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(54) Title: SEARCH TECHNIQUES USING ASSOCIATION GRAPHS

(57) Abstract: A computer-implemented method is provided, which includes presenting to a user (30) a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level. An indication (550) of a desired one of the levels, and a search query (52) consisting of one or more query terms, are received from the user (30). Responsively to the search query, a search result listing (54) is generated. At least a portion of the search result listing (54) is ranked at least in part responsively to the indication (550), and at least a portion of the ranked search result (54) listing is presented to the user (30). Other embodiments are also described.

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SEARCH TECHNIQUES USING ASSOCIATION GRAPHS

CROSS-REFERENCES TO RELATED APPLICATIONS

The present patent application claims the benefit of the following provisional patent applications, all of which are assigned to the assignee of the present application and are incorporated herein by reference:

- US Provisional Patent Application 60/793,253, filed April 20, 2006, entitled, "Methods for using association graphs in search engines";
- US Provisional Patent Application 60/796,188, filed May 1, 2006, entitled, "Apparatus and methods thereof for search engine personalization";
- US Provisional Patent Application 60/829,136, filed October 11, 2006, entitled, "Apparatus and methods thereof for search phrase refinement";
- US Provisional Patent Application 60/829,135, filed October 11, 2006, entitled, "Apparatus and methods thereof for using explicit query refinements to tune search results ranking factors";
- US Provisional Patent Application 60/829,132, filed October 11, 2006, entitled, "Apparatus and methods thereof for adaptive ranking mechanism using association graphs and contextual analysis";
- US Provisional Patent Application 60/886,193, filed January 23, 2007, entitled, "Multi-directional and auto-adaptive relevance and search system and methods thereof"; and
- US Provisional Patent Application 60/887,580, filed January 31, 2007, entitled, "Searchable banner display and apparatus that enables exploring destination content prior to reaching it."

FIELD OF THE INVENTION

The present invention relates generally to improving results returned by search engines, and specifically to techniques for ranking and/or modifying such search results.

BACKGROUND OF THE INVENTION

Internet search engines have become fundamental tools for nearly all users seeking

information and sites on the World Wide Web (WWW). Users can find vast amounts of data and select the data that appears to best match specific search criteria. Free-text searches are generally performed by providing a search phrase including one or more keywords, and optionally Boolean operators. The most widely used free-text search engines currently are provided by Google, Inc. and Yahoo, Inc.

Based on the search phrase provided by a user, a search engine generally returns a list of documents from which the user selects those that appear most relevant. The list typically includes a snippet from each of documents that includes one or more of the keywords, and the URL of the document. Typically, the search engine presents the list of documents in descending order according to general, static criteria established by the search engine provider. Numerous techniques have been developed for ranking the list in order to provide the results most likely to be relevant to a typical user. Some of these techniques take into account the order of the keywords provided by the user.

Such static ranking systems often present high-ranking results that do not match the interests or skills of the searcher, or that do not provide results that correctly reflect the intended meaning of keywords having more than one meaning. For example, a software engineer looking for Java (i.e., software) and a traveler looking for Java (i.e., the island) receive the same results for a query that includes the same keywords, even though their searches had different intended meanings.

Some search engines, such as the one provided by AOL, Inc., attempt to overcome this drawback by using user profiles that specify certain static characteristics of each user. Such characteristics may include information such as the searcher's age, location, job, and education. Each user must provide this information and keep it updated as the user's interests change over time. Such information often does not accurately reflect the user's skill levels in various interest areas. Such profiles also generally fail to adequately reflect the full diversity of the user's interests.

Some search engines are configured to rank results of multi-keyword searches using merge algorithms. For example, the search engine may use criteria to separately rank the results for each of the keywords searched separately, and merge the separate rankings to produce a list of search results containing all of the keywords. Some search engines use collaborative filtering based on social networks, forums, communities, or other types of groups, in an attempt to supply more relevant search results.

US Patent Application Publication 2005/0076003 to DuBose et al., which is incorporated herein by reference, describes a process for sorting results returned in response to a search query according to learned associations between one or more prior search query search terms and selected results of said prior search queries.

US Patent 6,732,088 to Glance, which is incorporated herein by reference, describes techniques for facilitating searching a data collection, such as the WWW, that take advantage of the collective ability of all users to create queries to the data collection. First, a node-link graph of all queries submitted to a data collection within a given period of time is constructed. In the case of the WWW, the queries would be to a particular search engine. In the graph, each node is a query. There is a link made between two nodes whenever the two queries are judged to be related. A first key idea is that the determination of relatedness depends on the documents returned by the queries, not on the actual terms in the queries themselves. For example, a criterion for relatedness could be that of the top ten documents returned for each query, the two lists have at least one document in common. A second key idea is that the construction of the query graph transforms single user usage of the data collection (e.g., search) into collaborative usage. As a result, all users can tap into the knowledge base of queries submitted by others, because each of the related queries represents the knowledge of the user who submitted the query.

US Patent 6,513,036 to Fruensgaard et al., which is incorporated herein by reference, describes techniques for searching and presenting electronic information from one or more information sources where the retrieval and presentation of information depends on context representations defined for a user performing the search, other users being similar to the user performing the search, and references to information. The context representation of each object affects/influences all the other objects with which it is in contact during the search process. This is described as ensuring a dynamic update of the relations between the objects and their properties.

US Patent Application Publication 2002/0133483 to Klenk et al., which is incorporated herein by reference, describes a system for automatically determining a characterizing strength which indicates how well a text in a database describes a search query. The system comprises a database storing a plurality of m texts, a search engine for processing the search query in order to identify those k texts from the plurality of m texts

that match the search query. The system further comprises a calculation engine for calculating the characterizing strengths of each of the k texts that match the search query. The characterizing strength is calculated by creating a graph with nodes and links, whereby words of the text are represented by nodes and the relationship between words is represented by means of the links; evolving the graph according to a pre-defined set of rules; determining the neighborhood of the word, whereby the neighborhood comprises those nodes that are connected through one or a few links to the word; and calculating the characterizing strength based on the topological structure of the neighborhood.

US Patent 5,926,812 to Hilsenrath et al., which is incorporated herein by reference, describes a method for comparing the contents of two sets of documents, including extracting from a set of documents corresponding sets of document extract entries. The method further includes generating from the sets of document extract entries corresponding sets of word clusters. Each word cluster comprises a cluster word list having N words, an NxN total distance matrix, and an NxN number of connections matrix. The preferred embodiment includes grouping similar word clusters and combining the similar word clusters to form a single word cluster for each group. The grouping comprises evaluating a measure of cluster similarity between two word clusters, and placing them in a common group of similar word clusters if the measure of similarity exceeds a predetermined value. Evaluating the cluster similarity comprises intersecting clusters to form subclusters and calculating a function of the subclusters. In the preferred embodiment, the method is implemented in a system to automatically identify database documents which are of interest to a given user or users. In this implementation, the method comprises automatically deriving the first set of documents from a local data storage device, such as a user's hard disk. The method also comprises deriving the second set of documents from a second data storage device, such as a network machine. These techniques are described as providing fast and accurate searching to identify documents of interest to a particular user or users without any need for the user or users to specify what search criteria to use.

US Patent 6,772,150 to Whitman et al., which is incorporated herein by reference, describes a search engine system that uses information about historical query submissions to a search engine to suggest previously-submitted, related search phrases to users. The related search phrases are preferably suggested based on a most recent set of query submission data (e.g., the last two weeks of submissions), and thus strongly reflect the

current searching patterns or interests of users.

US Patent 6,289,353 to Hazlehurst et al., which is incorporated herein by reference, describes an intelligent Query Engine system that automatically develops multiple information spaces in which different types of real-world objects (e.g., documents, users, products) can be represented. Machine learning techniques are used to facilitate automated emergence of information spaces in which objects are represented as vectors of real numbers. The system then delivers information to users based upon similarity measures applied to the representation of the objects in these information spaces. The system simultaneously classifies documents, users, products, and other objects. Documents are managed by collators that act as classifiers of overlapping portions of the database of documents. Collators evolve to meet the demands for information delivery expressed by user feedback. Liaisons act on the behalf of users to elicit information from the population of collators. This information is then presented to users upon logging into the system via Internet or another communication channel. Mites handle incoming documents from multiple information sources (e.g., in-house editorial staff, third-party news feeds, large databases, and WWW spiders) and feed documents to those collators which provide a good fit for the new documents.

US Patent Application Publication 2003/0123443 to Anwar, which is incorporated herein by reference, describes a search engine that utilizes both record based data and user activity data to develop, update, and refine ranking protocols, and to identify words and phrases that give rise to search ambiguity so that the engine can interact with the user to better respond to user queries and enhance data acquisition from databases, intranets, and internets.

The following patents, patent application publications, and other publications, all of which are incorporated herein by reference, may be of interest:

US Patent Application Publication 2005/0055341 to Haahr et al.

US Patent 5,987,457 to Ballard

US Patent 6,363,379 to Jacobson et al.

US Patent 6,347,313 to Ma et al.

US Patent 6,321,226 to Garber et al.

US Patent 6,189,002 to Roitblat

US Patent 6,167,397 to Jacobson et al.

US Patent 5,864,845 to Voorhees et al.

US Patent 5,825,943 to DeVito et al.

US Patent Application Publication 2005/0144158 to Capper et al.

US Patent Application Publication 2005/0114324 to Mayer

US Patent Application Publication 2005/0055341 to Haahr et al.

US Patent 5,857,179 to Vaithyanathan et al.

US Patent 7,139,755 to Hammond

US Patent 7,152,061 to Curtis et al.

US Patent 6,904,588 to Reddy et al.

US Patent 6,842,906 to Bowman-Amuha

US Patent 6,539,396 to Bowman-Amuha

US Patent Application Publication 2004/0249809 to Ramani et al.

US Patent Application Publication 2003/0058277 to Bowman-Amuha

US Patent 6,925,460 to Kummamuru et al.

US Patent 6,920,448 to Kincaid et al.

US Patent Application Publication 2006/0074883 to Teevan et al.

US Patent Application Publication 2006/0059134 to Palmon et al.

US Patent Application Publication 2006/0047643 to Chaman

US Patent Application Publication 2005/0216434 to Haveliwala et al.

US Patent Application Publication 2003/0061206 to Qian

US Patent Application Publication 2002/0073088 to Beckmann et al.

SUMMARY OF THE INVENTION

In some embodiments of the present invention, a search system is provided that clusters users, search topics, and search result documents in multi-layer association graphs in order to return meaningful, focused results to search queries. The search system

utilizes the multi-directional transfer of information from users to documents, in addition to the conventional transfer of information from documents to users, in order to provide search results that are based on personal search characteristics of the user, characteristics of communities to which the user implicitly belongs, and/or characteristics of the global community of users. The search system uses clustering-based techniques to rank search results, and to present search refinement options to the users. The search system performs the clustering based on the search terms used by the users, the search terms used by other users, and the terms in documents to which the users are exposed and select for viewing.

In some embodiments of the present invention, the search system provides personalized search results responsively to associations between search terms and documents returned to a user during previous searches. These associations are represented by a unique personal profile for each user, which typically comprises a personal association graph (PAG). The use of a PAG enables the search system to return search results to the user ranked at least in part based on search terms not included in a current search query, but which are associated in the user's PAG with search terms included in the current query. Furthermore, the search system extracts relevant terms from documents selected by the user, and adds these to the user's PAG in association with relevant search terms, thereby providing information that helps the system focus future search results.

In some embodiments of the present invention, the search system provides search results responsively to characteristics of communities to which the user implicitly belongs, as determined by the contribution of the user's PAG to topic profiles of these communities, which typically comprise respective topic association groups (TAGs). Each TAG represents the interactions of a plurality of searches conducted by a plurality of users within a single topic. For example, a physicist, a veterinarian, and a writer may be associated with a TAG regarding "quantum physics," a TAG regarding "animal food," and a TAG regarding "writing," respectively, because their respective PAGs reflect past search interests in these areas. All three users may conduct searches using the same search query term "cat." The physicist, because of his association with the topic "quantum physics," is presented with search results containing the phrase "Schrodinger's cat experiment," the veterinarian with search results regarding cat food, and the writer with information about the musical "Cats." It is noted that each of these users may have first used the specific term "cat" in their current searches. The search engine is

nevertheless able to provide meaningful results using the associations of "cat" in the users' respective TAGs.

In some embodiments of the present invention, the search system constructs a document profile for each search result document selected by a user. (The search result documents are typically presented to the user as a list of snippets associated with respective documents.) Each document profile typically comprises a document association graph, (DAG), which represents the interactions between a single document and a plurality of searches conducted by a plurality of users, and provides information regarding the associations of key search terms with the document. An important feature of some embodiments of the present invention is that not all of the search terms associated with a given document by its DAG necessarily actually appear in the document's snippet, or even in the entirety of the document. It is often the case that search terms in a DAG do not appear in the associated document's snippet or in the associated document.

In some embodiments of the present invention, the system ranks results and/or offers refinement options based on association scores between (a) DAGs of search result documents and (b) the PAG of the searching user, one or more TAGs associated with the user or the current query, a group association graph (GRAG) that combines the PAGs of multiple associated users of the system, and/or a global association graph (GAG) that combines the strongest interests of multiple users of the system.

In some embodiments of the present invention, the search system clusters users that contributed to a given TAG, based on the users' relative contributions to the strengths of associations within the TAG. Similarly, the search engine clusters documents that contributed to a given TAG, based on the documents' relative contributions to the strengths of association within the TAG.

The techniques of these embodiments of the present invention thus involve users not only as information consumers, but also as significant suppliers of information. This supply of information creates an implicit collaboration between users via the searches they perform, and the communities they thereby implicitly create. Such communities are formed by grouping users responsively to characteristics and interests of users implicit in their searches, rather than based on social networking or explicit tagging of interests by the users.

In some embodiments of the present invention, the system uses profiles that do not

comprise association graphs, such as lists (e.g., ranked lists), vectors, sets of sets, and a non-associative multi-dimensional matrix (e.g., three or more dimensions).. For example, the system may use personal profiles that do not comprise PAGs, topic profiles that do not comprise TAGs, document profiles that do not comprise DAGs, global profiles that do not comprise GAGs, and/or group profiles that do not comprise GRAGs.

There is therefore provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

presenting to a user a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level;

receiving from the user an indication of a desired one of the levels;

receiving from a user a search query consisting of one or more query terms;

responsively to the search query, generating a search result listing;

ranking at least a portion of the search result listing at least in part responsively to the indication; and

presenting at least a portion of the ranked search result listing to the user.

In an embodiment of the present invention, the desired level of personalization includes the personalized level, receiving the indication includes receiving the indication of the personalized level, and ranking includes:

constructing a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches;

calculating respective correlation scores between the personal profile and a plurality of search result documents of the at least a portion of search result listing; and

ranking the at least a portion of the search result listing at least in part responsively to the correlation scores.

For some applications, the personal profile includes a personal association graph (PAG), each of the previous searches includes one or more previous query terms, and constructing the personal profile includes constructing the PAG including at least a portion of the previous query terms as vertices. For some applications, generating the search result listing includes generating the search result listing responsively to the query terms and at least one of the previous query terms in the PAG linked to all of the query terms in the

PAG. Alternatively or additionally, generating the search result listing includes generating the search result listing responsively to the query terms and a high point term of a hotspot of the PAG.

In an embodiment, the user is one of a plurality of users, the desired level of personalization includes the community level, receiving the indication includes receiving the indication of the community level, and ranking includes:

constructing a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic;

calculating respective correlation scores between the topic profile and a plurality of search result documents of the at least a portion of search result listing; and

ranking the at least a portion of the search result listing at least in part responsively to the correlation scores.

For some applications, the topic profile includes a topic association graph (TAG), each of the previous searches includes one or more previous query terms, and constructing the topic profile includes constructing the TAG including at least a portion of the previous query terms as vertices.

In an embodiment, the user is one of a plurality of users, the desired level of personalization includes the community level, receiving the indication includes receiving the indication of the community level, and ranking includes:

constructing a plurality of personal profiles for respective users in the plurality of users, each of which personal profiles represents interactions of a plurality of previous searches conducted by one of the users with a respective plurality of previous search result documents presented to the one of the users during the previous searches;

identifying a subset of the personal profiles as correlated with one another;

constructing a group profile by combining at least a portion of each of the personal profiles in the subset;

calculating respective correlation scores between the group profile a plurality of search result documents of the at least a portion of search result listing; and

ranking the at least a portion of the search result listing at least in part responsively to the correlation scores.

In an embodiment, the personal profiles include respective personal association graph (PAGs), each of the previous searches includes one or more first query terms,

constructing the personal profiles includes constructing the PAGs including at least a portion of the first query terms as vertices, the group profile includes a group association graph (GRAG), and constructing the group profile includes constructing the GRAG by combining at least a portion of each of the PAGs in the subset. For some applications, generating the search result listing includes generating the search result listing responsively to the query terms and at least one of the previous query terms in the GRAG linked to all of the query terms in the GRAG.

In an embodiment, the user is one of a plurality of users, the desired level of personalization includes a global level that is not personalized, receiving the indication includes receiving the indication of the global level, and ranking includes:

constructing a global profile that represents interactions of a plurality of previous searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches;

calculating respective correlation scores between the global profile and a plurality of search result documents of the at least a portion of search result listing; and

ranking the at least a portion of the search result listing at least in part responsively to the correlation scores.

For some applications, the global profile includes a global association graph (GAG), each of the previous searches includes one or more previous query terms, and constructing the global profile includes constructing the GAG including at least a portion of the previous query terms as vertices. For some applications, generating the search result listing includes generating the search result listing responsively to the query terms and at least one of the previous query terms in the GAG linked to all of the query terms in the GAG.

In an embodiment, the user is one of a plurality of users, and ranking includes:

constructing a plurality of document profiles associated with a respective plurality of search result documents, each of which document profiles represents interactions of (a) a plurality of previous searches conducted by the plurality of users with (b) the respective search result document associated with the document profile; and

ranking the at least a portion of the search result listing at least in part responsively to the indication and respective correlation scores between the query terms and at least a portion of the document profiles.

For some applications, the plurality of document profiles includes a respective plurality of document association graphs (DAGs), the previous searches include one or more respective previous query terms, and constructing the plurality of document profiles includes constructing the plurality of DAGs, each of which includes one or more of the previous query terms as vertices.

There is further provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

receiving from a user a first search query consisting of one or more first query terms;

receiving from the user an indication of a desired level of personalization of refinement options for the search query;

responsively to the search query, generating a set of one or more refinement terms at least in part responsively to the indication;

presenting the set of refinement terms to the user;

responsively to a selection of at least one of the refinement terms by the user, adding the selected at least one refinement term to the first search query to generate a second search query; and

presenting search results to the user responsively to the second search query.

For some applications, the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and presenting the set of refinement terms includes presenting the primary and secondary refinement terms.

For some applications, the desired level of personalization is selected from a range of personalization levels between a personalized level and a global level that is not personalized. For some applications, the range of personalization levels includes a community level between the personalized level and the global level.

In an embodiment, the desired level of personalization includes a personalized level, receiving the indication includes receiving the indication of the personalized level, and generating the set of one or more refinement terms includes:

constructing a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches, each

of previous searches includes one or more previous query terms; and

selecting at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the personal profile.

For some applications, the personal profile includes a personal association graph (PAG), constructing the personal profile includes constructing the PAG including at least a portion of the previous query terms as vertices, and selecting the previous query term includes selecting the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the PAG.

In an embodiment, the user is one of a plurality of users, the desired level of personalization includes the community level, receiving the indication includes receiving the indication of the community level, and generating the set of one or more refinement terms includes:

constructing a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, each of the previous searches includes one or more previous query terms; and

selecting at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the topic profile.

For some applications, the topic profile includes a topic association graph (TAG), constructing the personal profile includes constructing the TAG including at least a portion of the previous query terms as vertices, and selecting the previous query term includes selecting the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the TAG.

In an embodiment, the user is one of a plurality of users, the desired level of personalization includes a global level that is not personalized, receiving the indication includes receiving the indication of the global level, and generating the set of one or more refinement terms includes:

constructing a global profile that represents interactions of a plurality of searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, each of the previous searches includes one or more previous query terms; and

selecting at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the global profile.

For some applications, the global profile includes a global association graph (GAG), constructing the global profile includes constructing the GAG including at least a portion of the previous query terms as vertices, and selecting the previous query term includes selecting the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the GAG.

There is still further provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

receiving from a plurality of first users a respective plurality of first search queries, each of which consists of one or more first query terms;

presenting to the plurality of first users respective first search result listings, each of which includes one or more first snippets associated with one or more respective search result documents;

constructing a plurality of document profiles, each of which (a) is associated with one of the first snippets selected by one or more of the first users from the respective first search result listings, and (b) represents an interaction of one or more of the first query terms with the first snippet;

receiving from a second user a second search query, which consists of one or more second query terms;

responsively to the second search query, generating a second search result listing, which includes at least a portion of the one or more first snippets;

performing a comparison between (a) the second search query and (b) one or more of the document profiles associated with the first snippets included in the second search result listing;

ranking at least a portion of the second search result listing at least in part responsively to comparison; and

presenting at least a portion of the ranked second search result listing to the second user.

In an embodiment, constructing the document profiles includes constructing the document profiles such that at least one of the document profiles includes one or more of

the first query terms that do not appear in the first snippet associated with the document profile.

In an embodiment, ranking includes:

presenting to the second user a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level;

receiving from the user an indication of a desired one of the levels; and

ranking the at least a portion of the second search result listing at least in part responsively to the indication.

In an embodiment, the document profiles include respective document association graphs (DAGs), each of which includes a plurality of the first query terms as DAG vertices. For some applications, constructing the document profiles includes constructing the DAGs such that at least one of the DAGs includes as vertices one or more of the first query terms that do not appear in the first snippet associated with the document profile. For some applications, receiving the second search query includes receiving the second search query, which consists of the one or more second query terms organized linearly, and transforming the second search query into a query association graph including the one or more second query terms as query association graph vertices, and performing the comparison includes performing the comparison between (a) the query association graph and (b) the one or more of the DAGs associated with the first snippets included in the second search result listing.

For some applications, performing the comparison includes constructing a personal association graph (PAG) for the second user that represents interactions of a plurality of previous searches conducted by the second user with a respective plurality of previous search result documents presented to the second user during the previous searches, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, and the comparison includes a correlation between (a) a subgraph of the PAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the PAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and ranking includes ranking the at least a portion of the second search result listing at least in part responsively to the

correlation.

For some applications, the method includes:

receiving a selection made by the second user of one of the first snippets included in the ranked second search result listing;

calculating a query score for the second search query; and

responsively to the query score:

incrementing edge scores of the PAG between vertices of the PAG respectively including the second query terms; and

incrementing edge scores of the DAG associated with the selected first snippet between vertices of the DAG respectively including the second query terms.

For some applications, incrementing the edge scores of the PAG includes adding one of the second query terms to the PAG as a new vertex upon finding the second query term is not already included in the PAG. Alternatively or additionally, incrementing the edge scores of the DAG includes adding one of the second query terms to the DAG as a new vertex upon finding the second query term is not already included in the DAG.

In an embodiment, calculating the query score includes calculating the query score responsively to at least one attribute selected from the group consisting of: a query-specific attribute, a second-user-query-interaction attribute, and a second-user-result-interaction attribute.

For some applications, the attribute includes the query-specific attribute, and calculating the query score includes calculating the query score responsively to the query-specific attribute. For example, the query-specific attribute may include a measure of a number of keywords in the second query, and calculating the query score includes calculating the query score responsively to the measure of the number of keywords.

For some applications, the attribute includes the second-user-query-interaction attribute, and calculating the query score includes calculating the query score responsively to the user-query-interaction attribute. For example, the second-user-query-interaction attribute may include an association score of a subgraph of the PAG that consists of the second query terms, and calculating the query score includes calculating the query score responsively to the association score. Alternatively or additionally, the second-user-query-interaction attribute may include a level of focus of the second user regarding the second query, and calculating the query score includes calculating the query score

responsively to the level of focus.

For some applications, the attribute includes a second-user-result-interaction attribute, and calculating the query score includes calculating the query score responsively to the second-user-result-interaction attribute. For example, the second-user-result-interaction attribute may include a relative position of the selected first snippet in the ranked second search result listing, and calculating the query score includes calculating the query score responsively to the relative position. Alternatively or additionally, the second-user-result-interaction attribute may include an amount of time spent by the second user after selecting the selected first snippet before returning to the ranked second search result listing to make a subsequent selection from the ranked second search result listing.

In an embodiment, performing the comparison includes constructing a topic association graph (TAG) that represents interactions of a plurality of previous searches conducted within a single topic by a plurality of previous users including the second user, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, the comparison includes a correlation between (a) a subgraph of the TAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the PAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and ranking includes ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

In an embodiment, performing the comparison includes constructing a global association graph (GAG) that represents interactions of a plurality of searches conducted by a plurality of previous users including the second user with a respective plurality of previous search result documents presented to the previous users during the searches, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, the comparison includes a correlation between (a) a subgraph of the GAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the GAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and ranking includes ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

There is additionally provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

receiving from a user a plurality of first search queries, each of which consists of one or more first query terms;

presenting to the user a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents;

constructing a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices;

receiving from the user a second search query that consists of one or more second query terms;

responsively to the second search query, generating a second search result listing;

calculating respective correlation scores between the PAG and a plurality of second search result documents of at least a portion of the second search result listing;

ranking the at least a portion of the second search result listing at least in part responsively to the correlation scores; and

presenting the ranked second search result listing to the user.

In an embodiment, calculating the respective correlation scores includes:

constructing a PAG matrix representing at least a portion of the PAG;

constructing respective document matrices for the plurality of search result document; and

calculating the respective correlation scores using the PAG matrix and the respective document matrices.

In an embodiment, the user is one of a plurality of users, and calculating the respective correlation scores includes:

constructing a plurality of document profiles respectively associated with the plurality of second search result documents, each of which document profiles represents interactions of (a) a plurality of previous searches conducted by the plurality of users with (b) the respective second search result document associated with the document profile; and

calculating the respective correlation scores between the PAG and the plurality of document profiles respectively associated with the plurality of second search result

documents.

For some applications, each of the plurality of previous searches includes one or more previous query terms, the document profiles include respective document association graphs, each of which includes one or more of the previous query terms as vertices, and calculating the respective correlation scores includes calculating the respective correlation scores between the PAG and the plurality of DAGs respectively associated with the plurality of second search result documents.

In an embodiment, calculating the respective correlation scores includes:

constructing a subgraph of the PAG that consists of the second query terms and one or more additional first query terms of the PAG; and

calculating the respective correlation scores between the subgraph and the plurality of the second search result documents.

For some applications, all of the one or more additional first query terms of the PAG are directly linked to all of the second query terms within the PAG, and constructing the subgraph of the PAG includes constructing the subgraph of the PAG that consists of the second query terms and the one or more additional first query terms of the PAG that are directly linked to all of the second query terms within the PAG.

There is still additionally provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

receiving from a user a plurality of first search queries, each of which consists of one or more first query terms;

presenting to the user a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents;

constructing a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices;

receiving from the user a second search query that consists of one or more second query terms included in a portion of the vertices of the PAG;

responsively to the second search query, generating a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query

terms in the PAG;

presenting the set of refinement terms to the user;

responsively to a selection of at least one of the refinement terms by the user, adding the selected at least one refinement term to the second search query to generate a third search query; and

presenting search results to the user responsively to the third search query.

For some applications, generating the set includes selecting the first query term for inclusion in the set responsively to finding that the first query term is directly linked to all of the second query terms in the PAG.

For some applications, the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and presenting the set of refinement terms includes presenting the primary and secondary refinement terms.

There is yet additionally provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

receiving from a plurality of users a respective plurality of first search queries, each of which consists of one or more first query terms, the plurality of users including a plurality of first users, and a second user;

constructing a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms;

receiving from the second user a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG;

responsively to the second search query, generating a second search result listing including a plurality of documents;

ranking at least a portion of the second search result listing at least in part responsively to a comparison between (a) the TAG and (b) at least a portion of the documents of the second search result listing; and

presenting at least a portion of the ranked second search result listing to the second user.

For some applications, constructing the TAG includes:

constructing respective personal profiles for each of the users of the portion of the users, each of which profiles represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches; and

combining respective portions of the personal profiles, which portions are associated with the topic, to form the TAG.

For some applications, the personal profiles include respective personal association graphs (PAGs), each of the previous searches includes one or more query terms, and constructing the respective personal profiles includes constructing the respective PAGs including at least a portion of the query terms as vertices.

For some applications, constructing the TAG includes extracting one or more hotspots from each of the PAGs, and combining the hotspots to form the TAG.

In an embodiment, ranking includes:

constructing a subgraph of the TAG that consists of the second query terms and one or more additional first query terms of the TAG, the comparison includes a comparison between (a) the subgraph of TAG and (b) the at least a portion of the documents; and

ranking the at least a portion of the second search result listing at least in part responsively to the comparison.

For some applications, all of the one or more additional first query terms of the TAG are directly linked to all of the second query terms within the TAG, and constructing the subgraph of the TAG includes constructing the subgraph of the TAG that consists of the second query terms and the one or more additional first query terms of the TAG that are directly linked to all of the second query terms within the TAG.

There is also provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

receiving from a plurality of users a respective plurality of first search queries, each of which consists of one or more first query terms, the plurality of users including a plurality of first users, and a second user;

constructing a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic

and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms;

receiving from the second user a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG;

responsively to the second search query, generating a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the TAG;

presenting the set of refinement terms to the second user;

responsively to a selection of at least one of the refinement terms by the second user, adding the selected at least one refinement term to the second search query to generate a third search query; and

presenting search results to the second user responsively to the third search query.

For some applications, generating the set includes selecting the first query term for inclusion in the set responsively to finding that the first query term is directly linked to all of the second query terms in the TAG.

For some applications, the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and presenting the set of refinement terms includes presenting the primary and secondary refinement terms.

In an embodiment, constructing the TAG includes:

constructing respective personal profiles for each of the users of the portion of the users, each of which profiles represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches; and

combining respective portions of the personal profiles, which portions are associated with the topic, to form the TAG.

For some applications, the personal profiles include respective personal association graphs (PAGs), each of the previous searches includes one or more query terms, and constructing the respective personal profiles includes constructing the respective PAGs including at least a portion of the query terms as vertices. For some applications, constructing the TAG includes extracting one or more hotspots from each of

the PAGs, and combining the hotspots to form the TAG.

There is further provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

receiving from a user a first search query consisting of one or more first query terms;

responsively to the search query, generating and presenting to the user a search result listing that includes at least a first snippet associated with a first search result document, and a second snippet associated with a second search result document;

presenting, in association with the first snippet, a first set of one or more refinement terms, and, in association with the second snippet, a second set of one or more refinement terms, the first set is different from the second set;

responsively to a selection of one of the refinement terms of the first set or second set, adding the selected one of the refinement terms to the search query to generate a refined second search query; and

responsively to the refined second search query, generating and presenting to the user a refined search result listing.

In an embodiment, generating the first set of refinement terms includes generating the first set of refinement terms by:

constructing a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches, each of previous searches includes one or more previous query terms, and

selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the personal profile.

For some applications, the personal profile includes a personal association graph (PAG), constructing the personal profile includes constructing the PAG including at least a portion of the previous query terms as vertices, and selecting the previous query term includes selecting the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the PAG.

In an embodiment, the user is one of a plurality of users, and generating the first

set of refinement terms includes generating the first set of refinement terms by:

constructing a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, each of the previous searches includes one or more previous query terms, and

selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the topic profile.

For some applications, the topic profile includes a topic association graph (TAG), constructing the personal profile includes constructing the TAG including at least a portion of the previous query terms as vertices, and selecting the previous query term includes selecting the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the TAG.

In an embodiment, the user is one of a plurality of users, and generating the first set of refinement terms includes generating the first set of refinement terms by:

constructing a global profile that represents interactions of a plurality of searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, each of the previous searches includes one or more previous query terms, and

selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the global profile.

For some applications, the global profile includes a global association graph (GAG), constructing the global profile includes constructing the GAG including at least a portion of the previous query terms as vertices, and selecting the previous query term includes selecting the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the GAG.

There is still further provided, in accordance with an embodiment of the present invention, a computer-implemented method including:

constructing a plurality of personal profiles for a respective plurality of users, each of which personal profiles represents interactions of a plurality of first searches conducted

by one of the users with a respective plurality of first search result documents presented to the user during the first searches;

identifying a subset of the personal profiles as correlated with one another;

constructing a group profile by combining at least a portion of each of the personal profiles in the subset;

receiving a second search query from one of the users whose personal profile is included in the subset;

responsively to the second search query, generating a search result listing;

calculating respective correlation scores between the group profile and a plurality of second search result documents of at least a portion of the second search result listing;

ranking the at least a portion of the second search result listing at least in part responsively to the correlation scores; and

presenting the ranked second search result listing to the one of the users.

In an embodiment, the personal profiles include respective personal association graph (PAGs), each of the first searches includes one or more first query terms, constructing the personal profiles includes constructing the PAGs including at least a portion of the first query terms as vertices, the group profile includes a group association graph (GRAG), and constructing the group profile includes constructing the GRAG by combining at least a portion of each of the PAGs in the subset.

There is additionally provided, in accordance with an embodiment of the present invention, apparatus including:

an interface for communicating with a user; and

a processor, which is configured to present to the user, via the interface, a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level; receive from the user, via the interface, an indication of a desired one of the levels; receive from a user, via the interface, a search query consisting of one or more query terms; responsively to the search query, generate a search result listing; rank at least a portion of the search result listing at least in part responsively to the indication; and present at least a portion of the ranked search result listing to the user via the interface.

There is still additionally provided, in accordance with an embodiment of the present invention, apparatus including:

an interface for communicating with a user; and

a processor, configured to receive from the user, via the interface, a first search query consisting of one or more first query terms; receive from the user, via the interface, an indication of a desired level of personalization of refinement options for the search query; responsively to the search query, generate a set of one or more refinement terms at least in part responsively to the indication; present the set of refinement terms to the user via the interface; responsively to a selection of at least one of the refinement terms by the user, add the selected at least one refinement term to the first search query to generate a second search query; and present to the user, via the interface, search results responsively to the second search query.

There is yet additionally provided, in accordance with an embodiment of the present invention, apparatus including:

an interface for communicating with a plurality of first users and with a second user; and

a processor, which is configured to receive from the plurality of first users, via the interface, a respective plurality of first search queries, each of which consists of one or more first query terms; present to the plurality of first users, via the interface, respective first search result listings, each of which includes one or more first snippets associated with one or more respective search result documents; construct a plurality of document profiles, each of which (a) is associated with one of the first snippets selected by one or more of the first users from the respective first search result listings, and (b) represents an interaction of one or more of the first query terms with the first snippet; receiving from the second user, via the interface, a second search query, which consists of one or more second query terms; responsively to the second search query, generate a second search result listing, which includes at least a portion of the one or more first snippets; perform a comparison between (a) the second search query and (b) one or more of the document profiles associated with the first snippets included in the second search result listing; rank at least a portion of the second search result listing at least in part responsively to comparison; and present at least a portion of the ranked second search result listing to the second user via the interface.

There is yet additionally provided, in accordance with an embodiment of the present invention, apparatus including:

an interface for communicating with a user; and

a processor, which is configured to receive from the user, via the interface, a plurality of first search queries, each of which consists of one or more first query terms; present to the user, via the interface, a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents; construct a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices; receive from the user, via the interface, a second search query that consists of one or more second query terms; responsively to the second search query, generate a second search result listing; calculate respective correlation scores between the PAG and a plurality of second search result documents of at least a portion of the second search result listing; rank the at least a portion of the second search result listing at least in part responsively to the correlation scores; and present the ranked second search result listing to the user via the interface.

There is also provided, in accordance with an embodiment of the present invention, apparatus including:

an interface for communicating with a user; and

a processor, configured to receive from the user, via the interface, a plurality of first search queries, each of which consists of one or more first query terms; present to the user, via the interface, a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents; constructing a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices; receiving from the user, via the interface, a second search query that consists of one or more second query terms included in a portion of the vertices of the PAG; responsively to the second search query, generate a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the PAG; present the set of refinement terms to the user via the interface; responsively to a selection of at least one of the refinement terms by the user, add the selected at least one refinement term to the second search query to generate a third search query; and present to the user, via the interface, search results

responsively to the third search query.

There is further provided, in accordance with an embodiment of the present invention, aapparatus including:

an interface for communicating with a plurality of users, which includes a plurality of first users, and a second user; and

a processor, configured to receive from the plurality of users, via the interface, a respective plurality of first search queries, each of which consists of one or more first query terms; construct a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms; receive from the second user, via the interface, a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG; responsively to the second search query, generate a second search result listing including a plurality of documents; rank at least a portion of the second search result listing at least in part responsively to a comparison between (a) the TAG and (b) at least a portion of the documents of the second search result listing; and presenting at least a portion of the ranked second search result listing to the second user via the interface.

There is still further provided, in accordance with an embodiment of the present invention , apparatus including:

an interface for communicating with a plurality of users, which includes a plurality of first users, and a second user; and

a processor, configured to receive from the plurality of users, via the interface, a respective plurality of first search queries, each of which consists of one or more first query terms; construct a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms; receive from the second user, via the interface, a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG; responsively to the second search query, generate a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively

to a level of association of the first query term with the second query terms in the TAG; present the set of refinement terms to the second user via the interface; responsively to a selection of at least one of the refinement terms by the second user, add the selected at least one refinement term to the second search query to generate a third search query; and present to the second user, via the interface, search results responsively to the third search query.

There is additionally provided, in accordance with an embodiment of the present invention, apparatus including:

an interface for communicating with a user; and

a processor, which is configured to receive from the user, via the interface, a first search query consisting of one or more first query terms; responsively to the search query, generate and present to the user, via the interface, a search result listing that includes at least a first snippet associated with a first search result document, and a second snippet associated with a second search result document; present, in association with the first snippet, a first set of one or more refinement terms, and, in association with the second snippet, a second set of one or more refinement terms, the first set is different from the second set; responsively to a selection of one of the refinement terms of the first set or second set, add the selected one of the refinement terms to the search query to generate a refined second search query; and responsively to the refined second search query, generate and present to the user, via the interface, a refined search result listing.

There is still additionally provided, in accordance with an embodiment of the present invention, apparatus including:

an interface for communicating with a plurality of users; and

a processor, configured to construct a plurality of personal profiles for the respective plurality of users, each of which personal profiles represents interactions of a plurality of first searches conducted by one of the users with a respective plurality of first search result documents presented to the user during the first searches; identify a subset of the personal profiles as correlated with one another; construct a group profile by combining at least a portion of each of the personal profiles in the subset; receive, via the interface, a second search query from one of the users whose personal profile is included in the subset; responsively to the second search query, generate a search result listing; calculate respective correlation scores between the group profile and a plurality of second

search result documents of at least a portion of the second search result listing; rank the at least a portion of the second search result listing at least in part responsively to the correlation scores; and present the ranked second search result listing to the one of the users via the interface.

There is yet additionally provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to present to a user a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level; receive from the user an indication of a desired one of the levels; receive from a user a search query consisting of one or more query terms; responsively to the search query, generate a search result listing; rank at least a portion of the search result listing at least in part responsively to the indication; and present at least a portion of the ranked search result listing to the user.

There is also provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a user a first search query consisting of one or more first query terms; receive from the user an indication of a desired level of personalization of refinement options for the search query; responsively to the search query, generate a set of one or more refinement terms at least in part responsively to the indication; present the set of refinement terms to the user; responsively to a selection of at least one of the refinement terms by the user, add the selected at least one refinement term to the first search query to generate a second search query; and present to the user search results responsively to the second search query.

There is further provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a plurality of first users a respective plurality of first search queries, each of which consists of one or

more first query terms; present to the plurality of first users respective first search result listings, each of which includes one or more first snippets associated with one or more respective search result documents; construct a plurality of document profiles, each of which (a) is associated with one of the first snippets selected by one or more of the first users from the respective first search result listings, and (b) represents an interaction of one or more of the first query terms with the first snippet; receiving from a second user a second search query, which consists of one or more second query terms; responsively to the second search query, generate a second search result listing, which includes at least a portion of the one or more first snippets; perform a comparison between (a) the second search query and (b) one or more of the document profiles associated with the first snippets included in the second search result listing; rank at least a portion of the second search result listing at least in part responsively to comparison; and present at least a portion of the ranked second search result listing to the second user.

There is still further provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a user a plurality of first search queries, each of which consists of one or more first query terms; present to the user a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents; construct a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices; receive from the user a second search query that consists of one or more second query terms; responsively to the second search query, generate a second search result listing; calculate respective correlation scores between the PAG and a plurality of second search result documents of at least a portion of the second search result listing; rank the at least a portion of the second search result listing at least in part responsively to the correlation scores; and present the ranked second search result listing to the user.

There is additionally provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which

instructions, when read by a computer, cause the computer to receive from a user a plurality of first search queries, each of which consists of one or more first query terms; present to the user a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents; constructing a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices; receiving from the user a second search query that consists of one or more second query terms included in a portion of the vertices of the PAG; responsively to the second search query, generate a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the PAG; present the set of refinement terms to the user; responsively to a selection of at least one of the refinement terms by the user, add the selected at least one refinement term to the second search query to generate a third search query; and present to the user search results responsively to the third search query.

There is still additionally provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a plurality of users a respective plurality of first search queries, each of which consists of one or more first query terms, the plurality of users including a plurality of first users, and a second user; construct a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms; receive from the second user a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG; responsively to the second search query, generate a second search result listing including a plurality of documents; rank at least a portion of the second search result listing at least in part responsively to a comparison between (a) the TAG and (b) at least a portion of the documents of the second search result listing; and presenting at least a portion of the ranked second search result listing to the second user.

There is yet additionally provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a plurality of users a respective plurality of first search queries, each of which consists of one or more first query terms, the plurality of users including a plurality of first users, and a second user; construct a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms; receive from the second user a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG; responsively to the second search query, generate a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the TAG; present the set of refinement terms to the second user; responsively to a selection of at least one of the refinement terms by the second user, add the selected at least one refinement term to the second search query to generate a third search query; and present to the second user search results responsively to the third search query.

There is also provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from the user a first search query consisting of one or more first query terms; responsively to the search query, generate and present to the user a search result listing that includes at least a first snippet associated with a first search result document, and a second snippet associated with a second search result document; present, in association with the first snippet, a first set of one or more refinement terms, and, in association with the second snippet, a second set of one or more refinement terms, the first set is different from the second set; responsively to a selection of one of the refinement terms of the first set or second set, add the selected one of the refinement terms to the search query to generate a refined second search query; and responsively to the refined second search query, generate and present to the user a refined search result listing.

There is further provided, in accordance with an embodiment of the present invention, a computer software product for executing a process, the product including a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to construct a plurality of personal profiles for the respective plurality of users, each of which personal profiles represents interactions of a plurality of first searches conducted by one of the users with a respective plurality of first search result documents presented to the user during the first searches; identify a subset of the personal profiles as correlated with one another; construct a group profile by combining at least a portion of each of the personal profiles in the subset; receive a second search query from one of the users whose personal profile is included in the subset; responsively to the second search query, generate a search result listing; calculate respective correlation scores between the group profile and a plurality of second search result documents of at least a portion of the second search result listing; rank the at least a portion of the second search result listing at least in part responsively to the correlation scores; and present the ranked second search result listing to the one of the users.

The present invention will be more fully understood from the following detailed description of embodiments thereof, taken together with the drawings, in which:

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic, pictorial illustration of a search system, in accordance with an embodiment of the present invention;

Fig. 2 is a more detailed schematic, pictorial illustration of the search system of Fig. 1, in accordance with an embodiment of the present invention;

Fig. 3 shows an exemplary association graph, in accordance with an embodiment of the present invention;

Fig. 4 shows an exemplary association adjacency matrix that represents the same association information represented by the association graph of Fig. 3, in accordance with an embodiment of the present invention;

Fig. 5 shows an exemplary data structure used by the search system of Fig. 1 to store the association graph of Fig. 3, in accordance with an embodiment of the present invention;

Fig. 6 shows two subgraphs of the association graph of Fig. 3, in accordance with an embodiment of the present invention;

Fig. 7 is a flowchart schematically illustrating a method for processing interaction events, in accordance with an embodiment of the present invention;

Fig. 8 is a schematic illustration of data flow associated with the method of Fig. 7, in accordance with an embodiment of the present invention;

Fig. 9 is a flowchart schematically illustrating a method for creating and updating a personal association graph (PAG), in accordance with an embodiment of the present invention;

Fig. 10 is a flowchart schematically illustrating a method for extracting hotspots from a PAG, in accordance with an embodiment of the present invention;

Fig. 11 is an exemplary hotspot, in accordance with an embodiment of the present invention;

Figs. 12A-B show an exemplary topic index, in accordance with an embodiment of the present invention;

Fig. 13 shows an exemplary topic association graph (TAG), in accordance with an embodiment of the present invention;

Fig. 14 is a schematic illustration of an exemplary screenshot of a browser including a search field and search results, in accordance with an embodiment of the present invention;

Fig. 15 is a flowchart schematically illustrating a method for performing a search and ranking the results thereof pursuant to a personal-based preference, in accordance with an embodiment of the present invention;

Fig. 16 is a schematic illustration of an exemplary screenshot of a browser including refinement options, in accordance with an embodiment of the present invention;

Fig. 17 is a flowchart schematically illustrating a method for presenting refinement options pursuant to a personal-based preference, in accordance with an embodiment of the present invention;

Fig. 18 is a flowchart schematically illustrating a method for presenting refinement options pursuant to a community-based preference, in accordance with an embodiment of

the present invention;

Fig. 19 is a flowchart schematically illustrating a method for presenting refinement options pursuant to a global-based preference, in accordance with an embodiment of the present invention; and

Fig. 20 is a schematic illustration of an exemplary screenshot of a browser including search results integrated with refinement options, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF EMBODIMENTS

SYSTEM OVERVIEW

Fig. 1 is a schematic, pictorial illustration of a search system 10, in accordance with an embodiment of the present invention. Search system 10 comprises a search server 20, an interface, such as a web server 22, and a memory 24. Typically, search system 10 comprises one or more standard computer servers with appropriate memory, communication interfaces and software for carrying out the functions prescribed by the present invention. This software may be downloaded to the system in electronic form over a network, for example, or it may alternatively be supplied on tangible media, such as CD-ROM. Memory 24 comprises a non-volatile memory, such as one or more hard disk drives, and/or a volatile memory, such as random-access memory (RAM).

A plurality of users 30 use respective workstations 32, such as a personal computers, to remotely access search system 10 via a wide-area network (WAN) 34, such as the Internet. Alternatively, one or more of users 30 access search system 10 via a local area network (LAN), or both a LAN and a WAN. Typically, a web browser 36 running on each workstation 32 communicates with web server 22. The web browser facilitates entry and refinement of search queries, and displays search results returned from web server 22. Each of workstations 32 comprises a central processing unit (CPU), system memory, a non-volatile memory such as a hard disk drive, a display, input and output means such as a keyboard and a mouse, and a network interface card (NIC). For some applications, workstation 32 implements an agent 38, typically in software. Agent 38 executes certain processes locally at workstation 32, for example such as described hereinbelow with reference to Fig. 9. Typically, the software of agent 38 is downloaded over WAN 34. Workstations 32 comprises software for carrying out the functions

prescribed by the present invention. This software may be downloaded to the system in electronic form over a network, for example, or it may alternatively be supplied on tangible media, such as CD-ROM.

In an embodiment of the present invention, search server 20 utilizes search results obtained from an external search engine 40, as described hereinbelow with reference to Fig. 15. For some applications, external search engine 40 is publicly accessible, such as via the Internet. For other applications, the external search engine is a dedicated search engine that provides searching of a particular website or domain, of resources on a private network, such as an intranet and/or enterprise network, or of a particular computer, such as one of workstations 32. Alternatively, search system 10 comprises a search engine that performs the search functionality of external search engine 40, such as mining and crawling the resources to be searched (configuration not shown).

Reference is made to Fig. 2, which is a more detailed schematic, pictorial illustration of search system 10, in accordance with an embodiment of the present invention. Search server 20 comprises a background processor 50, which collects and analyzes interactions between users 30 and search system 10, as described in detail hereinbelow with reference to Figs. 7-13. Such interactions typically include: (a) search queries entered by a user in a search field 52 of browser 36, or populated using the search refinement techniques described hereinbelow with reference to Figs. 16-20; and (b) clicks on search results 54 by a user.

Search server 20 further comprises an online processor 60, which provides online services to users 30. These services include one or more of:

- search services, which are provided by an internal search processor 62 of online processor 60, as described hereinbelow with reference to Figs. 14-15. Internal search processor 62 typically provides search results via web server 22 as search results 54 in browser 36;
- refinement services, which are provided by a refinement processor 64 of online processor 60, as described hereinbelow with reference to Figs. 16-19. Refinement processor 64 typically provides refinement suggestions via web server 22 as refinement options 66 in browser 36. (In the art, and in the applications assigned to the assignee of the present application that are incorporated hereinbelow by reference, a "refinement option" is

sometimes referred to as an "advisory" or as "advisory information."); and

- advertising services, which are provided by an advertising processor 70 of online processor 60, as described hereinbelow. Advertisement processor 60 typically provides advertisements via web server 22 in an advertisement area 72 in browser 36. Alternatively or additionally, the advertisements are integrated with search results 54, and/or displayed in a popup window, as is known in the art, or using other advertising display techniques known in the art.

Search system 10 generally performs gives higher priority to the processes performed by online processor 60 than to those performed by background processor 50, in order to avoid an interruption of the online services. System 10 typically implements background and online services in a well-balanced parallel and distributed environment, as is known in the art.

ASSOCIATION GRAPH OVERVIEW

Reference is made to Fig. 3, which shows an exemplary association graph 100, in accordance with an embodiment of the present invention. Many of the techniques of embodiments of the present invention utilize association graphs such as illustrated by association graph 100. These association graphs are typically generated and maintained by background processor 50, as described hereinbelow with reference to Figs. 7-13. Although exemplary association graph 100 includes only limited degrees of association, search system 10 often develops larger and more complex association graphs, which may include degrees of association greater than two.

Search system 10 uses association graphs to cluster users, their search interests and patterns, and information regarding search result documents in respective clusters. Search system 10 creates and maintains one or more of the following association graphs:

- a personal association graph (PAG), which is created for each user 30, as described hereinbelow with reference to Figs. 7-9. In general, each PAG represents the interactions of a plurality documents with a single user;

- a hotspot association graph (generally referred to herein simply as a "hotspot"), one or more of which are extracted from each PAG, as described hereinbelow with reference to Figs. 10-11. In general, a hotspot

includes a portion of a PAG that represents an area of particular importance to the user of the PAG;

- a topic association graph (TAG), which is created for each topic identified by background processor 50, as described hereinbelow with reference to Figs. 12-13. In general, a TAG represents the interactions of a plurality of searches conducted by a plurality users within a single topic;
- a document association graph (DAG), which is created for each document (typically represented by a unique URL) selected from search results 54 by any user 30, as described hereinbelow with reference to Figs. 7-8. In general, a DAG represents the interactions with a single document of a plurality of searches conducted by a plurality of users;
- a global association graph (GAG), which represents a merger of all or a large portion of the PAGs or their hotspots, as described hereinbelow with reference to Figs. 7-8. In general, a GAG represents the interactions of a plurality of users with all or a large portion of the document set of a particular deployment of search system 10; and
- a group association graph (GRAG), which represents a merger of a plurality of correlated PAGs or their hotspots, as described hereinbelow.

Each association graph comprises one or more vertices, each of which is linked to one or more other vertices by respective edges. Furthermore, a vertex may be linked to itself by an edge in some instances, as described hereinbelow. In the art, and in the applications assigned to the assignee of the present application that are incorporated hereinbelow by reference, "vertices" are sometimes referred to as "nodes," and "edges" are sometimes referred to as "arcs" or "links."

An association graph can be represented visually as a plurality of vertices linked (i.e., connected) by lines representing edges, as shown in Fig. 3, or as an adjacency matrix, as described hereinbelow with reference to Fig. 4. Search system 10 stores association graphs using one or more data structures, such as described hereinbelow with reference to Fig. 5. The phrase "association graph," as used herein, including in the claims, includes any data structure that conceptually includes vertices linked by edges, regardless of the nomenclature used to describe the data structure, or how it may be

represented, stored, structured, and/or manipulated in memory and/or another storage medium. For some applications, the association graph comprises a hypergraph, i.e., more than one edge links some pairs of vertices. For some applications, the association graph is not directed, i.e., the edges do not include a direction, while for other applications, the association graph is at least partly directed, i.e., at least a portion of the edges include a direction. For some applications, by linking a plurality of directed edges, the search system develops multi-vertex paths of connectivity among vertices.

Each vertex of an associate graph includes a single term, which consists of one or more keywords. Typically, when a term includes a plurality of keywords, the keywords are order-sensitive. In exemplary association graph 100 shown in Fig. 3, a first vertex 110 includes the single-keyword term "physics," while a second vertex 112 includes the single-keyword term "angular." Each edge has a score that represents the strength of the association of the vertices linked by the edge. For example, an edge 114 that links vertices 110 and 112 has a score 116 equal to 90. As mentioned above, a vertex may be linked to itself; for example, vertex 110 has a self-referential score 118 equal to 70. Association scores are typically, but not necessarily, symmetric, i.e., are not directed.

Fig. 4 shows an exemplary association adjacency matrix 150 that represents the same association information represented by association graph 100 of Fig. 3, in accordance with an embodiment of the present invention. Each value of matrix 150 represents the association score of the vertices listed on the corresponding vertical and horizontal labels of the matrix. For example, score 116 of edge 114 of association graph 100 of Fig. 3 is found at the intersection of vertex 110 ("physics") and vertex 112 ("angular"), and self-referential score 118 is found at the intersection of vertex 110 with itself. Typically, but not necessarily, the matrix is symmetric, so it need only specify values on the diagonal (for self-referential scores) and on one side of the diagonal.

Fig. 5 shows an exemplary data structure 160 used by search system 10 to store association graph 100 in memory 24, in accordance with an embodiment of the present invention. Numerous other data structures for storing association graphs will be evident to those skilled in the art, and are considered within the scope of the present invention. Data structure 160 comprises a persistent graph 162, which comprises a graph header 164, a graph data section 166, an offset array 168, a term index 170, and a graph footer 172. Graph data section 166 comprises a sequence of data for terms. The data for each term

includes a term vertex 174 and an adjacency list 176. Offset array 168 comprises a sequence of offsets 178, which indicate the offsets of corresponding term vertices 174. Term index 170 typically comprises a hash table (e.g., a dense hash table) of the term and the offset. Graph footer typically comprises the graph data length. Additional details regarding data structure 160 are shown in the figure. In the table, "time stamp" is abbreviated "TS."

In an embodiment of the present invention, search system 10 uses timestamp to provide decay over time within the different types of association graphs, such that the weight given to older associations decreases gradually over time. The association graphs thus reflect the users' current interests, which typically change over time.

For clarity of presentation, in the present application, including in the claims, a vertex of an association graph including a term is sometimes referred to simply as the term itself. For example, it may be stated that a first term of an association graph is linked to a second term of the association graph, rather than more verbosely stating that a first vertex of an association graph containing a first term is linked to a second vertex of the association graph containing a second term.

Association scores

Reference is made to Fig. 6, which shows two subgraphs of association graph 100 of Fig. 3, in accordance with an embodiment of the present invention. Numerous embodiments of the present invention utilize an association score that represents the strength of association among one or more vertices of a subgraph of an association graph. The association score typically takes into consideration both the scores of the edges within the subgraph, and a measure of balance among the scores. Subgraphs having greater balance are considered to have a greater strength of association, *ceteris paribus*.

In an embodiment of the present invention, the association score of a subgraph of an association graph is (a) positively related to a measure of an average of the edge scores linking the vertices within the subgraph, and (b) inversely related to a measure of variability of the edge scores. For example, the association score of the subgraph may be equal to the quotient of (a) the measure of the average, and (b) the measure of the variability. Optionally, the divisor (b) equals the sum of the measure of the variability and a constant, such as 1. For example, the measure of the average may be an arithmetic

mean, a geometric mean, a median, or a mode, and the measure of variability may be a standard deviation or a variance.

For some applications, search system 10 uses the following equation to calculate the association score of a subgraph:

$$association\_score = \frac{average\_edge\_score}{(1+\sqrt{\text{var}(edge\_score)})} \quad \text{(Equation 1)}$$

In Fig. 6, exemplary association graph 100 includes first and second subgraphs 200 and 202. Subgraph 200 includes vertices 110 ("physics"), 112 ("angular"), and 204 ("spin"), linked by edges 114, 206, and 208. Applying Equation 1, the association score of subgraph 200 is calculated as:

$$\frac{(90+60+54)/3}{1+\text{sqrt}[(90-68)^2+(60-68)^2+(54-68)^2]}$$

$$= 68 / [1+\text{sqrt}(248)]$$

$$= 4.06$$

If, for example, score 116 of edge 114 were 57 instead of 90, the association score would be 16.52. This higher score reflects the greater balance of subgraph 200, which outweighs the lower average than in the earlier example.

For some applications, the edge scores of the subgraph are normalized before applying Equation 1, typically by dividing each of the edge scores by a normalization factor equal to the greatest edge score in the subgraph, such that each edge score receives a normalized value of between 0 and 1. The result returned by Equation 1 is typically multiplied by the normalization factor. This normalization technique is reflected by the following equation:

$$association\_score = normalization\_factor \bullet \frac{average\_normalized\_edge\_score}{(1+\sqrt{\text{var}(edge\_score)})} \quad \text{(Equation 2)}$$

Application of Equation 2 to the exemplary values given above yields the following calculation of the association score of subgraph 200:

$$90 \bullet (90/90+60/90+54/90)/3$$

1+sqrt[(1–0.756)^2+(0.667-0.756)^2+(0.6-0.756)^2]

= 90 • 0.756 / [1+sqrt(0.175)]

= 57.9

Typically, the association score of a subgraph is defined to be zero if not all vertices of the subgraph are linked to all other vertices of the subgraph. The association score of subgraph 202 is thus zero, because vertex 204 ("spin") is linked to neither a vertex 210 ("winners") nor a vertex 212 ("prize") of the subgraph. Alternatively, for some applications, this condition is less rigid. For example, the association score may be non-zero if all of the vertices of the subgraph are linked to at least one other vertex of the subgraph, but not necessarily all of the other vertices of the subgraph.

THE BACKGROUND PROCESSOR

Reference is again made to Fig. 2. As mentioned above, background processor 50 collects and analyzes interactions between users 30 and search system 10. Background processor 50 comprises a feedback logger 300 and a feedback processor 302. Search-related events generated by user 30 enter feedback logger 300 in real-time, and the logger appends them to log files stored in at least one log 304, typically with no or minimal processing of the events. Such events include the entry of a search query consisting of one or more search terms into search field 52 of browser 36, selection of search results 54 of browser 36, selection of refinement options 66 of browser 36, and selection of advertisements in advertisement area 72 of browser 36.

Feedback processor 302 retrieves and processes the events stored in log 304. Such processing typically uses a pipeline architecture, in which packages of event data move in the pipeline from processing station to processing station, and are converted and/or integrated into various knowledge components, as described hereinbelow. Typically, the volume of data and the frequency of data transition/computation are reduced as the event data moves along the pipeline. For some applications, feedback processor 302 processes the events using techniques described in Dean J et al., "MapReduce: Simplified Data Processing on Large Clusters," USENIX Association OSDI '04: 6th Symposium on Operating System Design and Implementation, pp. 137–150 (2004), which is incorporated herein by reference.

Reference is made to Figs. 7 and 8, which are a flowchart schematically

illustrating a method 350 for processing interaction events, and a schematic illustration of data flow associated with the method, respectively, in accordance with an embodiment of the present invention. Method 350 begins with the receipt of an interaction event by feedback processor 302, at an event receipt step 360. Typically, an interaction event 362 (Fig. 8) is generated each time one of users 30 selects a document 364 (often associated with a URL) presented by search system 10 in response to a search query entered by the user. A single interaction event 362 thus represents a single interaction between a single query of a single user 30 and a single selected document 364. Typically, each document 364 is represented by a snippet that includes one or more of the keywords of the query, and the URL of the document.

A search query consists of one or more keywords, and, optionally, operators, such as Boolean operators and quotation marks. As mentioned above, the association graphs of embodiments of the present invention (e.g., PAGs, TAGs, DAGs, GRAGs, and the GAG) include vertices, each of which contains a single term. A term consists of one or more keywords, in a particular order. For some applications, feedback processor 302 attempts to resolve the keywords of a search query entered by user 30 into one or more multi-keyword terms, in order to find the best matches between the keywords of the query and the terms stored in the associations graphs. To perform such resolution, the feedback processor checks whether combinations of two or more of adjacent keywords in the query, preserving their order, match any of the vertices in the relevant association graph(s). Optionally, in making this determination, the feedback processor also takes into consideration the association score of the possible multi-keyword term with the other keywords and/or terms of the query.

Optionally, feedback processor 302 begins processing of events retrieved from log 304 by filtering out low quality events and adding information to valuable events, at a filtering step 366.

Feedback processor 302 passes each interaction event to two channels: a personal processing channel 370, and a document processing channel 372. Upon entrance to personal processing channel 370, feedback processor 302 updates a personal association graph (PAG) 374 (Fig. 8) of user 30, at an update PAG step 376. If the current interaction event is the first for the user, the feedback processor creates a new PAG for the user. A detailed description of the PAG updating process is provided hereinbelow with reference

to Fig. 9.

Processing in personal processing channel 370 continues with the extraction of one or more hotspots 378 (Fig. 8) from the respective PAGs of each of users 30, at a hotspot extraction step 380. Hotspots 378 are subgraphs of a PAG that represent areas of particular importance to the user of the PAG. A detailed description of the hotspot extraction process is provided hereinbelow with reference to Figs. 10 and 11.

Feedback processor 302 analyzes hotspots 378 of a plurality of users 30, such as all users 30 of a particular deployment of search system 10, to build a topic index 382 (Fig. 8), at a topic analysis step 384. For some applications, to more efficiently analyze changes in hotspots 378, feedback processor 302 calculates a hotspot difference graph 386 (Fig. 8) for each hotspot 378, which reflects changes to the hotspot since the feedback processor last analyzed the hotspot. Topic index 382 is updated based on hotspot difference graph 386, rather than directly based on hotspot 378. A detailed description of the topic index creation and maintenance process is provided hereinbelow with reference to Figs. 12A-B.

At a topic association graph (TAG) processing step 390, feedback processor 302 analyzes topic index 382 to create and/or update one or more TAGs 392 (Fig. 8). TAGs 392 represent respective topics in which a plurality of users 30 have expressed, and, for some applications, continue to express, a strong interest. A detailed description of the TAG creation and maintenance process is provided hereinbelow with reference to Fig. 13.

For some applications, feedback processor 302 merges all hotspots 378 or hotspot difference graphs 386 of a particular deployment of search system 10, to create and maintain a global association graph (GAG) 396 (Fig. 8), at a global association processing step 398. The GAG represents the combined strongest interests of all users 30 of search system 10. (Alternatively, the feedback processor merges all or a large portion of the PAGs of a particular deployment of search system 10 to generate the GAG.)

As mentioned above, feedback processor 302 passes each interaction event to two channels: personal processing channel 370, and document processing channel 372. Upon entrance to document processing channel 372, feedback processor 302 updates a document association graph (DAG) 400 (Fig. 8) of the particular document 364 associated with interaction event 362, at an update DAG step 402. Generally, the same vertices, edge scores, and/or edge score updates generated from a given interaction event 362 are

added to the DAG of the associated document as are added to the associated PAG of the user at update PAG step 376 above. Typically, such DAG updates include the same addition of terms from search results added to PAGs and/or incrementing of scores of such search results already included in the association graph, as described at steps 470 and 472 of method 450, described hereinbelow with reference to Fig. 9.

In an embodiment of the present invention, at update DAG step 402 the feedback processor additionally updates the DAG to reflect associations not directly included in the query terms, by adding relevant terms to the DAG. For example, such associations may be derived from the user's associations, associations of one or more communities to which the user belongs (either TAG-based or GRAG-based), or global associations reflected in the GAG. It is noted that the use of these techniques results in the inclusion of search terms in a DAG that do not appear in the associated document's snippet or in the associated document.

For some applications, feedback processor 302 uses one or more of the following techniques for adding such associations not directly included in the query terms:

- the feedback processor adds at least a portion of at least one of the hotspots of user 30 to the DAG, such as the entire hotspot or the high point of the hotspot;
- the feedback processor adds at least a portion of at least one of the topic IDs associated with user 30, as described hereinbelow with reference to Figs. 12A-B and 13. For some applications, the feedback processor also adds one or more vertices directly connected to the topic ID in the associated TAG thereof; and
- the feedback processor adds one or more terms directly connected to all of the search terms in the user's PAG, at least one of the TAGs, at least one of the GRAGs, or the GAG.

Typically, the feedback processor damps the edge scores of these terms when adding them to the DAG, for example using damping techniques similar to those described hereinbelow at steps 470 and 42 of method 450, described hereinbelow with reference to Fig. 9.

At a URL indices step 404, feedback processor 302 updates one or more URL

indices 406 (Fig. 8) associated with DAGs 400. URL indices 406 comprise a collection of inverted lists that are used by internal search processor 62 to efficiently locate appropriate URLs. The indices are built and updated based on data from the DAGs, or, alternatively or additionally, based on data from documents 364.

Typically, feedback processor 302 performs update PAG step 376 and update DAG step 402 at a high frequency, and the other steps of method 350 at a lower frequency.

Personal association graphs (PAGs)

Reference is made to Fig. 9, which is a flowchart schematically illustrating a method 450 for creating and updating a PAG, in accordance with an embodiment of the present invention. Method 450 is performed at step 376 of method 350, described hereinabove with reference to Fig. 7.

Method 450 begins at a query score calculation step 452, at which feedback processor 302 calculates a query score for interaction event 362 (Fig. 8). The query score represents a level of relevance to the user of the query and its respective search results. Techniques for calculating the query score are described hereinbelow.

Feedback processor 302 checks whether the calculated query score exceeds an external threshold, at an external threshold check step 454. The external threshold is set at a level that reduces the likelihood of search information that is important to a particular user, but not to the search community, entering TAGs 392 and GAG 396 (Fig. 8). If the feedback processor finds that the query score does not exceed the external threshold, the feedback processor checks whether the query score exceeds an internal threshold, at an internal threshold check step 456. The internal threshold is set to a level that reduces the likelihood of search information entering the PAG for searches that are relatively unimportant for the user. If the feedback processor finds that the query score does not exceed the internal threshold, method 450 concludes at a non-update step 458, at which the feedback processor does not update the PAG.

If, on the other hand, feedback processor 302 finds at check step 456 that the query score does exceed the internal threshold, the feedback processor updates the PAG with the search terms of the query and the query score, at an update PAG step 460 (as mentioned above, each term includes one or more keywords). Any search terms not

already included to the PAG are added thereto as vertices. The edge scores between the vertices holding the search terms of the query (whether the vertices were already included in the PAG, or newly added) are incremented by an increment value calculated based on the query score. For some applications, feedback processor 302 sets the increment amount equal to the quotient of the query score and the number of search terms in the query. If the query includes only a single search term, the entire increment value (which equals the query score) is added to the self-referential score of the vertex of the PAG including the search term. If the query includes exactly two search terms, the increment value (which equals half of the query score) is added to the score of the edge between the two vertices respectively containing the two search terms. If the query includes three or more search terms, the score of each of the edges between each pair of vertices containing the search terms is incremented by the increment value.

For example, assume that association graph 100 shown in Fig. 3 is a PAG; the query includes the search terms "physics" and "angular," neither of which were previously added to the PAG; and the query score is 90. The feedback processor adds vertices 110 ("physics") and 112 ("angular") to the PAG, and sets edge score 116 equal to 45, which equals the query score (90) divided by the number of search terms (2).

In an embodiment of the present invention, the query score of a given query is dependent upon one or more of the following attributes:

- query-specific attributes, such as a measure of the number of keywords in the query, such as the number itself, or the number after subtracting the number of stop words in the query;
- user-query-interaction attributes, such as the association score of the query within the user's PAG, or a level of focus of the user regarding the query; and
- user-result-interaction attributes, such as a relative position of a selected document in the search results for the query, or an amount of time spent by the user after selecting a document before returning to the same search results to select a subsequent document from the search results.

It is noted that the collection of these attributes by feedback processor 302 generally does not require any active user participation in generating the query score.

Query-specific attributes characterize aspects of the query that are often positively correlated with the quality of the interaction between the query and the results. These attributes include, but are not limited to:

- the number of keywords in the query. In general, more specific queries include a greater number of keywords, and thus are more indicative of a higher quality of interaction between the query and the results; and
- the number of stop words in the query (i.e., keywords that are so commonly used that they cannot contribute to relevancy of the query, such as conjunctions, prepositions, and articles). In general, the inclusion of stop words in a query is indicative a low level of user expertise in the topic of the query. Typically, the number of keywords in the number-of-keyword attribute mentioned above is counted after removing stop words.

User-query-interaction attributes characterize aspects of the user's interaction with the query that are often positively correlated with the quality of the interaction between the query and the results. These attributes include, but are not limited to:

- the association score of the query within the user's PAG. A higher association score generally correlates with a higher level of user expertise in the topic of the search. The association score is calculated using techniques described hereinabove with reference to Fig. 6. For example, using exemplary association graph 100 of Fig. 6 as a PAG, and Equation 2 to calculate the association score, the association score of the query consisted of the keywords "physics," "angular," and "spin" (representing subgraph 200) would be 57.9. For some applications, the association score is capped by a constant, such as 3; and
- a level of focus of the user regarding the query. A focused search within a specific topic is more indicative of a high-quality interaction than a quick search in which the user is just browsing the topic. The level of focus is typically represented by a focal grade.

In an embodiment of the present invention, feedback processor 302 calculates the focal grade of a query responsively to: (a) a measure of intersection of the set of terms of the query with a set of terms of a previous query conducted by the user, and (b) an

association score of the previous query within the PAG of the user, calculated using the techniques described hereinabove with reference to Fig. 6. For some applications, the feedback processor calculates the focal grade by calculating a product of (a) and (b).

For some applications, the feedback processor uses the following equation to calculate the focal grade of a query (q2):

$$\text{focal grade (q2)} = \frac{1}{\lambda}\text{cosine (q1,q2)} \cdot \text{(q1 score)} \quad \text{(Equation 3)}$$

wherein q1 is the previous query, q1 score is the association score of the previous query within the PAG of the user, and λ is a constant that serves as a normalization factor, so that $0 \leq$ focal grade ≤ 1. For example, λ may between about 5 and about 10, e.g., about 7. For some applications, the cosine, i.e., measure of intersection, of q1 and q2, is calculated as:

$$\text{cosine (q1, q2)} = set\_size(q1 \cap q2) / set\_size(q1) \quad \text{(Equation 4)}$$

Typically, in order to identify the previous query (q1), feedback processor 302 considers the cosine (q1, q2) for all previous queries within the past t minutes, beginning with the most recent previous query. The feedback processor uses the first previous query identified that has at least one term in the intersection set. Alternatively, the feedback processor uses the previous query in the past t minutes that has the greatest cosine. t is typically between about 15 minutes and about 1 hour, e.g., about 30 minutes. Typically, feedback processor 302 eliminates stop words from the current query and the previous queries before determining the measure of intersection.

User-result-interaction attributes characterize aspects of the user's interaction with the search results of the query that are often positively correlated with the quality of the interaction between the query and the results. These attributes include, but are not limited to:

- a relative position of a selected document in the search results for the query. Typically, search results 54 (Fig. 2) are displayed as a list of snippets from each of documents in the search results. Each snippet typically includes one or more of the keywords of the query, and the URL of the document. In general, the selection by the user of a document lower on the list provides more information regarding the quality of the match

between the selected document and the search query than the selection of the same document would provide if the document were located higher on the list, because the user decided to skip more documents not deemed to be relevant in order to arrive at the selected document; and

- an amount of time spent by the user after selecting a document before returning the same search results to select a subsequent document from the search results. For example, if the user returns to a Web page containing the search results within less than a threshold amount of time after selecting one of the results, this indicates that the user did not find the document meaningful for his search, and therefore did not interact with the document. For example, the threshold may be less than 5 seconds, such as less than 2 seconds.

In an embodiment of the present invention, feedback processor 302 uses the following equation for determining the query score:

query score =

$$\log\left(\frac{(\text{real keyword no.})\cdot log(1+\text{clicked URL position})}{(1+\text{stop words}/2)}\cdot(1+\text{focal grade})+1\right)\cdot(PAGscore(query)+1)$$

(Equation 5)

For some applications, the log of (1 + the clicked URL position on the list of documents) is capped by a constant, such as 3 (such that all results beyond position 999 on the list of results receive the same score).

Reference is again made to Fig. 9. For some applications, if feedback processor 302 finds at check step 454 of method 450 that the query score exceeds the external threshold, based on the search results the feedback processor adds one or more terms to the user's PAG that were not included in the user's query, and/or increments the scores of one or more terms already in the user's PAG that were not included in the user's query. Each such term includes one or more keywords. Such terms were implicitly included in the topic of the user's search, and thus may be of benefit for characterizing the user's search for future searches by the user or other users, and/or for characterizing the document(s) selected by the user in response to the query.

In order to add such terms and/or increment the scores thereof in the user's PAG,

at an identification and scoring step 470 feedback processor 302 identifies one or more terms (each of which includes one or more keywords) that occur most often (and, typically, cross a threshold level of occurrence) in the documents of the search results for the query, or the displayed snippets of the document. (The use of snippets rather than entire documents generally is more meaningful, because the user's selection of a document is based on the words that appear in the snippet, rather than those that appear in the entire document.) To identify these terms, the feedback processor typically uses a "bag of words" approach, as is known in the search engine art. The feedback processor considers each of the terms (which includes one or more keywords) to be a category. The feedback processor assigns a score to each of the categories, which is indicative of the likelihood that the category is meaningful to the topic being searched. The score is typically based on the frequency with which the category appears in the search result snippets, optionally weighted by the position on the list of results of the snippets in which the category is found. This category identification and scoring is typically performed before the user selects one of the documents. For some applications, the category scores are further adjusted based on information from the DAGs of the snippets in which the categories are found, or based on information from a cluster of related DAGs in which each of the DAGs is found.

When the user selects a document from the search results, the feedback processor identifies the categories that appear in the snippet of the document, or, alternatively, the document itself. Optionally, the score of each of the categories is further weighted based on the position of the selected snippet on the results list, typically giving a greater weight for later positions of the selected snippet on the list. At an update PAG step 472, the feedback processor adds new vertices to the PAG for any of the terms of these categories that do not already have vertices in the PAG. The feedback processor identifies vertices between (a) each the vertices of the PAG holding the search terms of the query, on the one hand, and (b) each of the vertices of the PAG holding the terms of the categories (whether the vertices were already included in the PAG, or newly added). The edges scores of these vertices are incremented based on respective increment values for each of the categories. For some applications, the category having the greatest category score of those categories in the snippet (or the sole category) is given an increment value equal to a percentage of the increment value calculated at update PAG step 460 hereinabove, such as between about 25% and about 75%, e.g., about 50%. Each of the other categories (if any)

is given a respective increment value equal to the increment value of the greatest category, times the category score of the other category, divided by the category score of the greatest category.

For example, assume exemplary association graph 100 of Fig. 6 is a PAG including a query consisting of the user-entered terms "physics," "angular," and "spin" (comprising subgraph 200), and the edge scores therebetween were incremented by an increment value of 30 at update PAG step 460 hereinabove. The feedback processor identifies that a snippet selected by the user in response to this query includes the term "particle," which has a category score of 20, and the term "momentum," which has a category score of 10. If not already present, new vertices are added to the PAG for "particle" and "momentum," both of which include edges with vertices 110 ("physics"), 112 ("angular"), and 204 ("spin"). Each of the three edges between "particle" and each of "physics," "angular," and "spin" is incremented by 15, which equals 50% of the increment value of 30 determined at update PAG step 460, and each of the three edges between "momentum" and each of "physics," "angular," and "spin" is incremented by 7.5, which equals 50% times 30 times the category score of "particle" (20), divided by the category score of "momentum" (10). If the identified category term includes a plurality of keywords (e.g., "nobel prize"), a new vertex is added to the PAG which includes the entire multi-keyword term as a single unit.

Typically, edges between the category terms (e.g., between "particle" and "momentum" in the example immediately above) are not incremented. Alternatively, they are incremented, typically after further damping their increment values.

This 25%-75% factor mentioned above serves to dampen the contribution of the terms added by inference to the PAG in comparison to those terms added to the PAG by explicit inclusion by the user in a query. Typically, if the query score is later adjusted, the increment values of the category terms are adjusted appropriately. Alternatively, the feedback processor otherwise dampens the edge scores of the added terms, such as by multiplying them by a value less than one.

In an embodiment of the present invention, the feedback processor adjusts the score of a category based on the frequency with which the keywords of the category are included in snippets appearing earlier (i.e., higher) on the list of snippets than the selected snippet appears. The feedback processor increases the score of the category based on how

infrequently the keywords of the category appear in the earlier, non-selected snippets, and decreases the score of the category based on how frequently the keywords of the category appear in the earlier, non-selected snippets. In other words, the processor applies an adjustment factor that is inversely related to a frequency of appearance of the category keywords in earlier, non-selected snippets. The assumption motivating these adjustments is that the user is more likely to have chosen the selected snippet (rather than an earlier snippet) because of the presence of the category keywords if the category keywords do not also appear in earlier snippets.

After, before, or in parallel with performing step 472, the feedback processor performs update PAG step 460, described hereinabove, to update the PAG with the query keywords and their score.

Although feedback processor 302 is described hereinabove as performing the steps of method 450, for some applications, all or a portion of these steps are performed by agent 38, described hereinabove with reference to Fig. 1. For example, agent 38 may create and maintain a single user's PAG locally on workstation 32. Alternatively or additionally, agent 38 performs data collection for creating and maintaining the user's PAG, such as to secure the user's privacy, and transfers only relevant parameters for clustering to feedback processor 302 over WAN 34.

In an embodiment of the present invention, feedback processor 302 performs steps 460 and 470-472 for all queries, regardless of whether their query scores exceed the internal and external thresholds described hereinabove at steps 454 and 456. Alternatively, the feedback processor performs steps 460 and 470-472 for queries whose query scores exceed a single threshold. Alternatively, the feedback processor uses another test to determine whether to perform step 460 and/or steps 470-472.

Hotspots

Reference is now made to Fig. 10, which is a flowchart schematically illustrating a method 500 for extracting hotspots from a PAG, in accordance with an embodiment of the present invention. Method 500 is performed at step 380 of method 350, described hereinabove with reference to Fig. 7. At a high point identification step 502, feedback processor 302 identifies one or more high points of each PAG. The number of hotspots and/or high points identified per PAG is typically based on the size of the PAG. A high

point is a vertex of a PAG that is more prominent than other vertices of the PAG, typically because: (a) the vertex has many edges, (b) the degree of the vertex (equal to the sum of the scores of its edges and any self-referential score) is high, and/or (c) the association score of a subgraph consisting of the vertex and its edges is high (as calculated using techniques described hereinabove with reference to Fig. 6). For some applications, such prominence is calculated relative to other vertices of the PAG. For some applications, such prominence is established only if threshold values for these criteria are met. For example, if exemplary association graph 100 of Fig. 6 is used as a PAG, vertex 110 ("physics") may represent a high point, e.g., because it has many edges, because its degree is high, and/or because its surrounding association score is high.

For each high point identified at step 502, feedback processor 302 identifies zero or more surrounding vertices within n degrees of separation of the high point, at a surrounding vertices identification step 504. For some applications, n is 1, while for other applications, n is greater than 1, such as 2 or 3. For some applications, the feedback processor includes only those surrounding vertices whose edges with the high point have scores exceeding a threshold score. For example, the feedback processor may identify surrounding vertices 112 ("angular"), 212 ("prize"), and 510 ("engine"), because the edge score of each of these vertices is at least 70.

At a hotspot identification step 512, the feedback processor identifies the combination of each identified high point of the PAG and its surrounding vertices as a hotspot. Each high point is considered a primary term, each surrounding vertex having one degree of separation from the high point is considered a secondary term, each surrounding vertex having two degrees of separation from the high point is considered a tertiary term, and so forth. Typically, when calculating the edge scores of the hotspot, the feedback processor includes all of the edge scores between all vertices of the hotspot. Alternatively, edge scores between secondary terms of the vertex are not included unless they have at least a certain statistically-important strength. For some applications, when the feedback processor identifies two directly linked high points in a PAG, a single hotspot is constructed from both high points and all other vertices of the PAG within a certain number of degrees of either high point, e.g., within one degree.

Alternatively or additionally, feedback processor 302 identifies hotspots of a PAG using graph partitioning techniques, as are known in the art (although not for the purpose

of identifying hotspots), such as isoperimetric techniques or spectral techniques. These techniques are used to identify clusters with the PAG, which the feedback processor considers to be hotpots. For some applications, to identify hotspots, the feedback processor uses both these techniques and the hotspot-identification techniques described above in combination.

Reference is made to Fig. 11, which is an exemplary hotspot 520, in accordance with an embodiment of the present invention. As mentioned hereinabove, each hotspot is an association graph, which can be represented, for example, as a graph or an adjacency matrix, and can be stored in an appropriate data structure, such as described hereinabove with reference to Fig. 5. Exemplary hotspot 520, shown in Fig. 11, is an association graph of the hotspot described by way of example at steps 502, 502, and 512 hereinabove.

For some applications, feedback processor 302 eliminates secondary edges that are not statistically significant, e.g., that have a score that is beyond a certain number of standard deviations from the average score of the hotspot, such as one standard deviation.

Topic index

Reference is made to Figs. 12A-B, which show an exemplary topic index 530, in accordance with an embodiment of the present invention. Feedback processor 302 creates and maintains topic index 382 (Fig. 8) at topic analysis step 384 of method 350, described hereinabove with reference to Fig. 7. As best seen in Fig. 8, topic index 382 is populated using information from a plurality of hotspots 378 generated from a plurality of PAGs 374 of a plurality of users 30. Typically, these pluralities respectively include all hotspots 378, all PAGs 374, and all users 30 of a particular deployment of search system 10.

As shown in Fig. 12A, each row of topic index 530 holds a primary index and, optionally, a secondary index, the terms of which are extracted from hotspots 378, together with the user identification code of the user 30 associated with the hotspot, the association score between the vertices of the hotspot holding the terms of the primary and secondary indices, and a list one the IDs of the one or more search results documents that contributed to the entry. The topic index thus serves to cluster related documents via their IDs.

The primary index consists of one more terms, each of which consists of one or more keywords. For example, using the data from hotspot 520 of Fig. 11, and assuming it

was generated from a user 30 having an ID "001" who interacted with documents having the IDs 24, 26, and 123, the first row of topic index 530 indicates that, for user 001, the primary index includes the term "physics," which is linked to the term "engine" of the secondary index by an edge having a score of 70, and the primary and secondary terms have one degree of separation. The second row of topic index 530 indicates that, for a second user having ID "002" who interacted with documents having IDs 25, 27, and 123, the primary index has a term "physics" that is linked to the term "engine" of the secondary index by an edge having a score of 80, and the primary and secondary terms have one degree of separation.

When a term (which may include more than one keyword) is first added to the topic index, the term is added as a new primary index. If the term is added without any associated terms, the association score is simply the self-referential score of the term. When a term associated with the term(s) of a primary index in the topic index is added to the topic index from a hotspot (or hotspot difference graph), the new term is added as a secondary index.

For some applications, when a number of entries (each representing a different user) in the topic index containing the same primary and secondary indices crosses a threshold value, the term of the secondary index is combined with the term(s) of the primary index in order to create a multi-term primary index. The association score of the entry is equal to the association score of the terms of the primary index. The secondary index of the term is cleared. Fig. 12B shows the addition of the term "engine" to "physics" in the primary index, because the number of users (including user IDs 001, 002, and 004) reached the threshold value of three. For some applications, feedback processor 302 sets the threshold number of users separately for each primary index. For example, the threshold may be inversely related to the frequency with which the search terms are used by users of a particular deployment of search system 10, e.g., based on the scores of the search terms in GAG 396.

The cleared secondary index is later populated when a term is added to the topic index that is associated with all of the terms of the primary index. Such an additional term is also moved to the primary index when a threshold number of users having the same multi-term primary index also have the same secondary index. A topic index thus generally includes a mix of terms having different degrees of separation. For some

applications, feedback processor 302 adds tertiary indices to provide second-degree associations even before the respective secondary terms have been promoted to be added to their respective primary indices.

It will be appreciated that the structure of topic index 530 is exemplary only, and that feedback processor 302 may use numerous data structures to store, organize, and retrieve the information stored in topic index 530, as will be evident to those skilled in the art who have read the present application.

As mentioned above regarding step 384 of method 350, described hereinabove with reference to Fig. 7, for some applications feedback processor 302 maintains topic index 382 by calculating a hotspot difference graph 386 (Fig. 8) for each hotspot 378. Each hotspot difference graph 386 reflects changes to the associated hotspot since the feedback processor last analyzed the hotspot. Topic index 382 is updated based on hotspot difference graph 386, rather than directly based on hotspot 378. The edge scores of the hotspot difference graphs are added to the appropriate values stored in topic index 382. Similarly, terms and groups of terms newly added to a hotspot difference graph are added to topic index 382. Since most values in the hotspot difference graphs will be null or zero at any given iteration, the use thereof enables feedback processor 302 to more efficiently analyze changes in hotspots 378 and update topic index 382.

In an embodiment of the present invention, topic index 382 includes a timestamp for each row, indicating when it was last updated. For some applications, feedback processor 302 uses the timestamp to provide decay over time, such that the weight given to older associations decreases gradually over time, until the associations are eventually removed from the topic index.

Topic association graphs (TAGs)

Reference is made to Fig. 13, which shows an exemplary topic association graph (TAG) 540, in accordance with an embodiment of the present invention. Feedback processor 302 creates and maintains TAGs at step 390 of method 350, described hereinabove with reference to Fig. 7. In general, a TAG represents the interactions of a plurality of searches conducted by a plurality of users within a single topic. A TAG thus associates its topic with keywords, terms, pairs of words, and clusters of words, based on the search interactions of a plurality of users 30. The TAG is often a source of terms

relevant to a user associated with the TAG, even thought the user has not explicitly identified such relevant terms by incorporating them in a search query.

For each primary index of topic index 382 the association score of which crosses a threshold value (for single-term threshold values), or receives multiple terms, as described above with reference to Fig. 12B, feedback processor: (a) creates a topic ID, which consists of the terms of the primary index, (b) adds the topic ID to a topic dictionary 394 (Fig. 8), and creates a new TAG 392 for the topic ID. As mentioned above, primary indices sometimes contain a single term (which may include a plurality of keywords), and sometimes contain a plurality of terms (each of which may include a plurality of keywords). Search system 10 uses the topic dictionary to efficiently access and track topic IDs, without having to extract this information from individual TAGs or the topic index. For some applications, the threshold number of users is set according to a frequency of utilization of the term in searches, e.g., is inversely related to the frequency of utilization. The threshold is thus lower for uncommonly used search terms than commonly used search terms.

In an embodiment of the present invention, each TAG 392 is a summation of all of the hotpots that contributed the topic of the TAG. Alternatively, in another embodiment, each TAG 392 is a summation of all associations within one degree of the topic ID of the TAG within all PAGs that contributed to the topic of the TAG.

In either embodiment, the resulting TAG sometimes includes vertices and/or secondary edges that were not necessarily members of any term-groups of topic index 382. A secondary edge of a TAG is an edge not included in a topic ID, such as an edge between two non-primary vertices for a TAG that has only primary and secondary vertices. For example, in TAG 540 of Fig. 13, an edge 532 is secondary. The score of edge 532 is typically the sum of the scores of this edge in all hotspots in which it appears, or the sum of the scores of this edge in all associations within one degree of the topic ID of the TAG within all PAGs that contributed to the topic of the TAG. For example, if we assume that association graph 100 of Fig. 3 represents the PAG of user ID 001, the score 75 of edge 532 of TAG 540 is the sum of the score 30 of an edge 534 of the PAG and one or more matching edges of PAGs of other users that have a sum of 45 (other PAGs not shown). In an embodiment of the present invention, instead of deriving topic index 382 and TAGs 392 from hotspots 378 (or hotspot difference graphs 386), feedback processor

302 derives the TAGs directly from PAGs 374 (or PAG difference graphs, which are analogous to hotspot difference graphs).

Group association graphs (GRAGs)

In an embodiment of the present invention, feedback processor 302 creates one or more GRAGs 536 by merging a plurality of correlated PAGs or their hotspots. For some applications, the feedback processor determines measures of association (e.g., correlations) among PAGs by building respective adjacency matrices for the PAGs, and determining measures of association (e.g., correlations) of the matrices. For some applications, the feedback processor calculates the measures of association using techniques described hereinbelow at matrix correlation calculation step 572 of method 560, described hereinbelow with reference to Fig. 15. The same user 30 is often a member of a plurality of GRAGs based on the user's plurality of search interests.

THE ONLINE PROCESSOR

Reference is again made to Fig. 2. As mentioned above, online processor 60 provides online services to users 30, including search services, refinement services, and advertising services. Each of these services is now described in detail.

The internal search processor

Reference is made to Fig. 14, which is a schematic illustration of an exemplary screenshot of browser 36 including search field 52 and search results 54, in accordance with an embodiment of the present invention. In general, internal search processor 62 of online processor 60 (Fig. 2) receives a search query in search field 52, and, responsively to the query, presents search results 54, typically as snippets from each of the documents in the search results. The search query typically includes one or more terms that are initially organized linearly in search field 52 (each of the terms includes one or more keywords).

Each snippet includes one or more of the keywords of the query, and the URL of the document. Using the techniques described herein, internal search processor 62 ranks and orders the results based on characteristics of the particular user, one or more communities to which the user belongs, and/or global characteristics of all of the users of the particular deployment of search system 10. For some applications, user 30 selects a

desired preference regarding which of these characteristics should be used for ranking, such as by using a sliding pointer 550, or other means that will be evident to those skilled in the art who have read the present application.

Such preferences typically include one or more of:

- a personal-based preference – internal search processor 62 determines the ranking of search results based at least in part on user-specific information, typically as reflected in PAG 374 of the user, as described hereinbelow with reference to Fig. 15;
- a community-based preference – internal search processor 62 determines the ranking of search results based at least in part on community-specific information, typically as reflected in one or more TAGs 392 associated with the user and/or the query, as described hereinbelow; and
- a global-based preference – internal search processor 62 determines the ranking of search results based at least in part on information regarding all or a large portion of the users of the particular deployment of search system 10, typically as reflected in GAG 396.

In an embodiment of the present invention, user 30 is able to select a mixture of two or more of the preferences, for example by positioning sliding pointer 550 between two of the preferences. Internal search processor 62 ranks the search results based on a combination of the selected preferences, typically weighted by the position of the slider. For some applications, internal search processor 62 combines the selected preferences by normalizing the scores calculated below at matrix correlation calculation step 572 at least partially responsively to the position of the slider.

For some applications, internal search processor 62 stores and indexes snippets from documents that were selected from search results, typically together with the search query from which the search results were generated. For example, the internal search processor may use the Apache Lucene search engine (distributed by the Apache Software Foundation) for such storing and indexing.

Reference is made to Fig. 15, which is a flowchart schematically illustrating a method 560 for performing a search and ranking the results thereof pursuant to a personal-based preference, in accordance with an embodiment of the present invention. At a query

receipt step 562, internal search processor 62 receives a search query from user 30, typically via search field 52. Typically, the user 30 types in the keywords, and/or selects refinement options for addition to the query, such as described hereinbelow with reference to Figs. 16-19. For some applications, the query is only searched when the user gives an instruction to execute the search, such as by clicking on a search button 564 (Fig. 14). Alternatively, preliminary search results are displayed to the user in real time as the user enters keywords into the search field.

Internal search processor 62 collects a subset of all search results for the search query, at a subset result collection step 566. As mentioned hereinabove, for some applications, search server 20 utilizes search results obtained from an external search engine 40, while for other applications, search system 10 comprises a search engine that performs the search functionality of external search engine 40. In either case, for most typical queries, the search engine returns thousands, or even millions, of results. At step 566 internal search processor 62 collects a portion of these results expected to be potentially of particular relevance to the query, and then ranks this portion for presentation to user 30.

In order to collect the portion of the search results, internal search processor 62 generates a plurality of search engine search queries based on the search query of user 30, and separately sends each of these search engine search queries to the search engine (e.g., external search engine 40). The internal search processor adds to the collection the top n results of each of these searches, as ranked by the search engine. Typically, n is between about 50 and about 150, such as about 100. For some applications, n is different for each of the search engine search queries.

The search engine search queries based on the search query include one or more of the following:

- the search query of user 30 itself, i.e., without any further processing;
- one or more PAG-based search engine search queries – each of which consists of the search query of user 30, with the separate addition of each of the terms in the user's PAG 374 that are directly linked to all of the terms in the search query. (As mentioned above, each term consists of one or more keywords.) In other words, the internal search processor creates a separate expanded search engine search query for each of these terms in

the user's PAG, and separately sends each of these expanded search engine search queries to the search engine. Alternatively, if two or more of these terms in the user's PAG are highly associated with one another, these two or more terms are together added to the search query to generate a single expanded search engine search query for the terms. For some applications, the internal search processor creates expanded search engine search queries for only the portion of the linked terms within the PAG which have the greatest association scores with the search query of user 30; and

- one or more user-hotspot-based search engine search queries – each of which consists of the search query of user 30, with the separate addition of the high point term of each hotspot of the user's PAG 374. (As mentioned above, each term consists of one or more keywords.) In other words, the internal search processor creates a separate search engine search query for each of these high point terms, and separately sends each of these expanded search engine search queries to the search engine. Alternatively, the internal search processor creates expanded search engine search queries for only the portion of the high point terms whose hotspots have the greatest association scores within the PAG. For some applications, the internal search processor creates an expanded search engine search query only for each of the high point terms that the internal search processor validates against GAG 396 and/or one or more query-related TAGs 392. The internal search processor typically performs such validation by checking that all of the terms of the query and the high point term are linked in the GAG and/or query-related TAGs.

At a PAG query matrix generation step 568, internal search processor 62 generates one or more subgraphs of the user's PAG, each of which consists of all of the terms of the search query plus one or more terms of the PAG that are most highly linked in the PAG to all of the terms of the search query, typically as determined using the association scores of the subgraph consisting of the query terms plus each candidate term directly linked to all of the query terms in the PAG. The internal search processor determines the number of such terms to add to the subgraphs based on the strength of the association scores of each of the terms with the terms of the search query. If the user's PAG does not include all of

the terms of the search query, internal search processor 62 typically cannot perform a personal ranking of the search results. This generally occurs when a search query represents an interest of the user not expressed in previous searches conducted by the user using the particular deployment of the search system 10.

Internal search processor 62 represents each of the subgraphs as an adjacency matrix, using techniques described hereinabove with reference to Fig. 4. Typically, the internal search processor establishes an order of the terms of the matrix beginning with the terms of the search query entered by the user, followed by the other remaining terms of the subgraph in descending order of their association scores with the terms of the search query.

At a DAG query matrix generation step 570, internal search processor 62 generates a matrix for each DAG 400 associated with each of the search result documents collected at step 566 above, for each of the PAG adjacency matrices generated at step 568 above. The size of each of the DAG matrices is set to match the size of the respective PAG matrix generated at step 568 above. The strongest terms of the DAG are included in the DAG matrix.

At a matrix correlation calculation step 572, internal search processor 62 calculates respective correlation scores between each of the PAG matrices generated at step 568 and each of the DAG matrices generated at step 570. Numerous techniques for calculating such scores will be evident to those skilled in the art who have read the present application. For example, such scores may be based on the scalar product of the PAG and DAG matrices. For some applications, when calculating the scores, greater weight is given to diagonals or values near the main diagonal. For some applications, terms that are absent from the PAG or DAG matrix are given reduced weights. For some applications, influence weights are assigned to the terms of PAG matrices responsively to a maturity of the PAG, calculated for example using Equation 9, *mutatis mutandis*..

For some applications, internal search processor 62 uses the following equation to the correlation score between a PAG matrix and a DAG matrix:

$$\text{Correlation score} = \sum_{\forall i,j} DAGM_{i,j} * PAGM_{i,j} \alpha^{|i-j+1|} \quad \text{(Equation 6)}$$

wherein DAGM is the DAG matrix, and PAGM is the PAG matrix.

In an embodiment of the present invention, internal search processor 62 calculates a DAG query score for each DAG 400 associated with each of the search result documents collected at step 566 above. These DAG query scores are used at ranking step 574 hereinbelow. The DAG query score is a measure of correlation between the terms of the search query and the DAG. For some applications, the DAG query score is calculated responsively to an association score of the terms of the search query (as a subgroup) within the DAG, for example calculated using techniques described hereinabove with reference to Fig. 6. For other applications, the internal search processor calculates the DAG query score by building a matrix that represents the association scores between every two query terms in the DAG. For example, internal search processor 62 may use the following equation for calculating the DAG query score:

$$\text{DAG query score} = \sum_{\forall i,j} W_{i,j} * \alpha^{|i-j+1|} \qquad (0 \le i < n), (i \le j < n) \quad \text{(Equation 7)}$$

wherein $W_{i,j}$ is the association score between query terms q_1 and q_2, and α is constant, typically between 0 and 1, such as about 0.5.

For some applications, the resulting DAG query score is multiplied by a scaling factor **ß**. For example, the scaling factor may be calculated using the following equation:

$$\beta = \text{AQT/MS} * (\text{DAG maturity}) \qquad \text{(Equation 8)}$$

wherein AQT is an average query term (the average to total score in the DAG of the query terms), MS is a maximum total score (the highest total score (of the strongest term) in the DAG), and DAG maturity reflects a level of maturity of the DAG. For example, if it is assumed that a mature DAG has about 500 vertices, the DAG maturity may be calculated using the following equation:

$$\text{DAG maturity} = \sqrt{1 + \frac{\#\,of\ terms\ in\ the\ DAG}{500}} \qquad \text{(Equation 9)}$$

At a ranking step 574, internal search processor 62 assigns a ranking score to each of the search result documents collected at step 568 above. The ranking scores typically are based on a combination of one or more of the following elements:

- a voting score, typically how many times a given document has been selected for viewing by any user of the particular deployment of search system 10;

- the DAG query score, as described hereinabove; and
- the PAG/DAG matrix correlation scores calculated at step 572 above.

For some applications, internal search processor 62 calculates the ranking score of each each of the search result documents collected at step 566 above by summing the voting score, DAG query score, and PAG/DAG matrix correlation scores for the document. Alternatively, only one or two of these scores are included in the sum. Typically, before summing the scores, internal search processor 62 normalizes the scores by:

- calculating the average of all voting scores for the top n documents ;
- calculating the average of all DAG query score for the top n documents;
- calculating the average of all PAG/DAG matrix correlation scores for the top n documents;
- finding the maximum value of the three averages;
- finding a coefficient for the other two average values, equal to the maximum value divided by each of the respective other two averages; and
- normalizing the values of the two scores having the coefficients by multiplying these values by their respective coefficients.

Internal search processor 62 typically combines these internal rankings with the rankings generated by the search engine (e.g., external search engine 40) in response to the user's search query. In some deployments (particularly early in the deployment), only a portion of the search result documents generated by the external search engine have sufficiently mature DAGs to generate the ranking scores described above. The internal search processor therefore relies on a combination of the ranking scores assigned by the external search engine, and, for those documents assigned a ranking score as described, a combination of the external ranking score and this assigned ranking score.

For some applications, the internal search processor performs this combining by taking the external rankings and modifying the ranking of those that have internal rankings (calculated as described above) responsively to such internal rankings. For example, the internal search processor may use the following method to perform such re-ranking:

- normalizing the internal scores calculated as described above. For example, if the search result document with the highest score has a score of x, the normalized score of each other page may be set to (k/x*non-normalized score), where k is a constant such as 100;
- getting the positional rank of each search result document in the list of search result documents (or portion of thereof being used) generated by the external search engine; and
- for each document on the externally-generated list having an internal score, re-ranking the document responsively to the normalized internal score, such as by using the following equation:

new rank (i.e., position in search result list) =

$$(\text{external position}) - \frac{(\text{external position})}{2} * (\frac{\text{internal normalized score}}{100}) = (EP)(1 - \frac{(IS)}{200})$$

(Equation 10)

For some applications, if two documents receive the same re-ranking position, the document with the highest original position on the externally-generated list is positioned earlier on the newly ranked list.

In an embodiment of the present invention, internal search processor 62 determines a community-based ranking of the search results using the techniques of method 560, described hereinabove with reference to Fig. 15, except that the internal search processor substitutes one or more TAGs 392 for the PAG used in method 560. The internal search processor selects one or more TAGs that may be a good source of ranking information. Minimally, in order for a TAG to be a candidate, the TAG must include all of the terms in the query. Typically, to select the candidate TAGs, internal search processor 62 determines one or both of top query-associated TAGs, and top user-associated TAGs. Typically, the internal search processor determines the top query-associated TAGs using techniques described hereinbelow at query-associated TAG determination step 806 of method 800, described with reference to Fig. 18, and the top user-associated TAGs using techniques described hereinbelow at user-associated TAG determination step 808 of method 800, *mutatis mutandis*. For some applications, these TAGs are used separately to generate search results from the search engine, while for

other applications they are combined, such as described at step 810 of method 800, described hereinbelow with reference to Fig. 18. For some applications, internal search processor 62 substitutes one or more the above-mentioned TAGs for the PAG at PAG query matrix generation step 568.

In an embodiment of the present invention, to determine the community-based ranking using the techniques of method 560, the search engine queries performed by internal search processor 62 include one or more GRAG-based search engine search queries. Each of these queries consists of the search query of user 30, with the separate addition of each of the terms in each of the GRAGs to which user 30 belongs that are directly linked to all of the terms in the search query. (As mentioned above, each term consists of one or more keywords.) In other words, the internal search processor creates a separate expanded search engine search query for each of these terms in the GRAGs, and separately sends each of these expanded search engine search queries to the search engine. For some applications, the internal search processor creates expanded search engine search queries for only the portion of the linked terms within the GRAG which have the greatest association scores with the search query of user 30. The addition of terms from GRAGs is particularly useful when the user's search query includes terms not in the user's PAG. In this case, the GRAGs may provide additional terms that are relevant to users who have similar PAGs to the PAG of the searching user. For some applications, terms are added from GRAGs only when the user's PAG cannot adequately provide additional terms. For some applications, internal search processor 62 substitutes one or more the above-mentioned GRAGs, or TAGs mentioned in the previous paragraph, for the PAG at PAG query matrix generation step 568.

In an embodiment of the present invention, internal search processor 62 determines a global-based ranking of the search results using the techniques of method 560, described hereinabove with reference to Fig. 15, except that the internal search processor substitutes a subgraph of GAG 396 for the PAG used in method 560. The subgraph typically consists of the search terms of the user's search query plus all or a portion of the terms of the GAG that are directly linked to all of the search terms. For some applications, internal search processor 62 substitutes the subgraph of the GAG for the PAG at PAG query matrix generation step 568.

The refinement processor

Reference is made to Fig. 16, which is a schematic illustration of an exemplary screenshot of browser 36 including refinement options 66, in accordance with an embodiment of the present invention. As mentioned above, refinement processor 64 of online processor 60 (Fig. 2) provides refinement options 66 in browser 36. Refinement options 66 are displayed on the main web page in the browser, in a dropdown list, in a window or frame in the browser, in a popup window, or otherwise as is known in the art.

As keywords or terms are added to search field 52 (either by user 30 typing in the keywords, or selecting previously presented refinement options for addition to the query), refinement processor 64 provides refinement options 66 in real-time or close to real-time. For some applications, refinement options comprise primary refinement options 700, and secondary refinement options 702 for at least a portion of the primary refinement options. The primary refinement options are those options that are most closely related to the search query, and the secondary refinement options are those options that are more distantly related to the search query, and are also related to their associated primary refinement option. For some applications, the refinement options comprise additional levels, which are typically hierarchical. For example, the refinement options may include tertiary refinement options for at least a portion of the secondary refinement options, which are still more distantly related to the search query, ad are also related to the their associated primary and secondary refinement options. For some applications, refinement processor 64 drives web server 22 to display the secondary, tertiary, and any additional levels of refinement options using a hierarchical presentation structure, such as a tree.

In the exemplary screenshot shown in Fig. 16, the search query consists of "physics," and primary refinement options 700 consist of "angular," "prize," and "engine." Secondary refinement options 702 for "angular" consist of "spin," "momentum," and "particle."

In an embodiment of the present invention, search system 10 provides user 30 with a plurality of preferences for how refinement processor 64 determines which refinement options 66 to provide, and the ordering of the options. For some applications, user 30 selects the desired preference using sliding pointer 550, or other means that will be evident to those skilled in the art who have read the present application. Typically, the same sliding pointer 550 is provided for selecting refinement preferences as for selecting ranking preferences, as described hereinabove with reference to Fig. 14. Alternatively,

separate sliding pointers are provided for indicating these preferences separately.

Such preferences typically include one or more of:

- a personal-based preference – refinement processor 64 determines which refinement options 66 to provide based on user-specific information, typically as reflected in PAG 374 of the user, as described hereinbelow with reference to Fig. 17;
- a community-based preference – refinement processor 64 determines which refinement options 66 to provide based on community-specific information, typically as reflected in one or more TAGs 392 associated with the user and/or the query, as described hereinbelow with reference to Fig. 18; and
- a global-based preference – refinement processor 64 determines which refinement options 66 to provide based on information regarding all or a large portion of the users of the particular deployment of search system 10, typically as reflected in GAG 396, as described hereinbelow with reference to Fig. 19.

In an embodiment of the present invention, user 30 is able to select a mixture of two or more of the preferences, for example by positioning sliding pointer 550 between two of the preferences. Refinement processor 64 provides refinement options 66 based on a combination of the selected preferences, typically weighted by the position of the slider. For some applications, the weighting is performed by setting the number of refinement options contributed by each of the preferences responsively to the relative position of the slider between the preferences.

Reference is made to Fig. 17, which is a flowchart schematically illustrating a method 750 for presenting refinement options 66 pursuant to a personal-based preference, in accordance with an embodiment of the present invention. In this embodiment, refinement processor 64 determines which refinement options 66 to provide based on user-specific information, typically as reflected in PAG 374 of the user. Method 750 begins with the receipt of a search query by refinement processor 64, at a query receipt step 752. As mentioned above, a query consists of a one or more terms, each of which consists of one or more keywords. Although the query is typically displayed as a list of

keywords, search system 10 typically stores the query as a collection of terms, each of which may include more than one keyword. For some applications, before refinement processor 64 presents the refinement options, internal search processor 62 automatically executes a search of the query, while for other applications, the query is searched only if the user gives an instruction to execute the search, such as by clicking on search button 564.

At a primary refinement options determination step 754, refinement processor 64 determines which primary options 700 (Fig. 16) to present to the user. Typically, refinement processor 64 determines a set of candidate refinement options by identifying all vertices of PAG 374 of the user that are directly linked to all of the terms of the query. For example, if we assume that association graph 100 of Fig. 3 represents the PAG of the user, and the query consists of "physics," refinement processor 64 would determine the following candidate refinement options: "spin," "angular," "momentum," "particle," "java," "engine," "open," "nobel," "prize," and "winners." Refinement processor 64 ranks these candidates, typically by: (a) creating respective subgraphs of the PAG consisting of the search terms (in this example, "physics") and the respective candidate refinement option, and (b) calculating an association score for each of the subgraphs, typically using techniques described hereinabove with reference to Fig. 6. The refinement processor typically selects as primary refinement options 700 the candidates with the top n scores, e.g., n equals 1, 2, 3, 4, or 5. In example shown in Fig. 16, n = 3 and the candidates "angular," "prize," and "engine" have the top three scores, and are thus selected as primary refinement options 700. Alternatively, the refinement processor selects as primary refinement options 700 the candidates that have at least a threshold association score, or the candidates with the top n scores that also have at least the threshold association score.

The refinement options (primary and secondary) sometimes include at least one multi-keyword term, which, for some applications, is presented to the user as a unified term (e.g., the multiple keywords are underlined together), and, for other applications, is presented to the user as separate keywords.

At a secondary refinement options determination step 756 (which is optional), refinement processor 64 determines which secondary options 702 (Fig. 16) to present to the user for each of primary refinement options 700 determined at step 754. Typically,

for each given primary refinement option 700, refinement processor 64 determines a set of candidate secondary refinement options by identifying all vertices of PAG 374 of the user that are directly linked to all of the terms of the query and the given primary refinement option. For example, if we assume that association graph 100 of Fig. 3 represents the PAG of the user, the query consists of "physics," and the given primary refinement option is "angular," refinement processor 64 would determine the following candidate secondary refinement options: "spin," "momentum," and "particle," and "engine." Refinement processor 64 ranks these candidates, typically by: (a) creating respective subgraphs of the PAG consisting of the search terms (in this example, "physics"), the given primary refinement option (in this example, "angular"), and the respective candidate secondary refinement option, and (b) calculating an association score for each of the subgraphs, typically using techniques described hereinabove with reference to Fig. 6. The refinement processor typically selects as primary refinement options 700 the candidates with the top m scores, e.g., m equals 1, 2, 3, 4, or 5. In example shown in Fig. 16, m = 2 and the candidates "spin" and "momentum" have the top two scores, and are thus selected as secondary refinement options 702 for the primary refinement option "angular." Alternatively, the refinement processor selects as secondary refinement options 702 the candidates that have at least a threshold association score, or the candidates with the top m scores that also have at least the threshold association score.

User 30 selects one of the refinement options (typically by clicking on it), at a refinement option selection step 758. The selected refinement option is added to the query, at a query refinement step 760. Multi-keyword term refinement options are typically added to the query as a single term. For some applications, internal search processor 62 automatically executes a search of the refined query, while for other applications, the refined query is only searched if the user gives an instruction to execute the search, such as by clicking on search button 564. In either case, method 750 generates new refinement options responsively to the refined query, by returning to step 754.

Reference is made to Fig. 18, which is a flowchart schematically illustrating a method 800 for presenting refinement options 66 pursuant to a community-based preference, in accordance with an embodiment of the present invention. In this embodiment, refinement processor 64 determines which refinement options 66 to provide based on community-specific information, typically as reflected in one or more TAGs 392 associated with the user and/or the query. Method 800 begins with the receipt of a query

by refinement processor 64, at a query receipt step 752. For some applications, before refinement processor 64 presents the refinement options, internal search processor 62 automatically executes a search of the query, while for other applications, the query is only searched if the user gives an instruction to execute the search, such as by clicking on search button 564.

At a candidate TAG selection step 804, refinement processor 64 selects one or more TAGs 392 that may be a good source of refinement options 66. Minimally, in order for a TAG to be a candidate, the TAG must include all of the terms in the query. Typically, to select the candidate TAGs, refinement processor 64 determines one or both of top query-associated TAGs, at a query-associated TAG determination step 806, and top user-associated TAGs, at a user-associated TAG determination step 808.

In an embodiment of the present invention, to determine the top query-associated TAGs, refinement processor 64 identifies all TAGs that contain all of the terms of the query. The refinement processor ranks the identified TAGs. For example, the ranking may be based on a comparison of the query with the term-group (topic ID) of each of the TAGs, or the association score of the subgraph of each of the TAGs which subgraph includes the terms of the query. The refinement processor selects the top n ranked TAGs (e.g., 5), and/or TAGs having at least a threshold comparison score with the query.

In an embodiment of the present invention, to determine the top user-associated TAGs, refinement processor 64 identifies all TAGs that contain all of the terms of the query, and to which the user contributed (i.e., terms and/or edge scores from the user's PAG were added to the TAG, typically via topic index 382, as described hereinabove with reference to Fig. 13). The refinement processor scores each of the identified TAGs, typically based on: (a) the user's contribution to the TAG's term-group (topic ID) score in relation to the TAG's total term-group score; (b) the association score of the TAG's term-group (topic ID) in the user's PAG; or (c) a combination of (a) and (b). For example, the combination may be calculated by taking the product of (a) and (b), the product of (b) and the square root of (a), or the product of (a) and the square root of (b). The refinement processor selects the top m ranked TAGs (e.g., 5), and/or TAGs having at least a threshold score.

At a TAG merger step 810, refinement processor 64 merges all of the candidate TAGs identified at candidate TAG selection step 804, to generate a merged community

association graph. Alternatively, for each TAG the refinement processor generates a subgraph that consists of all terms in the TAG that are directly linked to all of the terms of the query. The refinement processor merges these subgraphs to generate the community association graph.

At a refinement option determination step 812, refinement processor 64 determines one or more primary refinement options 700, and, optionally, one or more secondary refinement options 702. The refinement processor typically uses the techniques described hereinabove at steps 754 and 756 of method 750, described with reference to Fig. 17, except that the refinement processor analyzes the merged community association graph instead of the user's PAG.

User 30 selects one of the refinement options (typically by clicking on it), at a refinement option selection step 814. The selected refinement option is added to the query, at a query refinement step 816. For some applications, internal search processor 62 automatically executes a search of the refined query, while for other applications, the refined query is only searched if the user gives an instruction to execute the search, such as by clicking on search button 564. In either case, method 800 generates new refinement options responsively to the refined query, by returning to step 804.

In an embodiment of the present invention, the refinement processor performs method 800 using one or more GRAGs instead of TAGs.

Reference is made to Fig. 19, which is a flowchart schematically illustrating a method 830 for presenting refinement options 66 pursuant to a global-based preference, in accordance with an embodiment of the present invention. In this embodiment, refinement processor 64 determines which refinement options 66 to provide based on information regarding all or a large portion of the users of the particular deployment of search system 10, typically as reflected in GAG 396.

Method 830 begins with the receipt of a query by refinement processor 64, at a query receipt step 832. For some applications, before refinement processor 64 presents the refinement options, internal search processor 62 automatically executes a search of the query, while for other applications, the query is only searched if the user gives an instruction to execute the search, such as by clicking on search button 564.

At a refinement option determination step 834, refinement processor 64

determines one or more primary refinement options 700, and, optionally, one or more secondary refinement options 702. The refinement processor typically uses the techniques described hereinabove at steps 754 and 756 of method 750, described with reference to Fig. 17, except that the refinement processor analyzes GAG 396 instead of the user's PAG.

User 30 selects one of the refinement options (typically by clicking on it), at a refinement option selection step 836. The selected refinement option is added to the query, at a query refinement step 838. For some applications, internal search processor 62 automatically executes a search of the refined query, while for other applications, the refined query is only searched if the user gives an instruction to execute the search, such as by clicking on search button 564. In either case, method 800 generates new refinement options responsively to the refined query, by returning to step 834.

Reference is made to Fig. 20, which is a schematic illustration of an exemplary screenshot 900 of browser 36 including search results 54 integrated with refinement options 66, in accordance with an embodiment of the present invention. In this embodiment, online processor 60 drives web server 22 to display refinement options 66 (either primary refinement options 700 or secondary refinement options 702) in association with respective snippets 902 of search results 54. For display in association with each displayed snippet 902, refinement processor 64 selects one or more refinement terms that are of particular relevance to the snippet. Selecting one of the refinement terms by user 30 (typically by clicking on it) causes the online processor to add the selected term to search query 52, such as described hereinabove with at step 758 of method 750, described hereinabove with reference to Fig. 17.

For some applications, refinement processor 64 selects as refinement terms for each snippet 902 those terms in DAG 400 of the document associated with the snippet that have the greatest association scores with the terms of the search query in the DAG. Alternatively or additionally, the refinement processor selects as refinement terms one or more terms from one or more hotspots of DAG 400, which may be determined using techniques described hereinabove with reference to Figs. 10-11, *mutatis mudandis*. For some applications, the refinement processor identifies candidate refinement terms from the one or more hotspots of DAG 400, and compares these terms to refinement options identified as described hereinabove with reference to Figs. 16-19. As mentioned above,

these refinement options may be identified responsively to a level of personalization selected by the user.

For some applications, techniques of this embodiment are used in combination with search engine techniques otherwise known in the art, without necessarily using the association-based clustering techniques of embodiments of the present invention. For example, the refinement options may be identified using techniques known in the art for generating refinement options, including, but not limited to, those described in some of the patent or non-patent references incorporated by reference in the Background of the Invention section.

In an embodiment of the present invention, refinement processor 64 uses one or more of the refinement terms to create a tag cloud, which presents additional search queries that may be of interest to the user, as is known in the art. The refinement processor identifies terms that are most closely associated with the search query, using techniques described herein.

The advertisement processor

In an embodiment of the present invention, advertisement processor 70 of online processor 60 provides advertisement services, via web server 22 in advertisement area 72 in browser 36 (Fig. 2). Alternatively or additionally, the advertisements are integrated with search results 54, and/or displayed in a popup window, as is known in the art, or using other advertising display techniques known in the art. The advertising processor uses advertisement search and ranking techniques similar to those used for ranking document search results, as described hereinabove.

In some embodiments of the present invention, search system 10 uses only association graphs (e.g., PAGs, TAGs, and DAGs) that are characterized by a certain level of maturity, which may be measured, for example, by the number of edges of the association graph, or a total association score of the association graph. Immature association graphs generally do not provide meaningful information, so they are not used until they collect sufficient information over time.

The word "document," as used in the present application, including the claims, is to be understood broadly as referring to any digital unit of information, including, but not limited to, files (e.g., containing text, media, or hyperlinks), Web pages, newsgroup

postings, and e-mails, which can be stored electronically on a computer or a network.

In some embodiments of the present invention, the search techniques described herein are combined with contextual search techniques known in the art.

Techniques of embodiments of the present invention typically improve the efficiency of searching, and conserve the use of computer resources.

The scope of the present invention includes embodiments described in the following applications, which are assigned to the assignee of the present application and are incorporated herein by reference. In an embodiment, techniques and apparatus described in one or more of the following applications are combined with techniques and apparatus described herein:

- US Provisional Patent Application 60/793,253, filed April 20, 2006, entitled, "Methods for using association graphs in search engines";
- US Provisional Patent Application 60/796,188, filed May 1, 2006, entitled, "Apparatus and methods thereof for search engine personalization";
- US Provisional Patent Application 60/829,136, filed October 11, 2006, entitled, "Apparatus and methods thereof for search phrase refinement";
- US Provisional Patent Application 60/829,135, filed October 11, 2006, entitled, "Apparatus and methods thereof for using explicit query refinements to tune search results ranking factors";
- US Provisional Patent Application 60/829,132, filed October 11, 2006, entitled, "Apparatus and methods thereof for adaptive ranking mechanism using association graphs and contextual analysis";
- US Provisional Patent Application 60/886,193, filed January 23, 2007, entitled, "Multi-directional and auto-adaptive relevance and search system and methods thereof";
- US Provisional Patent Application 60/887,580, filed January 31, 2007, entitled, "Searchable banner display and apparatus that enables exploring destination content prior to reaching it"; and
- US Provisional Patent Application 60/741,902, filed in January 2006, entitled, "A multi-directional and auto-adaptive relevance and search

system and methods thereof."

It will be appreciated by persons skilled in the art that the present invention is not limited to what has been particularly shown and described hereinabove. Rather, the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove, as well as variations and modifications thereof that are not in the prior art, which would occur to persons skilled in the art upon reading the foregoing description.

CLAIMS

1. A computer-implemented method comprising:

presenting to a user a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level;

receiving from the user an indication of a desired one of the levels;

receiving from a user a search query consisting of one or more query terms;

responsively to the search query, generating a search result listing;

ranking at least a portion of the search result listing at least in part responsively to the indication; and

presenting at least a portion of the ranked search result listing to the user.

2. The method according to claim 1,

wherein the desired level of personalization includes the personalized level,

wherein receiving the indication comprises receiving the indication of the personalized level, and

wherein ranking comprises:

constructing a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches;

calculating respective correlation scores between the personal profile and a plurality of search result documents of the at least a portion of search result listing; and

ranking the at least a portion of the search result listing at least in part responsively to the correlation scores.

3. The method according to claim 2, wherein the personal profile includes a personal association graph (PAG), wherein each of the previous searches includes one or more previous query terms, and wherein constructing the personal profile comprises constructing the PAG including at least a portion of the previous query terms as vertices.

4. The method according to claim 3, wherein generating the search result listing comprises generating the search result listing responsively to the query terms and at least one of the previous query terms in the PAG linked to all of the query terms in the PAG.

5. The method according to claim 3, wherein generating the search result listing

comprises generating the search result listing responsively to the query terms and a high point term of a hotspot of the PAG.

6. The method according to claim 1,

wherein the user is one of a plurality of users,

wherein the desired level of personalization includes the community level,

wherein receiving the indication comprises receiving the indication of the community level, and

wherein ranking comprises:

constructing a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic;

calculating respective correlation scores between the topic profile and a plurality of search result documents of the at least a portion of search result listing; and

ranking the at least a portion of the search result listing at least in part responsively to the correlation scores.

7. The method according to claim 6, wherein the topic profile includes a topic association graph (TAG), wherein each of the previous searches includes one or more previous query terms, and wherein constructing the topic profile comprises constructing the TAG including at least a portion of the previous query terms as vertices.

8. The method according to claim 1,

wherein the user is one of a plurality of users,

wherein the desired level of personalization includes the community level,

wherein receiving the indication comprises receiving the indication of the community level, and

wherein ranking comprises:

constructing a plurality of personal profiles for respective users in the plurality of users, each of which personal profiles represents interactions of a plurality of previous searches conducted by one of the users with a respective plurality of previous search result documents presented to the one of the users during the previous searches;

identifying a subset of the personal profiles as correlated with one another;

constructing a group profile by combining at least a portion of each of the personal profiles in the subset;

calculating respective correlation scores between the group profile a plurality of

search result documents of the at least a portion of search result listing; and

ranking the at least a portion of the search result listing at least in part responsively to the correlation scores.

9. The method according to claim 8,

wherein the personal profiles include respective personal association graph (PAGs),

wherein each of the previous searches includes one or more first query terms,

wherein constructing the personal profiles comprises constructing the PAGs including at least a portion of the first query terms as vertices,

wherein the group profile includes a group association graph (GRAG), and

wherein constructing the group profile comprises constructing the GRAG by combining at least a portion of each of the PAGs in the subset.

10. The method according to claim 9, wherein generating the search result listing comprises generating the search result listing responsively to the query terms and at least one of the previous query terms in the GRAG linked to all of the query terms in the GRAG.

11. The method according to claim 1,

wherein the user is one of a plurality of users,

wherein the desired level of personalization includes a global level that is not personalized,

wherein receiving the indication comprises receiving the indication of the global level, and

wherein ranking comprises:

constructing a global profile that represents interactions of a plurality of previous searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches;

calculating respective correlation scores between the global profile and a plurality of search result documents of the at least a portion of search result listing; and

ranking the at least a portion of the search result listing at least in part responsively to the correlation scores.

12. The method according to claim 11, wherein the global profile includes a global association graph (GAG), wherein each of the previous searches includes one or more

previous query terms, and wherein constructing the global profile comprises constructing the GAG including at least a portion of the previous query terms as vertices.

13. The method according to claim 12, wherein generating the search result listing comprises generating the search result listing responsively to the query terms and at least one of the previous query terms in the GAG linked to all of the query terms in the GAG.

14. The method according to claim 1, wherein the user is one of a plurality of users, and wherein ranking comprises:

constructing a plurality of document profiles associated with a respective plurality of search result documents, each of which document profiles represents interactions of (a) a plurality of previous searches conducted by the plurality of users with (b) the respective search result document associated with the document profile; and

ranking the at least a portion of the search result listing at least in part responsively to the indication and respective correlation scores between the query terms and at least a portion of the document profiles.

15. The method according to claim 14, wherein the plurality of document profiles includes a respective plurality of document association graphs (DAGs), wherein the previous searches include one or more respective previous query terms, and wherein constructing the plurality of document profiles comprises constructing the plurality of DAGs, each of which includes one or more of the previous query terms as vertices.

16. A computer-implemented method comprising:

receiving from a user a first search query consisting of one or more first query terms;

receiving from the user an indication of a desired level of personalization of refinement options for the search query;

responsively to the search query, generating a set of one or more refinement terms at least in part responsively to the indication;

presenting the set of refinement terms to the user;

responsively to a selection of at least one of the refinement terms by the user, adding the selected at least one refinement term to the first search query to generate a second search query; and

presenting search results to the user responsively to the second search query.

17. The method according to claim 16, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein presenting the set of refinement terms comprises presenting the primary and secondary refinement terms.

18. The method according to any one of claims 16-17, wherein the desired level of personalization is selected from a range of personalization levels between a personalized level and a global level that is not personalized.

19. The method according to claim 18, wherein the range of personalization levels includes a community level between the personalized level and the global level.

20. The method according to any one of claims 16-17,

wherein the desired level of personalization includes a personalized level,

wherein receiving the indication comprises receiving the indication of the personalized level, and

wherein generating the set of one or more refinement terms comprises:

constructing a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches, wherein each of previous searches includes one or more previous query terms; and

selecting at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the personal profile.

21. The method according to claim 20, wherein the personal profile includes a personal association graph (PAG), wherein constructing the personal profile comprises constructing the PAG including at least a portion of the previous query terms as vertices, and wherein selecting the previous query term comprises selecting the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the PAG.

22. The method according to any one of claims 16-17,

wherein the user is one of a plurality of users,

wherein the desired level of personalization includes the community level,

wherein receiving the indication comprises receiving the indication of the

community level, and

wherein generating the set of one or more refinement terms comprises:

constructing a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, wherein each of the previous searches includes one or more previous query terms; and

selecting at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the topic profile.

23. The method according to claim 22, wherein the topic profile includes a topic association graph (TAG), wherein constructing the personal profile comprises constructing the TAG including at least a portion of the previous query terms as vertices, and wherein selecting the previous query term comprises selecting the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the TAG.

24. The method according to any one of claims 16-17,

wherein the user is one of a plurality of users,

wherein the desired level of personalization includes a global level that is not personalized,

wherein receiving the indication comprises receiving the indication of the global level, and

wherein generating the set of one or more refinement terms comprises:

constructing a global profile that represents interactions of a plurality of searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, wherein each of the previous searches includes one or more previous query terms; and

selecting at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the global profile.

25. The method according to claim 24, wherein the global profile includes a global association graph (GAG), wherein constructing the global profile comprises constructing the GAG including at least a portion of the previous query terms as vertices, and wherein selecting the previous query term comprises selecting the previous query term for

inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the GAG.

26. A computer-implemented method comprising:

receiving from a plurality of first users a respective plurality of first search queries, each of which consists of one or more first query terms;

presenting to the plurality of first users respective first search result listings, each of which includes one or more first snippets associated with one or more respective search result documents;

constructing a plurality of document profiles, each of which (a) is associated with one of the first snippets selected by one or more of the first users from the respective first search result listings, and (b) represents an interaction of one or more of the first query terms with the first snippet;

receiving from a second user a second search query, which consists of one or more second query terms;

responsively to the second search query, generating a second search result listing, which includes at least a portion of the one or more first snippets;

performing a comparison between (a) the second search query and (b) one or more of the document profiles associated with the first snippets included in the second search result listing;

ranking at least a portion of the second search result listing at least in part responsively to comparison; and

presenting at least a portion of the ranked second search result listing to the second user.

27. The method according to claim 26, wherein constructing the document profiles comprises constructing the document profiles such that at least one of the document profiles includes one or more of the first query terms that do not appear in the first snippet associated with the document profile.

28. The method according to claim 26, wherein ranking comprises:

presenting to the second user a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level;

receiving from the user an indication of a desired one of the levels; and

ranking the at least a portion of the second search result listing at least in part responsively to the indication.

29. The method according to any one of claims 26-28, wherein the document profiles include respective document association graphs (DAGs), each of which includes a plurality of the first query terms as DAG vertices.

30. The method according to claim 29, wherein constructing the document profiles comprises constructing the DAGs such that at least one of the DAGs includes as vertices one or more of the first query terms that do not appear in the first snippet associated with the document profile.

31. The method according to claim 29,

wherein receiving the second search query comprises receiving the second search query, which consists of the one or more second query terms organized linearly, and transforming the second search query into a query association graph including the one or more second query terms as query association graph vertices, and

performing the comparison comprises performing the comparison between (a) the query association graph and (b) the one or more of the DAGs associated with the first snippets included in the second search result listing.

32. The method according to claim 29, wherein performing the comparison comprises constructing a personal association graph (PAG) for the second user that represents interactions of a plurality of previous searches conducted by the second user with a respective plurality of previous search result documents presented to the second user during the previous searches, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, wherein the comparison includes a correlation between (a) a subgraph of the PAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the PAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

33. The method according to claim 32, comprising:

receiving a selection made by the second user of one of the first snippets included in the ranked second search result listing;

calculating a query score for the second search query; and

responsively to the query score:

incrementing edge scores of the PAG between vertices of the PAG respectively including the second query terms; and

incrementing edge scores of the DAG associated with the selected first snippet between vertices of the DAG respectively including the second query terms.

34. The method according to claim 33, wherein incrementing the edge scores of the PAG comprises adding one of the second query terms to the PAG as a new vertex upon finding the second query term is not already included in the PAG.

35. The method according to claim 33, wherein incrementing the edge scores of the DAG comprises adding one of the second query terms to the DAG as a new vertex upon finding the second query term is not already included in the DAG.

36. The method according to claim 33, wherein calculating the query score comprises calculating the query score responsively to at least one attribute selected from the group consisting of: a query-specific attribute, a second-user-query-interaction attribute, and a second-user-result-interaction attribute.

37. The method according to claim 36, wherein the attribute includes the query-specific attribute, and wherein calculating the query score comprises calculating the query score responsively to the query-specific attribute.

38. The method according to claim 37, wherein the query-specific attribute includes a measure of a number of keywords in the second query, and wherein calculating the query score comprises calculating the query score responsively to the measure of the number of keywords.

39. The method according to claim 36, wherein the attribute includes the second-user-query-interaction attribute, and wherein calculating the query score comprises calculating the query score responsively to the user-query-interaction attribute.

40. The method according to claim 39, wherein the second-user-query-interaction attribute includes an association score of a subgraph of the PAG that consists of the second query terms, and wherein calculating the query score comprises calculating the query score responsively to the association score.

41. The method according to claim 39, wherein the second-user-query-interaction

attribute includes a level of focus of the second user regarding the second query, and wherein calculating the query score comprises calculating the query score responsively to the level of focus.

42. The method according to claim 36, wherein the attribute includes a second-user-result-interaction attribute, and wherein calculating the query score comprises calculating the query score responsively to the second-user-result-interaction attribute.

43. The method according to claim 42, wherein the second-user-result-interaction attribute includes a relative position of the selected first snippet in the ranked second search result listing, and wherein calculating the query score comprises calculating the query score responsively to the relative position.

44. The method according to claim 42, wherein the second-user-result-interaction attribute includes an amount of time spent by the second user after selecting the selected first snippet before returning to the ranked second search result listing to make a subsequent selection from the ranked second search result listing.

45. The method according to claim 29, wherein performing the comparison comprises constructing a topic association graph (TAG) that represents interactions of a plurality of previous searches conducted within a single topic by a plurality of previous users including the second user, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, wherein the comparison includes a correlation between (a) a subgraph of the TAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the PAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

46. The method according to claim 29, wherein performing the comparison comprises constructing a global association graph (GAG) that represents interactions of a plurality of searches conducted by a plurality of previous users including the second user with a respective plurality of previous search result documents presented to the previous users during the searches, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, wherein the comparison includes a correlation between (a) a subgraph of the GAG consisting of: (i) the one or more second

query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the GAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

47. A computer-implemented method comprising:

receiving from a user a plurality of first search queries, each of which consists of one or more first query terms;

presenting to the user a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents;

constructing a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices;

receiving from the user a second search query that consists of one or more second query terms;

responsively to the second search query, generating a second search result listing;

calculating respective correlation scores between the PAG and a plurality of second search result documents of at least a portion of the second search result listing;

ranking the at least a portion of the second search result listing at least in part responsively to the correlation scores; and

presenting the ranked second search result listing to the user.

48. The method according to claim 47, wherein calculating the respective correlation scores comprises:

constructing a PAG matrix representing at least a portion of the PAG;

constructing respective document matrices for the plurality of search result document; and

calculating the respective correlation scores using the PAG matrix and the respective document matrices.

49. The method according to any one of claims 47-48, wherein the user is one of a plurality of users, and wherein calculating the respective correlation scores comprises:

constructing a plurality of document profiles respectively associated with the

plurality of second search result documents, each of which document profiles represents interactions of (a) a plurality of previous searches conducted by the plurality of users with (b) the respective second search result document associated with the document profile; and

calculating the respective correlation scores between the PAG and the plurality of document profiles respectively associated with the plurality of second search result documents.

50. The method according to claim 49, wherein each of the plurality of previous searches includes one or more previous query terms, wherein the document profiles include respective document association graphs, each of which includes one or more of the previous query terms as vertices, and wherein calculating the respective correlation scores comprises calculating the respective correlation scores between the PAG and the plurality of DAGs respectively associated with the plurality of second search result documents.

51. The method according to any one of claims 47-48, wherein calculating the respective correlation scores comprises:

constructing a subgraph of the PAG that consists of the second query terms and one or more additional first query terms of the PAG; and

calculating the respective correlation scores between the subgraph and the plurality of the second search result documents.

52. The method according to claim 51, wherein all of the one or more additional first query terms of the PAG are directly linked to all of the second query terms within the PAG, and wherein constructing the subgraph of the PAG comprises constructing the subgraph of the PAG that consists of the second query terms and the one or more additional first query terms of the PAG that are directly linked to all of the second query terms within the PAG.

53. A computer-implemented method comprising:

receiving from a user a plurality of first search queries, each of which consists of one or more first query terms;

presenting to the user a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents;

constructing a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices;

receiving from the user a second search query that consists of one or more second query terms included in a portion of the vertices of the PAG;

responsively to the second search query, generating a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the PAG;

presenting the set of refinement terms to the user;

responsively to a selection of at least one of the refinement terms by the user, adding the selected at least one refinement term to the second search query to generate a third search query; and

presenting search results to the user responsively to the third search query.

54. The method according to claim 53, wherein generating the set comprises selecting the first query term for inclusion in the set responsively to finding that the first query term is directly linked to all of the second query terms in the PAG.

55. The method according to any one of claims 53-54, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein presenting the set of refinement terms comprises presenting the primary and secondary refinement terms.

56. A computer-implemented method comprising:

receiving from a plurality of users a respective plurality of first search queries, each of which consists of one or more first query terms, wherein the plurality of users includes a plurality of first users, and a second user;

constructing a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms;

receiving from the second user a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG;

responsively to the second search query, generating a second search result listing including a plurality of documents;

ranking at least a portion of the second search result listing at least in part responsively to a comparison between (a) the TAG and (b) at least a portion of the documents of the second search result listing; and

presenting at least a portion of the ranked second search result listing to the second user.

57. The method according to claim 56, wherein constructing the TAG comprises:

constructing respective personal profiles for each of the users of the portion of the users, each of which profiles represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches; and

combining respective portions of the personal profiles, which portions are associated with the topic, to form the TAG.

58. The method according to claim 57, wherein the personal profiles include respective personal association graphs (PAGs), wherein each of the previous searches includes one or more query terms, and wherein constructing the respective personal profiles comprises constructing the respective PAGs including at least a portion of the query terms as vertices.

59. The method according to claim 58, wherein constructing the TAG comprises:

extracting one or more hotspots from each of the PAGs; and

combining the hotspots to form the TAG.

60. The method according to claim 56, wherein ranking comprises:

constructing a subgraph of the TAG that consists of the second query terms and one or more additional first query terms of the TAG, wherein the comparison includes a comparison between (a) the subgraph of TAG and (b) the at least a portion of the documents; and

ranking the at least a portion of the second search result listing at least in part responsively to the comparison.

61. The method according to claim 60, wherein all of the one or more additional first query terms of the TAG are directly linked to all of the second query terms within the TAG, and wherein constructing the subgraph of the TAG comprises constructing the

subgraph of the TAG that consists of the second query terms and the one or more additional first query terms of the TAG that are directly linked to all of the second query terms within the TAG.

62. A computer-implemented method comprising:

receiving from a plurality of users a respective plurality of first search queries, each of which consists of one or more first query terms, wherein the plurality of users includes a plurality of first users, and a second user;

constructing a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms;

receiving from the second user a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG;

responsively to the second search query, generating a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the TAG;

presenting the set of refinement terms to the second user;

responsively to a selection of at least one of the refinement terms by the second user, adding the selected at least one refinement term to the second search query to generate a third search query; and

presenting search results to the second user responsively to the third search query.

63. The method according to claim 62, wherein generating the set comprises selecting the first query term for inclusion in the set responsively to finding that the first query term is directly linked to all of the second query terms in the TAG.

64. The method according to claim 62, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein presenting the set of refinement terms comprises presenting the primary and secondary refinement terms.

65. The method according to any one of claims 62-64, wherein constructing the TAG comprises:

constructing respective personal profiles for each of the users of the portion of the users, each of which profiles represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches; and

combining respective portions of the personal profiles, which portions are associated with the topic, to form the TAG.

66. The method according to claim 65, wherein the personal profiles include respective personal association graphs (PAGs), wherein each of the previous searches includes one or more query terms, and wherein constructing the respective personal profiles comprises constructing the respective PAGs including at least a portion of the query terms as vertices.

67. The method according to claim 66, wherein constructing the TAG comprises:

extracting one or more hotspots from each of the PAGs; and

combining the hotspots to form the TAG.

68. A computer-implemented method comprising:

receiving from a user a first search query consisting of one or more first query terms;

responsively to the search query, generating and presenting to the user a search result listing that includes at least a first snippet associated with a first search result document, and a second snippet associated with a second search result document;

presenting, in association with the first snippet, a first set of one or more refinement terms, and, in association with the second snippet, a second set of one or more refinement terms, wherein the first set is different from the second set;

responsively to a selection of one of the refinement terms of the first set or second set, adding the selected one of the refinement terms to the search query to generate a refined second search query; and

responsively to the refined second search query, generating and presenting to the user a refined search result listing.

69. The method according to claim 68, wherein generating the first set of refinement terms comprises generating the first set of refinement terms by:

constructing a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of

previous search result documents presented to the user during the previous searches, wherein each of previous searches includes one or more previous query terms, and

selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the personal profile.

70. The method according to claim 69, wherein the personal profile includes a personal association graph (PAG), wherein constructing the personal profile comprises constructing the PAG including at least a portion of the previous query terms as vertices, and wherein selecting the previous query term comprises selecting the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the PAG.

71. The method according to claim 68, wherein the user is one of a plurality of users, and wherein generating the first set of refinement terms comprises generating the first set of refinement terms by:

constructing a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, wherein each of the previous searches includes one or more previous query terms, and

selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the topic profile.

72. The method according to claim 71, wherein the topic profile includes a topic association graph (TAG), wherein constructing the personal profile comprises constructing the TAG including at least a portion of the previous query terms as vertices, and wherein selecting the previous query term comprises selecting the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the TAG.

73. The method according to claim 68, wherein the user is one of a plurality of users, and wherein generating the first set of refinement terms comprises generating the first set of refinement terms by:

constructing a global profile that represents interactions of a plurality of searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, wherein each of the previous

searches includes one or more previous query terms, and

selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the global profile.

74. The method according to claim 73, wherein the global profile includes a global association graph (GAG), wherein constructing the global profile comprises constructing the GAG including at least a portion of the previous query terms as vertices, and wherein selecting the previous query term comprises selecting the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the GAG.

75. A computer-implemented method comprising:

constructing a plurality of personal profiles for a respective plurality of users, each of which personal profiles represents interactions of a plurality of first searches conducted by one of the users with a respective plurality of first search result documents presented to the user during the first searches;

identifying a subset of the personal profiles as correlated with one another;

constructing a group profile by combining at least a portion of each of the personal profiles in the subset;

receiving a second search query from one of the users whose personal profile is included in the subset;

responsively to the second search query, generating a search result listing;

calculating respective correlation scores between the group profile and a plurality of second search result documents of at least a portion of the second search result listing;

ranking the at least a portion of the second search result listing at least in part responsively to the correlation scores; and

presenting the ranked second search result listing to the one of the users.

76. The method according to claim 75,

wherein the personal profiles include respective personal association graph (PAGs),

wherein each of the first searches includes one or more first query terms,

wherein constructing the personal profiles comprises constructing the PAGs including at least a portion of the first query terms as vertices,

wherein the group profile includes a group association graph (GRAG), and

wherein constructing the group profile comprises constructing the GRAG by combining at least a portion of each of the PAGs in the subset.

77. Apparatus comprising:

an interface for communicating with a user; and

a processor, which is configured to present to the user, via the interface, a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level; receive from the user, via the interface, an indication of a desired one of the levels; receive from a user, via the interface, a search query consisting of one or more query terms; responsively to the search query, generate a search result listing; rank at least a portion of the search result listing at least in part responsively to the indication; and present at least a portion of the ranked search result listing to the user via the interface.

78. The apparatus according to claim 77, wherein the desired level of personalization includes the personalized level, and wherein the processor is configured to receive the indication of the personalized level, construct a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches, calculate respective correlation scores between the personal profile and a plurality of search result documents of the at least a portion of search result listing, and rank the at least a portion of the search result listing at least in part responsively to the correlation scores.

79. The apparatus according to claim 78, wherein the personal profile includes a personal association graph (PAG), wherein each of the previous searches includes one or more previous query terms, and wherein the processor is configured to construct the personal profile by constructing the PAG including at least a portion of the previous query terms as vertices.

80. The apparatus according to claim 79, wherein the processor is configured to generate the search result listing responsively to the query terms and at least one of the previous query terms in the PAG linked to all of the query terms in the PAG.

81. The apparatus according to claim 79, wherein the processor is configured to

generate the search result listing responsively to the query terms and a high point term of a hotspot of the PAG.

82. The apparatus according to claim 77, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, wherein the desired level of personalization includes the community level, and wherein the processor is configured to receive the indication of the community level, construct a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, calculate respective correlation scores between the topic profile and a plurality of search result documents of the at least a portion of search result listing, and rank the at least a portion of the search result listing at least in part responsively to the correlation scores.

83. The apparatus according to claim 82, wherein the topic profile includes a topic association graph (TAG), wherein each of the previous searches includes one or more previous query terms, and wherein the processor is configured to construct the topic profile by constructing the TAG including at least a portion of the previous query terms as vertices.

84. The apparatus according to claim 77, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, wherein the desired level of personalization includes the community level, and wherein the processor is configured to receive the indication of the community level; construct a plurality of personal profiles for respective users in the plurality of users, each of which personal profiles represents interactions of a plurality of previous searches conducted by one of the users with a respective plurality of previous search result documents presented to the one of the users during the previous searches; identify a subset of the personal profiles as correlated with one another; construct a group profile by combining at least a portion of each of the personal profiles in the subset; calculate respective correlation scores between the group profile a plurality of search result documents of the at least a portion of search result listing; and rank the at least a portion of the search result listing at least in part responsively to the correlation scores.

85. The apparatus according to claim 84, wherein the personal profiles include respective personal association graph (PAGs), wherein each of the previous searches includes one or more first query terms, wherein the processor is configured to construct

the personal profiles by constructing the PAGs including at least a portion of the first query terms as vertices, wherein the group profile includes a group association graph (GRAG), and wherein the processor is configured to construct the group profile by constructing the GRAG by combining at least a portion of each of the PAGs in the subset.

86. The apparatus according to claim 85, wherein the processor is configured to generate the search result listing responsively to the query terms and at least one of the previous query terms in the GRAG linked to all of the query terms in the GRAG.

87. The apparatus according to claim 77, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, wherein the desired level of personalization includes a global level that is not personalized, and wherein the processor is configured to receive the indication of the global level, construct a global profile that represents interactions of a plurality of previous searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, calculate respective correlation scores between the global profile and a plurality of search result documents of the at least a portion of search result listing, and rank the at least a portion of the search result listing at least in part responsively to the correlation scores.

88. The apparatus according to claim 87, wherein the global profile includes a global association graph (GAG), wherein each of the previous searches includes one or more previous query terms, and wherein the processor is configured to construct the global profile by constructing the GAG including at least a portion of the previous query terms as vertices.

89. The apparatus according to claim 88, wherein the processor is configured to generate the search result listing responsively to the query terms and at least one of the previous query terms in the GAG linked to all of the query terms in the GAG.

90. The apparatus according to claim 77, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, and wherein the processor is configured to construct a plurality of document profiles associated with a respective plurality of search result documents, each of which document profiles represents interactions of (a) a plurality of previous searches conducted by the plurality of users with (b) the respective search result document associated with the document profile, and rank the at least a portion of the search result listing at least in part

responsively to the indication and respective correlation scores between the query terms and at least a portion of the document profiles.

91. The apparatus according to claim 90, wherein the plurality of document profiles includes a respective plurality of document association graphs (DAGs), wherein the previous searches include one or more respective previous query terms, and wherein the processor is configured to construct the plurality of document profiles by constructing the plurality of DAGs, each of which includes one or more of the previous query terms as vertices.

92. Apparatus comprising:

an interface for communicating with a user; and

a processor, configured to receive from the user, via the interface, a first search query consisting of one or more first query terms; receive from the user, via the interface, an indication of a desired level of personalization of refinement options for the search query; responsively to the search query, generate a set of one or more refinement terms at least in part responsively to the indication; present the set of refinement terms to the user via the interface; responsively to a selection of at least one of the refinement terms by the user, add the selected at least one refinement term to the first search query to generate a second search query; and present to the user, via the interface, search results responsively to the second search query.

93. The apparatus according to claim 92, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein the processor is configured to present the primary and secondary refinement terms to the user via the interface.

94. The apparatus according to any one of claims 92-93, wherein the desired level of personalization is selected from a range of personalization levels between a personalized level and a global level that is not personalized.

95. The apparatus according to claim 94, wherein the range of personalization levels includes a community level between the personalized level and the global level.

96. The apparatus according to any one of claims 92-93, wherein the desired level of personalization includes a personalized level, and wherein the processor is configured to

receive the indication of the personalized level; construct a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches, wherein each of previous searches includes one or more previous query terms; and select at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the personal profile.

97. The apparatus according to claim 96, wherein the personal profile includes a personal association graph (PAG), and wherein the processor is configured to construct the personal profile by constructing the PAG including at least a portion of the previous query terms as vertices, and to select the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the PAG.

98. The apparatus according to any one of claims 92-93, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, wherein the desired level of personalization includes the community level, and wherein the processor is configured to receive the indication of the community level; construct a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, wherein each of the previous searches includes one or more previous query terms; and select at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the topic profile.

99. The apparatus according to claim 98, wherein the topic profile includes a topic association graph (TAG), and wherein the processor is configured to construct the personal profile by constructing the TAG including at least a portion of the previous query terms as vertices, and to select the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the TAG.

100. The apparatus according to any one of claims 92-93, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, wherein the desired level of personalization includes a global level that is not

personalized, and wherein the processor is configured to receive the indication of the global level; construct a global profile that represents interactions of a plurality of searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, wherein each of the previous searches includes one or more previous query terms; and select at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the global profile.

101. The apparatus according to claim 100, wherein the global profile includes a global association graph (GAG), and wherein the processor is configured to construct the global profile by constructing the GAG including at least a portion of the previous query terms as vertices, and to select the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the GAG.

102. Apparatus comprising:

an interface for communicating with a plurality of first users and with a second user; and

a processor, which is configured to receive from the plurality of first users, via the interface, a respective plurality of first search queries, each of which consists of one or more first query terms; present to the plurality of first users, via the interface, respective first search result listings, each of which includes one or more first snippets associated with one or more respective search result documents; construct a plurality of document profiles, each of which (a) is associated with one of the first snippets selected by one or more of the first users from the respective first search result listings, and (b) represents an interaction of one or more of the first query terms with the first snippet; receiving from the second user, via the interface, a second search query, which consists of one or more second query terms; responsively to the second search query, generate a second search result listing, which includes at least a portion of the one or more first snippets; perform a comparison between (a) the second search query and (b) one or more of the document profiles associated with the first snippets included in the second search result listing; rank at least a portion of the second search result listing at least in part responsively to comparison; and present at least a portion of the ranked second search result listing to the

second user via the interface.

103. The apparatus according to claim 102, wherein the processor is configured to construct the document profiles such that at least one of the document profiles includes one or more of the first query terms that do not appear in the first snippet associated with the document profile.

104. The apparatus according to claim 102, wherein the processor is configured to presenting to the second user, via the interface, a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level; receive from the user, via the interface, an indication of a desired one of the levels; and rank the at least a portion of the second search result listing at least in part responsively to the indication.

105. The apparatus according to any one of claims 102-104, wherein the document profiles include respective document association graphs (DAGs), each of which includes a plurality of the first query terms as DAG vertices.

106. The apparatus according to claim 105, wherein the processor is configured to construct the document profiles by constructing the DAGs such that at least one of the DAGs includes as vertices one or more of the first query terms that do not appear in the first snippet associated with the document profile.

107. The apparatus according to claim 105, wherein the processor is configured to receive the second search query, which consists of the one or more second query terms organized linearly; transform the second search query into a query association graph including the one or more second query terms as query association graph vertices; and perform the comparison between (a) the query association graph and (b) the one or more of the DAGs associated with the first snippets included in the second search result listing.

108. The apparatus according to claim 105, wherein the processor is configured to perform the comparison by constructing a personal association graph (PAG) for the second user that represents interactions of a plurality of previous searches conducted by the second user with a respective plurality of previous search result documents presented to the second user during the previous searches, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, and wherein the comparison includes a correlation between (a) a subgraph of the PAG

consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the PAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

109. The apparatus according to claim 108, wherein the processor is configured to receive a selection made by the second user of one of the first snippets included in the ranked second search result listing; calculate a query score for the second search query; and responsively to the query score: increment edge scores of the PAG between vertices of the PAG respectively including the second query terms, and increment edge scores of the DAG associated with the selected first snippet between vertices of the DAG respectively including the second query terms.

110. The apparatus according to claim 109, wherein the processor is configured to increment the edge scores of the PAG by adding one of the second query terms to the PAG as a new vertex upon finding the second query term is not already included in the PAG.

111. The apparatus according to claim 109, wherein the processor is configured to increment the edge scores of the DAG by adding one of the second query terms to the DAG as a new vertex upon finding the second query term is not already included in the DAG.

112. The apparatus according to claim 109, wherein the processor is configured to calculate the query score responsively to at least one attribute selected from the group consisting of: a query-specific attribute, a second-user-query-interaction attribute, and a second-user-result-interaction attribute.

113. The apparatus according to claim 112, wherein the attribute includes the query-specific attribute, and wherein the processor is configured to calculate the query score responsively to the query-specific attribute.

114. The apparatus according to claim 113, wherein the query-specific attribute includes a measure of a number of keywords in the second query, and wherein the processor is configured to calculate the query score responsively to the measure of the number of keywords.

115. The apparatus according to claim 112, wherein the attribute includes the second-user-query-interaction attribute, and wherein the processor is configured to calculate the query score responsively to the user-query-interaction attribute.

116. The apparatus according to claim 115, wherein the second-user-query-interaction attribute includes an association score of a subgraph of the PAG that consists of the second query terms, and wherein the processor is configured to calculate the query score responsively to the association score.

117. The apparatus according to claim 115, wherein the second-user-query-interaction attribute includes a level of focus of the second user regarding the second query, and wherein the processor is configured to calculate the query score responsively to the level of focus.

118. The apparatus according to claim 112, wherein the attribute includes a second-user-result-interaction attribute, and wherein the processor is configured to calculate the query score responsively to the second-user-result-interaction attribute.

119. The apparatus according to claim 118, wherein the second-user-result-interaction attribute includes a relative position of the selected first snippet in the ranked second search result listing, and wherein the processor is configured to calculate the query score responsively to the relative position.

120. The apparatus according to claim 118, wherein the second-user-result-interaction attribute includes an amount of time spent by the second user after selecting the selected first snippet before returning to the ranked second search result listing to make a subsequent selection from the ranked second search result listing.

121. The apparatus according to claim 105, wherein the processor is configured to perform the comparison by constructing a topic association graph (TAG) that represents interactions of a plurality of previous searches conducted within a single topic by a plurality of previous users including the second user, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, and wherein the comparison includes a correlation between (a) a subgraph of the TAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the PAG and (b) the one or more DAGs associated with the first snippets included in the

second search result listing, and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

122. The apparatus according to claim 105, wherein the processor is configured to perform the comparison by constructing a global association graph (GAG) that represents interactions of a plurality of searches conducted by a plurality of previous users including the second user with a respective plurality of previous search result documents presented to the previous users during the searches, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, and wherein the comparison includes a correlation between (a) a subgraph of the GAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the GAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

123. Apparatus comprising:

an interface for communicating with a user; and

a processor, which is configured to receive from the user, via the interface, a plurality of first search queries, each of which consists of one or more first query terms; present to the user, via the interface, a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents; construct a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices; receive from the user, via the interface, a second search query that consists of one or more second query terms; responsively to the second search query, generate a second search result listing; calculate respective correlation scores between the PAG and a plurality of second search result documents of at least a portion of the second search result listing; rank the at least a portion of the second search result listing at least in part responsively to the correlation scores; and present the ranked second search result listing to the user via the interface.

124. The apparatus according to claim 123, wherein the processor is configured to calculate the respective correlation scores by: constructing a PAG matrix representing at

least a portion of the PAG, constructing respective document matrices for the plurality of search result document, and calculating the respective correlation scores using the PAG matrix and the respective document matrices.

125. The apparatus according to any one of claims 123-124, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, and wherein the processor is configured to calculate the respective correlation scores by: constructing a plurality of document profiles respectively associated with the plurality of second search result documents, each of which document profiles represents interactions of (a) a plurality of previous searches conducted by the plurality of users with (b) the respective second search result document associated with the document profile; and calculating the respective correlation scores between the PAG and the plurality of document profiles respectively associated with the plurality of second search result documents.

126. The apparatus according to claim 125, wherein each of the plurality of previous searches includes one or more previous query terms, wherein the document profiles include respective document association graphs, each of which includes one or more of the previous query terms as vertices, and wherein the processor is configured to calculate the respective correlation scores between the PAG and the plurality of DAGs respectively associated with the plurality of second search result documents.

127. The apparatus according to any one of claims 123-124, wherein the processor is configured to construct a subgraph of the PAG that consists of the second query terms and one or more additional first query terms of the PAG, and calculate the respective correlation scores between the subgraph and the plurality of the second search result documents.

128. The apparatus according to claim 127, wherein all of the one or more additional first query terms of the PAG are directly linked to all of the second query terms within the PAG, and wherein the processor is configured to construct the subgraph of the PAG that consists of the second query terms and the one or more additional first query terms of the PAG that are directly linked to all of the second query terms within the PAG.

129. Apparatus comprising:

an interface for communicating with a user; and

a processor, configured to receive from the user, via the interface, a plurality of first search queries, each of which consists of one or more first query terms; present to the user, via the interface, a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents; constructing a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices; receiving from the user, via the interface, a second search query that consists of one or more second query terms included in a portion of the vertices of the PAG; responsively to the second search query, generate a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the PAG; present the set of refinement terms to the user via the interface; responsively to a selection of at least one of the refinement terms by the user, add the selected at least one refinement term to the second search query to generate a third search query; and present to the user, via the interface, search results responsively to the third search query.

130. The apparatus according to claim 129, wherein the processor is configured to select the first query term for inclusion in the set responsively to finding that the first query term is directly linked to all of the second query terms in the PAG.

131. The apparatus according to any one of claims 129-130, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein the processor is configured to present the primary and secondary refinement terms.

132. Apparatus comprising:

an interface for communicating with a plurality of users, which includes a plurality of first users, and a second user; and

a processor, configured to receive from the plurality of users, via the interface, a respective plurality of first search queries, each of which consists of one or more first query terms; construct a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the

first search queries, and includes as vertices at least a portion of the first query terms; receive from the second user, via the interface, a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG; responsively to the second search query, generate a second search result listing including a plurality of documents; rank at least a portion of the second search result listing at least in part responsively to a comparison between (a) the TAG and (b) at least a portion of the documents of the second search result listing; and presenting at least a portion of the ranked second search result listing to the second user via the interface.

133. The apparatus according to claim 132, wherein the processor is configured to construct the TAG by: constructing respective personal profiles for each of the users of the portion of the users, each of which profiles represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches; and combining respective portions of the personal profiles, which portions are associated with the topic, to form the TAG.

134. The apparatus according to claim 133, wherein the personal profiles include respective personal association graphs (PAGs), wherein each of the previous searches includes one or more query terms, and wherein the processor is configured to construct the respective personal profiles by constructing the respective PAGs including at least a portion of the query terms as vertices.

135. The apparatus according to claim 134, wherein the processor is configured to construct the TAG by extracting one or more hotspots from each of the PAGs, and combining the hotspots to form the TAG.

136. The apparatus according to claim 132, wherein the processor is configured to rank by: constructing a subgraph of the TAG that consists of the second query terms and one or more additional first query terms of the TAG, wherein the comparison includes a comparison between (a) the subgraph of TAG and (b) the at least a portion of the documents; and ranking the at least a portion of the second search result listing at least in part responsively to the comparison.

137. The apparatus according to claim 136, wherein all of the one or more additional first query terms of the TAG are directly linked to all of the second query terms within the TAG, and wherein the processor is configured to construct the subgraph of the TAG that

consists of the second query terms and the one or more additional first query terms of the TAG that are directly linked to all of the second query terms within the TAG.

138. Apparatus comprising:

an interface for communicating with a plurality of users, which includes a plurality of first users, and a second user; and

a processor, configured to receive from the plurality of users, via the interface, a respective plurality of first search queries, each of which consists of one or more first query terms; construct a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms; receive from the second user, via the interface, a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG; responsively to the second search query, generate a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the TAG; present the set of refinement terms to the second user via the interface; responsively to a selection of at least one of the refinement terms by the second user, add the selected at least one refinement term to the second search query to generate a third search query; and present to the second user, via the interface, search results responsively to the third search query.

139. The apparatus according to claim 138, wherein the processor is configured to select the first query term for inclusion in the set responsively to finding that the first query term is directly linked to all of the second query terms in the TAG.

140. The apparatus according to claim 138, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein the processor is configured to present the primary and secondary refinement terms.

141. The apparatus according to any one of claims 138-140, wherein the processor is configured to construct the TAG by: constructing respective personal profiles for each of the users of the portion of the users, each of which profiles represents interactions of a

plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches; and combining respective portions of the personal profiles, which portions are associated with the topic, to form the TAG.

142. The apparatus according to claim 141, wherein the personal profiles include respective personal association graphs (PAGs), wherein each of the previous searches includes one or more query terms, and wherein the processor is configured to construct the respective personal profiles by constructing the respective PAGs including at least a portion of the query terms as vertices.

143. The apparatus according to claim 142, wherein the processor is configured to construct the TAG by extracting one or more hotspots from each of the PAGs, and combining the hotspots to form the TAG.

144. Apparatus comprising:

an interface for communicating with a user; and

a processor, which is configured to receive from the user, via the interface, a first search query consisting of one or more first query terms; responsively to the search query, generate and present to the user, via the interface, a search result listing that includes at least a first snippet associated with a first search result document, and a second snippet associated with a second search result document; present, in association with the first snippet, a first set of one or more refinement terms, and, in association with the second snippet, a second set of one or more refinement terms, wherein the first set is different from the second set; responsively to a selection of one of the refinement terms of the first set or second set, add the selected one of the refinement terms to the search query to generate a refined second search query; and responsively to the refined second search query, generate and present to the user, via the interface, a refined search result listing.

145. The apparatus according to claim 144, wherein the processor is configured to presenting the first set of refinement terms by constructing a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches, wherein each of previous searches include one or more previous query terms; and selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query

term with the first query terms in the personal profile.

146. The apparatus according to claim 145, wherein the personal profile includes a personal association graph (PAG), wherein the processor is configured to construct the personal profile by constructing the PAG including at least a portion of the previous query terms as vertices, and wherein the processor is configured to select the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the PAG.

147. The apparatus according to claim 144, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, and wherein the processor is configured to generate the first set of refinement terms by: constructing a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, wherein each of the previous searches includes one or more previous query terms; and selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the topic profile.

148. The apparatus according to claim 147, wherein the topic profile includes a topic association graph (TAG), wherein the processor is configured to construct the personal profile by constructing the TAG including at least a portion of the previous query terms as vertices, and wherein the processor is configured to select the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the TAG.

149. The apparatus according to claim 144, wherein the user is one of a plurality of users, wherein the interface is configured to communicate with the plurality of users, and wherein the processor is configured to generate the first set of refinement terms by: constructing a global profile that represents interactions of a plurality of searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, wherein each of the previous searches includes one or more previous query terms; and selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the global profile.

150. The apparatus according to claim 149, wherein the global profile includes a global association graph (GAG), wherein the processor is configured to construct the global profile by constructing the GAG including at least a portion of the previous query terms as vertices, and wherein the processor is configured to select the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the GAG.

151. Apparatus comprising:

an interface for communicating with a plurality of users; and

a processor, configured to construct a plurality of personal profiles for the respective plurality of users, each of which personal profiles represents interactions of a plurality of first searches conducted by one of the users with a respective plurality of first search result documents presented to the user during the first searches; identify a subset of the personal profiles as correlated with one another; construct a group profile by combining at least a portion of each of the personal profiles in the subset; receive, via the interface, a second search query from one of the users whose personal profile is included in the subset; responsively to the second search query, generate a search result listing; calculate respective correlation scores between the group profile and a plurality of second search result documents of at least a portion of the second search result listing; rank the at least a portion of the second search result listing at least in part responsively to the correlation scores; and present the ranked second search result listing to the one of the users via the interface.

152. The apparatus according to claim 151, wherein the personal profiles include respective personal association graph (PAGs), wherein each of the first searches includes one or more first query terms, wherein the processor is configured to construct the personal profiles by constructing the PAGs including at least a portion of the first query terms as vertices, wherein the group profile includes a group association graph (GAG), and wherein the processor is configured to construct the group profile by constructing the GAG by combining at least a portion of each of the PAGs in the subset.

153. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to present to a user a range of levels of personalization of search results, including a personalized level, a global level

that is not personalized, and a community level between the personalized level and the global level; receive from the user an indication of a desired one of the levels; receive from a user a search query consisting of one or more query terms; responsively to the search query, generate a search result listing; rank at least a portion of the search result listing at least in part responsively to the indication; and present at least a portion of the ranked search result listing to the user.

154. The computer software product according to claim 153, wherein the desired level of personalization includes the personalized level, and wherein the instructions, when read by the computer, cause the computer to receive the indication of the personalized level, construct a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches, calculate respective correlation scores between the personal profile and a plurality of search result documents of the at least a portion of search result listing, and rank the at least a portion of the search result listing at least in part responsively to the correlation scores.

155. The computer software product according to claim 154, wherein the personal profile includes a personal association graph (PAG), wherein each of the previous searches includes one or more previous query terms, and wherein the instructions, when read by the computer, cause the computer to construct the personal profile by constructing the PAG including at least a portion of the previous query terms as vertices.

156. The computer software product according to claim 155, wherein the instructions, when read by the computer, cause the computer to generate the search result listing responsively to the query terms and at least one of the previous query terms in the PAG linked to all of the query terms in the PAG.

157. The computer software product according to claim 155, wherein the instructions, when read by the computer, cause the computer to generate the search result listing responsively to the query terms and a high point term of a hotspot of the PAG.

158. The computer software product according to claim 153, wherein the user is one of a plurality of users, wherein the desired level of personalization includes the community level, and wherein the instructions, when read by the computer, cause the computer to receive the indication of the community level, construct a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a

single topic, calculate respective correlation scores between the topic profile and a plurality of search result documents of the at least a portion of search result listing, and rank the at least a portion of the search result listing at least in part responsively to the correlation scores.

159. The computer software product according to claim 158, wherein the topic profile includes a topic association graph (TAG), wherein each of the previous searches includes one or more previous query terms, and wherein the instructions, when read by the computer, cause the computer to construct the topic profile by constructing the TAG including at least a portion of the previous query terms as vertices.

160. The computer software product according to claim 153, wherein the user is one of a plurality of users, wherein the desired level of personalization includes the community level, and wherein the instructions, when read by the computer, cause the computer to receive the indication of the community level; construct a plurality of personal profiles for respective users in the plurality of users, each of which personal profiles represents interactions of a plurality of previous searches conducted by one of the users with a respective plurality of previous search result documents presented to the one of the users during the previous searches; identify a subset of the personal profiles as correlated with one another; construct a group profile by combining at least a portion of each of the personal profiles in the subset; calculate respective correlation scores between the group profile a plurality of search result documents of the at least a portion of search result listing; and rank the at least a portion of the search result listing at least in part responsively to the correlation scores.

161. The computer software product according to claim 160, wherein the personal profiles include respective personal association graph (PAGs), wherein each of the previous searches includes one or more first query terms, wherein the instructions, when read by the computer, cause the computer to construct the personal profiles by constructing the PAGs including at least a portion of the first query terms as vertices, wherein the group profile includes a group association graph (GRAG), and wherein the instructions, when read by the computer, cause the computer to construct the group profile by constructing the GRAG by combining at least a portion of each of the PAGs in the subset.

162. The computer software product according to claim 161, wherein the instructions,

when read by the computer, cause the computer to generate the search result listing responsively to the query terms and at least one of the previous query terms in the GRAG linked to all of the query terms in the GRAG.

163. The computer software product according to claim 153, wherein the user is one of a plurality of users, wherein the desired level of personalization includes a global level that is not personalized, and wherein the instructions, when read by the computer, cause the computer to receive the indication of the global level, construct a global profile that represents interactions of a plurality of previous searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, calculate respective correlation scores between the global profile and a plurality of search result documents of the at least a portion of search result listing, and rank the at least a portion of the search result listing at least in part responsively to the correlation scores.

164. The computer software product according to claim 163, wherein the global profile includes a global association graph (GAG), wherein each of the previous searches includes one or more previous query terms, and wherein the instructions, when read by the computer, cause the computer to construct the global profile by constructing the GAG including at least a portion of the previous query terms as vertices.

165. The computer software product according to claim 164, wherein the instructions, when read by the computer, cause the computer to generate the search result listing responsively to the query terms and at least one of the previous query terms in the GAG linked to all of the query terms in the GAG.

166. The computer software product according to claim 153, wherein the user is one of a plurality of users, and wherein the instructions, when read by the computer, cause the computer to construct a plurality of document profiles associated with a respective plurality of search result documents, each of which document profiles represents interactions of (a) a plurality of previous searches conducted by the plurality of users with (b) the respective search result document associated with the document profile, and rank the at least a portion of the search result listing at least in part responsively to the indication and respective correlation scores between the query terms and at least a portion of the document profiles.

167. The computer software product according to claim 166, wherein the plurality of

document profiles includes a respective plurality of document association graphs (DAGs), wherein the previous searches include one or more respective previous query terms, and wherein the instructions, when read by the computer, cause the computer to construct the plurality of document profiles by constructing the plurality of DAGs, each of which includes one or more of the previous query terms as vertices.

168. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a user a first search query consisting of one or more first query terms; receive from the user an indication of a desired level of personalization of refinement options for the search query; responsively to the search query, generate a set of one or more refinement terms at least in part responsively to the indication; present the set of refinement terms to the user; responsively to a selection of at least one of the refinement terms by the user, add the selected at least one refinement term to the first search query to generate a second search query; and present to the user search results responsively to the second search query.

169. The computer software product according to claim 168, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein the instructions, when read by the computer, cause the computer to present the primary and secondary refinement terms to the user.

170. The computer software product according to any one of claims 168-169, wherein the desired level of personalization is selected from a range of personalization levels between a personalized level and a global level that is not personalized.

171. The computer software product according to claim 170, wherein the range of personalization levels includes a community level between the personalized level and the global level.

172. The computer software product according to any one of claims 168-169, wherein the desired level of personalization includes a personalized level, and wherein the instructions, when read by the computer, cause the computer to receive the indication of the personalized level; construct a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of

previous search result documents presented to the user during the previous searches, wherein each of previous searches includes one or more previous query terms; and select at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the personal profile.

173. The computer software product according to claim 172, wherein the personal profile includes a personal association graph (PAG), and wherein the instructions, when read by the computer, cause the computer to construct the personal profile by constructing the PAG including at least a portion of the previous query terms as vertices, and to select the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the PAG.

174. The computer software product according to any one of claims 168-169, wherein the user is one of a plurality of users, wherein the desired level of personalization includes the community level, and wherein the instructions, when read by the computer, cause the computer to receive the indication of the community level; construct a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, wherein each of the previous searches includes one or more previous query terms; and select at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the topic profile.

175. The computer software product according to claim 174, wherein the topic profile includes a topic association graph (TAG), and wherein the instructions, when read by the computer, cause the computer to construct the personal profile by constructing the TAG including at least a portion of the previous query terms as vertices, and to select the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the TAG.

176. The computer software product according to any one of claims 168-169, wherein the user is one of a plurality of users, wherein the desired level of personalization includes a global level that is not personalized, and wherein the instructions, when read by the computer, cause the computer to receive the indication of the global level; construct a global profile that represents interactions of a plurality of searches conducted by the plurality of users with a respective plurality of previous search result documents presented

to the users during the searches, wherein each of the previous searches includes one or more previous query terms; and select at least one of the previous query terms for inclusion in the set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the global profile.

177. The computer software product according to claim 176, wherein the global profile includes a global association graph (GAG), and wherein the instructions, when read by the computer, cause the computer to construct the global profile by constructing the GAG including at least a portion of the previous query terms as vertices, and to select the previous query term for inclusion in the set responsively to finding that the previous query term is directly linked to all of the first query terms in the GAG.

178. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a plurality of first users a respective plurality of first search queries, each of which consists of one or more first query terms; present to the plurality of first users respective first search result listings, each of which includes one or more first snippets associated with one or more respective search result documents; construct a plurality of document profiles, each of which (a) is associated with one of the first snippets selected by one or more of the first users from the respective first search result listings, and (b) represents an interaction of one or more of the first query terms with the first snippet; receiving from a second user a second search query, which consists of one or more second query terms; responsively to the second search query, generate a second search result listing, which includes at least a portion of the one or more first snippets; perform a comparison between (a) the second search query and (b) one or more of the document profiles associated with the first snippets included in the second search result listing; rank at least a portion of the second search result listing at least in part responsively to comparison; and present at least a portion of the ranked second search result listing to the second user.

179. The computer software product according to claim 178, wherein the instructions, when read by the computer, cause the computer to construct the document profiles such that at least one of the document profiles includes one or more of the first query terms that do not appear in the first snippet associated with the document profile.

180. The computer software product according to claim 178, wherein the instructions,

when read by the computer, cause the computer to present to the second user a range of levels of personalization of search results, including a personalized level, a global level that is not personalized, and a community level between the personalized level and the global level; receive from the user an indication of a desired one of the levels; and rank the at least a portion of the second search result listing at least in part responsively to the indication.

181. The computer software product according to any one of claims 178-180, wherein the document profiles include respective document association graphs (DAGs), each of which includes a plurality of the first query terms as DAG vertices.

182. The computer software product according to claim 181, wherein the instructions, when read by the computer, cause the computer to construct the document profiles by constructing the DAGs such that at least one of the DAGs includes as vertices one or more of the first query terms that do not appear in the first snippet associated with the document profile.

183. The computer software product according to claim 181, wherein the instructions, when read by the computer, cause the computer to receive the second search query, which consists of the one or more second query terms organized linearly; transform the second search query into a query association graph including the one or more second query terms as query association graph vertices; and perform the comparison between (a) the query association graph and (b) the one or more of the DAGs associated with the first snippets included in the second search result listing.

184. The computer software product according to claim 181, wherein the instructions, when read by the computer, cause the computer to perform the comparison by constructing a personal association graph (PAG) for the second user that represents interactions of a plurality of previous searches conducted by the second user with a respective plurality of previous search result documents presented to the second user during the previous searches, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, and wherein the comparison includes a correlation between (a) a subgraph of the PAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the PAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing,

and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

185. The computer software product according to claim 184, wherein the instructions, when read by the computer, cause the computer to receive a selection made by the second user of one of the first snippets included in the ranked second search result listing; calculate a query score for the second search query; and responsively to the query score: increment edge scores of the PAG between vertices of the PAG respectively including the second query terms, and increment edge scores of the DAG associated with the selected first snippet between vertices of the DAG respectively including the second query terms.

186. The computer software product according to claim 185, wherein the instructions, when read by the computer, cause the computer to increment the edge scores of the PAG by adding one of the second query terms to the PAG as a new vertex upon finding the second query term is not already included in the PAG.

187. The computer software product according to claim 185, wherein the instructions, when read by the computer, cause the computer to increment the edge scores of the DAG by adding one of the second query terms to the DAG as a new vertex upon finding the second query term is not already included in the DAG.

188. The computer software product according to claim 185, wherein the instructions, when read by the computer, cause the computer to calculate the query score responsively to at least one attribute selected from the group consisting of: a query-specific attribute, a second-user-query-interaction attribute, and a second-user-result-interaction attribute.

189. The computer software product according to claim 188, wherein the attribute includes the query-specific attribute, and wherein the instructions, when read by the computer, cause the computer to calculate the query score responsively to the query-specific attribute.

190. The computer software product according to claim 189, wherein the query-specific attribute includes a measure of a number of keywords in the second query, and wherein the instructions, when read by the computer, cause the computer to calculate the query score responsively to the measure of the number of keywords.

191. The computer software product according to claim 188, wherein the attribute includes the second-user-query-interaction attribute, and wherein the instructions, when

read by the computer, cause the computer to calculate the query score responsively to the user-query-interaction attribute.

192. The computer software product according to claim 191, wherein the second-user-query-interaction attribute includes an association score of a subgraph of the PAG that consists of the second query terms, and wherein the instructions, when read by the computer, cause the computer to calculate the query score responsively to the association score.

193. The computer software product according to claim 191, wherein the second-user-query-interaction attribute includes a level of focus of the second user regarding the second query, and wherein the instructions, when read by the computer, cause the computer to calculate the query score responsively to the level of focus.

194. The computer software product according to claim 188, wherein the attribute includes a second-user-result-interaction attribute, and wherein the instructions, when read by the computer, cause the computer to calculate the query score responsively to the second-user-result-interaction attribute.

195. The computer software product according to claim 194, wherein the second-user-result-interaction attribute includes a relative position of the selected first snippet in the ranked second search result listing, and wherein the instructions, when read by the computer, cause the computer to calculate the query score responsively to the relative position.

196. The computer software product according to claim 194, wherein the second-user-result-interaction attribute includes an amount of time spent by the second user after selecting the selected first snippet before returning to the ranked second search result listing to make a subsequent selection from the ranked second search result listing.

197. The computer software product according to claim 181, wherein the instructions, when read by the computer, cause the computer to perform the comparison by constructing a topic association graph (TAG) that represents interactions of a plurality of previous searches conducted within a single topic by a plurality of previous users including the second user, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, and wherein the comparison includes a correlation between (a) a subgraph of the TAG consisting of: (i)

the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the PAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

198. The computer software product according to claim 181, wherein the instructions, when read by the computer, cause the computer to perform the comparison by constructing a global association graph (GAG) that represents interactions of a plurality of searches conducted by a plurality of previous users including the second user with a respective plurality of previous search result documents presented to the previous users during the searches, and includes as vertices at least a portion of one or more previous query terms used in the plurality of previous searches, and wherein the comparison includes a correlation between (a) a subgraph of the GAG consisting of: (i) the one or more second query terms, and (ii) at least one additional previous query term directly linked to all of the one or more second query terms in the GAG and (b) the one or more DAGs associated with the first snippets included in the second search result listing, and wherein ranking comprises ranking the at least a portion of the second search result listing at least in part responsively to the correlation.

199. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a user a plurality of first search queries, each of which consists of one or more first query terms; present to the user a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents; construct a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices; receive from the user a second search query that consists of one or more second query terms; responsively to the second search query, generate a second search result listing; calculate respective correlation scores between the PAG and a plurality of second search result documents of at least a portion of the second search result listing; rank the at least a portion of the second search result listing at least in part responsively to the correlation scores; and

present the ranked second search result listing to the user.

200. The computer software product according to claim 199, wherein the instructions, when read by the computer, cause the computer to calculate the respective correlation scores by: constructing a PAG matrix representing at least a portion of the PAG, constructing respective document matrices for the plurality of search result document, and calculating the respective correlation scores using the PAG matrix and the respective document matrices.

201. The computer software product according to any one of claims 199-200, wherein the user is one of a plurality of users, and wherein the instructions, when read by the computer, cause the computer to calculate the respective correlation scores by: constructing a plurality of document profiles respectively associated with the plurality of second search result documents, each of which document profiles represents interactions of (a) a plurality of previous searches conducted by the plurality of users with (b) the respective second search result document associated with the document profile; and calculating the respective correlation scores between the PAG and the plurality of document profiles respectively associated with the plurality of second search result documents.

202. The computer software product according to claim 201, wherein each of the plurality of previous searches includes one or more previous query terms, wherein the document profiles include respective document association graphs, each of which includes one or more of the previous query terms as vertices, and wherein the instructions, when read by the computer, cause the computer to calculate the respective correlation scores between the PAG and the plurality of DAGs respectively associated with the plurality of second search result documents.

203. The computer software product according to any one of claims 199-200, wherein the instructions, when read by the computer, cause the computer to construct a subgraph of the PAG that consists of the second query terms and one or more additional first query terms of the PAG, and calculate the respective correlation scores between the subgraph and the plurality of the second search result documents.

204. The computer software product according to claim 203, wherein all of the one or more additional first query terms of the PAG are directly linked to all of the second query terms within the PAG, and wherein the instructions, when read by the computer, cause the

computer to construct the subgraph of the PAG that consists of the second query terms and the one or more additional first query terms of the PAG that are directly linked to all of the second query terms within the PAG.

205. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a user a plurality of first search queries, each of which consists of one or more first query terms; present to the user a plurality of respective first search result listings, each of which includes one or more first snippets associated with one or more respective first search result documents; constructing a personal association graph (PAG) for the user that represents interactions between the user and a plurality of the first snippets, and includes at least a portion of the one or more first query terms as vertices; receiving from the user a second search query that consists of one or more second query terms included in a portion of the vertices of the PAG; responsively to the second search query, generate a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the PAG; present the set of refinement terms to the user; responsively to a selection of at least one of the refinement terms by the user, add the selected at least one refinement term to the second search query to generate a third search query; and present to the user search results responsively to the third search query.

206. The computer software product according to claim 205, wherein the instructions, when read by the computer, cause the computer to select the first query term for inclusion in the set responsively to finding that the first query term is directly linked to all of the second query terms in the PAG.

207. The computer software product according to any one of claims 205-206, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein the instructions, when read by the computer, cause the computer to present the primary and secondary refinement terms.

208. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which

instructions, when read by a computer, cause the computer to receive from a plurality of users a respective plurality of first search queries, each of which consists of one or more first query terms, wherein the plurality of users includes a plurality of first users, and a second user; construct a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms; receive from the second user a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG; responsively to the second search query, generate a second search result listing including a plurality of documents; rank at least a portion of the second search result listing at least in part responsively to a comparison between (a) the TAG and (b) at least a portion of the documents of the second search result listing; and presenting at least a portion of the ranked second search result listing to the second user.

209. The computer software product according to claim 208, wherein the instructions, when read by the computer, cause the computer to construct the TAG by: constructing respective personal profiles for each of the users of the portion of the users, each of which profiles represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches; and combining respective portions of the personal profiles, which portions are associated with the topic, to form the TAG.

210. The computer software product according to claim 209, wherein the personal profiles include respective personal association graphs (PAGs), wherein each of the previous searches includes one or more query terms, and wherein the instructions, when read by the computer, cause the computer to construct the respective personal profiles by constructing the respective PAGs including at least a portion of the query terms as vertices.

211. The computer software product according to claim 210, wherein the instructions, when read by the computer, cause the computer to construct the TAG by extracting one or more hotspots from each of the PAGs, and combining the hotspots to form the TAG.

212. The computer software product according to claim 208, wherein the instructions, when read by the computer, cause the computer to rank by: constructing a subgraph of the

TAG that consists of the second query terms and one or more additional first query terms of the TAG, wherein the comparison includes a comparison between (a) the subgraph of TAG and (b) the at least a portion of the documents; and ranking the at least a portion of the second search result listing at least in part responsively to the comparison.

213. The computer software product according to claim 212, wherein all of the one or more additional first query terms of the TAG are directly linked to all of the second query terms within the TAG, and wherein the instructions, when read by the computer, cause the computer to construct the subgraph of the TAG that consists of the second query terms and the one or more additional first query terms of the TAG that are directly linked to all of the second query terms within the TAG.

214. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from a plurality of users a respective plurality of first search queries, each of which consists of one or more first query terms, wherein the plurality of users includes a plurality of first users, and a second user; construct a topic association graph (TAG) that represents interactions of a portion of the users with (a) a portion of the first queries conducted within a single topic and (b) respective first search result listings generated responsively to the portion of the first search queries, and includes as vertices at least a portion of the first query terms; receive from the second user a second search query, which consists of one or more second query terms included in a portion of the vertices of the TAG; responsively to the second search query, generate a set of one or more refinement terms including at least one of the first query terms selected for inclusion in the set responsively to a level of association of the first query term with the second query terms in the TAG; present the set of refinement terms to the second user; responsively to a selection of at least one of the refinement terms by the second user, add the selected at least one refinement term to the second search query to generate a third search query; and present to the second user search results responsively to the third search query.

215. The computer software product according to claim 214, wherein the instructions, when read by the computer, cause the computer to select the first query term for inclusion in the set responsively to finding that the first query term is directly linked to all of the second query terms in the TAG.

216. The computer software product according to claim 214, wherein the set of refinement terms includes one or more primary refinement terms, and one or more secondary refinement terms associated with at least one of the one or more primary refinement terms, and wherein the instructions, when read by the computer, cause the computer to present the primary and secondary refinement terms.

217. The computer software product according to any one of claims 214-216, wherein the instructions, when read by the computer, cause the computer to construct the TAG by: constructing respective personal profiles for each of the users of the portion of the users, each of which profiles represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches; and combining respective portions of the personal profiles, which portions are associated with the topic, to form the TAG.

218. The computer software product according to claim 217, wherein the personal profiles include respective personal association graphs (PAGs), wherein each of the previous searches includes one or more query terms, and wherein the instructions, when read by the computer, cause the computer to construct the respective personal profiles by constructing the respective PAGs including at least a portion of the query terms as vertices.

219. The computer software product according to claim 218, wherein the instructions, when read by the computer, cause the computer to construct the TAG by extracting one or more hotspots from each of the PAGs, and combining the hotspots to form the TAG.

220. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to receive from the user a first search query consisting of one or more first query terms; responsively to the search query, generate and present to the user a search result listing that includes at least a first snippet associated with a first search result document, and a second snippet associated with a second search result document; present, in association with the first snippet, a first set of one or more refinement terms, and, in association with the second snippet, a second set of one or more refinement terms, wherein the first set is different from the second set; responsively to a selection of one of the refinement terms of the first set or second set, add the selected one of the refinement terms to the search query to generate a refined second

search query; and responsively to the refined second search query, generate and present to the user a refined search result listing.

221. The computer software product according to claim 220, wherein the instructions, when read by the computer, cause the computer to presenting the first set of refinement terms by constructing a personal profile for the user that represents interactions of a plurality of previous searches conducted by the user with a respective plurality of previous search result documents presented to the user during the previous searches, wherein each of previous searches include one or more previous query terms; and selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the personal profile.

222. The computer software product according to claim 221, wherein the personal profile includes a personal association graph (PAG), wherein the instructions, when read by the computer, cause the computer to construct the personal profile by constructing the PAG including at least a portion of the previous query terms as vertices, and wherein the instructions, when read by the computer, cause the computer to select the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the PAG.

223. The computer software product according to claim 220, wherein the user is one of a plurality of users, and wherein the instructions, when read by the computer, cause the computer to generate the first set of refinement terms by: constructing a topic profile that represents interactions of a plurality of previous searches conducted by the plurality of users within a single topic, wherein each of the previous searches includes one or more previous query terms; and selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the topic profile.

224. The computer software product according to claim 223, wherein the topic profile includes a topic association graph (TAG), wherein the instructions, when read by the computer, cause the computer to construct the personal profile by constructing the TAG including at least a portion of the previous query terms as vertices, and wherein the instructions, when read by the computer, cause the computer to select the previous query term for inclusion in the first set responsively to finding that the previous query term is

directly linked to all of the first query terms in the TAG.

225. The computer software product according to claim 220, wherein the user is one of a plurality of users, and wherein the instructions, when read by the computer, cause the computer to generate the first set of refinement terms by: constructing a global profile that represents interactions of a plurality of searches conducted by the plurality of users with a respective plurality of previous search result documents presented to the users during the searches, wherein each of the previous searches includes one or more previous query terms; and selecting at least one of the previous query terms for inclusion in the first set as one of the refinement terms, responsively to a level of association of the previous query term with the first query terms in the global profile.

226. The computer software product according to claim 225, wherein the global profile includes a global association graph (GAG), wherein the instructions, when read by the computer, cause the computer to construct the global profile by constructing the GAG including at least a portion of the previous query terms as vertices, and wherein the instructions, when read by the computer, cause the computer to select the previous query term for inclusion in the first set responsively to finding that the previous query term is directly linked to all of the first query terms in the GAG.

227. A computer software product for executing a process, the product comprising a tangible computer-readable medium in which program instructions are stored, which instructions, when read by a computer, cause the computer to construct a plurality of personal profiles for the respective plurality of users, each of which personal profiles represents interactions of a plurality of first searches conducted by one of the users with a respective plurality of first search result documents presented to the user during the first searches; identify a subset of the personal profiles as correlated with one another; construct a group profile by combining at least a portion of each of the personal profiles in the subset; receive a second search query from one of the users whose personal profile is included in the subset; responsively to the second search query, generate a search result listing; calculate respective correlation scores between the group profile and a plurality of second search result documents of at least a portion of the second search result listing; rank the at least a portion of the second search result listing at least in part responsively to the correlation scores; and present the ranked second search result listing to the one of the users.

228. The computer software product according to claim 227, wherein the personal profiles include respective personal association graph (PAGs), wherein each of the first searches includes one or more first query terms, wherein the instructions, when read by the computer, cause the computer to construct the personal profiles by constructing the PAGs including at least a portion of the first query terms as vertices, wherein the group profile includes a group association graph (GAG), and wherein the instructions, when read by the computer, cause the computer to construct the group profile by constructing the GAG by combining at least a portion of each of the PAGs in the subset.

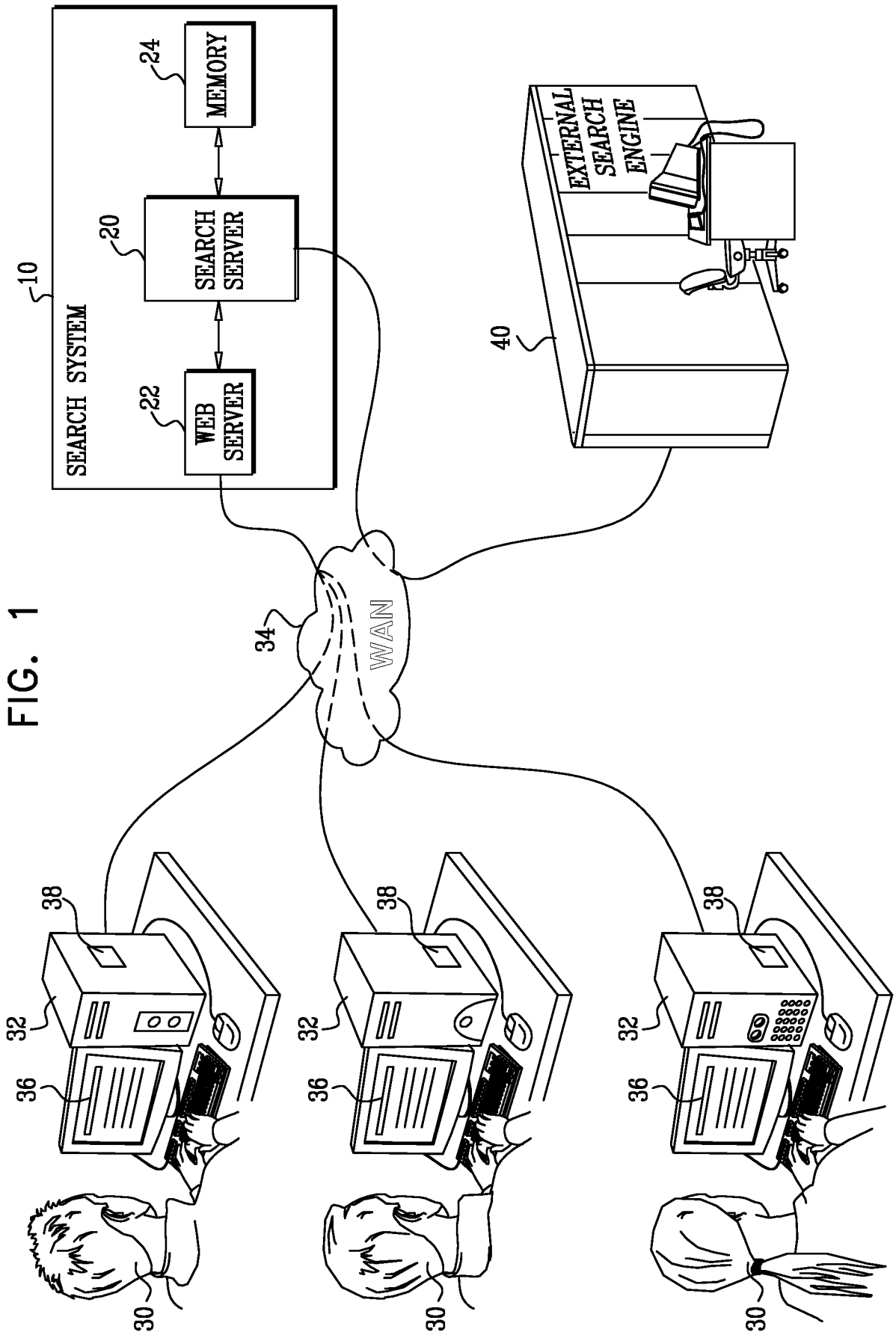

SEARCH SYSTEM
10
SEARCH SERVER
20
MEMORY
24
WEB SERVER
22
EXTERNAL SEARCH ENGINE
40
WAN
34
30
32
36
38

FIG. 1

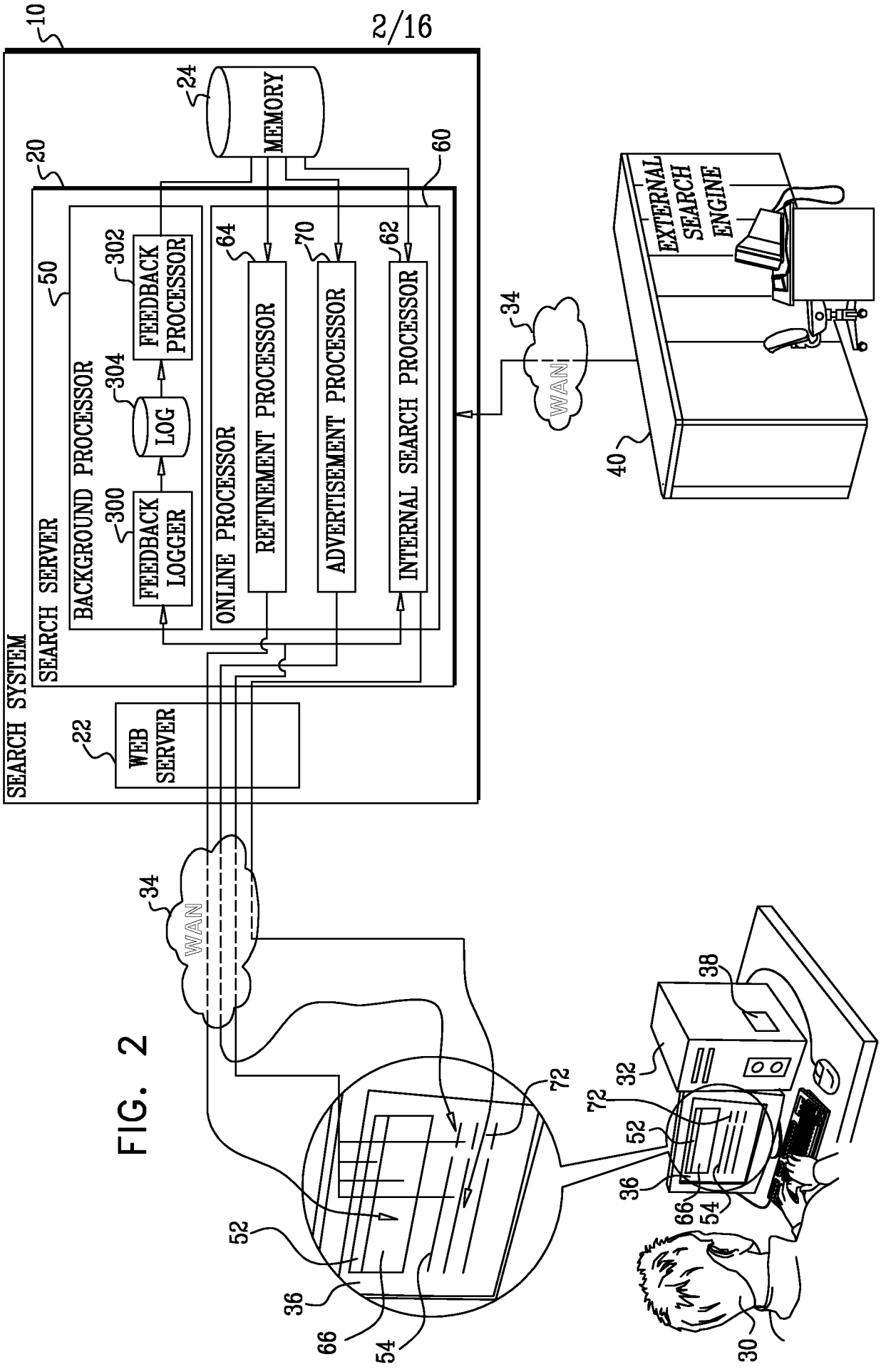

10
SEARCH SYSTEM
20
SEARCH SERVER
50
BACKGROUND PROCESSOR
300
FEEDBACK LOGGER
304
LOG
302
FEEDBACK PROCESSOR
ONLINE PROCESSOR
64
REFINEMENT PROCESSOR
70
ADVERTISEMENT PROCESSOR
62
INTERNAL SEARCH PROCESSOR
22
WEB SERVER
24
MEMORY
60
34
WAN
40
EXTERNAL SEARCH ENGINE
34
WAN
38
32
72
52
36
66
54
30

FIG. 2

FIG. 3

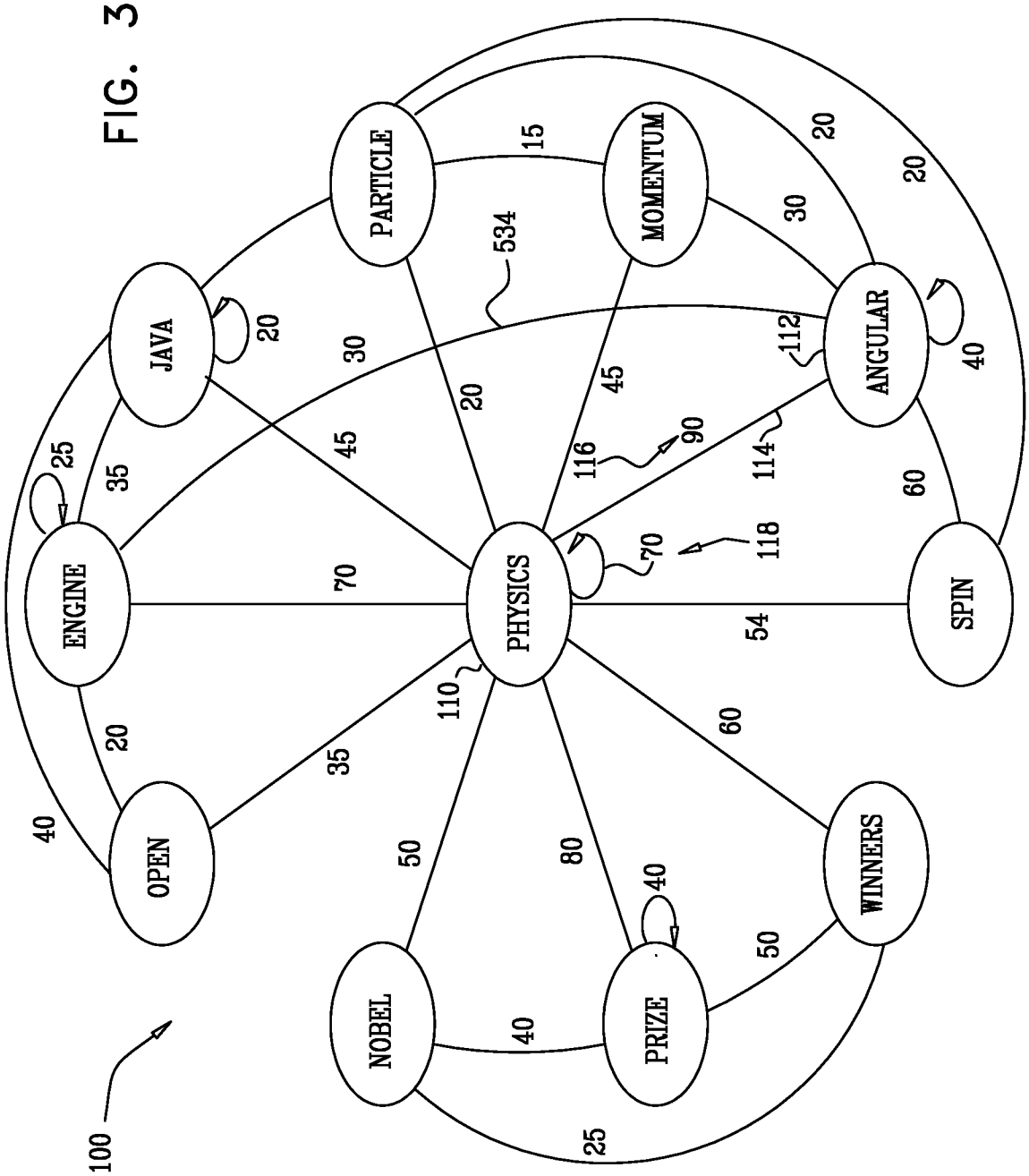

PARTICLE
MOMENTUM
JAVA
ANGULAR
ENGINE
PHYSICS
SPIN
OPEN
WINNERS
NOBEL
PRIZE
534
112
114
116
118
110
90
100
15
20
30
45
70
35
25
40
50
54
60
80

FIG. 4

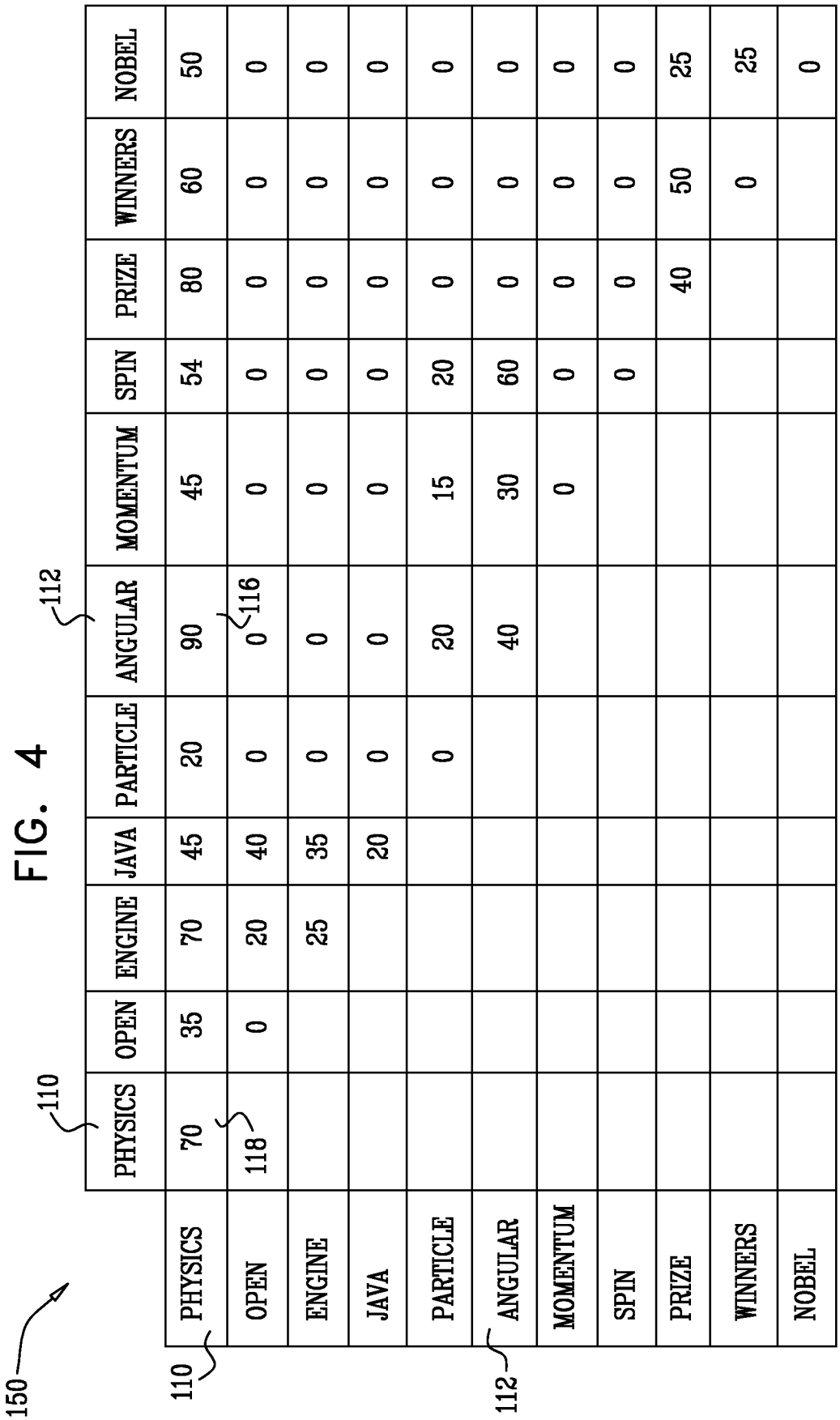

150
110
112
116
118
PHYSICS
OPEN
ENGINE
JAVA
PARTICLE
ANGULAR
MOMENTUM
SPIN
PRIZE
WINNERS
NOBEL

FIG. 5

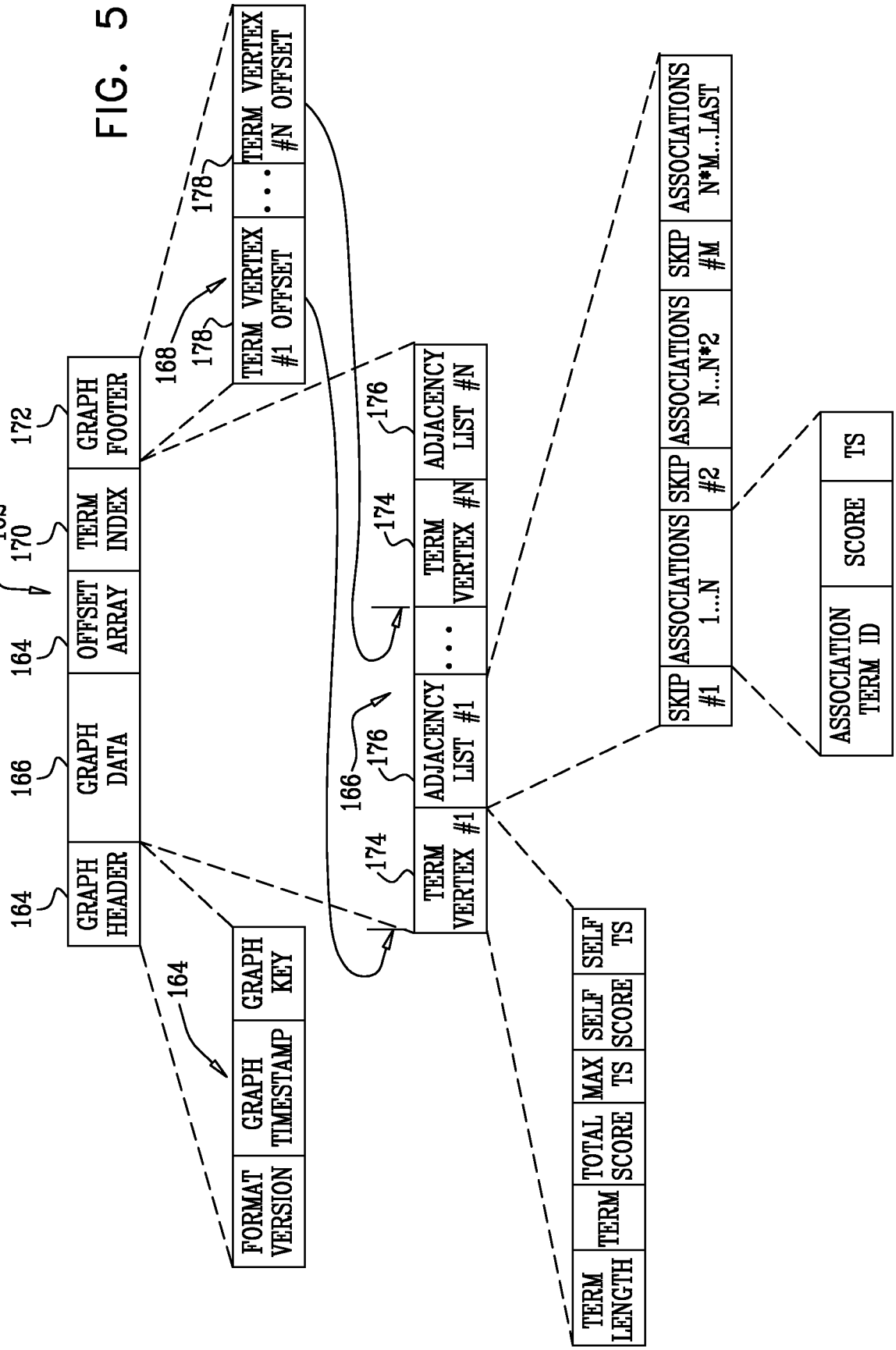

GRAPH HEADER
GRAPH DATA
OFFSET ARRAY
TERM INDEX
GRAPH FOOTER
FORMAT VERSION
GRAPH TIMESTAMP
GRAPH KEY
TERM LENGTH
TERM
TOTAL SCORE
MAX TS
SELF SCORE
SELF TS
TERM VERTEX #1
ADJACENCY LIST #1
...
TERM VERTEX #N
ADJACENCY LIST #N
TERM VERTEX #1 OFFSET
...
TERM VERTEX #N OFFSET
SKIP #1
ASSOCIATIONS 1...N
SKIP #2
ASSOCIATIONS N...N*2
SKIP #M
ASSOCIATIONS N*M...LAST
ASSOCIATION TERM ID
SCORE
TS
162
164
166
168
170
172
174
176
178

FIG. 6

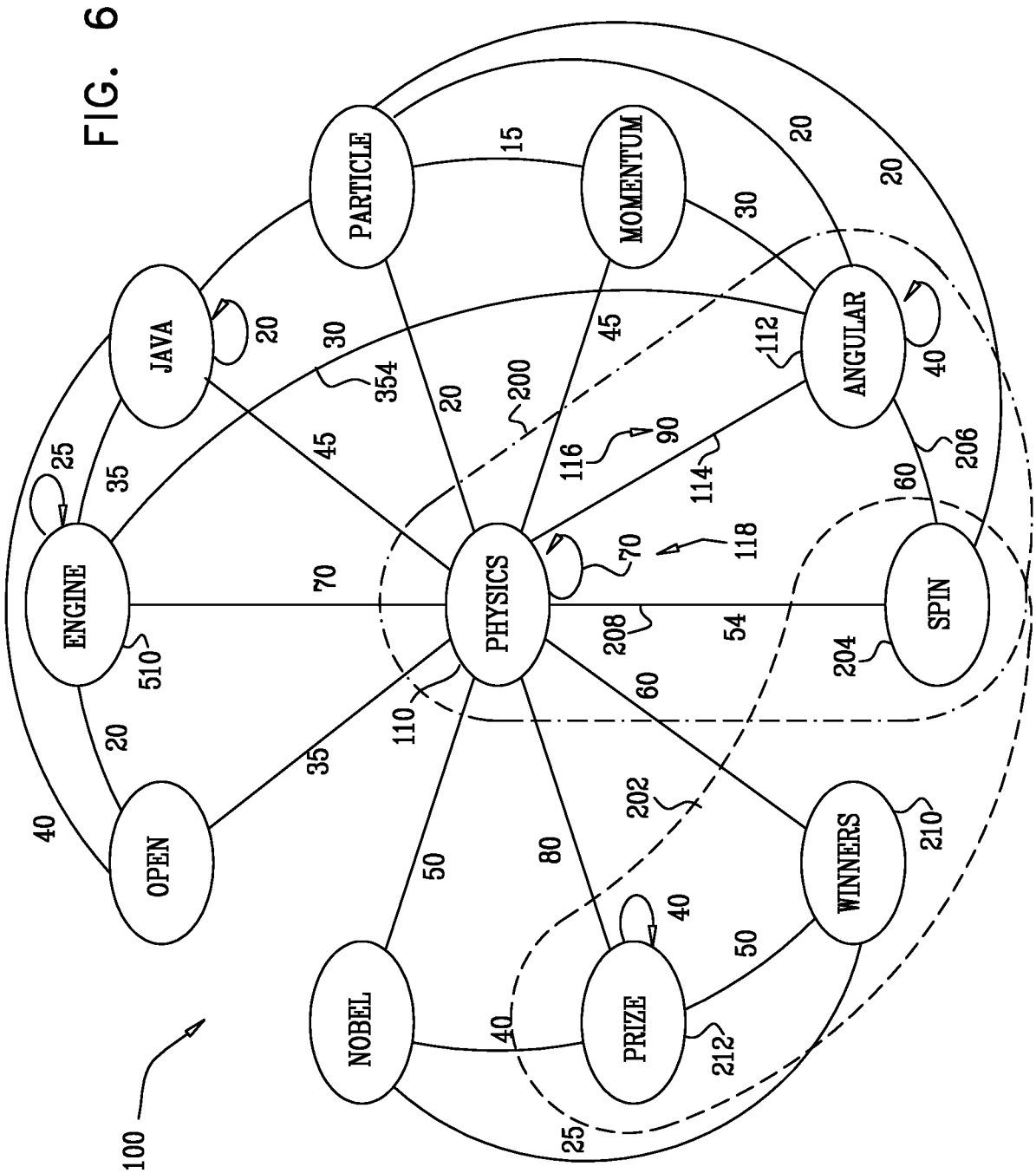
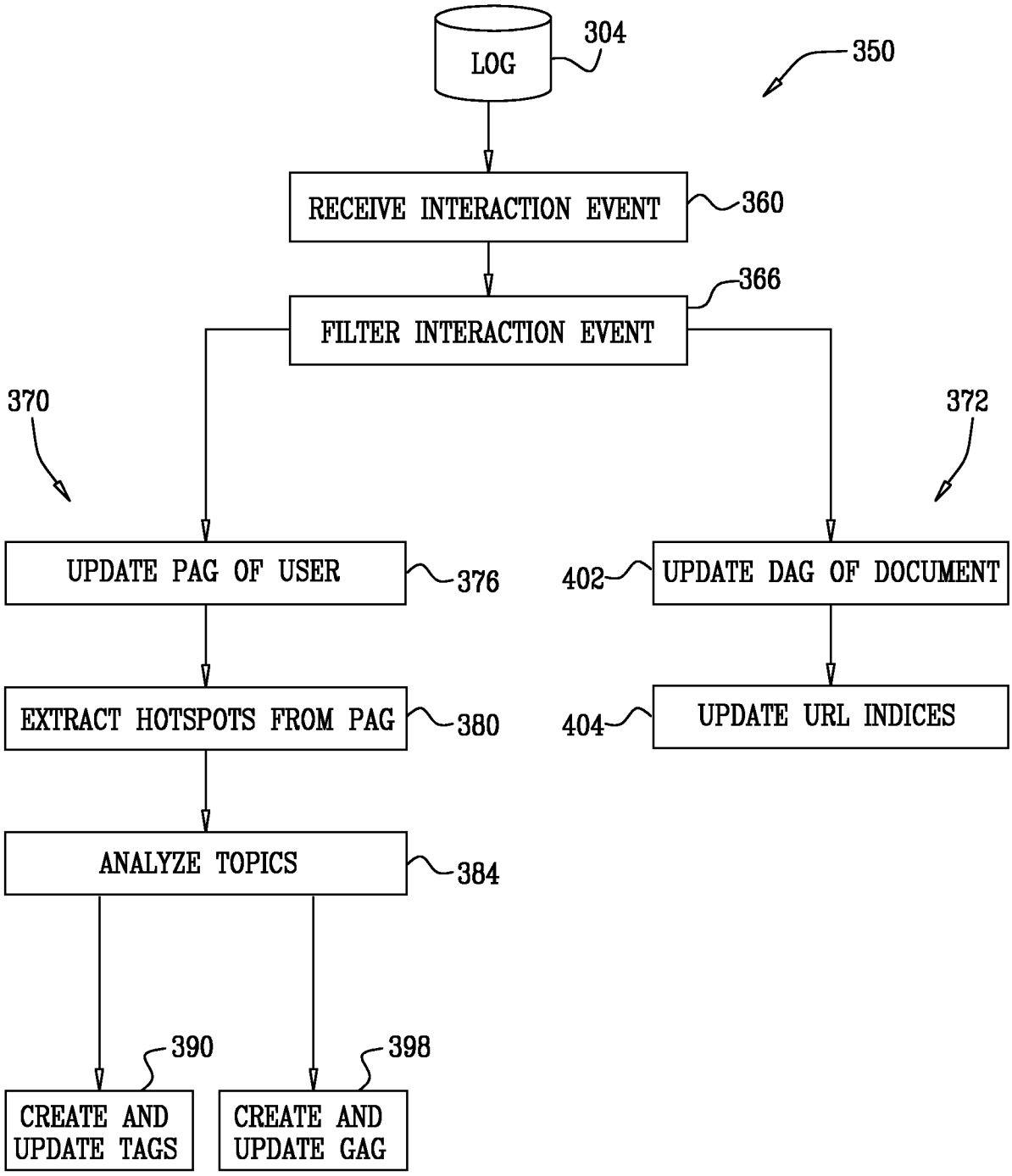

PARTICLE
MOMENTUM
JAVA
ANGULAR
ENGINE
PHYSICS
SPIN
OPEN
WINNERS
NOBEL
PRIZE
100
110
112
114
116
118
200
202
204
206
208
210
212
354
510
15
20
25
30
35
40
45
50
54
60
70
80
90

FIG. 7


LOG
304
350
RECEIVE INTERACTION EVENT
360
FILTER INTERACTION EVENT
366
370
372
UPDATE PAG OF USER
376
402
UPDATE DAG OF DOCUMENT
EXTRACT HOTSPOTS FROM PAG
380
404
UPDATE URL INDICES
ANALYZE TOPICS
384
390
398
CREATE AND UPDATE TAGS
CREATE AND UPDATE GAG

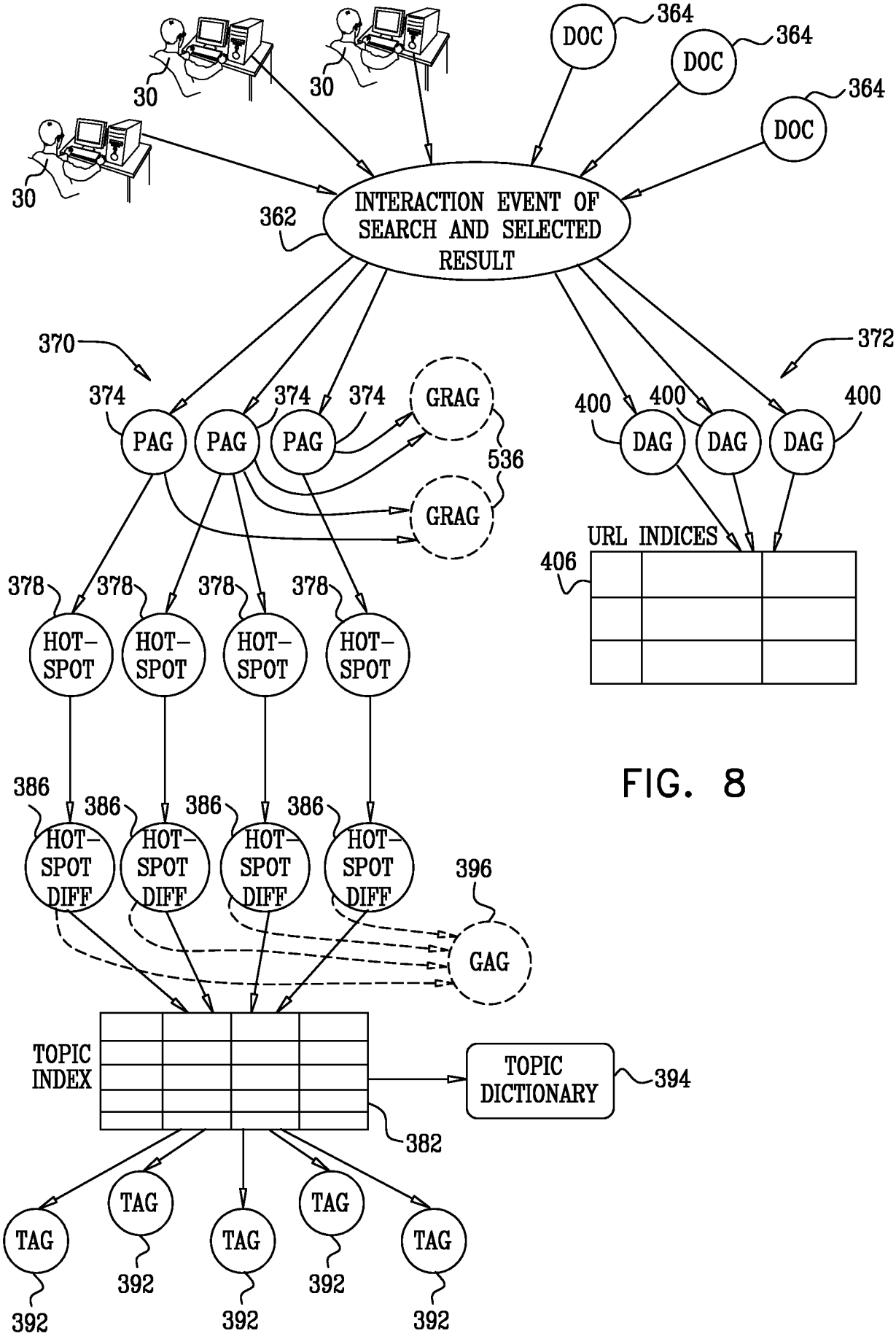

30
30
30
DOC
364
DOC
364
DOC
364
INTERACTION EVENT OF SEARCH AND SELECTED RESULT
362
370
372
374
374
374
PAG
PAG
PAG
GRAG
536
GRAG
400
400
400
DAG
DAG
DAG
URL INDICES
406
378
378
378
378
HOT-SPOT
HOT-SPOT
HOT-SPOT
HOT-SPOT
386
386
386
386
HOT-SPOT DIFF
HOT-SPOT DIFF
HOT-SPOT DIFF
HOT-SPOT DIFF
396
GAG
TOPIC INDEX
TOPIC DICTIONARY
394
382
TAG
TAG
TAG
TAG
TAG
392
392
392
392
392

FIG. 8

FIG. 9

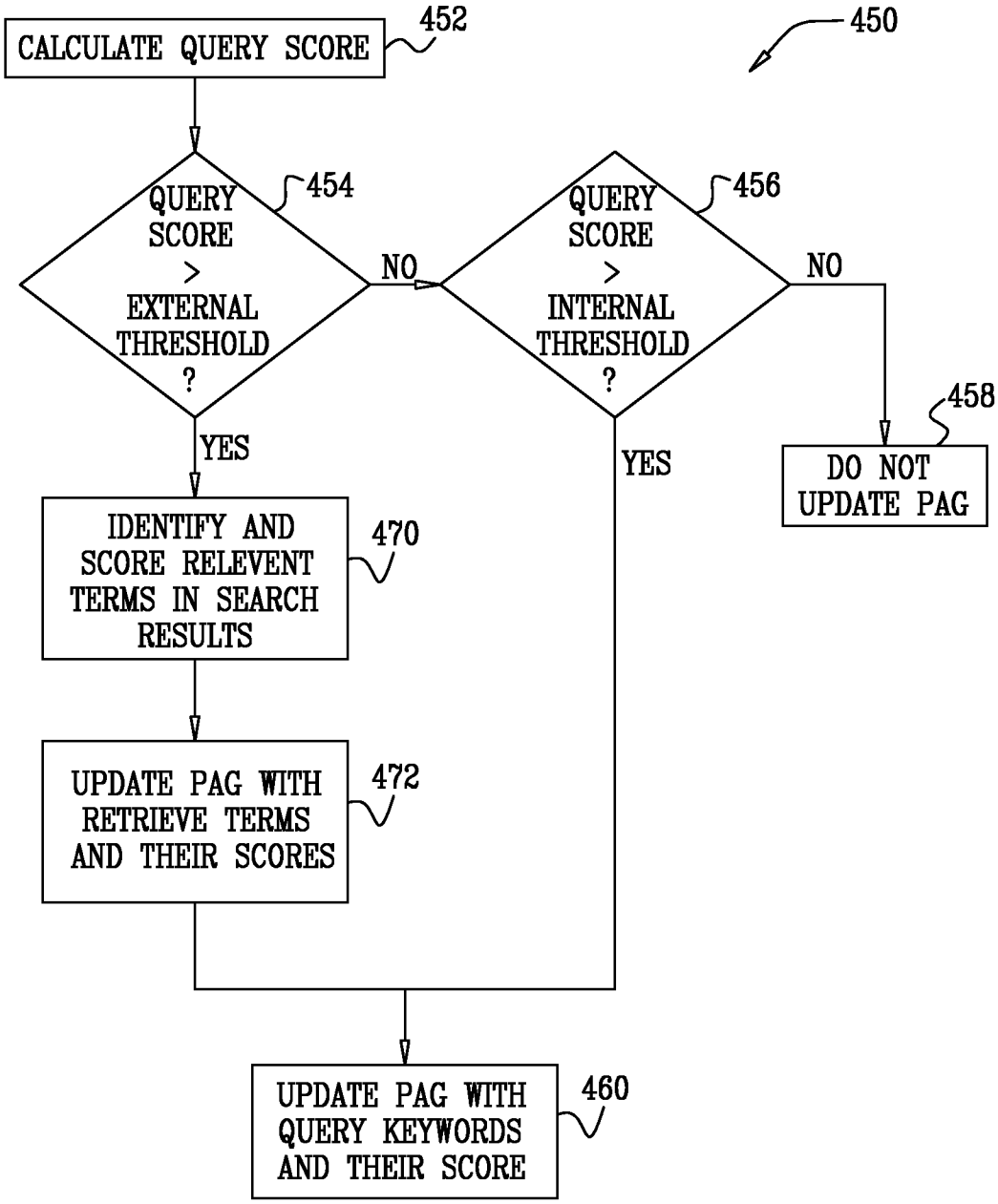

CALCULATE QUERY SCORE
452
450
QUERY SCORE > EXTERNAL THRESHOLD ?
454
NO
QUERY SCORE > INTERNAL THRESHOLD ?
456
NO
458
DO NOT UPDATE PAG
YES
YES
IDENTIFY AND SCORE RELEVENT TERMS IN SEARCH RESULTS
470
UPDATE PAG WITH RETRIEVE TERMS AND THEIR SCORES
472
UPDATE PAG WITH QUERY KEYWORDS AND THEIR SCORE
460

FIG. 10

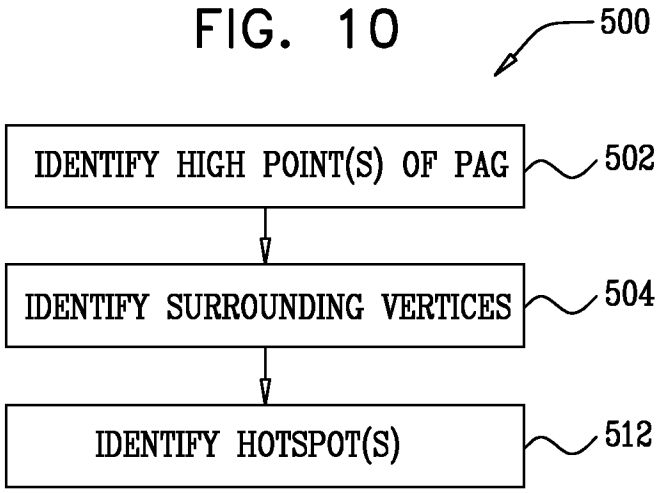

500
IDENTIFY HIGH POINT(S) OF PAG
502
IDENTIFY SURROUNDING VERTICES
504
IDENTIFY HOTSPOT(S)
512

FIG. 11

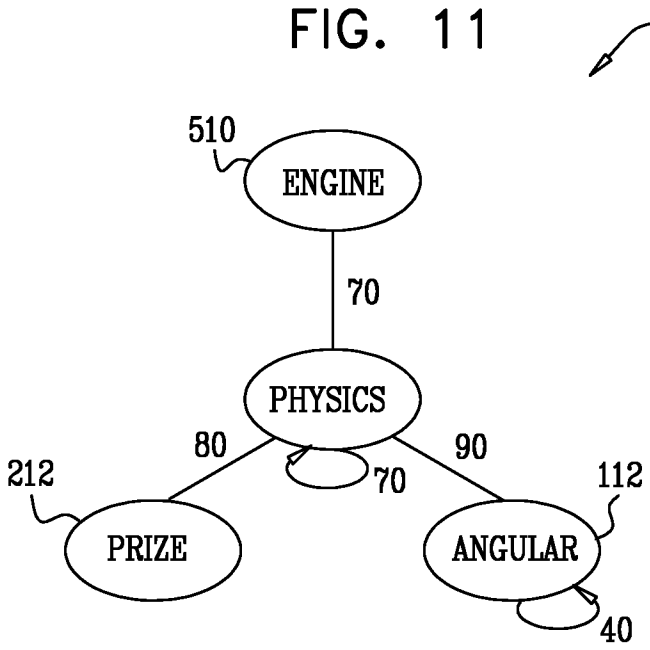

520
510
ENGINE
70
PHYSICS
80
90
212
70
112
PRIZE
ANGULAR
40

FIG. 12A

530

PRIMARY INDEX	SECONDARY INDEX	USER ID	ASSOCIATION SCORE	DEGREE	URL ID(S)
PHYSICS	ENGINE	001	70	1	24,26,123
		002	80	1	25,27,123
		004	100	1	140,190,400
PHYSICS	ANGULAR	003	75	1	140,20,420
		005	80	1	135,500,312
		001	90	1	130,523,300
		002	120	1	24,800,673
PHYSICS	PRIZE	001	80	1	415,715,716
		003	110	1	416,715,843
PHYSICS	RELATIVITY	002	80	1	100,120,905
		005	90	1	111,135,906
		008	110	1	112,176,5
		009	150	1	112,177,920
GEOMETRY	POINTS	010	80	1	43,50,116
		013	90	1	42,50,999
		012	95	1	905,55,124
GEOMETRY	PLANES	014	100	1	110,87,12
		012	105	1	19,104,12
		010	110	1	18,550,113

FIG. 12B

530

PRIMARY INDEX	SECONDARY INDEX	USER ID	ASSOCIATION SCORE	DEGREE	URL ID(S)
PHYSICS+ ENGINE		001	70		
		002	80		
		003	100		

FIG. 13

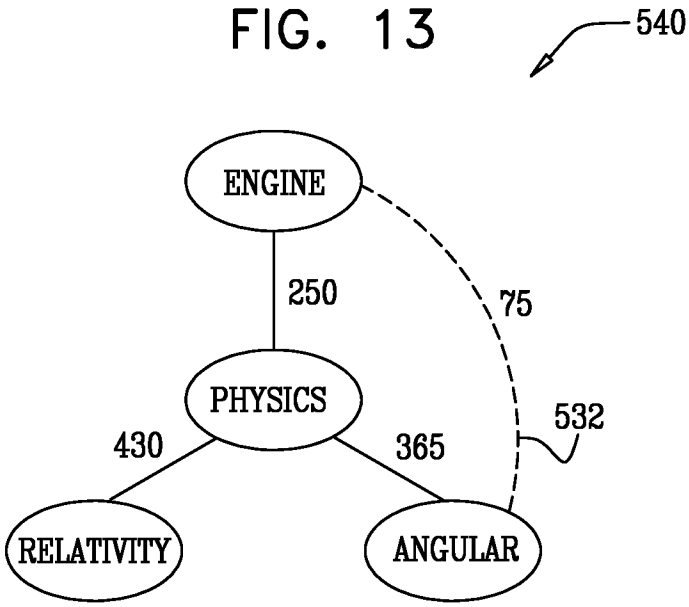

540
ENGINE
250
75
PHYSICS
532
430
365
RELATIVITY
ANGULAR

FIG. 14

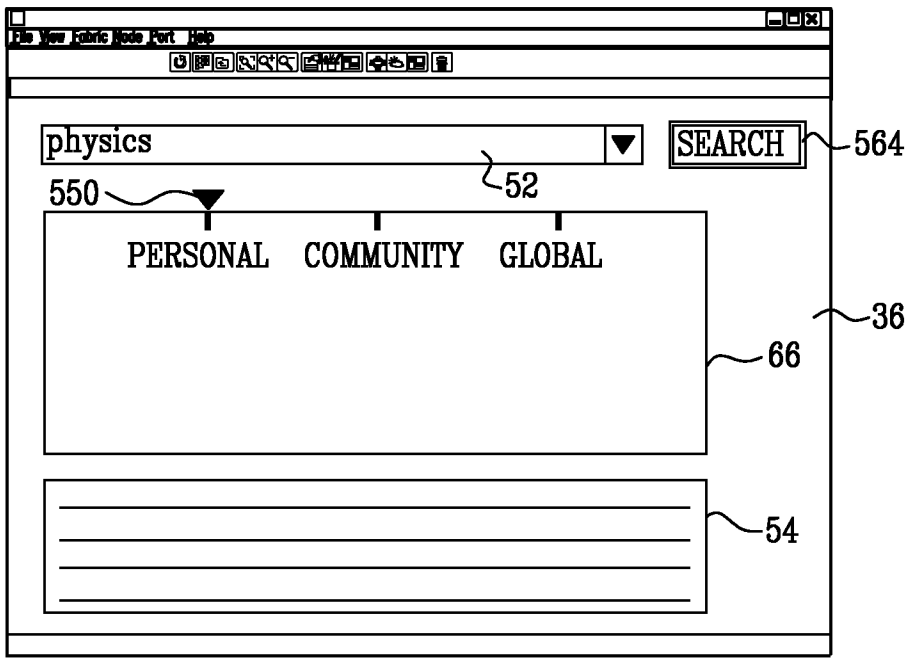

physics
SEARCH
564
52
550
PERSONAL
COMMUNITY
GLOBAL
36
66
54

FIG. 15

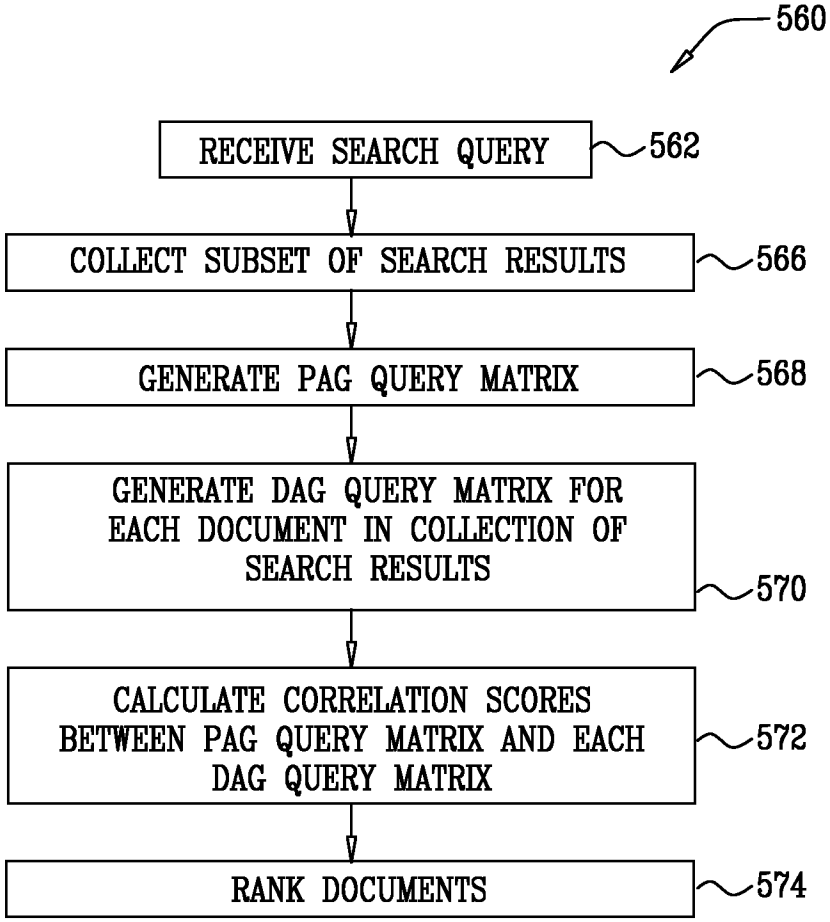

560
RECEIVE SEARCH QUERY
562
COLLECT SUBSET OF SEARCH RESULTS
566
GENERATE PAG QUERY MATRIX
568
GENERATE DAG QUERY MATRIX FOR EACH DOCUMENT IN COLLECTION OF SEARCH RESULTS
570
CALCULATE CORRELATION SCORES BETWEEN PAG QUERY MATRIX AND EACH DAG QUERY MATRIX
572
RANK DOCUMENTS
574

FIG. 16

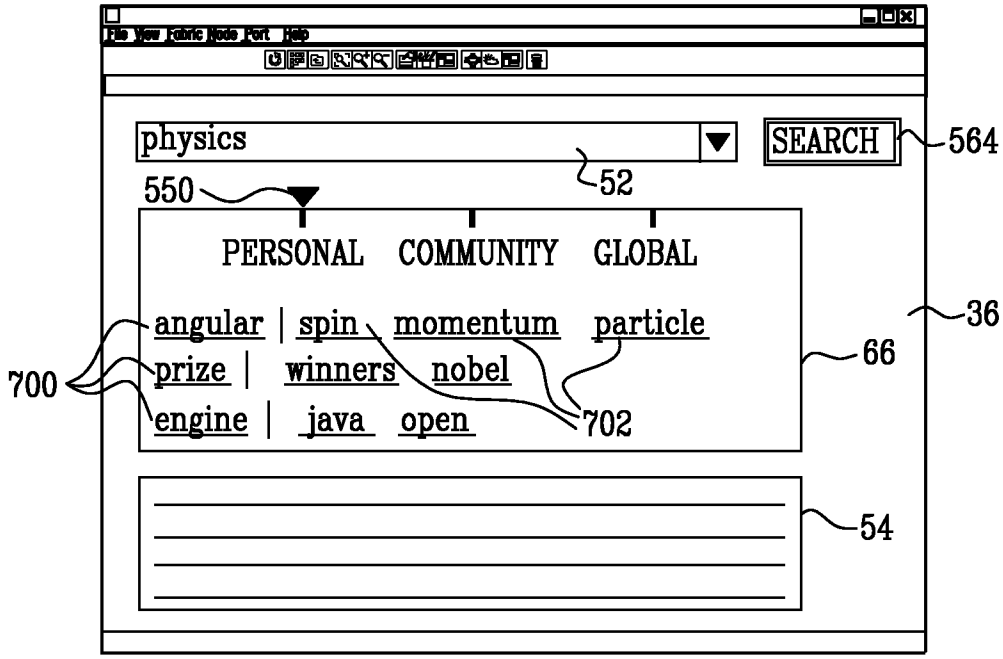

physics
SEARCH
564
52
550
PERSONAL
COMMUNITY
GLOBAL
angular | spin momentum particle
prize | winners nobel
engine | java open
700
702
66
36
54

FIG. 17

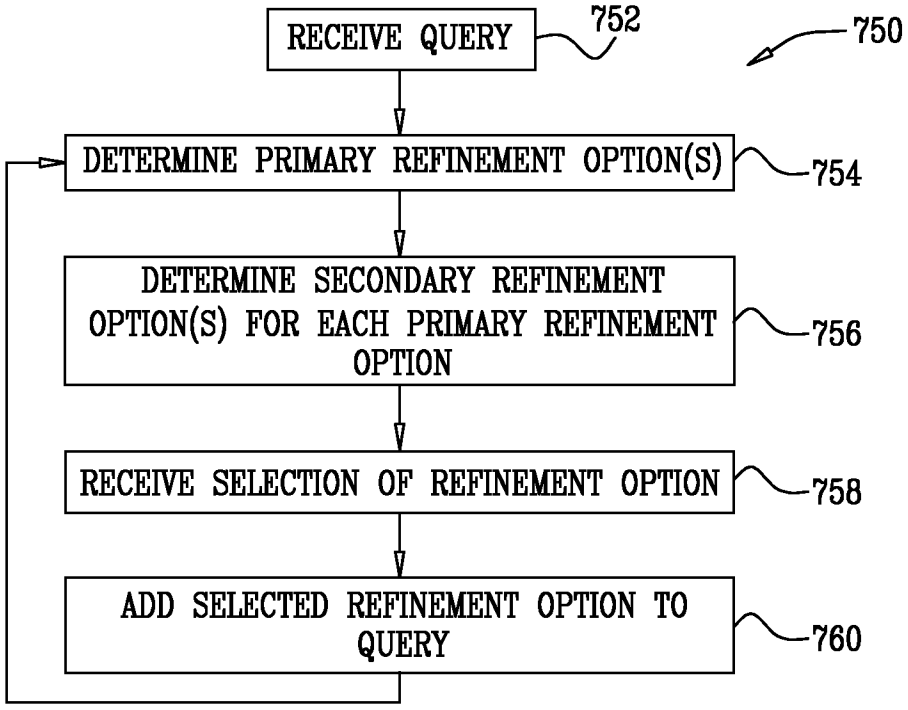

RECEIVE QUERY
752
750
DETERMINE PRIMARY REFINEMENT OPTION(S)
754
DETERMINE SECONDARY REFINEMENT OPTION(S) FOR EACH PRIMARY REFINEMENT OPTION
756
RECEIVE SELECTION OF REFINEMENT OPTION
758
ADD SELECTED REFINEMENT OPTION TO QUERY
760

FIG. 18

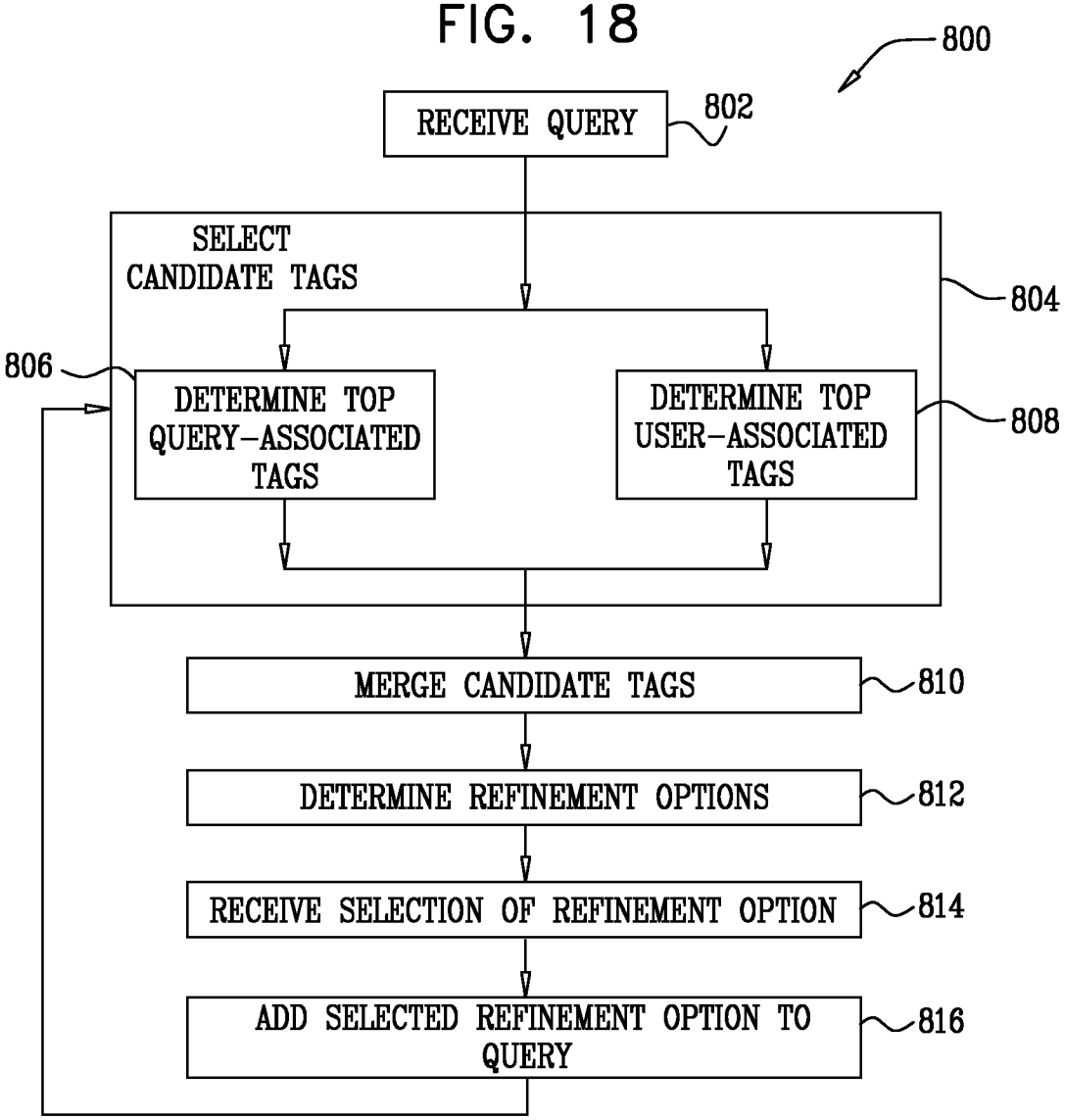

800
RECEIVE QUERY
802
SELECT CANDIDATE TAGS
804
806
DETERMINE TOP QUERY-ASSOCIATED TAGS
DETERMINE TOP USER-ASSOCIATED TAGS
808
MERGE CANDIDATE TAGS
810
DETERMINE REFINEMENT OPTIONS
812
RECEIVE SELECTION OF REFINEMENT OPTION
814
ADD SELECTED REFINEMENT OPTION TO QUERY
816

FIG. 19

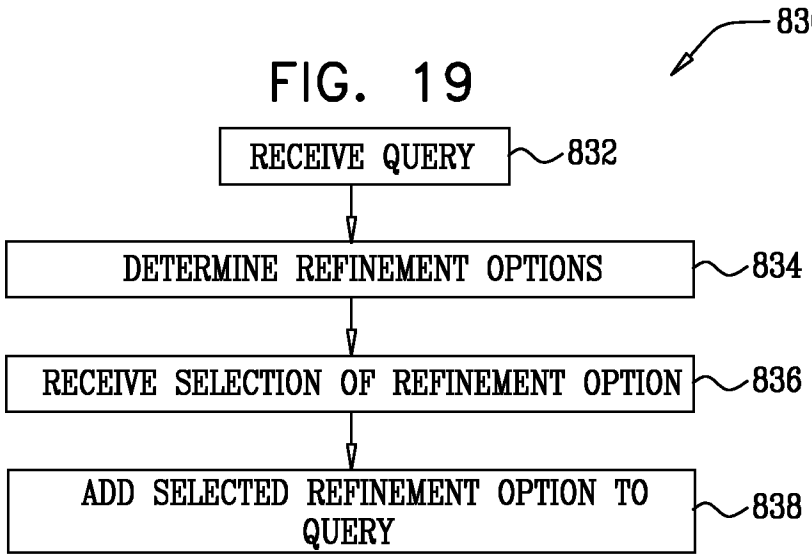
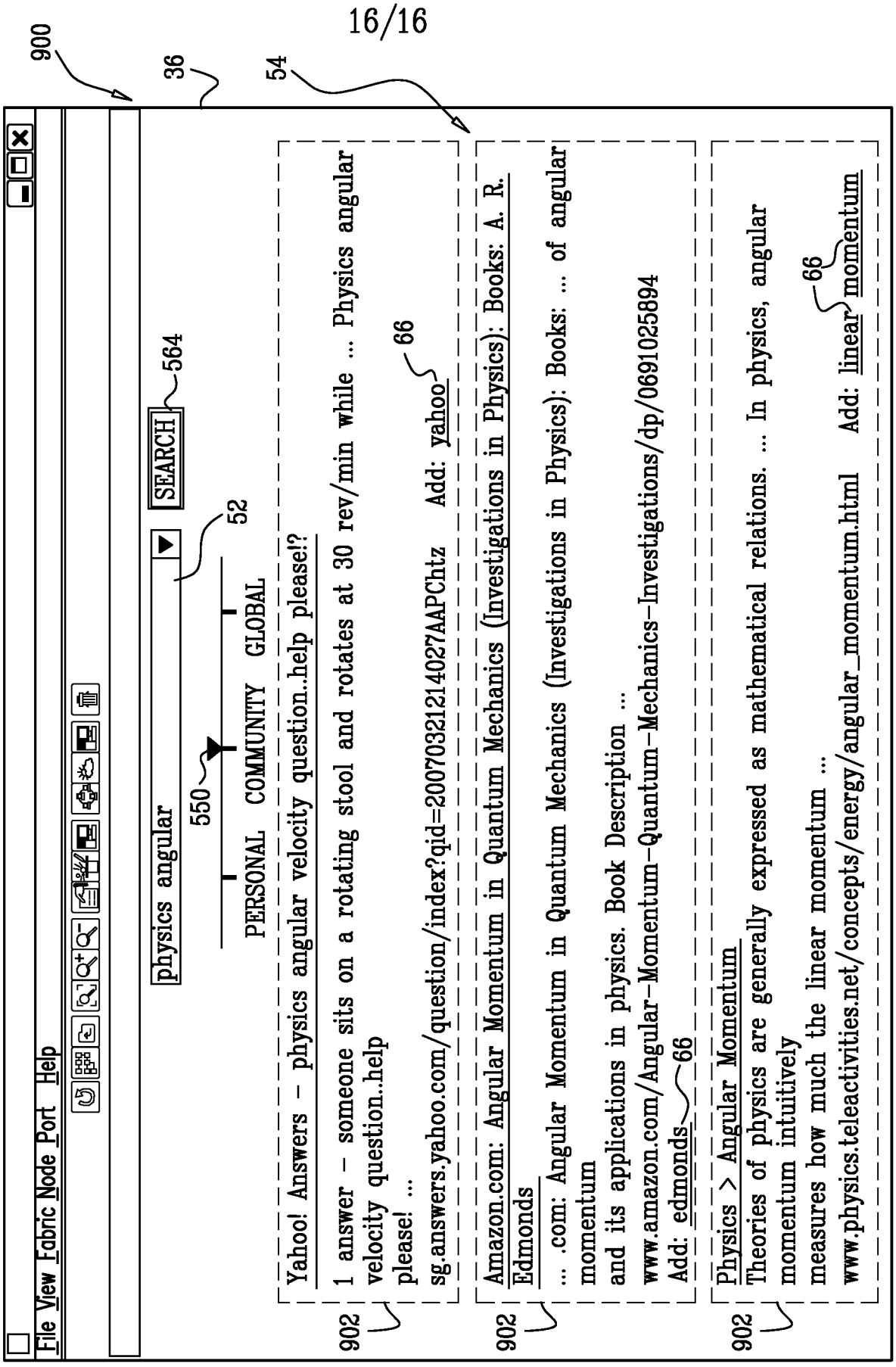

830
RECEIVE QUERY
832
DETERMINE REFINEMENT OPTIONS
834
RECEIVE SELECTION OF REFINEMENT OPTION
836
ADD SELECTED REFINEMENT OPTION TO QUERY
838

FIG. 20


900
36
54
File View Fabric Node Port Help
physics angular
SEARCH
564
550
52
PERSONAL COMMUNITY GLOBAL
902
Yahoo! Answers - physics angular velocity question..help please!?
1 answer - someone sits on a rotating stool and rotates at 30 rev/min while ... Physics angular velocity question..help please! ...
sg.answers.yahoo.com/question/index?qid=20070321214027AAPChtz Add: yahoo
66
902
Amazon.com: Angular Momentum in Quantum Mechanics (Investigations in Physics): Books: A. R. Edmonds
... .com: Angular Momentum in Quantum Mechanics (Investigations in Physics): Books: ... of angular momentum and its applications in physics. Book Description ...
www.amazon.com/Angular-Momentum-Quantum-Mechanics-Investigations/dp/0691025894
Add: edmonds
66
902
Physics > Angular Momentum
Theories of physics are generally expressed as mathematical relations. ... In physics, angular momentum intuitively measures how much the linear momentum ...
www.physics.teleactivities.net/concepts/energy/angular_momentum.html Add: linear momentum
66