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Luna et al.

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(45) Date of Patent: *Dec. 3, 2019

(54) **OPTIMIZING MOBILE NETWORK TRAFFIC COORDINATION ACROSS MULTIPLE APPLICATIONS RUNNING ON A MOBILE DEVICE**

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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.

This patent is subject to a terminal disclaimer.

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Related U.S. Application Data

(60) Continuation of application No. 16/164,601, filed on Oct. 18, 2018, which is a continuation of application

(Continued)

(51) **Int. Cl.**

H04W 52/02 (2009.01)
H04L 12/12 (2006.01)

(Continued)

(52) **U.S. Cl.**

CPC ***H04W 52/0261*** (2013.01); ***G06F 1/3231*** (2013.01); ***G06F 1/3278*** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC ... H04L 67/32; H04L 67/2895; H04L 67/288; H04L 67/2833; H04L 67/28;

(Continued)

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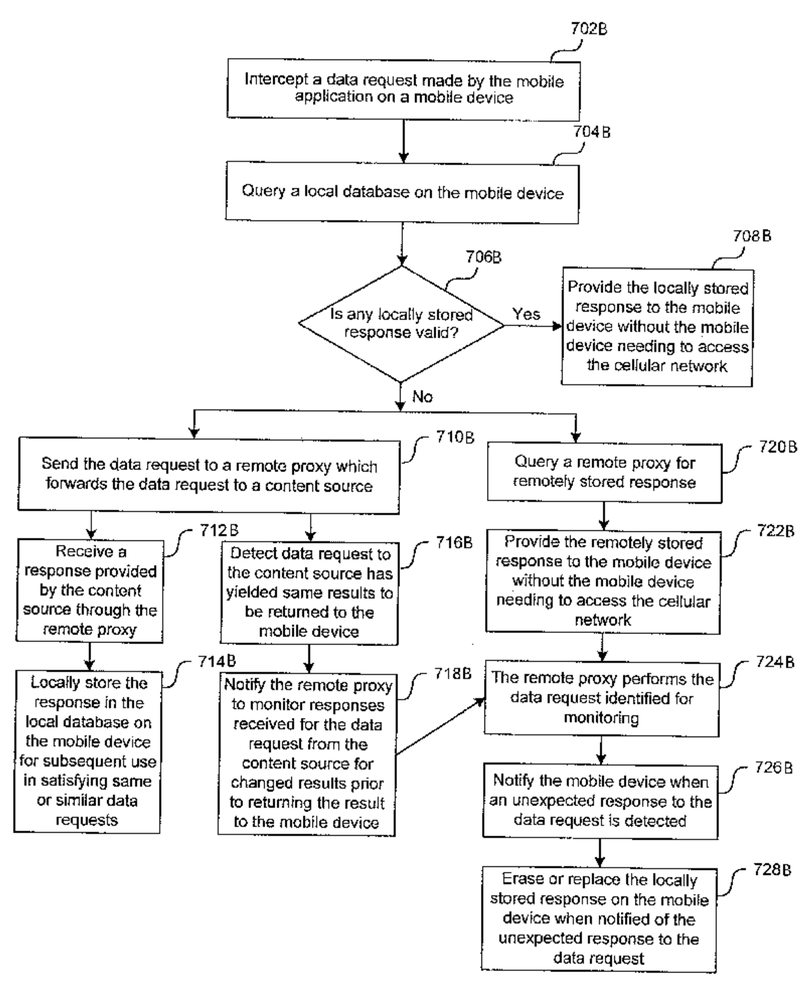
Primary Examiner — Mewale A Ambaye
(74) *Attorney, Agent, or Firm* — NK Patent Law

(57) **ABSTRACT**

Systems and methods for prediction of activity session for mobile network use optimization and user experience enhancement are disclosed. In one aspect, embodiments of the present disclosure include a method, which may be implemented on a system for enhancing user experience with a mobile application on a mobile device including, using user activity characteristics at a mobile device and server activity characteristics of a host server to anticipate a future activity session at the mobile device and transferring impending content from the host server the mobile device to pre-cache content on the mobile device to support predicted data activity for the future activity session that has been predicted.

6 Claims, 29 Drawing Sheets



Related U.S. Application Data

No. 16/046,960, filed on Jul. 26, 2018, now Pat. No. 10,194,398, which is a continuation of application No. 15/595,104, filed on May 15, 2017, now Pat. No. 10,091,734, which is a continuation of application No. 14/710,167, filed on May 12, 2015, now Pat. No. 9,671,851, which is a continuation of application No. 13/477,625, filed on May 22, 2012, now abandoned, which is a division of application No. 13/407,406, filed on Feb. 28, 2012, now abandoned, which is a continuation of application No. 13/178,598, filed on Jul. 8, 2011, now abandoned, said application No. 14/710,167 is a continuation of application No. 14/467,922, filed on Aug. 25, 2014, now Pat. No. 9,247,019, which is a division of application No. 13/188,553, filed on Jul. 22, 2011, now Pat. No. 8,886,176, said application No. 14/710,167 is a continuation of application No. 13/355,443, filed on Jan. 20, 2012, now Pat. No. 9,049,179, which is a continuation of application No. 13/115,631, filed on May 25, 2011, now Pat. No. 9,043,433, said application No. 14/710,167 is a continuation of application No. 13/115,740, filed on May 25, 2011, now abandoned.

(60) Provisional application No. 61/430,828, filed on Jan. 7, 2011, provisional application No. 61/416,033, filed on Nov. 22, 2010, provisional application No. 61/416,020, filed on Nov. 22, 2010, provisional application No. 61/408,846, filed on Nov. 1, 2010, provisional application No. 61/408,854, filed on Nov. 1, 2010, provisional application No. 61/408,858, filed on Nov. 1, 2010, provisional application No. 61/408,829, filed on Nov. 1, 2010, provisional application No. 61/408,826, filed on Nov. 1, 2010, provisional application No. 61/408,820, filed on Nov. 1, 2010, provisional application No. 61/408,839, filed on Nov. 1, 2010, provisional application No. 61/367,870, filed on Jul. 26, 2010, provisional application No. 61/367,871, filed on Jul. 26, 2010.

(51) **Int. Cl.**

G06F 1/3287	(2019.01)
G06F 1/3234	(2019.01)
G06F 1/3231	(2019.01)
H04L 29/08	(2006.01)
H04W 52/00	(2009.01)
G06F 16/957	(2019.01)

(52) **U.S. Cl.**

CPC ***G06F 1/3287*** (2013.01); ***G06F 16/9574*** (2019.01); ***H04L 12/12*** (2013.01); ***H04L 67/22*** (2013.01); ***H04W 52/00*** (2013.01); ***H04W 52/02*** (2013.01); ***H04W 52/0219*** (2013.01); ***H04W 52/0222*** (2013.01); ***H04W 52/0229*** (2013.01); ***H04W 52/0235*** (2013.01); ***H04W 52/0254*** (2013.01); ***H04W 52/0258*** (2013.01); *Y02D 10/157* (2018.01); *Y02D 10/171* (2018.01); *Y02D 10/173* (2018.01); *Y02D 70/00* (2018.01); *Y02D 70/1222* (2018.01); *Y02D 70/1224* (2018.01); *Y02D 70/1242* (2018.01); *Y02D 70/1246* (2018.01); *Y02D 70/1262* (2018.01); *Y02D 70/1264* (2018.01); *Y02D 70/142* (2018.01); *Y02D 70/144* (2018.01); *Y02D 70/146* (2018.01); *Y02D 70/164* (2018.01); *Y02D 70/23* (2018.01); *Y02D 70/26* (2018.01)

(58) **Field of Classification Search**

CPC H04L 67/145; H04L 67/04; H04L 76/02; H04W 74/06; H04W 72/1221

See application file for complete search history.

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CIPO, Second Office Action in Chinese Patent Application No. 2018101824685 dated Jun. 28, 2019.

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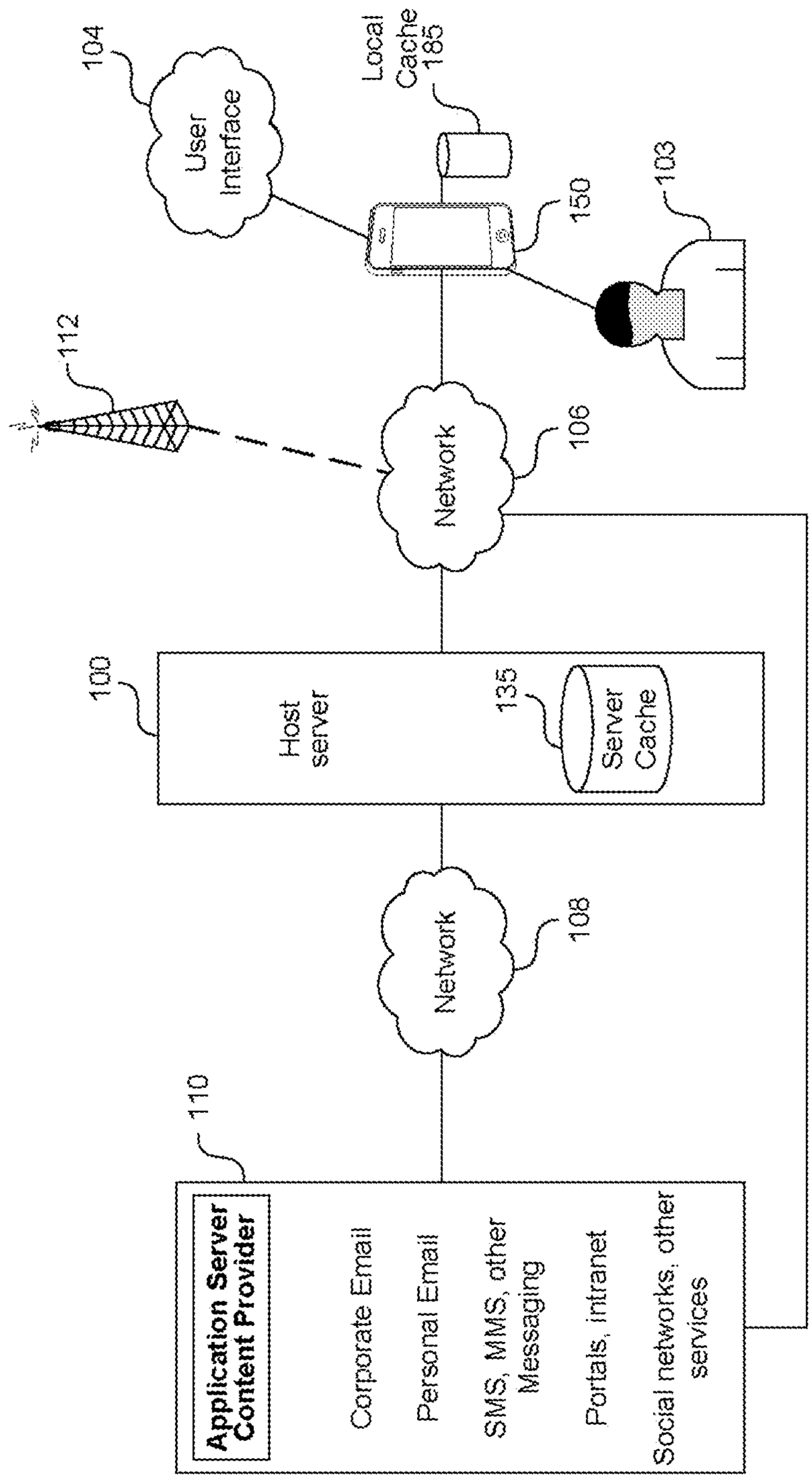
104
User Interface
Local Cache 185
150
103
112
Network
106
100
Host server
135
Server Cache
Network
108
110
Application Server Content Provider
Corporate Email
Personal Email
SMS, MMS, other Messaging
Portals, intranet
Social networks, other services

FIG. 1A

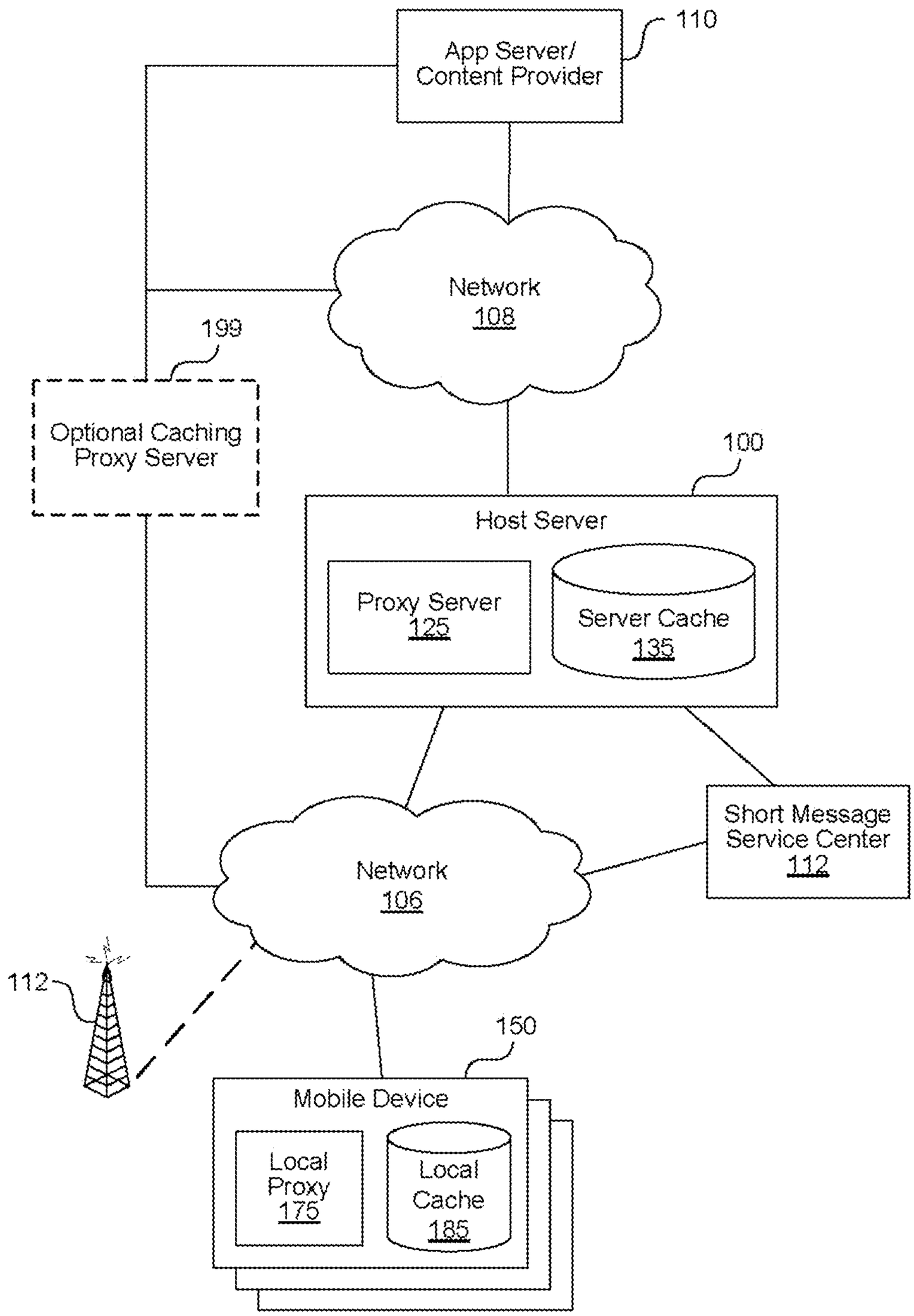
App Server/
Content Provider
110
Network
108
199
Optional Caching
Proxy Server
100
Host Server
Proxy Server
125
Server Cache
135
Short Message
Service Center
112
Network
106
112
150
Mobile Device
Local
Proxy
175
Local
Cache
185

FIG. 1B

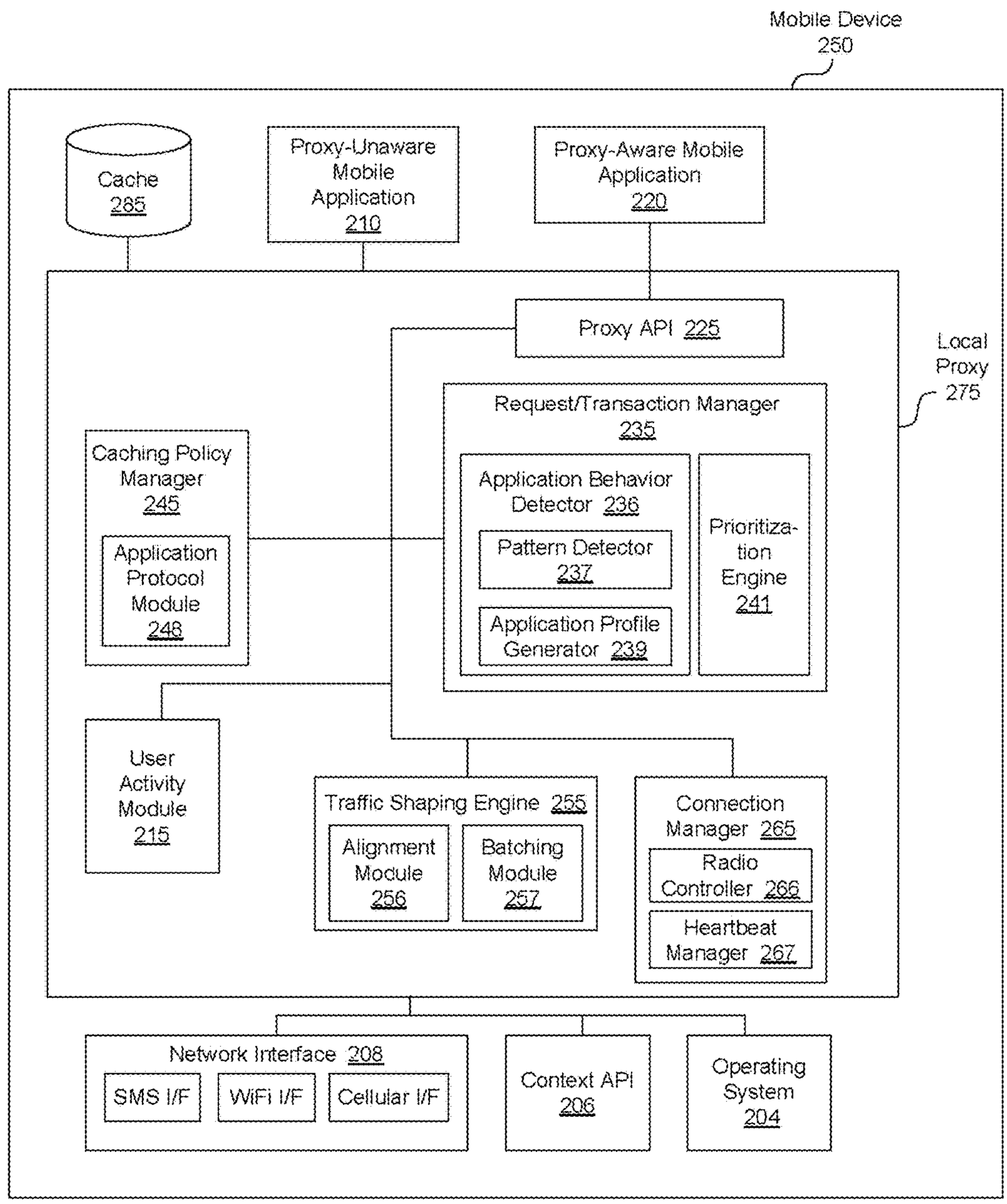
Mobile Device
250
Cache
285
Proxy-Unaware
Mobile
Application
210
Proxy-Aware Mobile
Application
220
Proxy API 225
Local
Proxy
275
Request/Transaction Manager
235
Caching Policy
Manager
245
Application
Protocol
Module
248
Application Behavior
Detector 236
Pattern Detector
237
Application Profile
Generator 239
Prioritiza-
tion
Engine
241
User
Activity
Module
215
Traffic Shaping Engine 255
Alignment
Module
256
Batching
Module
257
Connection
Manager 265
Radio
Controller 266
Heartbeat
Manager 267
Network Interface 208
SMS I/F
WiFi I/F
Cellular I/F
Context API
206
Operating
System
204

FIG. 2A

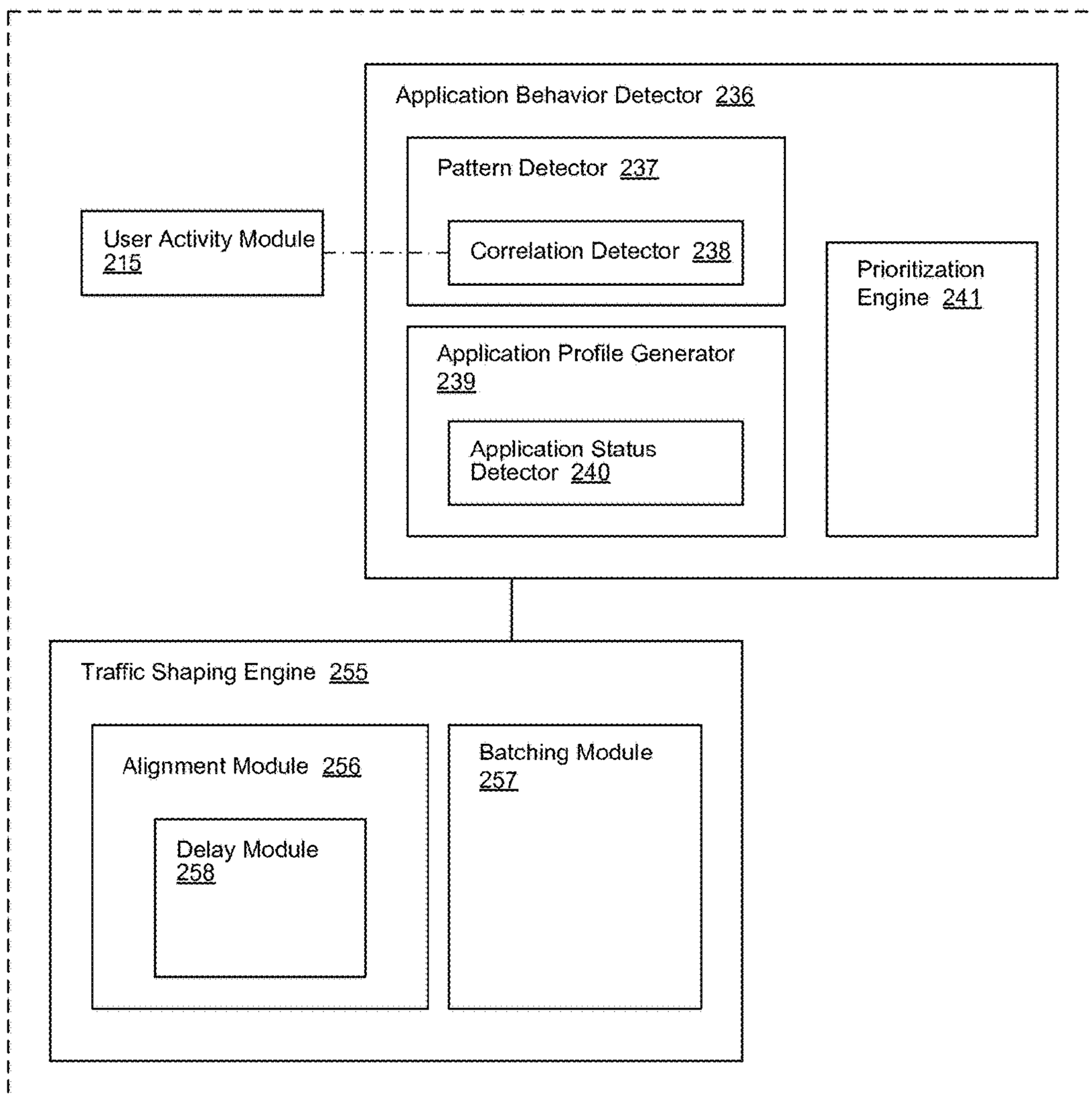
Application Behavior Detector 236
Pattern Detector 237
User Activity Module 215
Correlation Detector 238
Prioritization Engine 241
Application Profile Generator 239
Application Status Detector 240
Traffic Shaping Engine 255
Alignment Module 256
Batching Module 257
Delay Module 258

FIG. 2B

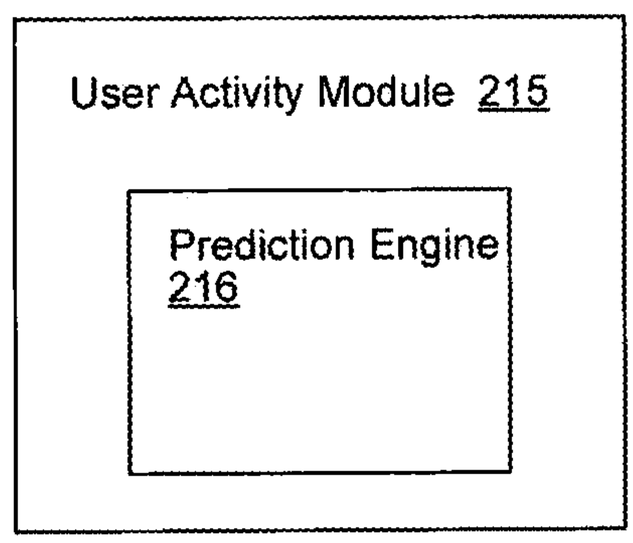

FIG. 2C

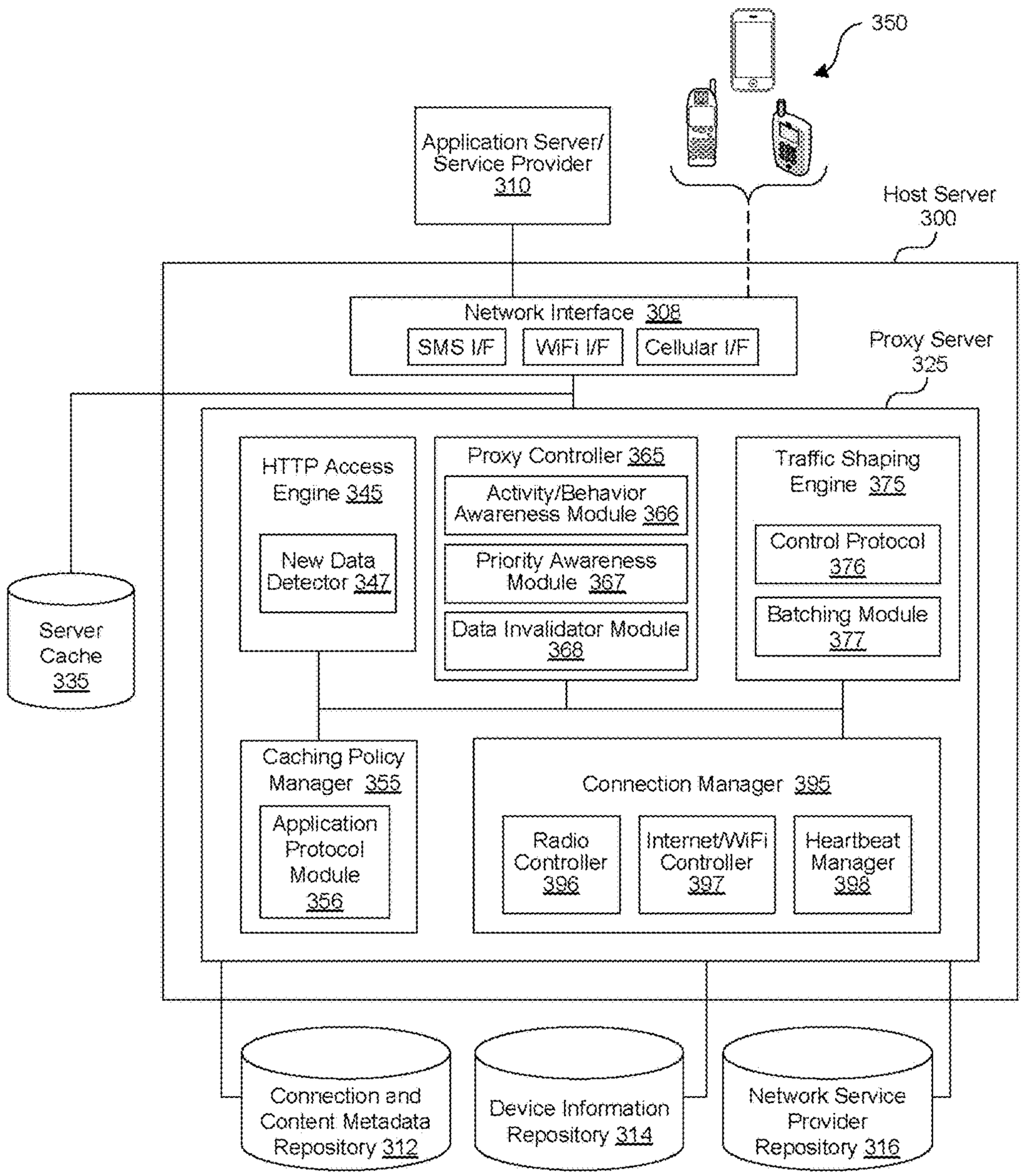
350
Application Server/ Service Provider 310
Host Server 300
Network Interface 308
SMS I/F
WiFi I/F
Cellular I/F
Proxy Server 325
HTTP Access Engine 345
New Data Detector 347
Proxy Controller 365
Activity/Behavior Awareness Module 366
Priority Awareness Module 367
Data Invalidator Module 368
Traffic Shaping Engine 375
Control Protocol 376
Batching Module 377
Server Cache 335
Caching Policy Manager 355
Application Protocol Module 356
Connection Manager 395
Radio Controller 396
Internet/WiFi Controller 397
Heartbeat Manager 398
Connection and Content Metadata Repository 312
Device Information Repository 314
Network Service Provider Repository 316

FIG. 3A

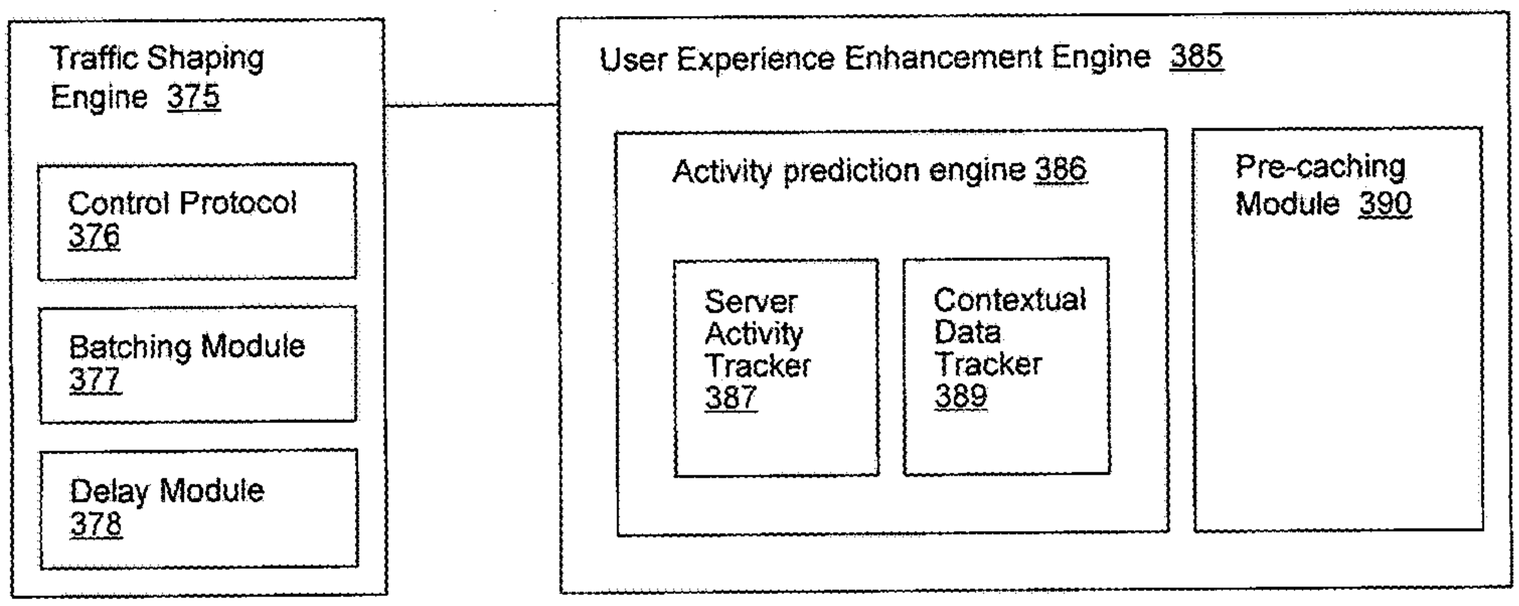
Traffic Shaping Engine 375
Control Protocol 376
Batching Module 377
Delay Module 378
User Experience Enhancement Engine 385
Activity prediction engine 386
Server Activity Tracker 387
Contextual Data Tracker 389
Pre-caching Module 390

FIG. 3B

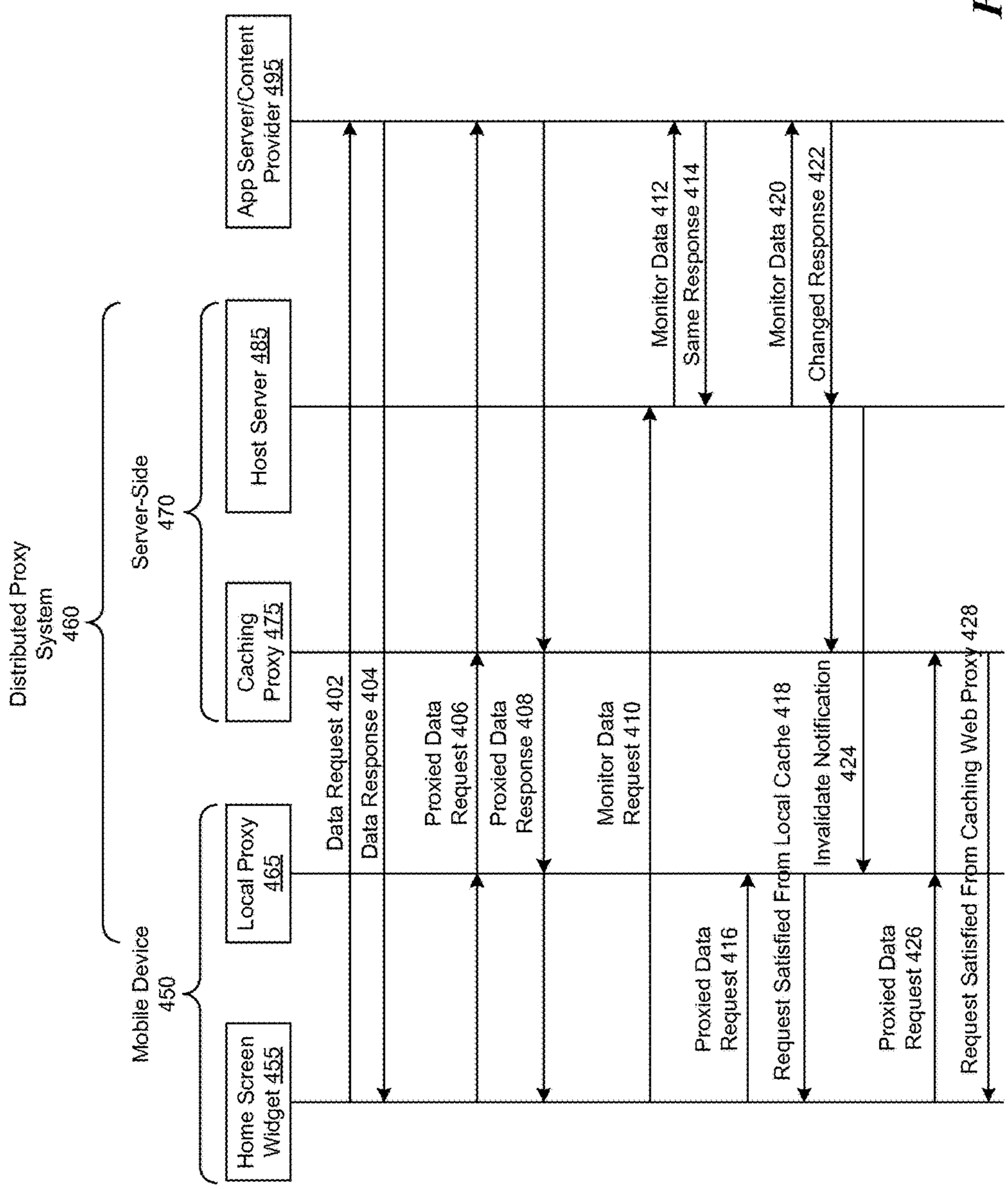
Distributed Proxy System 460
Mobile Device 450
Server-Side 470
Home Screen Widget 455
Local Proxy 465
Caching Proxy 475
Host Server 485
App Server/Content Provider 495
Data Request 402
Data Response 404
Proxied Data Request 406
Proxied Data Response 408
Monitor Data Request 410
Monitor Data 412
Same Response 414
Proxied Data Request 416
Monitor Data 420
Changed Response 422
Request Satisfied From Local Cache 418
Invalidate Notification 424
Proxied Data Request 426
Request Satisfied From Caching Web Proxy 428

FIG. 4A

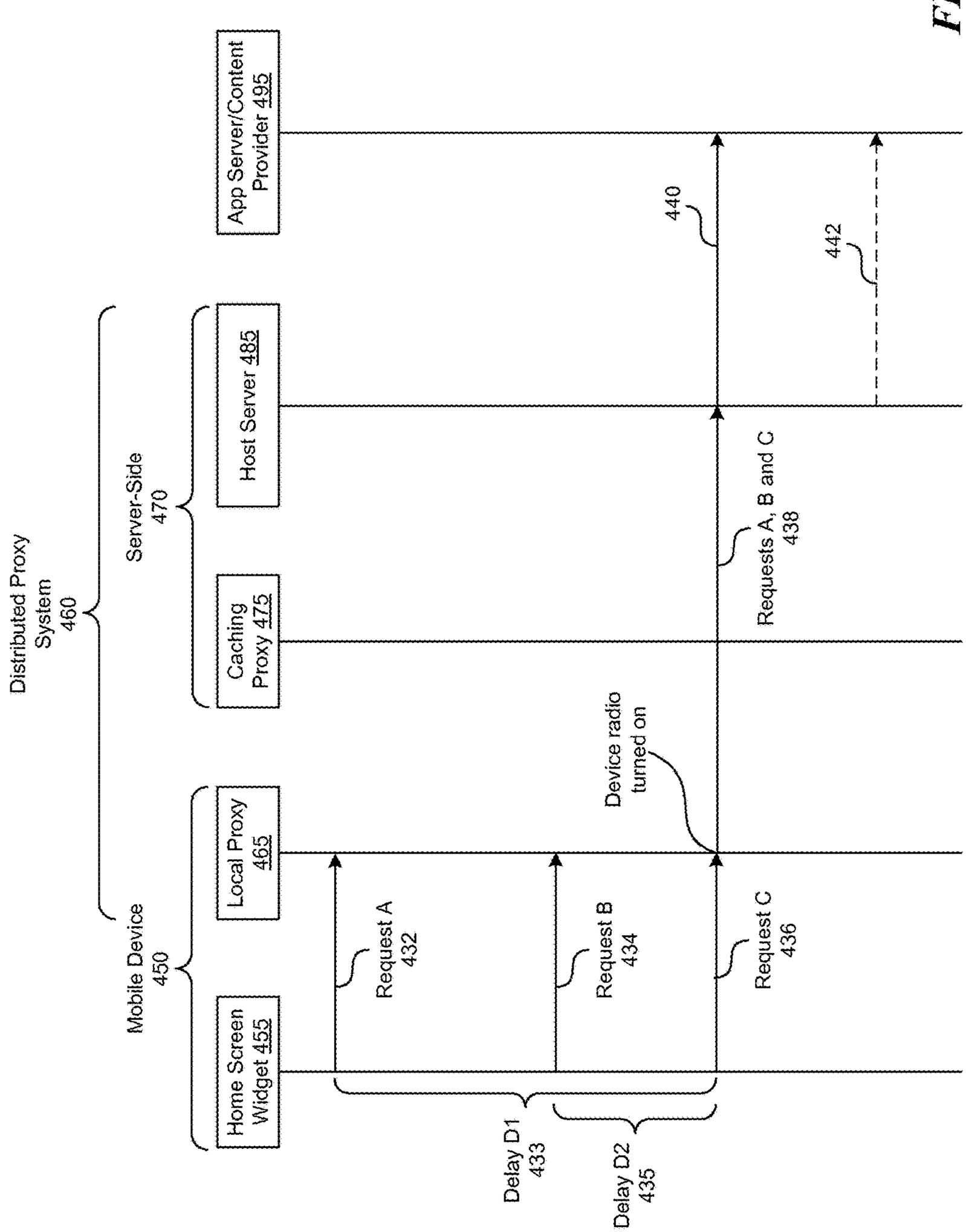
Distributed Proxy System 460
Mobile Device 450
Server-Side 470
Home Screen Widget 455
Local Proxy 465
Caching Proxy 475
Host Server 485
App Server/Content Provider 495
Request A 432
Request B 434
Request C 436
Device radio turned on
Requests A, B and C 438
440
442
Delay D1 433
Delay D2 435

FIG. 4B

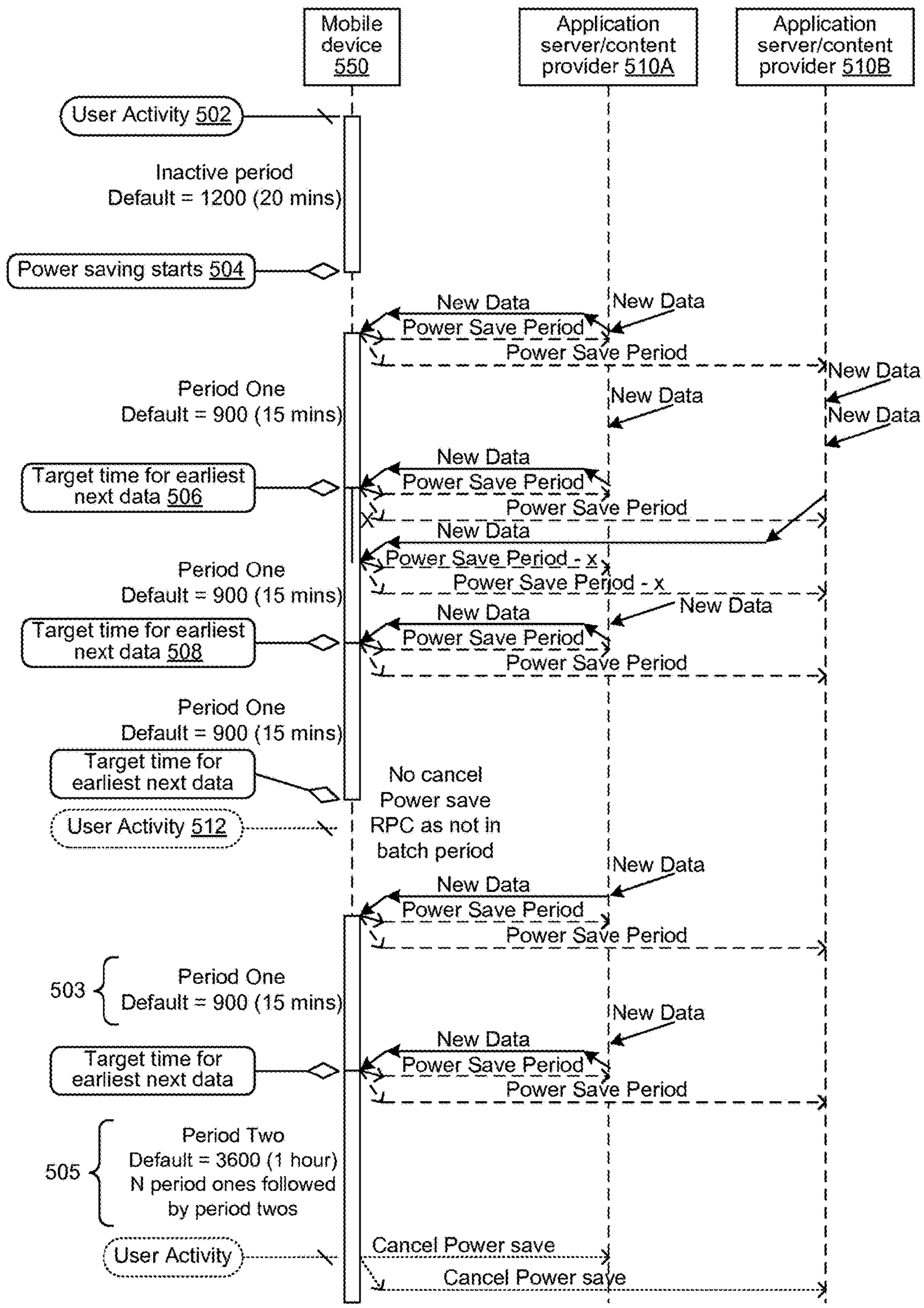
Mobile device 550
Application server/content provider 510A
Application server/content provider 510B
User Activity 502
Inactive period
Default = 1200 (20 mins)
Power saving starts 504
New Data
Power Save Period
Period One
Default = 900 (15 mins)
Target time for earliest next data 506
Power Save Period - x
Target time for earliest next data 508
Target time for earliest next data
User Activity 512
No cancel Power save RPC as not in batch period
503
Period Two
Default = 3600 (1 hour)
N period ones followed by period twos
505
User Activity
Cancel Power save

FIG. 5

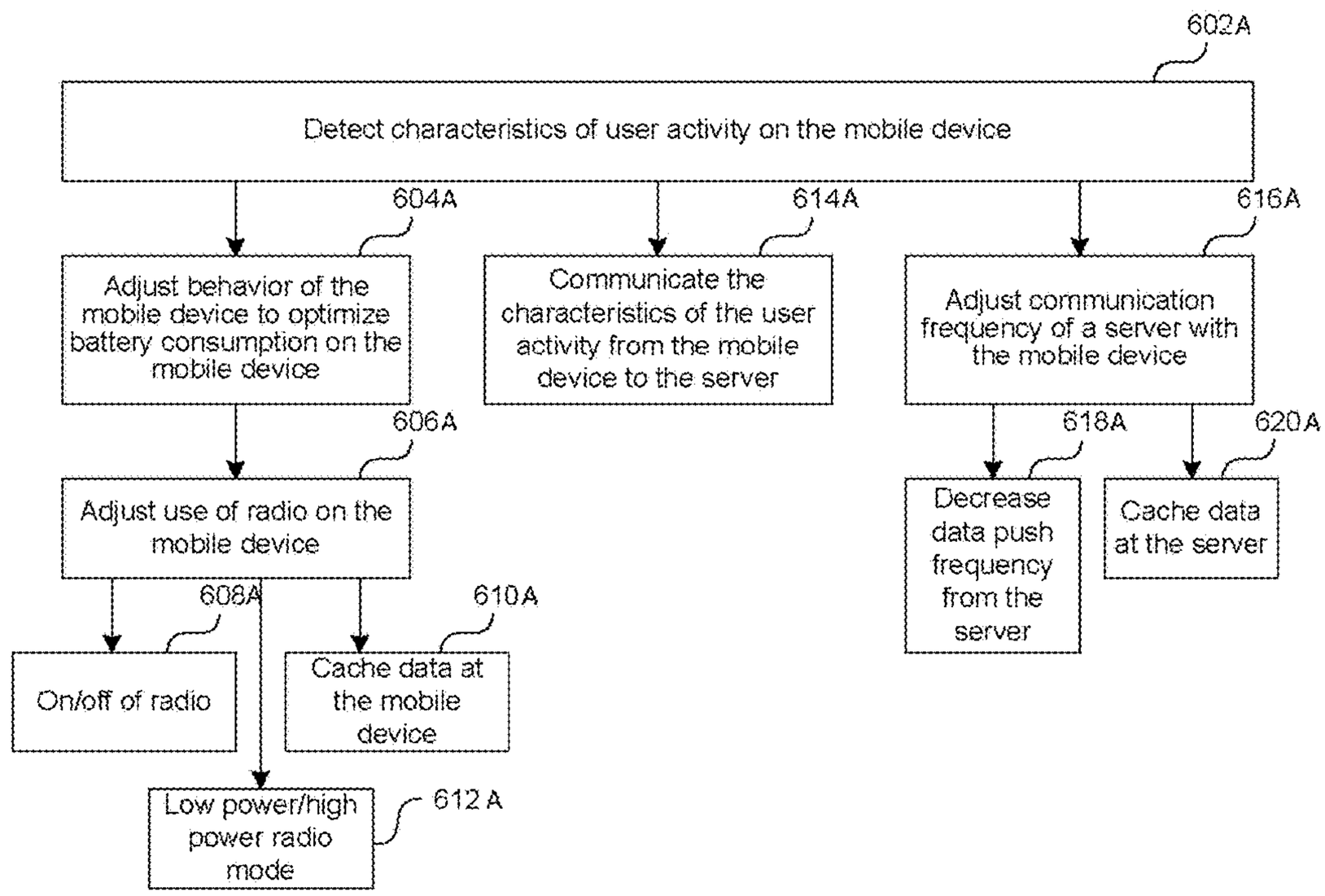
602A
Detect characteristics of user activity on the mobile device
604A
Adjust behavior of the mobile device to optimize battery consumption on the mobile device
614A
Communicate the characteristics of the user activity from the mobile device to the server
616A
Adjust communication frequency of a server with the mobile device
606A
Adjust use of radio on the mobile device
618A
Decrease data push frequency from the server
620A
Cache data at the server
608A
On/off of radio
610A
Cache data at the mobile device
Low power/high power radio mode
612 A

FIG. 6A

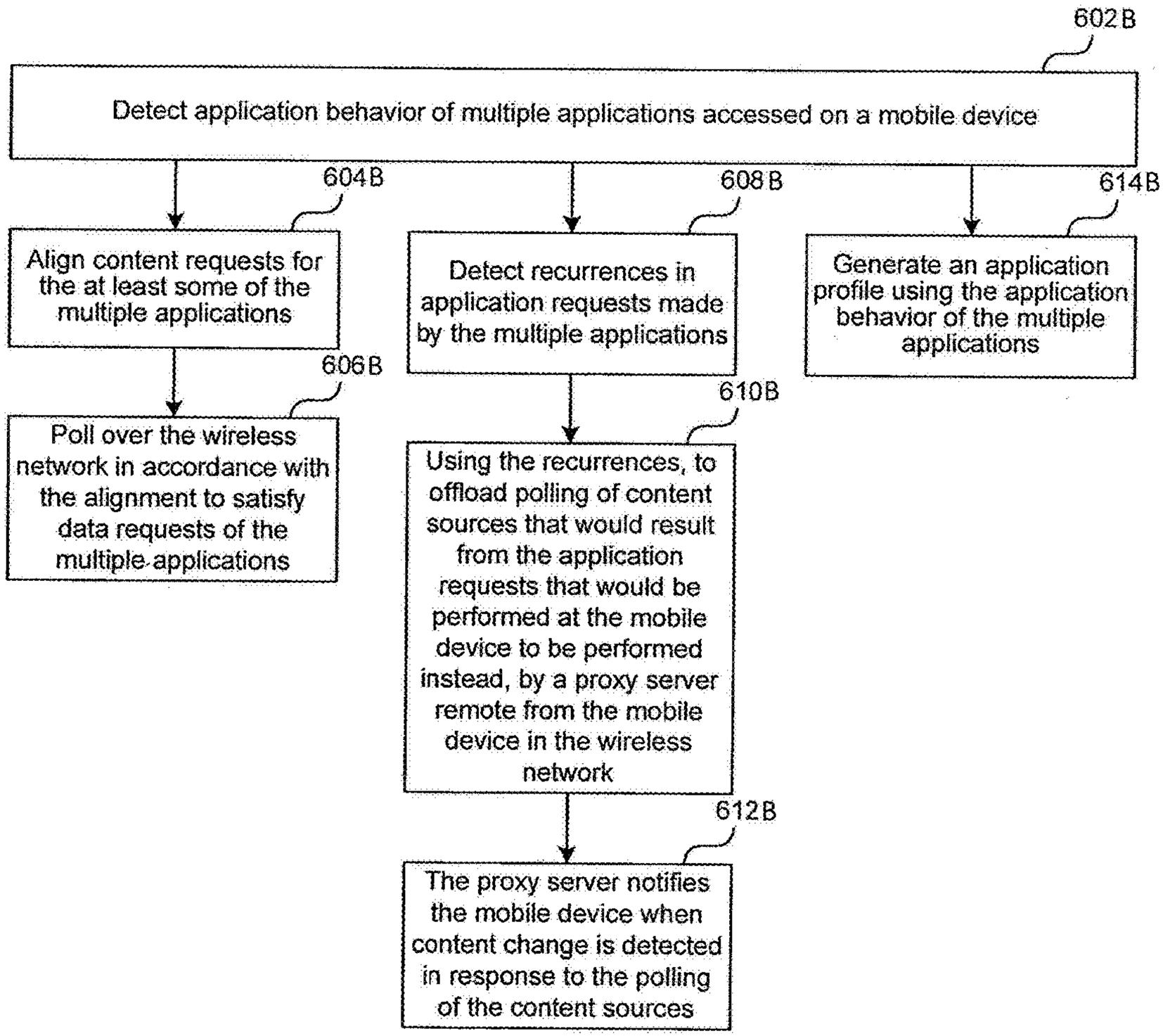
602B
Detect application behavior of multiple applications accessed on a mobile device
604B
Align content requests for the at least some of the multiple applications
606B
Poll over the wireless network in accordance with the alignment to satisfy data requests of the multiple applications
608B
Detect recurrences in application requests made by the multiple applications
610B
Using the recurrences, to offload polling of content sources that would result from the application requests that would be performed at the mobile device to be performed instead, by a proxy server remote from the mobile device in the wireless network
612B
The proxy server notifies the mobile device when content change is detected in response to the polling of the content sources
614B
Generate an application profile using the application behavior of the multiple applications

FIG. 6B

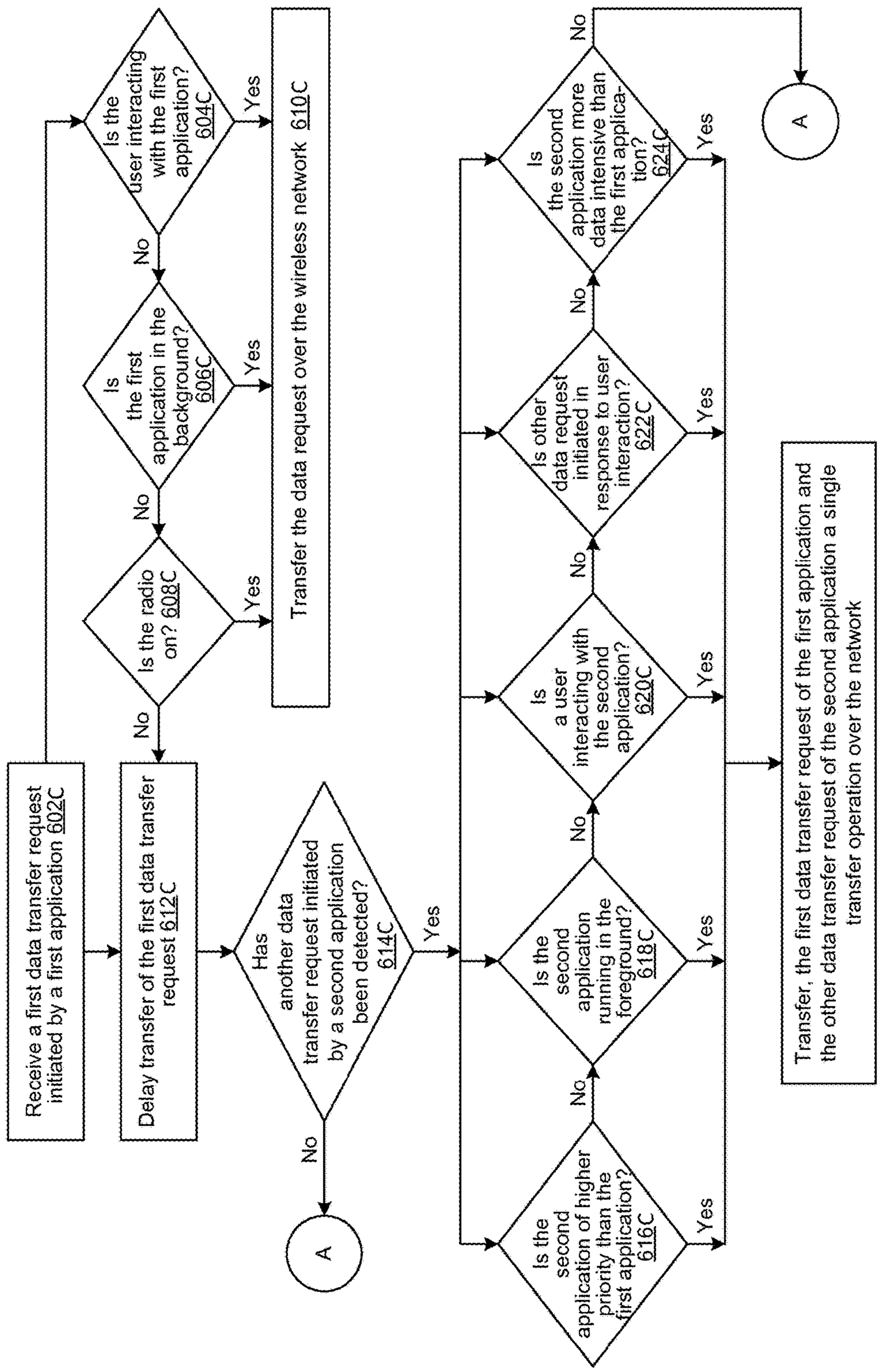
Receive a first data transfer request initiated by a first application 602C
Is the user interacting with the first application? 604C
Yes
No
Is the first application in the background? 606C
Yes
No
Is the radio on? 608C
Yes
No
Transfer the data request over the wireless network 610C
Delay transfer of the first data transfer request 612C
Has another data transfer request initiated by a second application been detected? 614C
Yes
No
A
Is the second application of higher priority than the first application? 616C
Yes
No
Is the second application running in the foreground? 618C
Yes
No
Is a user interacting with the second application? 620C
Yes
No
Is other data request initiated in response to user interaction? 622C
Yes
No
Is the second application more data intensive than the first application? 624C
Yes
No
A
Transfer, the first data transfer request of the first application and the other data transfer request of the second application a single transfer operation over the network

FIG. 6C

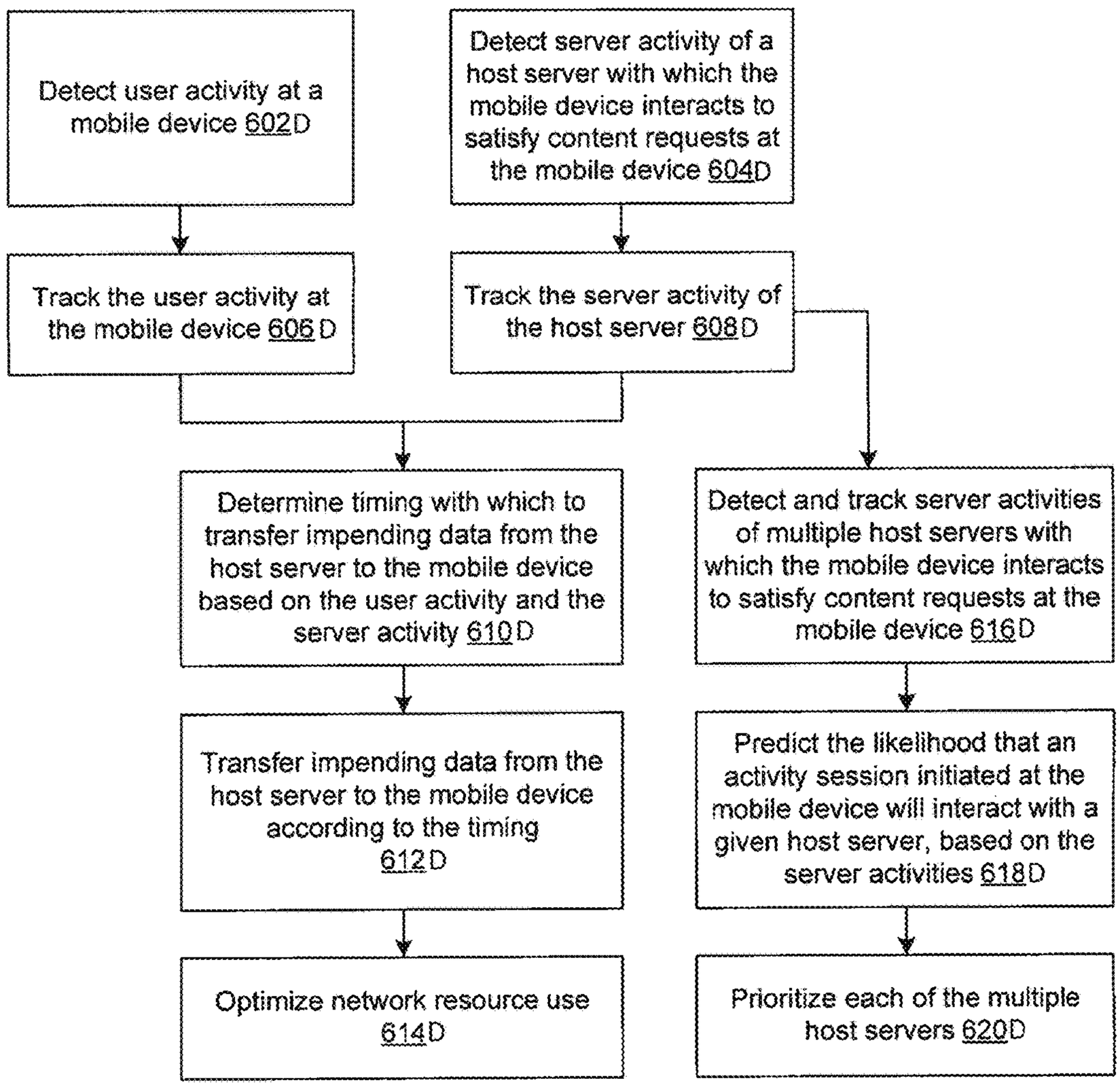
Detect user activity at a mobile device 602D
Detect server activity of a host server with which the mobile device interacts to satisfy content requests at the mobile device 604D
Track the user activity at the mobile device 606D
Track the server activity of the host server 608D
Determine timing with which to transfer impending data from the host server to the mobile device based on the user activity and the server activity 610D
Detect and track server activities of multiple host servers with which the mobile device interacts to satisfy content requests at the mobile device 616D
Transfer impending data from the host server to the mobile device according to the timing 612D
Predict the likelihood that an activity session initiated at the mobile device will interact with a given host server, based on the server activities 618D
Optimize network resource use 614D
Prioritize each of the multiple host servers 620D

FIG. 6D

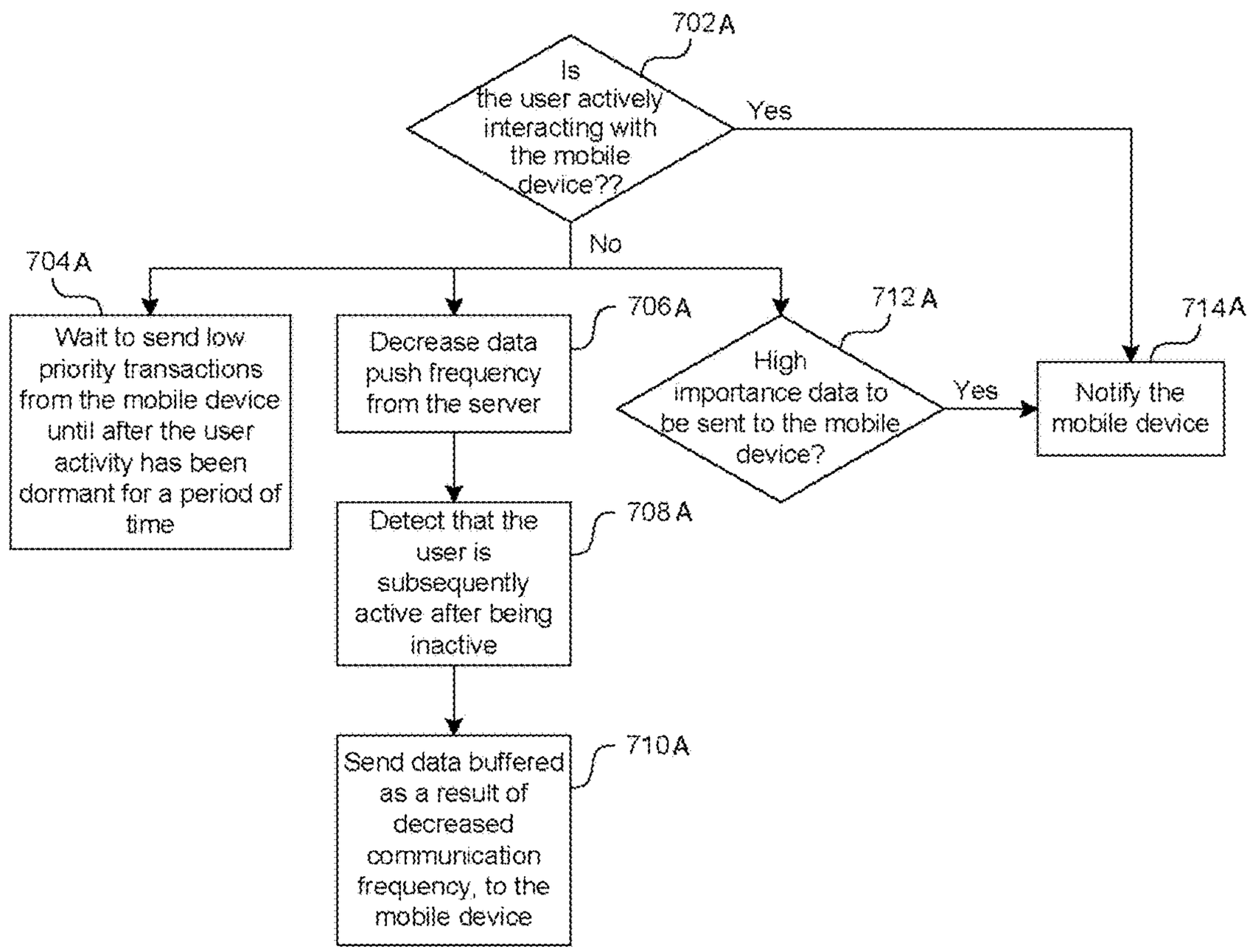
702A
Is the user actively interacting with the mobile device??
Yes
No
704A
Wait to send low priority transactions from the mobile device until after the user activity has been dormant for a period of time
706A
Decrease data push frequency from the server
712A
High importance data to be sent to the mobile device?
Yes
714A
Notify the mobile device
708A
Detect that the user is subsequently active after being inactive
710A
Send data buffered as a result of decreased communication frequency, to the mobile device

FIG. 7A

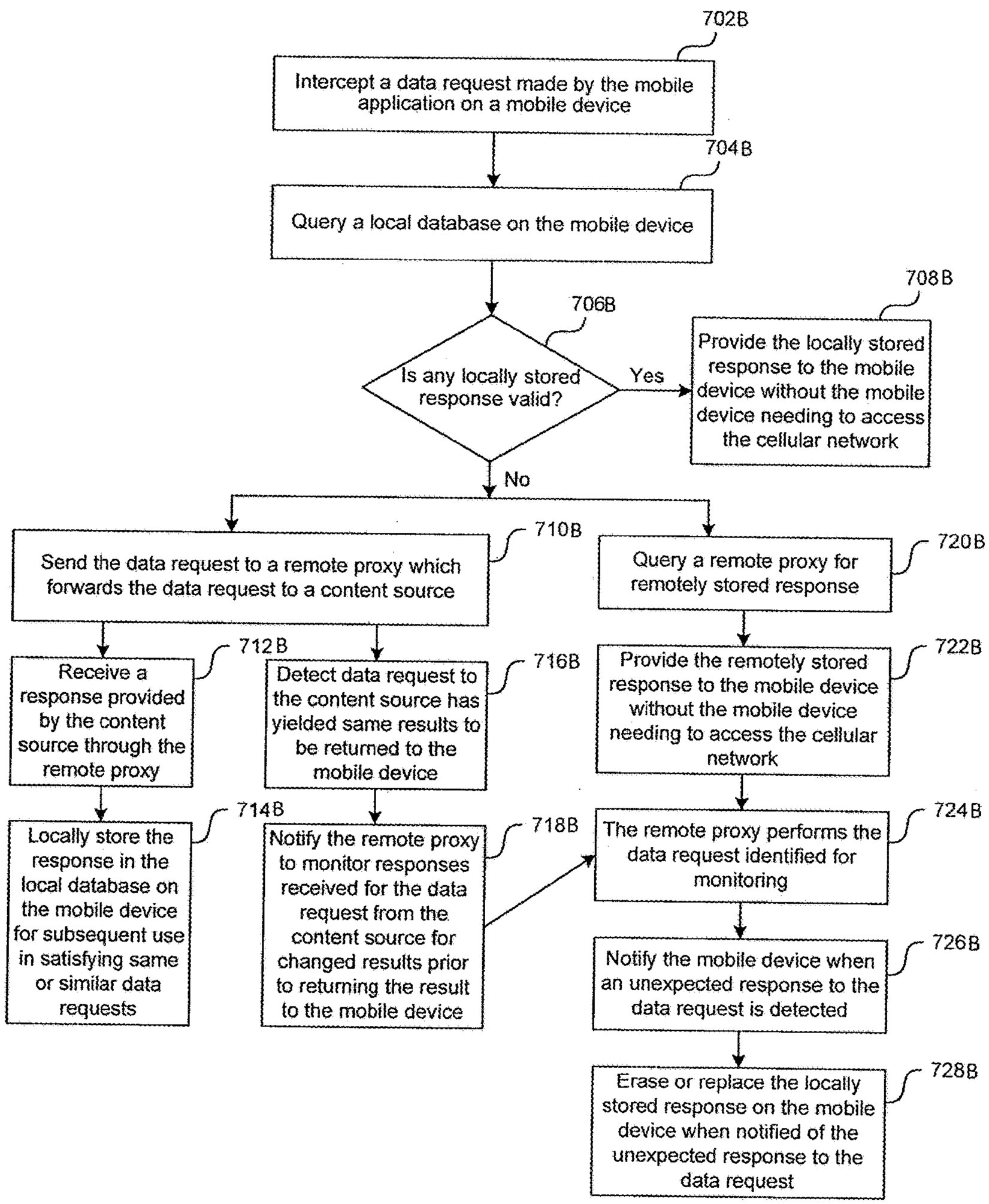
702B
Intercept a data request made by the mobile application on a mobile device
704B
Query a local database on the mobile device
706B
Is any locally stored response valid?
Yes
708B
Provide the locally stored response to the mobile device without the mobile device needing to access the cellular network
No
710B
Send the data request to a remote proxy which forwards the data request to a content source
720B
Query a remote proxy for remotely stored response
712B
Receive a response provided by the content source through the remote proxy
716B
Detect data request to the content source has yielded same results to be returned to the mobile device
722B
Provide the remotely stored response to the mobile device without the mobile device needing to access the cellular network
714B
Locally store the response in the local database on the mobile device for subsequent use in satisfying same or similar data requests
718B
Notify the remote proxy to monitor responses received for the data request from the content source for changed results prior to returning the result to the mobile device
724B
The remote proxy performs the data request identified for monitoring
726B
Notify the mobile device when an unexpected response to the data request is detected
728B
Erase or replace the locally stored response on the mobile device when notified of the unexpected response to the data request

FIG. 7B

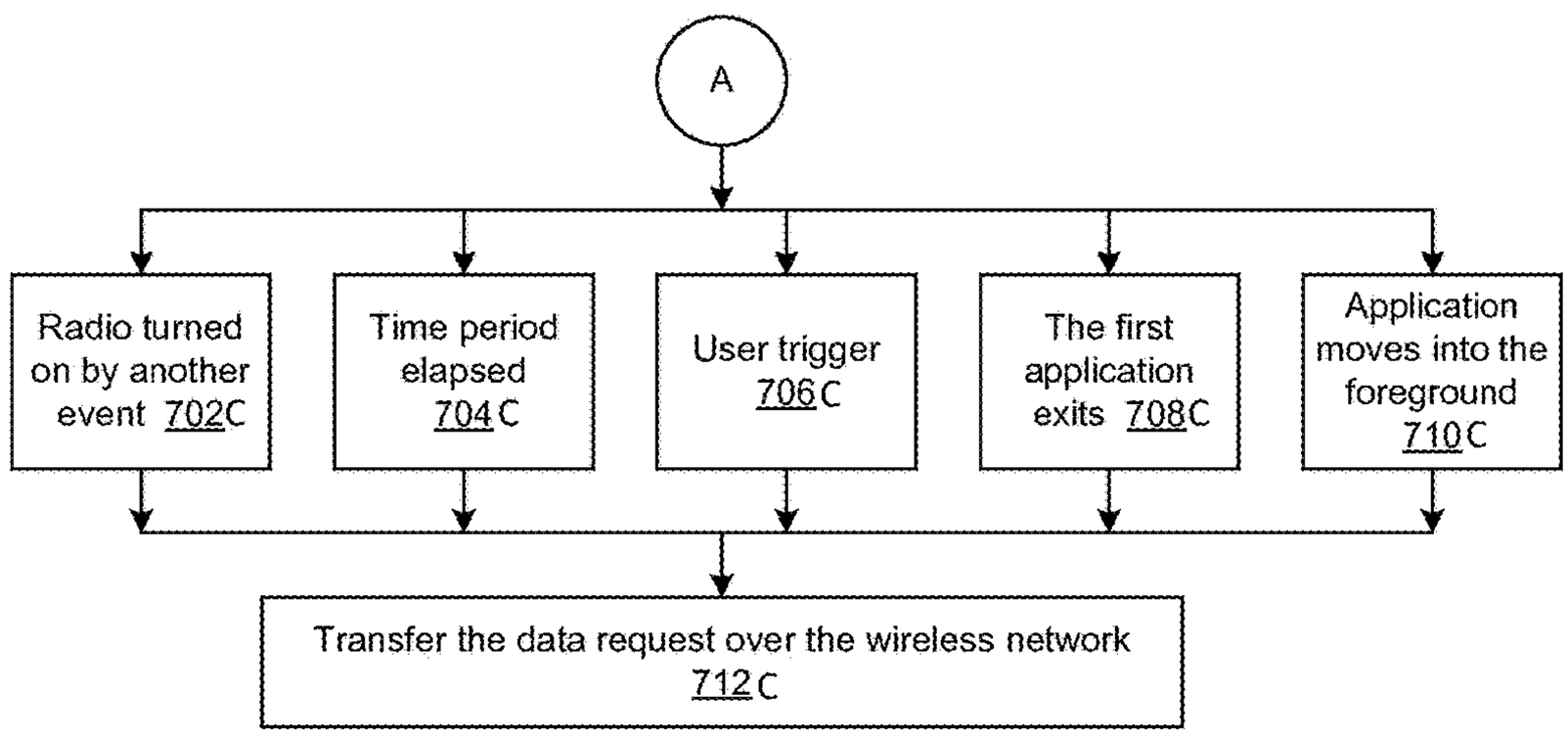
A
Radio turned on by another event 702C
Time period elapsed 704C
User trigger 706C
The first application exits 708C
Application moves into the foreground 710C
Transfer the data request over the wireless network 712C

FIG. 7C

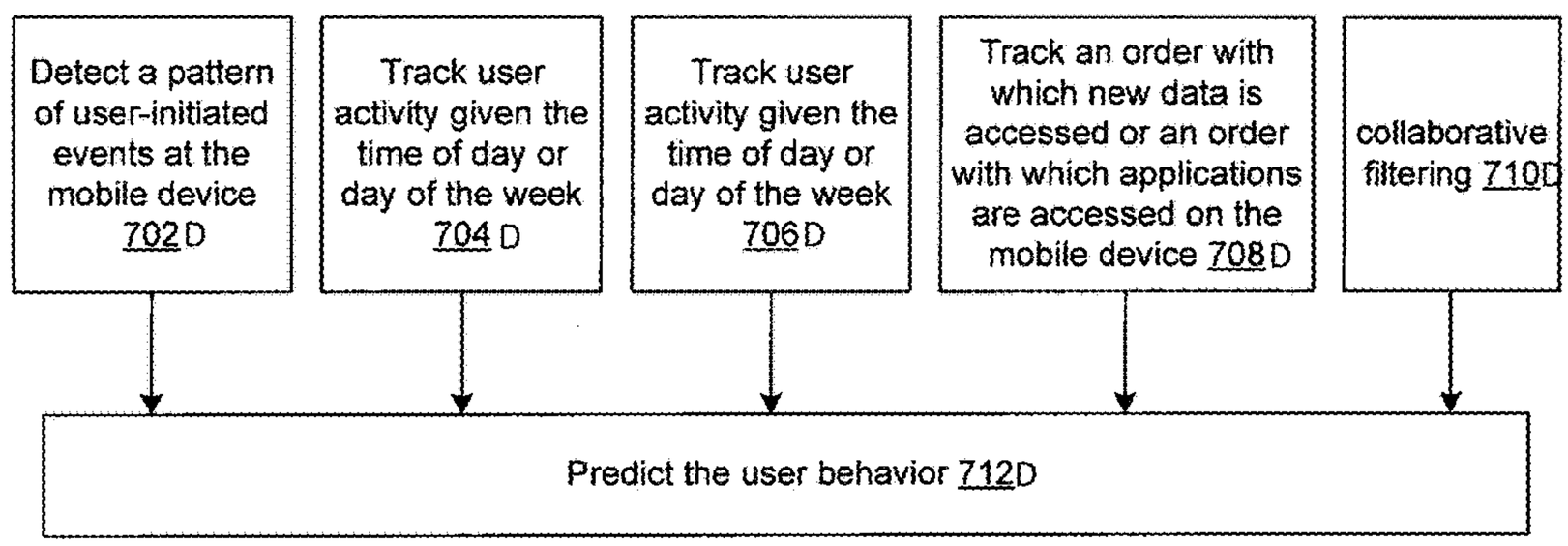
Detect a pattern of user-initiated events at the mobile device 702D
Track user activity given the time of day or day of the week 704 D
Track user activity given the time of day or day of the week 706D
Track an order with which new data is accessed or an order with which applications are accessed on the mobile device 708D
collaborative filtering 710D
Predict the user behavior 712D

FIG. 7D

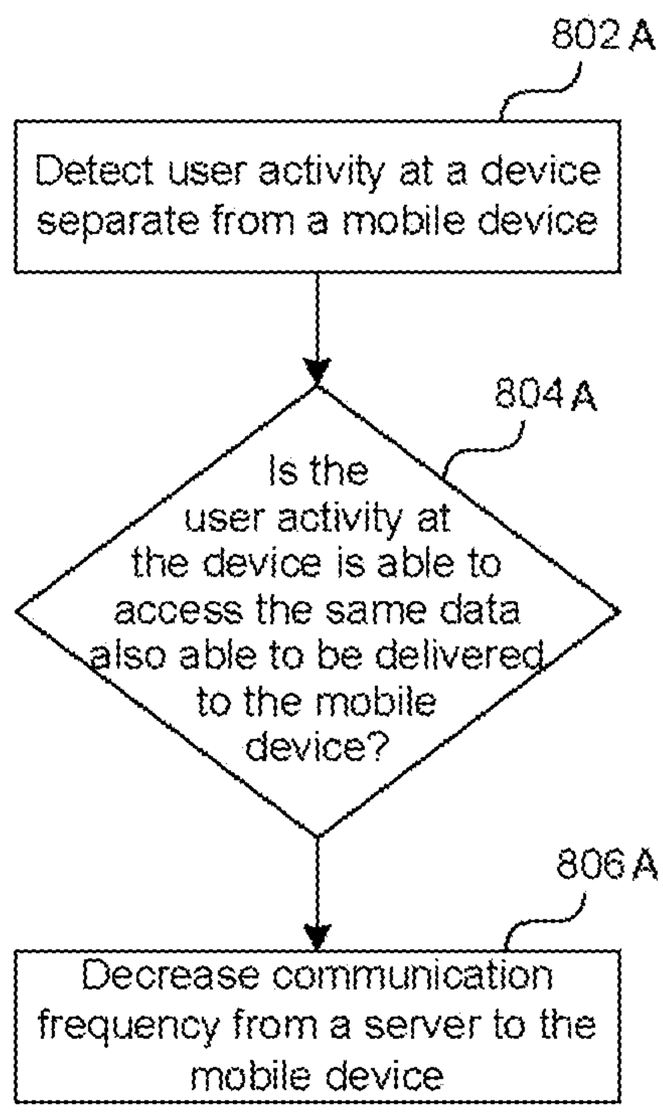
802 A
Detect user activity at a device separate from a mobile device
804 A
Is the user activity at the device is able to access the same data also able to be delivered to the mobile device?
806 A
Decrease communication frequency from a server to the mobile device

FIG. 8A

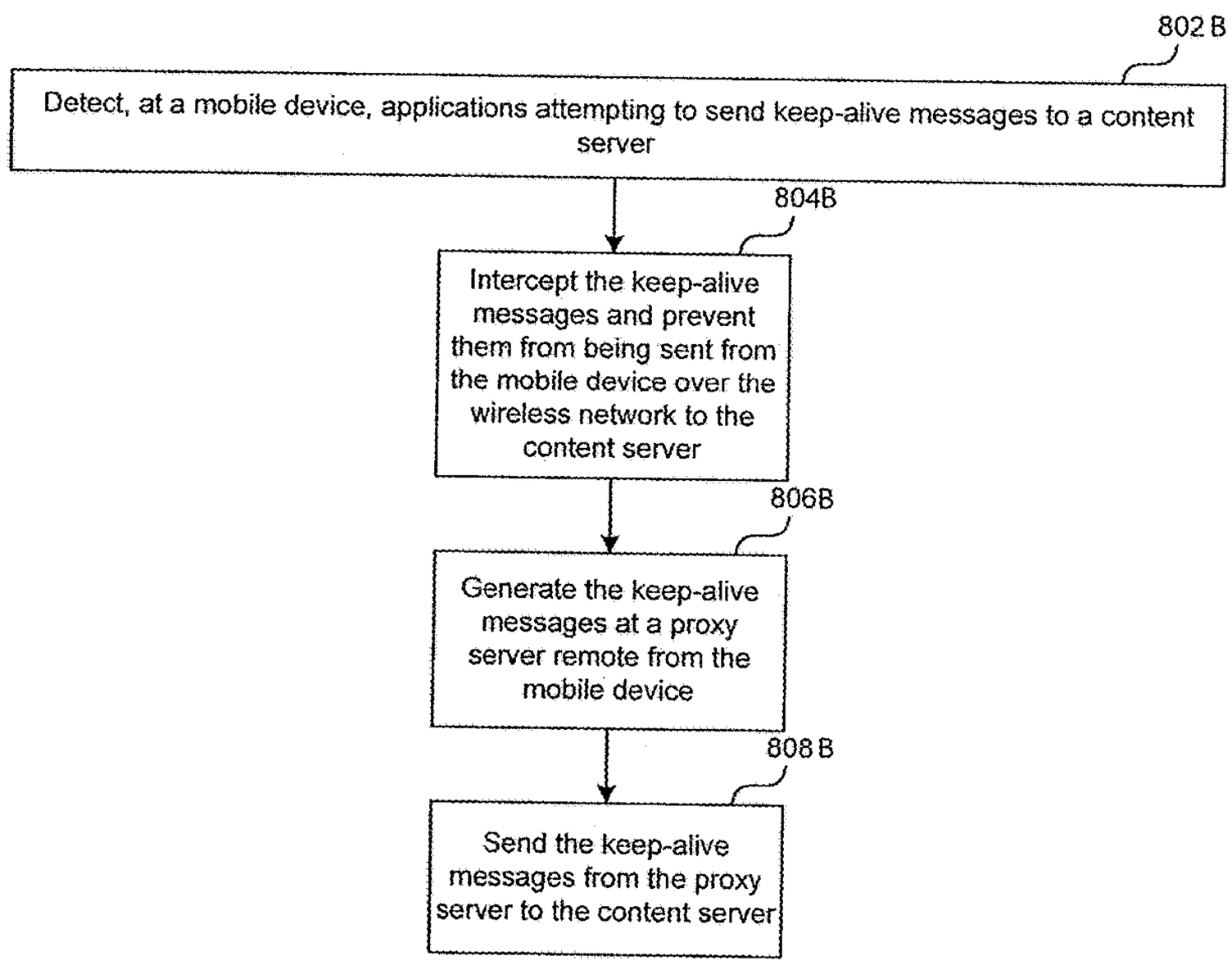
802 B
Detect, at a mobile device, applications attempting to send keep-alive messages to a content server
804B
Intercept the keep-alive messages and prevent them from being sent from the mobile device over the wireless network to the content server
806B
Generate the keep-alive messages at a proxy server remote from the mobile device
808 B
Send the keep-alive messages from the proxy server to the content server

FIG. 8B

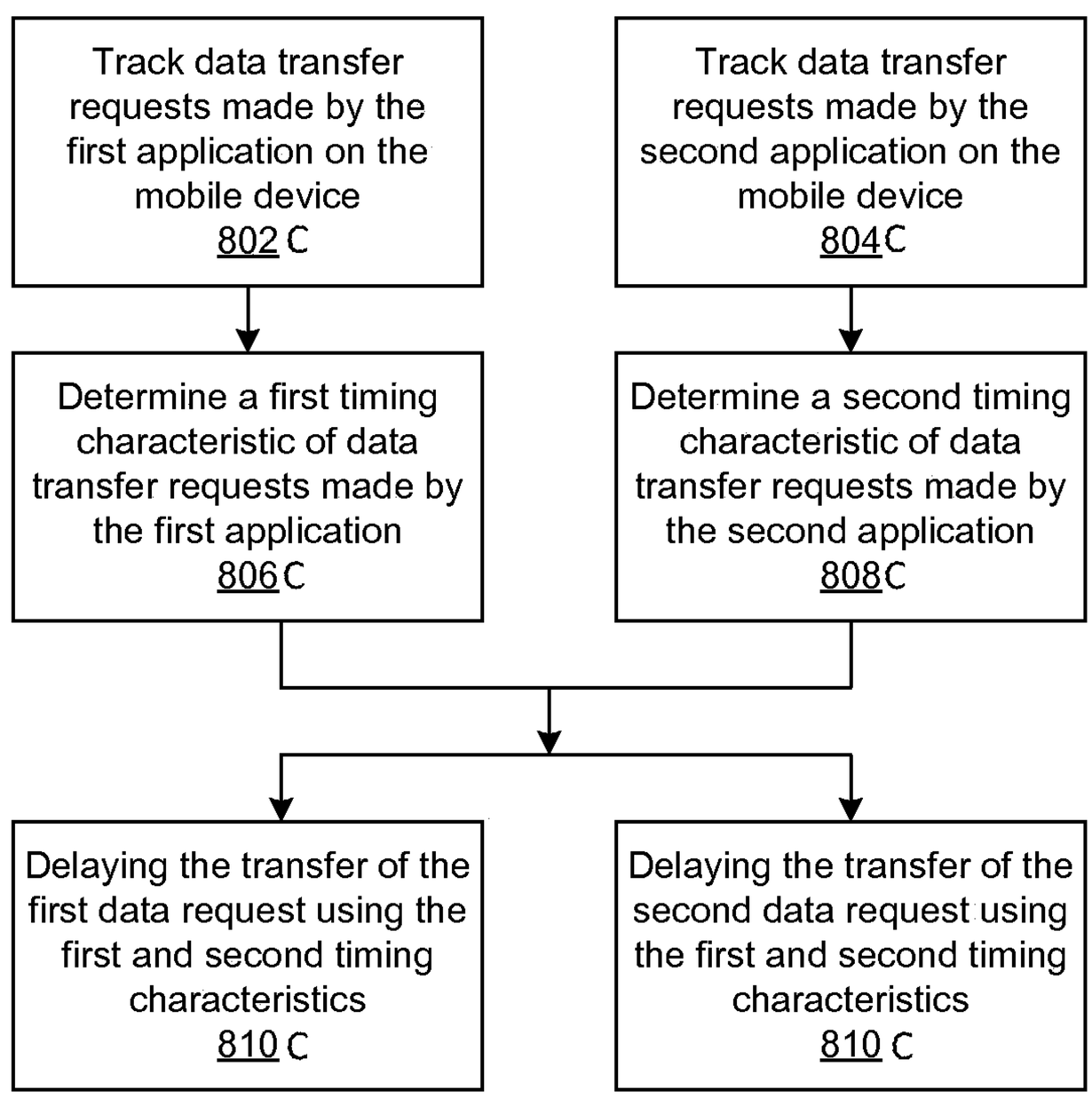
Track data transfer requests made by the first application on the mobile device
802C
Track data transfer requests made by the second application on the mobile device
804C
Determine a first timing characteristic of data transfer requests made by the first application
806C
Determine a second timing characteristic of data transfer requests made by the second application
808C
Delaying the transfer of the first data request using the first and second timing characteristics
810C
Delaying the transfer of the second data request using the first and second timing characteristics
810C

FIG. 8C

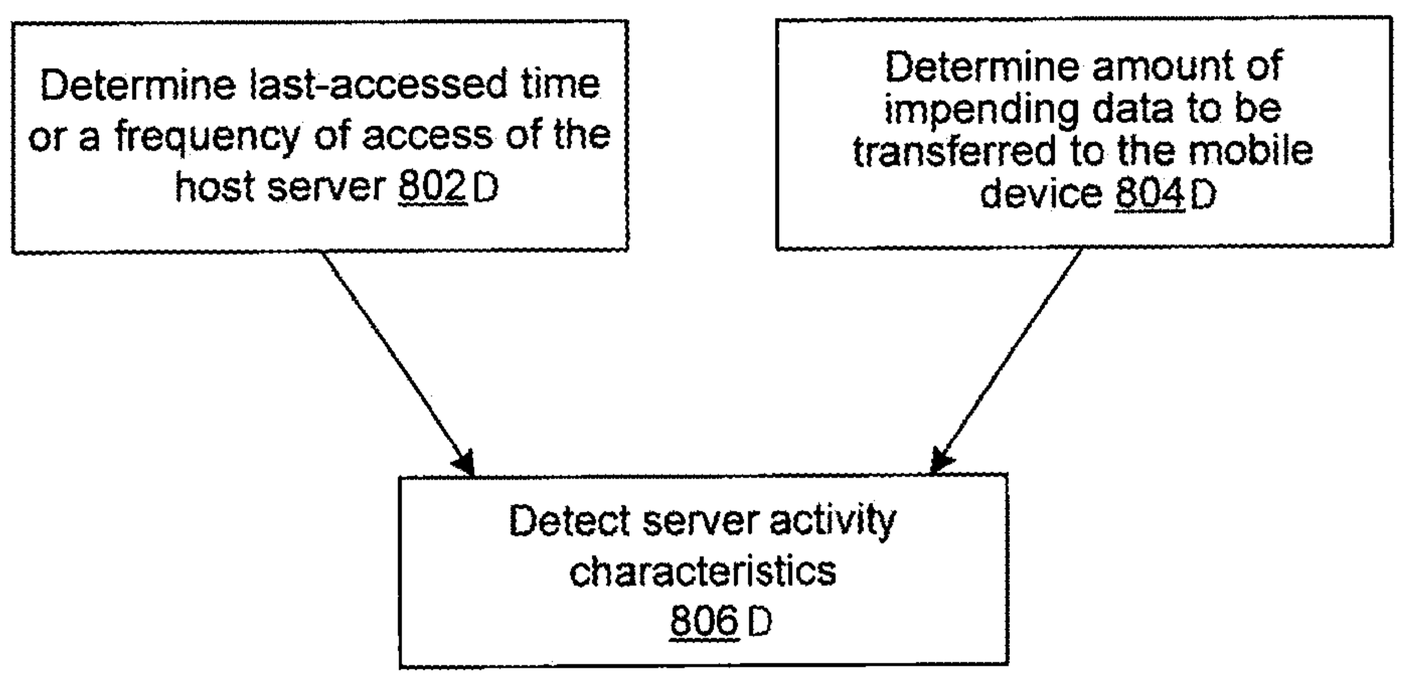
Determine last-accessed time or a frequency of access of the host server 802D
Determine amount of impending data to be transferred to the mobile device 804D
Detect server activity characteristics 806D

FIG. 8D

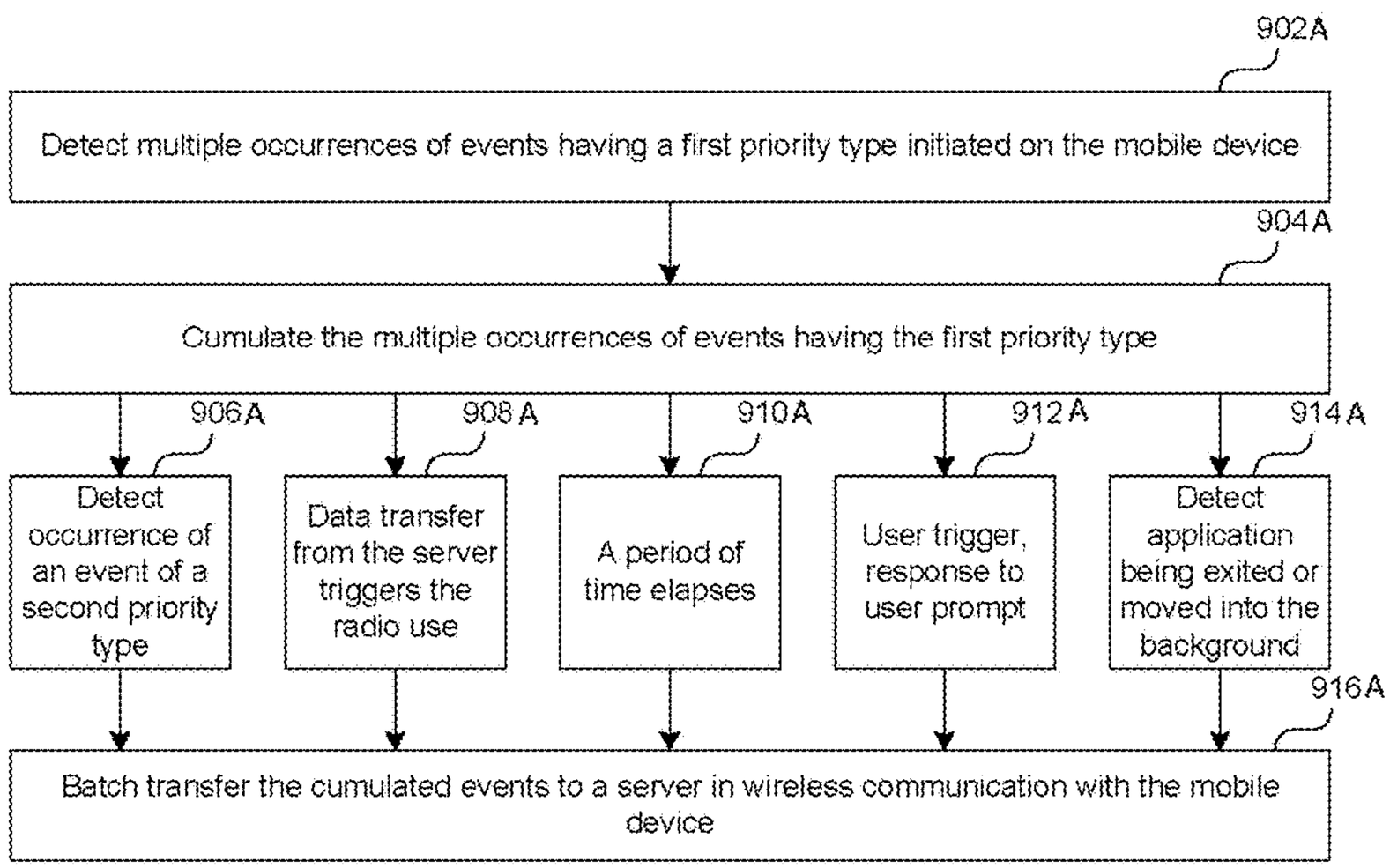
902A
Detect multiple occurrences of events having a first priority type initiated on the mobile device
904A
Cumulate the multiple occurrences of events having the first priority type
906A
908A
910A
912A
914A
Detect occurrence of an event of a second priority type
Data transfer from the server triggers the radio use
A period of time elapses
User trigger, response to user prompt
Detect application being exited or moved into the background
916A
Batch transfer the cumulated events to a server in wireless communication with the mobile device

FIG. 9A

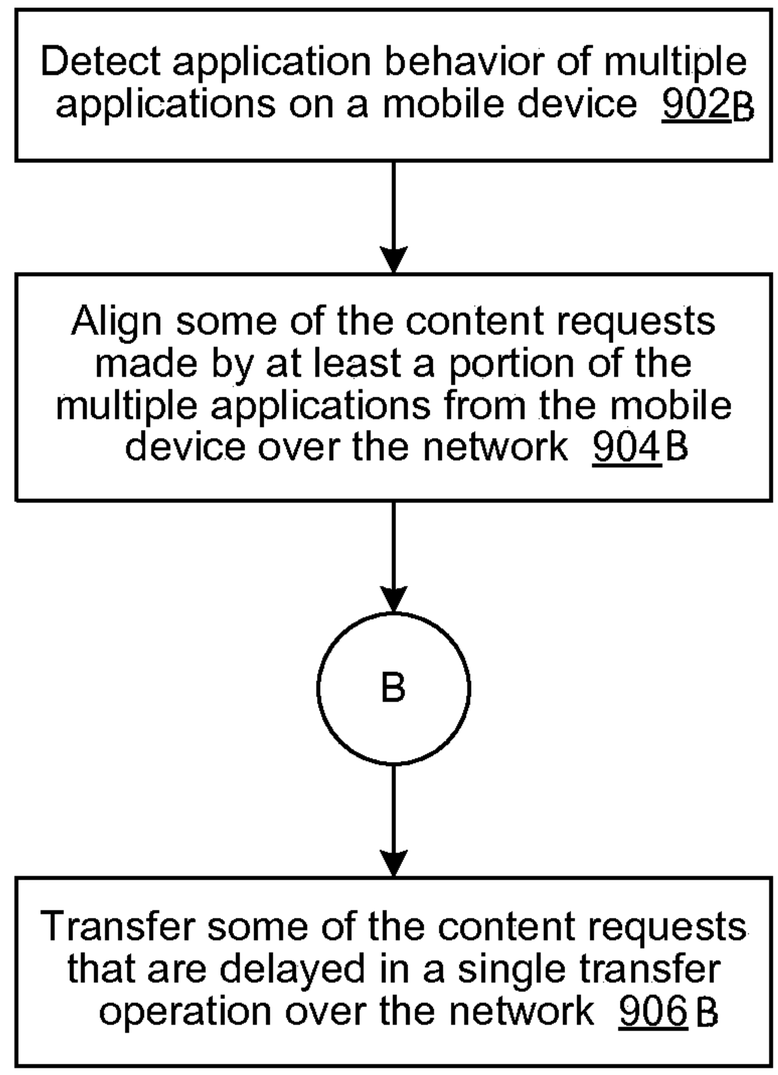
Detect application behavior of multiple applications on a mobile device 902B
Align some of the content requests made by at least a portion of the multiple applications from the mobile device over the network 904B
B
Transfer some of the content requests that are delayed in a single transfer operation over the network 906B

FIG. 9B

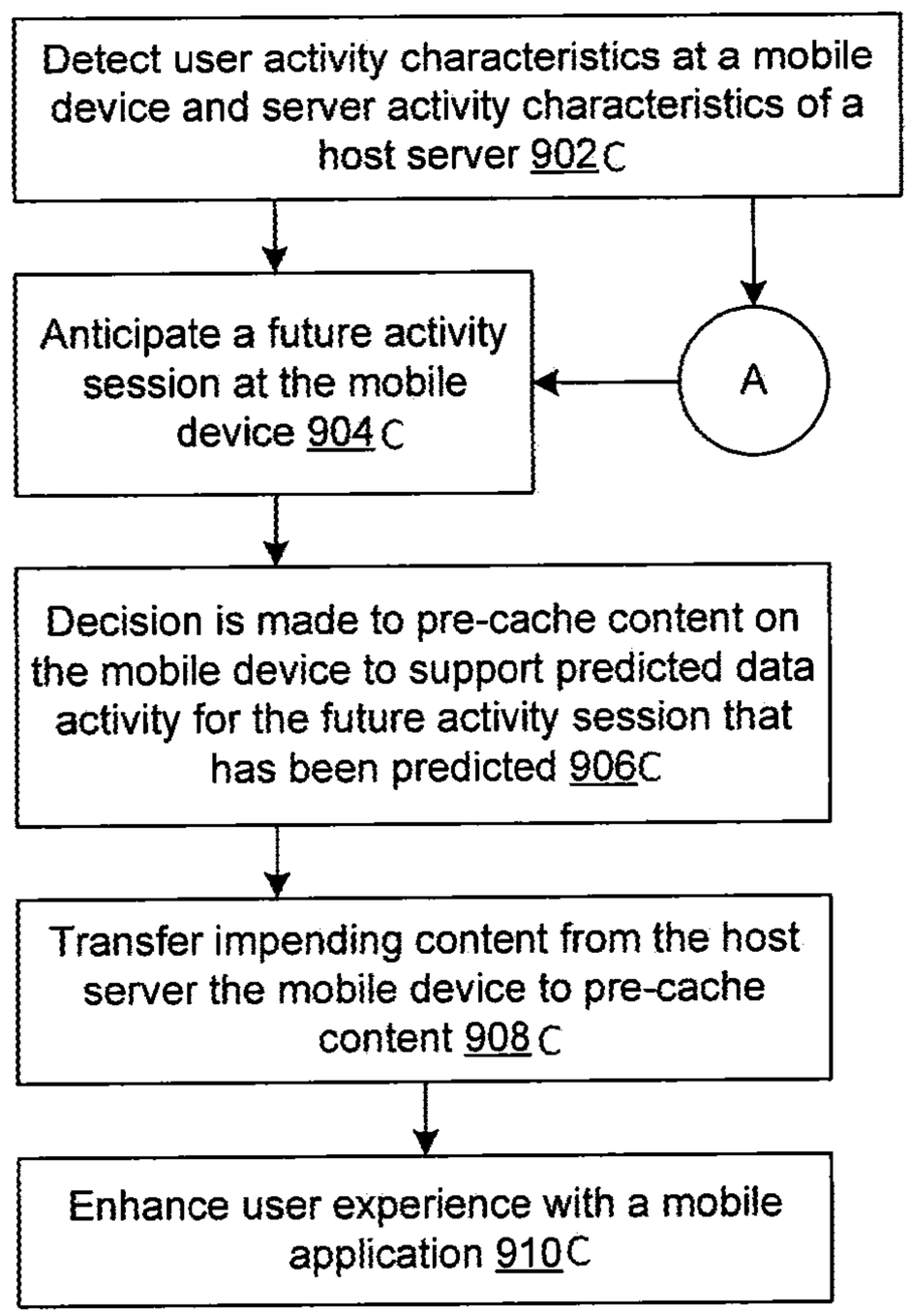
Detect user activity characteristics at a mobile device and server activity characteristics of a host server 902C
Anticipate a future activity session at the mobile device 904C
A
Decision is made to pre-cache content on the mobile device to support predicted data activity for the future activity session that has been predicted 906C
Transfer impending content from the host server the mobile device to pre-cache content 908C
Enhance user experience with a mobile application 910C

FIG. 9C

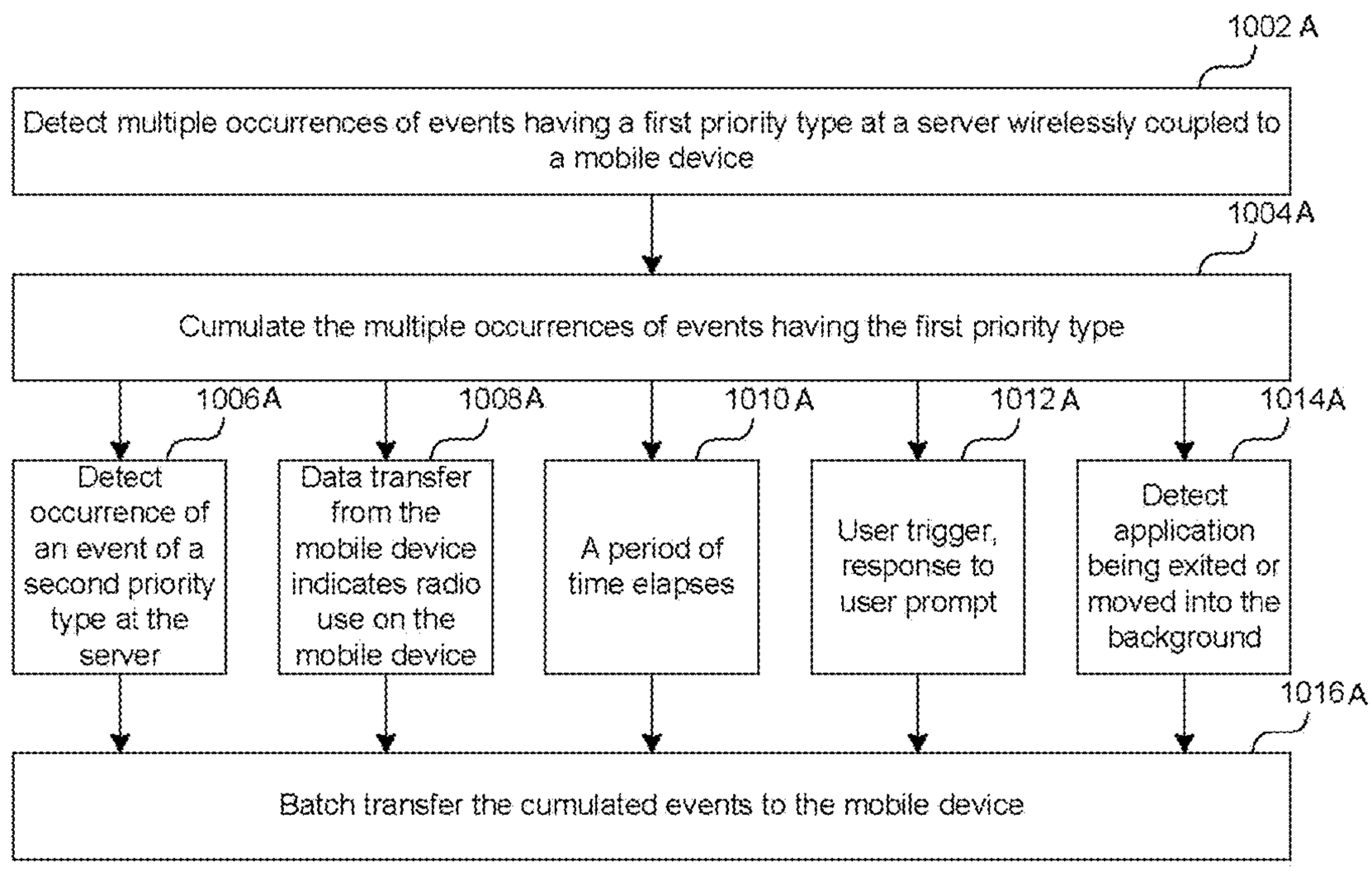
1002 A
Detect multiple occurrences of events having a first priority type at a server wirelessly coupled to a mobile device
1004 A
Cumulate the multiple occurrences of events having the first priority type
1006A
1008A
1010 A
1012 A
1014A
Detect occurrence of an event of a second priority type at the server
Data transfer from the mobile device indicates radio use on the mobile device
A period of time elapses
User trigger, response to user prompt
Detect application being exited or moved into the background
1016A
Batch transfer the cumulated events to the mobile device

FIG. 10A

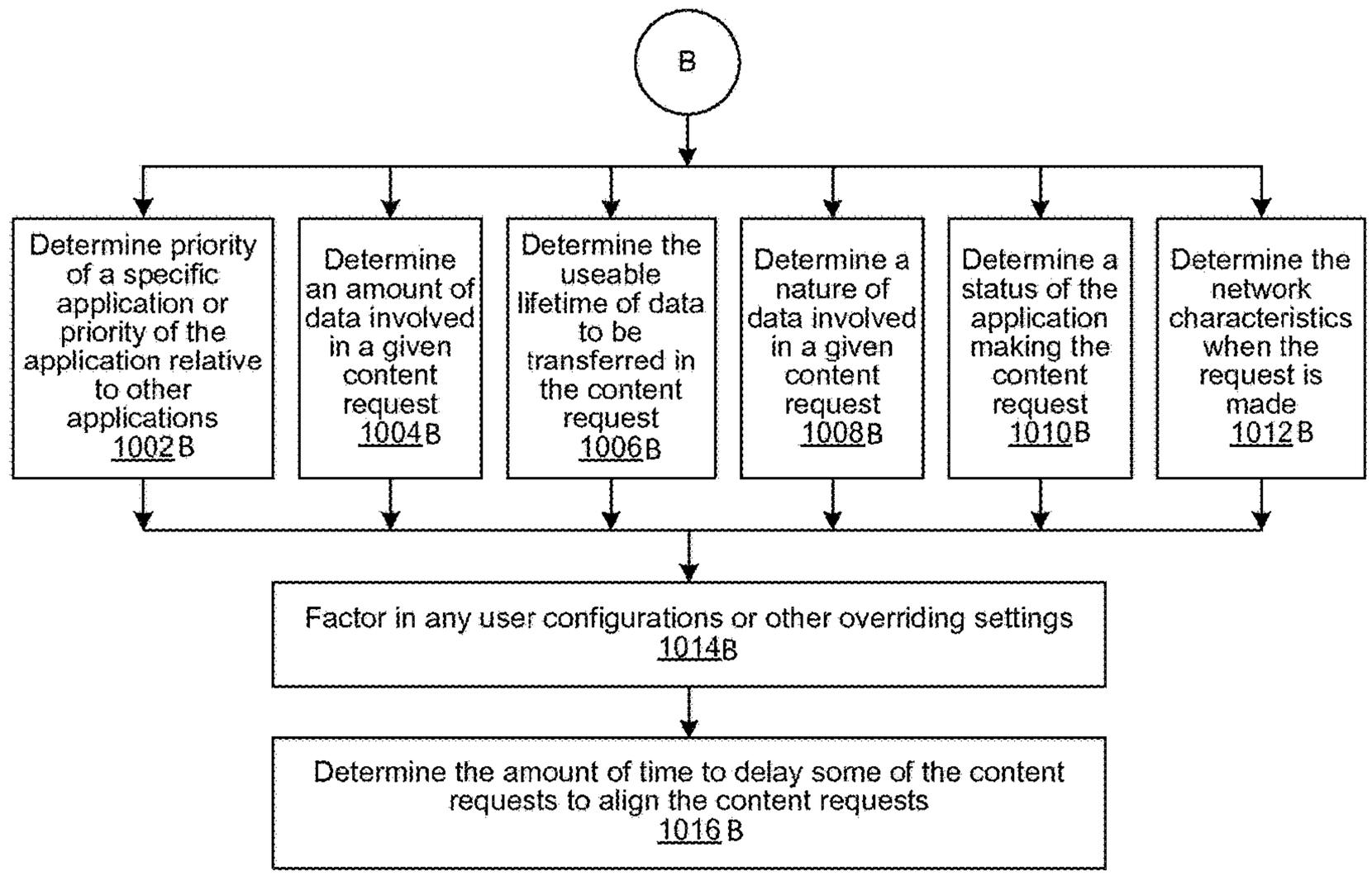
B
Determine priority of a specific application or priority of the application relative to other applications 1002B
Determine an amount of data involved in a given content request 1004B
Determine the useable lifetime of data to be transferred in the content request 1006B
Determine a nature of data involved in a given content request 1008B
Determine a status of the application making the content request 1010B
Determine the network characteristics when the request is made 1012B
Factor in any user configurations or other overriding settings 1014B
Determine the amount of time to delay some of the content requests to align the content requests 1016B

FIG. 10B

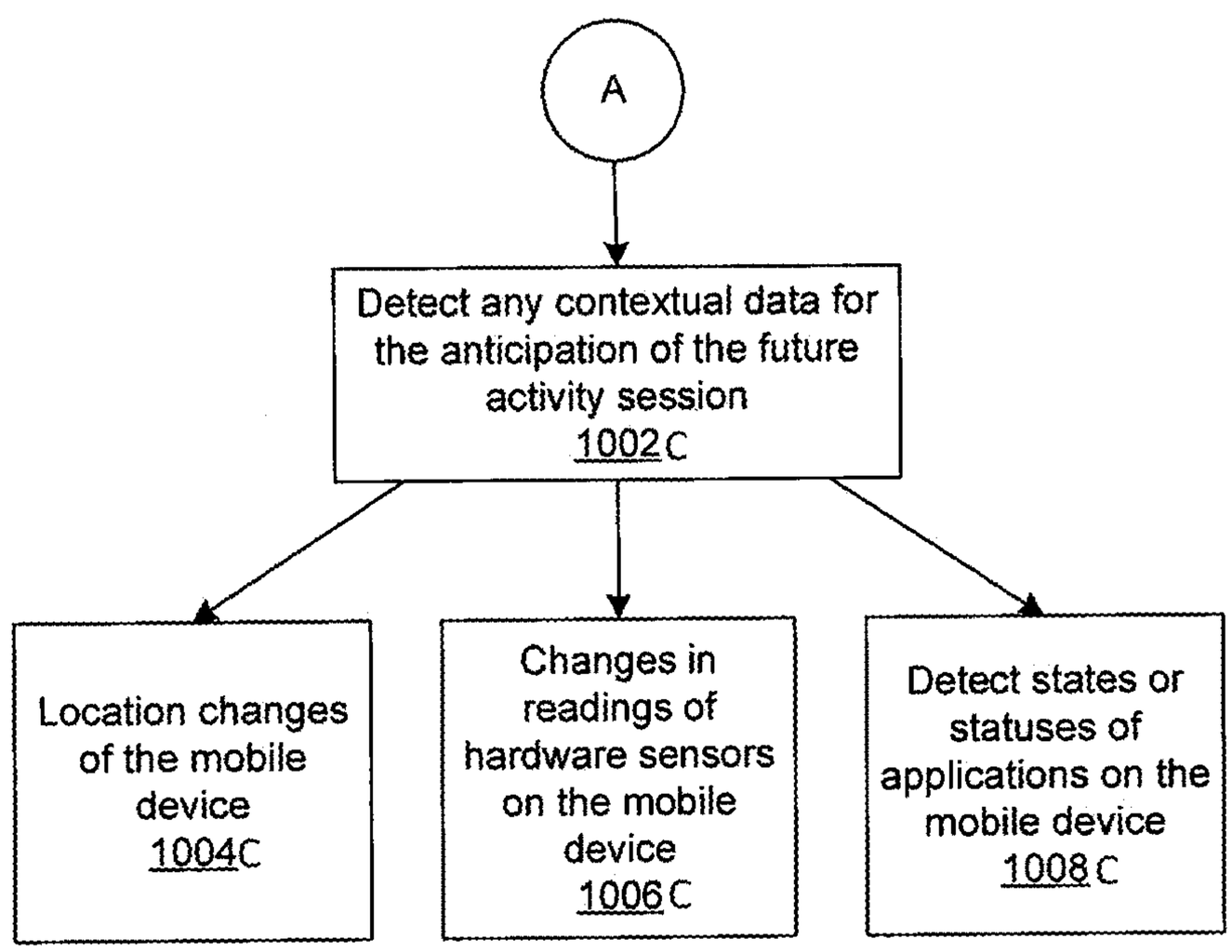
A
Detect any contextual data for the anticipation of the future activity session
1002C
Location changes of the mobile device
1004C
Changes in readings of hardware sensors on the mobile device
1006C
Detect states or statuses of applications on the mobile device
1008C

FIG. 10C

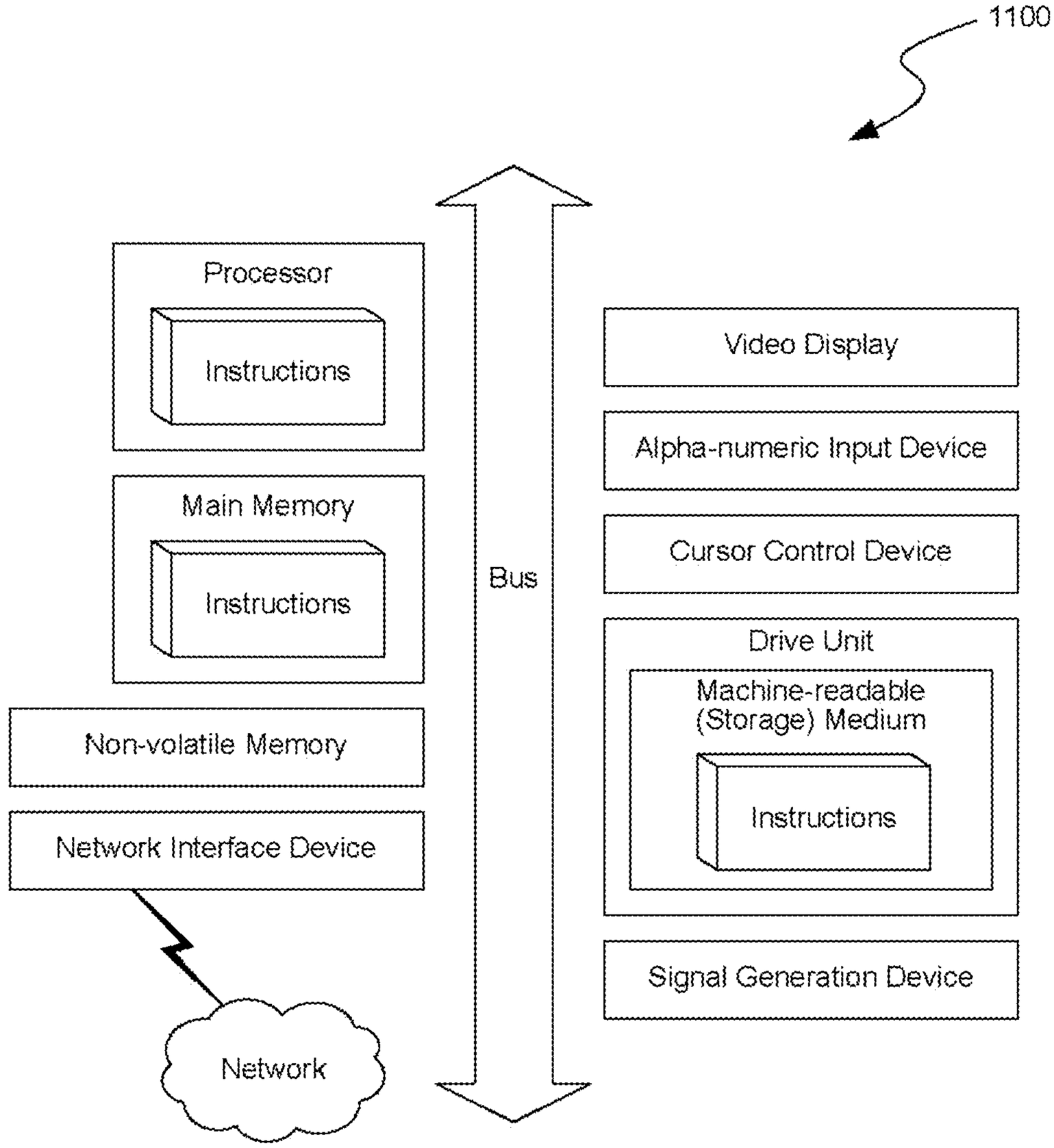
1100
Processor
Instructions
Main Memory
Instructions
Non-volatile Memory
Network Interface Device
Network
Bus
Video Display
Alpha-numeric Input Device
Cursor Control Device
Drive Unit
Machine-readable
(Storage) Medium
Instructions
Signal Generation Device

FIG. 11

OPTIMIZING MOBILE NETWORK TRAFFIC COORDINATION ACROSS MULTIPLE APPLICATIONS RUNNING ON A MOBILE DEVICE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 16/164,601 filed Oct. 18, 2018, which is a continuation of U.S. patent application Ser. No. 16/046,960 filed Jul. 26, 2018, issued as U.S. Pat. No. 10,194,398 on Jan. 29, 2019, which is a continuation of U.S. patent application Ser. No. 15/595,104 filed May 15, 2017, issued as U.S. Pat. No. 10,091,734 on Oct. 2, 2018, which is a continuation of U.S. patent application Ser. No. 14/710,167 filed May 12, 2015, issued as U.S. Pat. No. 9,671,851 on Jun. 6, 2017, which is a continuation of U.S. patent application Ser. No. 13/477,625 filed May 22, 2012, which is a division of U.S. patent application Ser. No. 13/407,406 filed Feb. 28, 2012, which is a continuation of U.S. patent application Ser. No. 13/178,598 filed Jul. 8, 2011, which claims the benefit of U.S. Provisional Applications No. 61/430,828 filed Jan. 7, 2011, No. 61/416,033 filed Nov. 22, 2010, No. 61/416,020 filed Nov. 22, 2010, No. 61/408,846 filed Nov. 1, 2010, No. 61/408,854 filed Nov. 1, 2010, No. 61/408,858 filed Nov. 1, 2010, No. 61/408,829 filed Nov. 1, 2010, No. 61/408,826 filed Nov. 1, 2010, No. 61/408,820 filed Nov. 1, 2010, No. 61/408,839 filed Nov. 1, 2010, No. 61/367,870 filed Jul. 26, 2010, and No. 61/367,871 filed Jul. 26, 2010, each of which is incorporated herein by reference in its entirety.

U.S. patent application Ser. No. 14/710,167 filed May 12, 2015, issued as U.S. Pat. No. 9,671,851 on Jun. 6, 2017, is also a continuation of U.S. patent application Ser. No. 14/467,922 filed Aug. 25, 2014, issued as U.S. Pat. No. 9,247,019 on Jan. 26, 2016, which is a division of U.S. patent application Ser. No. 13/188,553 filed Jul. 22, 2011, issued as U.S. Pat. No. 8,886,176 on Nov. 11, 2018, which claims the benefit of U.S. Provisional Applications No. 61/430,828 filed Jan. 7, 2011, No. 61/416,033 filed Nov. 22, 2010, No. 61/416,020 filed Nov. 22, 2010, No. 61/408,846 filed Nov. 1, 2010, No. 61/408,854 filed Nov. 1, 2010, No. 61/408,858 filed Nov. 1, 2010, No. 61/408,829 filed Nov. 1, 2010, No. 61/408,826 filed Nov. 1, 2010, No. 61/408,820 filed Nov. 1, 2010, No. 61/408,839 filed Nov. 1, 2010, No. 61/367,870 filed Jul. 26, 2010, and No. 61/367,871 filed Jul. 26, 2010, each of which is incorporated herein by reference in its entirety.

U.S. patent application Ser. No. 14/710,167 filed May 12, 2015, issued as U.S. Pat. No. 9,671,851 on Jun. 6, 2017, is also a continuation of U.S. patent application Ser. No. 13/355,443 filed Jan. 20, 2012, issued as U.S. Pat. No. 9,049,179 on Jun. 2, 2015, which is a continuation of U.S. patent application Ser. No. 13/115,631 filed May 25, 2011, issued as U.S. Pat. No. 9,043,433 on May 26, 2015, which claims the benefit of U.S. Provisional Applications No. 61/430,828 filed Jan. 7, 2011, No. 61/416,033 filed Nov. 22, 2010, No. 61/416,020 filed Nov. 22, 2010, No. 61/408,846 filed Nov. 1, 2010, No. 61/408,854 filed Nov. 1, 2010, No. 61/408,858 filed Nov. 1, 2010, No. 61/408,829 filed Nov. 1, 2010, No. 61/408,826 filed Nov. 1, 2010, No. 61/408,820 filed Nov. 1, 2010, No. 61/408,839 filed Nov. 1, 2010, No. 61/367,870 filed Jul. 26, 2010, and No. 61/367,871 filed Jul. 26, 2010, each of which is incorporated herein by reference in its entirety.

U.S. patent application Ser. No. 14/710,167 filed May 12, 2015, issued as U.S. Pat. No. 9,671,851 on Jun. 6, 2017, is also a continuation of U.S. patent application Ser. No. 13/115,740 filed May 25, 2011, which claims the benefit of U.S. Provisional Applications No. 61/430,828 filed Jan. 7, 2011, No. 61/416,033 filed Nov. 22, 2010, No. 61/416,020 filed Nov. 22, 2010, No. 61/408,846 filed Nov. 1, 2010, No. 61/408,854 filed Nov. 1, 2010, No. 61/408,858 filed Nov. 1, 2010, No. 61/408,829 filed Nov. 1, 2010, No. 61/408,826 filed Nov. 1, 2010, No. 61/408,820 filed Nov. 1, 2010, No. 61/408,839 filed Nov. 1, 2010, No. 61/367,870 filed Jul. 26, 2010, and No. 61/367,871 filed Jul. 26, 2010, each of which is incorporated herein by reference in its entirety.

BACKGROUND

When WCDMA was specified, there was little attention to requirements posed by applications whose functions are based on actions initiated by the network, in contrast to functions initiated by the user or by the device. Such applications include, for example, push email, instant messaging, visual voicemail and voice and video telephony, and others. Such applications typically require an always-on IP connection and frequent transmit of small bits of data. WCDMA networks are designed and optimized for high-throughput of large amounts of data, not for applications that require frequent, but low-throughput and/or small amounts of data. Each transaction puts the mobile device radio in a high power mode for considerable length of time—typically between 15-30 seconds. As the high power mode can consume as much as 100× the power as an idle mode, these network-initiated applications quickly drain battery in WCDMA networks. The issue has been exacerbated by the rapid increase of popularity of applications with network-initiated functionalities, such as push email.

Lack of proper support has prompted a number of vendors to provide documents to guide their operator partners and independent software vendors to configure their networks and applications to perform better in WCDMA networks. This guidance focuses on: configuring networks to go to stay on high-power radio mode as short as possible and making periodic keep alive messages that are used to maintain an always-on TCP/IP connection as infrequent as possible. Such solutions typically assume lack of coordination between the user, the application and the network.

Furthermore, application protocols may provide long-lived connections that allow servers to push updated data to a mobile device without the need of the client to periodically re-establish the connection or to periodically query for changes. However, the mobile device needs to be sure that the connection remains usable by periodically sending some data, often called a keep-alive message, to the server and making sure the server is receiving this data. While the amount of data sent for a single keep-alive is not a lot and the keep-alive interval for an individual application is not too short, the cumulative effect of multiple applications performing this individually will amount to small pieces of data being sent very frequently. Frequently sending bursts of data in a wireless network also result in high battery consumption due to the constant need of powering/re-powering the radio module.

Furthermore, in general, mobile application usage is sporadic in nature. For example, there can be periods of user inactivity (e.g., during working hours or when the user is sleeping) followed by periods of multiple application usage, such as where a user is updating their Facebook status, sending a Tweet, checking their email, and using other

applications to get an update of their online information. This doesn't mean, however, that the mobile device is inactive during user inactivity: the device may be actively downloading new content such as advertisements, polling for email, and receiving push notifications for activities on the Internet, thus utilizing occupying network bandwidth and consuming device power even when the user is not interacting with the mobile device or otherwise expecting data.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A illustrates an example diagram of a system where a host server facilitates management of traffic between client devices and an application server or content provider in a wireless network for resource conservation.

FIG. **1**B illustrates an example diagram of a proxy and cache system distributed between the host server and device which facilitates network traffic management between a device and an application server/content provider for resource conservation.

FIG. **2**A depicts a block diagram illustrating an example of client-side components in a distributed proxy and cache system residing on a mobile device that manages traffic in a wireless network for resource conservation.

FIG. **2**B depicts a block diagram illustrating another example of components in the application behavior detector and the traffic shaping engine in the local proxy on the client-side of the distributed proxy system shown in the example of FIG. **2**A.

FIG. **2**C depicts a block diagram illustrating another example of the user activity module having a prediction engine in the local proxy on the client-side of the distributed proxy system shown in the example of FIG. **2**A.

FIG. **3**A depicts a block diagram illustrating an example of server-side components in a distributed proxy and cache system that manages traffic in a wireless network for resource conservation.

FIG. **3**B depicts a block diagram illustrating another example of the server-side components of the distributed proxy system shown in the example of FIG. **3**A as further including a user experience enhancement engine and with the traffic shaping engine further including a delay module.

FIG. **4**A depicts a timing diagram showing how data requests from a mobile device to an application server/content provider in a wireless network can be coordinated by a distributed proxy system in a manner such that network and battery resources are conserved through using content caching and monitoring performed by the distributed proxy system.

FIG. **4**B depicts a timing diagram showing how data requests from a mobile device to an application server/content provider in a wireless network can be aligned at the local proxy in the distributed proxy system to optimize network and radio use.

FIG. **5** depicts a diagram showing one example process for implementing a hybrid IP and SMS power saving mode on a mobile device using a distributed proxy and cache system (e.g., such as the distributed system shown in the example of FIG. **1**B).

FIG. **6**A depicts a flow chart illustrating example processes through which context awareness is used for traffic management.

FIG. **6**B depicts a flow chart illustrating example processes through which application behavior on a mobile device is used for traffic optimization.

FIG. **6**C depicts a flow chart illustrating example selection processes through which data transfer requests of multiple applications can be coordinated into a single transfer operation.

FIG. **6**D depicts a flow chart illustrating an example process for using user activity and/or application server/provider activity to time the transfer of data from the host to the mobile device to optimize use of network resources.

FIG. **7**A depicts a flow chart illustrating an example process for managing traffic in a wireless network based on user interaction with a mobile device.

FIG. **7**B depicts a flow chart illustrating an example process for mobile application traffic optimization through data monitoring and coordination in a distributed proxy and cache system.

FIG. **7**C depicts an example of triggering events that would cause a data request to be transferred without alignment with another data request.

FIG. **7**D depicts an example of processes which can be used for user behavior prediction.

FIG. **8**A depicts a flow chart illustrating another example process for managing traffic in a wireless network based on user interaction with a mobile device.

FIG. **8**B depicts a flow chart illustrating an example process for preventing applications from needing to send keep-alive messages to maintain an IP connection with a content server.

FIG. **8**C depicts a flow chart illustrating an example process for using timing characteristics of data requests made by individual applications to delay transfer of one or more of the data requests made by one of the individual applications.

FIG. **8**D depicts an example of processes which can be used to detect application server/content provider characteristics.

FIG. **9**A depicts a flow chart illustrating an example process for managing traffic initiated from a mobile device in a wireless network through batching of event transfer based on event priority.

FIG. **9**B depicts a flow chart illustrating an example process for using application behavior of multiple applications to align their content requests made over the network.

FIG. **9**C depicts a flow chart illustrating an example process to anticipate a future activity session at a mobile device to enhance user experience with a mobile application.

FIG. **10**A depicts a flow chart illustrating another example process for managing traffic initiated remotely from a mobile device in a wireless network through batching of event transfer based on event priority.

FIG. **10**B depicts an example of processes through which the time of delay for content requests can be determined to align content requests over the wireless network.

FIG. **10**C depicts an example of processes through which contextual data for use in anticipation of future activity sessions can be determined.

FIG. **11** shows a diagrammatic representation of a machine in the example form of a computer system within which a set of instructions, for causing the machine to perform any one or more of the methodologies discussed herein, may be executed.

DETAILED DESCRIPTION

The following 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 certain instances, well-known or

conventional details are not described in order to avoid obscuring the description. References to one or an embodiment in the present disclosure can be, but not necessarily are, references to the same embodiment; and, such references mean at least one of the embodiments.

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 other embodiments.

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. Certain 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, certain 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 same thing can be said in more than one way.

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 certain terms are provided. A recital of one or more synonyms does not exclude the use of other synonyms. The use of examples anywhere in this specification including examples of any terms 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.

Without intent to limit the scope of the disclosure, examples of 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.

Embodiments of the present disclosure include systems and methods for mobile application traffic optimization.

Embodiments of the present disclosure include systems and methods for context aware traffic management for network and device resource conservation.

Embodiments of the present disclosure include systems and methods for mobile network traffic coordination across multiple applications.

Embodiments of the present disclosure include systems and methods for prediction of activity session for mobile network use optimization and/or user experience enhancement.

One embodiment of the disclosed technology includes, a system that optimizes multiple aspects of the connection with wired and wireless networks and devices through a comprehensive view of device and application activity including: loading, current application needs on a device, controlling the type of access (push vs. pull or hybrid), location, concentration of users in a single area, time of day, how often the user interacts with the application, content or device, and using this information to shape traffic to a cooperative client/server or simultaneously mobile devices without a cooperative client. Because the disclosed server is not tied to any specific network provider it has visibility into the network performance across all service providers. This enables optimizations to be applied to devices regardless of the operator or service provider, thereby enhancing the user experience and managing network utilization while roaming. Bandwidth has been considered a major issue in wireless networks today. More and more research has been done related to the need for additional bandwidth to solve access problems—many of the performance enhancing solutions and next generation standards, such as LTE, 4G, and WiMAX are focused on providing increased bandwidth. A key problem is lack of bandwidth on the signaling channel more so than the data channel.

Embodiments of the disclosed technology includes, for example, alignment of requests from multiple applications to minimize the need for several polling requests; leverage specific content types to determine how to proxy/manage a connection/content; and apply specific heuristics associated with device, user behavioral patterns (how often they interact with the device/application) and/or network parameters.

Embodiments of the present technology can further include, moving recurring HTTP polls performed by various widgets, RSS readers, etc., to remote network node (e.g., Network operation center (NOC)), thus considerably lowering device battery/power consumption, radio channel signaling, and bandwidth usage. Additionally, the offloading can be performed transparently so that existing applications do not need to be changed.

In some embodiments, this can be implemented using a local proxy on the mobile device which automatically detects recurring requests for the same content (RSS feed, Widget data set) that matches a specific rule (e.g., happens every 15 minutes). The local proxy can automatically cache the content on the mobile device while delegating the polling to the server (e.g., a proxy server operated as an element of a communications network). The server can then notify the mobile/client proxy if the content changes, and if content has not changed (or not changed sufficiently, or in an identified manner or amount) the mobile proxy provides the latest version in its cache to the user (without need to utilize the radio at all). This way the mobile device (e.g., a mobile phone, smart phone, etc.) does not need to open up (e.g., thus powering on the radio) or use a data connection if the request is for content that is monitored and that has been not flagged as new, changed, or otherwise different.

The logic for automatically adding content sources/application servers (e.g., including URLs/content) to be monitored can also check for various factors like how often the content is the same, how often the same request is made (is there a fixed interval/pattern?), which application is requesting the data, etc. Similar rules to decide between using the cache and request the data from the original source may also be implemented and executed by the local proxy and/or server.

For example, when the request comes at an unscheduled/unexpected time (user initiated check), or after every (n)

consecutive times the response has been provided from the cache, etc., or if the application is running in the background vs. in a more interactive mode of the foreground. As more and more mobile applications base their features on resources available in the network, this becomes increasingly important. In addition, the disclosed technology allows elimination of unnecessary chatter from the network, benefiting the operators trying to optimize the wireless spectrum usage.

Cross Application Traffic Coordination

In one embodiment of the present disclosure, a group of applications [A, B, C . . .] may have a timeline of transfers of data from the mobile device (or client (e.g., mobile application, software agent, widget, etc.) on the mobile device) to the network, or from the network to the mobile device (for receipt by the client). The time of the transfers can be represented as:

Application A: tA1, tA2, tA3, . . .

Application B: tB1, tB2, tB3, . . .

Application C: tC1, tC2, tC3, . . .

Each of the times 't' can have a natural point of occurring based upon the independent activity of the corresponding application as operations are executed at the application server/provider and/or on the software client on the mobile device. For example, an application can transfer a message, an event, or other types of data to the network (or vice versa) at a regular or semi-regular series of times as part of polling, satisfying a device, application, or user request, application maintenance, or other operation.

Similarly, an application can transfer a message, event, or other types data via the network (or vice versa) at a regular, semi-regular, or irregular series of times to perform its inherent functions or operations, such as synchronizing two data stores, determining the contents of a data store, accessing new data from the application server/service provider, communicating with a peer device (e.g., another device with the same application or another application with which the requesting application interacts), exchanging control messages, etc.

In some instances, there is typically no correlation or weak correlation between the times at which data transfers or event transactions occur for one application as compared to a second application on a given mobile device, or for different data requests for the same application. In some cases, there may be a stronger correlation between the times at which a transfer occurs for one application as compared to a second application (e.g., where an operation of a first application is dependent upon or triggers an operation of a second application, or where a user typically executes an operation of one application in conjunction with an operation of a second application). Note that in some instances, the second application may be the same application as the first application and that correlations can be tracked and determined for multiple requests sent by one application in a similar fashion.

In some embodiments, in order to optimize (e.g., typically to minimize) the number of times that a device (e.g., a mobile device or smart phone) radio is turned on to decrease the consumption of power (and hence conserve its battery or other power source), a distributed proxy system including a local proxy and/or proxy server can operate to intercept the events or transactions (or requests for transfer) of information. When intercepted, the local proxy and/or the proxy server can delay (or expedite) the time at which one or more of these transfers would normally occur in order to perform multiple transfers together as part of a single transfer operation (i.e., instead of performing multiple, individual transfers). Alternatively, the local and/or proxy server can pre-retrieve data for a non-priority application or less important/time sensitive application whose polls are typically expected to happen before another application having higher priority, for example. In other words, a delay could be negative resulting in content pre-retrieval for alignment with an anticipated data request which typically happens before the request of the lesser priority application.

The delay time (D) can represent a maximum time delay value (or in some instances, expedited time value) after receipt of a request to make such a transfer, with the value of D determined so as to enable the collection of as many of the transfers as feasible in a single, optimized data transfer. The delay times or expedited times of one or more transfers are determined so as to factor in any potential impact on performance and user experience. Ideally, the system determines D to prevent undesired penalties or inefficiencies, and to prevent undesired impact on the user experience. Note that as described above, the delay 'D' could be negative or positive for alignment purposes (e.g., to implement a delayed or an expedited transfer).

In some embodiments, delay time 'D' (use to represent both positive and negative delays (effectively and expedited transfer)) can be determined based on consideration of one or more of the following factors: the priority of the application (or the relative priority of one application in comparison to another), the nature or amount of data involved in the transfer (e.g., whether it represents fresh data, a housekeeping function, a control instruction, etc.), the status of the application (e.g., active, inactive, background, foreground, etc.), a useable lifetime of the data to be transferred (a period before it becomes stale), the interval between the transfer times of multiple data requests for a single application, the interval between the transfer times across more than one application (e.g., the largest transfer time interval based on consideration of all active applications), network characteristics (available bandwidth, network latency, etc.), or another relevant factor.

In some embodiments, the delay time 'D' of specific events/transactions can be controlled by the mobile device (e.g., platform, device settings, or OS specifications), network service provider, and/or the user as part of optimizing the battery life to align data transfer requests across multiple applications or the same application, as opposed to performing each data transfer individually. In some instances, the user can manually configure a setting specifying that requests across multiple applications or the same application are to be batched. The user can enable the setting, and allow the system to configure the details. In addition, the user can specify preferences, priorities, or any other constraints related to alignment of data request transfer of the mobile network.

Activity Session Method

As will be described, in some embodiments the present disclosure is directed to a method for augmenting a distributed proxy-based solution by introducing the concept of an "activity session". An activity session is a pattern of multiple mobile application use by a user that can be "predicted" by using contextual clues available to a local proxy on a mobile device. Based on the prediction, a multiplex connection can be created and pre-caching of content can be performed to support the data activity during the session, thus minimizing the signaling overhead as well as the multiplexed transaction duration. In some embodiments this approach will also provide the additional benefit of an improved user experience (e.g., by reducing a perceived latency).

In one embodiment, an activity session is a pattern of multiple mobile application use by a mobile user that can be "predicted" (or otherwise anticipated or expected) based on contextual clues detected and analyzed by a local proxy on a device (e.g., the user's mobile or portable phone, smartphone) and/or by a proxy server in a distributed proxy system.

Based on the prediction, a multiplex connection can be created and pre-caching of content can be performed to support the data activity during the session, thus minimizing the signaling overhead as well as the multiplexed transaction duration. Further, in some embodiments this approach can provide enhanced user experience by reducing or eliminating user wait times or other sources of latency in the user experience.

Connection Optimization

TCP connections, such as persistent TCP sessions and TCP connection pooling can be utilized for reusing connections. Both techniques on a mobile device allow previously-established TCP connections to the same server (e.g., a host server, an application server, or content provider) to be reused for multiple HTTP transactions, which saves connection establishment and tear-down times between transactions. However, with multiple applications running, and each establishing its own TCP connections to multiple host servers (application servers/content providers), there are potentially many TCP connections being established on a mobile device during a given time of network activity.

A benefit of a distributed proxy system (such as that shown in the examples of FIGS. **1**A-**1**B), where each component (i.e., the local proxy in the mobile device and the proxy server in the host server) is acknowledged by the system and each other, is that a single TCP connection can be used to transport all of the application traffic during an established activity session.

For example, the WebMUX and SCP protocols allow multiplexing of multiple sessions of application-level protocols (such as HTTP) over a single TCP connection. In one embodiment, an activity session can be supported by a multiplexed TCP connection using these or additional mechanisms. In another embodiment, the activity session is supported by a TCP connection pool, with the connection reuse enhanced by nature of connecting to a single and known proxy server such as the disclosed proxy system.

Prediction Basis

The disclosed distributed proxy and cache system can eliminate or decrease resource consumption of "background" data access of mobile applications and processes in order to improve signaling efficiency, power consumption (battery life), and use of network resources. The prioritization or prediction of the occurring of data access or the background data access may be based on one or more data types or characteristics, heuristics, algorithms, collaborative filtering techniques, etc. that process data to determine a most likely behavior by a user.

For example, the data processing may determine that there is a relatively high correlation between a user accessing one type of application, followed by them accessing a second application. Or, that when a user becomes active on their device after a certain amount of time, they are likely to engage in a series of actions, data requests, etc. Or, that when sufficient new data (notifications, messages, etc.) has become available to the user, they are likely to access it in a certain order (such as by activating a series of applications or generating a series of requests in a certain order).

In some embodiments, or in addition to the server prediction approach described above, the mobile device may use contextual cues available via hardware sensors or application activity indications to predict the likelihood of the start of an activity session. For example, the local proxy may monitor location changes in the device to predict that a location update may be sent to a location-based service, or may monitor user activity at certain geographical locations and anticipate an activity session, for example, based on historical application usage at a particular location. The anticipated activity session, which can be derived by means of hardware context on the mobile device (e.g., the state or operating status of the device), can be the same or different in structure as that created by the proxy server (e.g., server **100** of FIGS. **1**A-**1**B).

Establishing the Activity Session

An activity session may be recognized and activated based on a predicted activity session by either the proxy server or the local proxy in the following manner. On the device side, application activity after a period of inactivity, during which a potential activity session has been identified, can cause the local proxy to compare the data request to a list of host URLs associated with a predicted/anticipated activity session.

If the data activity matches a higher-priority entry in the URL list, for example, based on a priority threshold, the data activity may trigger the start of an activity session based on the predicted activity session. If there is no match or a lower-priority match, then the activity session may not be initiated. Other embodiments may include other prioritization schemes or priority criteria to determine when or if an activity session will be established. A predicted activity session can be recognized and converted to an Activity Session in the host server (proxy server) in a similar manner.

In some embodiments, if an activity session is detected or created by the local proxy, the local proxy can request a multiplexed connection be established to optimize the signaling during the session. If an activity session is identified by the server, the existing TCP connection opened from the mobile device can be converted into a multiplexed session and used for the optimized connection. Alternatively, the first data request from the mobile device can be accomplished outside of the multiplexed connection, and the multiplexed connection can be established for subsequent data transfers.

Once an activity session is established and has been acknowledged by the local proxy and/or proxy server, the proxy server can now proactively cache data (e.g., access the URLs or application servers/providers anticipated in the predicted activity sessions) for more rapid access to content anticipated to be needed in the predicted activity session. The system can "piggy-back" transfer of the anticipated data with other data requested by the mobile device for caching in the local cache on the mobile device. These mechanisms effectively increase the availability of desired data on the mobile, and shorten the duration of an established connection needed for the present activity session.

One example of a use case for the present technology is described as follows:

i. Predicting an activity session based on push activity in the idle state:

1. While user is sleeping, his phone has received three push notifications from Facebook, and five emails;
2. When user wakes up and checks his phone, he sees these notifications and emails. His natural tendency is to open these two applications and check his emails and Facebook status;
3. Upon the transition from screen-lock to unlock, the server recognizes that based on the push activity, the

user is likely to get access to these two applications. The device sends a state change notification to the server, and in response, the server sends an activity session indicator to the device. The server pre-caches information relevant to the session, and creates a persistent connection with the device to support the activity session;

4. User accesses the services, and is pleased that the relevant data seems to be already on his device;
5. The persistent connection is managed by the device and server to time out based on certain criteria, to maximize device battery life.

ii. Predicting an activity session based on a change in geographical location during idle state—as a user moves between locations, the system can recognize that they are more likely to engage in certain requests or activities based on the transit route or the new location.

iii. Predicting an activity session based on receiving a phone call in idle state based on previous user behavior, the system now recognizes that the user is likely to engage in certain behaviors upon accessing the call (such as checking a specific applications, making certain updates, accessing certain contacts in the contact book, etc.).

FIG. **1**A illustrates an example diagram of a system where a host server **100** facilitates management of traffic between client devices **102** and an application server or content provider **110** in a wireless network for resource conservation.

The client devices **102**A-D can be any system and/or device, and/or any combination of devices/systems that is able to establish a connection, including wired, wireless, cellular connections with another device, a server and/or other systems such as host server **100** and/or application server/content provider **110**. Client devices **102** will typically include a display and/or other output functionalities to present information and data exchanged between among the devices **102** and/or the host server **100** and/or application server/content provider **110**.

For example, the client devices **102** can include mobile, hand held or portable devices or non-portable devices and can be any of, but not limited to, a server desktop, a desktop computer, a computer cluster, or portable devices including, a notebook, a laptop computer, a handheld computer, a palmtop computer, a mobile phone, a cell phone, a smart phone, a PDA, a Blackberry device, a Palm device, Treo, a handheld tablet (e.g., an iPad or any other tablet), a hand held console, a hand held gaming device or console, any SuperPhone such as the iPhone, and/or any other portable, mobile, hand held devices, etc. In one embodiment, the client devices **102**, host server **100**, and app server **110** are coupled via a network **106** and/or a network **108**. In some embodiments, the devices **102** and host server **100** may be directly connected to one another.

The input mechanism on client devices **102** can include touch screen keypad (including single touch, multi-touch, gesture sensing in 2D or 3D, etc.), a physical keypad, a mouse, a pointer, a track pad, motion detector (e.g., including 1-axis, 2-axis, 3-axis accelerometer, etc.), a light sensor, capacitance sensor, resistance sensor, temperature sensor, proximity sensor, a piezoelectric device, device orientation detector (e.g., electronic compass, tilt sensor, rotation sensor, gyroscope, accelerometer), or a combination of the above.

Signals received or detected indicating user activity at client devices **102** through one or more of the above input mechanism, or others, can be used in the disclosed technology in acquiring context awareness at the client device **102**. Context awareness at client devices **102** generally includes, by way of example but not limitation, client device **102** operation or state acknowledgement, management, user activity/behavior/interaction awareness, detection, sensing, tracking, trending, and/or application (e.g., mobile applications) type, behavior, activity, operating state, etc.

Context awareness in the present disclosure also includes knowledge and detection of network side contextual data and can include network information such as network capacity, bandwidth, traffic, type of network/connectivity, and/or any other operational state data. Network side contextual data can be received from and/or queried from network service providers (e.g., cell provider **112** and/or Internet service providers) of the network **106** and/or network **108** (e.g., by the host server and/or devices **102**). In addition to application context awareness as determined from the client **102** side, the application context awareness may also be received from or obtained/queried from the respective application/service providers **110** (by the host **100** and/or client devices **102**).

The host server **100** can use, for example, contextual information obtained for client devices **102**, networks **106**/**108**, applications (e.g., mobile applications), application server/provider **110**, or any combination of the above, to manage the traffic in the system to satisfy data needs of the client devices **102** (e.g., to satisfy application or any other request including HTTP request). In one embodiment, the traffic is managed by the host server **100** to satisfy data requests made in response to explicit or non-explicit user **103** requests and/or device/application maintenance tasks. The traffic can be managed such that network consumption, for example, use of the cellular network is conserved for effective and efficient bandwidth utilization. In addition, the host server **100** can manage and coordinate such traffic in the system such that use of device **102** side resources (e.g., including but not limited to battery power consumption, radio use, processor/memory use) are optimized with a general philosophy for resource conservation while still optimizing performance and user experience.

For example, in context of battery conservation, the device **150** can observe user activity (for example, by observing user keystrokes, backlight status, or other signals via one or more input mechanisms, etc.) and alters device **102** behaviors. The device **150** can also request the host server **100** to alter the behavior for network resource consumption based on user activity or behavior.

In one embodiment, the traffic management for resource conservation is performed using a distributed system between the host server **100** and client device **102**. The distributed system can include proxy server and cache components on the server **100** side and on the client **102** side, for example, as shown by the server cache **135** on the server **100** side and the local cache **150** on the client **102** side.

Functions and techniques disclosed for context aware traffic management for resource conservation in networks (e.g., network **106** and/or **108**) and devices **102**, reside in a distributed proxy and cache system. The proxy and cache system can be distributed between, and reside on, a given client device **102** in part or in whole and/or host server **100** in part or in whole. The distributed proxy and cache system are illustrated with further reference to the example diagram shown in FIG. **1**B. Functions and techniques performed by the proxy and cache components in the client device **102**, the host server **100**, and the related components therein are described, respectively, in detail with further reference to the examples of FIGS. **2**A-**3**B.

In one embodiment, client devices **102** communicate with the host server **100** and/or the application server **110** over network **106**, which can be a cellular network. To facilitate overall traffic management between devices **102** and various application servers/content providers **110** to implement network (bandwidth utilization) and device resource (e.g., battery consumption), the host server **100** can communicate with the application server/providers **110** over the network **108**, which can include the Internet.

In general, the networks **106** and/or **108**, over which the client devices **102**, the host server **100**, and/or application server **110** communicate, may be a cellular network, a telephonic network, an open network, such as the Internet, or a private network, such as an intranet and/or the extranet, or any combination thereof. For example, the Internet can provide file transfer, remote log in, email, news, RSS, cloud-based services, instant messaging, visual voicemail, push mail, VoIP, and other services through any known or convenient protocol, such as, but is not limited to the TCP/IP protocol, UDP, HTTP, DNS, Open System Interconnections (OSI), FTP, UPnP, iSCSI, NSF, ISDN, PDH, RS-232, SDH, SONET, etc.

The networks **106** and/or **108** can be any collection of distinct networks operating wholly or partially in conjunction to provide connectivity to the client devices **102** and the host server **100** and may appear as one or more networks to the serviced systems and devices. In one embodiment, communications to and from the client devices **102** can be achieved by, an open network, such as the Internet, or a private network, such as an intranet and/or the extranet. In one embodiment, communications can be achieved by a secure communications protocol, such as secure sockets layer (SSL), or transport layer security (TLS).

In addition, communications can be achieved via one or more networks, such as, but are not limited to, one or more of WiMAX, a Local Area Network (LAN), Wireless Local Area Network (WLAN), a Personal area network (PAN), a Campus area network (CAN), a Metropolitan area network (MAN), a Wide area network (WAN), a Wireless wide area network (WWAN), enabled with technologies such as, by way of example, Global System for Mobile Communications (GSM), Personal Communications Service (PCS), Digital Advanced Mobile Phone Service (D-Amps), Bluetooth, Wi-Fi, Fixed Wireless Data, 2G, 2.5G, 3G, 4G, IMT-Advanced, pre-4G, 3G LTE, 3GPP LTE, LTE Advanced, mobile WiMAX, WiMAX **2**, WirelessMAN-Advanced networks, enhanced data rates for GSM evolution (EDGE), General packet radio service (GPRS), enhanced GPRS, iBurst, UMTS, HSPDA, HSUPA, HSPA, UMTS-TDD, 1×RTT, EV-DO, messaging protocols such as, TCP/IP, SMS, MMS, extensible messaging and presence protocol (XMPP), real time messaging protocol (RTMP), instant messaging and presence protocol (IMPP), instant messaging, USSD, IRC, or any other wireless data networks or messaging protocols.

FIG. **1**B illustrates an example diagram of a proxy and cache system distributed between the host server **100** and device **150** which facilitates network traffic management between the device **150** and an application server/content provider **100** (e.g., a source server) for resource conservation.

The distributed proxy and cache system can include, for example, the proxy server **125** (e.g., remote proxy) and the server cache, **135** components on the server side. The server-side proxy **125** and cache **135** can, as illustrated, reside internal to the host server **100**. In addition, the proxy server **125** and cache **135** on the server-side can be partially or wholly external to the host server **100** and in communication via one or more of the networks **106** and **108**. For example, the proxy server **125** may be external to the host server and the server cache **135** may be maintained at the host server **100**. Alternatively, the proxy server **125** may be within the host server **100** while the server cache is external to the host server **100**. In addition, each of the proxy server **125** and the cache **135** may be partially internal to the host server **100** and partially external to the host server **100**.

The distributed system can also, include, in one embodiment, client-side components, including by way of example but not limitation, a local proxy **175** (e.g., a mobile client on a mobile device) and/or a local cache **185**, which can, as illustrated, reside internal to the device **150** (e.g., a mobile device).

In addition, the client-side proxy **175** and local cache **185** can be partially or wholly external to the device **150** and in communication via one or more of the networks **106** and **108**. For example, the local proxy **175** may be external to the device **150** and the local cache **185** may be maintained at the device **150**. Alternatively, the local proxy **175** may be within the device **150** while the local cache **185** is external to the device **150**. In addition, each of the proxy **175** and the cache **185** may be partially internal to the host server **100** and partially external to the host server **100**.

In one embodiment, the distributed system can include an optional caching proxy server **199**. The caching proxy server **199** can be a component which is operated by the application server/content provider **110**, the host server **100**, or a network service provider **112**, and or any combination of the above to facilitate network traffic management for network and device resource conservation. Proxy server **199** can be used, for example, for caching content to be provided to the device **150**, for example, from one or more of, the application server/provider **110**, host server **100**, and/or a network service provider **112**. Content caching can also be entirely or partially performed by the remote proxy **125** to satisfy application requests or other data requests at the device **150**.

In context aware traffic management and optimization for resource conservation in a network (e.g., cellular or other wireless networks), characteristics of user activity/behavior and/or application behavior at a mobile device **150** can be tracked by the local proxy **175** and communicated, over the network **106** to the proxy server **125** component in the host server **100**, for example, as connection metadata. The proxy server **125** which in turn is coupled to the application server/provider **110** provides content and data to satisfy requests made at the device **150**.

In addition, the local proxy **175** can identify and retrieve mobile device properties including, one or more of, battery level, network that the device is registered on, radio state, whether the mobile device is being used (e.g., interacted with by a user). In some instances, the local proxy **175** can delay, expedite (pre-fetch) and/or modify data prior to transmission to the proxy server **125**, when appropriate, as will be further detailed with references to the description associated with the examples of FIGS. **2**A-**3**B.

The local database **185** can be included in the local proxy **175** or coupled to the proxy **175** and can be queried for a locally stored response to the data request prior to the data request being forwarded on to the proxy server **125**. Locally cached responses can be used by the local proxy **175** to satisfy certain application requests of the mobile device **150**, by retrieving cached content stored in the cache storage **185**, when the cached content is still valid.

Similarly, the proxy server **125** of the host server **100** can also delay, expedite, or modify data from the local proxy

prior to transmission to the content sources (e.g., the app server/content provider **110**). In addition, the proxy server **125** uses device properties and connection metadata to generate rules for satisfying request of applications on the mobile device **150**. The proxy server **125** can gather real time traffic information about requests of applications for later use in optimizing similar connections with the mobile device **150** or other mobile devices.

In general, the local proxy **175** and the proxy server **125** are transparent to the multiple applications executing on the mobile device. The local proxy **175** is generally transparent to the operating system or platform of the mobile device and may or may not be specific to device manufacturers. For example, the local proxy may be implemented without adding a TCP stack and thus act transparently to both the US and the mobile applications. In some instances, the local proxy **175** is optionally customizable in part or in whole to be device specific. In some embodiments, the local proxy **175** may be bundled into a wireless model, into a firewall, and/or a router.

In one embodiment, the host server **100** can in some instances, utilize the store and forward functions of a short message service center (SMSC) **112**, such as that provided by the network service provider **112**, in communicating with the device **150** in achieving network traffic management. As will be further described with reference to the examples of FIG. **3**A and/or FIG. **3**B, the host server **100** can forward content or HTTP responses to the SMSC **112** such that it is automatically forwarded to the device **150** if available, and for subsequent forwarding if the device **150** is not currently available.

In general, the disclosed distributed proxy and cache system allows optimization of network usage, for example, by serving requests from the local cache **185**, the local proxy **175** reduces the number of requests that need to be satisfied over the network **106**. Further, the local proxy **175** and the proxy server **125** may filter irrelevant data from the communicated data. In addition, the local proxy **175** and the proxy server **125** can also accumulate low priority data and send it in batches to avoid the protocol overhead of sending individual data fragments. The local proxy **175** and the proxy server **125** can also compress or transcode the traffic, reducing the amount of data sent over the network **106** and/or **108**. The signaling traffic in the network **106** and/or **108** can be reduced, as the networks are now used less often and the network traffic can be synchronized among individual applications.

With respect to the battery life of the mobile device **150**, by serving application or content requests from the local cache **185**, the local proxy **175** can reduce the number of times the radio module is powered up. The local proxy **175** and the proxy server **125** can work in conjunction to accumulate low priority data and send it in batches to reduce the number of times and/or amount of time when the radio is powered up. The local proxy **175** can synchronize the network use by performing the batched data transfer for all connections simultaneously.

FIG. **2**A depicts a block diagram illustrating an example of client-side components in a distributed proxy and cache system residing on a device **250** that manages traffic in a wireless network for resource conservation.

The device **250**, which can be a portable or mobile device, such as a portable phone, generally includes, for example, a network interface **208**, an operating system **204**, a context API **206**, and mobile applications which may be proxy unaware **210** or proxy aware **220**. Note that the device **250** is specifically illustrated in the example of FIG. **2**A as a mobile device, such is not a limitation and that device **250** may be any portable/mobile or non-portable device able to receive, transmit signals to satisfy data requests over a network including wired or wireless networks (e.g., Wi-Fi, cellular, Bluetooth, etc.).

The network interface **208** can be a networking module that enables the device **250** to mediate data in a network with an entity that is external to the host server **250**, through any known and/or convenient communications protocol supported by the host and the external entity. The network interface **208** can include one or more of a network adaptor card, a wireless network interface card (e.g., SMS interface, Wi-Fi interface, interfaces for various generations of mobile communication standards including but not limited to 1G, 2G, 3G, 3.5G, 4G, LTE, etc.), Bluetooth, a router, an access point, a wireless router, a switch, a multilayer switch, a protocol converter, a gateway, a bridge, bridge router, a hub, a digital media receiver, and/or a repeater.

Device **250** can further include, client-side components of the distributed proxy and cache system which can include, a local proxy **275** (e.g., a mobile client of a mobile device) and a cache **285**. In one embodiment, the local proxy **275** includes a user activity module **215**, a proxy API **225**, a request/transaction manager **235**, a caching policy manager **245**, a traffic shaping engine **255**, and/or a connection manager **265**. The traffic shaping engine **255** may further include an alignment module **256** and/or a batching module **257**, the connection manager **265** may further include a radio controller **266**. The request/transaction manager **235** can further include an application behavior detector **236** and/or a prioritization engine **241**, the application behavior detector **236** may further include a pattern detector **237** and/or and application profile generator **239**. Additional or less components/modules/engines can be included in the local proxy **275** and each illustrated component.

As used herein, a "module," "a manager," a "handler," a "detector," an "interface," or an "engine" includes a general purpose, dedicated or shared processor and, typically, firmware or software modules that are executed by the processor. Depending upon implementation-specific or other considerations, the module, manager, hander, or engine can be centralized or its functionality distributed. The module, manager, hander, or engine can include general or special purpose hardware, firmware, or software embodied in a computer-readable (storage) medium for execution by the processor. As used herein, a computer-readable medium or computer-readable storage medium is intended to include all mediums that are statutory (e.g., in the United States, under 35 U.S.C. 101), and to specifically exclude all mediums that are non-statutory in nature to the extent that the exclusion is necessary for a claim that includes the computer-readable (storage) medium to be valid. Known statutory computer-readable mediums include hardware (e.g., registers, random access memory (RAM), non-volatile (NV) storage, to name a few), but may or may not be limited to hardware.

In one embodiment, a portion of the distributed proxy and cache system for network traffic management resides in or is in communication with device **250**, including local proxy **275** (mobile client) and/or cache **285**. The local proxy **275** can provide an interface on the device **250** for users to access device applications and services including email, IM, voice mail, visual voicemail, feeds, Internet, other applications, etc.

The proxy **275** is generally application independent and can be used by applications (e.g., both proxy aware and proxy-unaware mobile applications **210** and **220**) to open TCP connections to a remote server (e.g., the server **100** in

the examples of FIGS. **1**A-**1**B and/or server proxy **125**/**325** shown in the examples of FIG. **1**B and FIG. **3**A). In some instances, the local proxy **275** includes a proxy API **225** which can be optionally used to interface with proxy-aware applications **220** (or mobile applications on a mobile device).

The applications **210** and **220** can generally include any user application, widgets, software, HTTP-based application, web browsers, video or other multimedia streaming or downloading application, video games, social network applications, email clients, RSS management applications, application stores, document management applications, productivity enhancement applications, etc. The applications can be provided with the device OS, by the device manufacturer, by the network service provider, downloaded by the user, or provided by others.

One embodiment of the local proxy **275** includes or is coupled to a context API **206**, as shown. The context API **206** may be a part of the operating system **204** or device platform or independent of the operating system **204**, as illustrated. The operating system **204** can include any operating system including but not limited to, any previous, current, and/or future versions/releases of, Windows Mobile, iOS, Android, Symbian, Palm OS, Brew MP, Java 2 Micro Edition (J2ME), Blackberry, etc.

The context API **206** may be a plug-in to the operating system **204** or a particular client application on the device **250**. The context API **206** can detect signals indicative of user or device activity, for example, sensing motion, gesture, device location, changes in device location, device backlight, keystrokes, clicks, activated touch screen, mouse click or detection of other pointer devices. The context API **206** can be coupled to input devices or sensors on the device **250** to identify these signals. Such signals can generally include input received in response to explicit user input at an input device/mechanism at the device **250** and/or collected from ambient signals/contextual cues detected at or in the vicinity of the device **250** (e.g., light, motion, piezoelectric, etc.).

In one embodiment, the user activity module **215** interacts with the context API **206** to identify, determine, infer, detect, compute, predict, and/or anticipate, characteristics of user activity on the device **250**. Various inputs collected by the context API **206** can be aggregated by the user activity module **215** to generate a profile for characteristics of user activity. Such a profile can be generated by the module **215** with various temporal characteristics. For instance, user activity profile can be generated in real-time for a given instant to provide a view of what the user is doing or not doing at a given time (e.g., defined by a time window, in the last minute, in the last 30 seconds, etc.), a user activity profile can also be generated for a 'session' defined by an application or web page that describes the characteristics of user behavior with respect to a specific task they are engaged in on the device **250**, or for a specific time period (e.g., for the last 2 hours, for the last 5 hours).

Additionally, characteristic profiles can be generated by the user activity module **215** to depict a historical trend for user activity and behavior (e.g., 1 week, 1 mo, 2 mo, etc.). Such historical profiles can also be used to deduce trends of user behavior, for example, access frequency at different times of day, trends for certain days of the week (weekends or week days), user activity trends based on location data (e.g., IP address, GPS, or cell tower coordinate data) or changes in location data (e.g., user activity based on user location, or user activity based on whether the user is on the go, or traveling outside a home region, etc.) to obtain user activity characteristics.

In one embodiment, user activity module **215** can detect and track user activity with respect to applications, documents, files, windows, icons, and folders on the device **250**. For example, the user activity module **215** can detect when an application or window (e.g., a web browser) has been exited, closed, minimized, maximized, opened, moved into the foreground, or into the background, multimedia content playback, etc.

In one embodiment, characteristics of the user activity on the device **250** can be used to locally adjust behavior of the device (e.g., mobile device) to optimize its resource consumption such as battery/power consumption and more generally, consumption of other device resources including memory, storage, and processing power. In one embodiment, the use of a radio on a device can be adjusted based on characteristics of user behavior (e.g., by the radio controller **266** of the connection manager **265**) coupled to the user activity module **215**. For example, the radio controller **266** can turn the radio on or off, based on characteristics of the user activity on the device **250**. In addition, the radio controller **266** can adjust the power mode of the radio (e.g., to be in a higher power mode or lower power mode) depending on characteristics of user activity.

In one embodiment, characteristics of the user activity on device **250** can also be used to cause another device (e.g., other computers, a mobile device, or a non-portable device) or server (e.g., host server **100** and **300** in the examples of FIGS. **1**A-**1**B and FIGS. **3**A-**3**B) which can communicate (e.g., via a cellular or other network) with the device **250** to modify its communication frequency with the device **250**. The local proxy **275** can use the characteristics information of user behavior determined by the user activity module **215** to instruct the remote device as to how to modulate its communication frequency (e.g., decreasing communication frequency, such as data push frequency if the user is idle, requesting that the remote device notify the device **250** if new data, changed data, different, data, or data of a certain level of importance becomes available, etc.).

In one embodiment, the user activity module **215** can, in response to determining that user activity characteristics indicate that a user is active after a period of inactivity, request that a remote device (e.g., server host server **100** and **300** in the examples of FIGS. **1**A-**1**B and FIGS. **3**A-**3**B) send the data that was buffered as a result of the previously decreased communication frequency.

In addition, or in alternative, the local proxy **275** can communicate the characteristics of user activity at the device **250** to the remote device (e.g., host server **100** and **300** in the examples of FIGS. **1**A-B and FIGS. **3**A-**3**B) and the remote device determines how to alter its own communication frequency with the device **250** for network resource conservation and conservation of device **250** resources.

One embodiment of the local proxy **275** further includes a request/transaction manager **235**, which can detect, identify, intercept, process, manage, data requests initiated on the device **250**, for example, by applications **210** and/or **220**, and/or directly/indirectly by a user request. The request/transaction manager **235** can determine how and when to process a given request or transaction, or a set of requests/transactions, based on transaction characteristics.

The request/transaction manager **235** can prioritize requests or transactions made by applications and/or users at the device **250**, for example by the prioritization engine **241**. Importance or priority of requests/transactions can be determined by the manager **235** by applying a rule set, for example, according to time sensitivity of the transaction, time sensitivity of the content in the transaction, time

criticality of the transaction, time criticality of the data transmitted in the transaction, and/or time criticality or importance of an application making the request.

In addition, transaction characteristics can also depend on whether the transaction was a result of user-interaction or other user initiated action on the device (e.g., user interaction with a mobile application). In general, a time critical transaction can include a transaction resulting from a user-initiated data transfer, and can be prioritized as such. Transaction characteristics can also depend on the amount of data that will be transferred or is anticipated to be transferred as a result of the request/requested transaction. For example, the connection manager **265**, can adjust the radio mode (e.g., high power or low power mode via the radio controller **266**) based on the amount of data that will need to be transferred.

In addition, the radio controller **266**/connection manager **265** can adjust the radio power mode (high or low) based on time criticality/sensitivity of the transaction. The radio controller **266** can trigger the use of high power radio mode when a time-critical transaction (e.g., a transaction resulting from a user-initiated data transfer, an application running in the foreground, any other event meeting a certain criteria) is initiated or detected.

In general, the priorities can be determined or set by default, for example, based on device platform, device manufacturer, operating system, etc. Priorities can alternatively or in additionally be set by the particular application; for example, the Facebook mobile application can set its own priorities for various transactions (e.g., a status update can be of higher priority than an add friend request or a poke request, a message send request can be of higher priority than a message delete request, for example), an email client or IM chat client may have its own configurations for priority. The prioritization engine **241** may include set of rules for assigning priority.

The prioritization engine **241** can also track network provider limitations or specifications on application or transaction priority in determining an overall priority status for a request/transaction. Furthermore, priority can in part or in whole be determined by user preferences, either explicit or implicit. A user, can in general, set priorities at different tiers, such as, specific priorities for sessions, or types, or applications (e.g., a browsing session, a gaming session, versus an IM chat session, the user may set a gaming session to always have higher priority than an IM chat session, which may have higher priority than web-browsing session). A user can set application-specific priorities, (e.g., a user may set Facebook related transactions to have a higher priority than LinkedIn related transactions), for specific transaction types (e.g., for all send message requests across all applications to have higher priority than message delete requests, for all calendar-related events to have a high priority, etc.), and/or for specific folders.

The prioritization engine **241** can track and resolve conflicts in priorities set by different entities. For example, manual settings specified by the user may take precedence over device OS settings, network provider parameters/limitations (e.g., set in default for a network service area, geographic locale, set for a specific time of day, or set based on service/fee type) may limit any user-specified settings and/or application-set priorities. In some instances, a manual sync request received from a user can override some, most, or all priority settings in that the requested synchronization is performed when requested, regardless of the individually assigned priority or an overall priority ranking for the requested action.

Priority can be specified and tracked internally in any known and/or convenient manner, including but not limited to, a binary representation, a multi-valued representation, a graded representation and all are considered to be within the scope of the disclosed technology.

TABLE I

Change (initiated on device)	Priority	Change (initiated on server)	Priority
Send email	High	Receive email	High
Delete email	Low	Edit email	Often not possible to sync (Low if possible)
(Un)read email	Low		
Move message	Low		
Read more	High		
Down load attachment	High	New email in deleted items	Low
New Calendar event	High	Delete an email	Low
Edit/change Calendar event	High	(Un)Read an email	Low
		Move messages	Low
Add a contact	High	Any calendar change	High
Edit a contact	High	Any contact change	High
Search contacts	High	Wipe/lock device	High
Change a setting	High	Settings change	High
Manual send/receive	High	Any folder change	High
IM status change	Medium	Connector restart	High (if no changes nothing is sent)
Auction outbid or change notification	High		
Weather Updates	Low	Social Network Status Updates	Medium
		Severe Weather Alerts	High
		News Updates	Low

Table I above shows, for illustration purposes, some examples of transactions with examples of assigned priorities in a binary representation scheme. Additional assignments are possible for additional types of events, requests, transactions, and as previously described, priority assignments can be made at more or less granular levels, e.g., at the session level or at the application level, etc.

As shown by way of example in the above table, in general, lower priority requests/transactions can include, updating message status as being read, unread, deleting of messages, deletion of contacts; higher priority requests/transactions, can in some instances include, status updates, new IM chat message, new email, calendar event update/cancellation/deletion, an event in a mobile gaming session, or other entertainment related events, a purchase confirmation through a web purchase or online, request to load additional or download content, contact book related events, a transaction to change a device setting, location-aware or location-based events/transactions, or any other events/request/transactions initiated by a user or where the user is known to be, expected to be, or suspected to be waiting for a response, etc.

Inbox pruning events (e.g., email, or any other types of messages), are generally considered low priority and absent other impending events, generally will not trigger use of the radio on the device **250**. Specifically, pruning events to remove old email or other content can be 'piggy backed' with other communications if the radio is not otherwise on, at the time of a scheduled pruning event. For example, if the user has preferences set to 'keep messages for 7 days old,' then instead of powering on the device radio to initiate a message delete from the device **250** the moment that the message has exceeded 7 days old, the message is deleted when the radio is powered on next. If the radio is already on, then pruning may occur as regularly scheduled.

The request/transaction manager **235**, can use the priorities for requests (e.g., by the prioritization engine **241**) to

manage outgoing traffic from the device **250** for resource optimization (e.g., to utilize the device radio more efficiently for battery conservation). For example, transactions/requests below a certain priority ranking may not trigger use of the radio on the device **250** if the radio is not already switched on, as controlled by the connection manager **265**. In contrast, the radio controller **266** can turn on the radio such a request can be sent when a request for a transaction is detected to be over a certain priority level.

In one embodiment, priority assignments (such as that determined by the local proxy **275** or another device/entity) can be used cause a remote device to modify its communication with the frequency with the mobile device. For example, the remote device can be configured to send notifications to the device **250** when data of higher importance is available to be sent to the mobile device.

In one embodiment, transaction priority can be used in conjunction with characteristics of user activity in shaping or managing traffic, for example, by the traffic shaping engine **255**. For example, the traffic shaping engine **255** can, in response to detecting that a user is dormant or inactive, wait to send low priority transactions from the device **250**, for a period of time. In addition, the traffic shaping engine **255** can allow multiple low priority transactions to accumulate for batch transferring from the device **250** (e.g., via the batching module **257**). In one embodiment, the priorities can be set, configured, or readjusted by a user. For example, content depicted in Table I in the same or similar form can be accessible in a user interface on the device **250** and for example, used by the user to adjust or view the priorities.

The batching module **257** can initiate batch transfer based on certain criteria. For example, batch transfer (e.g., of multiple occurrences of events, some of which occurred at different instances in time) may occur after a certain number of low priority events have been detected, or after an amount of time elapsed after the first of the low priority event was initiated. In addition, the batching module **257** can initiate batch transfer of the cumulated low priority events when a higher priority event is initiated or detected at the device **250**. Batch transfer can otherwise be initiated when radio use is triggered for another reason (e.g., to receive data from a remote device such as host server **100** or **300**). In one embodiment, an impending pruning event (pruning of an inbox), or any other low priority events, can be executed when a batch transfer occurs.

In general, the batching capability can be disabled or enabled at the event/transaction level, application level, or session level, based on any one or combination of the following: user configuration, device limitations/settings, manufacturer specification, network provider parameters/limitations, platform specific limitations/settings, device OS settings, etc. In one embodiment, batch transfer can be initiated when an application/window/file is closed out, exited, or moved into the background; users can optionally be prompted before initiating a batch transfer; users can also manually trigger batch transfers.

In one embodiment, the local proxy **275** locally adjusts radio use on the device **250** by caching data in the cache **285**. When requests or transactions from the device **250** can be satisfied by content stored in the cache **285**, the radio controller **266** need not activate the radio to send the request to a remote entity (e.g., the host server **100**, **300**, as shown in FIGS. **1**A-**1**B and FIGS. **3**A-**3**B or a content provider/application server such as the server/provider **110** shown in the examples of FIGS. **1**A-**1**B). As such, the local proxy **275** can use the local cache **285** and the cache policy manager **245** to locally store data for satisfying data requests to eliminate or reduce the use of the device radio for conservation of network resources and device battery consumption.

In leveraging the local cache, once the request/transaction manager **225** intercepts a data request by an application on the device **250**, the local repository **285** can be queried to determine if there is any locally stored response, and also determine whether the response is valid. When a valid response is available in the local cache **285**, the response can be provided to the application on the device **250** without the device **250** needing to access the cellular network.

If a valid response is not available, the local proxy **275** can query a remote proxy (e.g., the server proxy **325** of FIG. **3**A) to determine whether a remotely stored response is valid. If so, the remotely stored response (e.g., which may be stored on the server cache **135** or optional caching server **199** shown in the example of FIG. **1**B) can be provided to the mobile device, possibly without the mobile device **250** needing to access the cellular network, thus relieving consumption of network resources.

If a valid cache response is not available, or if cache responses are unavailable for the intercepted data request, the local proxy **275**, for example, the caching policy manager **245**, can send the data request to a remote proxy (e.g., server proxy **325** of FIG. **3**A) which forwards the data request to a content source (e.g., application server/content provider **110** of FIG. **1**A) and a response from the content source can be provided through the remote proxy, as will be further described in the description associated with the example host server **300** of FIG. **3**A. The cache policy manager **245** can manage or process requests that use a variety of protocols, including but not limited to HTTP, HTTPS, IMAP, POP, SMTP and/or ActiveSync. The caching policy manager **245** can locally store responses for data requests in the local database **285** as cache entries, for subsequent use in satisfying same or similar data requests.

The manager **245** can request that the remote proxy monitor responses for the data request, and the remote proxy can notify the device **250** when an unexpected response to the data request is detected. In such an event, the cache policy manager **245** can erase or replace the locally stored response(s) on the device **250** when notified of the unexpected response (e.g., new data, changed data, additional data, different response, etc.) to the data request. In one embodiment, the caching policy manager **245** is able to detect or identify the protocol used for a specific request, including but not limited to HTTP, HTTPS, IMAP, POP, SMTP and/or ActiveSync. In one embodiment, application specific handlers (e.g., via the application protocol module **246** of the manager **245**) on the local proxy **275** allows for optimization of any protocol that can be port mapped to a handler in the distributed proxy (e.g., port mapped on the proxy server **325** in the example of FIG. **3**A).

In one embodiment, the local proxy **275** notifies the remote proxy such that the remote proxy can monitor responses received for the data request from the content source for changed results prior to returning the result to the device **250**, for example, when the data request to the content source has yielded same results to be returned to the mobile device. In general, the local proxy **275** can simulate application server responses for applications on the device **250**, using locally cached content. This can prevent utilization of the cellular network for transactions where new/changed/different data is not available, thus freeing up network resources and preventing network congestion.

In one embodiment, the local proxy **275** includes an application behavior detector **236** to track, detect, observe,

monitor, applications (e.g., proxy aware and/or unaware applications **210** and **220**) accessed or installed on the device **250**. Application behaviors, or patterns in detected behaviors (e.g., via the pattern detector **237**) of one or more applications accessed on the device **250** can be used by the local proxy **275** to optimize traffic in a wireless network needed to satisfy the data needs of these applications.

For example, based on detected behavior of multiple applications, the traffic shaping engine **255** can align content requests made by at least some of the applications over the network (wireless network) (e.g., via the alignment module **256**). The alignment module can delay or expedite some earlier received requests to achieve alignment. When requests are aligned, the traffic shaping engine **255** can utilize the connection manager to poll over the network to satisfy application data requests. Content requests for multiple applications can be aligned based on behavior patterns or rules/settings including, for example, content types requested by the multiple applications (audio, video, text, etc.), mobile device parameters, and/or network parameters/traffic conditions, network service provider constraints/specifications, etc.

In one embodiment, the pattern detector **237** can detect recurrences in application requests made by the multiple applications, for example, by tracking patterns in application behavior. A tracked pattern can include, detecting that certain applications, as a background process, poll an application server regularly, at certain times of day, on certain days of the week, periodically in a predictable fashion, with a certain frequency, with a certain frequency in response to a certain type of event, in response to a certain type user query, frequency that requested content is the same, frequency with which a same request is made, interval between requests, applications making a request, or any combination of the above, for example.

Such recurrences can be used by traffic shaping engine **255** to offload polling of content from a content source (e.g., from an application server/content provider **110** of FIGS. **1**A-**1**B) that would result from the application requests that would be performed at the mobile device **250** to be performed instead, by a proxy server (e.g., proxy server **125** of FIG. **1**B or proxy server **325** of FIG. **3**A) remote from the device **250**. Traffic engine **255** can decide to offload the polling when the recurrences match a rule. For example, there are multiple occurrences or requests for the same resource that have exactly the same content, or returned value, or based on detection of repeatable time periods between requests and responses such as a resource that is requested at specific times during the day. The offloading of the polling can decrease the amount of bandwidth consumption needed by the mobile device **250** to establish a wireless (cellular) connection with the content source for repetitive content polls.

As a result of the offloading of the polling, locally cached content stored in the local cache **285** can be provided to satisfy data requests at the device **250**, when content change is not detected in the polling of the content sources. As such, when data has not changed, application data needs can be satisfied without needing to enable radio use or occupying cellular bandwidth in a wireless network. When data has changed, or when data is different, and/or new data has been received, the remote entity to which polling is offloaded, can notify the device **250**. The remote entity may be the host server **300** as shown in the example of FIG. **3**A.

In one embodiment, the local proxy **275** can mitigate the need/use of periodic keep alive messages (heartbeat messages) to maintain TCP/IP connections, which can consume significant amounts of power thus having detrimental impacts on mobile device battery life. The connection manager **265** in the local proxy (e.g., the heartbeat manager **267**) can detect, identify, and intercept any or all heartbeat (keep-alive) messages being sent from applications.

The heartbeat manager **267** can prevent any or all of these heartbeat messages from being sent over the cellular, or other network, and instead rely on the server component of the distributed proxy system (e.g., shown in FIG. **1**B) to generate the and send the heartbeat messages to maintain a connection with the backend (e.g., app server/provider **110** in the example of FIGS. **1**A-**1**B).

The local proxy **275** generally represents any one or a portion of the functions described for the individual managers, modules, and/or engines. The local proxy **275** and device **250** can include additional or less components; more or less functions can be included, in whole or in part, without deviating from the novel art of the disclosure.

FIG. **2**B depicts a block diagram illustrating another example of components in the application behavior detector **236** and the traffic shaping engine **255** in the local proxy **275** on the client-side of the distributed proxy system shown in the example of FIG. **2**A.

In one embodiment, the pattern detector **237** of the application behavior detector **236** further includes a correlation detector **238** and the application profile generator **239** further includes an application status detector **240**.

The correlation detector **238**, in one embodiment, can detect, determine, identify, compute, track, any correlations in the timing of data transfer requests made by applications, agents, and/or widgets accessed via (e.g., application streaming or accessed through a cloud) or running on the device **250**.

In general, correlation types include event-level correlations and application-level correlations, and can include system/application. The correlation detector **238** can track and monitor system/application triggered events and/or user-triggered events/transactions. In addition, the correlation detector **238** can identify or track correlations between events for a given application or across different applications.

A correlation can be detected, for example, when a first event/transaction type of a first application triggers the initiation of a second event/transaction type of the same application. The triggering can be detected by the correlation detector **238** through identifying patterns in the timing characteristics of such events occurring within the first application. For example, a correlation can include, an identification of the ordering of the first and second event/transaction types (e.g., the second event type always occurs after the first event type). A correlation can also include, determining that the first and second event/transaction types occur within a timeframe of one another (e.g., the first event type occurs within a 10 ms time window of the second event type), etc.

A correlation can also be detected, for example, when a specific event type of one application triggers a specific event type of another application (or has a timing or ordering relationship thereof). Similarly, the correlation detector **238** can detect that operation of one application (e.g., such as the launching of one application or any other activity) is related to the operation of another application. For example, the detector can determine that if one application is launched, the other application is also launched.

The detector can also detect that one application is always launched within a certain time window of another application being launched/accessed, or the activity status of one

application is linked to the application status of the activity status of another application (e.g., when one application moves into the foreground/background, the other application moves into the foreground/background, or when one application becomes active/inactive, the other application also changes state and becomes either active or inactive, etc.). Generally, such events/transactions detected and tracked for correlation can include system or application-initiated events, or user-triggered events (e.g., including explicit user requests or implicit user requests).

In some instances, the correlation detector **238** uses user activity module **215** and can also detect application or application event correlations in relation to and/or in conjunction with user activity. For example, the correlation detector **238** can determine that an occurrence of a first event type frequently causes the user to perform an action which triggers a second event (of the same application or different application). While examples are described herein for two events and examples given for two applications, note that the correlation detector **238** can track, detect, and identify correlations in occurrences of events/transactions, correlations for multiple events (e.g., 2, 3, 4, 5, etc.) that can be detected and identified.

In general, the correlation detector **238** tracks the timing characteristics of requests made by applications to detect correlations. The correlations can be incorporated into an application's profile by the profile generator **239**.

In one embodiment, the profile generator includes an application status detector **240**. The application status detector **240** can detect an activity state of an application on the device **250**. An activity state can indicate, by way of example but not limitation, whether a specific application is operating in the background or foreground on the mobile device **250**, whether the application is active or inactive, whether the application is being interacted with (e.g., by a user, or another application or device). The activity state or status of an application on the device **250** can also be included in an application's profile (e.g., by the profile generator **239**) along with any correlation with other events or applications and used for data request alignment.

For example, one embodiment of the alignment module **256** of the traffic shaping engine **255** which is able to use the application behavior (e.g., as determined by the application behavior detector **236**) of one or multiple applications on a device **250** to align some of the content requests (e.g., aligned by the alignment module **256**) made by the same application or at least a portion the multiple applications from the mobile device over the network. The application behaviors can be indicated in application profiles generated by the application profile generator **239**, for example.

In some instances the content requests (made by the same application or different applications) are aligned by delaying or expediting a time at which some of the content requests would occur without alignment and the traffic shaping engine **256** can transfer the content requests that are delayed or expedited in a single transfer operation over the network (cellular or other wireless network). The amount of time that a request can be delayed (time 'D') is generally determined (e.g., by the delay module **258**) to optimize a number of content requests able to be aligned in the single transfer operation. Hence delay module **258** can utilize the correlations in event/transaction occurrences within an application or across multiple applications as identified by the correlation detector **238** in determining delay time for aligning multiple requests.

The delay time 'D' (e.g., refers to the time by which a request is expedited or delayed) is generally determined based on application behavior (e.g., as determined by the application behavior detector **236** and/or indicated in an application profile). More specifically, the time that is delayed in transfer of a given content request can be determined based on priority of a specific application (e.g., as determined by the prioritization engine **241** of the application behavior detector **236**) making the given content request, or based on the priority of the specific application relative to other applications on the mobile device **250**. In addition, the delay module **258** can determine delays in transfer further based on, one or more of amount of data involved in the given content request, a nature of data involved in the given content request, usable lifetime of data to be transferred in the given content request, and/or network characteristics including available bandwidth or network latency.

Thus in one example of a system level operation in aligning requests, the local proxy **275** of the device **250** detects a first data request made via a first application and a second data request made via a second application, or where first and second data requests are made by the same application. The alignment module **256** of the traffic shaping engine **255** in the local proxy **275** on the device **250** can delay the transfer of the first data transfer request made via the first application to the proxy server (e.g., proxy server **125** or **325** in the examples of FIG. **1**B and FIG. **3**A) until another data transfer request made via the second application is detected by the local proxy **275** such that the transfer the first data transfer request and the second data transfer request occur in a single transfer operation over the network (thus needing to enable radio use only once, assuming that the radio was off on the device **250** when the first data request occurred).

The delay of the first data transfer request can be determined by the delay module **258** and the decision can be made when, for example, the second application is of a higher priority relative to the first application, or that the second application is running in the foreground, or that a user is interacting with the second application and the second data request is initiated in response to the user interaction, or that the second application is more data intensive than the first application.

FIG. **2**C depicts a block diagram illustrating another example of the user activity module **215** having a prediction engine **216** in the local proxy **275** on the client-side of the distributed proxy system shown in the example of FIG. **2**A.

As described in FIG. **2**A, the user activity module **215** is able to detect, track, monitor, process, analyze, user activities at the mobile device **250**. The user activities can be used to determine user activity characteristics such as tracking user activity given the time of day or day of the week, tracking frequency of application use, tracking an order with which new data is accessed or an order with which applications are accessed on the mobile device, etc. The activity module **215** can generally detect, determine, track, analyze user actions to determine characteristics for user actions, which can include habits, tendencies, or patterns.

The activity module **215** can identify a user's general behavior with respect to using the device **250**. For example, the activity module **215** can determine that a user uses the device **250** more frequently during certain hours of the day, or days of the week; the module can determine that the user **250** has a preference for calling vs. SMS based on time, day of week, etc; time/day-dependent preference for using certain applications, types of applications, checking certain email accounts (e.g., if a user tends to check one email account more frequently during the week and another email

account during the weekend), time/day-dependent frequency of checking certain applications (e.g., if a user checks Facebook more often on weekends, or in the afternoons during weekdays compared to in the morning; if a user Tweets more at night or in the day time; if a user uses Yelp mobile more on the weekends or on the weekdays, or during the daytime or night time); if a user tends to access, launch, check applications, accounts, services in a certain order (whether the ordering has time/day dependencies).

The user's behavior with respect to a particular application can be determined by the module **215**. For example, the activity module **215** can detect, identify, analyze, or process a user's activities on a certain application, account, or service. The module **215** can, for instance, determine that the user tends to use certain features but not others on a certain application (e.g., a user tends to use Facebook Walls for messaging rather than private messaging), a user tends to communicate with one individual via one service and another individual via another service, etc.

In addition to time/day dependent preferences or time/day dependent frequencies of use/access, the above actions may also include location-based dependencies, or location-based dependencies in conjunction with time/day based dependencies. For example, the activity module **215** can determine that a user uses Google maps when the device **250** is detected to be on-the-go, or when the user is away from a specific geo-location (e.g., home location or office location), etc. The activity module **215** can determine that the frequency with which a user uses certain applications or accounts changes with geo-location, and/or when the user is determined to be on-the-go, or traveling, etc.

In one embodiment, the user activity module **215** can detect, identify, and/or determining a user's quiet time (e.g., the user is sleeping or otherwise does not use the device **250** (e.g., or if the user is driving/commuting), a time when the user turns off certain connections, closes out of certain applications, or does not check certain applications, accounts, and/or services, etc.

Based on the tracked user behaviors, activities, habits, tendencies, the prediction engine **216** can use any of the information related to user activity characteristics to predict user behavior, and use the predicted user behavior to anticipate or predict future activity sessions at the device **250**. Predicted activity sessions can be used to facilitate data transfer to optimize network use and can have the advantage of also enhancing user experience with mobile applications/accounts.

For example, the prediction engine **216** can communicate any predicted activity sessions or predicted user behavior to the proxy server **325** for use in determining a timing with which to transfer impending data from the host server (e.g., server **300** of FIG. **3**A) to the device **250**. For example, the prediction engine **216** may, based on determined user activities and past behavior, determine that the user typically accesses his/her Outlook Enterprise email account at around 7:30 am most week day mornings. The prediction engine **216** can then generate a predicted activity session for this email access event for use by the host server to time when emails for the email account are transmitted to the device **250**.

For example, the server may not need to initiate a transaction to push emails received between 3 am-7 am to the device **250** until around 7:15 or some time before the predicted activity session since the user is not expected to access it until around 7:30 am. This way, network resources can be conserved, as can power consumption of the device **250**.

In some instances, the server can in addition to, or instead use the behavior of a content provider/application server (e.g., the server/provider **110** in the examples of FIG. **1**A-**1**B with which the mobile device **250** interacts to satisfy content requests or needs of the device **250**) to determine an optimal timing with which to transfer data to the mobile device, as will be further described in conjunction with the example of FIG. **3**B. The activity of the provider/server can be detected and/or tracked through the server-side of the proxy system, as shown in the example of FIG. **3**B.

FIG. **3**A depicts a block diagram illustrating an example of server-side components in a distributed proxy and cache system residing on a host server **300** that manages traffic in a wireless network for resource conservation.

The host server **300** generally includes, for example, a network interface **308** and/or one or more repositories **312**, **314**, **316**. Note that server **300** may be any portable/mobile or non-portable device, server, cluster of computers and/or other types of processing units (e.g., any number of a machine shown in the example of FIG. **11**) able to receive, transmit signals to satisfy data requests over a network including any wired or wireless networks (e.g., Wi-Fi, cellular, Bluetooth, etc.).

The network interface **308** can include networking module(s) or devices(s) that enable the server **300** to mediate data in a network with an entity that is external to the host server **300**, through any known and/or convenient communications protocol supported by the host and the external entity. Specifically, the network interface **308** allows the server **308** to communicate with multiple devices including mobile phone devices **350**, and/or one or more application servers/content providers **310**.

The host server **300** can store information about connections (e.g., network characteristics, conditions, types of connections, etc.) with devices in the connection metadata repository **312**. Additionally, any information about third party application or content providers can also be stored in **312**. The host server **300** can store information about devices (e.g., hardware capability, properties, device settings, device language, network capability, manufacturer, device model, OS, OS version, etc.) in the device information repository **314**. Additionally, the host server **300** can store information about network providers and the various network service areas in the network service provider repository **316**.

The communication enabled by **308** allows for simultaneous connections (e.g., including cellular connections) with devices **350** and/or connections (e.g., including wired/wireless, HTTP, Internet connections, LAN, Wi-Fi, etc.) with content servers/providers **310**, to manage the traffic between devices **350** and content providers **310**, for optimizing network resource utilization and/or to conserver power (battery) consumption on the serviced devices **350**. The host server **300** can communicate with mobile devices **350** serviced by different network service providers and/or in the same/different network service areas. The host server **300** can operate and is compatible with devices **350** with varying types or levels of mobile capabilities, including by way of example but not limitation, 1G, 2G, 2G transitional (2.5G, 2.75G), 3G (IMT-2000), 3G transitional (3.5G, 3.75G, 3.9G), 4G (IMT-advanced), etc.

In general, the network interface **308** can include one or more of a network adaptor card, a wireless network interface card (e.g., SMS interface, Wi-Fi interface, interfaces for various generations of mobile communication standards including but not limited to 1G, 2G, 3G, 3.5G, 4G type networks such as LTE, WiMAX, etc.), Bluetooth, Wi-Fi, or any other network whether or not connected via a a router,

an access point, a wireless router, a switch, a multilayer switch, a protocol converter, a gateway, a bridge, bridge router, a hub, a digital media receiver, and/or a repeater.

The host server **300** can further include, server-side components of the distributed proxy and cache system which can include, a proxy server **325** and a server cache **335**. In one embodiment, the server proxy **325** can include an HTTP access engine **345**, a caching policy manager **355**, a proxy controller **365**, a traffic shaping engine **375**, a new data detector **386**, and/or a connection manager **395**.

The HTTP access engine **345** may further include a heartbeat manager **346**, the proxy controller **365** may further include a data invalidator module **366**, the traffic shaping engine **375** may further include a control protocol **276** and a batching module **377**. Additional or less components/modules/engines can be included in the proxy server **325** and each illustrated component.

As used herein, a "module," "a manager," a "handler," a "detector," an "interface," a "controller," or an "engine" includes a general purpose, dedicated or shared processor and, typically, firmware or software modules that are executed by the processor. Depending upon implementation-specific or other considerations, the module, manager, handler, or engine can be centralized or its functionality distributed. The module, manager, handler, or engine can include general or special purpose hardware, firmware, or software embodied in a computer-readable (storage) medium for execution by the processor. As used herein, a computer-readable medium or computer-readable storage medium is intended to include all mediums that are statutory (e.g., in the United States, under 35 U.S.C. 101), and to specifically exclude all mediums that are non-statutory in nature to the extent that the exclusion is necessary for a claim that includes the computer-readable (storage) medium to be valid. Known statutory computer-readable mediums include hardware (e.g., registers, random access memory (RAM), non-volatile (NV) storage, to name a few), but may or may not be limited to hardware.

In the example of a device (e.g., mobile device **350**) making an application or content request to an app server or content provider **310**, the request may be intercepted and routed to the proxy server **325**, which is coupled to the device **350** and the provider **310**. Specifically, the proxy server is able to communicate with the local proxy (e.g., proxy **175** and **275** of the examples of FIG. **1** and FIGS. **2**A-**2**C respectively) of the device **350**, the local proxy forwards the data request to the proxy server **325** for, in some instances, further processing, and if needed, for transmission to the content server **310** for a response to the data request.

In such a configuration, the host **300**, or the proxy server **325** in the host server **300** can utilize intelligent information provided by the local proxy in adjusting its communication with the device in such a manner that optimizes use of network and device resources. For example, the proxy server **325** can identify characteristics of user activity on the device **350** to modify its communication frequency. The characteristics of user activity can be determined by, for example, the activity/behavior awareness module **366** in the proxy controller **365**, via information collected by the local proxy on the device **350**.

In one embodiment, communication frequency can be controlled by the connection manager **396** of the proxy server **325**, for example, to adjust push frequency of content or updates to the device **350**. For instance, push frequency can be decreased by the connection manager **396** when characteristics of the user activity indicate that the user is inactive. In one embodiment, when the characteristics of the user activity indicate that the user is subsequently active after a period of inactivity, the connection manager **396** can adjust the communication frequency with the device **350** to send data that was buffered as a result of decreased communication frequency, to the device **350**.

In addition, the proxy server **325** includes priority awareness of various requests, transactions, sessions, applications, and/or specific events. Such awareness can be determined by the local proxy on the device **350** and provided to the proxy server **325**. The priority awareness module **367** of the proxy server **325** can generally assess the priority (e.g., including time-criticality, time-sensitivity, etc.) of various events or applications; additionally, the priority awareness module **367** can track priorities determined by local proxies of devices **350**.

In one embodiment, through priority awareness, the connection manager **395** can further modify communication frequency (e.g., use or radio as controlled by the radio controller **396**) of the server **300** with the devices **350**. For example, the server **300** can notify the device **350**, thus requesting use of the radio if it is not already in use, when data or updates of an importance/priority level which meets a criteria becomes available to be sent.

In one embodiment, the proxy server **325** can detect multiple occurrences of events (e.g., transactions, content, data received from server/provider **310**) and allow the events to accumulate for batch transfer to device **350**. Batch transfer can be cumulated and transfer of events can be delayed based on priority awareness and/or user activity/application behavior awareness, as tracked by modules **366** and/or **367**. For example, batch transfer of multiple events (of a lower priority) to the device **350** can be initiated by the batching module **377** when an event of a higher priority (meeting a threshold or criteria) is detected at the server **300**. In addition, batch transfer from the server **300** can be triggered when the server receives data from the device **350**, indicating that the device radio is already in use and is thus on. In one embodiment, the proxy server **324** can order the each messages/packets in a batch for transmission based on event/transaction priority, such that higher priority content can be sent first, in case connection is lost or the battery dies, etc.

In one embodiment, the server **300** caches data (e.g., as managed by the caching policy manager **355**) such that communication frequency over a network (e.g., cellular network) with the device **350** can be modified (e.g., decreased). The data can be cached, for example in the server cache **335**, for subsequent retrieval or batch sending to the device **350** to potentially decrease the need to turn on the device **350** radio. The server cache **335** can be partially or wholly internal to the host server **300**, although in the example of FIG. **3**A, it is shown as being external to the host **300**. In some instances, the server cache **335** may be the same as and/or integrated in part or in whole with another cache managed by another entity (e.g., the optional caching proxy server **199** shown in the example of FIG. **1**B), such as being managed by an application server/content provider **110**, a network service provider, or another third party.

In one embodiment, content caching is performed locally on the device **350** with the assistance of host server **300**. For example, proxy server **325** in the host server **300** can query the application server/provider **310** with requests and monitor changes in responses. When changed, different or new responses are detected (e.g., by the new data detector **347**), the proxy server **325** can notify the mobile device **350**, such that the local proxy on the device **350** can make the decision

to invalidate (e.g., indicated as outdated) the relevant cache entries stored as any responses in its local cache. Alternatively, the data invalidator module **368** can automatically instruct the local proxy of the device **350** to invalidate certain cached data, based on received responses from the application server/provider **310**. The cached data is marked as invalid, and can get replaced or deleted when new content is received from the content server **310**.

Note that data change can be detected by the detector **347** in one or more ways. For example, the server/provider **310** can notify the host server **300** upon a change. The change can also be detected at the host server **300** in response to a direct poll of the source server/provider **310**. In some instances, the proxy server **325** can in addition, pre-load the local cache on the device **350** with the new/updated/changed/different data. This can be performed when the host server **300** detects that the radio on the mobile device is already in use, or when the server **300** has additional content/data to be sent to the device **350**.

One or more the above mechanisms can be implemented simultaneously or adjusted/configured based on application (e.g., different policies for different servers/providers **310**). In some instances, the source provider/server **310** may notify the host **300** for certain types of events (e.g., events meeting a priority threshold level). In addition, the provider/server **310** may be configured to notify the host **300** at specific time intervals, regardless of event priority.

In one embodiment, the proxy server **325** of the host **300** can monitor/track responses received for the data request from the content source for changed results prior to returning the result to the mobile device, such monitoring may be suitable when data request to the content source has yielded same results to be returned to the mobile device, thus preventing network/power consumption from being used when no new/changes are made to a particular requested. The local proxy of the device **350** can instruct the proxy server **325** to perform such monitoring or the proxy server **325** can automatically initiate such a process upon receiving a certain number of the same responses (e.g., or a number of the same responses in a period of time) for a particular request.

In one embodiment, the server **300**, for example, through the activity/behavior awareness module **366**, is able to identify or detect user activity, at a device that is separate from the mobile device **350**. For example, the module **366** may detect that a user's message inbox (e.g., email or types of inbox) is being accessed. This can indicate that the user is interacting with his/her application using a device other than the mobile device **350** and may not need frequent updates, if at all.

The server **300**, in this instance, can thus decrease the frequency with which new, different, changed, or updated content is sent to the mobile device **350**, or eliminate all communication for as long as the user is detected to be using another device for access. Such frequency decrease may be application specific (e.g., for the application with which the user is interacting with on another device), or it may be a general frequency decrease (e.g., since the user is detected to be interacting with one server or one application via another device, he/she could also use it to access other services) to the mobile device **350**.

In one embodiment, the host server **300** is able to poll content sources **310** on behalf of devices **350** to conserve power or battery consumption on devices **350**. For example, certain applications on the mobile device **350** can poll its respective server **310** in a predictable recurring fashion. Such recurrence or other types of application behaviors can be tracked by the activity/behavior module **366** in the proxy controller **365**. The host server **300** can thus poll content sources **310** for applications on the mobile device **350**, that would otherwise be performed by the device **350** through a wireless (e.g., including cellular connectivity). The host server can poll the sources **310** for new, different, updated, or changed data by way of the HTTP access engine **345** to establish HTTP connection or by way of radio controller **396** to connect to the source **310** over the cellular network. When new, different, updated, or changed data is detected, the new data detector can notify the device **350** that such data is available and/or provide the new/changed data to the device **350**.

In one embodiment, the connection manager **395** determines that the mobile device **350** is unavailable (e.g., the radio is turned off) and utilizes SMS to transmit content to the device **350**, for instance via the SMSC shown in the example of FIG. **1**B. SMS may be used to transmit invalidation messages, batches of invalidation messages, or even content in the case the content is small enough to fit into just a few (usually one or two) SMS messages. This avoids the need to access the radio channel to send overhead information. The host server **300** can use SMS for certain transactions or responses having a priority level above a threshold or otherwise meeting a criteria. The server **300** can also utilize SMS as an out-of-band trigger to maintain or wake-up an IP connection as an alternative to maintaining an always-on IP connection.

In one embodiment, the connection manager **395** in the proxy server **325** (e.g., the heartbeat manager **398**) can generate and/or transmit heartbeat messages on behalf of connected devices **350**, to maintain a backend connection with a provider **310** for applications running on devices **350**.

For example, in the distributed proxy system, local cache on the device **350** can prevent any or all heartbeat messages needed to maintain TCP/IP connections required for applications, from being sent over the cellular, or other network, and instead rely on the proxy server **325** on the host server **300** to generate and/or send the heartbeat messages to maintain a connection with the backend (e.g., app server/provider **110** in the example of FIGS. **1**A-**1**B). The proxy server can generate the keep-alive (heartbeat) messages independent of the operations of the local proxy on the mobile device.

The repositories **312**, **314**, and/or **316** can additionally store software, descriptive data, images, system information, drivers, and/or any other data item utilized by other components of the host server **300** and/or any other servers for operation. The repositories may be managed by a database management system (DBMS), for example but not limited to, Oracle, DB2, Microsoft Access, Microsoft SQL Server, PostgreSQL, MySQL, FileMaker, etc.

The repositories can be implemented via object-oriented technology and/or via text files, and can be managed by a distributed database management system, an object-oriented database management system (OODBMS) (e.g., ConceptBase, FastDB Main Memory Database Management System, JDOInstruments, ObjectDB, etc.), an object-relational database management system (ORDBMS) (e.g., Informix, OpenLink Virtuoso, VMDS, etc.), a file system, and/or any other convenient or known database management package.

FIG. **3**B depicts a block diagram illustrating another example of the server-side components of the distributed proxy system shown in the example of FIG. **3**A as further including a user experience (UE) enhancement engine **385** and with the traffic shaping engine **375** further including a delay module **378**.

The UE enhancement engine **385** may further include an activity prediction engine **386** having a server activity tracker **387**, a contextual data tracker **389** and/or a pre-caching engine **390**.

The server activity tracker **387** can track the activity or behavior of a server (application server/content provider **110** in the examples of FIG. **1**A-**1**B) for use in predicting data activity at the app server/content provider. The activity/behavior determined by the activity tracker can be used, for example, by the traffic shaping engine **375** in determining a timing with which data received from the server is to be transmitted to a mobile device. In general, the server is a host (e.g., Facebook server, email server, RSS service, any other web services, etc.) with which the mobile device interacts to satisfy content requests/needs.

In general, server activity/behavior can include any action or activity detected on the server for servicing content requests made by an associated application, service, or account on a device (e.g., device **250** in the example of FIG. **2**A). Server activity can include, for example, amount of impending data to be transferred to the mobile device, last-accessed time or a frequency of access, etc.

Determined or detected server activity can be used in determining a timing with which to transfer impending data from the host server. For example, if the activity tracker **387** detects that a recent data transfer was made from the Facebook server to the device, the traffic shaping engine **375**, may delay the time (e.g., via the delay module **378**) with which the next data transfer is to be made, for example, based on predicted future activity session. Alternatively, in response to determining that a large amount of data is impending at the host to be sent to the mobile device, the traffic shaping engine **375** may decide to initiate a transfer without delay or with minimal delay.

One embodiment of the activity prediction engine **386** further includes a contextual data tracker **389** to detect contextual data for use in the anticipation of future activity session(s). Contextual data can be used alone or in conjunction with server activity by the prediction engine **386** in anticipating future activity sessions (e.g., future activity, future data events/transactions at a content host/app server/provider).

Contextual data can include, for example, location changes or motion of a mobile device, states or statuses of applications on the mobile device (e.g., if the application is active or inactive, running in the foreground or background, if a user is actively interacting with the application or if background maintenance processes are running, etc.). Contextual data can be determined from one or more hardware sensors on a device, for example, device backlight, a device electronic compass, motion sensor, tilt sensor, light sensor, gesture sensor, input detector (keyboard, mouse, touch screen), proximity sensor, capacitive sensor, resistive sensor, image detector, a camera, GPS receiver, etc.

In one embodiment, the traffic shaping engine **375** can categorize the activity that is being processed by the host server **300** since the last user activity session. Predicted or anticipated activity sessions which can be generated by the activity prediction engine **386** can include:

1) A list of URLs representing application servers/content providers (e.g., the provider/server **110** of FIGS. **1**A-**1**B);

2) For each URL, a count of impending data that is available to the user for that URL to be transmitted to the device;

3) For each URL, a last-accessed time and/or a frequency of access.

Once created, the traffic shaping engine **375** can prioritize the app servers/content providers (or the representing URLs) based on last accessed time, frequency, impending data count, or other criteria to form a prioritized list of host URL targets. This predicted or anticipated activity session may form the basis for predicting whether a subsequent mobile device data request will activate the session (i.e., turn the predicted activity session into an activity session).

The predicted activity session can be used by the traffic shaping engine **375** to determining a timing with which to transfer impending data from the host server to the mobile device to support predicted data activity for the future activity session. In one embodiment, transfer of the impending content is performed over a multiplexed TCP connection supporting multiple HTTP sessions. In some instances, the impending content is transferred from the host server the mobile device to pre-cache content (e.g., by the pre-caching module **390**) on the mobile device to support predicted data activity for the future activity session. The pre-caching can enhance a user's experience since the data is provided to the user before it is actually requested (e.g., in the predicted activity session).

FIG. **4**A depicts a diagram showing how data requests from a mobile device **450** to an application server/content provider **496** in a wireless network can be coordinated by a distributed proxy system **460** in a manner such that network and battery resources are conserved through using content caching and monitoring performed by the distributed proxy system **460**.

In satisfying application or client requests on a mobile device **450** without the distributed proxy system **460**, the mobile device **450**, or the software widget executing on the device **450** performs a data request **402** (e.g., an HTTP GET, POST, or other request) directly to the application server **495** and receives a response **404** directly from the server/provider **495**. If the data has been updated, the widget on the mobile device **450** can refreshes itself to reflect the update and waits for small period of time and initiates another data request to the server/provider **495**.

In one embodiment, the requesting client or software widget **455** on the device **450** can utilize the distributed proxy system **460** in handling the data request made to server/provider **495**. In general, the distributed proxy system **460** can include a local proxy **465** (which is typically considered a client-side component of the system **460** and can reside on the mobile device **450**), a caching proxy (**475**, considered a server-side component **470** of the system **460** and can reside on the host server **485** or be wholly or partially external to the host server **485**), a host server **485**. The local proxy **465** can be connected to the proxy **475** and host server **485** via any network or combination of networks.

When the distributed proxy system **460** is used for data/application requests, the widget **455** can perform the data request **406** via the local proxy **465**. The local proxy **465**, can intercept the requests made by device applications, and can identify the connection type of the request (e.g., an HTTP get request or other types of requests). The local proxy **465** can then query the local cache for any previous information about the request (e.g., to determine whether a locally stored response is available and/or still valid). If a locally stored response is not available or if there is an invalid response stored, the local proxy **465** can update or store information about the request, the time it was made, and any additional data, in the local cache. The information can be updated for use in potentially satisfying subsequent requests.

The local proxy **465** can then send the request to the host server **485** and the server **485** can perform the request **406** and returns the results in response **408**. The local proxy **465** can store the result and in addition, information about the result and returns the result to the requesting widget **455**.

In one embodiment, if the same request has occurred multiple times (within a certain time period) and it has often yielded same results, the local proxy **465** can notify **410** the server **485** that the request should be monitored (e.g., steps **412** and **414**) for result changes prior to returning a result to the local proxy **465** or requesting widget **455**.

In one embodiment, if a request is marked for monitoring, the local proxy **465** can now store the results into the local cache. Now, when the data request **416**, for which a locally response is available, is made by the widget **455** and intercepted at the local proxy **465**, the proxy **465** can return the response **418** from the local cache without needing to establish a connection communication over the wireless network. In one embodiment, the response is stored at the server proxy in the server cache for subsequent use in satisfying same or similar data requests. The response can be stored in lieu of or in addition to storage on the local cache on the mobile device.

In addition, the server proxy performs the requests marked for monitoring **420** to determine whether the response **422** for the given request has changed. In general, the host server **485** can perform this monitoring independently of the widget **455** or local proxy **465** operations. Whenever an unexpected response **422** is received for a request, the server **485** can notify the local proxy **465** that the response has changed (e.g., the invalidate notification in step **424**) and that the locally stored response on the client should be erased or replaced with a new (e.g., changed or different) response.

In this case, a subsequent data request **426** by the widget **455** from the device **450** results in the data being returned from host server **485** (e.g., via the caching proxy **475**). Thus, through utilizing the distributed proxy system **460** the wireless (cellular) network is intelligently used when the content/data for the widget or software application **455** on the mobile device **450** has actually changed. As such, the traffic needed to check for the changes to application data is not performed over the wireless (cellular) network. This reduces the amount of generated network traffic and shortens the total time and the number of times the radio module is powered up on the mobile device **450**, thus reducing battery consumption, and in addition, frees up network bandwidth.

FIG. **4**B depicts a timing diagram showing how data requests from a mobile device **450** to an application server/content provider **495** in a wireless network can be aligned at the local proxy **465** in the distributed proxy system **460** to optimize network and radio use.

When a data request A **432** is detected at the local proxy **465** on the mobile device **450**, the local proxy **465** can determine that the radio on the mobile device **450** is currently off and decide to wait to transfer the request A **432** over the network. When data request B **434** is detected, the proxy **465** can determine (e.g., based on conditions and/or processes illustrated in the flow charts in the examples of FIGS. **6**A-**10**C) whether to transfer the data request B **434** and/or whether also to transfer the impending data request A **432**.

In the example shown in FIG. **4**B, the local proxy **465** does not transfer data requests A and B until data request C**436** is detected at the device **450** by the proxy **465**. The time 'D**1**' **433** with which request A **432** and time D**2**' **435** with which request B **434** are delayed, can be determined by the local proxy **465** (e.g., as described in conjunction with the traffic shaping module and delay module in the example of FIG. **2**B). The radio can be turned on when request C **436** is received and data transfers for requests A, B, and C **438** can be aligned at this point to be transferred to the host server **480** on the server-side **470** of the distributed proxy **460** which can forward the request to the server/provider **495**, immediately in transfer **440**, or possibly with some delay, in transfer **442**. Note that the data requests A, B, and C can all originate from the same application or different applications on the mobile device **450**.

FIG. **5** depicts a diagram showing one example process for implementing a hybrid IP and SMS power saving mode on a mobile device **550** using a distributed proxy and cache system (e.g., such as the distributed system shown in the example of FIG. **1**B).

In step **502**, the local proxy (e.g., proxy **175** in the example of FIG. **1**B) monitors the device for user activity. When the user is determined to be active, server push is active. For example, always-on-push IP connection can be maintained and if available, SMS triggers can be immediately sent to the mobile device **550** as it becomes available.

In process **504**, after the user has been detected to be inactive or idle over a period of time (e.g., the example is shown for a period of inactivity of 20 min.), the local proxy can adjust the device to go into the power saving mode. In the power saving mode, when the local proxy receives a message or a correspondence from a remote proxy (e.g., the server proxy **135** in the example of FIG. **1**B) on the server-side of the distributed proxy and cache system, the local proxy can respond with a call indicating that the device **550** is currently in power save mode (e.g., via a power save remote procedure call). In some instances, the local proxy take the opportunity to notify multiple accounts or providers (e.g., **510**A, and **510**B) of the current power save status (e.g., timed to use the same radio power-on event).

In one embodiment, the response from the local proxy can include a time (e.g., the power save period) indicating to the remote proxy (e.g., server proxy **135**) and/or the app server/providers **510**A/B when the device **550** is next able to receive changes or additional data. A default power savings period can be set by the local proxy. Consecutive power saving periods can increase in duration. For example, if a first power saving period has elapsed without an activity occurring, the device **550** can continue into a second power saving mode with a longer time period (e.g., see periods one 503 and period two 505). In general, any activity on the device takes the client out of power saving mode and ends that particular power save event.

In one embodiment, if new, change, or different data or event is received before the end of any one power saving period, then the wait period communicated to the servers **510**A/B can be the existing period, rather than an incremented time period. For example, in step **506**, since new content was received during the power saving mode, the next wait period communicated in step **508** to servers **510**A/B may again be the same time saving period. In response, the remote proxy server, upon receipt of power save notification from the device **550**, can stop sending changes (data or SMSs) for the period of time requested (the wait period). At the end of the wait period, any notifications received can be acted upon and changes sent to the device **550**, for example, as a single batched event or as individual events. If no notifications come in, then true push can be resumed with the data or an SMS being sent immediately to the device **550**. To optimize batch sending content to the mobile device **550**, the proxy server can start the poll or data

collect event earlier (before the end of a power save period) in order to increase the chance that the client will receive data at the next radio power on event.

In one embodiment, whenever new data or content comes into the device **550** while it is in a power saving mode, it can respond with the power saving remote procedure call to all end points currently registered (e.g., server/providers **510**A/B). Note that the wait period can be updated in operation in real time to accommodate operating conditions. For example, as the mobile device **550** sends additional power saving calls (e.g., with updated wait times) if multiple servers **510**A/B or others, respond to the end of a wait period with different delays, the local proxy can adjust the wait period on the fly to accommodate the different delays.

Detection of user activity **512** at the device **550** causes the power save mode to be exited. When the device **550** exits power save mode, it can send power save cancel call to the proxy server and immediately receives any changes associated with any pending notifications. This may require a poll to be run by the proxy server after receiving the power saving cancel call. If the latest power saving period has expired, then no power save cancel call may be needed as the proxy server will already be in traditional push operation mode.

In one embodiment, power save mode is not applied when the device **550** is plugged into a charger. This setting can be reconfigured or adjusted by the user or another party. In general, the power save mode can be turned on and off, for example, by the user via a user interface on device **550**. In general, timing of power events to receive data can be synced with any power save calls to optimize radio use.

FIG. **6**A depicts a flow chart illustrating example processes through which context awareness is used for traffic management.

In process **602**A, characteristics of user activity on the mobile device are detected. In process **604**A, behavior of the mobile device is adjusted to optimize battery consumption on the mobile device. The adjustment of the behavior of the mobile device can include, for example, adjusting the use of radio on the mobile device, as in process **606**A. In addition, in process **608**A, the radio can be switched on/off. Further, the radio can also be placed in low power or high power radio mode in process **612**A.

In addition, data can be cached at the mobile device in process **610**A to adjust radio use. Data may also be cached at the server in wireless communication with the mobile device to in order to modify communication frequency with the mobile device. In one embodiment, in response to detection of user activities on the mobile device, the characteristics of the user activity can be communicated from the mobile device to the server, in process **614**A.

Similarly, based on the user activity characteristics, communication frequency of a server with the mobile device can be adjusted in process **616**A. For example, data push frequency from the server to the mobile device is decreased, in process **618**A. Similarly, data can be cached at the server in process **620**A to adjust communication frequency.

In addition, characteristics of transactions occurring at the mobile device can also be used to locally adjust radio use on the mobile device. For example, characteristics of transactions include time criticality of the transactions and that a low power radio mode or a high power radio mode can be selected for use on the mobile device based on the time criticality of the transactions. Additionally, a low power radio mode or a high power radio mode is selected for use on the mobile device based on amount of data to be transferred in the transactions.

FIG. **6**B depicts a flow chart illustrating example processes through which application behavior on a mobile device is used for traffic optimization.

In process **602**B, application behavior of multiple applications accessed on a mobile device is detected. Using application behavior, the distributed proxy system can implement one or more of several processes for optimizing traffic.

For example, beginning in process **604**B, content requests for the at least some of the multiple applications are aligned and polling can be performed over the wireless network in accordance with the alignment to satisfy data requests of the multiple applications, in process **606**B. In one embodiment, content requests for some of the multiple applications can be aligned based on content types requested by the multiple applications. For example, content requests from different applications requesting RSS feeds can be aligned. In addition, content requests from different applications requesting content from the same sources may be aligned (e.g., a social networking application and a web page may both be requesting media content from an online video streaming site such as Youtube). In another example, multiple Facebook applications on one device (one from OEM, one from marketplace) that both poll for same data.

In addition, content requests can be aligned based on user's explicit and/or implicit preferences, user settings, mobile device parameters/parameters, and/or network parameters (e.g., network service provider specifications or limitations, etc.) or conditions (e.g., traffic, congestion, network outage, etc.). For example, when congestion is detected in a user's network service area, content requests can be aligned for the network is less congested. For example, when user is inactive, or when the battery is low, alignment may be performed more aggressively.

In some instances, the polling can be performed by the proxy server on behalf of multiple devices and can thus detect requests for polls from the same content source from multiple devices. The proxy server, can align such requests occurring around the same time (e.g., within a specific time period) for multiple devices and perform a poll of the source to satisfy the data needs of the multiple mobile devices. For example, during the Superbowl, the proxy server can detect a larger number of requests to poll ESPN.com or NFL.com for live score updates for the game. The proxy server can poll the content source once for a current score and provide the updates to each of the mobile devices that have applications which have (within a time period) requested polls for score updates.

In another example, beginning in process **608**B, recurrences in application requests made by the multiple applications are detected. Recurrences of application behavior can be identified by, for example, tracking patterns in application behavior.

Using the recurrences, polling of content sources as a result of the application requests that would be performed at the mobile device can now be offloaded, to be performed instead, for example, by a proxy server remote from the mobile device in the wireless network, in process **610**B. The application behavior can be tracked by, for example, a local proxy on the mobile device and communicated to the proxy server as connection metadata, for use in polling the content sources. The local proxy can delays or modifies data prior to transmission to the proxy serve and can additionally identify and retrieve mobile device properties including, one or more of, battery level, network that the device is registered on, radio state, whether the mobile device is being used. The offloading to the proxy server can be performed, for

example, when the recurrences match a rule or criteria. In addition, the proxy server and/or the local proxy can delay the delivery of a response received from a content source and/or perform additional modification, etc. For example, the local proxy can delay the presentation of the response via the mobile device to the user, in some instances.

Patterns of behavior can include, one or more of, by way of example but not limitation, frequency that requested content is the same, frequency with which a same request is made, interval between requests, applications making a request, frequency of requests at certain times of day, day of week. In addition, multi-application traffic patterns can also be detected and tracked.

In process **612**B, the proxy server can notify the mobile device when content change is detected in response to the polling of the content sources. In one embodiment, cached content, when available, can be provided to satisfy application requests when content change is not detected in the polling of the content sources. For example, the local proxy can include a local cache and can satisfy application requests on the mobile device using cached content stored in the local cache. In one embodiment, the decision to use cached content versus requesting data from the content source is determined based on the patterns in application behavior. In addition, an application profile can be generated, using the application behavior of the multiple applications, in process **614**B.

FIG. **7**A depicts a flow chart illustrating an example process for managing traffic in a wireless network based on user interaction with a mobile device.

In process **702**A, it is determined if the user actively interacting with the mobile device. If the user is actively interacting with the mobile device, the mobile device **714**A can be notified, as in process **714**A, of new data or changes in data.

If not, in process **704**A, device can wait to send low priority transactions until after the user activity has been dormant for a period of time, for example, low priority transactions include, one or more of, updating message status as being read, unread, and deleting of messages. In addition, low priority transactions can be sent when a higher priority transaction needs to be sent, thus utilizing the same radio power-up event. Low priority transactions can generally include application maintenance events, events not requested by a user, events scheduled to be in the future, such as, by way of example but not limitation, one or more of, updating message status as being read, unread, and deleting of messages.

Similarly, if the user is not active, data push frequency from the server can be decreased in process **706**A. In process **708**A, if the user is detected to be subsequently active after being inactive, then data buffered as a result of decreased communication frequency can be sent to the mobile device, in process **710**A.

Alternatively, even if the user is not actively interacting with the mobile device, an assessment can be made as to whether high importance data (e.g., data importance or priority meeting a threshold level) is pending to be sent to the mobile device, in process **712**A. If so, the mobile device is notified, in process **714**A. As a result of the notification, the mobile device radio can be enabled such that the high importance data can be sent to the mobile device. In general, the importance of data can be determined based on one or more of several criteria including but not limited to, application to which the data is relevant, time criticality, and time sensitivity, etc. An example of a time critical transaction includes a transaction resulting from a user-initiated data transfer.

FIG. **7**B depicts a flow chart illustrating an example process for mobile application traffic optimization through data monitoring and coordination in a distributed proxy and cache system.

In process **702**B, a data request made by the mobile application on a mobile device is intercepted. In process **704**B, a local cache on the mobile device is queried.

In process **706**B, it is determined whether a locally stored valid response exists (e.g., whether a locally stored response is available and if so, if the stored response is still valid. If so, in process **708**B, the locally stored response to the mobile device without the mobile device needing to access the cellular network

If not, a locally stored response is not available, or available but invalid, one or more of several approaches may be taken to optimize the traffic used in the wireless network for satisfying this request, as will be described below.

In one example, in process **710**B, the data request is sent to a remote proxy which forwards the data request to a content source. In general, the remote proxy can delay or modify data from the local proxy prior to transmission to the content sources. In one embodiment, the proxy server can use device properties and/or connection metadata to generate rules for satisfying request of applications on the mobile device. In addition, the proxy server can optionally gather real time traffic information about requests of applications for later use in optimizing similar connections with the mobile device or other mobile devices.

In process **712**B, a response provided by the content source is received through the remote proxy. In one embodiment, the remote proxy can simulate an application server authentication and querying a local cache on the mobile device to retrieve connection information if available or needed to connect to the content source. Upon authentication application server responses for the mobile application can be simulated by the remote proxy on the mobile device for data requests where responses are available in the local cache.

In process **714**B, the response is locally stored as cache entries in a local repository on the mobile device. The local cache entries can be stored for subsequent use in satisfying same or similar data request.

In addition, in process **716**B, data request to the content source is detected to yielded same results to be returned to the mobile device (e.g., detected by the local proxy on the mobile device). In response to such detection, the remote proxy is notified to monitor responses received for the data request from the content source for changed results prior to returning the result to the mobile device. In one embodiment, the local proxy can store the response as a cache entry in the local cache for the data request when the remote proxy is notified to monitor the responses for the data request.

In process **722**B, the remote proxy performs the data request identified for monitoring and notifies the mobile device when an unexpected response to the data request is detected. In process **724**B. The locally stored response on the mobile device is erased or replaced when notified of the unexpected response to the data request.

In another example, when a locally stored response is not available or otherwise invalid, in process **718**B, a remote proxy is queried for a remotely stored response. In process **720**B, the remotely stored response is provided to the mobile device without the mobile device needing to access the cellular network. In process **722**B, the remote proxy per-

forms the data request identified for monitoring and notifies the mobile device when an unexpected response to the data request is detected. In process **724**B, the locally stored response on the mobile device is erased or replaced when notified of the unexpected response to the data request.

FIG. **8**A depicts a flow chart illustrating another example process for managing traffic in a wireless network based on user interaction with a mobile device.

In process **802**A, user activity is detected at a device separate from a mobile device. In process **804**A, it is determined whether the user activity at the device is able to access the same data, content, or application, which is also setup to be delivered to or accessed at the mobile device. For example, user activity at the device separate from the mobile device can include user access of an email inbox or other types applications via an interface other than that accessed from the mobile device (e.g., from a laptop or desktop computer). Since the user is now accessing the client from another device, the user now may not need content to be updated as frequently on the mobile device. Thus, in process **806**A, communication frequency from a server to the mobile device is decreased.

FIG. **8**B depicts a flow chart illustrating an example process for preventing applications from needing to send keep-alive messages to maintain an IP connection with a content server.

In process **802**B, applications attempting to send keep-alive messages to a content server are detected at a mobile device.

In process **804**B, the keep-alive messages are intercepted and prevented from being sent from the mobile device over the wireless network to the content server. Since keep-alives are similar to any other (long-poll) requests—the content on the back end typically does not change and the proxy server can keep polling the content server.

In process **806**B, the keep-alive messages are generated at a proxy server remote from the mobile device and sent from the proxy server to the content server, in process **808**B.

FIG. **9**A depicts a flow chart illustrating an example process for managing traffic initiated from a mobile device in a wireless network through batching of event transfer based on event priority.

In process **902**A, multiple occurrences of events having a first priority type initiated on the mobile device are detected.

In process **904**A, the mobile device cumulates multiple occurrences of events having a first priority type initiated on the mobile device, before transfer over the wireless network. The first priority type can be a generally low priority type indicating a request or update which is not time critical or time sensitive. Thus, if the device radio is currently off, the radio may not be immediately turned on to transmit individual events which are not time critical, until other triggering events occur or other criteria is met.

For example, in process **906**A, occurrence of an event of a second priority type is detected, which can trigger batch transfer of the cumulated events to a server in wireless communication with the mobile device, in process **916**A, where the second priority type is of a higher priority than the first priority type.

In another example, in process **908**A, data transfer from the server can trigger the radio use on the mobile device, which can trigger batch transfer of the cumulated events to a server in wireless communication with the mobile device, in process **916**A. Alternatively, in process **910**A, after a period of time elapses, batch transfer of the cumulated events to a server in wireless communication with the mobile device can be triggered, in process **916**A.

In one embodiment, in process **912**A, a user trigger (e.g., a manual sync request) or in response to a user prompt, batch transfer of the cumulated events to a server in wireless communication with the mobile device can be triggered, in process **916**A. In process **914**A, when it is detected that an application is exited and/or moved into the background, batch transfer of the cumulated events to a server in wireless communication with the mobile device can be triggered, in process **916**A.

FIG. **10**A depicts a flow chart illustrating another example process for managing traffic initiated remotely from a mobile device in a wireless network through batching of event transfer based on event priority.

In process **1002**A, multiple occurrences of events having a first priority type are detected at a server wirelessly coupled to a mobile device. In process **1004**A, the server cumulates the multiple occurrences of events having a first priority type, before transfer over the wireless network. The first priority type may not be of a high priority type or having a priority exceeding a certain threshold level indicating a level or time criticality or urgency. Thus, such events, upon occurrence, may not be immediately transferred to the mobile device, until certain criterion is met, or until one or more triggering events occur.

For example, in process **1006**A, occurrence of an event of a second priority type is detected at the server, which can trigger batch transfer of the cumulated events to the mobile device, in process **1016**A, when the second priority type is of a higher priority than the first priority type. In another example, in process **1008**A, data transfer from the mobile device indicates the radio use on the mobile device, which can trigger batch transfer of the cumulated events to the mobile device, in process **1016**A.

Alternatively, in process **1010**A, after a period of time elapses, batch transfer of the cumulated events to the mobile device can be triggered, in process **1016**A. In process **1012**A, a user trigger or in response to a user prompt, batch transfer of the cumulated events to the mobile device can be triggered, in process **1016**A. In process **1014**A, when it is detected that an application is exited and/or moved into the background, batch transfer of the cumulated events to the mobile device can be triggered, in process **1016**A. In general, manual overrides or manual syncs can cause batch transfers to occur, either from the mobile device to the server or vice versa.

FIG. **6**C depicts a flow chart illustrating example selection processes through which data transfer requests of multiple applications can be coordinated into a single transfer operation.

In process **602**C, a first data transfer request initiated by a first application on a device or mobile device is received. One or more selection processes can be performed to determine whether to delay transfer of the first data transfer request, as shown in steps **604**C-**608**C, including, determining whether the user is interacting with the first application, whether the first application is in the foreground, or whether the radio of the mobile device on which the request is initiated is already on. Note that although the selection processes are illustrated and identified in a specific order, the order in which the system checks for applicability is not limited to such, any of the above conditions can be checked in any ordering or any combination with one of the other conditions.

If one of the above applies, in process **610**C, in general, a decision can be made to transfer the data request over the wireless (cellular or others) network, or to power on the radio (e.g., via the radio controller **256** shown in the example

of FIG. **2**A) to perform the transfer without or with minimal delay. Additional conditions that are not shown here which may cause the transfer of the data request to occur immediately or upon receipt may be included.

If none of the conditions in **604**C-**608**C applies (or other suitable conditions depending on the specific implementation), in process **612**C, the transfer of the first data transfer request can be delayed. In process **614**C, it is determined whether another data transfer request has been initiated. If not, the process continues at flow 'A' in FIG. **7**C.

If so, the system performs one or more of several condition checks shown in decision flows **616**C-**624**C including determining whether the second application is of higher priority than the first application, whether the second application running in the foreground, whether the user interacting with the second application, whether the other data request initiated in response to user interaction, and/or whether the second application is more data intensive than the first application. The flow chart continues at 'A' in FIG. **7**C if none of the above conditions apply.

If any of the above conditions apply, then in process **626**C, the first data transfer request of the first application and the other data transfer request of the second application are transferred in a single transfer operation over the network. Note that the conditions shown in **616**C-**624**C can be applied in any order or any combination with one another, although illustrated in the example flow chart as having a particular order.

FIG. **7**C depicts an example of triggering events that would cause a data request to be transferred without alignment with another data request.

The events shown in processes **702**C-**710**C can occur independently or in conjunction with one another and cause the data request to be transferred over the wireless network without or with minimal delay upon occurrences of these events. For example, in process **702**C, the mobile device radio is turned on due to another event. In process **704**C, a certain time period has elapsed, in process **706**C, a user trigger is detected, and/or the first application exits in process **708**C and/or moves into the background in process **710**C. When any of the above conditions are detected, n process **721**C, the data request is transferred over the wireless (cellular or others) network.

FIG. **8**C depicts a flow chart illustrating an example process for using timing characteristics of data requests made by individual applications to delay transfer of one or more of the data requests made by one of the individual applications.

In processes **802**C and **804**C, data transfer requests made by first and second application on the mobile device are tracked. For example, the transaction/request manager **235** of the local proxy **275** shown in the example of FIG. **2**A can detect the occurrence of the data transfer requests and request that the application behavior detector **236** begin to track correlations or other types of behaviors of the requesting applications.

In process **806**C, a first timing characteristic of data transfer requests made by the first application is determined and in process **808**C, a second timing characteristic of data transfer requests made by the second application is determined, and can be used, for example, by the correlation detector **238** to identify any correlations in the requests.

Based on the identified timing characteristics and any determined correlations or applicable priorities (e.g., as determined by the prioritization engine **238** in the example of FIG. **2**A). In process **810**C, the transfer of the first data request can be delayed using the first and second timing characteristics or in process **812**C, the transfer of the second data request can be delayed using the first and second timing characteristics. Such delay (e.g., determined by the delay module **258** of the local proxy shown in the example of FIG. **2**B) can be until another event occurs, until a manual (user) trigger is detected, or after a certain amount of time, or when another triggering event (e.g., user interaction) occurs. Note that the delays are user-configurable and can be tracked and factored into consideration by the delay module **258**.

While the example is illustrated and described for different applications (e.g., first and second applications are different applications), the process can similarly be applied to different requests within the same application (e.g., first and second applications may be the same application).

FIG. **9**B depicts a flow chart illustrating an example process for using application behavior of multiple applications to align their content requests made over the network.

In process **902**B, application behavior of multiple applications are detected on a mobile device. In general, the behaviors of any number of applications on the mobile device that are detected can be tracked. Any or all mobile applications on a device can be monitored for the potential for its requests to be aligned for traffic coordination. In addition, the user can select the applications to be aligned, or specify applications not to be tracked for traffic coordination. Furthermore, the device platform, manufacturer, OS settings, and/or network provider may have additional specifications or conditions for aligning traffic requests and selection of applications for traffic coordination.

In process **904**B, some of the content requests made by at least a portion the multiple applications from the mobile device over the network, are aligned. Process flow continues to step 'B' as shown in the example of FIG. **10**B which depicts an example of processes through which the time of delay 'D' for content requests can be determined to align content requests over the wireless network. In process **906**B, some of the content requests that are delayed in a single transfer operation are transferred over the network.

Example processes applied to determine delay time 'D' include, by way of example but not limitation: Determine priority of a specific application or priority of the application relative to other applications in process **1002**B, Determine an amount of data involved in a given content request in step **1004**B, Determine the useable lifetime of data to be transferred in the content request in step **1006**B, Determine a nature of data involved in a given content request in step **1008**B, Determine a status of the application making the content request in step **1010**B, and/or Determine the network characteristics when the request is made in step **1012**B. Any number of the above conditions can be applied in any order. Additional conditions which can be used may not be illustrated in the example above. In process **1014**B, any user configuration or overriding settings can be factored into consideration in determining delay to align content request, in process **1016**B.

FIG. **6**D depicts a flow chart illustrating an example process for using user activity and/or application server/provider activity to time the transfer of data from the host to the mobile device to optimize use of network resources.

In process **602**D, user activity at a mobile device is detected and tracked in process **606**D. In process **604**D, server activity is detected for a host server (e.g., an application server or content provider such as app server/provider **110** in the examples of FIGS. **1**A-**1**B) with which the mobile device interacts to satisfy content requests at the mobile device. In process **608**D, the server activity can be tracked. In one embodiment, the user behavior and activity are

detected and tracked by a local proxy on the mobile device and the server activity of the host server (app server/content provider) is tracked and detected by a remote proxy which is able to wirelessly communicate with the local proxy in a distributed proxy system. Some examples of the types of user activities and server activities that can be tracked or characterized are shown in the examples of FIGS. **7**D and **8**D.

Using the user activity and/or the server activity, the timing with which to transfer impending data from the host server to the mobile device is determined. In one embodiment, the timing is determined based on prediction of a future activity session at the mobile device.

In process **610**D and in process **612**D, the impending data is transferred from the host server to the mobile device according to the timing. The timing is generally determined such that network resource use is optimized and/or such that user experience is enhanced or preserved. For example, the transferring of impending data comprises pre-caching of content on the mobile device to support data activity for a future activity session predicted based on the user behavior and the server activity.

In addition, server activities of multiple host servers (e.g., multiple application servers or content providers including by way of example but not limitation, push notification servers, email hosts, RSS, web services, web sites, gaming sites, etc.) with which the mobile device interacts to satisfy content requests at the mobile device are detected and/or tracked in process **616**D. In process **618**D, based on the server activities of multiple hosts and providers, the likelihood that an activity session initiated at the mobile device will interact with a given host server (application server or provider) can be predicted. Based on the prediction, each of the multiple host servers are prioritized based on the prediction of likelihood an activity session initiated at the mobile device will interact with a given host server, in process **620**D.

FIG. **7**D depicts an example of processes which can be used to for user behavior prediction.

For example, the system (either the local proxy on the device side or the server proxy on the server side, or a combination thereof) can detect a pattern of user-initiated events at the mobile device, in process **702**D. For example, a pattern can include, a correlation in time between initiations of one application and another application, or correlation between initiation of one event/transaction and another event/transaction. The system can also track the user activity given the time of day or day of the week in process **704**D, and identify any patterns in user behavior such as preferences or habits with regards to application use frequency, which applications are used, and/or which activities the user is engaged in with each application,

The system can further track an order with which new data is accessed or an order with which applications are accessed on the mobile device, in process **708**D, and/or through collaborative filtering, in process **710**D. Any number of and combination of the above events can be used to predict user behavior, in step **712**D.

Note that user behavior can be determined for different contexts. For example, the system can determine user behavior with respect to accessing work email and behavior with respect to accessing personal email accounts (e.g., time of day or day of week a user accesses certain accounts, frequency, actions taken, features used, etc.). In addition, user behavior may also be determined with respect to different applications or services (e.g., when and how frequently a user uses Facebook, tweets, accesses Yelp, uses Maps/Location/Direction applications, etc.)

FIG. **8**D depicts an example of processes which can be used to detect app server/provider characteristics.

For example, the last last-accessed time or a frequency of access of the host server (application server/service provider) can be determined in process **802**D, or an amount of impending data to be transferred to the mobile device can be determined in process **804**D. In general, server activities can be detected and monitored by the server-side components (e.g., the proxy server) of the distributed proxy and cache system. Such information can be used alone or in conjunction to detect server activity characteristics, in process **806**D.

FIG. **9**C depicts a flow chart illustrating an example process to anticipate a future activity session at a mobile device to enhance user experience with a mobile application.

In process **902**C, user activity characteristics at a mobile device and server activity characteristics of a host server are detected. The host server is a server with which the mobile device interacts with to satisfy application requests (e.g., mobile applications) at the mobile device and can include, for example, application servers or content providers.

In process **904**C, a future activity session can be anticipated at the mobile device. In addition, contextual cues can be used in the anticipation of the activity session as illustrated at flow 'A' in the example of FIG. **10**C.

In process **906**C, decision is made to pre-cache content on the mobile device to support predicted data activity for the future activity session that has been predicted. In process **908**C, impending content is transferred from the host server the mobile device to pre-cache content, such that user experience with the mobile application can be enhanced.

FIG. **10**C depicts an example of processes through which contextual data for use in anticipation of future activity sessions can be determined.

For example, location change of the mobile device can be detected, in step **1004**C; changes in readings of hardware sensors (e.g., motion, GPS, temperature, tilt, vibration, capacitive, resistive, ambient light, device backlight, etc.) on the mobile device can be detected in **1006**C, and/or states or statuses of applications (e.g., activity state, foreground/background status, etc.) on the mobile device can be detected in **1008**C.

FIG. **11** shows a diagrammatic representation of a machine in the example form of a computer system within which a set of instructions, for causing the machine to perform any one or more of the methodologies discussed herein, may be executed.

In alternative embodiments, the machine operates as a standalone device or may be connected (e.g., networked) to other machines. In a networked deployment, the machine may operate in the capacity of a server or a client machine in a client-server network environment, or as a peer machine in a peer-to-peer (or distributed) network environment.

The machine may be a server computer, a client computer, a personal computer (PC), a user device, a tablet PC, a laptop computer, a set-top box (STB), a personal digital assistant (PDA), a cellular telephone, an iPhone, an iPad, a Blackberry, a processor, a telephone, a web appliance, a network router, switch or bridge, a console, a hand-held console, a (hand-held) gaming device, a music player, any portable, mobile, hand-held device, or any machine capable of executing a set of instructions (sequential or otherwise) that specify actions to be taken by that machine.

While the machine-readable medium or machine-readable storage medium is shown in an exemplary embodiment to be a single medium, the term "machine-readable medium" and

"machine-readable storage medium" should be taken to include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the one or more sets of instructions. The term "machine-readable medium" and "machine-readable storage medium" shall also be taken to include any medium that is capable of storing, encoding or carrying a set of instructions for execution by the machine and that cause the machine to perform any one or more of the methodologies of the presently disclosed technique and innovation.

In general, the routines executed to implement the embodiments of the disclosure, may be implemented as part of an operating system or a specific application, component, program, object, module or sequence of instructions referred to as "computer programs." The computer programs typically comprise one or more instructions set at various times in various memory and storage devices in a computer, and that, when read and executed by one or more processing units or processors in a computer, cause the computer to perform operations to execute elements involving the various aspects of the disclosure.

Moreover, while embodiments have been described in the context of fully functioning computers and computer systems, those skilled in the art will appreciate that the various embodiments are capable of being distributed as a program product in a variety of forms, and that the disclosure applies equally regardless of the particular type of machine or computer-readable media used to actually effect the distribution.

Further examples of machine-readable storage media, machine-readable media, or computer-readable (storage) media include but are not limited to recordable type media such as volatile and non-volatile memory devices, floppy and other removable disks, hard disk drives, optical disks (e.g., Compact Disk Read-Only Memory (CD ROMS), Digital Versatile Disks, (DVDs), etc.), among others, and transmission type media such as digital and analog communication links.

In some embodiments, the network interface device may enable the machine **1100** to mediate data in a network with an entity that is external to the host server, through any known and/or convenient communications protocol supported by the host and the external entity. The network interface device can include one or more of a network adaptor card, a wireless network interface card, a router, an access point, a wireless router, a switch, a multilayer switch, a protocol converter, a gateway, a bridge, bridge router, a hub, a digital media receiver, and/or a repeater.

In some embodiments, the network interface device can include a firewall which can, in some embodiments, govern and/or manage permission to access/proxy data in a computer network, and track varying levels of trust between different machines and/or applications. The firewall can be any number of modules having any combination of hardware and/or software components able to enforce a predetermined set of access rights between a particular set of machines and applications, machines and machines, and/or applications and applications, for example, to regulate the flow of traffic and resource sharing between these varying entities. The firewall may additionally manage and/or have access to an access control list which details permissions including for example, the access and operation rights of an object by an individual, a machine, and/or an application, and the circumstances under which the permission rights stand.

Other network security functions can be performed or included in the functions of the firewall, can be, for example, but are not limited to, intrusion-prevention, intrusion detection, next-generation firewall, personal firewall, etc. without deviating from the novel art of this disclosure.

Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise," "comprising," and the like are to be construed in an inclusive sense, as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to." As used herein, the terms "connected," "coupled," or any variant thereof, means any connection or coupling, either direct or indirect, between two or more elements; the coupling of connection between the elements can be physical, logical, or a combination thereof. Additionally, the words "herein," "above," "below," and words of similar import, when used in this application, shall refer to this application as a whole and not to any particular portions of this application. Where the context permits, words in the above Detailed Description using the singular or plural number may also include the plural or singular number respectively. The word "or," in reference to a list of two or more items, covers all of the following interpretations of the word: any of the items in the list, all of the items in the list, and any combination of the items in the list.

The above detailed description of embodiments of the disclosure is not intended to be exhaustive or to limit the teachings to the precise form disclosed above. While specific embodiments of, and examples for, the disclosure are described above for illustrative purposes, various equivalent modifications are possible within the scope of the disclosure, as those skilled in the relevant art will recognize. For example, while processes or blocks are presented in a given order, alternative embodiments may perform routines having steps, or employ systems having blocks, in a different order, and some processes or blocks may be deleted, moved, added, subdivided, combined, and/or modified to provide alternative or subcombinations. Each of these processes or blocks may be implemented in a variety of different ways. Also, while processes or blocks are at times shown as being performed in series, these processes or blocks may instead be performed in parallel, or may be performed at different times. Further any specific numbers noted herein are only examples: alternative implementations may employ differing values or ranges.

The teachings of the disclosure provided herein can be applied to other systems, not necessarily the system described above. The elements and acts of the various embodiments described above can be combined to provide further embodiments.

Any patents and applications and other references noted above, including any that may be listed in accompanying filing papers, are incorporated herein by reference. Aspects of the disclosure can be modified, if necessary, to employ the systems, functions, and concepts of the various references described above to provide yet further embodiments of the disclosure.

These and other changes can be made to the disclosure in light of the above Detailed Description. While the above description describes certain embodiments of the disclosure, and describes the best mode contemplated, no matter how detailed the above appears in text, the teachings can be practiced in many ways. Details of the system may vary considerably in its implementation details, while still being encompassed by the subject matter disclosed herein. As noted above, particular terminology used when describing certain features or aspects of the disclosure should not be taken to imply that the terminology is being redefined herein to be restricted to any specific characteristics, features, or

aspects of the disclosure with which that terminology is associated. In general, the terms used in the following claims should not be construed to limit the disclosure to the specific embodiments disclosed in the specification, unless the above Detailed Description section explicitly defines such terms. Accordingly, the actual scope of the disclosure encompasses not only the disclosed embodiments, but also all equivalent ways of practicing or implementing the disclosure under the claims.

While certain aspects of the disclosure are presented below in certain claim forms, the inventors contemplate the various aspects of the disclosure in any number of claim forms. For example, while only one aspect of the disclosure is recited as a means-plus-function claim under 35 U.S.C. § 112, ¶6, other aspects may likewise be embodied as a means-plus-function claim, or in other forms, such as being embodied in a computer-readable medium. (Any claims intended to be treated under 35 U.S.C. § 112, ¶6 will begin with the words "means for".) Accordingly, the applicant reserves the right to add additional claims after filing the application to pursue such additional claim forms for other aspects of the disclosure.

The invention claimed is:

1. A mobile device configured to manage connections made by the mobile device in a wireless network, the mobile device comprising:

a memory;

a radio;

a screen; and

a processor, the mobile device configured to:

delay a content request from a first application for transmission to a first application server over the wireless network, wherein the delayed content request from the first application includes a background data request;

delay a content request from a second application for transmission to a second application server over the wireless network wherein the delayed content request from the second application includes a background data request,

wherein, the delayed content request from the first application and the delayed content request from the second application are delayed while the mobile device screen is idle in response to inactivity of the mobile device;

allow a first message from a remote server distinct from the first application server and the second application server to be received while the content request from the first application and the content request from the second application are delayed;

wherein the first message from the remote server is directed to the first application and contains data from the first application server and is associated with the mobile device and the first application, wherein the first message informs the first application that there is new data to be fetched from the first application server;

transmit a second message associated with the first application to the remote server or the first application server in response to receipt of the first message from the remote server;

transmit the delayed content request from the first application to the first application server over the wireless network and the delayed content request from the second application to the second application server over the wireless network while the mobile device screen remains idle, wherein transmitting the delayed content request from the first application and the delayed content request from the second application occurs at about the same time,

wherein the delaying of the content request for the first application and the delaying of the content request for the second application can be enabled or disabled by a user of the mobile device on an application-by-application basis.

2. The mobile device according to claim **1**, wherein the mobile device is configured to delay a content request by batching a content request.

3. The mobile device of claim **1**, wherein transmission of the delayed content request occurs within a dynamically adjustable time window.

4. The mobile device of claim **1**, wherein an additional content request from the first application and an additional content request from the second application are delayed after the content requests have been transmitted, and, wherein the additional content requests from the first application and the second application are delayed while the mobile device screen remains idle.

5. The mobile device of claim **1**, wherein the first message from the remote server is received over a first communication connection between the remote server and the mobile device, and the new data is received over a second communication connection between the first application server and the mobile device.

6. The mobile device of claim **1**, wherein the mobile device screen is determined idle based on a backlight status of the screen.

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