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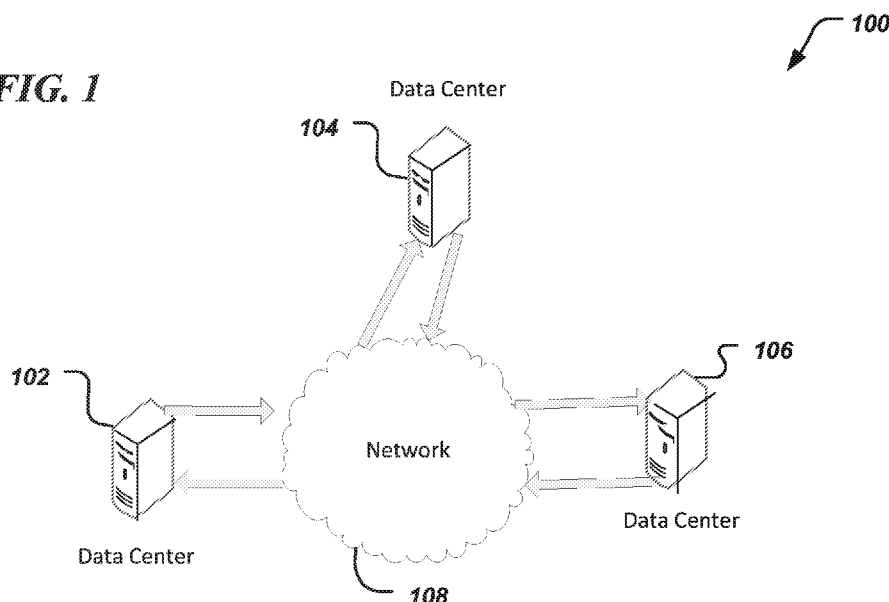
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(54) Title: TIERED INFRASTRUCTURE FOR HANDLING DATA

FIG. 1



(57) Abstract: The disclosure is directed to receiving a digitized content item that is indicated to be shared with users (e.g., all, some, or one) of a social networking system; selecting, based on one or more characteristics of the digitized content item, a second server computing device at which to further compute or store the digitized content item; and transmitting, to the second computing device, the digitized content item for storage at the second computing device. At least one of the characteristics can be a classification of a user who transmitted the digitized content item via the data communications network. By selecting second server computing devices based on characteristics, data communications network performance can be improved.



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KM, ML, MR, NE, SN, TD, TG).

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TIERED INFRASTRUCTURE FOR HANDLING DATA

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Patent Application No. 15/360,436, filed November 23, 2016, which is incorporated herein by reference in
5 its entirety.

BACKGROUND

[0002] Social networking systems enable a very large number of users (e.g., a billion users or more) to share data worldwide. To support this data sharing, the social networking systems have multiple data centers that are distributed around the
10 world. The multiple data centers enable the data to be distributed worldwide, e.g., to back up data or to store data near where the data will be consumed. Each of these data centers typically has a very large number of server computing devices. The server computing devices may be assigned various roles, e.g., compute, data storage, web site, etc.

[0003] Various specialized roles of server computing devices may be centrally located. As an example, server computing devices that transcode content from one content type to another (e.g., video in one format to video in a different format) may be centrally located.

[0004] Data centers may be built based on various requirements and
20 constraints. Data centers in developed countries can be large, where power and land are available. In countries where power and land are less available or there is a regulation concern, data centers may be smaller. Because larger data centers are easier to manage and provide superior scalability, they are preferred and tend to be built in a handful of locations. On the other hand, for flexibility and nimbleness, small
25 data centers are preferred and they are built in many places wherever there are users of the social networking system. As a result, the infrastructure for a social networking systems may have various sizes of data centers that are geographically dispersed.

[0005] In typical data center environments, data is stored wherever there is
30 capacity. However, social networks have specific characteristics of usage. As an

example, content generated by some users (e.g., celebrity users) may be more widely consumed than content generated by other users (e.g., common users). When a server computing device is selected for storing the generated content merely based on where there is capacity, consumers of data who are not located proximate to where the data is stored may experience various network delays before they can view or otherwise consume the stored data. These delays can occur, e.g., because of network bandwidth and latency issues between data centers or between the data center storing the data and the user who is requesting to consume (e.g., view or otherwise cause to be rendered) the stored data. Even if network bandwidth can be improved between data centers or users, such improvements can be expensive. Thus, determining where to locate data storage and computation resources can be useful.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. 1 is a block diagram illustrating an environment in which a tiered data storage architecture can be implemented, consistent with various embodiments.

[0007] FIG. 2 is a block diagram of an example implementation of tiers, consistent with various embodiments.

[0008] FIG. 3 is a flow diagram illustrating processing of content items that are uploaded to the system illustrated in FIG. 1, consistent with various embodiments.

[0009] FIG. 4 is a block diagram of a server of FIG. 1, consistent with various embodiments..

DETAILED DESCRIPTION

[0010] The disclosure is directed to a tiered infrastructure for handling data based on consumption characteristics. In various embodiments, a first server computing device of a social networking system receives, via a data communications network, a digitized content item that is indicated to be shared with users (e.g., all or a subset of users) of the social networking system. A server selection engine can then select, based on one or more characteristics of the digitized content item, a second server computing device at which to further compute and/or store the digitized content item. At least one of the characteristics can be a classification of a user who transmitted the digitized content item via the data communications

network. The further computation can be, for example, to transcode video files from one format to a different format. The selection engine can then transmit, to the second computing device, the digitized content item for further computation and/or storage at the second computing device. In some embodiments, the content item
5 can be large content that occupies a lot of networking bandwidth when it is transmitted, e.g., video.

[0011] The selection engine can select the second server computing device based on a classification of the user from whom the content item was received. As an example, if the content item was received from a celebrity, the selection engine
10 can select a second server computing device that is at a higher tier than if the user is classified as a general user. By selecting a higher tier, the content item is made more widely available directly, e.g., to multiple downstream server computing devices (e.g., nodes in a hierarchy). In various embodiments, the selection engine can operate at near real time, e.g., contemporaneously with receiving the content
15 items.

[0012] In some embodiments, the selection engine may first transmit the content item to a third server so that the third server can transcode the received content item the content item is stored at the second server computing device.

[0013] In some embodiments, the selection engine may select a classification
20 as a function of a number of friend connections the user who uploaded the content item has in a social graph. As an example, the more the users, the higher the selected tier for the second server computing device. As a further refinement, the tier can be selected based on the geographic proximity of the user's friends in the social network. In other words, the social networking system assumes that the
25 content item will be consumed by friends of the user. In some embodiments, the selection engine evaluates the Internet Protocol (IP) address of the computing device from which the digitized content item was received to select a nearby second server computing device at which the content item should be stored.

[0014] Thus, the server computing devices and the data centers may belong to
30 one or more tiers, wherein the tiers may be distributed based on geography or function. The selection engine can select an appropriate tier to minimize (or otherwise optimize) the bandwidth consumption that would be caused when the

content item is consumed, e.g., by friends indicated in the social networking system for the user who uploaded the content item.

[0015] The selection engine can select where to allocate computing or storage resources based on various rules. For example, for a live video streaming application, if the data uploaded by a celebrity and there are typically a large number of viewers around the world, leveraging compute/storage resources in a large data center may be preferred because there may be more resources available there and the data will be viewed around the world to be viewed by users worldwide. If the video is from a general user with most friends located in a local region, then a nearby data center would be preferred because the video will typically be viewed by local users.

[0016] In various embodiments, the rules the selection engine evaluates and responds to may be dynamically updated. For example, a general user's data (e.g. video stream) may become viral (meaning that it is being viewed by increasing numbers of users) and so it is then preferred to be computed or stored in a larger datacenter instead of a nearby datacenter.

[0017] In various embodiments, for a particular content item (e.g., video stream), the selection engine can select one data center for transcoding or otherwise processing it (e.g., assigning compute resources) and a different data center for storing it. As an example, the selection engine may select a data center that presently has more compute resources available for quickly processing the content item, and then a different data center to store it closer to users who will likely view the content item. As another example, the selection engine may select multiple data centers if redundancy is needed (e.g., for content items that are important or will be viewed by many users worldwide).

[0018] The objectives for the selection engine can be different, e.g., at different times or in different scenarios. As examples, to optimize for cost a more economical data center may be initially assigned; to reduce data communications latency, the closest data center may be assigned first; to balance network load, multiple data centers that are geographically dispersed may initially be assigned. One skilled in the art will recognize that other modifications may be made.

[0019] Thus, in various embodiments, the selection engine and associated components can determine or predict network traffic to select tiers having computing devices that are identified for computation and/or storage purposes. For the selection engine to select tiers (also "layers") to use for computing and/or storing digitized content, the engine can analyze the network address (e.g., IP address_ of the originating user (e.g., the user who is generating the network traffic such as by uploading video) and the network addresses of the consuming users (e.g., the users who are consuming the network traffic such as watching the videos). In some embodiments, the selection engine determines if most of the IP addresses are in a common geographical location or region. If so, the selection engine selects tiers that are in or proximate to that location. Proximity can be determined, e.g., as geographical proximity or network proximity (e.g., number of network hops). By selecting tiers that are proximate to the users, the selection engine reduces the consumed network bandwidth reduction and also reduces the networking latency.

[0020] In some embodiments, the selection engine can make its selections based on a "real-time" analysis of user activities. As examples, some users of a social network may not be consuming digitized content during portions of the day (e.g., during late nights) because they are offline whereas other social network users may just be coming online and so may begin consuming digitized content. The selection engine can retrieve in real time the IP addresses of all the users who are consuming the digitized content and then make an adjustment on which tiers should be selected, e.g., to minimize network bandwidth usage and latencies. Furthermore, the selection engine can also see if the IP addresses of the users can be grouped (e.g., into a few different "buckets") and all the users in each group are located close to each other geographically. If so, one or more separate tiers can be selected and used to compute and store the digitized content.

[0021] By selecting tiers in this manner, network utilization can be reduced because (1) the computation or storage "work" is performed proximate to end users (instead of traveling over long distances across network links); (2) performance is improved and latency for end users to access digitized content items is minimized; and (3) the social networking infrastructure can be more flexible because where electrical or computational power is abundant, large data centers can be built and where electrical or power is limited or regulation is tight, small data centers can be

built. These improvements make the expansion of the infrastructure (e.g., using multiple data centers) much more flexible than previously possible.

ENVIRONMENT

[0022] Turning now to the figures, FIG. 1 is a block diagram illustrating an environment 100 in which tiered data storage architecture can be implemented. The tiered architecture may be used to store data across various storage layers, e.g., to increase the efficiency of data storage. One or more data centers 102, 104, and 106 may be interconnected via a network 108 (e.g., the Internet). The data centers may be tiered. Alternatively, servers within the data centers (not illustrated) may be tiered. Tiering can be performed at a geographic or functional level. The higher the tier for a computing device, the more downstream devices in the network the computing device directly communicates with. In various embodiments, data centers 102, 104, and 106 can have different "sizes," meaning number and types of server computing devices, networking resources, etc.

[0023] FIG. 2 is a block diagram of an example implementation of tiers, consistent with various embodiments. The implementation 200 includes a top-level tier 203 that services tiers 205 and 207. Tier 205 services tiers 209 and 211, and tier 207 services tiers 213 and 215. The lowest-level tiers 209, 211, 213, and 215 may each service users or other tiers. Because of this tiered relationship, data is stored or provided by a higher tier, it is available to more users than when it stored at a lower tier. However, additional network hops may be required to consume data stored at higher tiers. In contrast, when data is not stored in the direct path between the user and the top-level tier, the data may have to transit even more tiers. As an example, when a user associated with tier 209 requests data that is stored at tier 207, the data may need to transit tiers 203 and 205 before arriving at tier 209. In contrast, if that data was to be stored at tier 205, it would only have to transit tier 209 before arriving at the user's computing device.

[0024] The illustrated implementation 200 also includes one or more selection engines 250. The selection engines can select a tier (or server computing device within a tier) at which uploaded data items should be stored. The selection engine can receive, store, and evaluate various "rules." These rules can evaluate various

characteristics, e.g., location of users, type of content, number of friend connections for the user who is uploading the content item, etc. The evaluation can indicate which tier or server computing device the content item should be stored at. By selecting an appropriate server computing device or tier, the selection engine
5 attempts to reduce the amount of network bandwidth and hops required to service requests for content items.

[0025] FIG. 3 is a flow diagram illustrating processing of content items that are uploaded to the system illustrated in FIG. 1, consistent with various embodiments. At block 303 of the illustrated routine 300, when a content item is uploaded by a user, it is received and processed. At block 305, e.g., as may be performed by a
10 selection engine, a server computing device and/or a tier is selected for storage of the content item. The selection can be based on various characteristics, e.g., pertaining to the content item or the user who uploaded it. As an example, based on the IP address of the user who uploaded the content item, the number of friends the
15 user has, or the celebrity status of the user, the content item may be stored at various tier levels. At block 307, the content item is transmitted to the selected server computing device or tier for storage.

[0026] FIG. 4 is a block diagram of a server of FIG. 1, consistent with various embodiments. The computing system 400 may be used to implement any of the
20 entities, components or services depicted in the examples of Figures 1-7 (and any other components described in this specification). The computing system 400 may include one or more central processing units ("processors") 405, memory 410, input/output devices 425 (e.g., keyboard and pointing devices, display devices), storage devices 420 (e.g., disk drives), and network adapters 430 (e.g., network
25 interfaces) that are connected to an interconnect 415. The interconnect 415 is illustrated as an abstraction that represents any one or more separate physical buses, point to point connections, or both connected by appropriate bridges, adapters, or controllers. The interconnect 415, therefore, may include, for example, a system bus, a Peripheral Component Interconnect (PCI) bus or PCI-Express bus,
30 a HyperTransport or industry standard architecture (ISA) bus, a small computer system interface (SCSI) bus, a universal serial bus (USB), IIC (I2C) bus, or an Institute of Electrical and Electronics Engineers (IEEE) standard 1394 bus, also called "Firewire".

[0027] The memory 410 and storage devices 420 are computer-readable storage media that may store instructions that implement at least portions of the described technology. In addition, the data structures and message structures may be stored or transmitted via a data transmission medium, such as a signal on a communications link. Various communications links may be used, such as the Internet, a local area network, a wide area network, or a point-to-point dial-up connection. Thus, computer-readable media can include computer-readable storage media (e.g., "non-transitory" media) and computer-readable transmission media.

[0028] The instructions stored in memory 410 can be implemented as software and/or firmware to program the processor(s) 405 to carry out actions described above. In some embodiments, such software or firmware may be initially provided to the processing system 400 by downloading it from a remote system through the computing system 400 (e.g., via network adapter 430).

[0029] The technology introduced herein can be implemented by, for example, programmable circuitry (e.g., one or more microprocessors) programmed with software and/or firmware, or entirely in special-purpose hardwired (non-programmable) circuitry, or in a combination of such forms. Special-purpose hardwired circuitry may be in the form of, for example, one or more ASICs, PLDs, FPGAs, etc.

Remarks

[0030] The above description and drawings are illustrative and are not to be construed as limiting. Numerous specific details are described to provide a thorough understanding of the disclosure. However, in some instances, well-known details are not described in order to avoid obscuring the description. Further, various modifications may be made without deviating from the scope of the embodiments. Accordingly, the embodiments are not limited except as by the appended claims.

[0031] Reference in this specification to "one embodiment" or "an embodiment" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the disclosure. The appearances of the phrase "in one embodiment" in various places in the specification are not necessarily all referring to the same embodiment, nor are

separate or alternative embodiments mutually exclusive of other embodiments. Moreover, various features are described which may be exhibited by some embodiments and not by others. Similarly, various requirements are described which may be requirements for some embodiments but not for other embodiments.

5 **[0032]** The terms used in this specification generally have their ordinary meanings in the art, within the context of the disclosure, and in the specific context where each term is used. Terms that are used to describe the disclosure are discussed below, or elsewhere in the specification, to provide additional guidance to the practitioner regarding the description of the disclosure. For convenience, some
10 terms may be highlighted, for example using italics and/or quotation marks. The use of highlighting has no influence on the scope and meaning of a term; the scope and meaning of a term is the same, in the same context, whether or not it is highlighted. It will be appreciated that the same thing can be said in more than one way. One will recognize that “memory” is one form of a “storage” and that the terms may on
15 occasion be used interchangeably.

[0033] Consequently, alternative language and synonyms may be used for any one or more of the terms discussed herein, nor is any special significance to be placed upon whether or not a term is elaborated or discussed herein. Synonyms for some terms are provided. A recital of one or more synonyms does not exclude the
20 use of other synonyms. The use of examples anywhere in this specification including examples of any term discussed herein is illustrative only, and is not intended to further limit the scope and meaning of the disclosure or of any exemplified term. Likewise, the disclosure is not limited to various embodiments given in this specification.

25 **[0034]** Those skilled in the art will appreciate that the logic illustrated in each of the flow diagrams discussed above, may be altered in various ways. For example, the order of the logic may be rearranged, substeps may be performed in parallel, illustrated logic may be omitted; other logic may be included, etc.

[0035] Without intent to further limit the scope of the disclosure, examples of
30 instruments, apparatus, methods and their related results according to the embodiments of the present disclosure are given below. Note that titles or subtitles may be used in the examples for convenience of a reader, which in no way should

limit the scope of the disclosure. Unless otherwise defined, all technical and scientific terms used herein have the same meaning as commonly understood by one of ordinary skill in the art to which this disclosure pertains. In the case of conflict, the present document, including definitions will control.

CLAIMS

I/We claim:

1. A method performed by a computing device, comprising:
receiving, via a data communications network at a first server computing
5 device, a digitized content item that is indicated to be shared with users
of a social network system;
selecting, based on one or more characteristics of the digitized content item, a
second server computing device at which to further compute or store
the digitized content item, wherein at least one of the characteristics is
10 a classification of a user who transmitted the digitized content item via
the data communications network; and
transmitting, to the second computing device, the digitized content item for
storage at the second computing device.
2. The method of claim 1, wherein in an event the user is classified as a
15 celebrity user, the selecting comprises selecting the second server computing device
at a higher tier than if the user is classified as a general user.
3. The method of claim 1, wherein the selecting is performed nearly
contemporaneously with the receiving.
4. The method of claim 1, further comprising transcoding, at a third
20 computing device proximate to the second server computing device, the digitized
content item prior to storage of the digitized content item.
5. The method of claim 1, wherein the classification is a function of a
number of friend connections the user has in a social graph.

6. The method of claim 1, wherein the selecting further includes evaluating the internet protocol address of the computing device from which the digitized content item was received.

7. A computer-readable storage device storing instructions, the instructions comprising:

instructions for receiving, via a data communications network at a first server computing device, a digitized content item that is indicated to be shared with users of a social network system;

instructions for selecting, based on one or more characteristics of the digitized content item, a second server computing device at which to further compute or store the digitized content item, wherein at least one of the characteristics is a classification of a user who transmitted the digitized content item via the data communications network; and

instructions for transmitting, to the second computing device, the digitized content item for storage at the second computing device.

8. The computer-readable storage device of claim 7, wherein in an event the user is classified as a celebrity user, the selecting comprises selecting the second server computing device at a higher tier than if the user is classified as a general user.

9. The computer-readable storage device of claim 7, wherein the selecting is performed nearly contemporaneously with the receiving.

10. The computer-readable storage device of claim 7, further comprising instructions for transcoding, at a third computing device proximate to the second server computing device, the digitized content item prior to storage of the digitized content item.

11. The computer-readable storage device of claim 17, wherein the classification is a function of a number of friend connections the user has in a social graph.

12. The computer-readable storage device of claim 7, wherein the instructions for selecting further comprises instructions for evaluating the internet protocol address of the computing device from which the digitized content item was received.

5 13. A system, comprising:

a component configured to receive, via a data communications network at a first server computing device, a digitized content item that is indicated to be shared with users of a social networking system;

10 a component configured to select, based on one or more characteristics of the digitized content item, a second server computing device at which to further compute or store the digitized content item, wherein at least one of the characteristics is a classification of a user who transmitted the digitized content item via the data communications network; and

15 a component configured to transmit, to the second computing device, the digitized content item for storage at the second computing device.

14. The system of claim 13, wherein in an event the user is classified as a celebrity user, the second server computing device is selected at a higher tier than if the user is classified as a general user.

20 15. The system of claim 13, wherein the second server computing device is selected nearly contemporaneously with the receiving.

16. The system of claim 13, further comprising a component configured to transcode, at a third computing device proximate to the second server computing device, the digitized content item prior to storage of the digitized content item.

25 17. The system of claim 13, wherein the classification is a function of a number of friend connections the user has in a social graph.

18. The system of claim 13, wherein the second server computing device is selected based on an evaluation of the internet protocol address of the computing device from which the digitized content item was received.

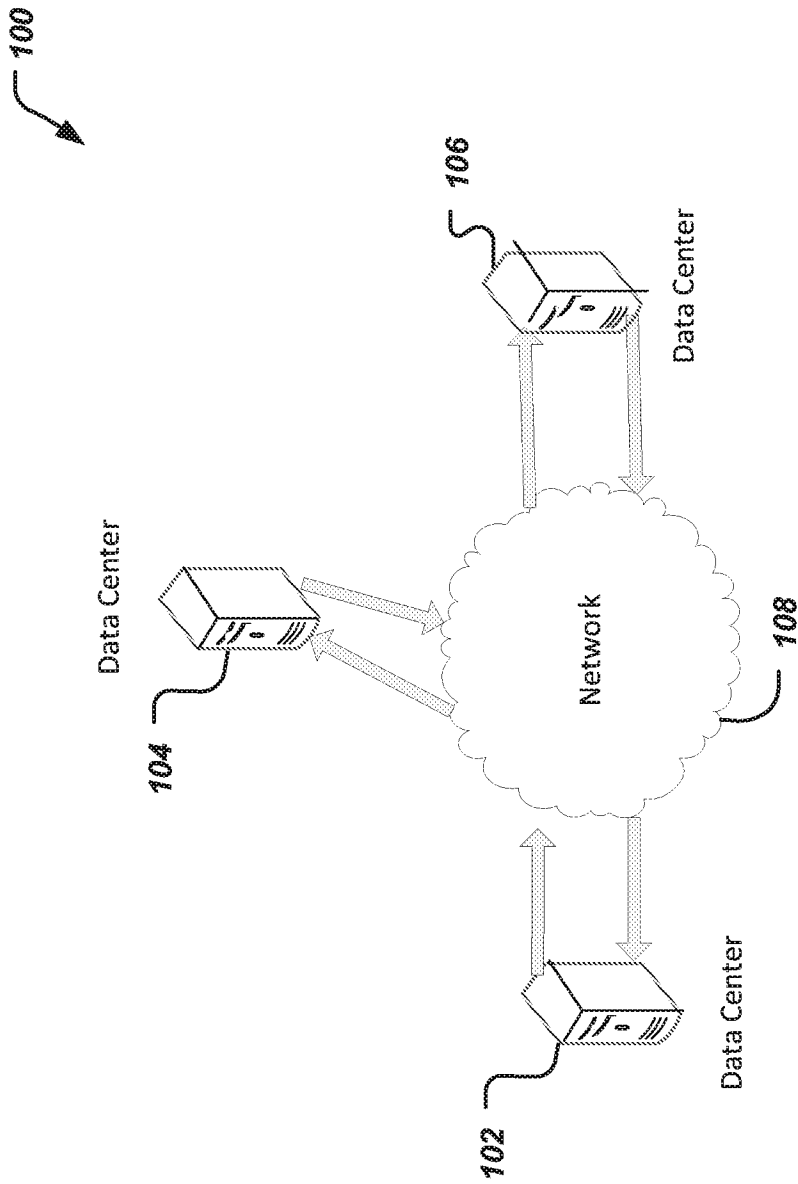
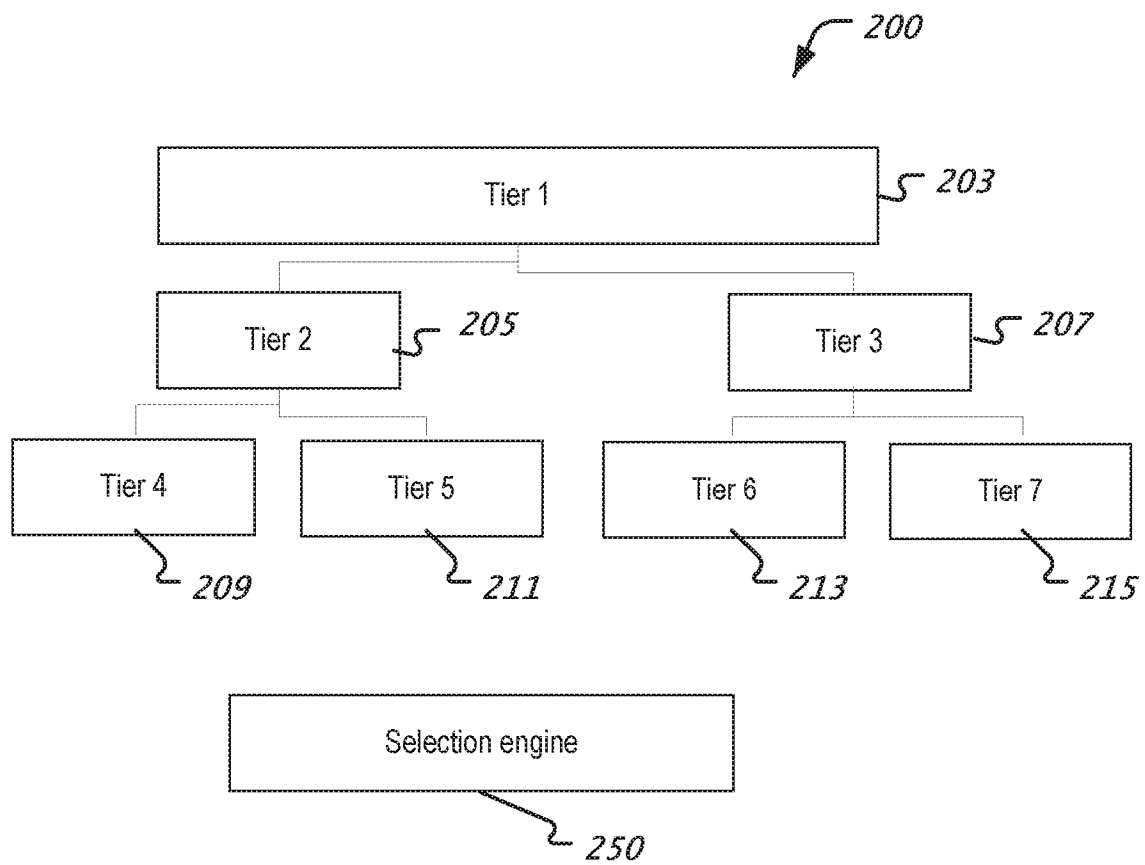
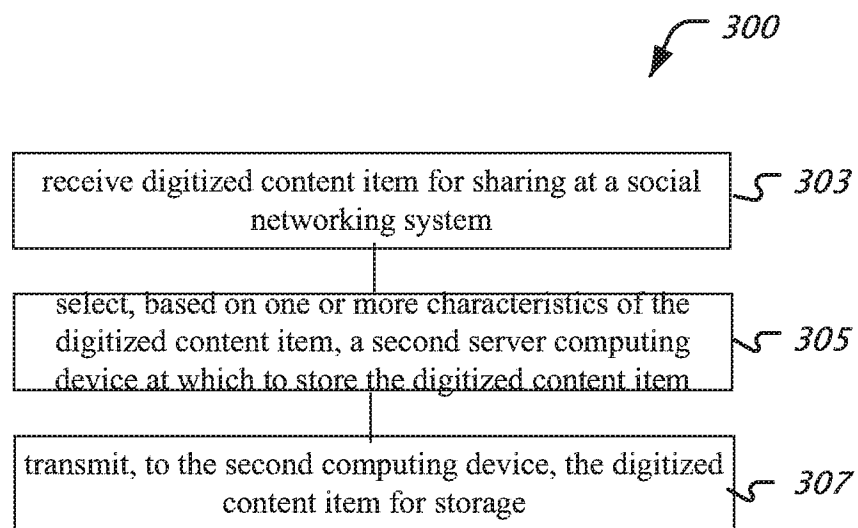


FIG. 1

**FIG. 2**

**FIG. 3**

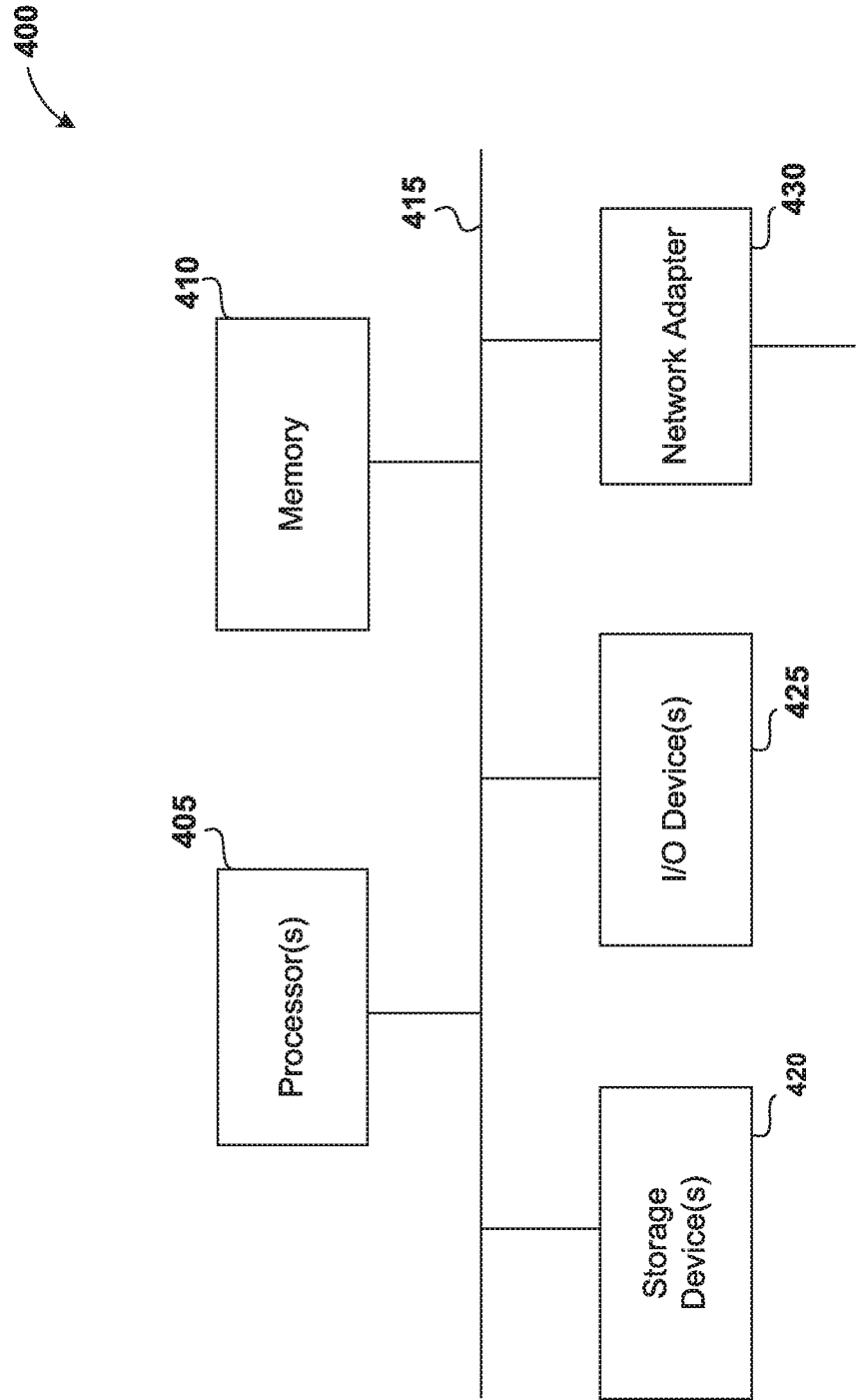


FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/015145**A. CLASSIFICATION OF SUBJECT MATTER****G06Q 50/00(2006.01)i, G06Q 50/30(2012.01)i, G06Q 50/10(2012.01)i, H04N 19/40(2014.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G06Q 50/00; H04L 12/58; G06Q 50/10; H04L 29/08; G06F 17/30; H04L 29/06; G06F 9/06; G06F 17/40; G06Q 50/30; H04N 19/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: social network, content, sharing, characteristics, storage

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2016-0028846 A1 (FACEBOOK, INC.) 28 January 2016 See paragraphs [0019]–[0020], [0022], [0046], [0049], [0087] and claims 1–2, 15.	1–18
Y	US 2016-0316014 A1 (MICROSOFT TECHNOLOGY LICENSING, LLC) 27 October 2016 See paragraph [0029] and claims 1, 7.	1–18
A	US 2016-0132613 A1 (OPEN TEXT S.A.) 12 May 2016 See paragraph [0068] and figures 11A–15.	1–18
A	KR 10-2014-0083289 A (LG UPLUS CORP.) 04 July 2014 See claims 1–9 and figures 2–3.	1–18
A	KR 10-2010-0058786 A (SK TELECOM CO., LTD.) 04 June 2010 See claims 1–6 and figures 1–4.	1–18



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

21 June 2017 (21.06.2017)

Date of mailing of the international search report

21 June 2017 (21.06.2017)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

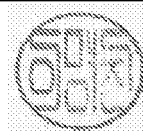


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INTERNATIONAL SEARCH REPORT

Information on patent family members

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