US010970293B2

US010970293B2

(12) **United States Patent**
Bendersky et al.

(10) **Patent No.:** **US 10,970,293 B2**
(45) **Date of Patent:** **Apr. 6, 2021**

(54) **RANKING SEARCH RESULT DOCUMENTS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **16/550,918**

(22) Filed: **Aug. 26, 2019**

(65) **Prior Publication Data**

US 2019/0377741 A1 Dec. 12, 2019

Related U.S. Application Data

(63) Continuation of application No. 15/332,839, filed on Oct. 24, 2016, now Pat. No. 10,394,832.

(51) **Int. Cl.**
G06F 16/2457	(2019.01)
G06F 16/248	(2019.01)
G06F 16/25	(2019.01)
G06F 16/335	(2019.01)

(52) **U.S. Cl.**
CPC *G06F 16/24578* (2019.01); *G06F 16/248* (2019.01); *G06F 16/252* (2019.01); *G06F 16/337* (2019.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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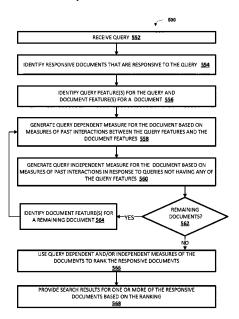
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(57) **ABSTRACT**

Methods and apparatus related to using document feature(s) of a document that is responsive to a query, and optionally query feature(s) of the query, to determine a presentation characteristic for presenting a search result that corresponds to the document. In some implementations, measures associated with the document feature(s) and/or query feature(s) may be used to determine the presentation characteristic. The measures may be based on past interactions, by corresponding users, with other documents that share one or more of the document features with the document, where a plurality of the other documents are different from the document (and optionally each different from one another). In some implementations, the document and/or the other documents include, or are restricted to, documents that are access restricted.

7 Claims, 7 Drawing Sheets

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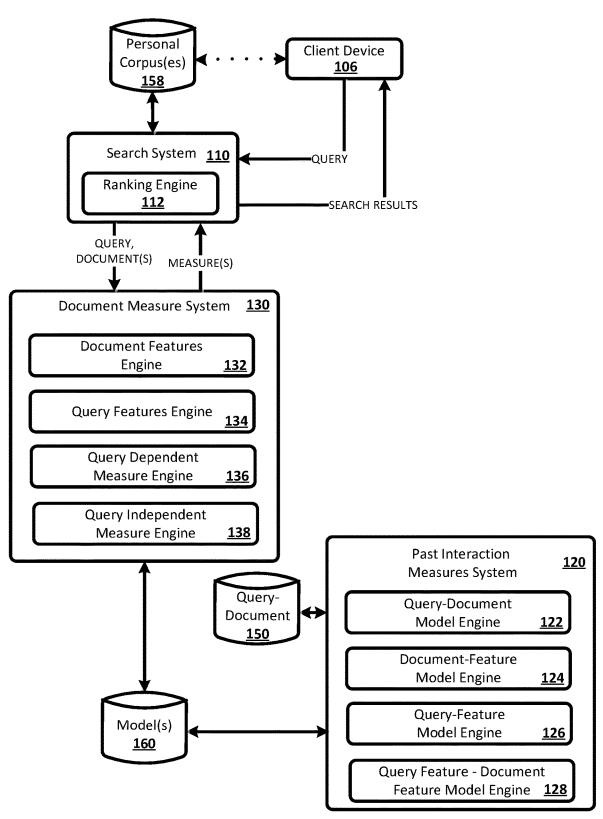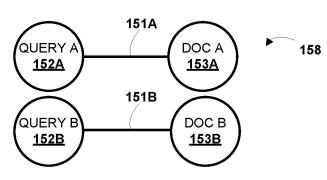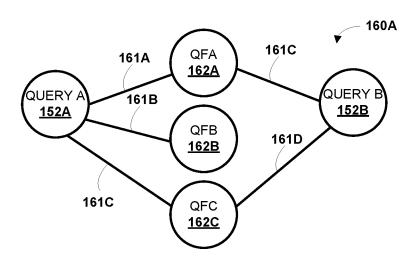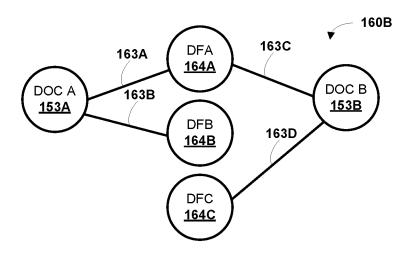
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FIG. 1

FIG. 2A

FIG. 2B

FIG. 2C

160C

QFA
162A

DFA
164A

QFB
162B

DFB
164C

QFC
162C

DFC
164C
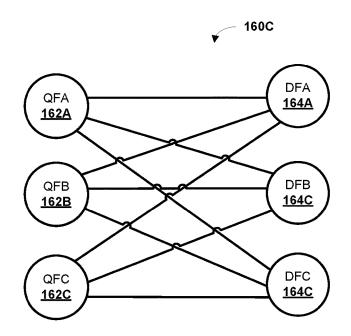
FIG. 2D

FROM: STORE@EXAMPLEURL.COM
TO: USER1
SUBJECT: PURCHASE
CONFIRMATION - 1A2B3C

DEAR USER 1:
YOUR ORDER OF BALD POTTER
(PAPERBACK) HAS BEEN RECEIVED.
IT WILL BE SHIPPED TO:

ADDRESS 1.

353A

FROM: STORE@EXAMPLEURL.COM
TO: USER2
SUBJECT: PURCHASE
CONFIRMATION - 2Z5C21

DEAR USER 2:
YOUR ORDER OF FEAR AND DISLIKE
IN LOS ANGELES (PAPERBACK) HAS
BEEN RECEIVED. IT WILL BE SHIPPED
TO:

ADDRESS 2.

353B

• • •

FROM: STORE@EXAMPLEURL.COM
TO: USER3
SUBJECT: PURCHASE
CONFIRMATION - A15FFX

DEAR USER 3:
YOUR ORDER OF KING OF THE
CIRCLES (HARDBACK) HAS BEEN
RECEIVED. IT WILL BE SHIPPED TO:

ADDRESS 3.

353C

FIG. 3

400

```
┌─────────────────────────────────────────────────────────┐
│          SELECT A PLURALITY OF DOCUMENT FEATURES          │
│                          452                              │
└─────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────┐
│            SELECT A PLURALITY OF QUERY FEATURES           │
│                          454                              │
└─────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────┐
│         SELECT QUERY FEATURE, DOCUMENT FEATURE TUPLE      │
│                          456                              │
└─────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────┐
│  GENERATE PAST INTERACTION MEASURE FOR TUPLE BASED ON A   │
│  QUANTITY OF PAST INTERACTONS WITH DOCUMENTS HAVING       │
│  DOCUMENT FEATURE OF THE TUPLE IN RESPONSE TO QUERIES     │
│  HAVING QUERY FEATURE OF THE TUPLE                        │
│                          458                              │
└─────────────────────────────────────────────────────────┘
                            │
                            ▼
┌─────────────────────────────────────────────────────────┐
│   STORE PAST INTERACTION MEASURE IN ASSOCIATION WITH THE  │
│   TUPLE                                                    │
│                          460                              │
└─────────────────────────────────────────────────────────┘
                            │
                            ▼
              ◇ REMAINING TUPLES? 462 ◇ ──NO──> END 464
```

REMAINING TUPLES? 462

—YES—

END 464

FIG. 4

500

RECEIVE QUERY **552**

IDENTIFY RESPONSIVE DOCUMENTS THAT ARE RESPONSIVE TO THE QUERY **554**

IDENTIFY QUERY FEATURE(S) FOR THE QUERY AND
DOCUMENT FEATURE(S) FOR A DOCUMENT **556**

GENERATE QUERY DEPENDENT MEASURE FOR THE DOCUMENT BASED ON
MEASURES OF PAST INTERACTIONS BETWEEN THE QUERY FEATURES AND THE
DOCUMENT FEATURES **558**

GENERATE QUERY INDEPENDENT MEASURE FOR THE DOCUMENT BASED ON
MEASURES OF PAST INTERACTIONS IN RESPONSE TO QUERIES NOT HAVING ANY OF
THE QUERY FEATURES **560**

IDENTIFY DOCUMENT FEATURE(S) FOR
A REMAINING DOCUMENT **564**

←YES— REMAINING
DOCUMENTS?
562

NO

USE QUERY DEPENDENT AND/OR INDEPENDENT MEASURES OF THE
DOCUMENTS TO RANK THE RESPONSIVE DOCUMENTS
566

PROVIDE SEARCH RESULTS FOR ONE OR MORE OF THE RESPONSIVE
DOCUMENTS BASED ON THE RANKING
568

FIG. 5

FIG. 6

FIG. 7

RANKING SEARCH RESULT DOCUMENTS

BACKGROUND

Search engines provide information about various documents such as web pages, images, text documents, multimedia content, and/or electronic communications. For example, in response to receiving a search query, a search engine identifies one or more documents that are responsive to the query. The search engine ranks the documents based on the relevance of the documents to the query and/or based on other ranking signal(s), and provides corresponding search results in response to the search query. The search results may include aspects of and/or links to the documents and may be provided based on the rankings.

SUMMARY

This specification is directed to technical features related to using document feature(s) of a given document that is responsive to a query, and optionally query feature(s) of the query, to determine a presentation characteristic for presenting a search result that corresponds to the given document—and, in response to the query, providing the search result for presentation with the presentation characteristic. In some implementations, the given document that is responsive to the query may be an access restricted document, such as an access restricted document that is accessible to only a user that submitted the query and optionally to other users designated by that user.

In some implementations, measures associated with the document feature(s) and/or query feature(s) may be used to determine the presentation characteristic. The measures may be based on past interactions, by corresponding users, with other documents that share one or more of the document features with the given document, where a plurality of the other documents are each different from the given document (and optionally each different from one another). Using such measures enables the past interactions with other documents to be leveraged in determining interaction-based relevance of the given document, optionally without reference to any query based past interactions that are specifically directed to the given document. In some implementations, the other documents include, or are restricted to, documents that are themselves access restricted.

In some implementations, in determining a presentation characteristic of a search result that corresponds to a given document that is responsive to a query, a query dependent measure for the given document is generated and used to determine the presentation characteristic. In some of those implementations, the query dependent measure is used to determine a score for the given document and that score is used to rank the given document relative to other responsive documents for the query (e.g., based on their corresponding scores, which may also be based on corresponding query dependent measures). For example, the query dependent measure may be utilized to modify an initial score for the given document (e.g., a score based on a degree of matching between the query and the given document), and the modified score utilized to rank the given document relative to other responsive documents for the query. The ranking may be utilized, for example, to determine which responsive documents are initially utilized in providing corresponding search results for presentation in response to the query and/or to determine a presentation order (or other display prominence) for the search results.

In some implementations, the query dependent measure for a given document that is responsive to a query is determined based on measures of past interactions between query features of the query and document features of the given document. Each of the measures may be based on a quantity of the past interactions, by corresponding users, with other documents having one or more of the document features when the other documents were presented in response to corresponding queries having one or more of the query features. Various past interactions may be utilized to determine the measures such as selections of search results corresponding to the other documents in response to the corresponding queries (e.g., a clicked to observed fraction), document access counts, cursor tracking, and/or touch gestures. In some implementations, the other documents themselves may include, or be restricted to, a plurality of access restricted documents, such as non-accessible documents that are each personal to a corresponding one of the other users and that are not accessible to the user.

In some implementations, a query independent measure for the given document is generated and additionally or alternatively used to determine the presentation characteristic. In some of those implementations, the query independent measure is based on measures of past interactions, by corresponding users, with other documents having one or more of the document features of the given document, when the other documents were presented in response to corresponding queries that include queries that do not include any of the query features. Accordingly, the query independent measure may provide an indication of the overall popularity of documents having the document feature(s), whereas the query dependent measure provides an indication of the popularity of documents having the document feature(s) in response to queries having the query features.

In some implementations, a method is provided that includes receiving a query that is entered by a user via a user interface input device of a computing device of the user. The method further includes identifying responsive documents that are responsive to the query, including an email sent to an email address of the user. The method further includes identifying one or more document features for the email. The document features include at least one email feature that is based on at least one of: From content, based on its presence in a From field of the email, and Subject content, based on its presence in a Subject field of the email. The method further includes identifying one or more query features for the query and generating a query dependent measure for the email based on measures of past interactions between the query features and the document features, where each of a plurality of the measures is based on a quantity of the past interactions, by corresponding users, with other documents having one or more of the document features when the other documents were presented in response to corresponding queries having one or more of the query features. The method further includes: using the query dependent measure for the email to determine a presentation characteristic for presenting an email search result that corresponds to the email; and providing, in response to the query, the email search result for presentation with the presentation characteristic.

This method and other implementations of technology disclosed herein may each optionally include one or more of the following features.

In some implementations, the at least one email feature is based on both the From content in the From field and the Subject content in the Subject field. In some of those implementations, the at least one email feature is co-occur-

rence of the From content in the From field and the Subject content in the Subject field. The From content may include a domain name of a sender email address of the email and/or the Subject content may include a template that includes one or more terms and one or more placeholders.

In some implementations, the at least one email feature is based on the Subject content in the Subject field and the Subject content includes a template that includes one or more terms and one or more placeholders.

In some implementations, the other documents on which the measures are based exclude the email.

In some implementations, the method further includes: generating a query independent measure for the email based on additional measures of additional past interactions with the document features in response to additional queries not having any of the query features; and further using the query independent measure for the email to determine the presentation characteristic for presenting the email search result that corresponds to the email.

In some implementations, using the query dependent measure for the email to determine the presentation characteristic comprises: determining a score for the email based on the query dependent measure; determining additional scores for other of the responsive documents; ranking the email relative to the other of the responsive documents based on the score and the additional scores; and determining the presentation characteristic based on the ranking.

In some implementations, the document features further include a category of the email. In some of those implementations, the method further includes using a machine learning model to determine the category of the email.

In some implementations, the past interactions with other documents having one or more of the document features includes selections of the other documents.

In some implementations, a method is provided that includes receiving a query entered by a user via a user interface input device of a computing device of the user, and identifying responsive documents that are responsive to the query. The responsive documents include access restricted documents of the user. The access restricted documents are user accessible to only the user and any restricted group of other users designated by the user. The method further includes identifying one or more query features for the query and, for each of a plurality of the access restricted documents: identifying one or more document features for the access restricted document; and generating a query dependent measure for the access restricted document based on measures of past interactions between the query features and the document features, where each of the measures is based on a quantity of the past interactions, by corresponding users, with other documents having one or more of the document features when the other documents were presented in response to corresponding queries having one or more of the query features, and where the other documents may optionally include a plurality of non-accessible documents that are not accessible to the user. The method further includes using the query dependent measures for the access restricted documents to determine a presentation order for the responsive documents and providing, in response to the query, one or more of the responsive documents for presentation based on the presentation order.

This method and other implementations of technology disclosed herein may each optionally include one or more of the following features.

In some implementations, the document features for the access restricted document comprise a template that is included in a particular field of the access restricted document.

In some implementations, the other documents exclude one or more of the access restricted documents.

In some implementations, the other documents on which a given measure of the measures is based consists of non-accessible documents that are not accessible to the user.

In some implementations, the method further includes: for each of the access restricted documents, generating a query independent measure for the access restricted document based on additional measures of additional past interactions with the document features in response to additional queries not having any of the query features; and further using the query independent measures for the access restricted documents to determine the presentation order for the responsive documents.

In some implementations, a method is provided that includes receiving a query entered by a user via a user interface input device of a computing device of the user, identifying responsive documents that are responsive to the query, and identifying one or more query features for the query. The method further includes, for each of a plurality of the documents: identifying one or more document features for the document and generating a query dependent measure for the document based on measures of past interactions between the query features and the document features, where each of the measures is based on a quantity of the past interactions, by corresponding users, with other documents having one or more of the document features when the other documents were presented in response to corresponding queries having one or more of the query features, and where the other documents include a plurality of documents that are in addition to the document. The method further includes using the query dependent measures for the documents to determine a presentation order for the responsive documents and providing, in response to the query, one or more of the responsive documents for presentation based on the presentation order.

In some implementations, a method is provided that includes: selecting a plurality of document features and selecting a plurality of query features. Selecting each of the document features includes selecting the document feature based on its occurrence in access restricted documents of at least a threshold quantity of users. Selecting each of the query features includes selecting the query feature based on its occurrence in access restricted queries of at least a threshold quantity of users. The access restricted queries are those for which at least one of the access restricted documents was provided in response. The method further includes, for each of a plurality of query feature, document feature tuples that each include at least one of the query features and at least one of the document features: generating a past interaction measure between the query features and the document features of the query feature, document feature tuple. Generating the past interaction measure is based on a quantity of past interactions with corresponding documents of the access restricted documents when the corresponding documents were presented in response to corresponding queries of the access restricted queries, where the corresponding documents have the document features of the query feature, document feature tuple, and where the corresponding queries have the query feature of the query feature, document feature tuple. The method further includes storing, in one or more computer readable media, each of the

past interaction measures in association with a corresponding query feature, document feature tuple.

This method and other implementations of technology disclosed herein may each optionally include one or more of the following features.

In some implementations, the method further includes: identifying a new document that is responsive to a new query of a given user and that includes a new query group of the document features; and generating a measure for the new document based on a group of the past interaction measures. The group of the past interaction measures may be selected based on the past interaction measures of the group being stored in association with query feature, document feature tuples that each include at least one of the document features of the new query group. The method further includes providing the new document in response to the new query based on the measure. In some of those implementations, the group of the past interaction measures is further selected based on the past interaction measures of the group being stored in association with query feature, document feature tuples that each include at least one query feature of the new query. In some implementations, the new document is omitted from the access restricted documents used in generating the past interaction measures.

In some implementations, a method is provided that includes selecting a plurality of document features and selecting a plurality of query features. The method further includes, for each of a plurality of query feature, document feature tuples that each include at least one of the query features and at least one of the document features: generating a past interaction measure between the query features and the document features of the query feature, document feature tuple, where: generating the past interaction measure is based on a quantity of past interactions with corresponding documents when the corresponding documents were presented in response to corresponding queries; the corresponding documents have the document features of the query feature, document feature tuple; and the corresponding queries have the query feature of the query feature, document feature tuple. The method further includes storing, in one or more computer readable media, each of the past interaction measures in association with a corresponding query feature, document feature tuple.

Other implementations may include one or more non-transitory computer readable storage media storing instructions executable by one or more processors to perform a method such as one or more of the methods described herein. Yet another implementation may include a system including memory and one or more processors operable to execute instructions, stored in the memory, to perform a method such as one or more of the methods described herein.

It should be appreciated that all combinations of the foregoing concepts and additional concepts described in greater detail herein are contemplated as being part of the subject matter disclosed herein. For example, all combinations of claimed subject matter appearing at the end of this disclosure are contemplated as being part of the subject matter disclosed herein.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an example environment in which some implementations disclosed herein may be implemented.

FIG. 2A illustrates a representation of a portion of a query-document model according to various implementations.

FIG. 2B illustrates a representation of a portion of a query-feature model according to various implementations.

FIG. 2C illustrates a representation of a portion of a document-feature model according to various implementations.

FIG. 2D illustrates a representation of a portion of a query feature—document feature model according to various implementations.

FIG. 3 illustrates an example of multiple access restricted documents of multiple users.

FIG. 4 is a flow chart illustrating an example method of generating past interaction measures for each of a plurality of query feature, document feature tuples.

FIG. 5 is a flow chart illustrating an example method of using query dependent and/or independent measures of documents that are responsive to a query to rank the documents, and providing corresponding search results based on the ranking.

FIG. 6 illustrates an example client computing device with a display screen displaying access restricted search results with presentation characteristics determined according to implementations disclosed herein.

FIG. 7 illustrates an example architecture of a computing device.

DETAILED DESCRIPTION

Some implementations disclosed herein may be applicable to access restricted documents. As used herein, an "access restricted document" is contrasted with a publicly accessible document (e.g., freely accessible to the public via the World Wide Web) and is an electronic document that is accessible to a restricted group of users. In some implementations, access to an access restricted document may be restricted to the restricted group of users based on login credentials of the restricted group of users, based on the access restricted document being accessible via a private network that is accessible to only the restricted group of users, and/or based on other techniques. As used herein, an "access restricted document of a user" is an access restricted document that is accessible to only the user and optionally to a restricted group of one or more other users that can be designated or otherwise controlled by the user. For example, an access restricted document of a user may be accessible to only the user as a function of: being stored locally on a computing device controlled by the user, being accessible via one or more computer applications via appropriate login credentials of the user, etc. For instance, emails of the user may be access restricted documents of the user that are accessible to only the user via appropriate login credentials of the user. Also, for instance, heterogeneous documents of a user stored in a cloud-based storage system may be access restricted documents of the user that are accessible to only the user via appropriate login credentials of the user. Optionally, one or more of the heterogeneous documents may also be accessible to a restricted group of other users based on an explicit authorization by the user via one or more computer applications. Also, for instance, various documents stored locally on a mobile phone, tablet, desktop, and/or other computing device(s) of a user may be access restricted documents of the user as a result of being stored locally on the computing device(s) of the user.

User interaction data (e.g., click-through rate) has been used to rank particular publicly accessible search result

documents for particular queries. For example, user interaction data may indicate that for a particular search query, a particular publicly accessible search result document that is responsive to the particular search query has a click-through rate, for that particular search query, that far exceeds that of any other publicly accessible search result documents that are responsive to the particular search query. Based on such an indication, a search result corresponding to the particular publicly accessible search result document may be ranked more prominently (e.g., provided for presentation more prominently), for the particular search query, than search results for the other responsive publicly accessible search result documents.

However, various techniques related to using user interaction data to rank publicly accessible search results for particular queries may not be applicable to various documents and/or may not provide desired performance. For example, various techniques may not be applicable to various access restricted documents (e.g., access restricted documents of a user submitting a query) and/or to various publicly accessible documents (e.g., publicly accessible documents that have no and/or relatively few interactions in response to queries).

As one example, assume a user submits a search query to search the user's personal email and that a plurality of responsive emails (that are access restricted documents of the user) are identified as responsive to the search query (e.g., the emails include one or more terms that match one or more terms of the search query). It may be the case that one or more (e.g., all) of the responsive emails may have never been presented and/or interacted with in response to prior searches of other users and/or of the user. For example, a particular email may be an email that was sent only to the user and with which the user has never previously interacted in response to a prior search query. Accordingly, there may not be any user interaction data associated with the particular email, rendering various techniques, related to using user interaction data to rank publicly accessible search results, ineffective to ranking the particular email.

As another example, assume a user submits a search query to search a corpus of access restricted documents that are accessible to a restricted group of users, and that a plurality of responsive documents are identified as responsive to the search query. It may be the case that one or more (e.g., all) of the responsive documents may have never been presented and/or interacted with in response to prior submissions of the search query and/or may have been presented and/or interacted with only a de minimis amount in response to prior submissions of the search query. Accordingly, there may not be sufficient user interaction data associated with such documents in response to the search query, rendering various techniques, related to using user interaction data to rank publicly accessible search results, ineffective to ranking such documents.

As yet another example, assume a user submits a search query to search a corpus of publicly accessible documents, and that a plurality of responsive documents are identified as responsive to the search query. It may be the case that one or more (e.g., all) of the responsive documents may have never been presented and/or interacted with in response to prior submissions of the search query and/or may have been presented and/or interacted with only a de minimis amount in response to prior submissions of the search query. Accordingly, there may not be sufficient user interaction data associated with such documents in response to the search query, rendering various techniques, related to using user

interaction data to rank publicly accessible search results, ineffective to ranking such documents.

This specification presents various technical features related to using document feature(s) of a document that is responsive to a query, and optionally query feature(s) of the query, to determine a presentation characteristic for presenting a search result that corresponds to the document—and, in response to the query, providing the search result for presentation with the presentation characteristic. Measures associated with the document feature(s) and/or query feature(s) may be used to determine the presentation characteristic. The measures may be based on past interactions, by corresponding users, with other documents that share one or more of the document features with the document, where a plurality of the other documents are each different from the document (and optionally each different from one another). Using such measures enables the past interactions to be leveraged in determining interaction-based relevance of the access restricted document, optionally without reference to any past interactions that are specifically directed to the access restricted document. In some implementations, the other documents include, or are restricted to, documents that are themselves access restricted.

In some implementations, in determining a presentation characteristic of a search result that corresponds to a document that is responsive to a query, a query dependent measure for the access restricted document is generated and used to determine the presentation characteristic. In some of those implementations, the query dependent measure is based on measures of past interactions between query features of the query and document features of the document. Each of the measures may be based on a quantity of the past interactions, by corresponding users, with other documents having one or more of the document features when the other documents were presented in response to corresponding queries having one or more of the query features.

As one example, assume a user utilizes an email search interface to submit a query of "book order number". A corpus of the user's emails that are each access restricted documents of the user may be searched and a plurality of responsive emails identified as responsive to the query. A particular responsive email may be from "store@exampleurl.com", may include a subject of "Confirmation of Order 1A2B3C", and may include a body with content that identifies a particular book purchased by the user, along with details of the purchase (e.g., date of purchase, shipping address, delivery date, cost). The particular responsive email may have never been interacted with by other users in response to queries of the other users (i.e., since it is personal to the user and not accessible to the other users)—and may have potentially never even been interacted with by the user in response to a query of the user. However, techniques described herein may still be utilized to determine a query dependent measure for the particular email based on measures of past interactions between query features of the query "book order number" and document features of the particular email.

For example, a first measure of past interactions may be determined based on a quantity of interactions of multiple users with other emails that include "store@exampleurl.com" in a From field and "Confirmation of Order [#]" (where [#] is a placeholder indicating an alpha and/or numeric string) in a Subject field, when those other emails were presented in response to corresponding queries having n-grams of "book order". Also, for example, a second measure of interactions may be determined based on a quantity of interactions of multiple users with other emails

that include "store@exampleurl.com" in a From field and "Confirmation of Order [#]" in a Subject field, when those other emails were presented in response to corresponding queries having n-grams of "order number". The query dependent measure may be generated based on the first measure, the second measure, and optionally other similarly determined measures. For example, the query dependent measure may be a sum, average, median, or other statistical combination of the measures.

The query dependent measure may be used to determine a presentation characteristic for the particular responsive email. For example, the query dependent measure may be utilized to modify an initial score for the particular responsive email (e.g., a score based on a degree of matching between the query and the particular email), and the score utilized to rank the particular email relative to other responsive emails (e.g., based on optionally modified initial scores for those emails). The ranking may be utilized, for example, to determine which responsive emails are initially utilized in providing corresponding search results for presentation in response to the query, to determine a presentation order (or other display prominence) for the search results, and/or to determine additional or alternative presentation characteristics for search results.

In some implementations, a query independent measure for the document is generated and additionally or alternatively used to determine the presentation characteristic. In some of those implementations, the query independent measure is based on measures of past interactions, by corresponding users, with other documents having one or more of the document features of the document when the other documents were presented in response to corresponding queries, where those queries include, or are restricted to, those that do not include any of the query features. Accordingly, the query independent measure may provide an indication of the overall popularity of documents having the document feature(s), whereas the query dependent measure provides an indication of the popularity of documents having the document feature(s) in response to queries having the query features.

In some implementations, a query dependent measure and/or a query independent measure of a document may be generated based on a query feature—document feature model. The query feature—document feature model may be generated based on a query-document model, a document-feature model, and/or a query-feature model.

The query-document model may be, for example, a bipartite graph that models the interactions between queries and documents, as indicated by one or more stored records of past queries and corresponding interactions. For example, the nodes of the query-document graph may indicate queries and documents. The edges may be between query and document nodes and may each represent, for example, whether the corresponding document was observed for the corresponding query (e.g., a corresponding search result presented in response to the corresponding query) and/or whether the document was interacted with (e.g., selection of a corresponding search result) for the corresponding query.

The document-feature model may be, for example, a bipartite graph that models the relationship between documents and their document features. Various features may be utilized, such as category features, structural features, and/or n-gram features. For example, category features of a document may indicate one or more categories to which the document belongs and may be based on, for example, applying features of the document to a classifier or other machine learning model and determining the category fea-

tures based on output generated over the machine learning model. As one example of categories, emails may belong to finance, travel, order confirmation, and/or other categories. Structural features may indicate templates and/or other contents of particular structural fields of documents. For example, for emails or other electronic communications, structural features may include: From content included in a From field of the electronic communication (e.g., a domain name of a sender's email address, a relationship of the sender to the user), Subject content included in a Subject field of the electronic communication (e.g., a particular template to which the Subject field conforms such as "Confirmation of Order [#]"), and/or a co-occurrence of particular From content and particular Subject content (i.e., the From Content and the Subject Content both occurring in their respective fields). Also, for example, structural features of an access restricted document may include a file type feature that is based on, for example, a file extension of the access restricted document. Other structural features may include content, such as template(s) and/or n-grams that appear in one or more particular additional and/or alternative fields of a document, such is in a title field of a document; in a title, location, and/or notes field of a calendar entry document; etc.

The query-feature model may be, for example, a bipartite graph that models the relationship between queries and their query features. The query features of a query may include, for example, one or more n-grams appearing in the query (e.g., the longest n-gram appearing in the query), one or more entities referenced in the query (e.g., a particular person, place, and/or thing), one or more entity categories referenced in the query (e.g., city, person's name, location, restaurant), grammatical features of the query, etc.

The query feature—document feature model may be, for example, a bipartite graph that is generated using the query-document graph, the document-feature graph, and the query-feature graph. The query feature—document feature model models the interactions between document features and query features. In other words, it models interactions between document and query features, instead of interactions directly between queries and documents. In some implementations, it is generated based on transforming the query-document model to the "document features" and "query features" space collectively modeled by the document-feature and query-feature models.

In many implementations, only features (query or document) that are present in at least a threshold number of times (in queries or documents) and/or for at least a threshold number of users may be utilized in generating the query-feature, document-feature, and/or the query feature—document feature graphs. In some of those implementations, this may ensure features do not include sensitive information by ensuring those features occur at least a threshold number of times and/or for at least a threshold number of users.

The query feature—document feature model may be utilized to determine, for a given document, a query independent measure and/or query dependent measure for the given document. For example, to determine a query dependent measure for a given query having given query feature(s), edges between the given query feature(s) and document features of the given document may be determined. Each of the edges provides a measure of past interactions between a corresponding query feature and a corresponding document feature. The measures may be combined (e.g., summed and/or other statistical combination) to determine the query dependent measure. Also, for example, to determine a query independent measure for the

given document, edges between all query features and document features of the document may be determined. The measures may be combined (e.g., summed and/or other statistical combination) to determine the query independent measure.

Referring now to FIG. 1, an example environment in which techniques disclosed herein may be implemented is illustrated. The example environment includes a client device 106, a search system 110, a past interaction measures system 120, and a document measure system 130. The example environment further includes personal corpus(es) 158 of a user of the client device 106. The personal corpus(es) 158 may each be stored on one or more corresponding non-transitory computer readable media, which may be on the client device 106 and/or remote from the client device 106 (e.g., on one or more remote servers). The personal corpus(es) 158 may each store one or more access restricted documents of the user such as electronic communications of the user (e.g., emails, SMS messages, chat messages, social networking messages), media files (e.g., audio files, image files, video files), word processing documents, calendar entries, contact entries, etc.

The example environment further includes a query-document model 150 that may be stored on one or more non-transitory computer readable media. The query-document model 150 may be, for example, a bipartite graph that models the interactions between queries and documents (including, or restricted to, access restricted documents), as indicated by one or more stored records of past queries and corresponding interactions. For example, the query-document model 150 may be generated based on records of past queries and corresponding interactions provided by the search system 110 and/or other search systems based on interactions with the search system(s) by multiple users via multiple corresponding client devices. The example environment further includes one or more additional models 160 that may be generated by the past interaction measures system 120 and utilized by the document measure system 130. For example, the one or more additional models 160 may include at least a query feature—document feature model.

A user of the client device 106 can submit queries to the search system 110 via one or more user interface input devices of the client device 106. For example, the user may speak the query using a microphone of the client device 106, type the query using a hardware and/or virtual keyboard of the client device 106, etc. In response to a query from the client device 106, the search system 110 searches the personal corpus(es) 158 to identify access restricted document(s) of the user (if any) that are responsive to the search query using, for example, conventional and/or other information retrieval techniques. In some implementations, the personal corpus(es) 158 may include an index that indexes documents thereof based on one or more features, and the search system 110 identifies responsive documents using the index. In some implementations, the search system 110 additionally or alternatively searches corpus(es) that include, or are restricted to, access restricted document(s) that are not access restricted documents of the user and/or publicly accessible document(s).

The search system 110 includes a ranking engine 112 that calculates scores for the documents identified as responsive to a search query, for example, using one or more ranking signals. Each ranking signal provides information about the document itself and/or the relationship between the document and the search query.

In many implementations, the ranking signals on which the ranking engine 112 calculates scores for a given document include a query dependent measure and/or a query independent measure generated by the document measure system 130 according to implementations described herein. In some implementations, the ranking engine 112 may utilize additional ranking signals, such as ranking signals that indicate a degree of matching between the given document and the search query. For example, the ranking signals for a document may be based on whether each of one or more query terms appears in the document, where each of one or more query terms appear in the document, the term frequency of each of one or more of the query terms that appear in the document, and/or the document frequency of each of one or more of the query terms that appear in the document.

The ranking engine 112 then ranks the responsive documents using the scores. The search system 110 uses the responsive documents ranked by the ranking engine 112 to generate search results to provide in response to the query. The search results include search results corresponding to the documents responsive to the search query. For example, each of one or more search results can include a title of a respective of the documents, a link to a respective of the documents, and/or a summary of content from a respective of the documents. For example, the summary of content may include a particular "snippet" or section of the document that is responsive to the search query. Also, for example, for a search result associated with an image document, the search result may include a reduced size display of the image document, a title associated with the image document, and/or a link to the image document. Also, for example, for a search results associated with a video document, the search result may include an image from the video, a segment of the video, a title of the video, and/or a link to the video. Other examples of search results include a summary of information responsive to the search query. The summary can be generated from one or more documents responsive to the search query and/or from other sources.

The search results are provided in a form that enables them to be presented to the user via one or more user interface output devices of the client device 106 (e.g., a display and/or a speaker). For example, the search results may be presented by the client device 106 in pop-up window(s) or other interface(s) rendered in an application executing on the client device 106 and/or as one or more search results conveyed to a user via audio. FIG. 6 presents one example of client device 106 displaying search results and is described in additional detail herein. The search results may be presented to the user with one or more presentation characteristics that are based on the ranking of the corresponding search result documents. For example, the most prominently displayed search result may be the highest ranked search result, the next most prominently displayed search result may be the second highest ranked search result, and so forth. Also, for example, only a subset of all of the search results may be initially presented and that subset may be selected based on the ranking.

The client device 106 may be, for example, a desktop computing device, a laptop computing device, a tablet computing device, a mobile phone computing device, a computing device of a vehicle of the user (e.g., an in-vehicle communications system, an in-vehicle entertainment system, an in-vehicle navigation system), or a wearable apparatus of the user that includes a computing device (e.g., a watch of the user having a computing device, glasses of the user having a computing device). Additional and/or alterna-

tive client devices may be provided. The client device **106** typically includes one or more applications to facilitate submission of search queries and the sending and receiving of data over a network.

Although depicted separately in FIG. **1**, in some implementations the search system **110** may be implemented, in whole or in part, by the client device **106**. For example, the personal corpus(es) **158** may include documents stored locally on the client device **106** and the search system **110** may search such locally stored documents. In some implementations, the search system **110** may be implemented, in whole or in part, by one or more remote computing devices and the client device **106** may communicate with the search system **110** through a network such as a local area network (LAN) or wide area network (WAN) (e.g., the Internet). Also, although FIG. **1** depicts the search system **110** interfacing with only client device **106** and only personal corpus(es) **158** that include access restricted documents of a user of the client device **106**, in some implementations the search system **110** may interface with multiple client devices and/or access multiple corpuses, such as personal corpus(es) of multiple users and/or non-personal corpus(es). For example, search system **110** may be an email search system of an email service and may search a personal email corpus of a first user in response to queries of the first user, may search a personal email corpus of a second user in response to queries of the second user, etc.

Also, although only a single search system **110** is illustrated in FIG. **1**, multiple search systems **110** may be provided and each may utilize query dependent and/or query independent measures provided by document measure system **130** (or a separate instance thereof). Also, although the search system **110** is illustrated as in communication with only personal corpus(es) **158**, in some implementations the search system **110** may additionally or alternatively search non-personal corpus(es), such as public corpus(es) and/or non-personal corpus(es) that include access restricted documents. For example, the search system **110** may additionally search public corpus(es) and provide search results that include both public content and access restricted content. Also, although document measure system **130** is illustrated in FIG. **1** as separate from the search system **110**, in some implementations one or more aspects of each may be combined in a single system. For example, in some implementations one or more aspects of the document measure system **130** may be implemented by the ranking engine **112** of the search system **110**.

In some implementations, document measure system **130** may include a document features engine **132**, a query features engine **134**, a query dependent measure engine **136**, and/or a query independent measure engine **138**. In some implementations, all or aspects of engines **132**, **134**, **136**, and/or **138** may be omitted, combined, and/or implemented in a component that is separate from document measure system **130**.

The document measure system **130** receives, from the search system **110**, an indication of a query that has been submitted to the search system **110** and/or an indication of one or more documents that have been identified by the search system **110** as responsive to the query, such as access restricted documents from the personal corpus(es) **158**.

The document features engine **132** identifies, for each of the documents, one or more document features for the document. Various document features may be identified, such as category features, structural features, and/or n-gram features described herein. For example, for an image document that is responsive to a query, document features may

include n-grams or other indications that indicate particular object(s) and/or class(es) of object(s) that are present in the image document (e.g., as determined based on automated image analysis and/or human applied tags). In some implementations, all or aspects of the document features engine **132** may be implemented by the search system **110**.

The query features engine **134** identifies, for the query, one or more query features for the query. Various query features may be identified, such as one or more n-grams appearing in the query, one or more entities referenced in the query, one or more entity categories referenced in the query, grammatical features, etc. In some implementations, all or aspects of the query features engine **134** may be implemented by the search system **110**.

The query dependent measure engine **136** generates a query dependent measure for each of the documents. In determining a query dependent measure for a document, the query dependent measure engine **136** determines past interaction measures that are assigned, in the model **160**, to the query features and document features determined by engines **132** and **134**. For example, assume query features QF**1** and QF**2** for a query (where QF indicates a query feature) and document features DF**1**, DF**2**, and DF**3** for an access restricted document responsive to the query (where DF indicates a document feature). The query dependent measure engine **136** may determine a past interaction measure for each of: QF**1** and DF**1**, QF**1** and DF**2**, QF**1** and DF**3**, QF**2** and DF**1**, QF**2** and DF**2**, and QF**2** and DF**3**. The query dependent measure engine **136** may then generate the query dependent measure for the access restricted document based on a combination of the six separate past interaction measures.

Each of the past interaction measures utilized by the query dependent measure engine **136** may be based on a quantity of the past interactions, by corresponding users, with other documents having one or more of the document features when the other documents were presented in response to corresponding queries having one or more of the query features. The other documents themselves may include, or be restricted to, a plurality of access restricted documents, such as non-accessible documents that are each personal to a corresponding one of the other users and that are not accessible to the user. Additional description of generating past interaction measures is provided herein.

The query independent measure engine **138** generates a query independent measure for each of the documents. In determining a query independent measure for a document, the query independent measure engine **138** determines past interaction measures that are assigned, in the model **160**, to a group of query features and to the document features determined by engine **134**. The group of query features include, or is restricted to, query features that are in addition to those determined by the query features engine **134**. Accordingly, the group of query features is independent from the query for which the document is responsive in the sense that it includes query features that are in addition to query features of the query. As one example, assume document features DF**1**, DF**2**, and DF**3** for an access restricted document (where DF indicates a document feature). The query independent measure engine **138** may determine: all of the past interaction measures between the group of query features and DF**1**, all of the past interaction measures between the group of query features and DF**2**, and all of the past interaction measures between the group of query features and DF**3**. For instance, assume the group of query features includes query features QF**1**-QF**1000**. For DF**1** past interactions measures may be determined for QF**1** and DF**1**,

QF2 and DF1, QF3 and DF1, . . . , and QF1000 and DF1. The query independent measure engine 136 may then generate the query dependent measure based on a combination of the past interaction measures.

The document measure system 130 provides the query dependent measure and/or the query independent measure for each of the documents to the search system 110. The ranking engine 112 may utilize the query dependent measures and/or the query independent measures in ranking the documents and may use the ranking in determining a presentation order and/or other presentation characteristic for search results for the documents. In some implementations, the ranking engine 112 utilizes the query dependent measure and/or the query independent measure to determine a score for the document and uses the score to rank the document. For example, the ranking engine 112 may adjust a base score for the document (e.g., a base score that is based on other ranking signals) in view of the query dependent measure and/or the query independent measure, to create a modified score.

As one example assume a base score of sc_b for a document for a query. This base score can be based on, for example, keyword matching and/or other ranking signal(s). The ranking engine 112 may determine a final score, sc_f based on $f(sc_b, M_d, M_{q,d})$ where M_d represents the query dependent measure for the document and where $M_{q,d}$ represents the query independent measure for the document. $f(\cdot)$ can optionally be a hand-tuned score or a machine learned ranking function. In some implementations, the ranking engine 112 keeps the base score (sc_b) fixed, and trains an adjustment $\delta(M_d, M_{q,d})$ over the base score sc_b. The scoring function $f(\cdot)$ thus becomes: $f(sc_b, M_d, M_{q,d}) = SC_b + \delta(M_d, M_{q,d})$. This adaptive formulation may be beneficial for environments where the base score is already highly optimized, and optionally disjoint with the query independent and/or query dependent measures.

In some implementations, past interaction measures system 120 may include a query-document model engine 122, a document-feature model engine 124, a query-feature model engine 126, and/or a query feature—document feature model engine 128. In some implementations, all or aspects of engines 122, 124, 126, and/or 128 may be omitted, combined, and/or implemented in a component that is separate from past interaction measures system 120.

The query-document model engine 122 generates the query-document model 150. In some implementations, all or aspects of the query-document model engine 122 may be implemented by the search system 110. The query-document model 150 may be, for example, a bipartite graph that models the interactions between queries and documents, as indicated by one or more stored records of past queries and corresponding interactions. For example, the nodes of the query-document graph may indicate queries and documents. The edges may be between query and document nodes and may each represent, for example, whether the corresponding document was observed for the corresponding query (e.g., a corresponding search result presented in response to the corresponding query) and/or whether the document was interacted with (e.g., selection of a corresponding search result) for the corresponding query. In some implementations, each of the edges may include a binary representation of whether an interaction occurred. In some implementations, the edges may be weighted based on a type of the interaction. For example a selection of a search result followed by access of the underlying document for at least a threshold time duration may be weighted more heavily than a selection that is followed by access of the underlying

document that is not for the threshold time duration, which may be weighted more heavily than a "hover" over the search result without a resulting selection.

In some implementations, the query-document model 150 may be represented by a triple $(Q, D, \mathcal{E}^{QD})$, where Q is the set of query nodes representing corresponding queries, D is the set of document nodes representing corresponding documents, and the edge set $\mathcal{E}^{QD}$ represents the edges connecting the query nodes and document nodes. The edges in the edge set $\mathcal{E}^{QD}$ may be parameterized by tuples of the form $e(q, d) = \langle \gamma_o(q, d), \gamma_c(q, d) \rangle$, where q represents a query node connected by the edge, d represents a document node connected by the edge, and parameterization functions γ_o (a, b) and γ_c(a, b) indicate that entities a and b were observed or clicked in the same search session, respectively.

In this specification, the term "graph" will be used broadly to refer to any mapping of a plurality of associated information items. A graph, or a portion of a graph, need not be present in a single storage device and may include pointers or other indications of information items that may be present on other storage devices. For example, a graph may include multiple nodes mapped to one another, with each node including an identifier of an entity or other information item that may be present in another data structure and/or another storage medium.

The document-feature model engine 124 generates a document-feature model that may optionally be included in the model(s) 160. The document-feature model engine 124 may generate the document features based on documents that are included in the query-document model 150. For example, for each of the documents of the query-document model 150, the engine 124 may identify one or more document features and define a relationship between the document and its document features. The document-feature model may be, for example, a bipartite graph that models the relationship between documents and their document features. For example, a first node in the model may represent a document feature and that node may be connected, by corresponding edges, to each of a plurality of document nodes that each represent a corresponding document that include the document feature. The edges may each indicate whether a corresponding feature is present in a corresponding document, and optionally a weight of the corresponding feature for the corresponding document (e.g., for a category feature the weight may indicate how strongly the document is associated with the category). Various features may be utilized, such as category features, structural features, and/or n-gram features.

In some implementations, the document-feature model may be represented by a triple (D, A^D, D), where $\mathcal{E}^D$ is the set of document nodes representing corresponding documents where A^D is the set of document feature nodes representing the set of document features, and the edge set ε^D represents the edges connecting the document nodes and the document feature nodes. The edges in the edge set ε^D may be parameterized by $e(d, a_{ij}^d)$, where $e(d, a_{ij}^d)$ indicates whether a corresponding feature is present in a corresponding document, and optionally a weight of the corresponding feature for the corresponding document.

The query-feature model engine 126 generates a query-feature model that may optionally be included in the model(s) 160. The query-feature model engine 126 may generate the features for queries that are included in query-document model 150. For example, for each of the queries of the query-document model 150, the engine 126 may identify one or more query features and define a

relationship between the query and its query features. The query-feature model may be, for example, a bipartite graph that models the relationship between queries and their query features. For example, a first node in the model may represent a query feature and that node may be connected, by corresponding edges, to each of a plurality of query nodes that each represent a corresponding query that include the query feature. The edges may each indicate whether a corresponding feature is present in a corresponding query, and optionally a weight of the corresponding feature for the corresponding query. Various features may be utilized, such as one or more n-grams appearing in the query, one or more entities referenced in the query, one or more entity categories referenced in the query, grammatical features of the query, etc.

The query-feature model may be represented by a triple $(Q, A^Q, \mathcal{E}^Q)$, where Q is the set of query nodes representing corresponding queries where A^Q is the set of query feature nodes representing the set of query features, and the edge set $\mathcal{E}^Q$ represents the edges connecting the query nodes and the query feature nodes. The edges in the edge set $\mathcal{E}^Q$ may be parameterized by $e(q, a_{kl}{}^q)$, where $e(q, a_{kl}{}^q)$ indicates whether a corresponding query feature is present in a corresponding query, and optionally a weight of the corresponding feature for the corresponding query.

The query feature—document feature model engine **128** generates a query feature—document feature model that may optionally be included in the model(s) **160**. The query feature—document feature model may be, for example, a bipartite graph that is generated using the query-document graph, the document-feature graph, and the query-feature graph. The query feature—document feature model models the interactions between document features and query features. In other words, it models interactions between document and query features, instead of interactions directly between queries and documents. In some implementations, it is generated based on transforming the query-document model to the "document features" and "query features" space collectively modeled by the document-feature and query-feature models.

The query feature-document feature model may be represented by a triple $(A^Q, A^D, \, \varepsilon^A)$, where A^Q is the set of query feature nodes representing the set of query features, A^D is the set of document feature nodes representing the set of document attributes, and the edge set ε^A represent the edges connecting the query feature nodes and the document feature nodes. The edges in the edge set ε^A each have a weight or other measure that is based on the quantity of past interactions between the query feature of the corresponding query feature node and the document feature of the corresponding document feature nodes. The edges in the edge set ε^A may be parameterized by:

$$e\left(a_{kl}^q, a_{ij}^d\right) = \sum_{q:e\left(q, a_{kl}^q\right)=1} \sum_{d:e\left(d, a_{ij}^d\right)=1} e(q, d) = \left\langle \gamma_o\!\left(a_{kl}^q, a_{ij}^d\right), \gamma_c\!\left(a_{kl}^q, a_{ij}^d\right) \right\rangle,$$

where the edge functions e(•) are each defined as set forth above. As appreciated by viewing the parametrization of the edges set forth above, the parameterization models query-document attribute observed and co-click associations via summation over all the queries and documents that can be associated with their respective attributes.

In many implementations, only features (query or document) that are present in at least a threshold number of times (in queries or documents) and/or for at least a threshold

number of users may be utilized in generating the query-feature, document-feature, and/or the query feature—document feature models. In some of those implementations, this may ensure feature nodes do not include sensitive information by ensuring features of those feature nodes occur at least a threshold number of times and/or for at least a threshold number of users. In some of those implementations, this may be achieved by removing, from the document-feature graph, any document feature nodes that do not have at least a threshold number of edges indicating presence in corresponding documents; and/or by removing, from the query-feature model, any query feature nodes that do not have at least a threshold number of edges indicating presence in corresponding queries. Additionally or alternatively, query feature nodes and/or document feature nodes may be removed from the query feature-document feature model utilizing similar techniques.

The query feature—document feature model may be utilized to determine, for a given document, a query independent measure and/or query dependent measure for the given document. For example, to determine a query dependent measure for a given query having given query feature(s), edges between the given query feature(s) and document features of the document may be determined. Each of the edges provides a measure of past interactions between a corresponding query feature and a corresponding document feature. The measures may be combined (e.g., summed and/or other statistical combination) to determine the query dependent measure. Also, for example, to determine a query independent measure for the given document, edges between a group of query features (that includes or is restricted to query features not included in the given query features) and document features of the document may be determined. The measures may be combined (e.g., summed and/or other statistical combination) to determine the query independent measure.

Additional description of various models that may be utilized in various implementations is provided with reference to FIGS. 2A-2D, and FIG. 3.

FIG. 2A illustrates a representation of a portion of the query-document model **158** according to various implementations. The portion includes a query node **152A** connected by an edge **151A** to a document node **153A**. The portion also includes a separate query node **152B** connected by an edge **151B** to another document node **153B**.

Query node **152A** represents a particular query and document node **153A** represents a particular document. For purposes of a working example, it will be assumed that query node **152A** represents a query of "book order number" and document node **153A** represents the email **353A** of FIG. **3**. The edge **151A** represents that a search result for the document corresponding to document node **153A** was interacted with by a user in response to the query corresponding to query node **152A**.

Query node **152B** represents a particular query that is distinct from the particular query represented by query node **152A** and document node **153A** represents a particular document that is distinct from that represented by document node **153A**. For purposes of the working example, it will be assumed that query node **152B** represents a query of "book order" and document node **153B** represents the email **353B** of FIG. **3**. The edge **151B** represents that a search result for the document corresponding to document node **153B** was interacted with by a user in response to the query corresponding to query node **152B**.

It is understood that the query-document model **158** will include a large number of additional query nodes, document

nodes, and edges. For example, additional edges will be provided that connect additional query nodes and additional document nodes. Also, for example, it is possible that additional edges may be connected to one or more of the nodes **152A**, **152B**, **153A**, and **153B**. For instance, the document represented by document node **153A** may have been selected in response to multiple distinct queries. Also, for instance, the query represented by query node **152A** may have been issued by multiple users and used to select multiple distinct documents, such as multiple access restricted documents of those users.

FIG. **2B** illustrates a representation of a portion of a query-feature model **160A** of model(s) **160** according to various implementations. Query node **152A** is connected to query feature nodes **162A-C** by corresponding edges **161A-C**, indicating the query represented by query node **152A** has the query features represented by query feature nodes **162A-C**. Query node **152B** is connected to query feature nodes **162A** and **162C** by corresponding edges **161A** and **161C**, but is not connected to query feature node **162B**. The lack of an edge between query node **152B** and query feature node **162B** indicates the query represented by query node **152B** does not have the query feature represented by query feature node **162B**. In some implementations an edge may still be defined, but may indicate that the feature is not present (e.g., that edge may be a "not present" edge, whereas edges **161C** and **161D** may be "present" edges).

Continuing with the working example, query feature node **162A** may be a query feature of an n-gram "book order", query feature node **162B** may be a query feature of an n-gram "book order number", and query feature node **162C** may be a query feature of an n-gram "order".

It is understood that the query-feature model will include a large number of additional query nodes, query feature nodes, and edges. For example, additional query feature nodes may be connected to each of query nodes **152A** and **152B**. Also, for example, each of query feature nodes **162A-C** may be connected to a plurality of additional query nodes. Also, for example, additional query nodes and additional query feature nodes will be provided with corresponding edges.

FIG. **2C** illustrates a representation of a portion of a document-feature model **160B** of model(s) **160** according to various implementations. Document node **153A** is connected to document feature nodes **164A** and **164B** by corresponding edges **163A** and **163B**, indicating the document represented by document node **153A** has the document features represented by document feature nodes **164A** and **164B**. Document node **153B** is connected to document feature nodes **164A** and **164C** by corresponding edges **163C** and **163D**, indicating the document represented by document node **153B** has the document features represented by document feature nodes **164A** and **164C**. The lack of an edge between document node **153A** and document feature node **164C** indicates the document represented by document node **153A** does not have the document feature represented by document feature node **164C**. Likewise, the lack of an edge between document node **153B** and document feature node **164B** indicates the document represented by document node **153B** does not have the document feature represented by document feature node **164B**. In some implementations, instead of lack of edges, edges may still be defined, but may indicate that the corresponding document feature is not present.

Continuing with the working example, document feature node **164A** may be a structural document feature such as one that indicates particular content in a From field and/or

Sender field that is present in the emails **353A** and **353B**. For example, the document feature node **164A** may indicate co-occurrence of the domain name "@exampleurl.com" in a From field and the template "Purchase Confirmation—[#]" in a Subject field, where [#] is a placeholder indicating an alpha and/or numeric string. As another example, the document feature node **164A** (or an additional document feature nod) may instead indicate co-occurrence of particular content in both a From field and Subject field (e.g., co-occurence of "store@exampleurl.com" in a From field and "Purchase Confirmation" in a Subject field), or that particular content is included in only one of the From field and the Subject field. Document feature node **164A** may indicate an n-gram from the body of the email **353A** such as the made-up book title "Bald Potter". Document feature node **164C** may indicate an n-gram from the body of the email **353A** such as the made-up book title "Fear and Dislike in Los Angeles".

It is understood that the document-feature model will include a large number of additional document nodes, document feature nodes, and edges. For example, additional document feature nodes may be connected to each of document nodes **153A** and **153B**. Also, for example, each of document feature nodes **164A-C** may be connected to a plurality of additional document nodes. Also, for example, additional document nodes and document feature nodes will be provided with corresponding edges.

FIG. **2D** illustrates a representation of a portion of a query feature-document feature model **160C** of model(s) **160** according to various implementations. The query feature nodes **162A-C** are each connected to each of the document feature nodes **164A-C** by corresponding edges. The edges of FIG. **2D** are not labeled for the sake of simplicity. Each of the edges of FIG. **2D** defines a corresponding past interaction measure between a corresponding query feature node and document feature node and may be generated based on the models illustrated in part in FIGS. **2A-2C**.

It is noted that, in generating the past interaction measures defined by the edges of FIG. **2D**, the two query to document interactions represented in FIG. **2A** will have a positive influence on the past interaction measures of all of the edges except the edge between query feature node **162B** and document feature node **164C**. That is because, as indicated by the models of FIGS. **2A-2C**, the interactions represented in FIG. **2A** do not indicate an interaction between query feature node **162B** and document feature node **164C**. In other words, since document feature node **164C** is associated with document node **153B**, but not with document node **153A**—and query feature node **162B** is associated with query node **152A**, but not query node **152B**—the interactions of FIG. **2A** do not map to interactions between the query feature node **162B** and the document feature node **164C**. As with the other models, it is understood that the query feature-document feature model will include a large number of additional query feature nodes, document feature nodes, and edges.

FIG. **4** is a flowchart illustrating an example method **400** of generating past interaction measures for each of a plurality of query feature, document feature tuples. For convenience, the operations of the flow chart are described with reference to a system that performs the operations. This system may include various components of various computer systems, such as one or more components of past interaction measures system **120**. Moreover, while operations of method **400** are shown in a particular order, this is not meant to be limiting. One or more operations may be reordered, omitted or added.

At block **452**, the system selects a plurality of document features. For example, the system may select the document features based on the document features occurring in access restricted documents of at least a threshold quantity of users and/or occurring in at least a threshold quantity of documents. In some implementations, the system selects the document features based on those features being features for documents included in a query-document model as described herein. In some implementations, in selecting the document features the system creates a document-features model as described herein.

At block **454**, the system selects a plurality of query features. For example, the system may select the query features based on the query features occurring in queries, for access restricted documents, of at least a threshold quantity of users and/or occurring in at least a threshold quantity of such queries. In some implementations, the system selects the query features based on those features being features for queries included in a query-document model as described herein. In some implementations, in selecting the query features the system creates a query-features model as described herein.

At block **456**, the system selects a query feature, document feature tuple. For example, the query feature, document feature tuple may be a single query feature and a single document feature. In some implementations, a single query feature and/or a single document feature may itself be a combination of features. For example, the single document feature may be the co-occurrence of: certain first content in a first particular field of a document; and certain second content in a second particular field of the document.

At block **458**, the system generates a past interaction measure for the tuple based on a quantity of past interactions with documents having document feature(s) of the tuple in response to queries having query feature(s) of the tuple. In some implementations, the system may generate the past interaction measure based on transforming a query-document model to a "document features" and "query features" space collectively modeled by document-feature and query-feature models as described herein.

At block **460**, the system stores the past interaction measure in association with the tuple. For example, the system may store the past interaction measure as a value for an edge that connects a query feature node that represents the query feature(s) of the tuple and a document feature node that represents the document feature(s) of the tuple. In some implementations, the past interaction measure may be stored in a query feature—document feature model as described herein.

At block **462**, the system determines whether there are remaining tuples to process. If so, the system proceeds back to block **456** to select another query feature, document feature tuple, and performs another iteration of blocks **458**, **460**, and **462**. The system may perform a large number of iterations of blocks **456**, **458**, **460**, and **462** to generate a large number of past interaction measures for a large number of tuples. Such iterations may be performed sequentially and/or in parallel.

If at block **460** the system determines there are not remaining tuples to process, the process ends at block **464**. The past interaction measures generated based on the method **400** may be utilized, for example, in method **500** described below and/or by the document measure system **130** as described herein.

FIG. **5** is a flow chart illustrating an example method **500** of using query dependent and/or independent measures of documents that are responsive to a query to rank the docu-

ments, and providing corresponding search results based on the ranking. For convenience, the operations of the flow chart are described with reference to a system that performs the operations. This system may include various components of various computer systems, such as one or more components of document measure system **130**. Moreover, while operations of method **500** are shown in a particular order, this is not meant to be limiting. One or more operations may be reordered, omitted or added.

At block **552**, the system receives a query.

At block **554**, the system identifies responsive documents that are responsive to the query. The responsive documents may optionally include, or be restricted to, access restricted documents.

At block **556**, the system identifies one or more query features for the query of block **552** and identifies one or more document features for a document of the responsive documents of block **554**.

At block **558**, the system generates a query dependent measure for the document based on measures of past interactions between the query features and the document features.

At block **560**, the system generates a query independent measure for the document based on measures of past interactions in response to queries not having any of the query features of the query received at block **552**. In some implementations, the system may perform only one of the blocks of **558** and **560**.

At block **562**, the system determines whether there are remaining documents to process. If so, the system proceeds to block **564** and identifies document features for one of the remaining documents. The system then performs another iteration of blocks **558** and **560** using those document features. The system may perform multiple iterations of blocks **564**, **558**, and **560**, each time for a different responsive document. The system may process all of the responsive documents, or a subset of the responsive documents (e.g., only the top X documents according to scores for those documents generated based on other ranking signal(s)). Multiple iterations may be performed sequentially and/or in parallel.

If, at block **562**, the system determines there are not remaining access restricted documents to process, the system proceeds to block **566**.

At block **566**, the system uses the query dependent measures generated in multiple iterations of block **558** and/or the query independent measures generated in multiple iterations of block **560** to rank the responsive documents identified at block **554**. For example, the system may adjust a base score for each of the responsive documents (e.g., a base score that is based on other ranking signal(s)) in view of the query dependent measure and/or the query independent measure, to create a modified score.

At block **568**, the system provides search results for one or more of the responsive documents based on the ranking of block **566**. Providing the search results based on the ranking of block **566** may include providing the search results with a presentation characteristic that is based on the ranking, such as a presentation order.

FIG. **6** illustrates an example of the client device **106** and a display screen **140** of the computing device **106**. The display screen **140** includes system interface elements **181**, **182**, **183** that may be interacted with by the user to cause the client device **106** to perform one or more actions. The display screen **140** also includes a search interface element **184**, where the user has entered a query "book order number" using, for example, a virtual keyboard or user

interface input provided via a microphone. Search results **185A**, **185B**, and **185C** are provided in response to the query.

In FIG. **6**, search result **185A** is presented first based on techniques described herein related to generating and utilizing a query dependent measure for the document corresponding to search result **185A**. The search result **185A** corresponds to email **353C** of FIG. **3**. In some implementations, the query dependent measure for the search result **185A** may be determined based at least in part on a past interaction measure that is between a query feature for the query "book order number" and a document feature that is based on content in one, or both, of the Subject field and the From field of the email **353C**. In some implementations, the past interaction measures based on which the query dependent measure for the search result **185A** is determined may be past interaction measures determined independent of the email **353C**. In some of those implementations, the past interaction measures may be determined based on distinct emails and/or other documents, such as emails **353A** and **353B** (FIG. **3**) that are access restricted documents personal to other users and that are inaccessible to the user that entered the query in FIG. **6**.

It is noted that in the example of FIG. **6**, the search result **185A** would not have been presented first without utilizing the query dependent measure. For example, using ranking signals that only take into account keyword matching may have caused search result **185A** and search result **185C** to be presented more prominently than search result **185A**, since those search results include terms of the query in the Subject field of their corresponding emails. For instance, search result **185B** is for an email having both "book" and "order" in its subject and search result **185C** is for another email having "order" in its subject. In contrast, document **353C** (the corresponding document for search result **185A**) does not have any of the terms of the query in its Subject field. Rather, it only includes one of the terms ("order") in a body of the email (see FIG. **3**). Accordingly, technical features described herein may be utilized to present the search result **185A** more prominently than it would be without the technical features and/or to present it initially, whereas it wouldn't have been presented initially without the technical features. This may lead to the relevant search result **185A** being more likely to be noticed and/or selected by the user in response to the query, which may give rise to various technical advantages. For example, it may reduce various computational resources that would otherwise be consumed had the search result not been presented more prominently, such as resources consumed as a result of: the user navigating through multiple search results to locate the search result **185A**, the user issuing a new search as a result of the search result **185A** not being noticed and/or presented initially, etc.

Although FIG. **6** and other examples are described with respect to email documents, many implementations described herein are additionally or alternatively applicable to other documents such as, but not limited to, other documents explicitly described herein (e.g., media documents (e.g., image documents, audio documents, video documents), calendar entry documents, contact entry documents, other electronic communications (e.g., social networking posts, chat messages)).

In situations in which the systems described herein collect personal information about users, or may make use of personal information, the users may be provided with an opportunity to control whether programs or features collect user information (e.g., information about a user's social network, social actions or activities, profession, a user's

preferences, or a user's current geographic location), or to control whether and/or how to receive content from the content server that may be more relevant to the user. Also, certain data may be treated in one or more ways before it is stored or used, so that personal identifiable information is removed. For example, a user's identity may be treated so that no personal identifiable information can be determined for the user, or a user's geographic location may be generalized where geographic location information is obtained (such as to a city, ZIP code, or state level), so that a particular geographic location of a user cannot be determined. Thus, the user may have control over how information is collected about the user and/or used.

FIG. **7** is a block diagram of an example computing device **710** that may optionally be utilized to perform one or more aspects of techniques described herein. In some implementations, one or more of the components of FIG. **1** may comprise one or more components of the example computing device **710**.

Computing device **710** typically includes at least one processor **714** which communicates with a number of peripheral devices via bus subsystem **712**. These peripheral devices may include a storage subsystem **724**, including, for example, a memory subsystem **725** and a file storage subsystem **726**, user interface output devices **720**, user interface input devices **722**, and a network interface subsystem **716**. The input and output devices allow user interaction with computing device **710**. Network interface subsystem **716** provides an interface to outside networks and is coupled to corresponding interface devices in other computing devices.

User interface input devices **722** may include a keyboard, pointing devices such as a mouse, trackball, touchpad, or graphics tablet, a scanner, a touchscreen incorporated into the display, audio input devices such as voice recognition systems, microphones, and/or other types of input devices. In general, use of the term "input device" is intended to include all possible types of devices and ways to input information into computing device **710** or onto a communication network.

User interface output devices **720** may include a display subsystem, a printer, a fax machine, or non-visual displays such as audio output devices. The display subsystem may include a cathode ray tube (CRT), a flat-panel device such as a liquid crystal display (LCD), a projection device, or some other mechanism for creating a visible image. The display subsystem may also provide non-visual display such as via audio output devices. In general, use of the term "output device" is intended to include all possible types of devices and ways to output information from computing device **710** to the user or to another machine or computing device.

Storage subsystem **724** stores programming and data constructs that provide the functionality of some or all of the modules described herein. For example, the storage subsystem **724** may include the logic to perform selected aspects of the methods of FIGS. **4** and/or **5**.

These software modules are generally executed by processor **714** alone or in combination with other processors. Memory **725** used in the storage subsystem **724** can include a number of memories including a main random access memory (RAM) **730** for storage of instructions and data during program execution and a read only memory (ROM) **732** in which fixed instructions are stored. A file storage subsystem **726** can provide persistent storage for program and data files, and may include a hard disk drive, a floppy disk drive along with associated removable media, a CD-ROM drive, an optical drive, or removable media cartridges. The modules implementing the functionality of certain

implementations may be stored by file storage subsystem **726** in the storage subsystem **724**, or in other machines accessible by the processor(s) **714**.

Bus subsystem **712** provides a mechanism for letting the various components and subsystems of computing device **710** communicate with each other as intended. Although bus subsystem **712** is shown schematically as a single bus, alternative implementations of the bus subsystem may use multiple busses.

Computing device **710** can be of varying types including a workstation, server, computing cluster, blade server, server farm, or any other data processing system or computing device. Due to the ever-changing nature of computers and networks, the description of computing device **710** depicted in FIG. **7** is intended only as a specific example for purposes of illustrating some implementations. Many other configurations of computing device **710** are possible having more or fewer components than the computing device depicted in FIG. **7**.

While several implementations have been described and illustrated herein, a variety of other means and/or structures for performing the function and/or obtaining the results and/or one or more of the advantages described herein may be utilized, and each of such variations and/or modifications is deemed to be within the scope of the implementations described herein. More generally, all parameters, dimensions, materials, and configurations described herein are meant to be exemplary and that the actual parameters, dimensions, materials, and/or configurations will depend upon the specific application or applications for which the teachings is/are used. Those skilled in the art will recognize, or be able to ascertain using no more than routine experimentation, many equivalents to the specific implementations described herein. It is, therefore, to be understood that the foregoing implementations are presented by way of example only and that, within the scope of the appended claims and equivalents thereto, implementations may be practiced otherwise than as specifically described and claimed. Implementations of the present disclosure are directed to each individual feature, system, article, material, kit, and/or method described herein. In addition, any combination of two or more such features, systems, articles, materials, kits, and/or methods, if such features, systems, articles, materials, kits, and/or methods are not mutually inconsistent, is included within the scope of the present disclosure.

What is claimed is:

1. A method implemented by one or more processors, comprising:

receiving a query, the query being entered by a user via a user interface input device of a computing device of the user;

identifying responsive documents that are responsive to the query, wherein the responsive documents are access restricted documents of the user, and wherein the access restricted documents are accessible to only the user and any restricted group of additional users designated by the user;

identifying one or more query features for the query;

for each of a plurality of the responsive documents:

identifying one or more document features, and

generating a query independent measure for the responsive document based on measures for one or more of the document features,

wherein each of the measures is based at least in part on past interactions, by corresponding users, with other documents, that are different from the responsive document but have one or more of the document features, when the other documents were presented in response to additional queries that do not include any of the query features,

wherein the other documents include access restricted documents, of the corresponding users, that are not accessible to the user,

wherein the query independent measure for a given document, of the responsive documents, is generated without reference to any past interactions that are specifically directed to the given document;

determining, based on the query independent measures for the responsive documents, a presentation order for the responsive documents; and

providing, in response to the query, one or more of the responsive documents for presentation based on the presentation order, the presentation being via a user interface output device of the computing device.

2. The method of claim **1**, wherein at least one of the responsive documents has never been presented in response to any prior submission of the query.

3. The method of claim **1**, wherein a given document feature, of the document features, is a template that includes one or more terms and one or more placeholders, wherein the one or more placeholders each indicate a particular type of string.

4. The method of claim **1**, wherein the access restricted documents are accessible to only the user and are not accessible to any of the restricted group of the additional users.

5. The method of claim **1**, wherein determining, based on the query independent measures for the responsive documents, the presentation order for the responsive documents, comprises:

determining scores for the responsive documents based on the query independent measures;

ranking the responsive documents based on the scores; and

determining the presentation order based on the ranking.

6. The method of claim **5**, further comprising:

for each of the responsive documents:

generating a query dependent measure based on additional measures of additional past interactions with the document features in response to additional queries having one or more of the query features; and

further using the query dependent measures for the access restricted documents to determine the presentation order for the responsive documents.

7. The method of claim **1**, wherein the past interactions include document selections.

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