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Halepovic et al.

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(54) **METHODS, DEVICES, AND SYSTEMS FOR ESTIMATING VIDEO DATA USAGE WITHOUT BANDWIDTH LIMITS**

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H04L 43/0894 (2022.01)
H04W 28/08 (2023.01)
H04W 28/20 (2009.01)
H04W 76/15 (2018.01)

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

CPC ***H04W 48/14*** (2013.01); ***H04L 43/0888*** (2013.01); ***H04L 43/0894*** (2013.01); ***H04W 28/0983*** (2020.05); ***H04W 28/20*** (2013.01); ***H04W 76/15*** (2018.02)

(58) **Field of Classification Search**

None

See application file for complete search history.

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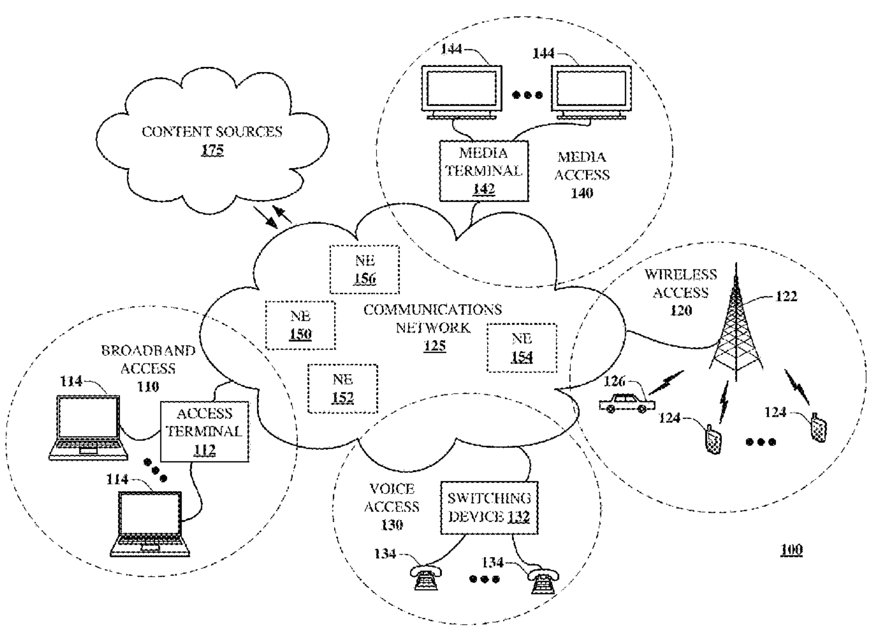
(57) **ABSTRACT**

Aspects of the subject disclosure may include, for example, adjusting bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limited allocation to a no bandwidth limited allocation, and measuring a first group of metrics associated with the first group of communication devices associated with the first communication network. Further embodiments include computing a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, the second group of communication devices have the no bandwidth limited allocation, and allocating a first group of network resources for the second group of communication devices according to the second group of metrics. Other embodiments are disclosed.

20 Claims, 19 Drawing Sheets



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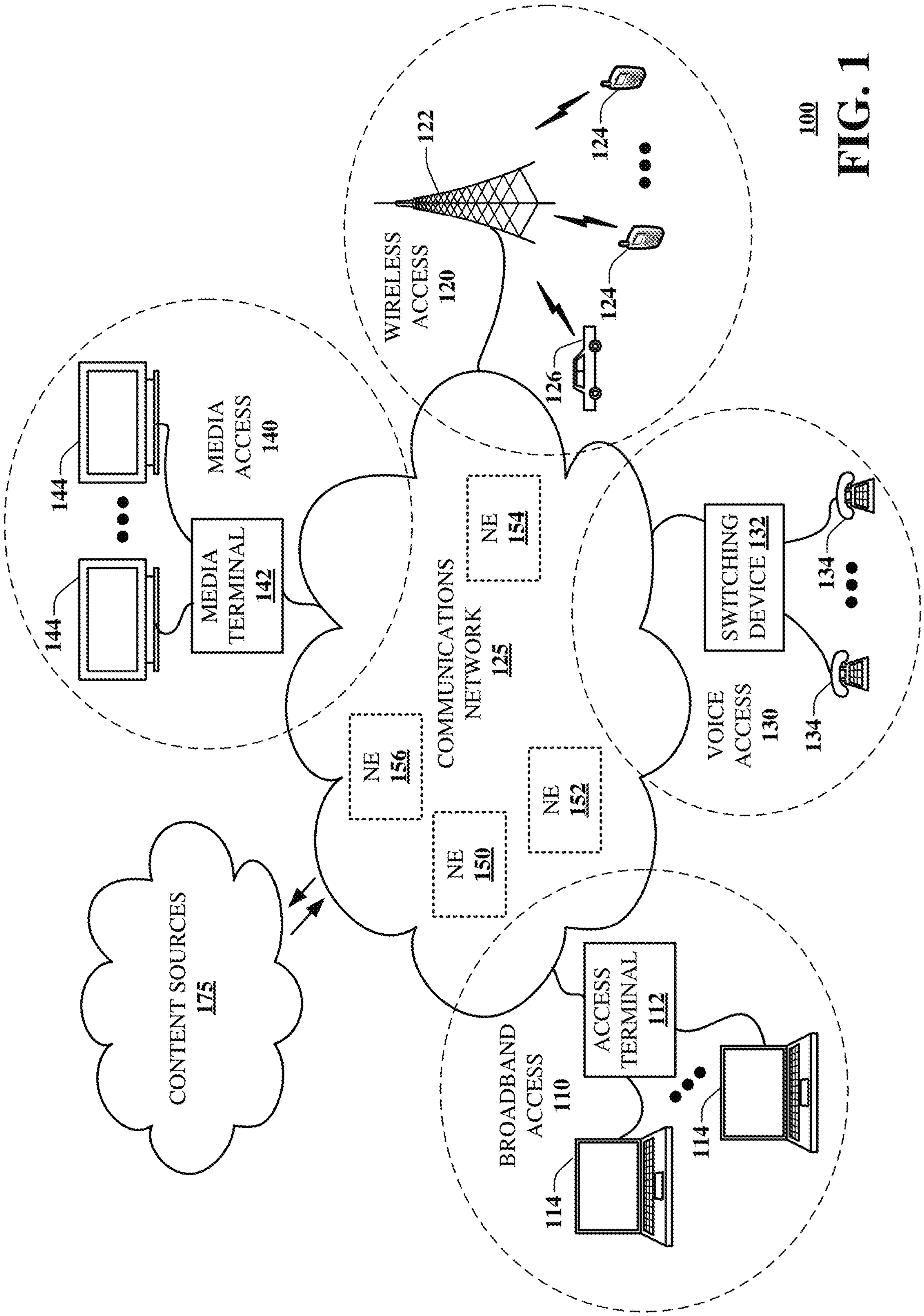
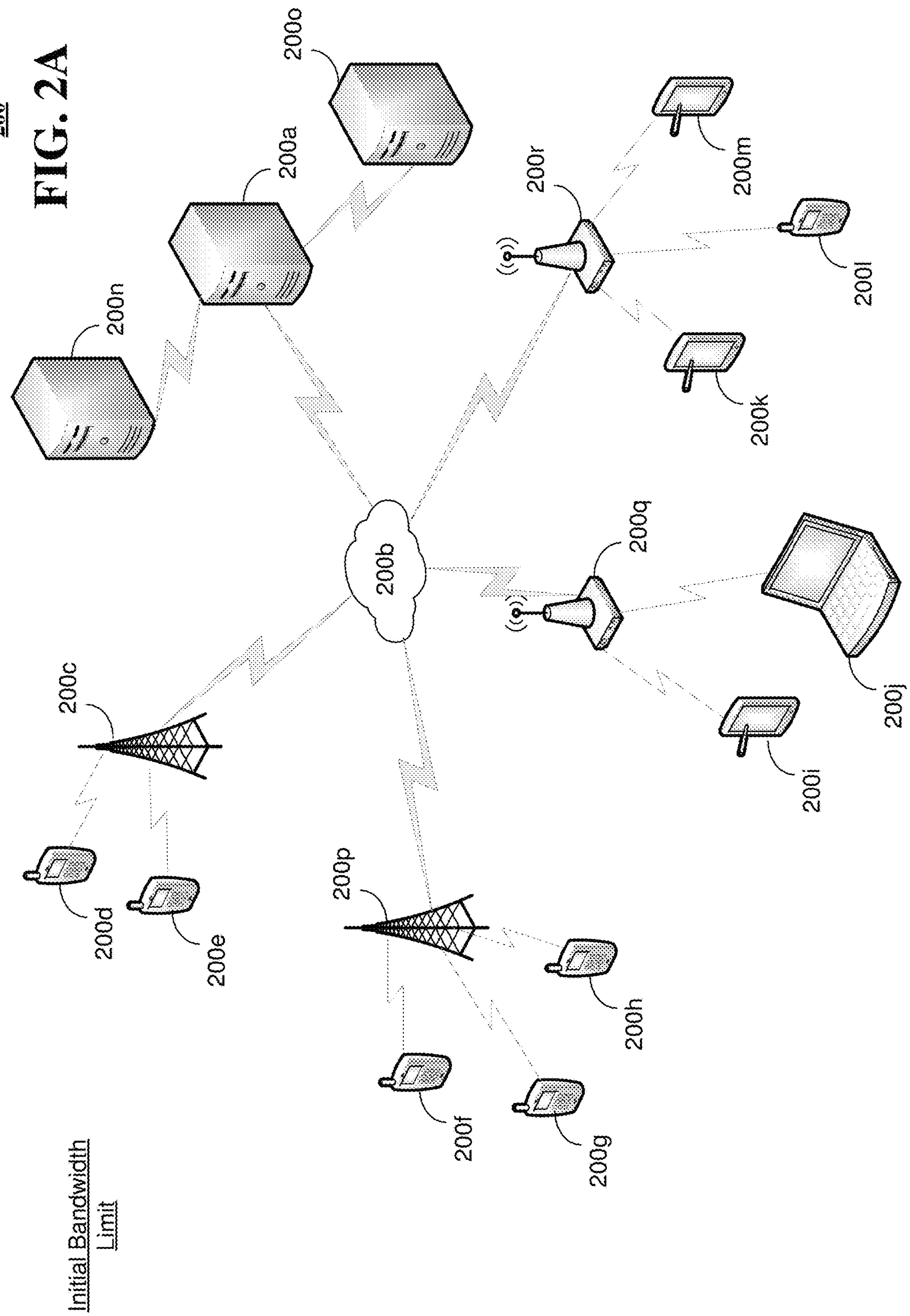

100
WIRELESS ACCESS 120
122
124
124
126
MEDIA ACCESS 140
144
144
MEDIA TERMINAL 142
COMMUNICATIONS NETWORK 125
NE 154
NE 156
NE 150
NE 152
SWITCHING DEVICE 132
134
134
VOICE ACCESS 130
CONTENT SOURCES 175
BROADBAND ACCESS 110
ACCESS TERMINAL 112
114
114

FIG. 1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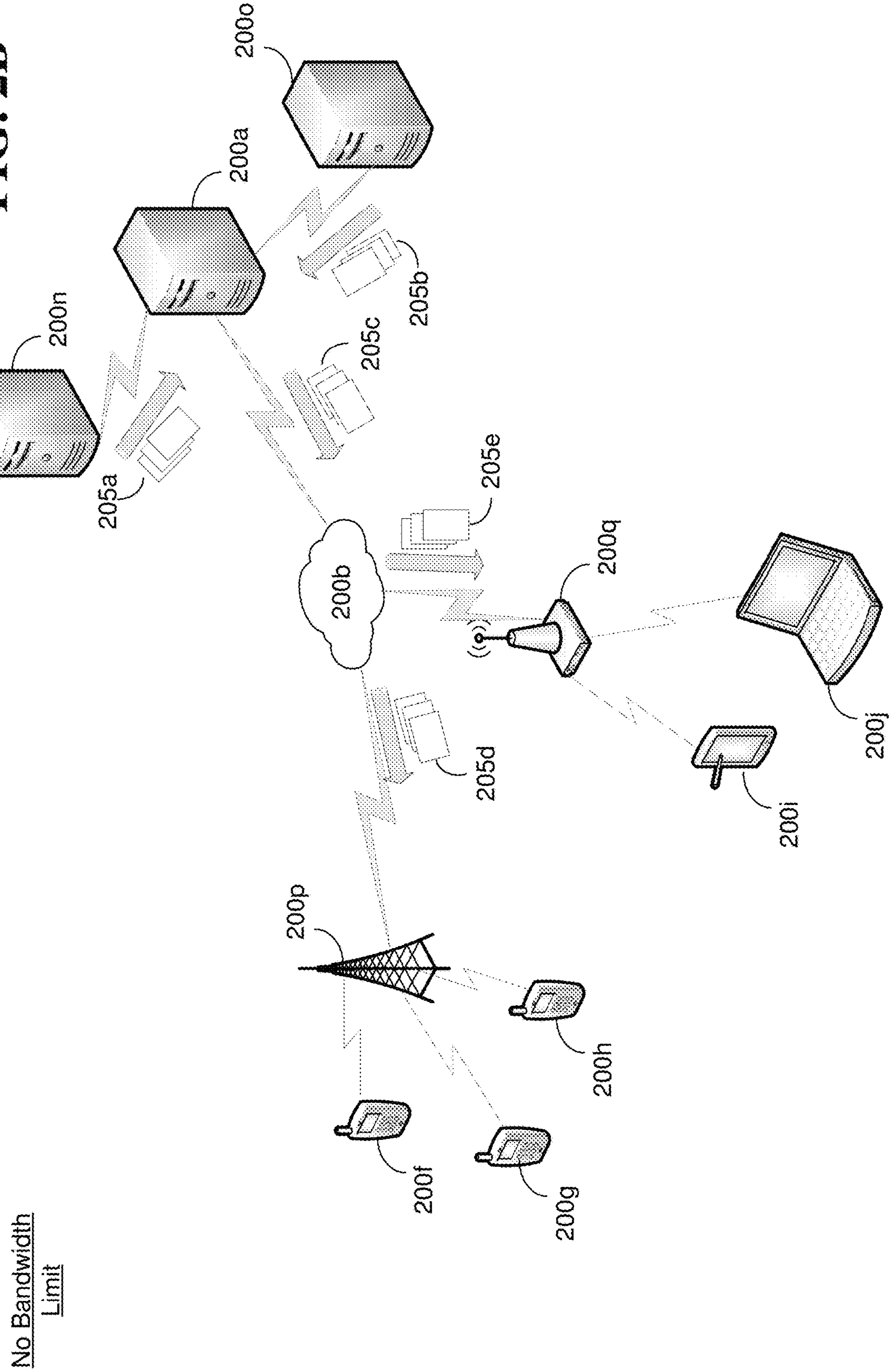
200a
200o
200r
200m
200l
200k
200b
200q
200j
200i
200c
200d
200e
200p
200h
200f
200g
Initial Bandwidth Limit

FIG. 2A

205

FIG. 2B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200j
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200p
200h
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200g
No Bandwidth Limit

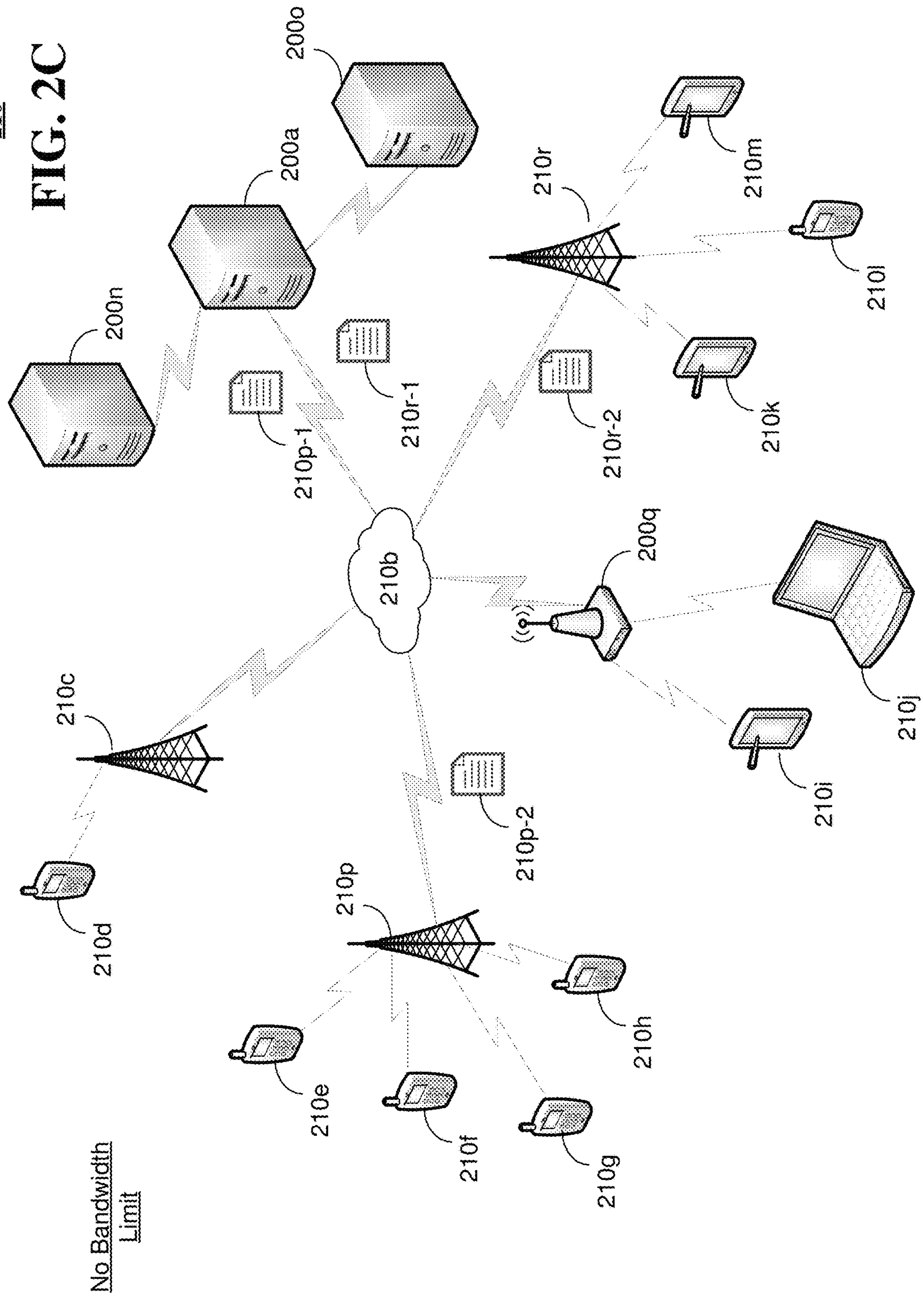
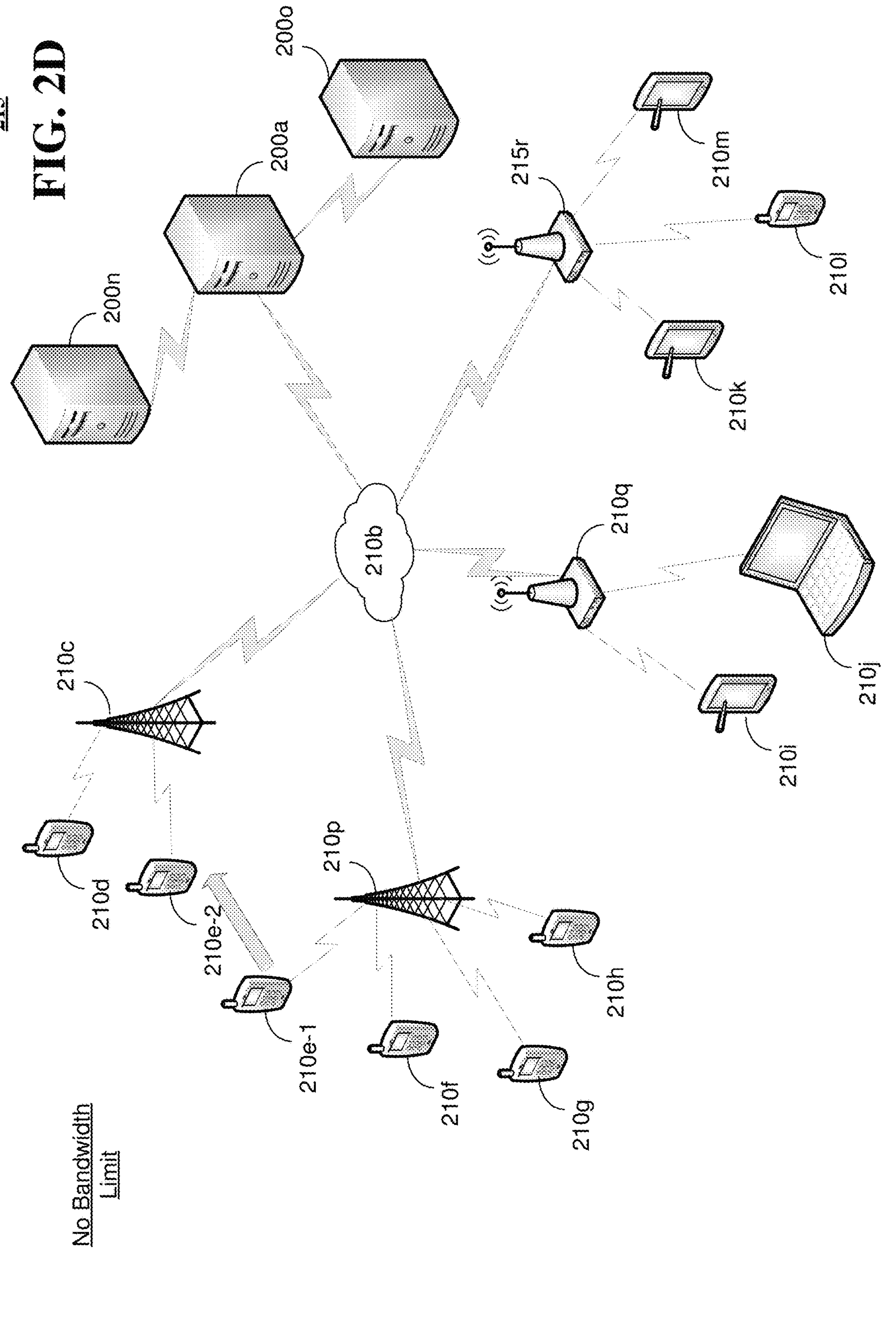

210
No Bandwidth Limit
200n
200a
200o
210p-1
210r-1
210r-2
210r
210m
210l
210k
210b
200q
210j
210i
210c
210d
210p
210p-2
210e
210f
210g
210h

FIG. 2C

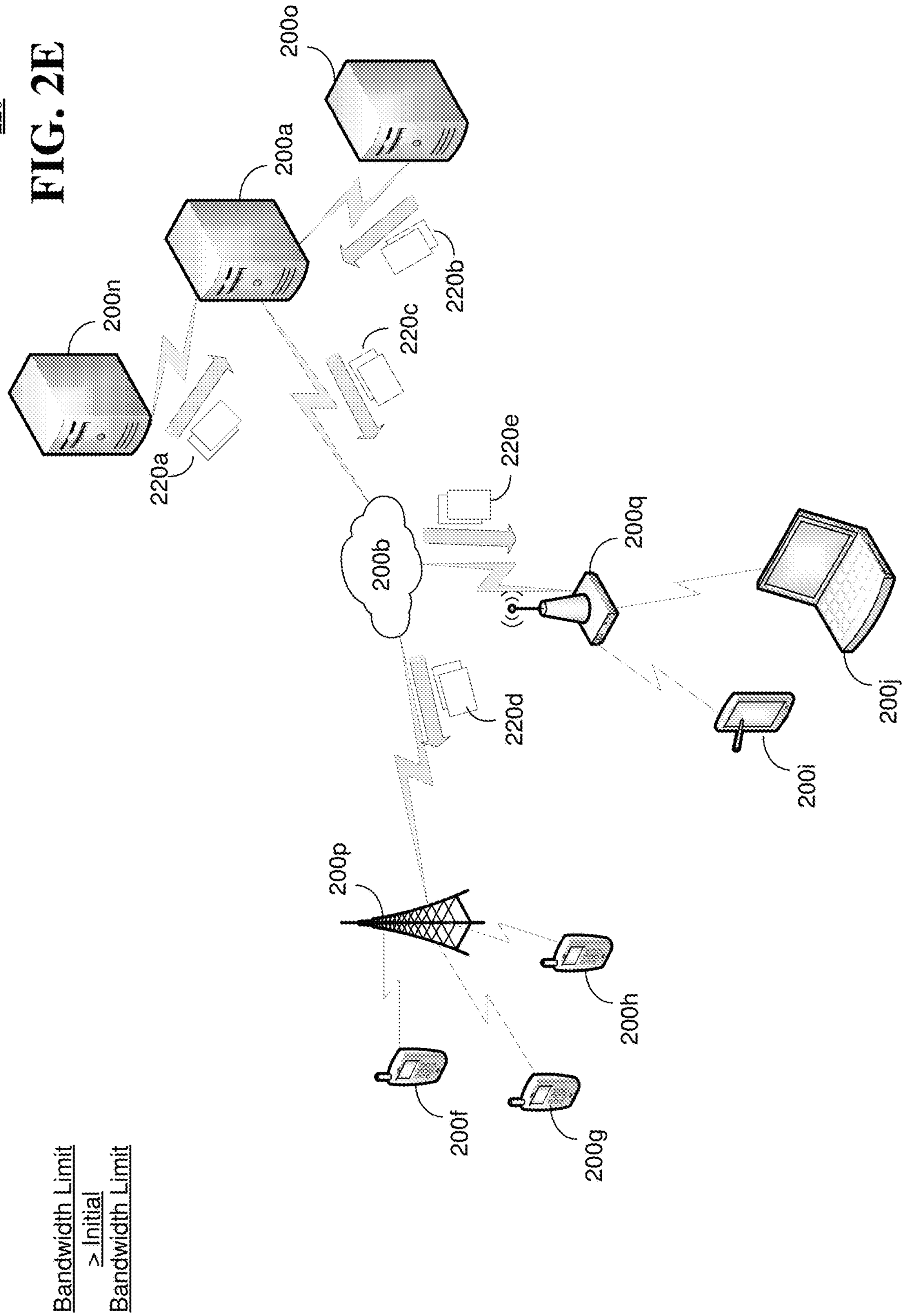
215

FIG. 2D


200n
200a
200o
215r
210m
210l
210k
210b
210q
210j
210i
210c
210d
210e-2
210p
210e-1
210f
210g
210h
No Bandwidth Limit

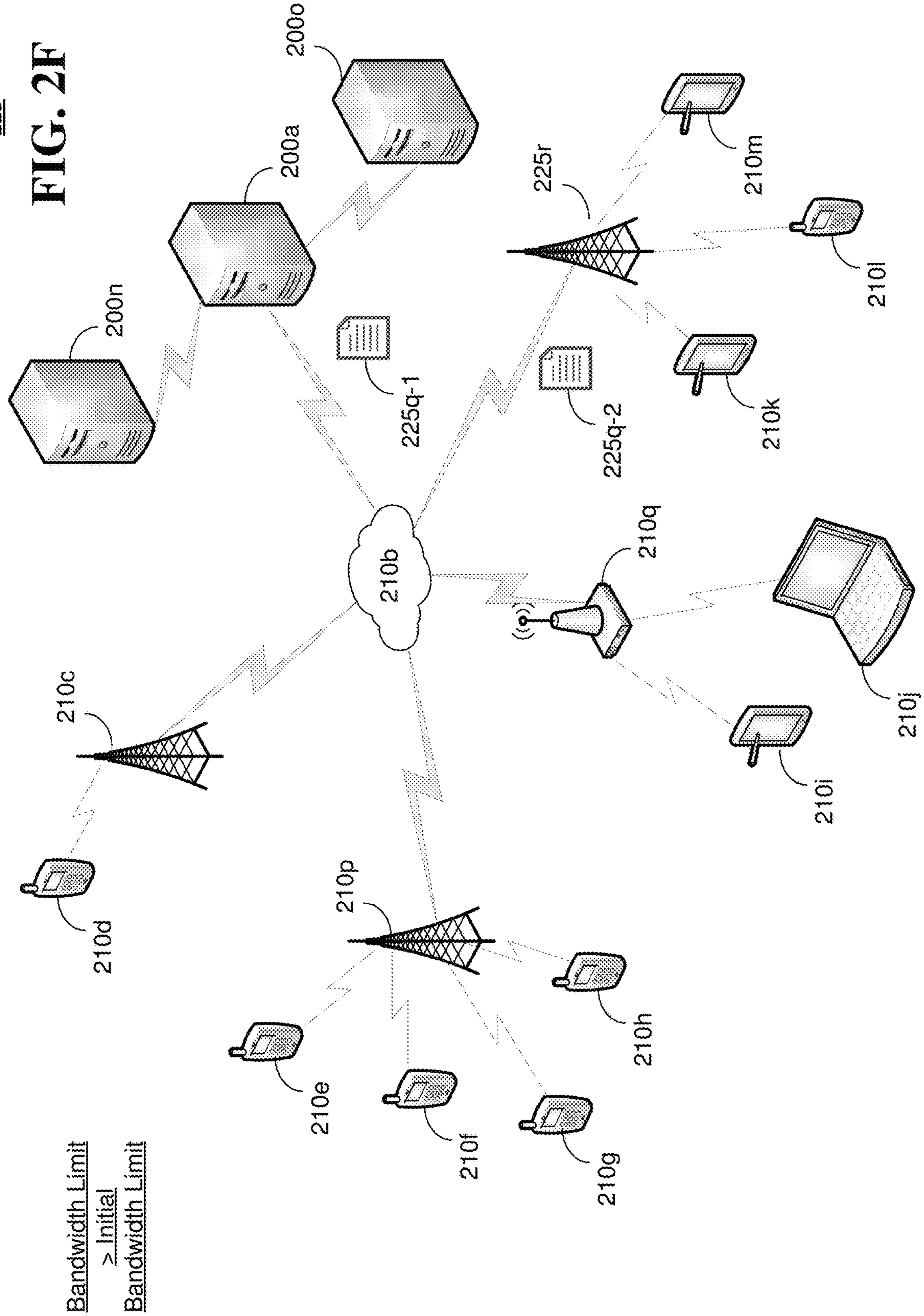
220

FIG. 2E


200o
200a
200n
220b
220c
220a
220e
200b
200q
200j
220d
200i
200p
200h
200f
200g
Bandwidth Limit
> Initial
Bandwidth Limit

225

FIG. 2F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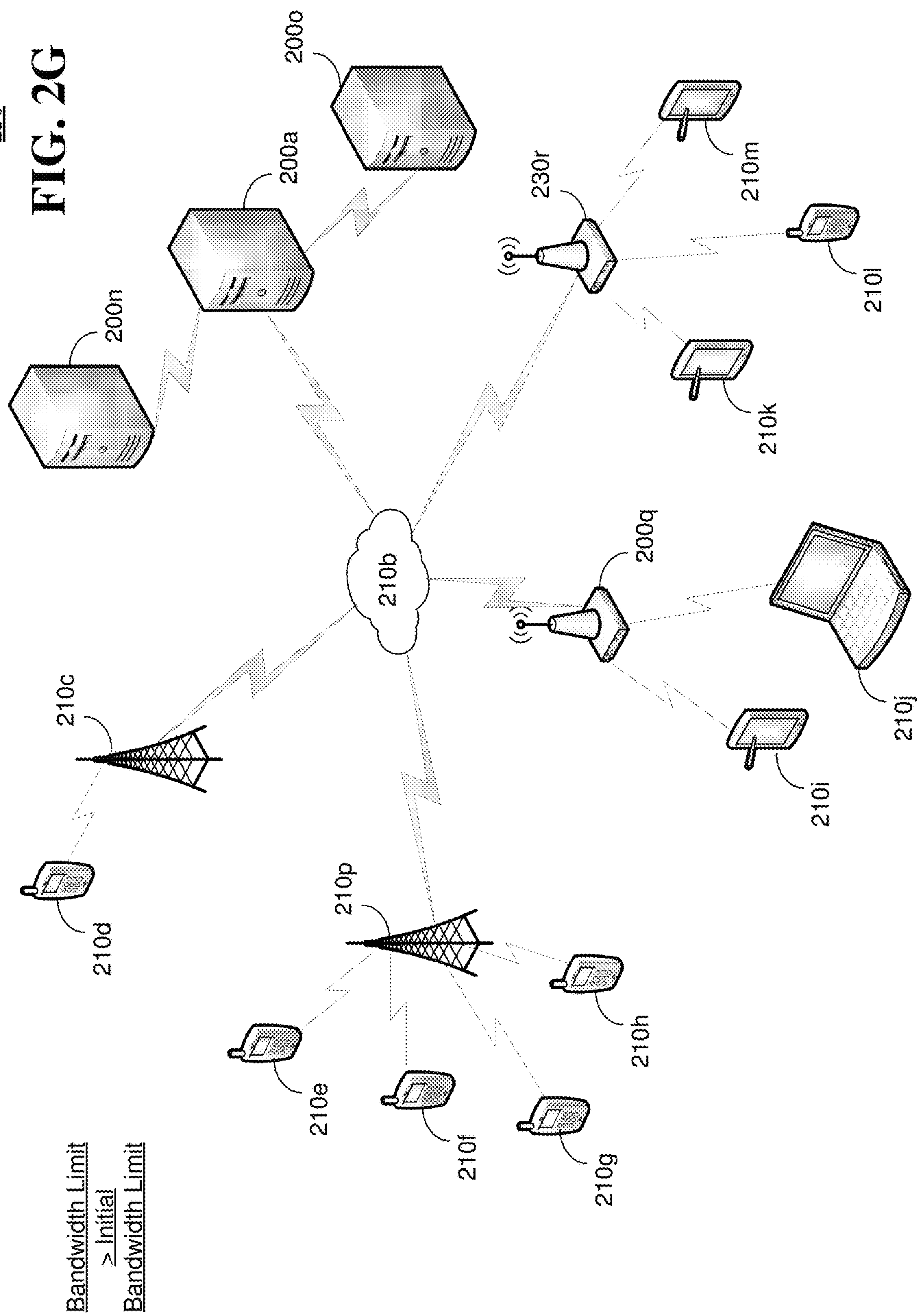
200o
225q-1
225q-2
225r
210b
210c
210d
210p
210e
210f
210g
210h
210q
210j
210i
210k
210l
210m
Bandwidth Limit
> Initial
Bandwidth Limit

230

FIG. 2G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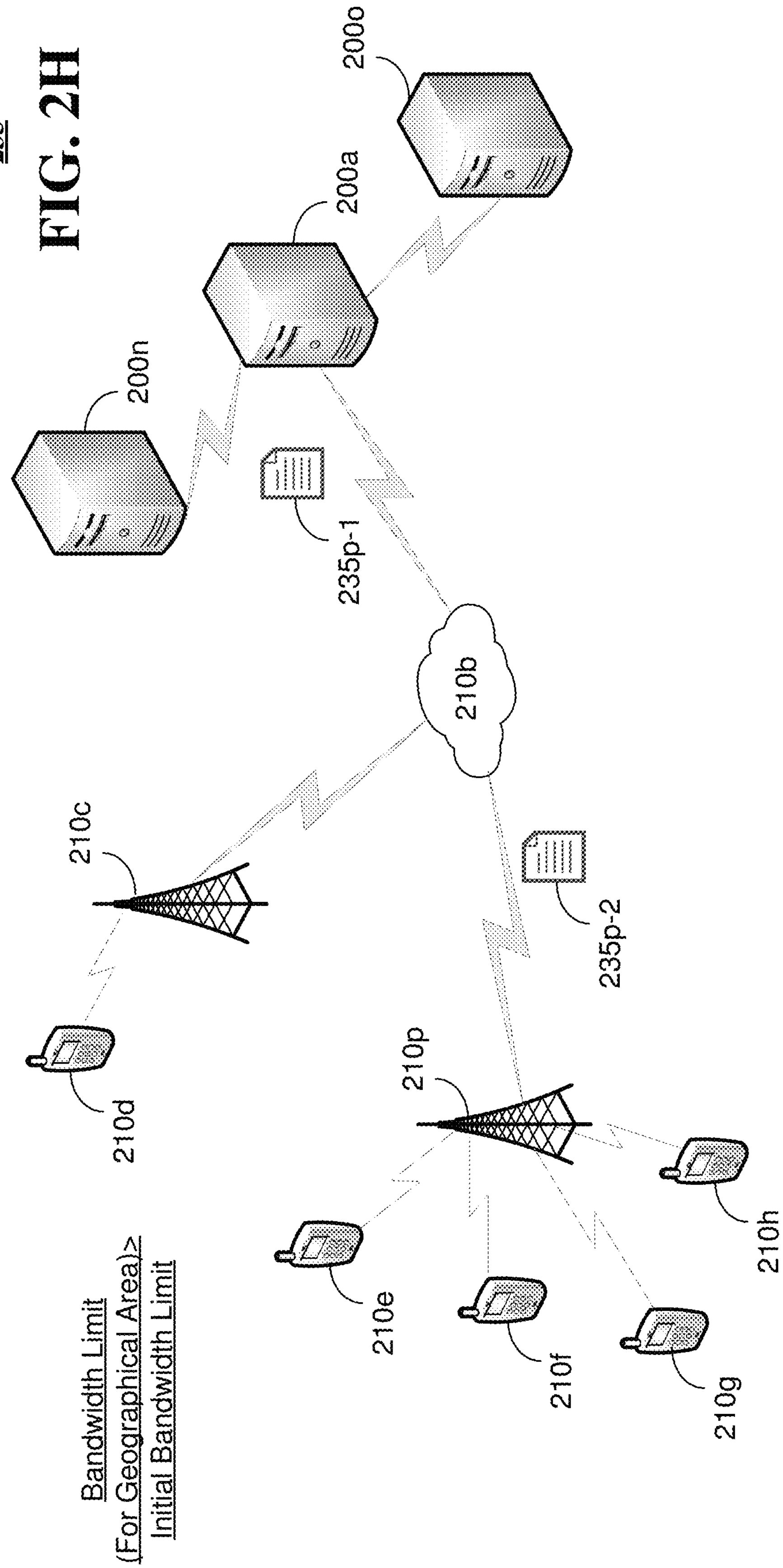
200a
200o
210b
210c
210d
210p
210e
210f
210g
210h
200q
210i
210j
230r
210k
210l
210m
Bandwidth Limit
> Initial
Bandwidth Limit

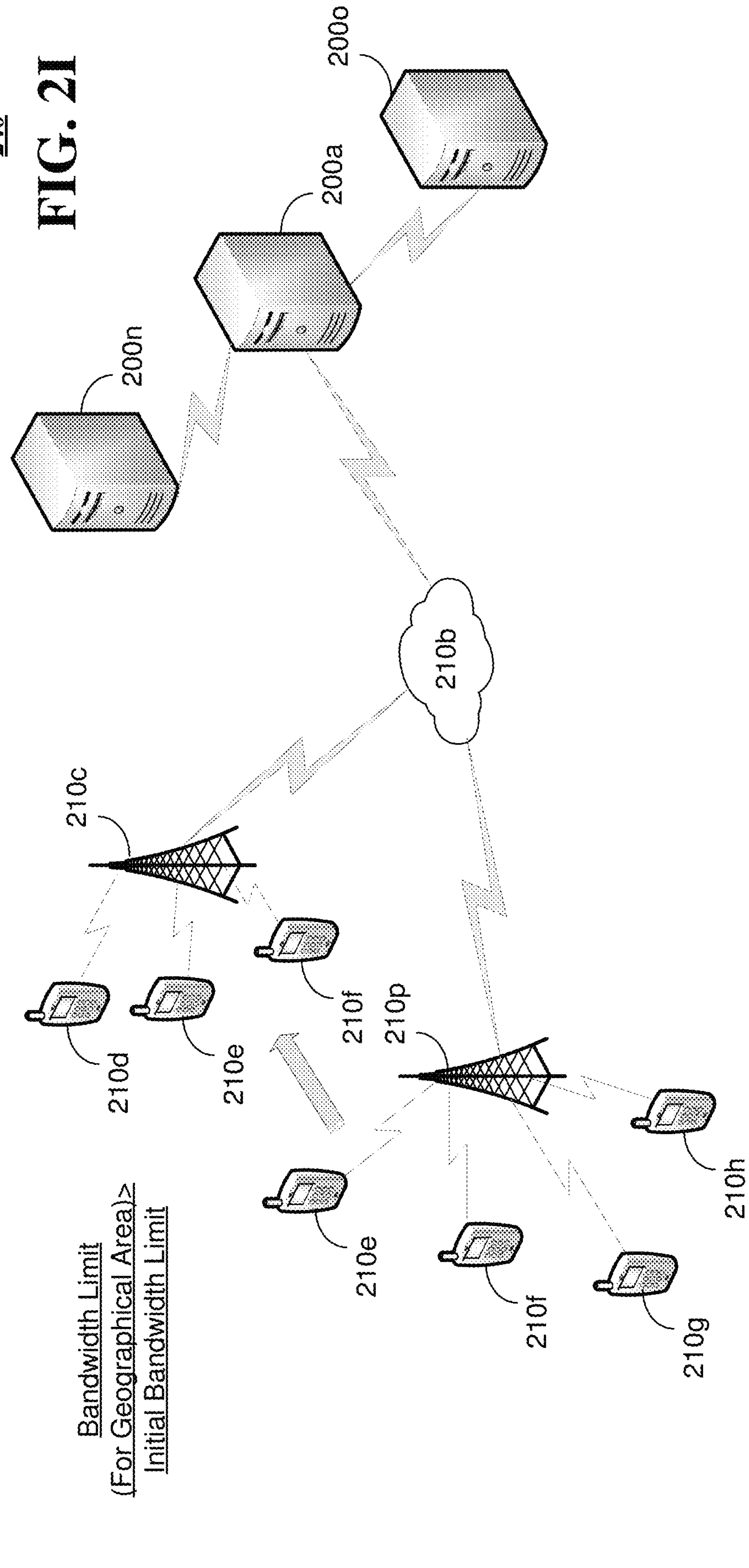
235

FIG. 2H


200o
200a
200n
235p-1
210b
210c
235p-2
210p
210d
210e
210f
210g
210h
Bandwidth Limit
(For Geographical Area)>
Initial Bandwidth Limit

240

FIG. 2I


200o
200a
200n
210b
210c
210d
210e
210f
210p
210e
210f
210g
210h
Bandwidth Limit
(For Geographical Area)>
Initial Bandwidth Limit

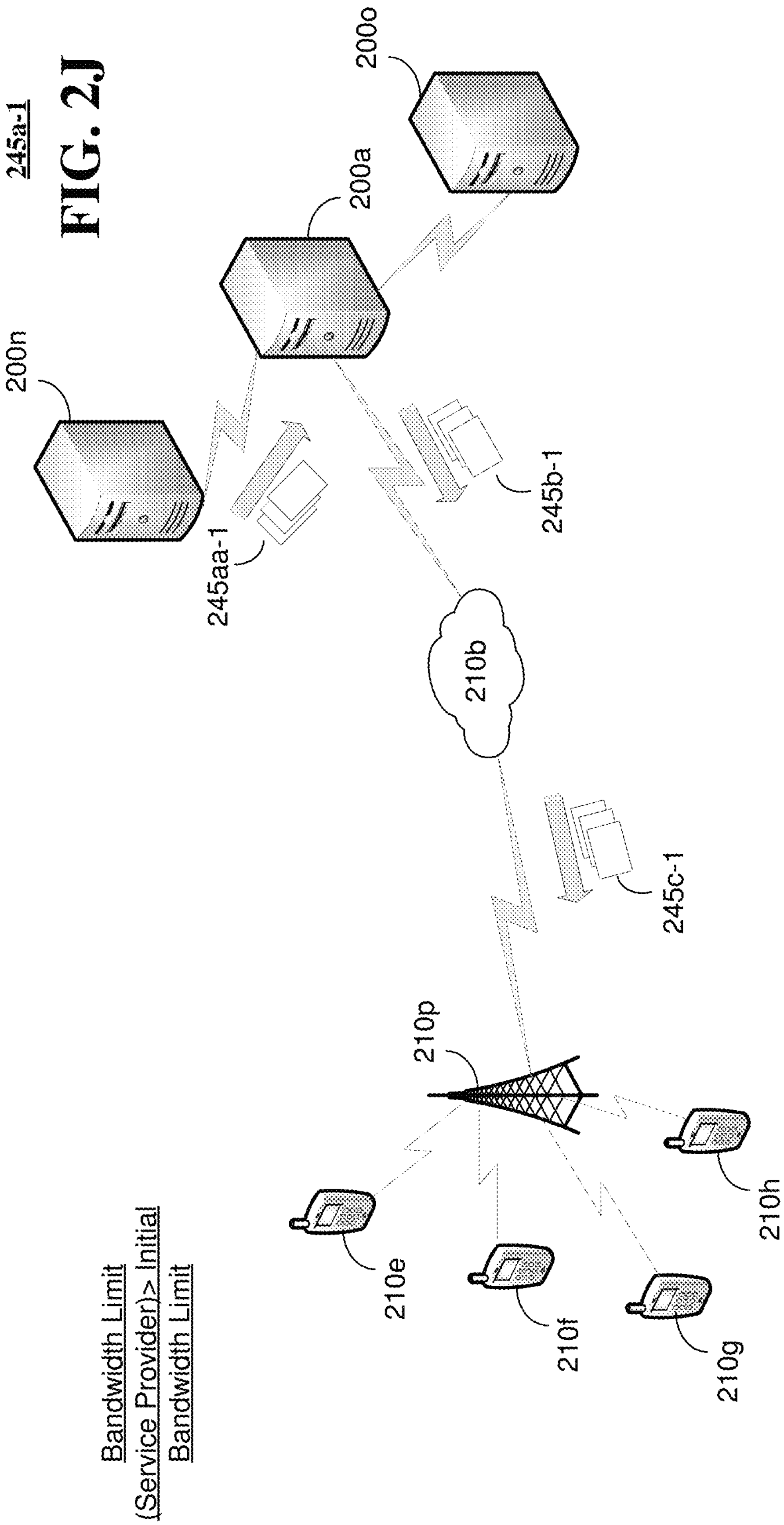

245a-1
200o
200a
200n
245aa-1
245b-1
210b
245c-1
210p
210e
210f
210g
210h
Bandwidth Limit
(Service Provider)> Initial
Bandwidth Limit

FIG. 2J

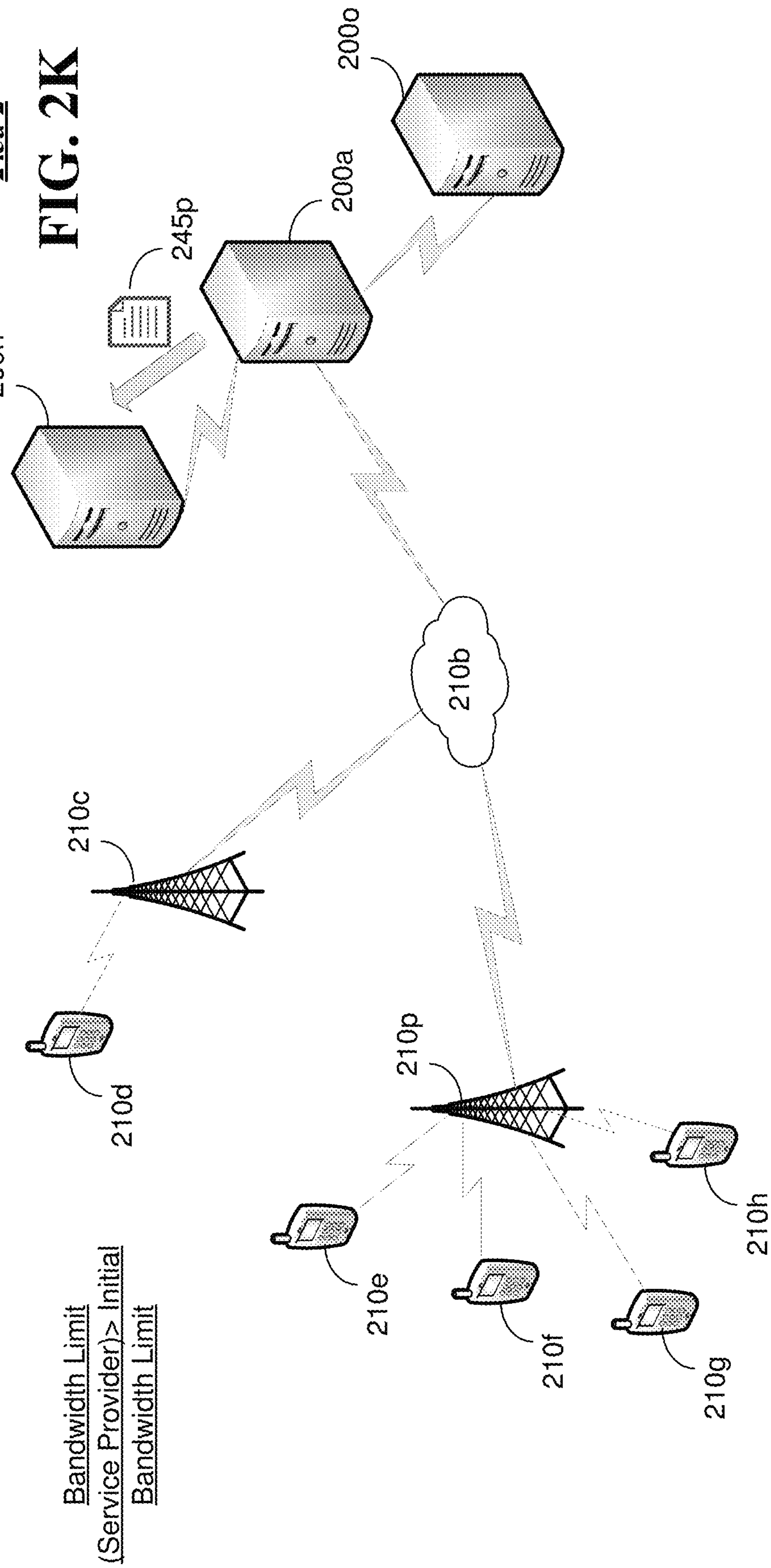

245a-2
200o
200a
245p
200n
210b
210c
210d
210p
210e
210f
210g
210h
Bandwidth Limit
(Service Provider)> Initial
Bandwidth Limit

FIG. 2K

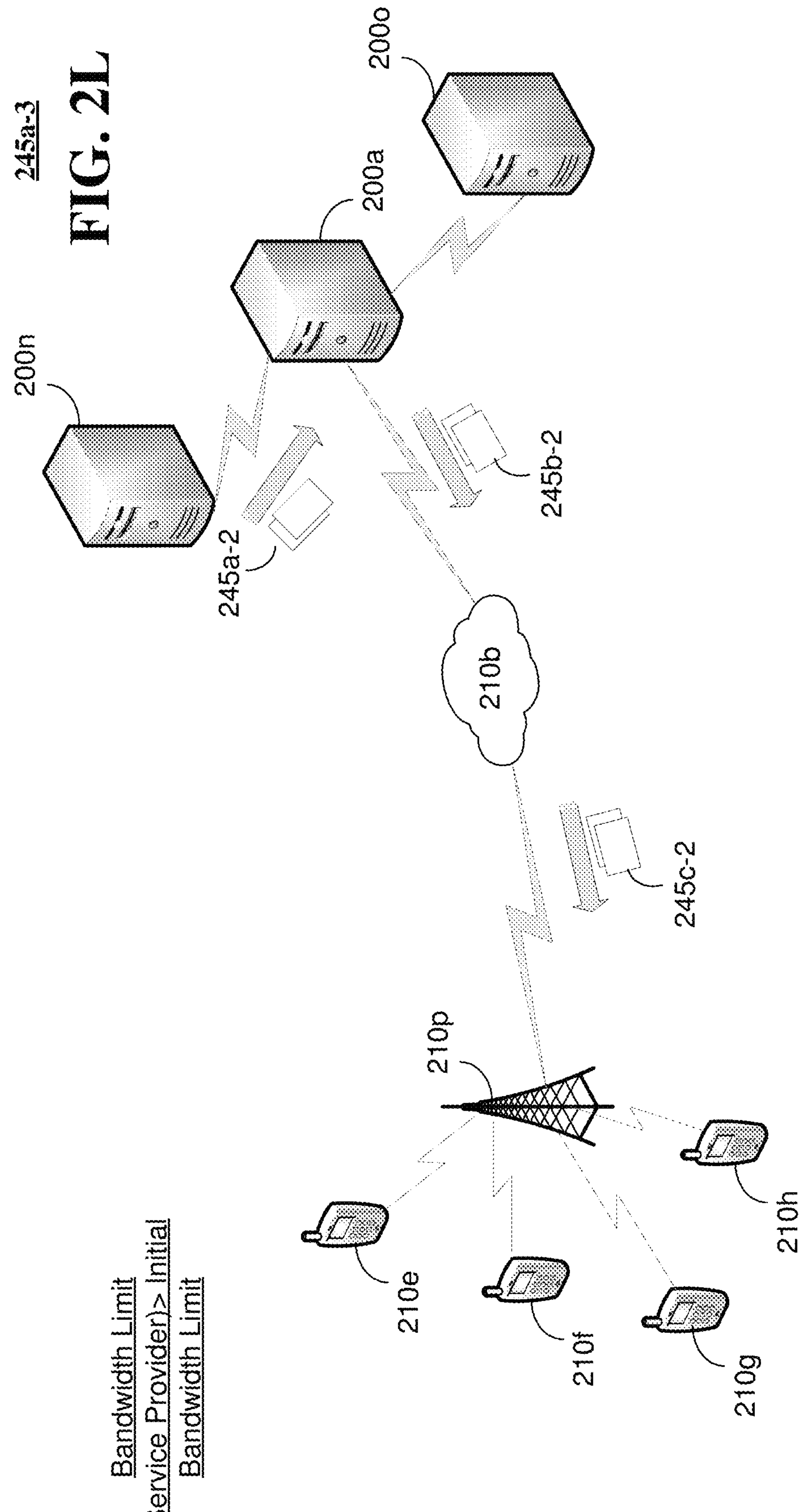
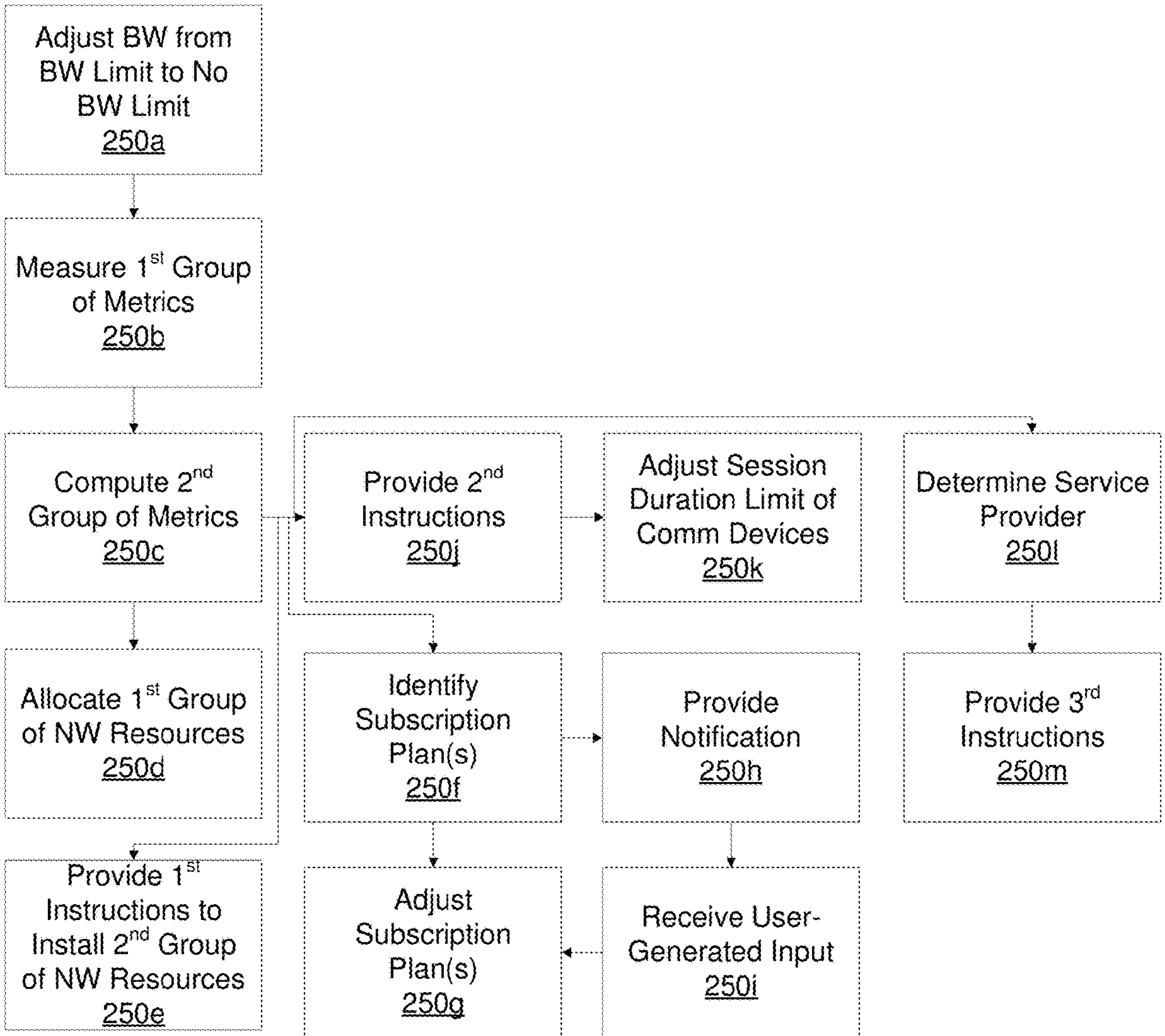

245a-3
200o
200a
200n
245a-2
245b-2
210b
245c-2
210p
210e
210f
210g
210h
Bandwidth Limit
(Service Provider)> Initial
Bandwidth Limit

FIG. 2L

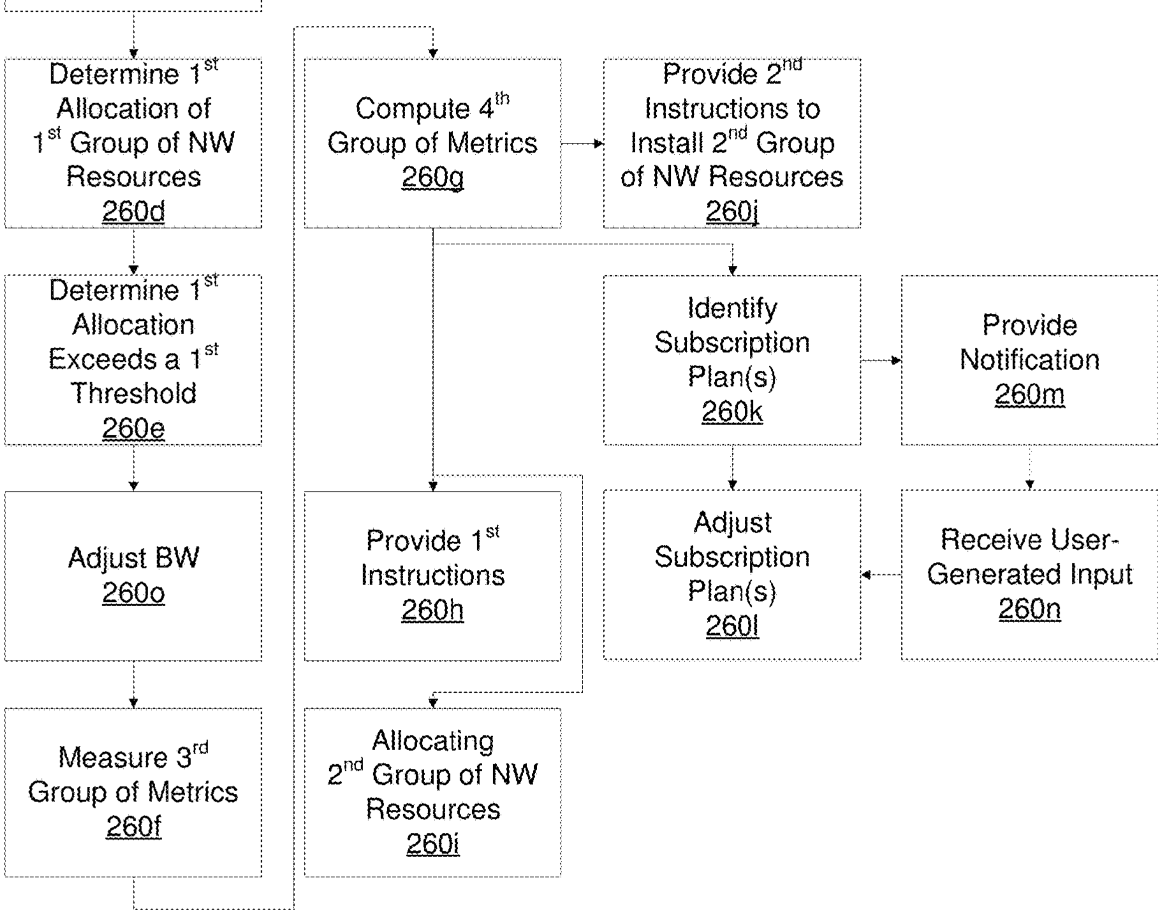


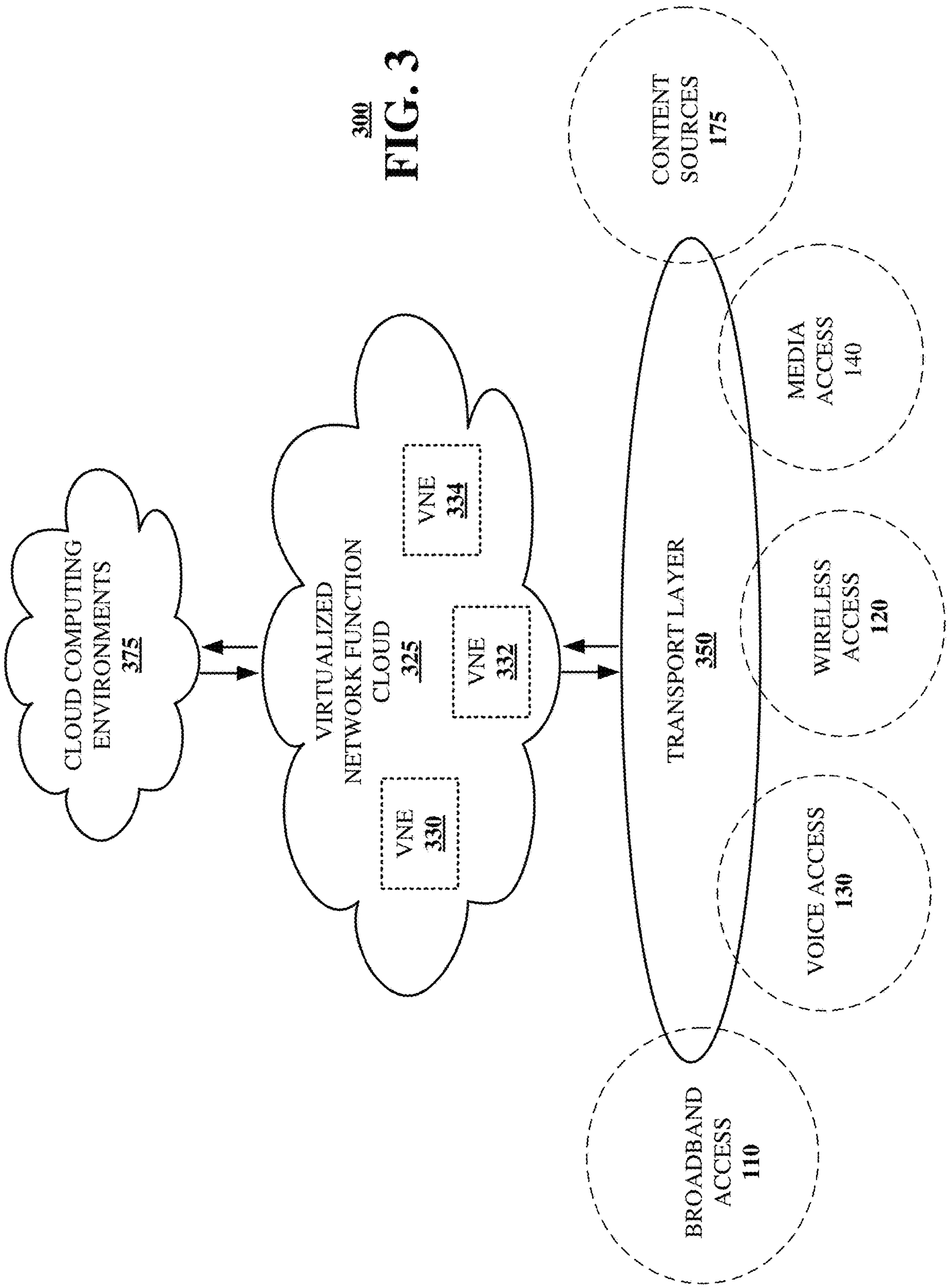
Adjust BW from BW Limit to No BW Limit 250a
Measure 1st Group of Metrics 250b
Compute 2nd Group of Metrics 250c
Allocate 1st Group of NW Resources 250d
Provide 1st Instructions to Install 2nd Group of NW Resources 250e
Provide 2nd Instructions 250j
Identify Subscription Plan(s) 250f
Adjust Subscription Plan(s) 250g
Adjust Session Duration Limit of Comm Devices 250k
Provide Notification 250h
Receive User-Generated Input 250i
Determine Service Provider 250l
Provide 3rd Instructions 250m

250

FIG. 2M

260
FIG. 2N


Adjust BW from BW Limit to No BW Limit 260a
Measure 1st Group of Metrics 260b
Compute 2nd Group of Metrics 260c
Determine 1st Allocation of 1st Group of NW Resources 260d
Determine 1st Allocation Exceeds a 1st Threshold 260e
Adjust BW 260o
Measure 3rd Group of Metrics 260f
Compute 4th Group of Metrics 260g
Provide 2nd Instructions to Install 2nd Group of NW Resources 260j
Identify Subscription Plan(s) 260k
Provide Notification 260m
Provide 1st Instructions 260h
Adjust Subscription Plan(s) 260l
Receive User-Generated Input 260n
Allocating 2nd Group of NW Resources 260i


CLOUD COMPUTING ENVIRONMENTS 375
VIRTUALIZED NETWORK FUNCTION CLOUD 325
VNE 330
VNE 332
VNE 334
TRANSPORT LAYER 350
CONTENT SOURCES 175
MEDIA ACCESS 140
WIRELESS ACCESS 120
VOICE ACCESS 130
BROADBAND ACCESS 110

300
FIG. 3

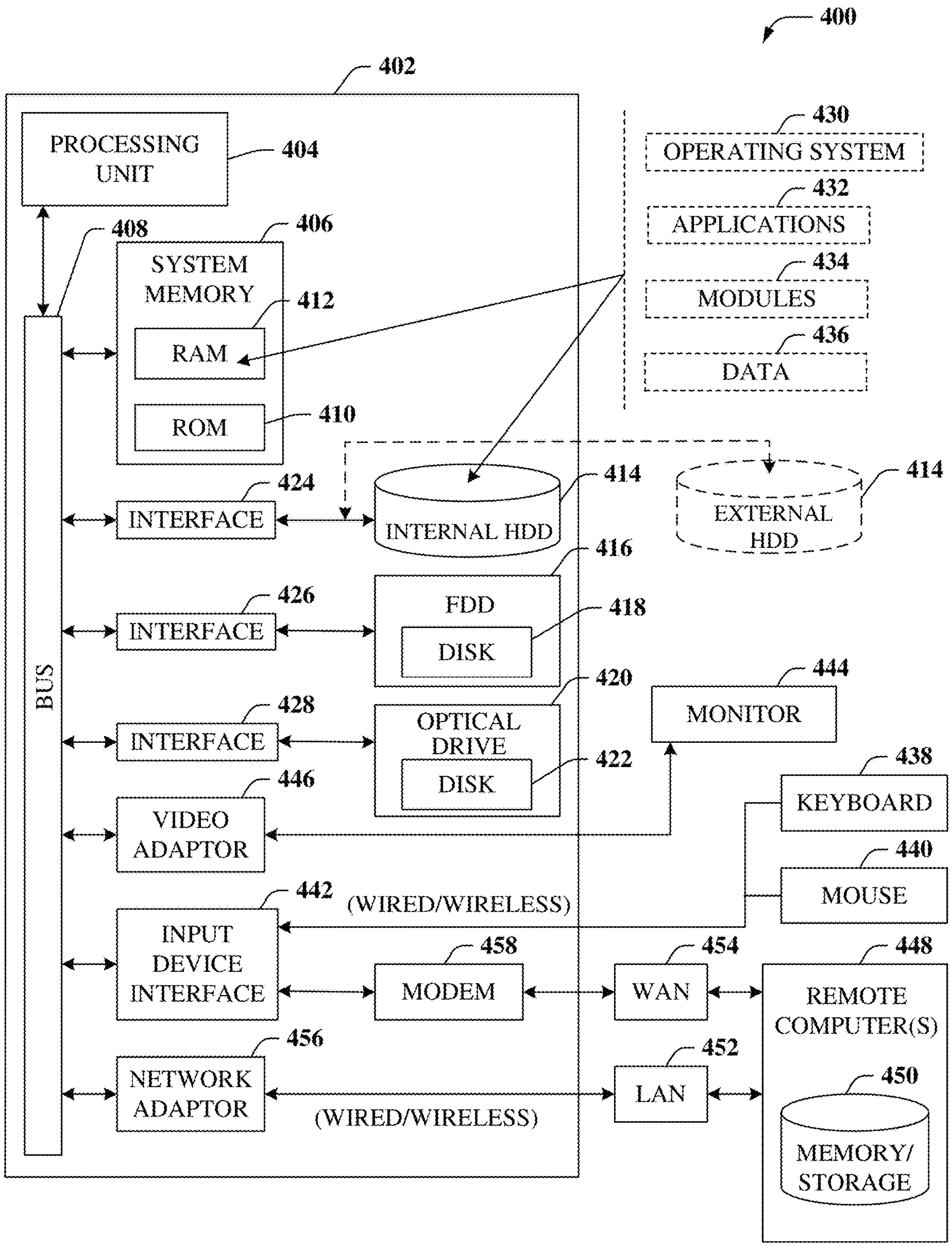

400
402
PROCESSING UNIT
404
408
406
SYSTEM MEMORY
412
RAM
ROM
410
BUS
424
INTERFACE
INTERNAL HDD
414
426
INTERFACE
416
FDD
DISK
418
428
INTERFACE
420
OPTICAL DRIVE
DISK
422
446
VIDEO ADAPTOR
442
INPUT DEVICE INTERFACE
(WIRED/WIRELESS)
458
MODEM
456
NETWORK ADAPTOR
(WIRED/WIRELESS)
430
OPERATING SYSTEM
432
APPLICATIONS
434
MODULES
436
DATA
414
EXTERNAL HDD
444
MONITOR
438
KEYBOARD
440
MOUSE
454
WAN
448
REMOTE COMPUTER(S)
452
LAN
450
MEMORY/ STORAGE

FIG. 4

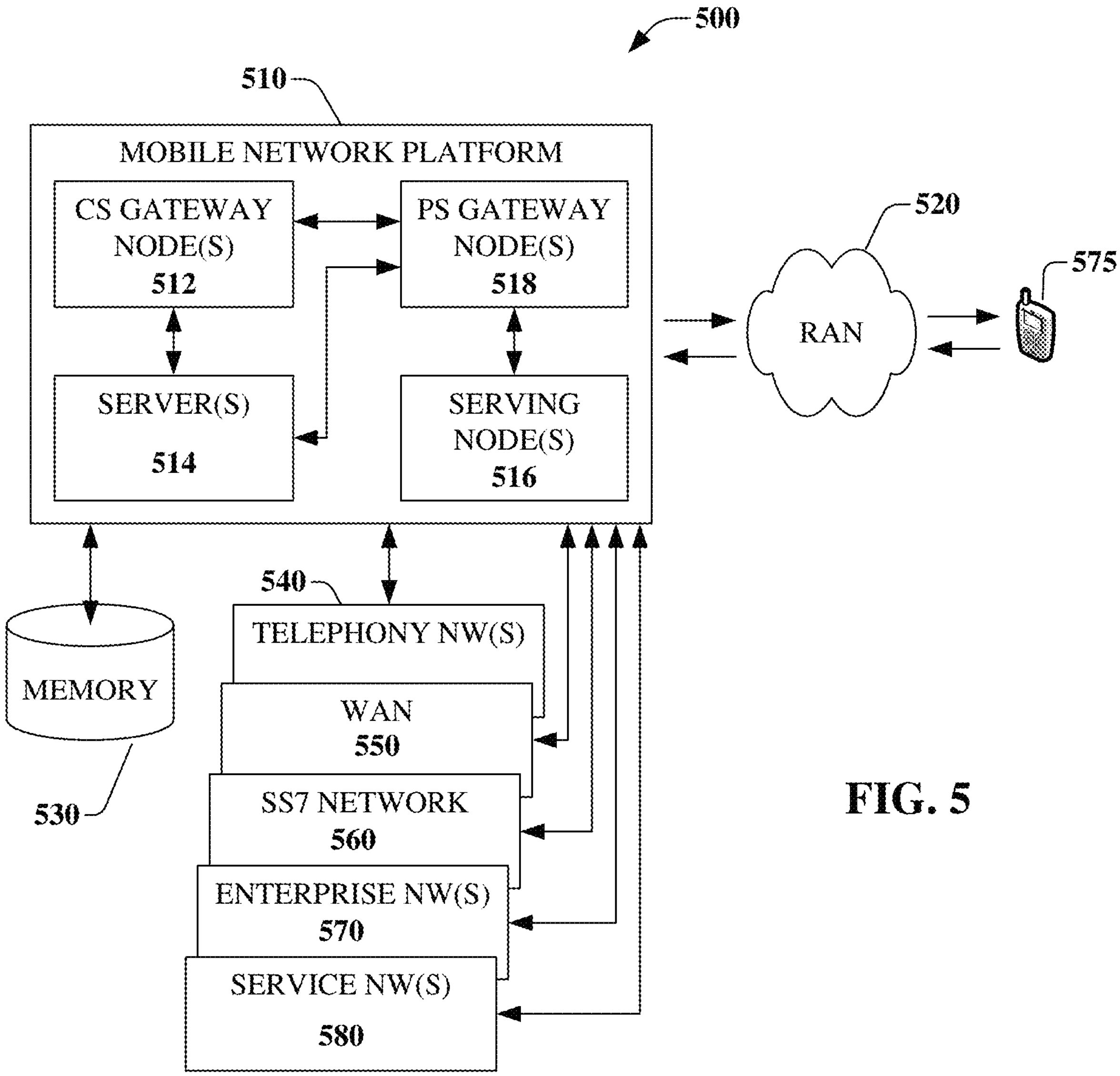
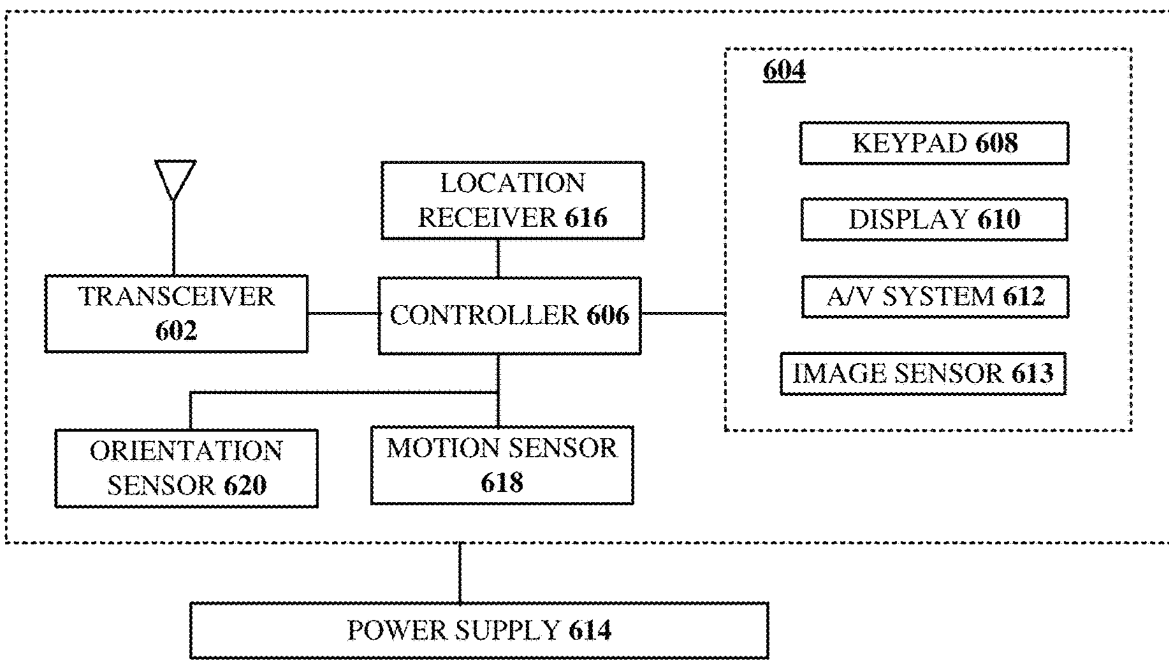

500
510
MOBILE NETWORK PLATFORM
CS GATEWAY NODE(S) 512
PS GATEWAY NODE(S) 518
SERVER(S) 514
SERVING NODE(S) 516
520
RAN
575
540
TELEPHONY NW(S)
MEMORY
530
WAN 550
SS7 NETWORK 560
ENTERPRISE NW(S) 570
SERVICE NW(S) 580

FIG. 5


604
KEYPAD 608
DISPLAY 610
A/V SYSTEM 612
IMAGE SENSOR 613
LOCATION RECEIVER 616
TRANSCEIVER 602
CONTROLLER 606
ORIENTATION SENSOR 620
MOTION SENSOR 618
POWER SUPPLY 614

600
FIG. 6

METHODS, DEVICES, AND SYSTEMS FOR ESTIMATING VIDEO DATA USAGE WITHOUT BANDWIDTH LIMITS

FIELD OF THE DISCLOSURE

The subject disclosure relates to methods, systems, and devices for estimating video data usage without bandwidth limits.

BACKGROUND

Video bandwidth can be limited on communication devices such as mobile phones and tablet computers by wireless carriers and Internet Service Providers (ISPs) to improve network performance. As these bandwidth limits have been operating in place for many years, estimating the increase of video data usage without bandwidth limits becomes a challenging task for ISPs. With video being the most dominant application on a wireless network, change of video data volume creates an impact on network performance and user experience. As customers demand a premium video experience, the industry may be moving towards removing video bandwidth limits.

Removing video bandwidth limits brings new demands on a mobile network. The key is to recognize that both network and user behavior changes contribute to the increase of data usage. ISPs often manage video traffic by preventing or reducing excessive data use in the mobile network by limiting video speed for mobile devices with small screens (such as mobile phones and/or tablet computers). For example, this bandwidth limit prevents 4-inch screen mobile devices from consuming unnecessary high-resolution video content and allows the video content service to send video content at a more appropriate resolution for such mobile devices. This protects consumers from paying for unnecessary data charges as well as prevent overloading the mobile network. Conventional methods estimate video content traffic increase by actively testing video content services and measure their data rate increase under no bandwidth limit constraints.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

FIG. **1** is a block diagram illustrating an exemplary, non-limiting embodiment of a communications network in accordance with various aspects described herein.

FIGS. **2**A-**2**L are block diagrams illustrating example, non-limiting embodiments of systems functioning within the communication network of FIG. **1** in accordance with various aspects described herein.

FIGS. **2**M-**2**N depict illustrative embodiments of methods in accordance with various aspects described herein.

FIG. **3** is a block diagram illustrating an example, non-limiting embodiment of a virtualized communication network in accordance with various aspects described herein.

FIG. **4** is a block diagram of an example, non-limiting embodiment of a computing environment in accordance with various aspects described herein.

FIG. **5** is a block diagram of an example, non-limiting embodiment of a mobile network platform in accordance with various aspects described herein.

FIG. **6** is a block diagram of an example, non-limiting embodiment of a communication device in accordance with various aspects described herein.

DETAILED DESCRIPTION

The subject disclosure describes, among other things, illustrative embodiments for adjusting bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limited allocation to a no bandwidth limited allocation, and measuring a first group of metrics associated with the first group of communication devices associated with the first communication network. Further embodiments include computing a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, the second group of communication devices have the no bandwidth limited allocation, and allocating a first group of network resources for the second group of communication devices according to the second group of metrics. Other embodiments are described in the subject disclosure.

One or more aspects of the subject disclosure include a device, comprising a processing system including a processor, and a memory that stores executable instructions that, when executed by the processing system, facilitate performance of operations. Operations can comprise adjusting bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limited allocation to a no bandwidth limited allocation, and measuring a first group of metrics associated with the first group of communication devices associated with the first communication network. Further operations can comprise computing a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, the second group of communication devices have the no bandwidth limited allocation, and allocating a first group of network resources for the second group of communication devices according to the second group of metrics.

One or more aspects of the subject disclosure include a non-transitory machine-readable medium, comprising executable instructions that, when executed by a processing system including a processor, facilitate performance of operations. The operations can comprise adjusting bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limited allocation to a no bandwidth limited allocation, and measuring a first group of metrics associated with the first group of communication devices associated with the first communication network. Further operations can comprise computing a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, wherein the second group of communication devices have the no bandwidth limited allocation, and providing first instructions to install a first group of network resources in the second communication network according to the second group of metrics.

One or more aspects of the subject disclosure include a method. The method can comprise adjusting, by a processing system including a processor, bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limited allocation to a no bandwidth limited allocation, and measuring, by the processing system, a first group of metrics associated with the first group of communication devices associated with the first communication network. Further, the method can comprise computing, by the processing system, a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, the second group of communication devices have no bandwidth limited allocation, identifying, by the processing system, a group of subscription plans associated with a first portion of the second group of communication devices, and adjusting, by the processing system, each of the group of subscription plans according to the second group of metrics.

Referring now to FIG. **1**, a block diagram is shown illustrating an example, non-limiting embodiment of a system **100** in accordance with various aspects described herein. For example, system **100** can facilitate in whole or in part allocation of network resources when no bandwidth limits are placed on communication devices communicatively coupled to the network. In particular, a communications network **125** is presented for providing broadband access **110** to a plurality of data terminals **114** via access terminal **112**, wireless access **120** to a plurality of mobile devices **124** and vehicle **126** via base station or access point **122**, voice access **130** to a plurality of telephony devices **134**, via switching device **132** and/or media access **140** to a plurality of audio/video display devices **144** via media terminal **142**. In addition, communication network **125** is coupled to one or more content sources **175** of audio, video, graphics, text and/or other media. While broadband access **110**, wireless access **120**, voice access **130** and media access **140** are shown separately, one or more of these forms of access can be combined to provide multiple access services to a single client device (e.g., mobile devices **124** can receive media content via media terminal **142**, data terminal **114** can be provided voice access via switching device **132**, and so on).

The communications network **125** includes a plurality of network elements (NE) **150**, **152**, **154**, **156**, etc. for facilitating the broadband access **110**, wireless access **120**, voice access **130**, media access **140** and/or the distribution of content from content sources **175**. The communications network **125** can include a circuit switched or packet switched network, a voice over Internet protocol (VOIP) network, Internet protocol (IP) network, a cable network, a passive or active optical network, a 4G, 5G, or higher generation wireless access network, WIMAX network, UltraWideband network, personal area network or other wireless access network, a broadcast satellite network and/or other communications network.

In various embodiments, the access terminal **112** can include a digital subscriber line access multiplexer (DSLAM), cable modem termination system (CMTS), optical line terminal (OLT) and/or other access terminal. The data terminals **114** can include personal computers, laptop computers, netbook computers, tablets or other computing devices along with digital subscriber line (DSL) modems, data over coax service interface specification (DOCSIS) modems or other cable modems, a wireless modem such as a 4G, 5G, or higher generation modem, an optical modem and/or other access devices.

In various embodiments, the base station or access point **122** can include a 4G, 5G, or higher generation base station, an access point that operates via an 802.11 standard such as 802.11n, 802.11ac or other wireless access terminal. The mobile devices **124** can include mobile phones, e-readers, tablets, phablets, wireless modems, and/or other mobile computing devices.

In various embodiments, the switching device **132** can include a private branch exchange or central office switch, a media services gateway, VoIP gateway or other gateway device and/or other switching device. The telephony devices **134** can include traditional telephones (with or without a terminal adapter), VoIP telephones and/or other telephony devices.

In various embodiments, the media terminal **142** can include a cable head-end or other TV head-end, a satellite receiver, gateway or other media terminal **142**. The display devices **144** can include televisions with or without a set top box, personal computers and/or other display devices.

In various embodiments, the content sources **175** include broadcast television and radio sources, video on demand platforms and streaming video and audio services platforms, one or more content data networks, data servers, web servers and other content servers, and/or other sources of media.

In various embodiments, the communications network **125** can include wired, optical and/or wireless links and the network elements **150**, **152**, **154**, **156**, etc. can include service switching points, signal transfer points, service control points, network gateways, media distribution hubs, servers, firewalls, routers, edge devices, switches and other network nodes for routing and controlling communications traffic over wired, optical and wireless links as part of the Internet and other public networks as well as one or more private networks, for managing subscriber access, for billing and network management and for supporting other network functions.

FIGS. **2**A-**2**L are block diagrams illustrating example, non-limiting embodiments of systems functioning within the communication network of FIG. **1** in accordance with various aspects described herein. One or more embodiments can include a generalized data-driven model for forecasting video data volume by the video service type, cell utilization, and video transfer duration to estimate mobility data traffic increase for a mobile network in which mobile devices are not constrained by any bandwidth limit. Other embodiments can estimate video traffic increase by actively testing video services and measure their data rate increase under no bandwidth limits. Then the ratios of the measured increases of tested services are then applied to the measured video traffic recorded from a network for a traffic increase estimate. This assumes the network conditions remain constant and customers would use the video services for the same amount of time.

One or more embodiments can include obtaining measurement of different aspects of a mobile network by removing video bandwidth limit for a time period, and reverse-engineer ratios of data increase for all video services. In some embodiments, video services can behave differently when cells of the mobile network become loaded and busy. In addition to bandwidth variations, customers may also consume more video content when bandwidth limits were removed. Other embodiments may find data increase patterns among video services at different cell Physical Resource Blocks (PRB) utilization levels. Further, many video services exhibit different bandwidth demands at different PRB levels. In addition to the bandwidth increase, the total data transfer duration for all video content services may also increase. This indicates customers may also consumed more video content during the time period. These can be valuable insights discovered by the measurements. Embodiments described herein, provide the following improvement over conventional approaches to estimate video content traffic increase in mobile networks with no bandwidth limits placed on mobile devices that include covering more video services than existing active testing can (e.g., dozens compared to several), correlating video traffic increase rates with different PRB utilization levels, and uncovered video consumption increase with longer session durations. Further benefits of some embodiments can include better understanding of customer video consumption behaviors, ability to prepare the mobile network for increased video limits, ability to manage network traffic based on application traffic and insights into experience, potential to monetize the knowledge by adapting consumption patterns in different markets, and developing of capacity planning and network monitoring solutions and tools.

In FIGS. **2**A-**2**L, in one or more embodiments, a group of metrics can be measured in mobile network **200***b* when no bandwidth limit is in place on communication devices and then a group of metrics can be computed (i.e. extrapolated) for mobile network **210***b* with no bandwidth limit is in place for communication devices based on the measured group of metrics to determine whether to allocate any network resources to accommodate the data volume in mobile network **210***b*. In other embodiments, a group of metrics can be measured in mobile network **200***b* when a bandwidth limit is placed on communication devices after no bandwidth limit was in place. Further, a group of metrics can be computed (i.e., extrapolated) for mobile network **210***b* in which the bandwidth limit are placed on communication devices based on the measured group of metrics to determine whether to allocate any network resources to accommodate the data volume in mobile network **210***b*.

Referring to FIG. **2**A, in one or more embodiments, system **200** comprises network management server **200***a* communicatively coupled to video content server **200***n* and video content server **2000**. Further, network management server **200***a* can be communicatively coupled to mobile network **200***b*. In addition, communication device **200***d* and communication device **200***e* can be communicatively coupled to mobile network **200***b* via base station **200***c*. Also, communication device **200***f*, communication device **200***g*, and communication device **200***h* can be communicatively coupled to mobile network **200***b* via base station **200***p*. Communication device **200***i* and communication device **200***i* can be communicatively coupled to mobile network **200***b* via millimeter wave (mmW) node **200***q*. Further, communication device **200***k*, communication device **200***l*, and communication device **200***m* can be communicatively coupled to mobile network **200***b* via mmW node **200***r*.

In one or more embodiments, mobile network **200***b* can comprise one or more wireless networks including cellular networks. However, in some embodiments, mobile network **200***b* can include wired networks that are communicatively coupled to network devices that assist in managing the mobile network **200***b*. Further, video content server **200***n* and video content server **2000** can be communicatively coupled to network management server **200***a* over either a wireless communication network, wired communication network, or a combination thereof. In addition, the network management server **200***a* can be communicatively coupled to mobile network **200***b* over a wireless communication network, a wired communication network, or combination thereof. Each of video content server **200***n* and video content server **2000** can be operated by a different video content service provider (e.g., Video-on-Demand provider, Facebook®, YouTube®, etc.). Also, each of network management server **200***a*, video content server **200***n*, video content server **2000** can include one or more servers in one location or spanning multiple locations, one or virtual servers in one location or spanning multiple locations, one or more cloud servers, or a combination thereof. Further, each communication device communicatively coupled to mobile network **200***b* can comprise a mobile device, mobile phone, smartphone, tablet computer, laptop computer, virtual reality device, augmented reality device, cross reality device, or any communication device capable of being communicatively coupled to mobile network **200***b*.

In one or more embodiments, the network management server **200***a* can provide instructions to each of the communication devices communicatively coupled to mobile network **200***b* that indicate to provision an initial bandwidth limit on each communication device for downloading or streaming video content from each of video content server **200***n* and video content server **2000** (or any other video content server communicatively coupled to mobile network **200***b*). In alternate embodiments, data packets are limited to a certain network rate to limit bandwidth associated with a communication device. The initial bandwidth limit is provisioned on each communication device so that the communication devices do not consume too much bandwidth on any portion of mobile network **200***b*, thereby inhibiting the providing of other services on the mobile network **200***b* (e.g., voice, data, etc.).

Referring to FIG. **2**B, in one or more embodiments, system **205** comprises a portion of system **200** that includes network management server **200***a*, video content server **200***n*, and video content server **2000**. Further, the network management server **200***a* can be communicatively coupled to mobile network **200***b*. In addition, communication device **200***f*, communication device **200***g*, and communication device **200***h* can be communicatively coupled to mobile network **200***b* via base station **200***p*. Also, communication device **200***i* and communication device **200***j* can be communicatively coupled to mobile network **200***b* over mmW node **200***q*.

In one or more embodiments, the network management server **200***a* can provide instructions to each of the communication devices communicatively coupled to mobile network **200***b* including communication device **200***d*, communication device **200***e*, communication device **200***f*, communication device **200***g*, communication device **200***h*, communication device **200***i*, communication device **200***j*, communication device **200***k*, communication device **200***l* and communication device **200***m* that indicate to adjust the bandwidth limit for downloading or streaming video content from the initial bandwidth limit to no bandwidth limit (or adjust the bandwidth allocation from the initial bandwidth limit to a no bandwidth limit based on limiting the data packets associated with a communication device to certain rate or not). Further, each of communication device **200***d*, communication device **200***e*, communication device **200***f*, communication device **200***g*, communication device **200***h*, communication device **200***i*, communication device **200***j*, communication device **200***k*, communication device **200***l* and communication device **200***m* can download or stream video content from one of video content server **200***n* or video content server **2000** under no bandwidth limit constraint. Video content delivered from video content server **200***n* and video content server **200***o* to the communication devices can include video content **205***a*, video content **205***b*, video content **205***c*, video content **205***d*, video content **205***e*. Each video content can comprise a group of packets. Further, network management server **200***a* can measure a group of metrics associated with the communication devices that download or stream the video content over mobile network **200***b*. The group of metrics can include one of physical resource block (PRB) utilization of different base stations, video content session durations of each communication device, data volume over mobile network **200***b*, throughput of mobile network **200***b*, latency through mobile network **200***b*, or any combination thereof.

Referring to FIG. **2**C, in one or more embodiments, system **210** comprises network management server **200***a* communicatively coupled to video content server **200***n* and video content server **2000**. Further, network management server **200***a* can be communicatively coupled to mobile network **210***b*. In addition, communication device **210***d* can be communicatively coupled to mobile network **210***b* via base station **210***c*. Also, communication device **210***e*, communication device **210***f*, communication device **210***g*, and communication device **210***h* can be communicatively coupled to mobile network **210***b* via base station **210***p*. Communication device **210***i* and communication device **210***i* can be communicatively coupled to mobile network **210***b* via mmW node **210***q*. Further, communication device **210***k*, communication device **210***l*, and communication device **210***m* can be communicatively coupled to mobile network **210***b* via base station **210***r*. Further, each communication device communicatively coupled to mobile network **200***b* can comprise a mobile device, mobile phone, smartphone, tablet computer, laptop computer, virtual reality device, augmented reality device, cross reality device, or any communication device capable of being communicatively coupled to mobile network **200***b*.

In one or more embodiments, the operator of mobile network **200***b* shown in FIGS. **2**A and **2**B can be the operator of mobile network **210***b*. Further, the network management server **200***a* can compute (e.g., extrapolate) a group of metrics associated with the communication devices of mobile network **210***b* including communication device **210***d*, communication device **210***e*, communication device **210***f*, communication device **210***g*, communication device **210***h*, communication device **210***i*, communication device **210***j*, communication device **210***k*, communication device **210***l*, and communication device **210***m* according to the group of metrics for mobile network **200***b* shown in FIGS. **2**A and **2**B. That is, the network operator has measured a group of metrics of mobile network **200***b* and would like to compute or extrapolate a group of metrics for mobile network **210***b* based on the measured group of metrics for various reasons. These reasons can include that mobile network **210***b* can be significantly larger than mobile network **200***b* such that measuring a group of metrics of mobile network **210***b* is cost prohibitive. In addition, network management server **200***a* can allocate different groups of network resources for a group of communication devices according to the group of metrics computed for mobile network **210***b*. The allocation of different groups of network resources can include providing instructions **210***p*-**1** and instructions **210***p*-**2** to base station **210***p* and providing instructions **210***r*-**1** and instructions **210***r*-**2** to base station **210***r*.

Referring to FIG. **2**D, in one or more embodiments, system **215** comprises network management server **200***a* communicatively coupled to video content server **200***n* and video content server **2000**. Further, network management server **200***a* can be communicatively coupled to mobile network **210***b*. In addition, communication device **210***d* can be communicatively coupled to mobile network **210***b* via base station **210***c*. Also, communication device **210***f*, communication device **210***g*, and communication device **210***h* can be communicatively coupled to mobile network **210***b* via base station **210***p*. In some embodiments, the instructions **210***p*-**1** and instructions **210***p*-**2** shown in FIG. **2**A, indicate to base station **210***p* to handover communication device **210***e* (e.g., communication device **210***e*-**1**) to base station **210***c* such that communication device **210***e* (e.g., communication device **210***e*-**2**) is communicatively coupled to mobile network **210***b* via base station **210***c*. The computed group of metrics of mobile network **210***b* may indicate to network management server **200***a* that the PRB utilization associated with base station **210***p* is above a PRB utilization threshold and that the PRB utilization associated with the base station **210***c* is below the PRB utilization threshold such that the network management server **200***a* provide instructions **210***p*-**1** and instructions **210***p*-**2** to allocate network resources accordingly (e.g. handover communication device **210***e* from base station **210***p* to base station **210***c*).

In one or more embodiments, communication device **210***i* and communication device **210***i* can be communicatively coupled to mobile network **210***b* via mmW node **210***q*. Further, communication device **210***k*, communication device **210***l*, and communication device **210***m* can be communicatively coupled to mobile network **210***b* via mmW **215***r*. That is, the instructions **210***q*-**1** and instructions **210***q*-**2** may have indicated to network operator personnel to decommission base station **210***r* and instead install mmW node **215***r* in its place to provide more bandwidth to communication device **210***k*, communication device **210***l*, and communication device **210***m* to accommodate an increase data volume due to no bandwidth limit constraint on communication device **210***k*, communication device **210***l*, and communication device **210***m*.

Referring to FIG. **2**E, in one or more embodiments, system **220** can comprise portions of system **200** that includes network management server **200***a*, video content server **200***n*, and video content server **2000**. Further, the network management server **200***a* can be communicatively coupled to mobile network **200***b*. In addition, communication device **200***f*, communication device **200***g*, and communication device **200***h* can be communicatively coupled to mobile network **200***b* via base station **200***p*. Also, communication device **200***i* and communication device **200***j* can be communicatively coupled to mobile network **200***b* over mmW node **200***q*.

In one or more embodiments, the network management server **200***a* can provide instructions to each of the communication device communicatively coupled to mobile network **200***b* including communication device **200***d*, communication device **200***e*, communication device **200***f*, communication device **200***g*, communication device **200***h*, communication device **200***i*, communication device **200***j*, communication device **200***k*, communication device **200***l* and communication device **200***m* that indicate to adjust the bandwidth limit of each communication device for downloading or streaming video content from no bandwidth limit to a bandwidth limit (or adjust the bandwidth allocation from no bandwidth limit to a bandwidth limit based on limiting the data packets associated with a communication device to certain rate or not). However, the bandwidth limit is greater than the initial bandwidth limit discussed when describing FIG. **2**A. Further, each of communication device **200***d*, communication device **200***e*, communication device **200***f*, communication device **200***g*, communication device **200***h*, communication device **200***i*, communication device **200***j*, communication device **200***k*, communication device **200***l* and communication device **200***m* can download or stream video content from one of video content server **200***n* or video content server **2000** under this bandwidth limit constraint. Video content delivered from video content server **200***n* and video content server **2000** to the communication devices can include video content **205***a*, video content **205***b*, video content **205***c*, video content **205***d*, video content **205***e*. Each video content can comprise a group of packets. Further, network management server **200***a* can measure a group of metrics associated with the communication devices that download or stream the video content over mobile network **200***b* under the bandwidth limit constraint. The group of metrics can include one of physical resource block (PRB) utilization of different base stations, video content session durations of each communication device, data volume over mobile network **200***b*, throughput of mobile network **200***b*, latency through mobile network **200***b*, or any combination thereof.

Referring to FIG. **2**F, in one or more embodiments, system **2225** comprises network management server **200***a* communicatively coupled to video content server **200***n* and video content server **2000**. Further, network management server **200***a* can be communicatively coupled to mobile network **210***b*. In addition, communication device **210***d* can be communicatively coupled to mobile network **210***b* via base station **210***c*. Also, communication device **210***e*, communication device **210***f*, communication device **210***g*, and communication device **210***h* can be communicatively coupled to mobile network **210***b* via base station **210***p*. Communication device **210***i* and communication device **210***i* can be communicatively coupled to mobile network **210***b* via mmW node **210***q*. Further, communication device **210***k*, communication device **210***l*, and communication device **210***m* can be communicatively coupled to mobile network **210***b* via base station **225***r*.

In one or more embodiments, the operator of mobile network **200***b* shown in FIGS. **2**A and **2**B can be the operator of mobile network **210***b*. Further, the network management server **200***a* can compute (e.g., extrapolate) a group of metrics associated with the communication devices of mobile network **210***b* including communication device **210***d*, communication device **210***e*, communication device **210***f*, communication device **210***g*, communication device **210***h*, communication device **210***i*, communication device **210***j*, communication device **210***k*, communication device **210***l*, and communication device **210***m* according to the group of metrics for mobile network **200***b* shown in FIG. **2**E. That is, the network operator has measured a group of metrics of mobile network **200***b* and would like to compute or extrapolate a group of metrics for mobile network **210***b* based on the measured group of metrics for various reasons. These reasons can include that mobile network **210***b* can be significantly larger than mobile network **200***b* such that measuring a group of metrics of mobile network **210***b* is cost prohibitive. In addition, network management server **200***a* can allocate different groups of network resources for a group of communication devices according to the group of metrics computed for mobile network **210***b*.

In one or more embodiments, the network management server **200***a* can determine an allocation of a group of network resources for a group of communication devices associated with mobile network **210***b* according to the computed group of metrics. Further, the network management server **200***a* can determine that the allocation of the network resources can be above an allocation threshold. For example, the computed group of metrics can indicate an increase of data volume to a portion of mobile network **201***b* but is unable to allocate the network resources to provide the amount of bandwidth to accommodate the increase in data volume. Thus, the network management server **200***a* can provide instructions to each communication device communicatively coupled to mobile network **200***b* shown in FIG. **2**E to adjust their bandwidth limit from no bandwidth limit to the bandwidth limit (i.e., that is greater than the initial bandwidth limit). Further, the network management server **200***a* can measure another group of metrics for communication devices communicatively coupled to mobile network **200***b* under this bandwidth limit constraint. Referring to FIG. **2**F, the network management server **200***a* can provide instructions to each communication device communicatively coupled to mobile network **210***b* to adjust its bandwidth limit for downloading or streaming video content to the bandwidth limit and the communication devices adjust themselves accordingly. In addition, the network management server **200***a* can compute another group of metrics for the communication devices communicatively coupled to mobile network **210***b* based on the measured group of metrics. Also, the network management server **200***a* can allocate another group of network resources for a group of communication devices of mobile network **210***b* according to the other computed group of metrics. Further, the network management server **200***a* can provide instructions **225***q*-**1** and instructions **225***q*-**2** to allocate network resources for a portion of mobile network **210***b* associated with a group of communication devices.

Referring to FIG. **2**G, in one or more embodiments, system **230** comprises network management server **200***a* communicatively coupled to video content server **200***n* and video content server **2000**. Further, network management server **200***a* can be communicatively coupled to mobile network **210***b*. In addition, communication device **210***d* can be communicatively coupled to mobile network **210***b* via base station **210***c*. Also, communication device **210***e*, communication device **210***f*, communication device **210***g*, and communication device **210***h* can be communicatively coupled to mobile network **210***b* via base station **210***p*.

In one or more embodiments, communication device **210***i* and communication device **210***i* can be communicatively coupled to mobile network **210***b* via mmW node **210***q*. Further, communication device **210***k*, communication device **210***l*, and communication device **210***m* can be communicatively coupled to mobile network **210***b* via mmW **215***r*. That is the instructions **225***q*-**1** and instructions **225***q*-**2** may have indicated to network operator personnel to decommission base station **225***r* and instead install mmW node **230***r* to provide more bandwidth to communication device **210***k*, communication device **210***l*, and communication device **210***m* because the computed group of metrics indicated an increase of data volume in the portion of mobile network **210***b* associated with communication device **210***k*, communication device **210***l*, and communication device **210***m*. Base station **225***r* shown in FIG. **2**F cannot accommodate the increase in data volume, however, the mmW node **230***r* can do and is allocated/installed accordingly.

Referring to FIG. **2**H, in one or more embodiments, system **235** comprises portions of system **225** that can include network management server **200***a* communicatively coupled to video content server **200***n* and video content server **2000**. Further, network management server **200***a* can be communicatively coupled to mobile network **210***b*. In addition, communication device **210***d* can be communicatively coupled to mobile network **210***b* via base station **210***c*. Also, communication device **210***e*, communication device **210***f*, communication device **210***g*, and communication device **210***h* can be communicatively coupled to mobile network **210***b* via base station **210***p*.

In one or more embodiments, network management server **200***a* can adjust the allocation of network resources for a time period according to the computed group of metrics for mobile network **210***b*. That is, for example, the coverage area associated with base station **210***p* may be traversed by a public transportation route (e.g., subway route, bus route, etc.) and commuters traveling during rush hour on the public transportation route may download or stream video content from video content server **200***n* or video content server **2000**. Thus, network management server **200***a* can provide instructions **235***p*-**1** and instructions **235***p*-**2** to base station **210***p* to adjust its network resources for communication device **210***e*, communication device **210***f*, communication device **210***g*, and communication device **210***h*.

Referring to FIG. **21**, in one or more embodiments, system **240** comprises portions of system **225** that can include network management server **200***a* communicatively coupled to video content server **200***n* and video content server **2000**. Further, network management server **200***a* can be communicatively coupled to mobile network **210***b*. In addition, communication device **210***d* can be communicatively coupled to mobile network **210***b* via base station **210***c*. Also, communication device **210***e*, communication device **210***f*, communication device **210***g*, and communication device **210***h* can be communicatively coupled to mobile network **210***b* via base station **210***p*. That is, for example, the instructions **235***p*-**1** and instructions **235***p*-**2** shown in FIG. **2**H can indicate to base station **210***p* to handover communication device **210***e* and communication device **210***f* to base station **210***c* because, prior to handover, the PRB utilization for base station **210***p* can exceed a PRB utilization threshold. However, after the handover, the PRB utilization for base station **210***p* can be below the PRB utilization threshold. That is, prior to the handover, the PRB utilization of base station **210***p* exceeded a PRB utilization threshold indicating that the base station may not be able to adequately serve the communication devices communicatively coupled to it. However, after the handover, and with its PRB utilization below the PRB utilization threshold, the base station **210***p* can adequately serve the communication devices (e.g., provide sufficient bandwidth).

Referring to FIGS. **2**J, **2**K, and **2**L in one or more embodiments, system **245***a*-**1**, system **245***a*-**2**, and system **245***a*-**3** comprise portions of system **225** that can include network management server **200***a* communicatively coupled to video content server **200***n* and video content server **2000**. Further, network management server **200***a* can be communicatively coupled to mobile network **210***b*. In addition, communication device **210***d* can be communicatively coupled to mobile network **210***b* via base station **210***c*. Also, communication device **210***e*, communication device **210***f*, communication device **210***g*, and communication device **210***h* can be communicatively coupled to mobile network **210***b* via base station **210***p*.

The network management server **200***a* can measure the throughput of packets **245***aa*-**1**, packets **245***b*-**1**, and packets **245***c*-**1** from video content server **200***n* to communication device **210***e*, communication device **210***f*, communication device **210***g*, and communication device **210***h* communicatively coupled to mobile network **210***b* via base station **210***p*. Further, the network management server **200***a* can determine a service provider operating video content server **200***n* is associated with a portion of the computed group of metrics for mobile network **210***b* as discussed when describing FIG. **2**F. Further, the throughput of the video content delivered by video content server **200***n* can be above a throughput threshold such that inhibits mobile network **210***b* to provide other services to communication devices communicatively coupled to it.

Referring to FIG. **2**K, in one or more embodiments, the network management server **200***a* can provide instructions **245***p* to video content server **200***n* that indicates adjusting a video content service delivered to a portion of the group of communication devices communicatively coupled to base station **210***p*. The instructions can include requesting the video content server **200***n* to reduce the throughput of packets during a video content viewing session by the communication devices communicatively coupled to base station **210***p* that is below the throughput threshold so that mobile network **210***b* can provide other services to communication devices communicatively coupled to it. For example, the video content server **200***n* can provide video content at a lower resolution to reduce the throughput of packets.

Referring to FIG. **2**L, in one or more embodiments, the video content server **200***n* can reduce the throughput of packets **245***aa*-**2**, packets **245***b*-**2**, and packets **245***c*-**2** associated with video content delivered to the communication devices communicatively coupled to base station **210***p* in response to the instructions **245***p* shown in FIG. **2**K.

Referring to FIG. **2**C and FIG. **2**F, in one or more embodiments, the subscription plans associated with users of communication devices communicatively coupled to mobile network **210***b* may be adjusted. That is, due to no bandwidth limit or a high bandwidth limit associated with each of the communication devices, users may have longer video content session durations than when there was a low bandwidth limit associated with each communication device. This can result in greater data volume over mobile network for a user associated with each communication device. The subscription plan for each user may penalize the user for consuming data over a specified limit with a fee. Thus, the network operator of mobile network **210***b* can adjust or request the user to adjust the subscription plan to avoid any penalty fees.

In one or more embodiments, the network management server **200***a* can identifying a group of subscription plans associated with a portion of a group of communication devices communicatively coupled to mobile network **210***b*. Further, the network management server **200***a* can provide a notification to each of the portion of the group of communication devices that can be used with an associated user to adjust their respective subscription plans. In addition, each user can select a subscription plan from a menu of subscription plans that are displayed in the notification or otherwise enter user-generated input to select an alternate subscription plan and provide the user-generated input to the network management server **200***a*. Also, the network management server can receive user-generated input from each of the portion of the group of communication devices resulting in a group of user-generated input. The network management server **200***a* can adjust each of the group of subscription plans according to the computed group of metrics and/or the group of user-generated input. In some embodiments the network management server **200***a* can provide instructions to a network device that manages user subscription plans to adjust the group of subscription plans according to the computed group of metrics and/or group of user-generated input.

FIGS. **2**M-**2**N depict illustrative embodiments of methods in accordance with various aspects described herein. Referring to FIG. **2**M, in one or more embodiments, aspects of method **250** can be implemented by a network management server. Method **250** can include the network management server, at **250***a*, adjusting bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limit to no bandwidth limit. Further, the method **250** can include the network management server, at **250***b*, measuring a first group of metrics associated with the first group of communication devices associated with the first communication network. In addition, the method **250** can include the network management server, at **250***c*, computing a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, in which there is no bandwidth limit allocated to the second group of communication devices. Also, the method **250** can include the network management server, at **250***d*, allocating a first group of network resources for the second group of communication devices according to the second group of metrics. In some embodiments, the first group of metrics and the second group of metrics include one of physical resource block (PRB) utilization, video content session durations, data volume, throughput, latency, or any combination thereof.

In one or more embodiments, the method **250** can include the network management server, at **250***e*, providing first instructions to install a second group of network resources in the second communication network according to the second group of metrics. Further, the method **250** can include the network management server, at **250***j*, providing second instructions to each of a second portion of the second group of communication devices that indicate to adjust each of the second portion of the second group of communication devices. In some embodiments, the second group of metrics comprises video content session durations associated with communication devices, and the second instructions indicate to a limit associated with a video content session duration for each of the second group of communication devices. Each of the second group of communication devices is adjusted to the limit associated with the video content session duration.

In one or more embodiments, the method **250** can include the network management server, at **250***f*, identifying a group of subscription plans associated with a first portion of the second group of communication devices. Further, the method **250** can include the network management server, at **250***g*, adjusting each of the group of subscription plans according to the second group of metrics. In addition, the method **250** can include the network management server, at **250***h*, providing a notification to each of the first portion of the second group of communication devices. Also, the method **250** can include the network management server, at **250***i*, receiving user-generated input from each of the first portion of the second group of communication devices resulting in a group of user generated input. Each of the first portion of the second group of communication devices provides the user-generated input in response to receiving the notification. Each of the group of user-generated input indicates a subscription plan, and the adjusting of each of the group of subscription plans can comprise adjusting the group of subscription plans according to the group of user-generated input.

In one or more embodiments, the method **250** can include the network management server, at **250***l*, determining a video content service provider is associated with a portion of the second group of metrics. Further, the method **250** can include the network management server, at **250***m*, providing third instructions to a video content server associated with the video content service provider that indicates adjusting a video content service delivered to a third portion of the second group of communication devices. Further, the video content server can adjust delivery of the video content service provided to the third portion of the second group of communication devices according to the third instructions.

Referring to FIG. **2**N, in one or more embodiments, aspects of method **260** can be implemented by a network management server. Method **260** can include the network management server, at **260***a*, adjusting bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a first bandwidth limit to no bandwidth limit. Further, the method **260** can include the network management server, at **260***b*, measuring a first group of metrics associated with the first group of communication devices associated with the first communication network. In addition, the method **260** can include the network management server, at **260***c*, computing a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, in which there is no bandwidth limit allocated to the second group of communication devices. Also, the method **260** can include the network management server, at **260***d*, determining a first allocation of a first group of network resources for the second group of communication devices according to the second group of metrics. The method **260** can include the network management server, at **260***e*, determining that the first allocation exceeds a first allocation threshold. Further, the method **260** can include the network management server, at **2600**, adjusting the bandwidth allocated for the first group of communication devices from no bandwidth limit to a second bandwidth limit. In addition, the method **260** can include the network management server, at **260***f*, measuring a third group of metrics associated with the first group of communication devices associated with the first communication network. Also, the method **260** can include the network management server, at **260***g*, computing a fourth group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the third group of metrics, in which the second bandwidth limit is allocated to each of the second group of communication devices. In some embodiments, the second bandwidth limit is greater than the first bandwidth limit. In further embodiments, the first group of metrics, the second group of metrics, the third group of metrics, and the fourth group of metrics include one of physical resource block (PRB) utilization, video content session durations, data volume, throughput, latency, or any combination thereof.

In one or more embodiments, the method **260** can include the network management server, **260***h*, providing first instructions to each of a first portion of the second group of communication devices that indicate to adjust a bandwidth limit on each of the first portion of the second group of communication devices to the second bandwidth limit. In additional embodiments, each of the first portion of the second group of communication devices can adjust its respective bandwidth to the second bandwidth limit accordingly. In further embodiments, the first portion of the second group of communication devices is associated with a geographic area. The first instructions further indicate to adjust the bandwidth limit on each of the first portion of the second group of communication devices to the second bandwidth limit for a time period. Further, the method **260** can include the network management server, **260***i*, allocating a second group of network resources for the second group of communication devices according to the fourth group of metrics. In addition, the method **260** can include the network management server, **260***j*, providing second instructions to install a third group of network resources in the second communication network according to the fourth group of metrics.

In one or more embodiments, the method **260** can include the network management server, **260***k*, identifying a group of subscription plans associated with a second portion of the second group of communication devices. Further, method **260** can include the network management server, **2601**, adjusting each of the group of subscription plans according to the fourth group of metrics. In addition, the method **260** can include the network management server, **260***m*, providing a notification to each of the second portion of the second group of communication devices. Also, method **260** can include the network management server, **260***n*, receiving user-generated input from each of the second portion of the second group of communication devices resulting in a group of user-generated input. Each of the second portion of the second group of communication devices provides the user-generated input in response to receiving the notification. Each of the group of user-generated input indicates a subscription plan, wherein the adjusting of each of the group of subscription plans comprises adjusting the group of subscription plans according to the group of user-generated input.

While for purposes of simplicity of explanation, the respective processes are shown and described as a series of blocks in FIGS. **2**M and **2**N, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the blocks, as some blocks may occur in different orders and/or concurrently with other blocks from what is depicted and described herein. Moreover, not all illustrated blocks may be required to implement the methods described herein. Further, one or more blocks can be performed in response to one or more other blocks.

In addition, portions of some embodiments can be combined with portions of other embodiments.

Referring now to FIG. **3**, a block diagram **300** is shown illustrating an example, non-limiting embodiment of a virtualized communication network in accordance with various aspects described herein. In particular a virtualized communication network is presented that can be used to implement some or all of the subsystems and functions of system **100**, the subsystems and functions of systems **200**, **205**, **210**, **215**, **220**, **225**, **230**, **235**, **240**, **245***a*-**1**, **245***a*-**2**, and **245***a*-**3**, and methods **250** and **260** presented in FIGS. **1**, **2**A-**2**N, and **3**. For example, virtualized communication network **300** can facilitate in whole or in part allocation of network resources when no bandwidth limits are placed on communication devices communicatively coupled to the network.

In particular, a cloud networking architecture is shown that leverages cloud technologies and supports rapid innovation and scalability via a transport layer **350**, a virtualized network function cloud **325** and/or one or more cloud computing environments **375**. In various embodiments, this cloud networking architecture is an open architecture that leverages application programming interfaces (APIs); reduces complexity from services and operations; supports more nimble business models; and rapidly and seamlessly scales to meet evolving customer requirements including traffic growth, diversity of traffic types, and diversity of performance and reliability expectations.

In contrast to traditional network elements-which are typically integrated to perform a single function, the virtualized communication network employs virtual network elements (VNEs) **330**, **332**, **334**, etc. that perform some or all of the functions of network elements **150**, **152**, **154**, **156**, etc. For example, the network architecture can provide a substrate of networking capability, often called Network Function Virtualization Infrastructure (NFVI) or simply infrastructure that is capable of being directed with software and Software Defined Networking (SDN) protocols to perform a broad variety of network functions and services. This infrastructure can include several types of substrates. The most typical type of substrate being servers that support Network Function Virtualization (NFV), followed by packet forwarding capabilities based on generic computing resources, with specialized network technologies brought to bear when general-purpose processors or general-purpose integrated circuit devices offered by merchants (referred to herein as merchant silicon) are not appropriate. In this case, communication services can be implemented as cloud-centric workloads.

As an example, a traditional network element **150** (shown in FIG. **1**), such as an edge router can be implemented via a VNE **330** composed of NFV software modules, merchant silicon, and associated controllers. The software can be written so that increasing workload consumes incremental resources from a common resource pool, and moreover so that it is elastic: so, the resources are only consumed when needed. In a similar fashion, other network elements such as other routers, switches, edge caches, and middle boxes are instantiated from the common resource pool. Such sharing of infrastructure across a broad set of uses makes planning and growing infrastructure easier to manage.

In an embodiment, the transport layer **350** includes fiber, cable, wired and/or wireless transport elements, network elements and interfaces to provide broadband access **110**, wireless access **120**, voice access **130**, media access **140** and/or access to content sources **175** for distribution of content to any or all of the access technologies. In particular, in some cases a network element needs to be positioned at a specific place, and this allows for less sharing of common infrastructure. Other times, the network elements have specific physical layer adapters that cannot be abstracted or virtualized and might require special DSP code and analog front ends (AFEs) that do not lend themselves to implementation as VNEs **330**, **332** or **334**. These network elements can be included in transport layer **350**.

The virtualized network function cloud **325** interfaces with the transport layer **350** to provide the VNEs **330**, **332**, **334**, etc. to provide specific NFVs. In particular, the virtualized network function cloud **325** leverages cloud operations, applications, and architectures to support networking workloads. The virtualized network elements **330**, **332** and **334** can employ network function software that provides either a one-for-one mapping of traditional network element function or alternately some combination of network functions designed for cloud computing. For example, VNEs **330**, **332** and **334** can include route reflectors, domain name system (DNS) servers, and dynamic host configuration protocol (DHCP) servers, system architecture evolution (SAE) and/or mobility management entity (MME) gateways, broadband network gateways, IP edge routers for IP-VPN, Ethernet and other services, load balancers, distributers and other network elements. Because these elements do not typically need to forward large amounts of traffic, their workload can be distributed across a number of servers—each of which adds a portion of the capability, and which creates an elastic function with higher availability overall than its former monolithic version. These virtual network elements **330**, **332**, **334**, etc. can be instantiated and managed using an orchestration approach similar to those used in cloud compute services.

The cloud computing environments **375** can interface with the virtualized network function cloud **325** via APIs that expose functional capabilities of the VNEs **330**, **332**, **334**, etc. to provide the flexible and expanded capabilities to the virtualized network function cloud **325**. In particular, network workloads may have applications distributed across the virtualized network function cloud **325** and cloud computing environment **375** and in the commercial cloud or might simply orchestrate workloads supported entirely in NFV infrastructure from these third-party locations.

Turning now to FIG. **4**, there is illustrated a block diagram of a computing environment in accordance with various aspects described herein. In order to provide additional context for various embodiments of the embodiments described herein, FIG. **4** and the following discussion are intended to provide a brief, general description of a suitable computing environment **400** in which the various embodiments of the subject disclosure can be implemented. In particular, computing environment **400** can be used in the implementation of network elements **150**, **152**, **154**, **156**, access terminal **112**, base station or access point **122**, switching device **132**, media terminal **142**, and/or VNEs **330**, **332**, **334**, etc. Each of these devices can be implemented via computer-executable instructions that can run on one or more computers, and/or in combination with other program modules and/or as a combination of hardware and software. For example, computing environment **400** can facilitate in whole or in part allocation of network resources when no bandwidth limits are placed on communication devices communicatively coupled to the network. Further, each of network management server **200***a*, video content server **200***n*, video content server **2000**, communication device **200***d*, communication device **200***e*, communication device **200***f*, communication device **200***g*, communication device **200***h*, communication device **200***i*, communication device **200***i*, communication device **200***j*, communication device **200***k*, communication device **200***l*, communication device **200***m*, base station **200***c*, base station **200***p*, mmW node **200***q*, mmW node **200***r*, communication device **210***d*, communication device **210***e*, communication device **210***f*, communication device **210***g*, communication device **210***h*, communication device **210***i*, communication device **210***i*, communication device **210***j*, communication device **210***k*, communication device **210***l*, communication device **210***m*, base station **210***c*, base station **210***p*, mmW node **210***q*, base station **210***r*, communication device **210***e***-1**, communication device **210***e***-2**, mmW node **215***r*, base station **225***r*, and mmW node **230***r* can comprise the computing environment **400**.

Generally, program modules comprise routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the methods can be practiced with other computer system configurations, comprising single-processor or multiprocessor computer systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

As used herein, a processing circuit includes one or more processors as well as other application specific circuits such as an application specific integrated circuit, digital logic circuit, state machine, programmable gate array or other circuit that processes input signals or data and that produces output signals or data in response thereto. It should be noted that while any functions and features described herein in association with the operation of a processor could likewise be performed by a processing circuit.

The illustrated embodiments of the embodiments herein can be also practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

Computing devices typically comprise a variety of media, which can comprise computer-readable storage media and/or communications media, which two terms are used herein differently from one another as follows. Computer-readable storage media can be any available storage media that can be accessed by the computer and comprises both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable instructions, program modules, structured data or unstructured data.

Computer-readable storage media can comprise, but are not limited to, random access memory (RAM), read only memory (ROM), electrically erasable programmable read only memory (EEPROM), flash memory or other memory technology, compact disk read only memory (CD-ROM), digital versatile disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices or other tangible and/or non-transitory media which can be used to store desired information. In this regard, the terms "tangible" or "non-transitory" herein as applied to storage, memory or computer-readable media, are to be understood to exclude only propagating transitory signals per se as modifiers and do not relinquish rights to all standard storage, memory or computer-readable media that are not only propagating transitory signals per se.

Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

Communications media typically embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and comprises any information delivery or transport media. The term "modulated data signal" or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communication media comprise wired media, such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media.

With reference again to FIG. **4**, the example environment can comprise a computer **402**, the computer **402** comprising a processing unit **404**, a system memory **406** and a system bus **408**. The system bus **408** couples system components including, but not limited to, the system memory **406** to the processing unit **404**. The processing unit **404** can be any of various commercially available processors. Dual microprocessors and other multiprocessor architectures can also be employed as the processing unit **404**.

The system bus **408** can be any of several types of bus structure that can further interconnect to a memory bus (with or without a memory controller), a peripheral bus, and a local bus using any of a variety of commercially available bus architectures. The system memory **406** comprises ROM **410** and RAM **412**. A basic input/output system (BIOS) can be stored in a non-volatile memory such as ROM, erasable programmable read only memory (EPROM), EEPROM, which BIOS contains the basic routines that help to transfer information between elements within the computer **402**, such as during startup. The RAM **412** can also comprise a high-speed RAM such as static RAM for caching data.

The computer **402** further comprises an internal hard disk drive (HDD) **414** (e.g., EIDE, SATA), which internal HDD **414** can also be configured for external use in a suitable chassis (not shown), a magnetic floppy disk drive (FDD) **416**, (e.g., to read from or write to a removable diskette **418**) and an optical disk drive **420**, (e.g., reading a CD-ROM disk **422** or, to read from or write to other high-capacity optical media such as the DVD). The HDD **414**, magnetic FDD **416** and optical disk drive **420** can be connected to the system bus **408** by a hard disk drive interface **424**, a magnetic disk drive interface **426** and an optical drive interface **428**, respectively. The hard disk drive interface **424** for external drive implementations comprises at least one or both of Universal Serial Bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) **1394** interface technologies. Other external drive connection technologies are within contemplation of the embodiments described herein.

The drives and their associated computer-readable storage media provide nonvolatile storage of data, data structures, computer-executable instructions, and so forth. For the computer **402**, the drives and storage media accommodate the storage of any data in a suitable digital format. Although the description of computer-readable storage media above refers to a hard disk drive (HDD), a removable magnetic diskette, and a removable optical media such as a CD or DVD, it should be appreciated by those skilled in the art that other types of storage media which are readable by a computer, such as zip drives, magnetic cassettes, flash memory cards, cartridges, and the like, can also be used in the example operating environment, and further, that any such storage media can contain computer-executable instructions for performing the methods described herein.

A number of program modules can be stored in the drives and RAM **412**, comprising an operating system **430**, one or more application programs **432**, other program modules **434** and program data **436**. All or portions of the operating system, applications, modules, and/or data can also be cached in the RAM **412**. The systems and methods described herein can be implemented utilizing various commercially available operating systems or combinations of operating systems.

A user can enter commands and information into the computer **402** through one or more wired/wireless input devices, e.g., a keyboard **438** and a pointing device, such as a mouse **440**. Other input devices (not shown) can comprise a microphone, an infrared (IR) remote control, a joystick, a game pad, a stylus pen, touch screen or the like. These and other input devices are often connected to the processing unit **404** through an input device interface **442** that can be coupled to the system bus **408**, but can be connected by other interfaces, such as a parallel port, an IEEE **1394** serial port, a game port, a universal serial bus (USB) port, an IR interface, etc.

A monitor **444** or other type of display device can be also connected to the system bus **408** via an interface, such as a video adapter **446**. It will also be appreciated that in alternative embodiments, a monitor **444** can also be any display device (e.g., another computer having a display, a smart phone, a tablet computer, etc.) for receiving display information associated with computer **402** via any communication means, including via the Internet and cloud-based networks. In addition to the monitor **444**, a computer typically comprises other peripheral output devices (not shown), such as speakers, printers, etc.

The computer **402** can operate in a networked environment using logical connections via wired and/or wireless communications to one or more remote computers, such as a remote computer(s) **448**. The remote computer(s) **448** can be a workstation, a server computer, a router, a personal computer, portable computer, microprocessor-based entertainment appliance, a peer device or other common network node, and typically comprises many or all of the elements described relative to the computer **402**, although, for purposes of brevity, only a remote memory/storage device **450** is illustrated. The logical connections depicted comprise wired/wireless connectivity to a local area network (LAN) **452** and/or larger networks, e.g., a wide area network (WAN) **454**. Such LAN and WAN networking environments are commonplace in offices and companies, and facilitate enterprise-wide computer networks, such as intranets, all of which can connect to a global communications network, e.g., the Internet.

When used in a LAN networking environment, the computer **402** can be connected to the LAN **452** through a wired and/or wireless communication network interface or adapter **456**. The adapter **456** can facilitate wired or wireless communication to the LAN **452**, which can also comprise a wireless AP disposed thereon for communicating with the adapter **456**.

When used in a WAN networking environment, the computer **402** can comprise a modem **458** or can be connected to a communications server on the WAN **454** or has other means for establishing communications over the WAN **454**, such as by way of the Internet. The modem **458**, which can be internal or external and a wired or wireless device, can be connected to the system bus **408** via the input device interface **442**. In a networked environment, program modules depicted relative to the computer **402** or portions thereof, can be stored in the remote memory/storage device **450**. It will be appreciated that the network connections shown are example and other means of establishing a communications link between the computers can be used.

The computer **402** can be operable to communicate with any wireless devices or entities operatively disposed in wireless communication, e.g., a printer, scanner, desktop and/or portable computer, portable data assistant, communications satellite, any piece of equipment or location associated with a wirelessly detectable tag (e.g., a kiosk, news stand, restroom), and telephone. This can comprise Wireless Fidelity (Wi-Fi) and BLUETOOTH® wireless technologies. Thus, the communication can be a predefined structure as with a conventional network or simply an ad hoc communication between at least two devices.

Wi-Fi can allow connection to the Internet from a couch at home, a bed in a hotel room or a conference room at work, without wires. Wi-Fi is a wireless technology similar to that used in a cell phone that enables such devices, e.g., computers, to send and receive data indoors and out; anywhere within the range of a base station. Wi-Fi networks use radio technologies called IEEE 802.11 (a, b, g, n, ac, ag, etc.) to provide secure, reliable, fast wireless connectivity. A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wired networks (which can use IEEE 802.3 or Ethernet). Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands for example or with products that contain both bands (dual band), so the networks can provide real-world performance similar to the basic 10BaseT wired Ethernet networks used in many offices.

Turning now to FIG. **5**, an embodiment **500** of a mobile network platform **510** is shown that is an example of network elements **150**, **152**, **154**, **156**, and/or VNEs **330**, **332**, **334**, etc. For example, platform **510** can facilitate in whole or in part allocation of network resources when no bandwidth limits are placed on communication devices communicatively coupled to the network. In one or more embodiments, the mobile network platform **510** can generate and receive signals transmitted and received by base stations or access points such as base station or access point **122**. Generally, mobile network platform **510** can comprise components, e.g., nodes, gateways, interfaces, servers, or disparate platforms, that facilitate both packet-switched (PS) (e.g., internet protocol (IP), frame relay, asynchronous transfer mode (ATM)) and circuit-switched (CS) traffic (e.g., voice and data), as well as control generation for networked wireless telecommunication. As a non-limiting example, mobile network platform **510** can be included in telecommunications carrier networks and can be considered carrier-side components as discussed elsewhere herein. Mobile network platform **510** comprises CS gateway node(s) **512** which can interface CS traffic received from legacy networks like telephony network(s) **540** (e.g., public switched telephone network (PSTN), or public land mobile network (PLMN)) or a signaling system #**7** (SS7) network **560**. CS gateway node(s) **512** can authorize and authenticate traffic (e.g., voice) arising from such networks. Additionally, CS gateway node(s) **512** can access mobility, or roaming, data generated through SS7 network **560**; for instance, mobility data stored in a visited location register (VLR), which can reside in memory **530**. Moreover, CS gateway node(s) **512** interfaces CS-based traffic and signaling and PS gateway node(s) **518**. As an example, in a 3GPP UMTS network, CS gateway node(s) **512** can be realized at least in part in gateway GPRS support node(s) (GGSN). It should be appreciated that functionality and specific operation of CS gateway node(s) **512**, PS gateway node(s) **518**, and serving node(s) **516**, is provided and dictated by radio technology (ies) utilized by mobile network platform **510** for telecommunication over a radio access network **520** with other devices, such as a radiotelephone **575**.

In addition to receiving and processing CS-switched traffic and signaling, PS gateway node(s) **518** can authorize and authenticate PS-based data sessions with served mobile devices. Data sessions can comprise traffic, or content(s), exchanged with networks external to the mobile network platform **510**, like wide area network(s) (WANs) **550**, enterprise network(s) **570**, and service network(s) **580**, which can be embodied in local area network(s) (LANs), can also be interfaced with mobile network platform **510** through PS gateway node(s) **518**. It is to be noted that WANs **550** and enterprise network(s) **570** can embody, at least in part, a service network(s) like IP multimedia subsystem (IMS). Based on radio technology layer(s) available in technology resource(s) or radio access network **520**, PS gateway node(s) **518** can generate packet data protocol contexts when a data session is established; other data structures that facilitate routing of packetized data also can be generated. To that end, in an aspect, PS gateway node(s) **518** can comprise a tunnel interface (e.g., tunnel termination gateway (TTG) in 3GPP UMTS network(s) (not shown)) which can facilitate packetized communication with disparate wireless network(s), such as Wi-Fi networks.

In embodiment **500**, mobile network platform **510** also comprises serving node(s) **516** that, based upon available radio technology layer(s) within technology resource(s) in the radio access network **520**, convey the various packetized flows of data streams received through PS gateway node(s) **518**. It is to be noted that for technology resource(s) that rely primarily on CS communication, server node(s) can deliver traffic without reliance on PS gateway node(s) **518**; for example, server node(s) can embody at least in part a mobile switching center. As an example, in a 3GPP UMTS network, serving node(s) **516** can be embodied in serving GPRS support node(s) (SGSN).

For radio technologies that exploit packetized communication, server(s) **514** in mobile network platform **510** can execute numerous applications that can generate multiple disparate packetized data streams or flows, and manage (e.g., schedule, queue, format . . .) such flows. Such application(s) can comprise add-on features to standard services (for example, provisioning, billing, customer support . . .) provided by mobile network platform **510**. Data streams (e.g., content(s) that are part of a voice call or data session) can be conveyed to PS gateway node(s) **518** for authorization/authentication and initiation of a data session, and to serving node(s) **516** for communication thereafter. In addition to application server, server(s) **514** can comprise utility server(s), a utility server can comprise a provisioning server, an operations and maintenance server, a security server that can implement at least in part a certificate authority and firewalls as well as other security mechanisms, and the like. In an aspect, security server(s) secure communication served through mobile network platform **510** to ensure network's operation and data integrity in addition to authorization and authentication procedures that CS gateway node(s) **512** and PS gateway node(s) **518** can enact. Moreover, provisioning server(s) can provision services from external network(s) like networks operated by a disparate service provider; for instance, WAN **550** or Global Positioning System (GPS) network(s) (not shown). Provisioning server(s) can also provision coverage through networks associated to mobile network platform **510** (e.g., deployed and operated by the same service provider), such as the distributed antennas networks shown in FIG. **1** (*s*) that enhance wireless service coverage by providing more network coverage.

It is to be noted that server(s) **514** can comprise one or more processors configured to confer at least in part the functionality of mobile network platform **510**. To that end, the one or more processors can execute code instructions stored in memory **530**, for example. It should be appreciated that server(s) **514** can comprise a content manager, which operates in substantially the same manner as described hereinbefore.

In example embodiment **500**, memory **530** can store information related to operation of mobile network platform **510**. Other operational information can comprise provisioning information of mobile devices served through mobile network platform **510**, subscriber databases; application intelligence, pricing schemes, e.g., promotional rates, flat-rate programs, couponing campaigns; technical specification(s) consistent with telecommunication protocols for operation of disparate radio, or wireless, technology layers; and so forth. Memory **530** can also store information from at least one of telephony network(s) **540**, WAN **550**, SS7 network **560**, or enterprise network(s) **570**. In an aspect, memory **530** can be, for example, accessed as part of a data store component or as a remotely connected memory store.

In order to provide a context for the various aspects of the disclosed subject matter, FIG. **5**, and the following discussion, are intended to provide a brief, general description of a suitable environment in which the various aspects of the disclosed subject matter can be implemented. While the subject matter has been described above in the general context of computer-executable instructions of a computer program that runs on a computer and/or computers, those skilled in the art will recognize that the disclosed subject matter also can be implemented in combination with other program modules. Generally, program modules comprise routines, programs, components, data structures, etc. that perform particular tasks and/or implement particular abstract data types.

Turning now to FIG. **6**, an illustrative embodiment of a communication device **600** is shown. The communication device **600** can serve as an illustrative embodiment of devices such as data terminals **114**, mobile devices **124**, vehicle **126**, display devices **144** or other client devices for communication via either communications network **125**. For example, communication device **600** can facilitate in whole or in part allocation of network resources when no bandwidth limits are placed on communication devices communicatively coupled to the network. Further, each of network management server **200***a*, video content server **200***n*, video content server **2000**, communication device **200***d*, communication device **200***e*, communication device **200***f*, communication device **200***g*, communication device **200***h*, communication device **200***i*, communication device **200***i*, communication device **200***j*, communication device **200***k*, communication device **200***l*, communication device **200***m*, base station **200***c*, base station **200***p*, mmW node **200***q*, mmW node **200***r*, communication device **210***d*, communication device **210***e*, communication device **210***f*, communication device **210***g*, communication device **210***h*, communication device **210***i*, communication device **210***i*, communication device **210***j*, communication device **210***k*, communication device **210***l*, communication device **210***m*, base station **210***c*, base station **210***p*, mmW node **210***q*, base station **210***r*, communication device **210***e*-**1**, communication device **210***e*-**2**, mmW node **215***r*, base station **225***r*, and mmW node **230***r* can comprise the communication device **600**.

The communication device **600** can comprise a wireline and/or wireless transceiver **602** (herein transceiver **602**), a user interface (UI) **604**, a power supply **614**, a location receiver **616**, a motion sensor **618**, an orientation sensor **620**, and a controller **606** for managing operations thereof. The transceiver **602** can support short-range or long-range wireless access technologies such as Bluetooth®, ZigBee®, Wi-Fi, DECT, or cellular communication technologies, just to mention a few (Bluetooth® and ZigBee® are trademarks registered by the Bluetooth® Special Interest Group and the ZigBee® Alliance, respectively). Cellular technologies can include, for example, CDMA-1X, UMTS/HSDPA, GSM/GPRS, TDMA/EDGE, EV/DO, WiMAX, SDR, LTE, as well as other next generation wireless communication technologies as they arise. The transceiver **602** can also be adapted to support circuit-switched wireline access technologies (such as PSTN), packet-switched wireline access technologies (such as TCP/IP, VoIP, etc.), and combinations thereof.

The UI **604** can include a depressible or touch-sensitive keypad **608** with a navigation mechanism such as a roller ball, a joystick, a mouse, or a navigation disk for manipulating operations of the communication device **600**. The keypad **608** can be an integral part of a housing assembly of the communication device **600** or an independent device operably coupled thereto by a tethered wireline interface (such as a USB cable) or a wireless interface supporting for example Bluetooth®. The keypad **608** can represent a numeric keypad commonly used by phones, and/or a QWERTY keypad with alphanumeric keys. The UI **604** can further include a display **610** such as monochrome or color LCD (Liquid Crystal Display), OLED (Organic Light Emitting Diode) or other suitable display technology for conveying images to an end user of the communication device **600**. In an embodiment where the display **610** is touch-sensitive, a portion or all of the keypad **608** can be presented by way of the display **610** with navigation features.

The display **610** can use touch screen technology to also serve as a user interface for detecting user input. As a touch screen display, the communication device **600** can be adapted to present a user interface having graphical user interface (GUI) elements that can be selected by a user with a touch of a finger. The display **610** can be equipped with capacitive, resistive or other forms of sensing technology to detect how much surface area of a user's finger has been placed on a portion of the touch screen display. This sensing information can be used to control the manipulation of the GUI elements or other functions of the user interface. The display **610** can be an integral part of the housing assembly of the communication device **600** or an independent device communicatively coupled thereto by a tethered wireline interface (such as a cable) or a wireless interface.

The UI **604** can also include an audio system **612** that utilizes audio technology for conveying low volume audio (such as audio heard in proximity of a human ear) and high-volume audio (such as speakerphone for hands free operation). The audio system **612** can further include a microphone for receiving audible signals of an end user. The audio system **612** can also be used for voice recognition applications. The UI **604** can further include an image sensor **613** such as a charged coupled device (CCD) camera for capturing still or moving images.

The power supply **614** can utilize common power management technologies such as replaceable and rechargeable batteries, supply regulation technologies, and/or charging system technologies for supplying energy to the components of the communication device **600** to facilitate long-range or short-range portable communications. Alternatively, or in combination, the charging system can utilize external power sources such as DC power supplied over a physical interface such as a USB port or other suitable tethering technologies.

The location receiver **616** can utilize location technology such as a global positioning system (GPS) receiver capable of assisted GPS for identifying a location of the communication device **600** based on signals generated by a constellation of GPS satellites, which can be used for facilitating location services such as navigation. The motion sensor **618** can utilize motion sensing technology such as an accelerometer, a gyroscope, or other suitable motion sensing technology to detect motion of the communication device **600** in three-dimensional space. The orientation sensor **620** can utilize orientation sensing technology such as a magnetometer to detect the orientation of the communication device **600** (north, south, west, and east, as well as combined orientations in degrees, minutes, or other suitable orientation metrics).

The communication device **600** can use the transceiver **602** to also determine a proximity to a cellular, Wi-Fi, Bluetooth®, or other wireless access points by sensing techniques such as utilizing a received signal strength indicator (RSSI) and/or signal time of arrival (TOA) or time of flight (TOF) measurements. The controller **606** can utilize computing technologies such as a microprocessor, a digital signal processor (DSP), programmable gate arrays, application specific integrated circuits, and/or a video processor with associated storage memory such as Flash, ROM, RAM, SRAM, DRAM or other storage technologies for executing computer instructions, controlling, and processing data supplied by the aforementioned components of the communication device **600**.

Other components not shown in FIG. **6** can be used in one or more embodiments of the subject disclosure. For instance, the communication device **600** can include a slot for adding or removing an identity module such as a Subscriber Identity Module (SIM) card or Universal Integrated Circuit Card (UICC). SIM or UICC cards can be used for identifying subscriber services, executing programs, storing subscriber data, and so on.

The terms "first," "second," "third," and so forth, as used in the claims, unless otherwise clear by context, is for clarity only and does not otherwise indicate or imply any order in time. For instance, "a first determination," "a second determination," and "a third determination," does not indicate or imply that the first determination is to be made before the second determination, or vice versa, etc.

In the subject specification, terms such as "store," "storage," "data store," data storage," "database," and substantially any other information storage component relevant to operation and functionality of a component, refer to "memory components," or entities embodied in a "memory" or components comprising the memory. It will be appreciated that the memory components described herein can be either volatile memory or nonvolatile memory, or can comprise both volatile and nonvolatile memory, by way of illustration, and not limitation, volatile memory, non-volatile memory, disk storage, and memory storage. Further, nonvolatile memory can be included in read only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable ROM (EEPROM), or flash memory. Volatile memory can comprise random access memory (RAM), which acts as external cache memory. By way of illustration and not limitation, RAM is available in many forms such as synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM). Additionally, the disclosed memory components of systems or methods herein are intended to comprise, without being limited to comprising, these and any other suitable types of memory.

Moreover, it will be noted that the disclosed subject matter can be practiced with other computer system configurations, comprising single-processor or multiprocessor computer systems, mini-computing devices, mainframe computers, as well as personal computers, hand-held computing devices (e.g., PDA, phone, smartphone, watch, tablet computers, netbook computers, etc.), microprocessor-based or programmable consumer or industrial electronics, and the like. The illustrated aspects can also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network; however, some if not all aspects of the subject disclosure can be practiced on stand-alone computers. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

In one or more embodiments, information regarding use of services can be generated including services being accessed, media consumption history, user preferences, and so forth. This information can be obtained by various methods including user input, detecting types of communications (e.g., video content vs. audio content), analysis of content streams, sampling, and so forth. The generating, obtaining and/or monitoring of this information can be responsive to an authorization provided by the user. In one or more embodiments, an analysis of data can be subject to authorization from user(s) associated with the data, such as an opt-in, an opt-out, acknowledgement requirements, notifications, selective authorization based on types of data, and so forth.

Some of the embodiments described herein can also employ artificial intelligence (AI) to facilitate automating one or more features described herein. The embodiments (e.g., in connection with automatically identifying acquired cell sites that provide a maximum value/benefit after addition to an existing communication network) can employ various AI-based schemes for carrying out various embodiments thereof. Moreover, the classifier can be employed to determine a ranking or priority of each cell site of the acquired network. A classifier is a function that maps an input attribute vector, $x=(x_1, x_2, x_3, x_4 \ldots x_n)$, to a confidence that the input belongs to a class, that is, $f(x)=\text{confidence (class)}$. Such classification can employ a probabilistic and/or statistical-based analysis (e.g., factoring into the analysis utilities and costs) to determine or infer an action that a user desires to be automatically performed. A support vector machine (SVM) is an example of a classifier that can be employed. The SVM operates by finding a hypersurface in the space of possible inputs, which the hypersurface attempts to split the triggering criteria from the non-triggering events. Intuitively, this makes the classification correct for testing data that is near, but not identical to training data. Other directed and undirected model classification approaches comprise, e.g., naïve Bayes, Bayesian networks, decision trees, neural networks, fuzzy logic models, and probabilistic classification models providing different patterns of independence can be employed. Classification as used herein also is inclusive of statistical regression that is utilized to develop models of priority.

As will be readily appreciated, one or more of the embodiments can employ classifiers that are explicitly trained (e.g., via a generic training data) as well as implicitly trained (e.g., via observing UE behavior, operator preferences, historical information, receiving extrinsic information). For example, SVMs can be configured via a learning or training phase within a classifier constructor and feature selection module. Thus, the classifier(s) can be used to automatically learn and perform a number of functions, including but not limited to determining according to predetermined criteria which of the acquired cell sites will benefit a maximum number of subscribers and/or which of the acquired cell sites will add minimum value to the existing communication network coverage, etc.

As used in some contexts in this application, in some embodiments, the terms "component," "system" and the like are intended to refer to, or comprise, a computer-related entity or an entity related to an operational apparatus with one or more specific functionalities, wherein the entity can be either hardware, a combination of hardware and software, software, or software in execution. As an example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, computer-executable instructions, a program, and/or a computer. By way of illustration and not limitation, both an application running on a server and the server can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers. In addition, these components can execute from various computer readable media having various data structures stored thereon. The components may communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems via the signal). As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry, which is operated by a software or firmware application executed by a processor, wherein the processor can be internal or external to the apparatus and executes at least a part of the software or firmware application. As yet another example, a component can be an apparatus that provides specific functionality through electronic components without mechanical parts, the electronic components can comprise a processor therein to execute software or firmware that confers at least in part the functionality of the electronic components. While various components have been illustrated as separate components, it will be appreciated that multiple components can be implemented as a single component, or a single component can be implemented as multiple components, without departing from example embodiments.

Further, the various embodiments can be implemented as a method, apparatus or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware or any combination thereof to control a computer to implement the disclosed subject matter. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device or computer-readable storage/communications media. For example, computer readable storage media can include, but are not limited to, magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips), optical disks (e.g., compact disk (CD), digital versatile disk (DVD)), smart cards, and flash memory devices (e.g., card, stick, key drive). Of course, those skilled in the art will recognize many modifications can be made to this configuration without departing from the scope or spirit of the various embodiments.

In addition, the words "example" and "exemplary" are used herein to mean serving as an instance or illustration. Any embodiment or design described herein as "example" or "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments or designs. Rather, use of the word example or exemplary is intended to present concepts in a concrete fashion. As used in this application, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or". That is, unless specified otherwise or clear from context, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then "X employs A or B" is satisfied under any of the foregoing instances. In addition, the articles "a" and "an" as used in this application and the appended claims should generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form.

Moreover, terms such as "user equipment," "mobile station," "mobile," subscriber station," "access terminal," "terminal," "handset," "mobile device" (and/or terms representing similar terminology) can refer to a wireless device utilized by a subscriber or user of a wireless communication service to receive or convey data, control, voice, video, sound, gaming or substantially any data-stream or signaling-stream. The foregoing terms are utilized interchangeably herein and with reference to the related drawings.

Furthermore, the terms "user," "subscriber," "customer," "consumer" and the like are employed interchangeably throughout, unless context warrants particular distinctions among the terms. It should be appreciated that such terms can refer to human entities or automated components supported through artificial intelligence (e.g., a capacity to make inference based, at least, on complex mathematical formalisms), which can provide simulated vision, sound recognition and so forth.

As employed herein, the term "processor" can refer to substantially any computing processing unit or device comprising, but not limited to comprising, single-core processors; single-processors with software multithread execution capability; multi-core processors; multi-core processors with software multithread execution capability; multi-core processors with hardware multithread technology; parallel platforms; and parallel platforms with distributed shared memory. Additionally, a processor can refer to an integrated circuit, an application specific integrated circuit (ASIC), a digital signal processor (DSP), a field programmable gate array (FPGA), a programmable logic controller (PLC), a complex programmable logic device (CPLD), a discrete gate or transistor logic, discrete hardware components or any combination thereof designed to perform the functions described herein. Processors can exploit nano-scale architectures such as, but not limited to, molecular and quantum-dot based transistors, switches and gates, in order to optimize space usage or enhance performance of user equipment. A processor can also be implemented as a combination of computing processing units.

As used herein, terms such as "data storage," data storage," "database," and substantially any other information storage component relevant to operation and functionality of a component, refer to "memory components," or entities embodied in a "memory" or components comprising the memory. It will be appreciated that the memory components or computer-readable storage media, described herein can be either volatile memory or nonvolatile memory or can include both volatile and nonvolatile memory.

What has been described above includes mere examples of various embodiments. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing these examples, but one of ordinary skill in the art can recognize that many further combinations and permutations of the present embodiments are possible. Accordingly, the embodiments disclosed and/or claimed herein are intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

In addition, a flow diagram may include a "start" and/or "continue" indication. The "start" and "continue" indications reflect that the steps presented can optionally be incorporated in or otherwise used in conjunction with other routines. In this context, "start" indicates the beginning of the first step presented and may be preceded by other activities not specifically shown. Further, the "continue" indication reflects that the steps presented may be performed multiple times and/or may be succeeded by other activities not specifically shown. Further, while a flow diagram indicates a particular ordering of steps, other orderings are likewise possible provided that the principles of causality are maintained.

As may also be used herein, the term(s) "operably coupled to", "coupled to", and/or "coupling" includes direct coupling between items and/or indirect coupling between items via one or more intervening items. Such items and intervening items include, but are not limited to, junctions, communication paths, components, circuit elements, circuits, functional blocks, and/or devices. As an example of indirect coupling, a signal conveyed from a first item to a second item may be modified by one or more intervening items by modifying the form, nature or format of information in a signal, while one or more elements of the information in the signal are nevertheless conveyed in a manner than can be recognized by the second item. In a further example of indirect coupling, an action in a first item can cause a reaction on the second item, as a result of actions and/or reactions in one or more intervening items.

Although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement which achieves the same or similar purpose may be substituted for the embodiments described or shown by the subject disclosure. The subject disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, can be used in the subject disclosure. For instance, one or more features from one or more embodiments can be combined with one or more features of one or more other embodiments. In one or more embodiments, features that are positively recited can also be negatively recited and excluded from the embodiment with or without replacement by another structural and/or functional feature. The steps or functions described with respect to the embodiments of the subject disclosure can be performed in any order. The steps or functions described with respect to the embodiments of the subject disclosure can be performed alone or in combination with other steps or functions of the subject disclosure, as well as from other embodiments or from other steps that have not been described in the subject disclosure. Further, more than or less than all of the features described with respect to an embodiment can also be utilized.

What is claimed is:

1. A device, comprising:

a processing system including a processor; and

a memory that stores executable instructions that, when executed by the processing system, facilitate performance of operations, the operations comprising:

adjusting bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limited allocation to a no bandwidth limited allocation;

measuring a first group of metrics associated with the first group of communication devices associated with the first communication network;

computing a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, wherein the second group of communication devices have the no bandwidth limited allocation; and

allocating a first group of network resources for the second group of communication devices according to the second group of metrics.

2. The device of claim **1**, wherein the first group of metrics and the second group of metrics include one of physical resource block (PRB) utilization, video content session durations, data volume, throughput, latency, or any combination thereof.

3. The device of claim **1**, wherein the operations comprise providing first instructions to install a second group of network resources in the second communication network according to the second group of metrics.

4. The device of claim **1**, wherein the operations comprise:

identifying a group of subscription plans associated with a first portion of the second group of communication devices; and

adjusting each of the group of subscription plans according to the second group of metrics.

5. The device of claim **4**, wherein the operations comprise:

providing a notification to each of the first portion of the second group of communication devices; and

receiving user-generated input from each of the first portion of the second group of communication devices resulting in a group of user-generated input, wherein each of the first portion of the second group of communication devices provides the user-generated input in response to receiving the notification, wherein each of the group of user-generated input indicates a subscription plan, wherein the adjusting of each of the group of subscription plans comprises adjusting the group of subscription plans according to the group of user-generated input.

6. The device of claim **1**, wherein the operations comprise providing second instructions to each of a second portion of the second group of communication devices that indicate to adjust each of the second portion of the second group of communication devices.

7. The device of claim **6**, wherein the second group of metrics comprises video content session durations, wherein the second instructions indicate a limit associated with a video content session duration for each of the second group of communication devices, wherein each of the second group of communication devices is adjusted according to the limit associated with the video content session duration.

8. The device of claim **1**, wherein the operations comprise:

determining a video content service provider is associated with a portion of the second group of metrics; and

providing third instructions to a video content server associated with the video content service provider that indicates adjusting a video content service delivered to a third portion of the second group of communication devices, wherein the video content server adjusts delivery of the video content service according to the third instructions.

9. A non-transitory machine-readable medium, comprising executable instructions that, when executed by a processing system including a processor, facilitate performance of operations, the operations comprising:

adjusting bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limited allocation to a no bandwidth limited allocation;

measuring a first group of metrics associated with the first group of communication devices associated with the first communication network;

computing a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, wherein the second group of communication devices have the no bandwidth limited allocation; and

providing first instructions to install a first group of network resources in the second communication network according to the second group of metrics.

10. The non-transitory machine-readable medium of claim **9**, wherein the first group of metrics and the second group of metrics include one of physical resource block (PRB) utilization, video content session durations, data volume, throughput, latency, or any combination thereof.

11. The non-transitory machine-readable medium of claim **9**, wherein the operations comprise allocating a second group of network resources for the second group of communication devices according to the second group of metrics.

12. The non-transitory machine-readable medium of claim **9**, wherein the operations comprise:

identifying a group of subscription plans associated with a first portion of the second group of communication devices; and

adjusting each of the group of subscription plans according to the second group of metrics.

13. The non-transitory machine-readable medium of claim **12**, wherein the operations comprise:

providing a notification to each of the first portion of the second group of communication devices; and

receiving user-generated input from each of the first portion of the second group of communication devices resulting in a group of user-generated input, wherein each of the first portion of the second group of communication devices provides the user-generated input in response to receiving the notification, wherein each of the group of user-generated input indicates a subscription plan, wherein the adjusting of each of the group of subscription plans comprises adjusting the group of subscription plans according to the group of user-generated input.

14. The non-transitory machine-readable medium of claim **9**, wherein the operations comprise providing second instructions to each of a second portion of the second group of communication devices that indicate to adjust each of the second portion of the second group of communication devices.

15. The non-transitory machine-readable medium of claim **14**, wherein the second group of metrics comprises video content session durations, wherein the second instructions indicate a limit associated with a video content session duration for each of the second group of communication devices, wherein each of the second group of communication devices is adjusted according to the limit associated with the video content session duration.

16. The non-transitory machine-readable medium of claim **9**, wherein the operations comprise:

determining a video content service provider is associated with a portion of the second group of metrics; and

providing third instructions to a video content server associated with the video content service provider that indicates adjusting a video content service delivered to a third portion of the second group of communication devices, wherein the video content server adjusts delivery of the video content service according to the third instructions.

17. A method, comprising:

adjusting, by a processing system including a processor, bandwidth allocated for a first group of communication devices communicatively coupled to a first communication network from a bandwidth limited allocation to a no bandwidth limited allocation;

measuring, by the processing system, a first group of metrics associated with the first group of communication devices associated with the first communication network;

computing, by the processing system, a second group of metrics associated with a second group of communication devices communicatively coupled to a second communication network according to the first group of metrics, wherein the second group of communication devices have no bandwidth limited allocation;

identifying, by the processing system, a group of subscription plans associated with a first portion of the second group of communication devices; and

adjusting, by the processing system, each of the group of subscription plans according to the second group of metrics.

18. The method of claim **17**, wherein the first group of metrics and the second group of metrics include one of physical resource block (PRB) utilization, video content session durations, data volume, throughput, latency, or any combination thereof.

19. The method of claim **17**, comprising providing, by the processing system, first instructions to install a first group of network resources in the second communication network according to the second group of metrics.

20. The method of claim **17**, comprising:

providing, by the processing system, a notification to each of the first portion of the second group of communication devices; and

receiving, by the processing system, user-generated input from each of the first portion of the second group of communication devices resulting in a group of user-generated input, wherein each of the first portion of the second group of communication devices provides the user-generated input in response to receiving the notification, wherein each of the group of user-generated input indicates a subscription plan, wherein the adjusting of each of the group of subscription plans comprises adjusting, by the processing system, the group of subscription plans according to the group of user-generated input.

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