result, the recommendations tend to be highly correlated to the user's current shopping interests. In other implementations, the recommendations may also be based on other items that are deemed to be of current interest to the user, such as items in the recent shopping cart contents of the user and/or items recently viewed by the user. Further, other indications of the user's current shopping interests could be incorporated into the process. For example, any search terms typed into the site's search engine during the user's browsing session could be captured and used to perform content-based filtering of the recommended items list.

FIG. **7** illustrates the sequence of steps that are performed by the shopping cart recommendations service to generate a set of shopping-cart-based recommendations. In step **282**, the similar items list for each popular item in the shopping cart is retrieved from the similar items table **60**. The similar items list for one or more additional items that are deemed to be of current interest could also be retrieved during this step, such as the list for an item recently deleted from the shopping cart or recently viewed for an extended period of time.

In step **286**, these similar items lists are merged while summing the commonality index (CI) values of the list items. In step **288**, the resulting list is sorted from highest-to-lowest score. In step **290**, the list is filtered to remove any items that exist in the shopping cart or have been purchased or rated by the user. Finally, in step **294**, the top M (e.g., 5) items of the list are returned as recommendations. The recommendations are preferably presented to the user on the same Web page (not shown) as the shopping cart contents.

If the user has defined multiple shopping carts, the recommendations generated by the FIG. **7** process may be based solely on the contents of the shopping cart currently selected for display. As described above, this allows the user to obtain recommendations that correspond to the role or purpose of a particular shopping cart (e.g., work versus home).

The various uses of shopping cart contents to generate recommendations as described above can be applied to other types of recommendation systems, including content-based systems. For example, the current and/or past contents of a shopping cart can be used to generate recommendations in a system in which mappings of items to lists of similar items are generated from a computer-based comparison of item contents. Methods for performing content-based similarity analyses of items are well known in the art, and are therefore not described herein.

Although this invention has been described in terms of certain preferred embodiments, other embodiments that are apparent to those of ordinary skill in the art are also within the scope of this invention. For example, although the embodiments described herein employ item lists, other programming methods for keeping track of and combining sets of similar items can be used. Accordingly, the scope of the present invention is intended to be defined only by reference to the appended claims.

In the claims which follow, reference characters used to denote process steps are provided for convenience of description only, and not to imply a particular order for performing the steps.

What is claimed is:

1. In a multi-user computer system that provides user access to a database of items, a method of recommending items to a user, the method comprising the computer-implemented steps of:

(a) generating a non-user-specific data structure which maps individual items of the database to corresponding sets of similar items in which similarities between items are based at least upon the collective item interests of a community of users;

(b) identifying items that are known to be of interest to the user;

(c) for each of a plurality of the items identified in step (b), accessing the data structure to identify a corresponding set of similar items;

(d) combining the sets of similar items identified in step (c) to generate a combined set of additionally similar items; and

(e) recommending at least some of the similar items of the combined set generated in step (d) to the user;

wherein step (a) is performed in an off-line mode, and steps (b)–(e) are performed substantially in real time in response to an online action by the user.

2. The method of claim **1**, wherein step (a) comprises analyzing purchase histories of users to identify correlations between purchases of items.

3. The method of claim **2**, wherein step (a) comprises, for each of a plurality of popular items, identifying other items for which a relatively large portion of users that purchased the popular item also purchased the other item.

4. The method of claim **3**, wherein step (a) comprises calculating, for each (popular item, other item) pair, a similarity score which reflects a number of users that purchased both the popular item and the other item relative to a number of users that purchased at least one of the popular item and the other item.

5. The method of claim **1**, wherein step (a) comprises calculating, for each of a plurality of item pairs (item_A, item_B), a similarity score which reflects a number of users that indicated an interest in both item_A and item_B relative to a number of users that indicated an interest in at least one of item_A and item_B.

6. The method of claim **5**, wherein step (a) comprises storing the similarity scores within the data structure, and step (d) comprises using the similarity scores to combine sets of similar items.

7. The method of claim **1**, wherein step (a) is repeated periodically, so that item similarities reflected in the data structure reflect current preferences of the community of users.

8. The method of claim **1**, wherein the computer system implements online shopping carts for allowing users to select and hold items for possible purchase, and step (b) comprises selecting items that are currently in the user's shopping cart.

9. The method of claim **1**, wherein step (b) comprises identifying a plurality of items that were previously purchased by the user.

10. The method of claim **1**, wherein step (b) comprises selecting only items that have been placed within a designated shopping cart of a plurality of shopping carts of the user, the method thereby generating recommendations that are specific to a role of the designated shopping cart.

11. The method of claim **1**, wherein step (d) comprises weighting at least some of the similar items sets identified in step (c) based on information about the user's affinity for corresponding items of known interest.

12. The method of claim **1**, wherein the computer system implements online shopping carts for allowing users to select and hold items for possible purchase, and keeps track of deletions of items from shopping carts, and wherein step (e) further comprises selecting to recommend to the user an item that was previously removed from the user's shopping cart.

13. The method of claim **1**, wherein step (a)–(e) are performed without requiring any users to have rated items.

14. The method of claim **1**, further comprising filtering out similar items identified in step (c) to remove items already purchased by the user.

15. The method of claim **1**, further comprising filtering out similar items identified in step (c) to remove items that do not fall within an item category designated by the user.

16. In a multi-user computer system that provides access to a database of items, a system for recommending items to users, comprising:

a first process which determines similarities between items by at least analyzing historical data that reflects item interests of a community of users, the first process generating a non-user-specific data structure which maps items to sets of similar items; and

a second process which generates personal recommendations for a user by accessing the data structure to identify similar items sets that correspond to items known to be of interest to the user, and by combining the identified similar items sets to generate a list of recommended items;

wherein the first process generates the data structure in an off-line mode, and the second process generates and displays the personal recommendations substantially in real time in response to online actions of users.

17. The system of claim **16**, wherein the first process determines a similarity between a pair of items, item_A and item_B, by at least calculating a similarity score which reflects a number of users that are interested in both item_A and item_B relative to a number of users that are interested in item_A or item_B.

18. The system of claim **17**, wherein the first process determines a similarity between a pair of items, item_A and item_B, by at least calculating a score value which reflects a number of users that purchased both item_A and item_B relative to a number of users that purchased item_A or item_B.

19. The system of claim **16**, wherein the first process generates and stores within the data structure similarity scores that indicate degrees of similarity between items, and the second process uses the similarity scores to combine sets of similar items.

20. The system of claim **16**, wherein the first process is an off-line process which executes separately from the second process, and the second process generates recommendations substantially in real-time in response to requests from users.

21. The system of claim **16**, wherein the first process is executed periodically to generate a new data structure, so that item similarities reflected in the data structure reflect current preferences of the community of users.

22. The system of claim **16**, wherein the computer system implements online shopping carts for allowing users to select and hold items for possible purchase, and wherein the second process generates recommendations for the user based on items that are currently in the user's shopping cart.

23. The system of claim 16, wherein the second process weights at least some of the identified similar items sets based on information about the user's affinity for corresponding items of known interest.

24. The system of claim 16, wherein the computer system allows a user to create multiple shopping carts within a single account, and the second process generates shopping cart specific recommendations to allow a user with multiple shopping carts to obtain recommendations specific to a role of a particular shopping cart.

25. The system of claim 16, wherein the system generates personal recommendations without requiring users to rate items.

26. The system of claim 16, wherein the second process filters out items already purchased by the user from the similar items sets identified from the data structure.

27. The system of claim 16, wherein the second process filters out items from the similar items sets identified from the data structure based on item categories specified by users.

28. In a system for generating personalized recommendations of items from a database of items that are accessed by a community of users, a method of recommending items to users, the method comprising:

in an off-line mode, for each of a plurality of first items:

(a) for each of a plurality of other items of the database, generating a respective score which indicates a degree of similarity between the first item and the other item such that the score is based on at least (i) a number of users that are interested in both the first item and the other item, and (ii) a number of users that are interested in the other item;

(b) sorting the plurality of other items according to the score values generated in step (a);

(c) truncating a list of items which results from step (b); and

(d) storing the truncated list generated in step (c) ("similar items list") together with corresponding scores generated in step (a) in a non-user-specific data structure for subsequent look-up;

subsequently, in response to an action performed by a user, performing the following steps substantially in real time:

(e) for each of a plurality of items that are known to be of interest to the user, accessing the data structure to identify a corresponding similar items list;

(f) combining the similar items lists identified in (e) to generate a combined list of similar items, wherein combining the similar items lists comprises combining scores of like items; and

(g) recommending at least some of the items from the combined list generated in (f) to the user.

29. The method of claim 28, wherein step (a) comprises calculating a score which is further based on the number of users that are interested in the first item.

30. The method as in claim 1, wherein the items are products that are available for online purchase.

31. The system as in claim 16, wherein the items are products that are available for online purchase.

32. The system as in claim 28, wherein the items are products that are available for online purchase.

33. A method of generating instant product recommendations for online users, comprising:

in an off-line mode, generating a data structure which maps each of a plurality of products directly to a corresponding set of similar products in which product similarities are indicated by similarity scores stored within the non-user-specific data structure; and

subsequently, in response to an action by an online user, immediately generating and displaying personal product recommendations for the user by at least (a) accessing the data structure to look up a respective set of similar products and associated similarity scores for each of multiple products known to be of interest to the user, (b) combining the sets of similar products identified in (a) into a ranked set in which rankings are based at least in-part on the similarity scores, and (c) selecting at least some of the products in the ranked set to display to the online user.

34. The method as in claim 33, wherein generating the data structure comprises using customer purchase histories to predict similarities between products.

35. The method as in claim 34, wherein generating the data structure further comprises generating, for each of multiple pairs of products, a similarity score which is based at least on a number of users that purchased both products in the pair.

36. The method as in claim 35, wherein generating the data structure further comprises using the purchase histories to determine popularity levels of products, and using said popularity levels to select the plurality of products for which to identify and store corresponding sets of similar products.

37. The method as in claim 33, wherein the action by the online user is a request to view a personal shopping cart, and the method comprises looking up from the data structure respective similar products sets for each of multiple products represented within the shopping cart.

38. The method as in claim 33, wherein the method comprises inhibiting selection in (c) of products already purchased by the user.

39. The method as in claim 33, wherein the data structure is a B-tree.

40. The method as in claim 33, further comprising replicating the data structure across multiple machines to accommodate heavy loads.

41. The method as in claim 1, wherein (d) comprises generating a ranked set of similar items in which a similar item's ranking reflects whether that similar item appears within more than one of the sets identified in step (c).

42. The system of claim 16, wherein the list of recommended items is a ranked list in which an item's ranking reflects whether that item appears within more than one of said similar items sets.

43. A computer-implemented method of recommending products to users, comprising:

generating, for each of a plurality of pairs of products, a respective score indicating a degree to which the products of the pair are deemed related to one another, wherein the score reflects a frequency with which the products of the pair co-occur within purchase histories of users;

storing the scores in a non-user-specific data structure that maps products to sets of related products; and

using the data structure and the scores to provide personalized product recommendations to each of multiple users.

44. The method as in claim 43, wherein using the data structure and scores to provide personalized product recommendations comprises:

identifying multiple products that are of interest to a user;

for each of the multiple products, accessing the data structure to identify a set of related products, to thereby identify multiple sets of related products;

combining the multiple sets of related products to generate a ranked set of related products in which product rankings reflect corresponding scores within the data structure; and

recommending products to the user from the ranked set.

45. The method as in claim **44**, wherein combining the multiple sets comprises combining scores of like products, so that a product's ranking reflects whether or not that product appears within more than one of the multiple sets.

46. The method as in claim **44**, wherein identifying multiple products that are of interest to the user comprises identifying products that are currently in a shopping cart of the user.

47. The method as in claim **46**, wherein recommending products to the user from the ranked set comprises displaying recommended products within a web page that displays current contents of the shopping cart.

48. The method as in claim **43**, wherein using the data structure and scores to provide personalized product recommendations comprises generating and displaying personal recommendations substantially in real time in response to online actions of users.

49. The method as in claim **43**, wherein the scores are generated and stored within the data structure in an off-line processing mode.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,266,649 B1
DATED : July 24, 2001
INVENTOR(S) : Linden et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 19,
Line 63, insert -- non-user-specific -- before "data structure".
Line 67, delete "non-user-specific".

Signed and Sealed this

Third Day of December, 2002

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

UNITED STATES PATENT AND TRADEMARK OFFICE

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PATENT NO. : 6,266,649 B1
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INVENTOR(S) : Linden et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 13,
Table 1, replace with the following equation:

$$CI(item_A,\ item_B) = \frac{customers\ of\ item_A\ and\ item_B}{\sqrt{(customers\ of\ item_A)\ x\ (customers\ of\ item_B)}}$$

Column 17,
Line 21, delete "additionally".

Signed and Sealed this

Twenty-seventh Day of April, 2004

JON W. DUDAS
Acting Director of the United States Patent and Trademark Office