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(54) **GRAPH SERVER QUERYING FOR MANAGING SOCIAL NETWORK INFORMATION FLOW**

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G06F 7/00	(2006.01)
G06F 17/30	(2006.01)
G06Q 30/02	(2012.01)
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H04L 29/06	(2006.01)

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CPC ***G06F 17/30867*** (2013.01); ***G06Q 30/02*** (2013.01); ***H04L 65/403*** (2013.01); ***H04L 67/10*** (2013.01); ***H04L 67/306*** (2013.01)

(58) **Field of Classification Search**

CPC G06F 17/30867; G06F 17/3089; G06F 17/30283; G06F 17/30766; G06F 17/30023

USPC 707/732, 736, 798

See application file for complete search history.

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(57) **ABSTRACT**

An online social network is managed using one server for database management tasks and another server, preferably in a distributed configuration, for CPU-intensive computational tasks, such as finding a shortest path between two members or a degree of separation between two members. The additional server has a memory device containing relationship information between members of the online social network and carries out the CPU-intensive computational tasks using this memory device. With this configuration, the number of database lookups is decreased and processing speed is thereby increased.

24 Claims, 6 Drawing Sheets

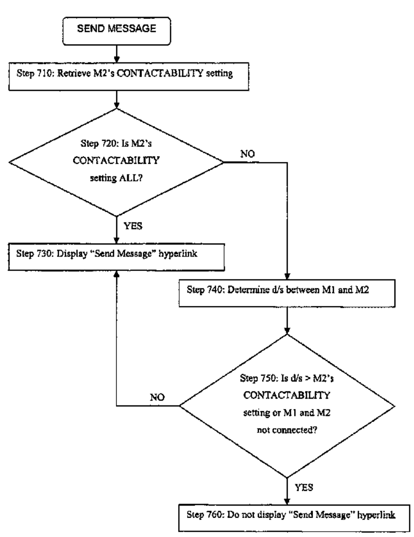

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FIG. 1

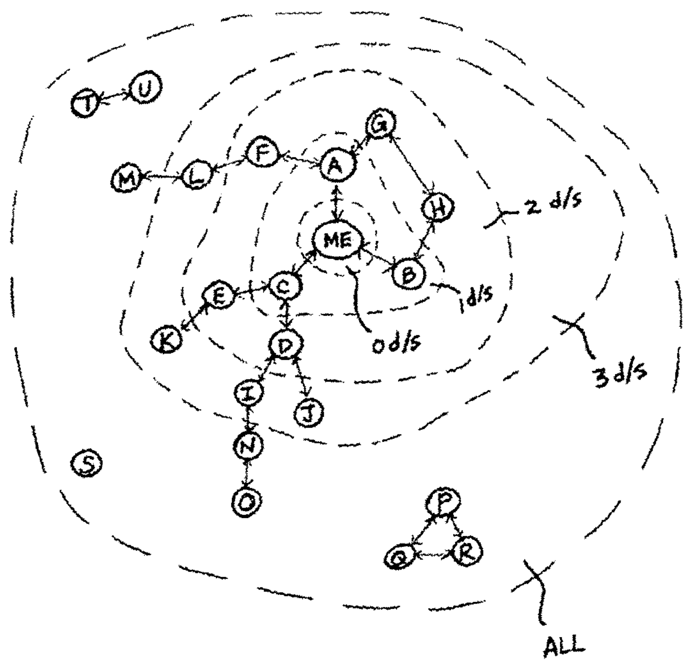
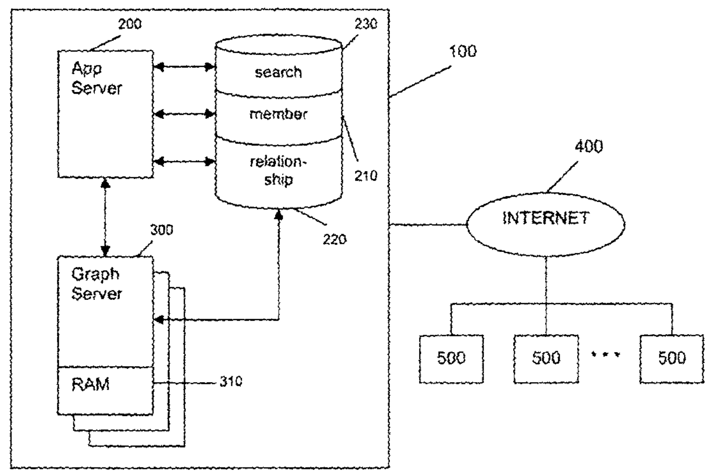


FIG. 2



200
App Server
230
search
member
relation-ship
210
220
100
400
INTERNET
300
Graph Server
RAM
310
500
500
500

FIG. 3

Adjacency List

ME: A, B, C
A: ME, F, G
B: ME, H
C: ME, D, E
D: C, I, J
E: C, K
F: A, L
G: A, H
H: B, G
I: D, N
J: D
K: E
L: F, M
M: L
N: I, O
O: N
P: Q, R
Q: P, R
R: P, Q
S:
T: U
U: T

FIG. 4

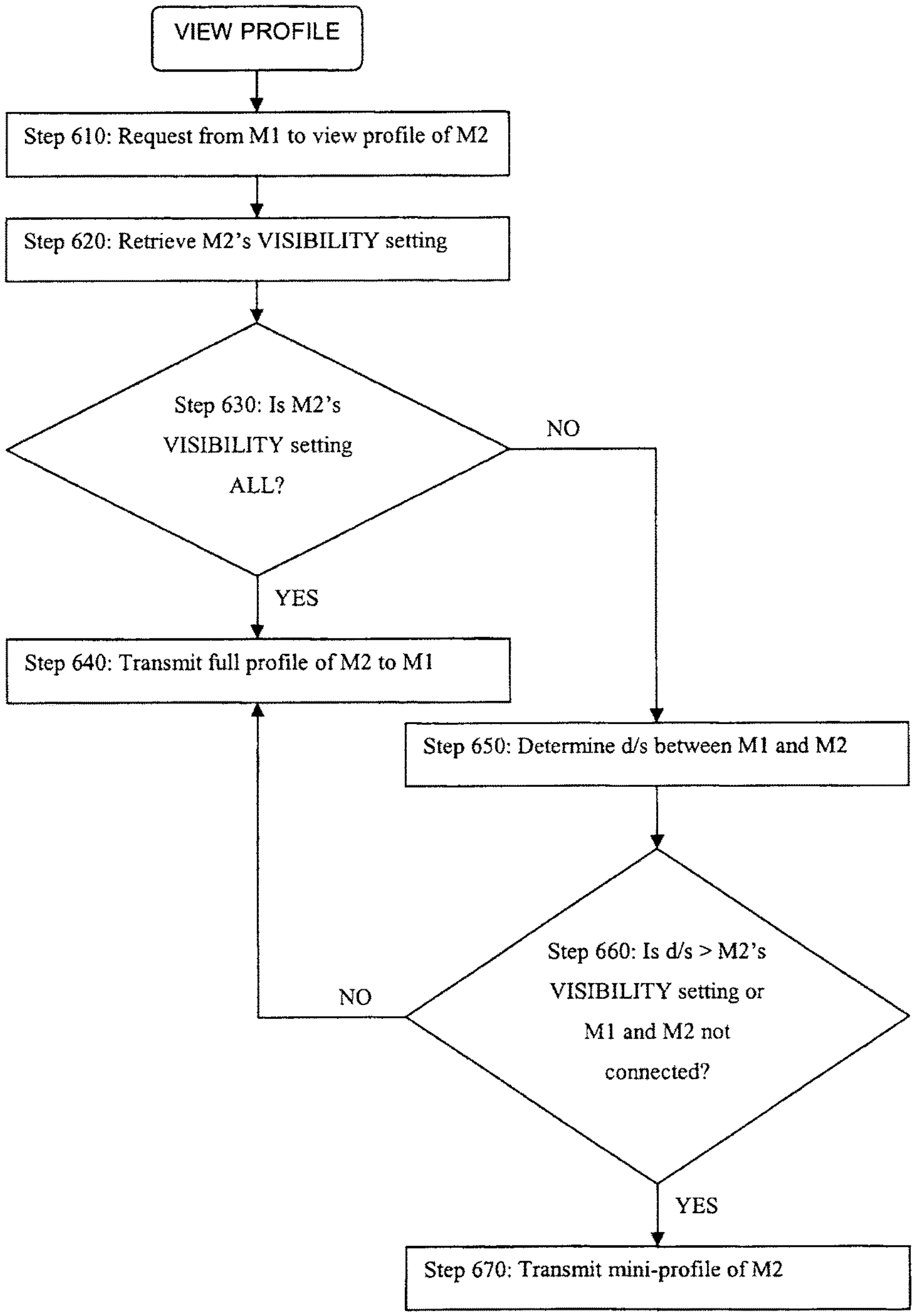

VIEW PROFILE
Step 610: Request from M1 to view profile of M2
Step 620: Retrieve M2's VISIBILITY setting
Step 630: Is M2's VISIBILITY setting ALL?
NO
YES
Step 640: Transmit full profile of M2 to M1
Step 650: Determine d/s between M1 and M2
Step 660: Is d/s > M2's VISIBILITY setting or M1 and M2 not connected?
NO
YES
Step 670: Transmit mini-profile of M2

FIG. 5

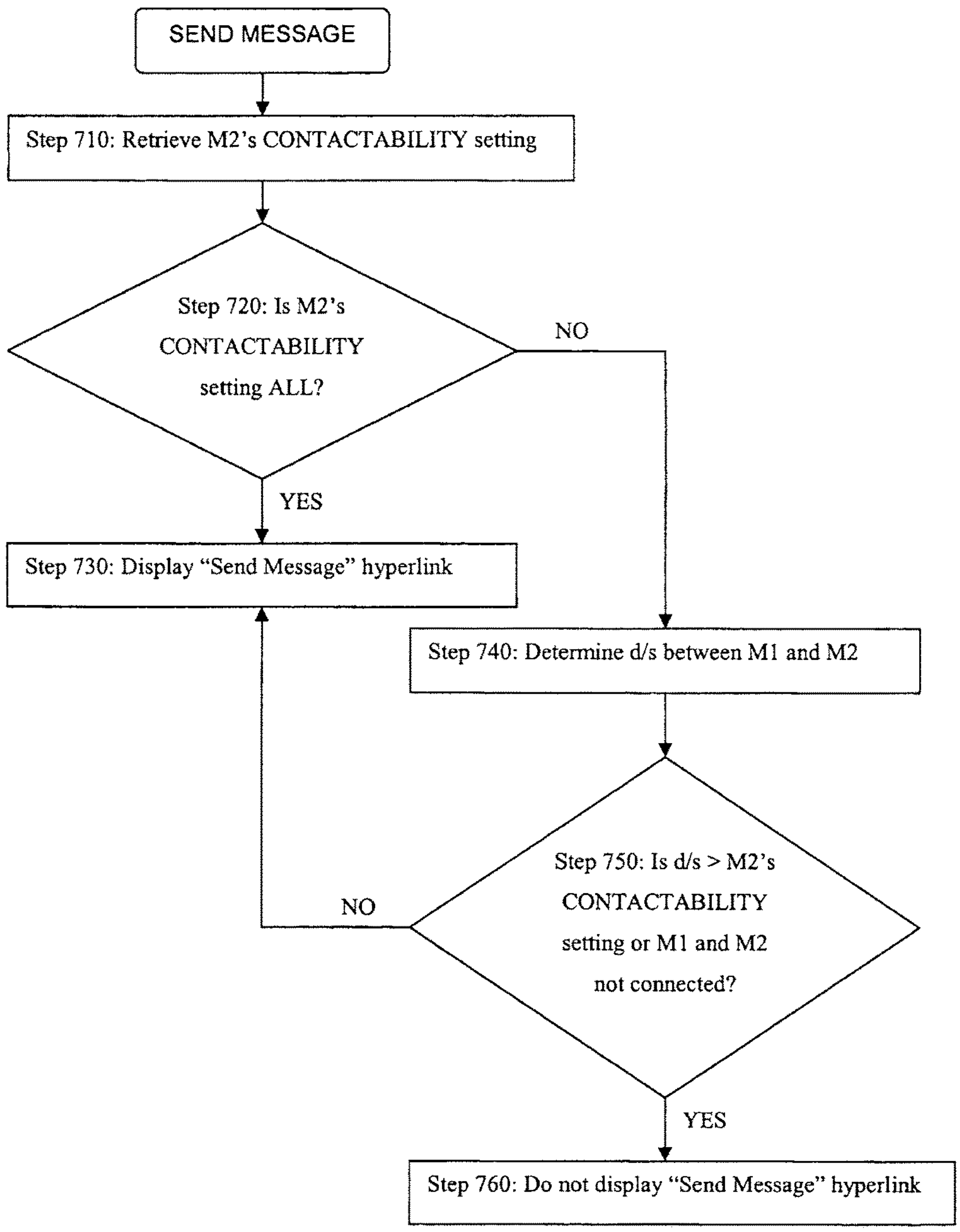
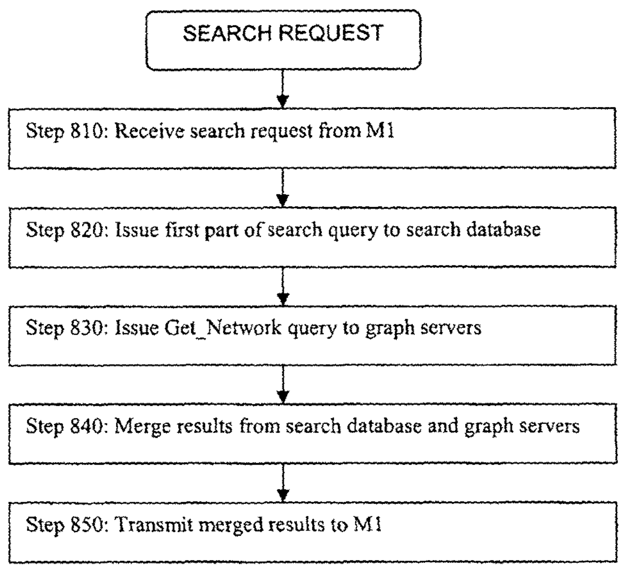

SEND MESSAGE
Step 710: Retrieve M2's CONTACTABILITY setting
Step 720: Is M2's CONTACTABILITY setting ALL?
NO
YES
Step 730: Display "Send Message" hyperlink
Step 740: Determine d/s between M1 and M2
Step 750: Is d/s > M2's CONTACTABILITY setting or M1 and M2 not connected?
NO
YES
Step 760: Do not display "Send Message" hyperlink

FIG. 6


SEARCH REQUEST
Step 810: Receive search request from M1
Step 820: Issue first part of search query to search database
Step 830: Issue Get_Network query to graph servers
Step 840: Merge results from search database and graph servers
Step 850: Transmit merged results to M1

GRAPH SERVER QUERYING FOR MANAGING SOCIAL NETWORK INFORMATION FLOW

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is a continuation of U.S. patent application Ser. No. 10/854,054, filed May 26, 2004, entitled "System and Method for Managing an Online Social Network," which is incorporated by reference herein for all purposes.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention generally relates to a system and method for managing an online social network, and more specifically, to a system and method for managing information exchange between members of an online social network.

Description of the Related Art

Online social networking sites have been rapidly gaining in popularity, and operators of online social networking sites have been adding servers and switches to their infrastructure to keep up with the increasing demand. Keeping up with the increasing demand has, however, proved to be difficult for two reasons. First, online social networking sites are virally marketed, as current members actively solicit nonmembers to sign up and join the network, and as a result, its growth has been very rapid. Second, the load on the social networking site is dependent not only on the total number of members but also on the total number of relationships. Because a member typically has multiple relationships, this means that the load increase associated with each new member is much greater than typical.

SUMMARY OF THE INVENTION

The present invention deals with the system load demands by improving the processing efficiencies of the online social networking site. The improvement in the processing efficiencies is achieved by providing one or more graph servers to be used in combination with the site's application server. The application server is configured to handle database management tasks, and the graph servers are configured to handle CPU-intensive computational tasks.

More specifically, the application server manages a database that contains member profile information and member relationship information. The graph servers keep track of how the members are socially connected to one another (hereinafter referred to as, "social network map") in a dedicated memory device, and process and respond to queries from the application server using the social network map stored in the dedicated memory device. The social network map that is stored in the dedicated memory device of the graph servers is updated to reflect any changes to the member relationship information that are made in the database.

Because the present invention processes relationship information using a social network map that is stored in a dedicated memory device, the number of database lookups is decreased and an improvement in the processing speed is achieved. Depending on the number of relationships that are tracked, a dramatic improvement in the processing speed might be achieved with the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram that conceptually represents the relationships between members in a social network;

FIG. **2** is a block diagram illustrating the system for managing an online social network according to an embodiment of the present invention;

FIG. **3** is a sample adjacency list that is maintained by the graphs servers of the present invention;

FIG. **4** is a flow diagram illustrating the method for processing a request by one member to view the profile of another member in the system of FIG. **2**;

FIG. **5** is a flow diagram illustrating the method for determining whether a member can be contacted by another member in the system of FIG. **2**; and

FIG. **6** is a flow diagram illustrating the method for processing a search request in the system of FIG. **2**.

DETAILED DESCRIPTION

A social network is generally defined by the relationships among groups of individuals, and may include relationships ranging from casual acquaintances to close familial bonds. A social network may be represented using a graph structure. Each node of the graph corresponds to a member of the social network. Edges connecting two nodes represent a relationship between two individuals. In addition, the degree of separation between any two nodes is defined as the minimum number of hops required to traverse the graph from one node to the other. A degree of separation between two members is a measure of relatedness between the two members.

FIG. **1** is a graph representation of a social network centered on a given individual (ME). Other members of this social network include A-U whose position, relative to ME's, is referred to by the degree of separation between ME and each other member. Friends of ME, which includes A, B, and C, are separated from ME by one degree of separation (1 d/s). A friend of a friend of ME is separated from ME by 2 d/s. As shown, D, E, F and G are each separated from ME by 2 d/s. A friend of a friend of a friend of ME is separated from ME by 3 d/s. FIG. **1** depicts all nodes separated from ME by more than 3 degrees of separation as belonging to the category ALL.

Degrees of separation in a social network are defined relative to an individual. For example, in ME's social network, H and ME are separated by 2 d/s, whereas in G's social network, H and G are separated by only 1 d/s. Accordingly, each individual will have their own set of first, second and third degree relationships.

As those skilled in the art understand, an individual's social network may be extended to include nodes to an Nth degree of separation. As the number of degrees increases beyond three, however, the number of nodes typically grows at an explosive rate and quickly begins to mirror the ALL set.

FIG. **2** is a block diagram illustrating a system for managing an online social network. As shown, FIG. **2** illustrates a computer system **100**, including an application server **200** and distributed graph servers **300**. The computer system **100** is connected to a network **400**, e.g., the Internet, and accessible over the network by a plurality of computers, which are collectively designated as **500**.

The application server **200** manages a member database **210**, a relationship database **220** and a search database **230**. The member database **210** contains profile information for each of the members in the online social network managed by the computer system **100**. The profile information may include, among other things: a unique member identifier, name, age, gender, location, hometown, a pointer to an image file, listing of interests, attributes, etc. The profile information also includes VISIBILITY and CONTACTABILITY settings, the uses of which are described below in connection with FIGS. **4** and **5**.

The relationship database **220** stores member relationship information in the following format: (MemberID_**1**, MemberID_**2**, Time, Add/Delete). MemberID_**1** and MemberID_**2** identify the two members whose relationship is defined by this input. Time is a variable corresponding to the time stamp of this input. Add/Delete is a variable indicating whether the friendship between MemberID_**1** and MemberID_**2** is to be added or deleted.

In addition, the contents of the member database **210** are indexed and optimized for search, and stored in the search database **230**. The member database **210**, the relationship database **220**, and the search database **230** are updated to reflect inputs of new member information and edits of existing member information that are made through the computers **500**.

The member database **210**, the relationship database **220**, and the search database **230** are depicted separately in the block diagram of FIG. **2** to illustrate that each performs a different function. The databases **210**, **220**, **230** may each represent a different database system, module, or software; or any two of the three or all three may be parts of the same database system, module, or software.

The application server **200** also manages the information exchange requests that it receives from the remote computers **500**. The information exchange requests may be a request to view a member's profile (FIG. **4**), a request to send messages to a member (FIG. **5**), or a search request (FIG. **6**). The application server **200** relies on the distributed graph servers **300** to process certain CPU-intensive tasks that are part of the information exchange request. The graph servers **300** receive a query from the application server **200**, process the query and return the query results to the application server **200**.

The graph servers **300** have a dedicated memory device **310**, such as a random access memory (RAM), in which an adjacency list that reflects the member relationship information is stored. A sample adjacency list that reflects the social network map of FIG. **1** is shown in FIG. **3**. A list item is generated for each member and contains a member identifier for that member and member identifier(s) corresponding to friend(s) of that member. As an alternative to the adjacency list, an adjacency matrix or any other graph data structure may be used.

The graph servers **300**, on a fixed interval, e.g., every five minutes, check the relationship database **220** for any incremental changes to the member relationship information. If there is, e.g., if (current time—5 minutes) is less than or equal to the time stamp corresponding to an entry in the relationship database **220**, the adjacency list stored in the dedicated memory device **510** is updated to reflect such incremental change. If a friendship is to be added, the adjacency list item for MemberID_**1** is amended to add MemberID_**2** and the adjacency list item for MemberID_**2** is amended to add MemberID_**1**. If a friendship is to be deleted, the adjacency list item for MemberID_**1** is amended to delete MemberID_**2** and the adjacency list item for MemberID_**2** is amended to delete MemberID_**1**. Alternatively, the adjacency list can be updated in real time, i.e., synchronously with the updates to the relationship database **220**.

The queries processed by the graph servers **300** include:

List_of_Members (M**1**, N d/s), which returns a list of member identifiers of all members who are exactly N d/s from member M**1**;

No_of_Members (M**1**, N d/s), which returns a raw number indicating the number of members who are exactly N dis from member M**1**;

Get_Network (M**1**, N d/s), which returns a list of member identifiers of all members that are within N dis from member M**1**;

Shortest_Path (M**1**, M**2**), which returns the shortest path, if any, between member M**1** and member M**2** (the shortest path is displayed in the form of member identifiers of those members disposed in the shortest path between member M**1** and member M**2**); and

Are_Connected? (M**1**, M**2**, degrees), which returns the degree of separation corresponding to the shortest path between member M**1** and member M**2**, if the two are connected. If the two are not connected, an error code indicating that the two members are not connected is returned.

For the calculation of the shortest path in the queries listed above, any of the shortest path algorithms for a node network defined by an adjacency list may be used, e.g., breadth first search algorithm. The algorithms for carrying out other calculations that are necessary to process the queries listed above are programmed using conventional techniques.

In FIG. **2**, a plurality of distributed graph servers **300** are depicted, and is preferred over a single graph server because the distributed structure permits resources to be shared. However, the present invention may also be practiced with a single graph server.

The application server **200** and the graphs servers **300** are depicted separately in the block diagram of FIG. **2** to illustrate that the two are performing separate processes. The application server **200** and the graphs servers **300** may be housed within a single physical structure, or they may be parts of a single processor that is programmed to carry out their separate processes in parallel.

FIG. **4** is a flow diagram illustrating the method for processing a request by one member (e.g., M**1**) to view the profile of another member (e.g., M**2**) in the system of FIG. **2**. In Step **610**, the application server **200** receives a request by member M**1** to view the profile of member M**2**. As an example, this happens when member M**1** clicks on a hyperlink associated with member M**2**. The full profile of member M**2** will be displayed if the d/s between M**1** and M**2** is less than or equal to the VISIBILITY setting set by member M**2** or if the VISIBILITY setting set by member M**2** is ALL. (VISIBILITY setting may be set at 1, 2, 3 or ALL.) Otherwise, only the mini-profile of member M**2** will be displayed. In Step **620**, the application server **200** retrieves M**2**'s VISIBILITY setting from the member database **210**. If M**2**'s VISIBILITY setting is ALL, the full profile of M**2** will be transmitted to M**1** for display at M**1**'s computer (Steps **630** and **640**). If not, the application server **200** sends the Are_Connected? query to the graph servers **300** to determine the d/s between member M**1** and member M**2** (Steps **630** and **650**). The graph servers **300** execute this query and return the dIs that it computed to the application server **200**. If the computed dIs is greater than the VISIBILITY setting or if member M**1** and member M**2** are not connected, the mini-profile of member M**2** and a message indicating that member M**2**'s full profile can only be viewed by members in his or her personal network is transmitted to M**1** for display at M**1**'s computer (Steps **660** and **670**). Otherwise, the full profile of member M**2** is transmitted to M**1** for display at M**1**'s computer (Steps **660** and **640**).

FIG. **5** is a flow diagram illustrating the method for determining whether a member can be contacted by another member in the system of FIG. **2**. In the example given herein, it is assumed that member M**1** is attempting to send a message to member M**2**. In Step **710**, the application server **200** retrieves the CONTACTABILITY setting of member M**2**. (CONTACTABILITY setting may be set as 1, 2, 3 or ALL.) If M**2**'s CONTACTABILITY setting is ALL, this means that member M**2** is permitting contact from anyone, and consequently, when member M**1** views member M**2**'s profile, a "Send Message" hyperlink will appear through which member M**1** will be able to send messages to member M**2** (Steps **720** and **730**). If M**2**'s CONTACTABILITY setting is not set to ALL, the application server **200** sends the Are_Connected? query to the graph servers **300** to determine the d/s between member M**1** and member M**2** (Steps **720** and **740**). The graph servers **300** execute this query and return the d/s that it computed to the application server **200**. If the computed d/s is greater than the CONTACTABILITY setting or if member M**1** and member M**2** are not connected, this means that member M**2** is not permitting contact from member M**1** and the "Send Message" hyperlink will not be displayed when member M**1** views member M**2**'s profile (Steps **750** and **760**). If the computed d/s is less than or equal to the CONTACTABILITY setting, this means that member M**2** is permitting contact from member M**1**, and consequently, when member M**1** views M**2**'s profile, a "Send Message" hyperlink will appear through which member M**2** will be able to send messages to member M**1** (Steps **750** and **730**).

FIG. **6** is a flow diagram illustrating the method for processing a search request in the system of FIG. **2**. In Step **810**, the application server **200** receives a search query input by member M**1**. The search query is divided into two parts. The first part specifies search terms for pre-selected categories such as gender, age, interests and location. The second part specifies a d/s setting, which may be set at 1, 2, 3 or ALL. For example, the search query may be: [gender (female), age (less than 30), d/s (at most 2)]. The first part of this search query is [gender (female), age (less than 30)] and the second part of this search query is [d/s (at most 2)]. In Step **820**, the application server **200** issues the first part of the search query to the search database **230** to obtain member identifiers for those members whose profiles meet the specified criteria. In Step **830**, the application server **200** issues a Get Network query to the graph servers **300** to obtain a list of member identifiers of all members that are within the d/s specified in the second part of the search query. The application server **200** merges the results from the search database **230** and the graph servers **300** (Step **840**), and transmits the merged results to member M**1** (Step **850**). After the merged results are delivered to member M**1**, the member may click on any of the results to view that member's profile and, if the "Send Message" hyperlink is displayed, attempt to send a message to that member through that hyperlink.

While particular embodiments according to the invention have been illustrated and described above, it will be clear that the invention can take a variety of forms and embodiments within the scope of the appended claims.

What is claimed is:

1. A method comprising:

by one or more computing devices, storing a list of member relationships in a social-networking system, the social-networking system comprising a graph comprising a plurality of nodes and edges connecting the nodes, wherein at least some of the nodes correspond to the members of the social-networking system;

by one or more computing devices, monitoring changes in relationship between the members of the social-networking system;

by one or more computing devices, updating the list in response to relationship changes;

by one or more computing devices, receiving from an application server a query;

by one or more computing devices, processing the query using the stored list of member relationships; and

by one or more computing devices, returning the query results to the application server, wherein the query results comprise degrees-of-separation information with respect to one or more members of the social-networking system.

2. The method of claim **1**, the query comprising a degrees-of-separation value and member identifier.

3. The method of claim **2**, the results comprising a list of all members of the social-networking system that are exactly the degrees-of-separation value from the member associated with the member identifier.

4. The method of claim **2**, the results comprising the number of members of the social-networking system within the degrees-of-separation value from the member associated with the member identifier.

5. The method of claim **1**, the query comprising a first member identifier and a second member identifier.

6. The method of claim **5**, the results comprising the shortest path between the member associated with the first member identifier and the member associated with the second member identifier.

7. The method of claim **6**, the results comprising a list of all members disposed in the shortest path.

8. The method of claim **5**, the results comprising the number of degrees of separation corresponding to the shortest path between the member associated with the first identifier and the member associated with the second identifier.

9. One or more computer-readable non-transitory storage media embodying software that is configured to, when executed:

store a list of member relationships in a social-networking system, the social-networking system comprising a graph comprising a plurality of nodes and edges connecting the nodes, wherein at least some of the nodes correspond to the members of the social-networking system;

monitor changes in relationship between the members of the social-networking system;

update the list in response to relationship changes;

receive, from an application server, a query;

process the query using the stored list of member relationships; and

return the query results to the application server, wherein the query results comprise degrees-of-separation information with respect to one or more members of the social-networking system.

10. The media of claim **9**, the query comprising a degrees-of-separation value and member identifier.

11. The media of claim 10, the results comprising a list of all members of the social-networking system that are exactly the degrees-of-separation value from the member associated with the member identifier.

12. The media of claim 10, the results comprising the number of members of the social-networking system within the degrees-of-separation value from the member associated with the member identifier.

13. The media of claim 9, the query comprising a first member identifier and a second member identifier.

14. The media of claim 13, the results comprising the shortest path between the member associated with the first member identifier and the member associated with the second member identifier.

15. The media of claim 14, the results comprising a list of all members disposed in the shortest path.

16. The media of claim 13, the results comprising the number of degrees of separation corresponding to the shortest path between the member associated with the first identifier and the member associated with the second identifier.

17. A system comprising:

one or more processors; and

a memory coupled to the processors comprising instructions executable by the processors, the processors being configured to, when executed:

store a list of member relationships in a social-networking system, the social-networking system comprising a graph comprising a plurality of nodes and edges connecting the nodes, wherein at least some of the nodes correspond to the members of the social-networking system;

monitor changes in relationship between the members of the social-networking system;

update the list in response to relationship changes;

receive, from an application server, a query;

process the query using the stored list of member relationships; and

return the query results to the application server, wherein the query results comprise degrees-of-separation information with respect to one or more members of the social-networking system.

18. The system of claim 17, the query comprising value and member identifier.

19. The system of claim 18, the results comprising a list of all members of the social-networking system that are exactly the degrees of separation value from the member associated with the member identifier.

20. The system of claim 18, the results comprising the number of members of the social-networking system within the degrees of separation value from the member associated with the member identifier.

21. The system of claim 17, the query comprising a first member identifier and a second member identifier.

22. The system of claim 21, the results comprising the shortest path between the member associated with the first member identifier and the member associated with the second member identifier.

23. The system of claim 22, the results comprising a list of all members disposed in the shortest path.

24. The system of claim 21, the results comprising the number of degrees of separation corresponding to the shortest path between the member associated with the first identifier and the member associated with the second identifier.

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