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(54) **ADJUSTING BANDWIDTH UTILIZATION OF WIRELESS NETWORK BASED ON POTENTIAL ISSUES BEING PREDICTED**

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H04W 28/22	(2006.01)

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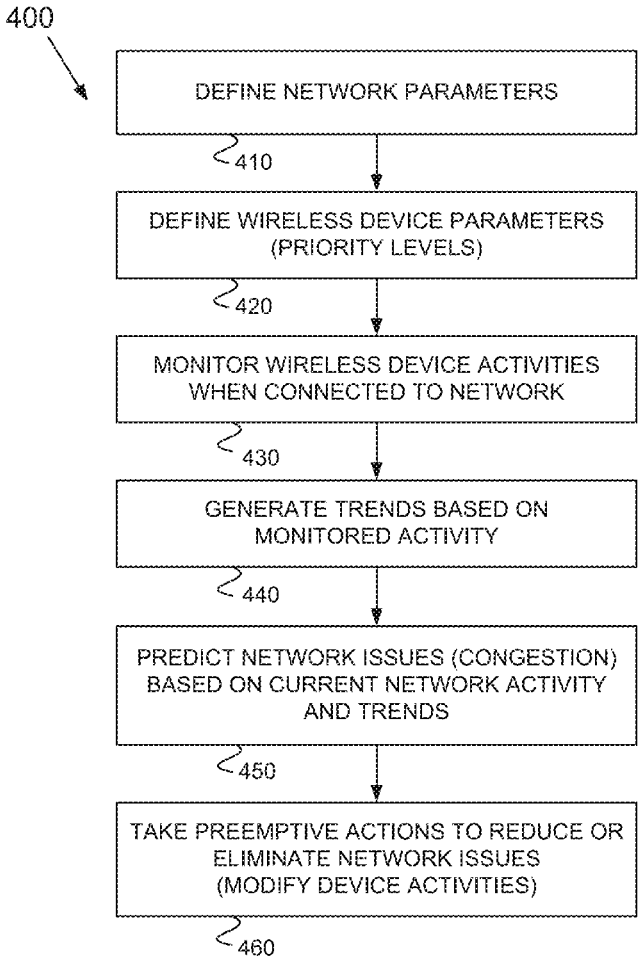
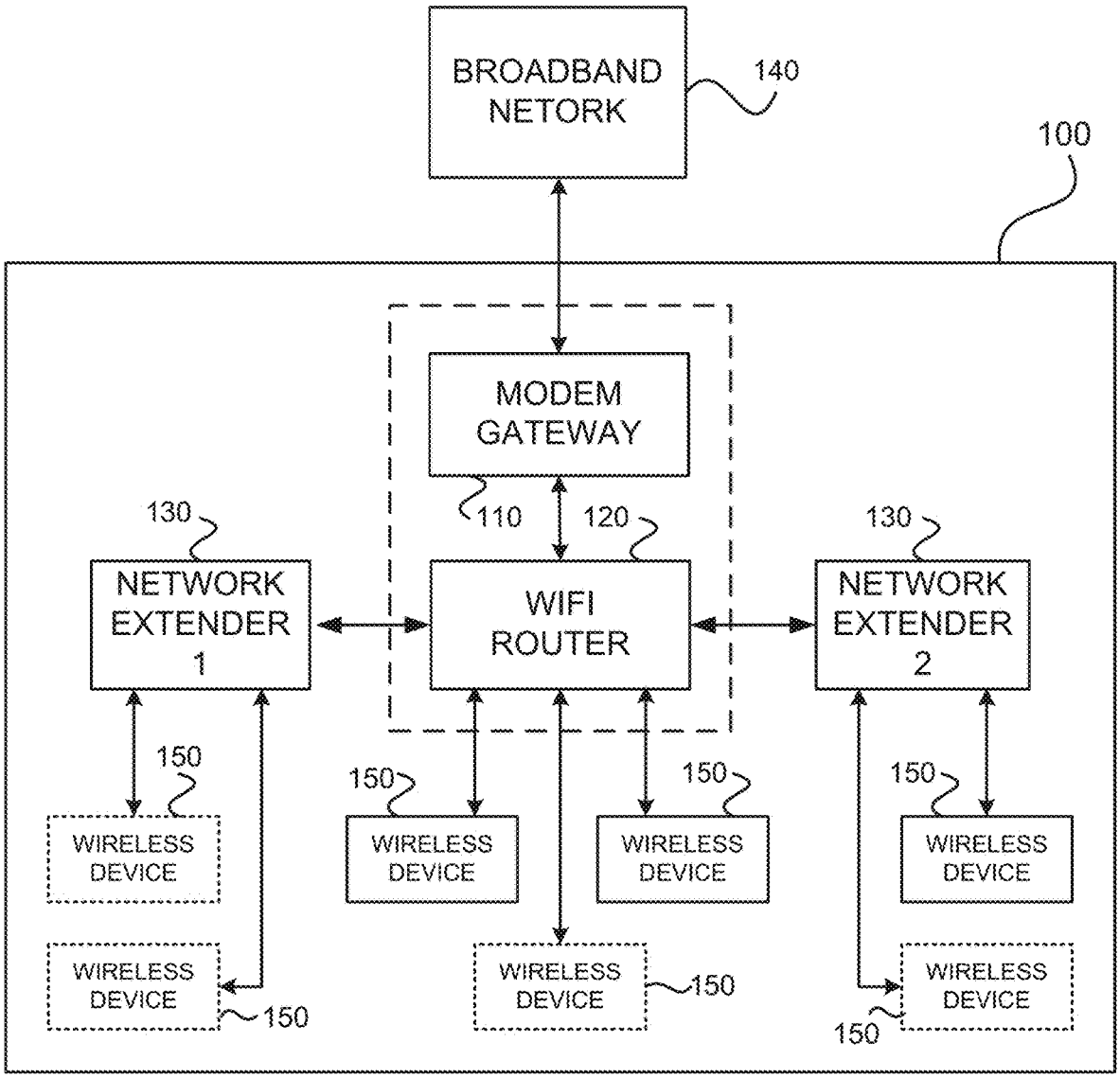
(57) **ABSTRACT**

Monitoring activities of wireless devices connected to a wireless network (e.g., when connected and to what access points, what activities, bandwidth utilized). Processing monitored activities to develop trends for wireless devices (e.g., likely time for connecting to which access points, likely activities performed, likely bandwidth usage, likely movement patterns). Predicting potential issues with the wireless network based on current network activities and predicted activities based on the developed trends. The potential issues may include congestion of an access point. Taking actions, including modifying activities of one or more wireless devices, to avoid the potential issues, reduce impact of the potential issues and/or prevent any performance degradation to high priority wireless devices. The activity modifications may include, for example, restricting/changing access point connectivity, limiting/modifying functions performed, modifying bit rate, changing frequency band, and delaying/restricting activities. Parameters associated with wireless devices may be identified, including identifying high priority wireless devices.




BROADBAND NETORK
140
100
MODEM GATEWAY
110
120
130
NETWORK EXTENDER 1
WIFI ROUTER
130
NETWORK EXTENDER 2
150
WIRELESS DEVICE
150
WIRELESS DEVICE
150
WIRELESS DEVICE
150
WIRELESS DEVICE
150
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WIRELESS DEVICE
150
WIRELESS DEVICE
150

FIG. 1

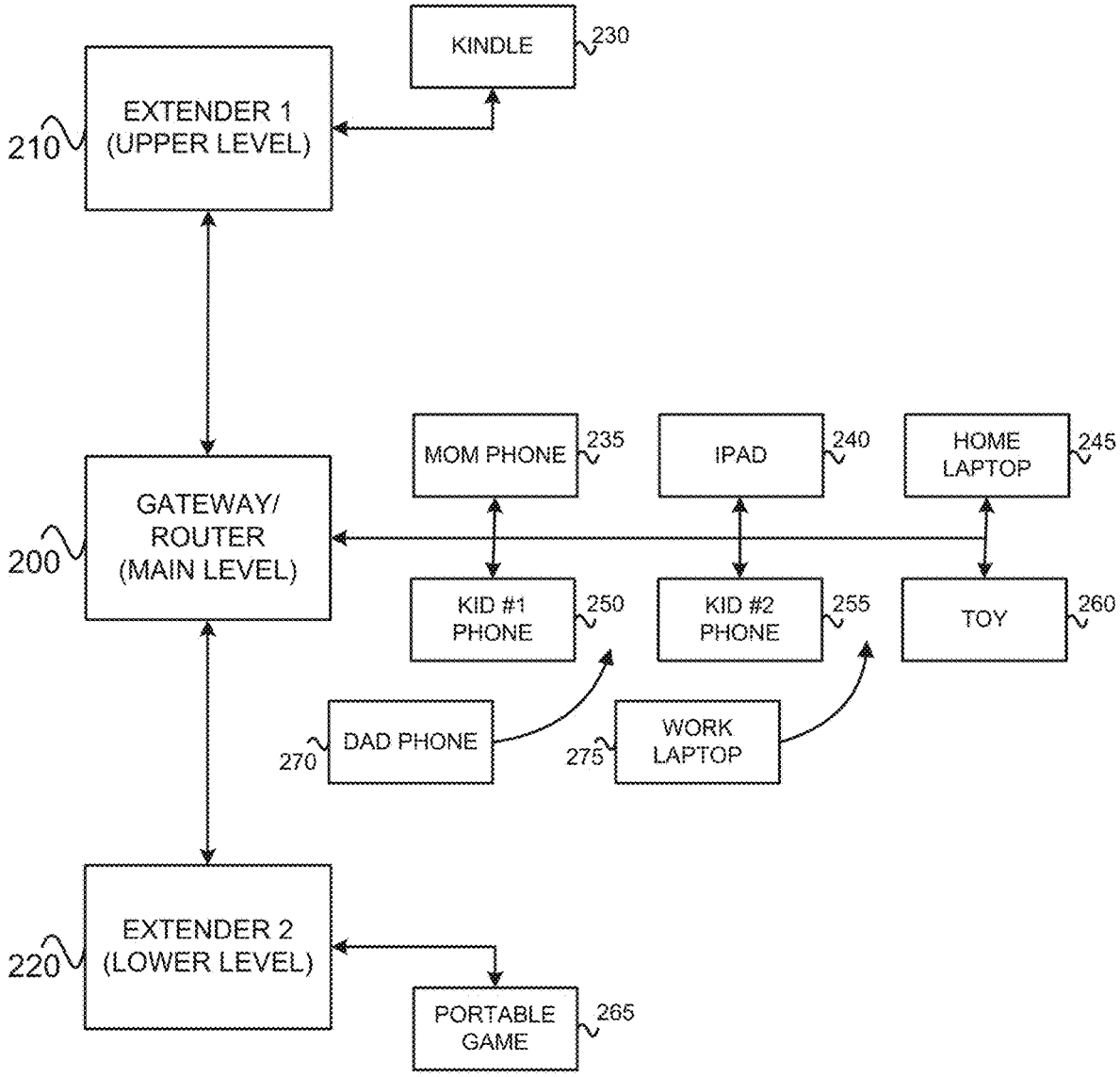
KINDLE
230
EXTENDER 1
(UPPER LEVEL)
210
MOM PHONE
235
IPAD
240
HOME
LAPTOP
245
GATEWAY/
ROUTER
(MAIN LEVEL)
200
KID #1
PHONE
250
KID #2
PHONE
255
TOY
260
DAD PHONE
270
WORK
LAPTOP
275
EXTENDER 2
(LOWER LEVEL)
220
PORTABLE
GAME
265

FIG. 2A

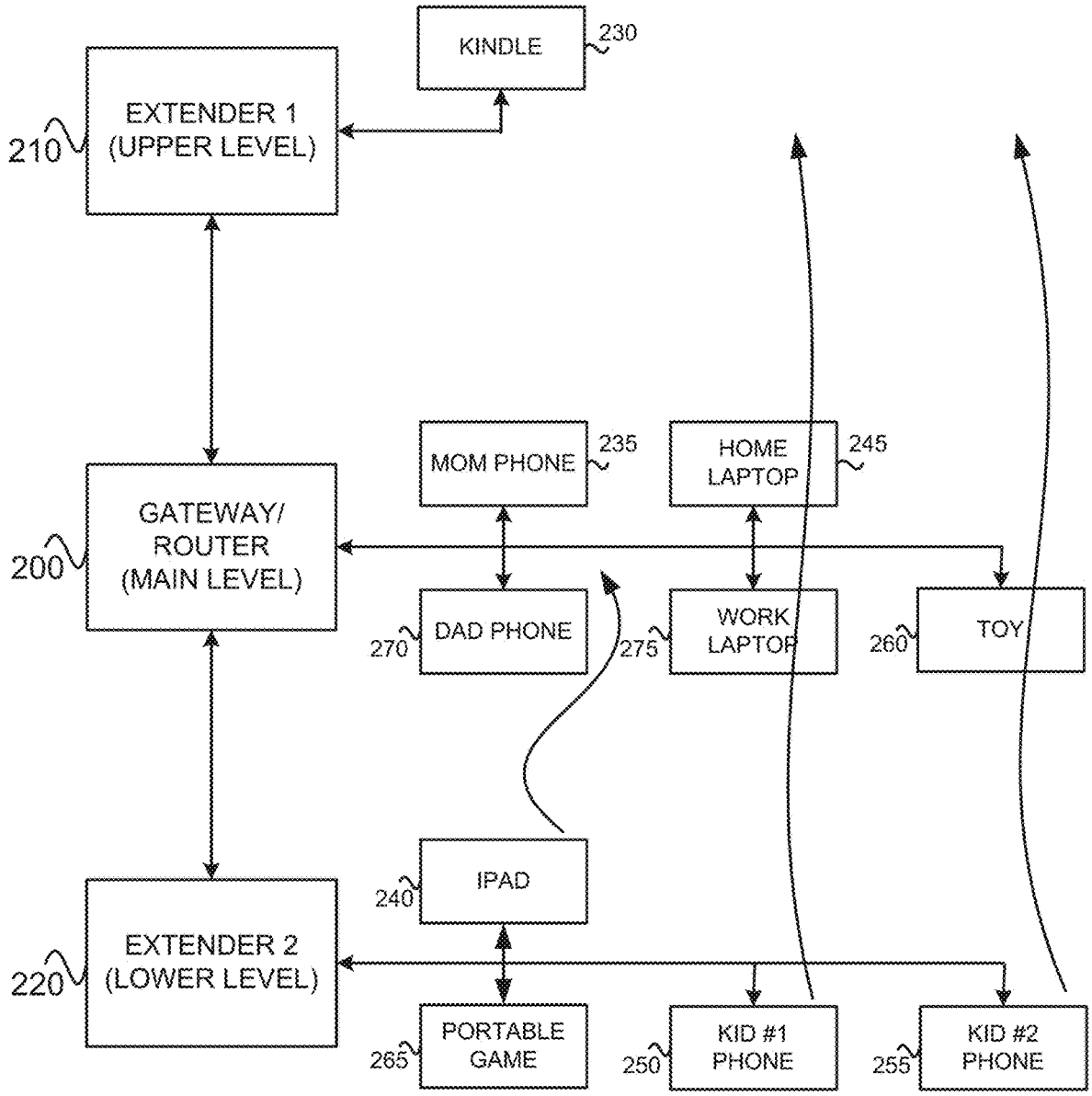
KINDLE
230
EXTENDER 1
(UPPER LEVEL)
210
MOM PHONE
235
HOME
LAPTOP
245
GATEWAY/
ROUTER
(MAIN LEVEL)
200
270
DAD PHONE
275
WORK
LAPTOP
260
TOY
240
IPAD
EXTENDER 2
(LOWER LEVEL)
220
265
PORTABLE
GAME
250
KID #1
PHONE
255
KID #2
PHONE

FIG. 2B

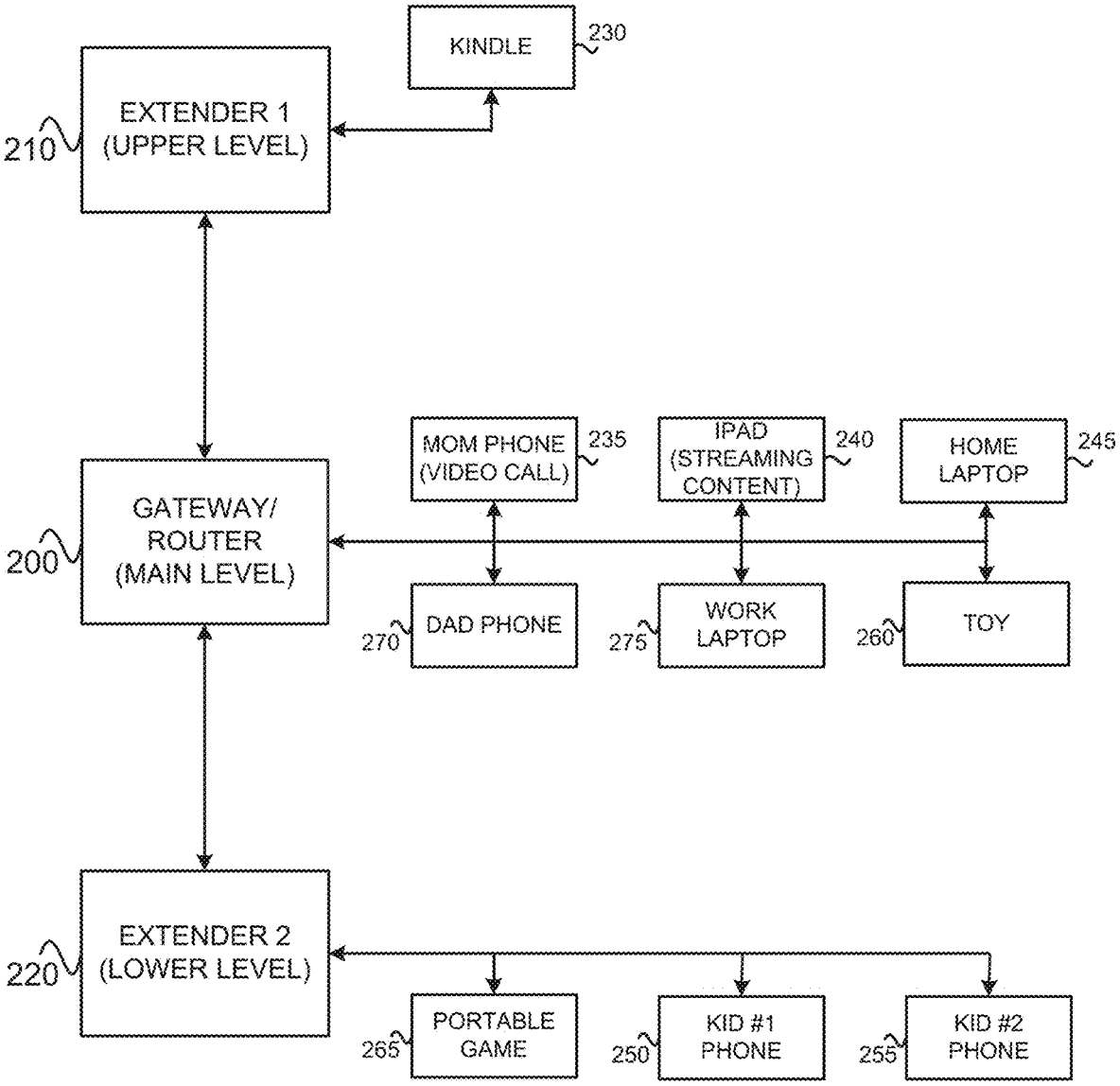
KINDLE
230
EXTENDER 1
(UPPER LEVEL)
210
MOM PHONE
(VIDEO CALL)
235
IPAD
(STREAMING
CONTENT)
240
HOME
LAPTOP
245
GATEWAY/
ROUTER
(MAIN LEVEL)
200
270
DAD PHONE
275
WORK
LAPTOP
260
TOY
EXTENDER 2
(LOWER LEVEL)
220
265
PORTABLE
GAME
250
KID #1
PHONE
255
KID #2
PHONE

FIG. 2C

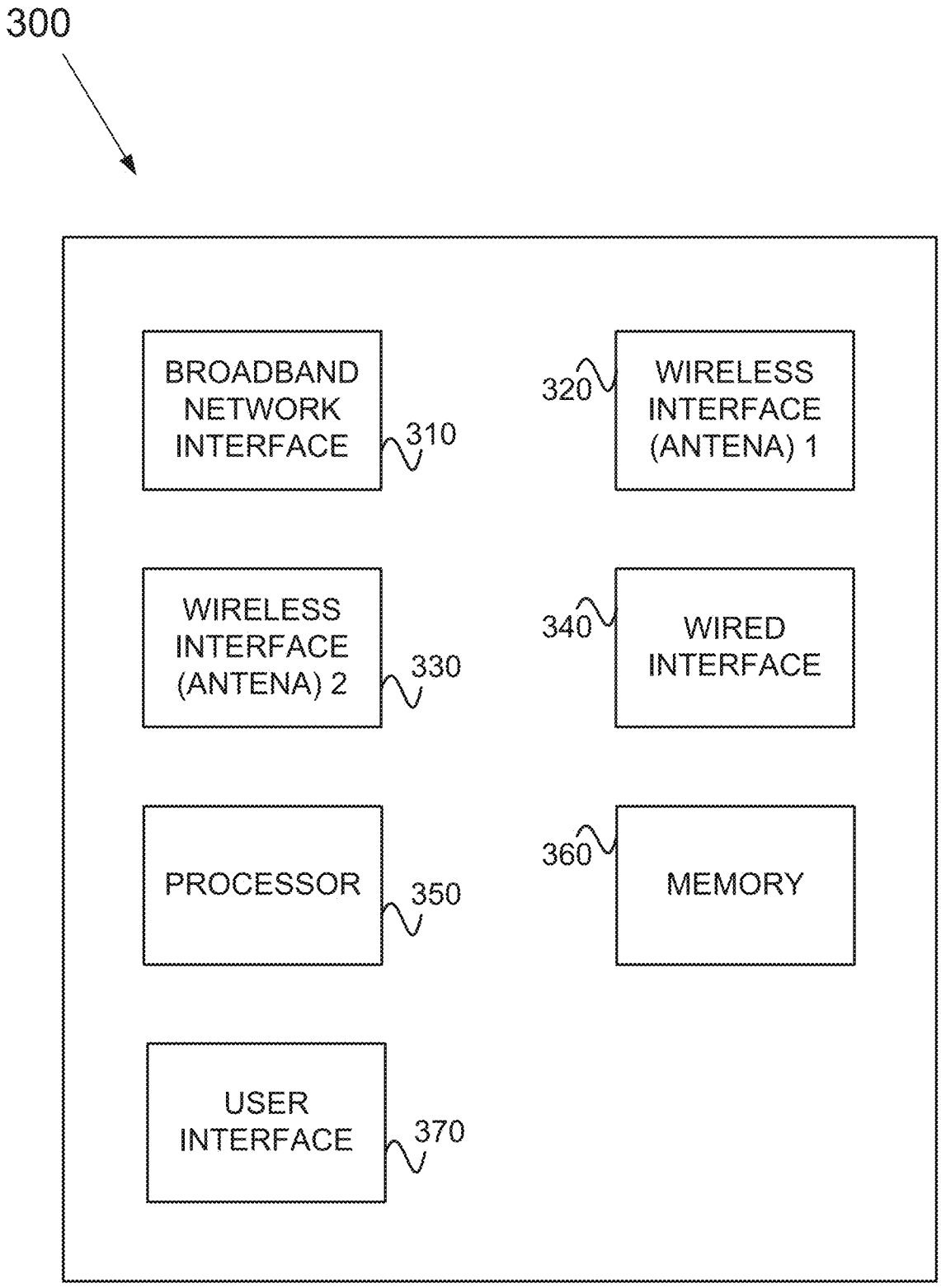
300
BROADBAND NETWORK INTERFACE
310
320
WIRELESS INTERFACE (ANTENA) 1
WIRELESS INTERFACE (ANTENA) 2
330
340
WIRED INTERFACE
PROCESSOR
350
360
MEMORY
USER INTERFACE
370

FIG. 3

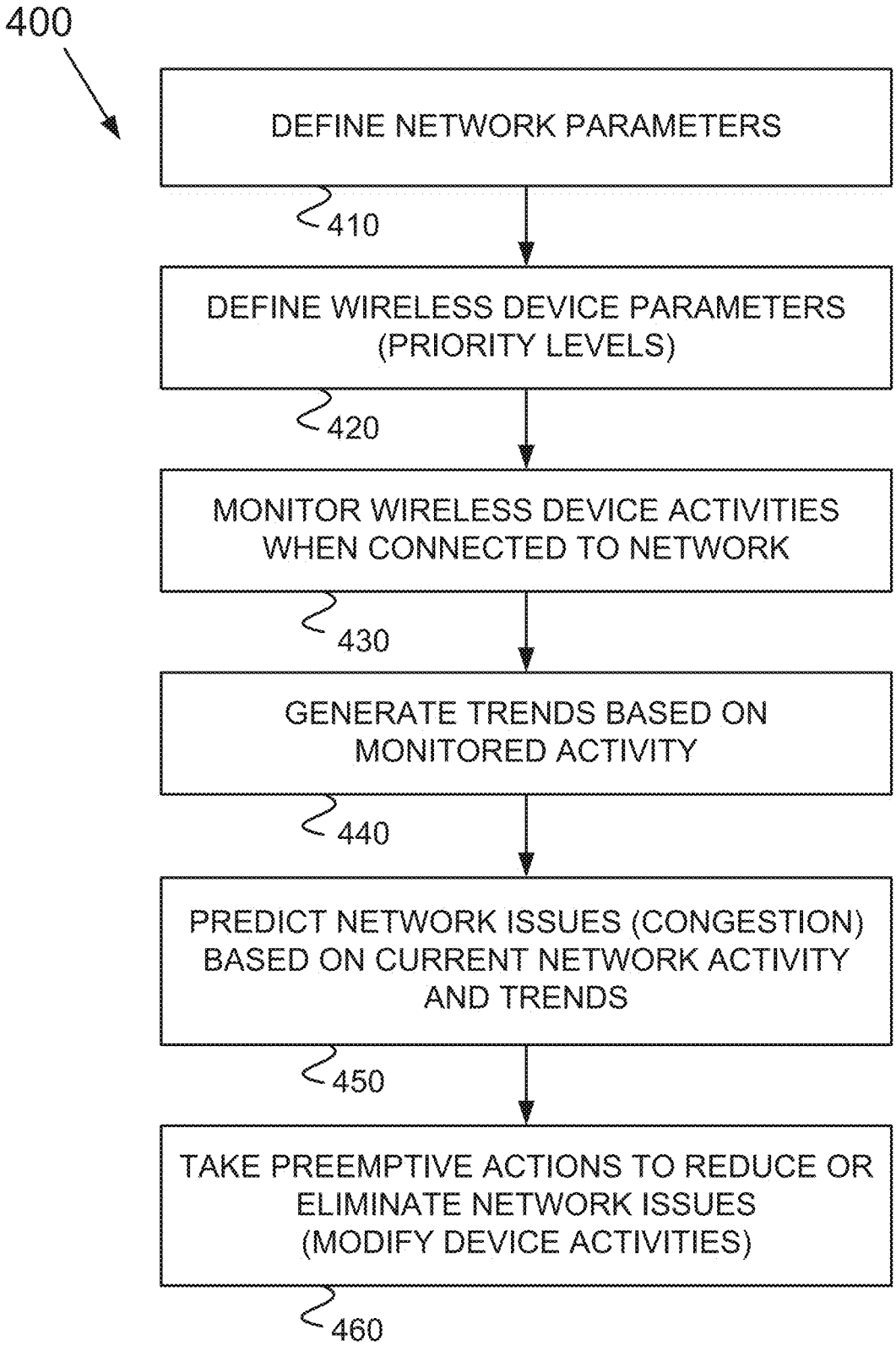
400
DEFINE NETWORK PARAMETERS
410
DEFINE WIRELESS DEVICE PARAMETERS (PRIORITY LEVELS)
420
MONITOR WIRELESS DEVICE ACTIVITIES WHEN CONNECTED TO NETWORK
430
GENERATE TRENDS BASED ON MONITORED ACTIVITY
440
PREDICT NETWORK ISSUES (CONGESTION) BASED ON CURRENT NETWORK ACTIVITY AND TRENDS
450
TAKE PREEMPTIVE ACTIONS TO REDUCE OR ELIMINATE NETWORK ISSUES (MODIFY DEVICE ACTIVITIES)
460

FIG. 4

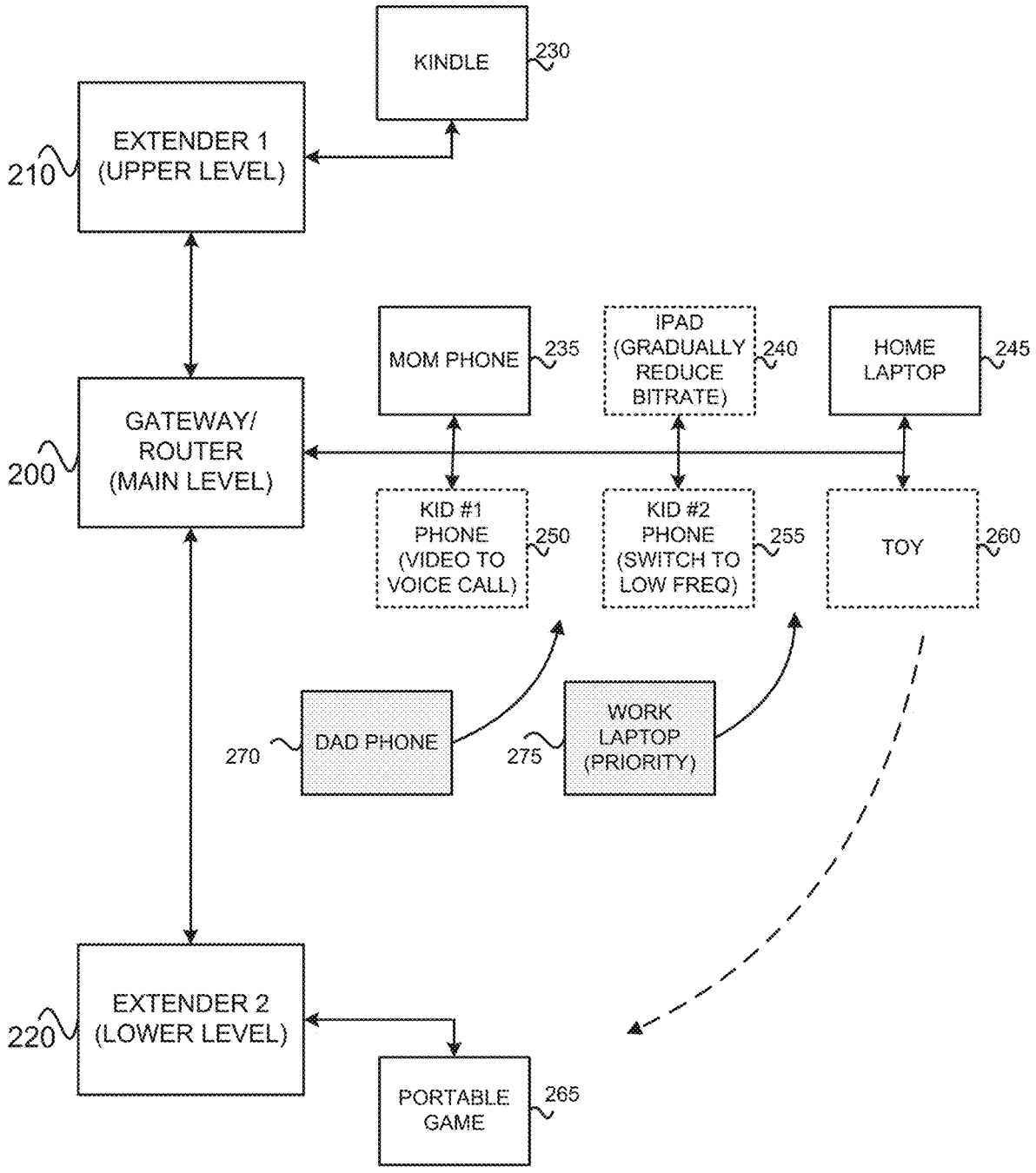
KINDLE
230
EXTENDER 1
(UPPER LEVEL)
210
MOM PHONE
235
IPAD
(GRADUALLY
REDUCE
BITRATE)
240
HOME
LAPTOP
245
GATEWAY/
ROUTER
(MAIN LEVEL)
200
KID #1
PHONE
(VIDEO TO
VOICE CALL)
250
KID #2
PHONE
(SWITCH TO
LOW FREQ)
255
TOY
260
270
DAD PHONE
275
WORK
LAPTOP
(PRIORITY)
EXTENDER 2
(LOWER LEVEL)
220
PORTABLE
GAME
265

FIG. 5A

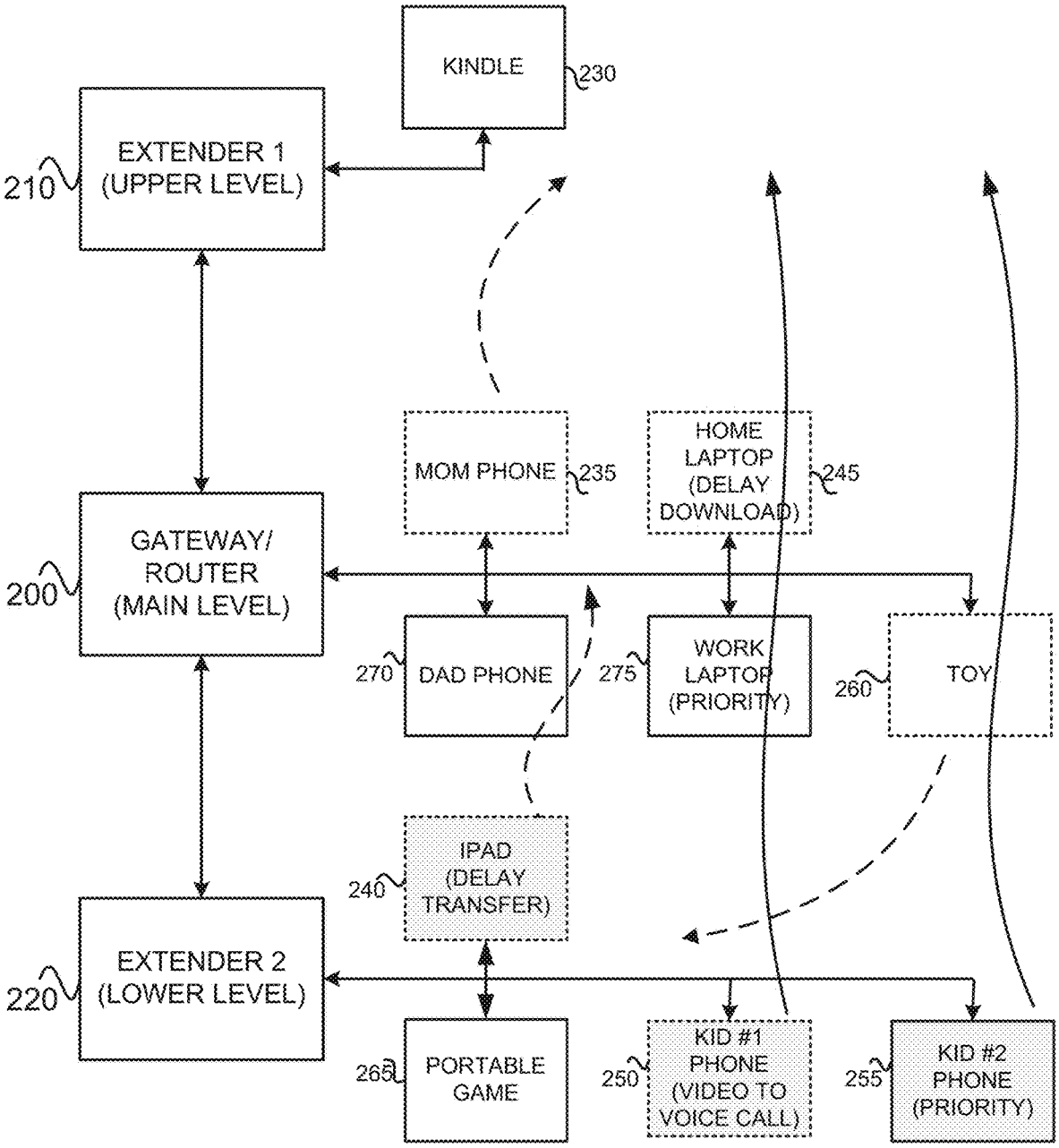
KINDLE
230
EXTENDER 1
(UPPER LEVEL)
210
MOM PHONE
235
HOME
LAPTOP
(DELAY
DOWNLOAD)
245
GATEWAY/
ROUTER
(MAIN LEVEL)
200
270
DAD PHONE
275
WORK
LAPTOP
(PRIORITY)
260
TOY
IPAD
(DELAY
TRANSFER)
240
EXTENDER 2
(LOWER LEVEL)
220
265
PORTABLE
GAME
250
KID #1
PHONE
(VIDEO TO
VOICE CALL)
255
KID #2
PHONE
(PRIORITY)

FIG. 5B

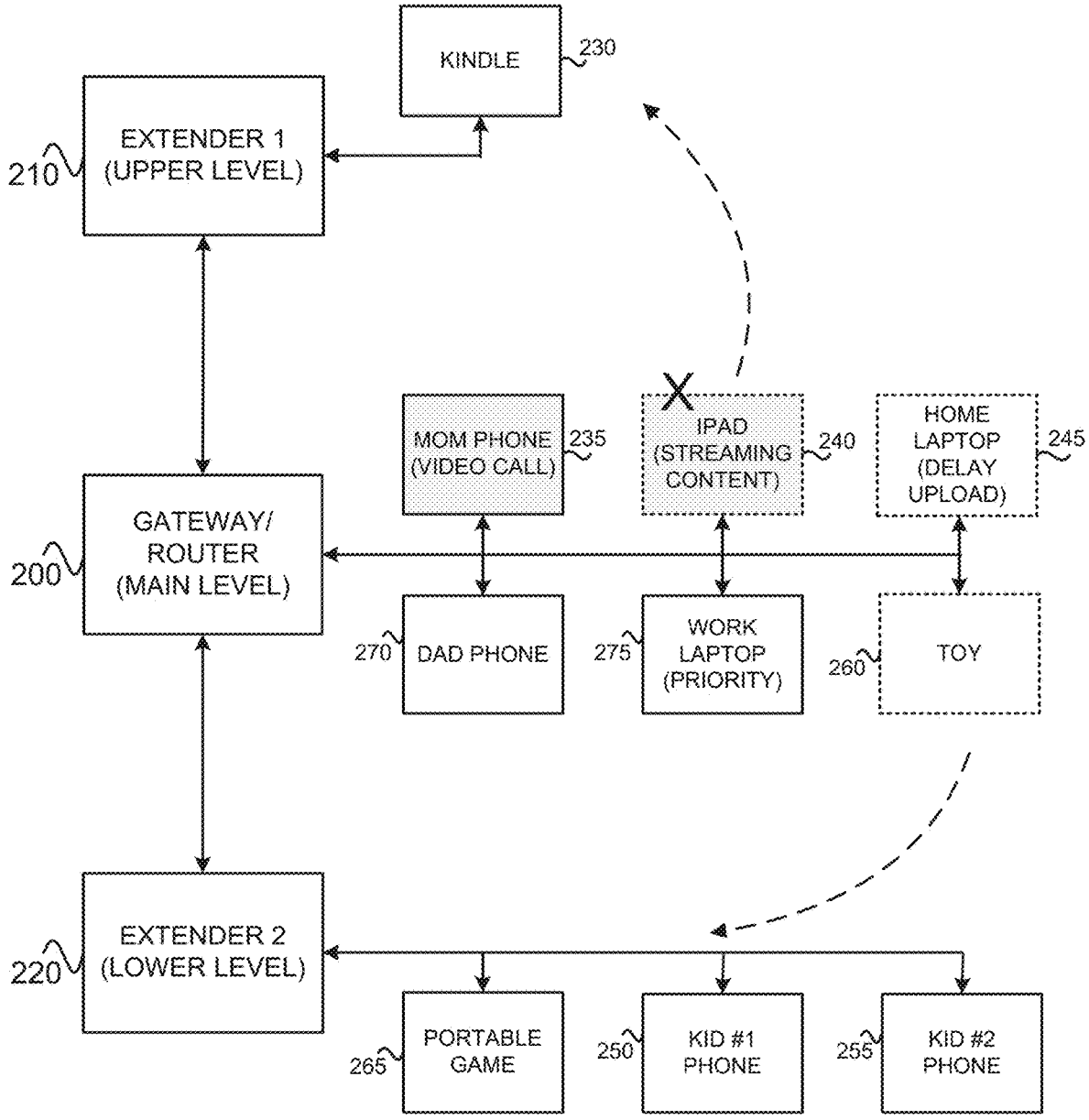
KINDLE
230
EXTENDER 1
(UPPER LEVEL)
210
MOM PHONE
(VIDEO CALL)
235
IPAD
(STREAMING
CONTENT)
240
HOME
LAPTOP
(DELAY
UPLOAD)
245
GATEWAY/
ROUTER
(MAIN LEVEL)
200
270
DAD PHONE
275
WORK
LAPTOP
(PRIORITY)
260
TOY
EXTENDER 2
(LOWER LEVEL)
220
265
PORTABLE
GAME
250
KID #1
PHONE
255
KID #2
PHONE

FIG. 5C

ADJUSTING BANDWIDTH UTILIZATION OF WIRELESS NETWORK BASED ON POTENTIAL ISSUES BEING PREDICTED

BACKGROUND

[0001] More and more devices are capable of communicating wirelessly. The wireless communications may be between wireless devices and/or with the Internet. The wireless communications between wireless devices may be accomplished using one or more wireless protocols. For example, wireless devices may communicate directly with one another using Bluetooth (IEEE 802.15.1). Alternatively, wireless devices may communicate with each other or with the Internet via a wireless local area network, such as WiFi (IEEE 802.11). To communicate via a WiFi network, the WiFi devices may directly connect to the WiFi network via an access point (e.g., router). Bluetooth devices may connect to the WiFi network utilizing a Bluetooth-WiFi bridge.

[0002] The wireless devices (Bluetooth and/or WiFi) include devices that typically remain in same location (stationary devices) and devices that are typically changing locations with a user (mobile devices). The stationary devices may include, but are not limited to, televisions, appliances, entertainment systems, door locks, and security cameras. The mobile devices may include, but are not limited to, computers, tablets, phones, watches (e.g., Apple Watch®), activity trackers (e.g., Fitbit®), electronic-readers (e.g., Kindle®), remote controls, headphones, toys and remote starters.

[0003] With the increase in the number and type of wireless devices that are in use every day comes a need for an increase in performance (e.g., speed, bandwidth, range) of wireless (e.g., WiFi) networks. Increased speed may be necessary to handle the increasing capabilities of many of these devices, such as ultra-high definition video. Increased bandwidth may be required to handle the increased number of devices that are likely accessing the WiFi network. Increased range is required as the wireless devices are likely located at varying distances from an access point for the WiFi network so the WiFi network needs to be able to communicate further distances.

[0004] Higher speed WiFi networks such as those operating at 5 GHz (5G networks) have been deployed. However, many WiFi devices are still designed for lower speed networks such as those operating at 2.4 GHz (2.4G networks). Accordingly, it is often the case where WiFi networks are designed to operate at multiple frequencies (e.g., 2.4G and 5G). A WiFi network may include a modem/gateway to connect to a broadband network (e.g., cable network, telco network, satellite network) provided by a service provider and a WiFi router to provide a WiFi access point to the broadband network. The WiFi router may include multiple antennas (e.g., 2.4G and 5G) so they can operate at multiple frequencies. The modem/gateway and WiFi router may be combined in a single device (main access point).

[0005] Furthermore, the WiFi network may utilize WiFi network extenders in order to expand the bandwidth and range of the WiFi networks to areas that may not be capable of receiving a WiFi signal from the main access point. The network extenders may provide the ability to connect to one or more of the WiFi networks (e.g., 2.4G, 5G) provided by the main access point by transmitting the WiFi signal from the location of the network extender. The network extenders may communicate with the main access point via a wired (e.g., home electrical wiring, coaxial cable, Ethernet cable) connection or a WiFi connection.

[0006] FIG. **1** illustrates an example high level system diagram of a WiFi network **100** within a location. The WiFi network **100** may include a gateway/modem **110**, a WiFi router **120** and one or more network extenders **130**. The gateway/modem **110** is for communicating with a broadband network **140**. The WiFi router **120** is connected to the gateway/modem **110** to provide a link between the WiFi network **100** and the broadband network **140**. The WiFi router **120** may include one or more antennas to transmit and receive WiFi signals to enable communications with wireless devices **150**. As the WiFi router **120** may not be capable of communicating with wireless devices **150** that are too far away, the network extenders **130** may be located at points remote from the WiFi router **120** to provide for additional WiFi communications with additional wireless devices **150**. The network extenders **130** may provide a subset or all of the frequency bands of the WiFi router **120**.

[0007] The location of the router **120** should be in close proximity to the gateway/modem **110**. According to one embodiment, the gateway/modem **110** and the router **120** may be combined into a single component. The gateway/modem **110** and the router **120** may be located in a central part of the location and/or an area where most wireless traffic is expected. For example, the gateway/modem **110** and the router **120** may be located on the main floor in a residence or may be located in a home office. The extenders **130** may be located at locations that the WiFi signal from the router **120** may not be strong, where sufficient WiFi traffic is expected, or where a quality WiFi signal is desired/required. For example, an extender **130** may be located on different floors from the router **120** or in a home office or an entertainment room where connectivity is important.

[0008] The wireless devices **150** connected to the router **120** or extenders **130** may be stationary devices (indicated as solid lines) or may be mobile devices (indicated by dashed lines). The wireless devices **150** may be connected to the access point (e.g., router **120**, extender **130**) that has the strongest signal strength. As illustrated, the router **120** is connected to three wireless devices **150** of which two are stationary and one is mobile, a first extender **130** (network extender **1**) is connected to two wireless devices **150** of which both are mobile, and a second extender **130** (network extender **2**) is connected to two wireless devices **150** of which one is stationary and one is mobile. The configuration of the wireless network **100** is not limited to any specific location for the router **120**, any number or location of the extenders **130**, any number of wireless devices being connected to the WiFi network or any wireless device connection topology. In fact, the number and access point connectivity configuration of the wireless devices **150** may vary over time as the wireless devices move within the location.

[0009] The WiFi network **100** may be configured in such a fashion that the router **120** and the extenders **130** have the same service set identifier (SSID) and password so that once a wireless device **150** connects to the network **100** via any access point it can be connected the network **100** via any other access point without having to select another SSID or enter another password. Certain access points or frequency bands may get congested based on the number of wireless devices **150** connected thereto and the activities being performed thereon.

SUMMARY

[0010] A method for using trends to predict potential issues and take actions to avoid the potential issues or limit impact thereof. The method includes monitoring activities of wireless devices connected to the wireless network. The monitored activities are processed to develop trends for the wireless devices. Potential issues with the wireless network are predicted based on current network activities and predicted activities based on the developed trends. Actions are taken to avoid the potential issues or reduce impact of the potential issues.

[0011] A device for using trends to predict potential issues and take actions to avoid the potential issues or limit impact thereof. The device includes a wireless interface to communicate with one or more wireless devices. A processor communicatively coupled to a memory for storing network configuration information, wherein the network configuration information includes network topology and wireless device parameters. A computer-readable storage medium to store instructions that when executed by the processor cause the processor to monitor activities of wireless devices connected to the wireless network. The monitored activities are processed to develop trends for the wireless devices. Predicting potential issues with the wireless network based on current network activities and predicted activities based on the developed trends. Taking actions to avoid the potential issues or reduce impact of the potential issues.

[0012] A non-transitory computer-readable storage medium containing stored instructions that when executed by a processor cause the processor to use trends to predict potential issues and take actions to avoid the potential issues or limit impact thereof by monitoring activities of wireless devices connected to the wireless network. The monitored activities are processed to develop trends for the wireless devices. Predicting potential issues with the wireless network based on current network activities and predicted activities based on the developed trends. Taking actions to avoid the potential issues or reduce impact of the potential issues.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Various features of the embodiments described in the following detailed description can be more fully appreciated when considered with reference to the accompanying figures, wherein the same numbers refer to the same elements.

[0014] FIG. **1** illustrates an example high level system diagram of a WiFi network within a location.

[0015] FIGS. **2**A-C illustrate examples of access points on a WiFi network becoming congested, according to one embodiment.

[0016] FIG. **3** illustrates an example high level functional diagram of an access point, such as a gateway/router for a WiFi network, according to one embodiment.

[0017] FIG. **4** illustrates an example process flow for controlling a WiFi network to limit performance issues caused by congestion, according to one embodiment.

[0018] FIGS. **5**A-C illustrate examples of utilizing priorities and trends to predict congestion on access points on a WiFi network and making changes to avoid, according to one embodiment.

DETAILED DESCRIPTION

[0019] Multiple wireless devices may connect to a WiFi network within a location (e.g., residence, business). The wireless devices may include stationary devices (e.g., televisions, appliances, entertainment systems, door locks, security cameras) and mobile devices (e.g., computers, tablets, phones, watches, activity trackers, e-readers). The mobile devices may move around the location and be connected to various access points within the location over time. Devices may connect and disconnect to the network over time. The connecting and disconnecting of the mobile devices may be based on, for example, the devices entering and leaving the location the WiFi network is located in, the devices being in and out of range of the WiFi network and/or the devices being powered on or off. The number, type, and specific devices connected to the network may change over time.

[0020] Over the course of time, the number of wireless devices connected to a specific access point may reach a point where performance is affected (the access point is congested). The performance may be affected in various manners including, but not limited to, the slowing of the wireless connection, one or more wireless devices being bumped from the access point, one or more wireless devices being transferred to another access point that may not be preferred, and/or a sudden change in the bit rate of an adaptive bit rate stream being provided to one or more of the devices. The loss or disturbance of connectivity, the reduction in bandwidth and/or the reduction in bit rate may be noticeable to the users and provide the users with a bad experience.

[0021] FIGS. **2**A-C illustrate examples of access points on a WiFi network becoming congested. The example WiFi network of FIGS. **2**A-C includes a gateway/router (main access point) **200**, a first network extender **210** and a second network extender **220**. As illustrated, the gateway/router **200** is located on a main level (e.g., kitchen, family room, office), the first network extender **210** is located on an upper level (e.g., bedrooms) and a second network extender **220** is located on a lower level (e.g., basement, game room). The configuration of the WiFi network is not limited to any specific number of network extenders and/or location of any of the access points (gateway/router **200**, network extenders **210**, **220**). For example, the network extenders **210**, **220** could be associated with specific rooms in the location rather than floors.

[0022] It should be noted that the access points and the wireless devices connected thereto may be identified by assigned names that are easy to remember. For example, the access points may be identified by location (e.g., main floor, master bedroom, basement, office) and the wireless devices may be identified by user name and device type (e.g., dad's phone, work laptop, Bob's Kindle®).

[0023] FIG. **2**A illustrates an example where an addition of several wireless devices to the WiFi network may cause congestion. As illustrated, a Kindle® **230** is connected to the first network extender **210**, mom's phone **235**, an iPad® **240**, a home laptop **245**, a first kid's phone **250**, a second kid's phone **255**, and a toy **260** are connected to the gateway/router **200** and a portable game **265** is connected to the second network extender **220**. When a dad comes home, the dad's phone **270** and the work laptop **275** attempt to connect to the network via the gateway/router **200**.

[0024] The addition of these two devices **270**, **275** to the gateway/router **200** may cause the gateway/router **200** to

become congested and may cause performance issues with some of the devices previously connected thereto **235-260** and/or those devices attempting to connect thereto **270-275**. The performance issues may include a reduction in the speed of one or more of the devices **235-260**, **270**, **275** and/or an abrupt reduction in the bit rate for adaptive bit rate streaming for one or more of the devices **235-260**, **270**, **275**. The wireless network may attempt to address the congestion issues in various manners including dropping one or more of the currently connected wireless devices **235-260** from the gateway/router **200**, not allowing one or more of the attempting to connect devices **270-275** to connect to the gateway/router **200**, rerouting one or more currently connected devices **235-260** or attempting to connect devices **270-275** to a different access point (e.g., **210**, **220**) that may not be a preferred access point (e.g., **200**).

[0025] FIG. **2**B illustrates an example where movement of several wireless devices connected to the WiFi network may cause congestion. As illustrated, the Kindle® **230** is connected to the first network extender **210**, mom's phone **235**, the home laptop **245**, dad's phone **270**, the work laptop **275** and the toy **260** are connected to the gateway/router **200** and the iPad® **240**, the portable game **265**, the first kid's phone **250** and the second kid's phone **255** are connected to the second network extender **220**. At a certain point, the iPad® **240** may be moved from the lower level to the main level which may cause the connection to the WiFi network to transition from the second network extender **220** to the gateway/router **200** and the kid's phones **250**, **255** may be moved from the lower level to the upper level which may cause the connection to the WiFi network to transition from the second network extender **220** to the first network extender **210** via the gateway/router **200**. That is, the first network extender **210** is a leaf node and can only hand off wireless devices to the gateway/router **200** (it cannot hand off wireless devices directly to the second network extender **220**).

[0026] The addition of the phones **250**, **255** (temporarily as they transition to the second network extender **220**) and the iPad® **240** to the gateway/router **200** may cause the gateway/router **200** to become congested and may cause performance issues with some of the devices previously connected thereto **235**, **245**, **260**, **270**, **275** and/or those devices attempting to connect thereto **240**, **250**, **255** (even if temporarily). The wireless network may attempt to address the congestion issues in various manners, but not all of the manners may be beneficial.

[0027] FIG. **2**C illustrates an example where changes in what actions the wireless devices are performing may cause congestion. As illustrated, the Kindle® **230** is connected to the first network extender **210**, the mom's phone **235**, the iPad® **240**, the home laptop **245**, the dad's phone **270**, the work laptop **275**, and the toy **260** are connected to the gateway/router **200** and the portable game **265**, the first kid's phone **250** and the second kid's phone **255** are connected to the second network extender **220**. At a certain point the mom's phone **235** may engage in a video call and the iPad® **240** may engage in streaming content.

[0028] The increase in the activity of the mom's phone **235** and the iPad® **240** may cause the gateway/router **200** to become congested and may cause performance issues with some of the devices connected thereto **235**, **240**, **245**, **260**, **270**, **275**. The wireless network may attempt to address the congestion issues in various manners, but not all of the manners may be beneficial.

[0029] While the loss of performance on any wireless device may not be desirable, the loss of performance on certain wireless devices may not be tolerable. For example, performance loss may be acceptable on a child's cell phone or gaming system but may not be tolerable on a work computer, a work phone or a student computer. According to one embodiment, in addition to setting up and configuring the network (e.g., number of access points, location of access points, naming access points, selecting passwords, naming devices), the WiFi network may have different parameters defined that may assist in the operation thereof. These parameters may define what to do in the event of congestion or how to avoid congestion so that the service impact is minimized. The parameters may be related to the access points in the network as well as the devices that may connect to the network. For example, the parameters may include, but are not limited to, network topology, layout of location the WiFi network is located at, relationship between network topology and location layout, station connectivity for the access points (e.g., is the access point a leaf node where it can only transition devices with one other access point), priority levels for the wireless devices, preferred access points in the network for the devices, priority activities for the wireless devices, types of activities the wireless devices may partake in, time frames when the wireless devices may be connected to the network and locations where devices may be within the location.

[0030] The configuration of the WiFi network and the defining one or more parameters may be done by a user and/or administrator thereof. The user/administrator may configure the WiFi network and define the one or more parameters using an app running on a smart phone and/or tablet or may use any computing device to logon to a website. The app and/or website may be associated with the broadband network service provider, often referred to as Internet service provider (ISP) or simply service provider. The user interface may define the WiFi network configuration and network/device parameters in an access point for the network, such as the main access point. The main access point may be the WiFi router **120** that is connected to the modem/gateway **110** or is possibly part of a combined gateway/router.

[0031] According to one embodiment, the access point for the WiFi network may track different activities about the network and the devices connected thereto and may process those activities to define trends thereabout. The trends may supplement the parameters defined by an administrator or may be additional information not provided by an administrator. For example, the network may determine the most probable time that stations may enter/exit the network, the most probable activities that the stations may partake in (e.g., video, audio, streaming, data) and times associated therewith, bandwidth requirements for the devices and times associated therewith, movement patterns of the devices and times associated therewith, access points the devices are likely to connect to and times associated therewith, and/or probability of devices entering different access points at different times.

[0032] The parameters defined about the network and the devices connected thereto and/or the trends generated may be used to control the network so that congestion is avoided

if possible and if congestion occurs that appropriate actions are taken so as to avoid service interruption or noticeable service changes (e.g., noticeable changes to video quality), especially to priority devices.

[0033] The network configuration, the activity data captured, and/or the parameters (defined/generated) may be stored in the access point (e.g., gateway/router), in a set top box (STB) or any other device having storage that is connected to the wireless network and/or in the cloud (e.g., storage provided to user by ISP).

[0034] FIG. **3** illustrates an example high level functional diagram of an access point, such as a gateway/router **300** for the WiFi network. The gateway/router **300** may include a broadband network interface **310**, a first WiFi interface (antenna) **320**, a second WiFi interface (antenna) **330**, a wired interface **340**, a processor **350**, memory **360** and a user interface **370**. Network extenders may have similar functional diagrams, but likely do not include the broadband network interface **310**. In addition, some network extenders may not include multiple WiFi interfaces but rather may be limited to operating at a single WiFi frequency.

[0035] The broadband network interface **310** is to provide connectivity to and communications with a broadband network **140**. The network interface **310** may include a connector, for example, a coaxial connector for receiving a coaxial cable and associated protocols for providing the necessary communications with the broadband network **140** (e.g., receiving data from and transmitting data to). The broadband network **140** provides access to external content and external system including the Internet.

[0036] The first and second WiFi interfaces (antennas) **320**, **330** are to provide WiFi communications between the gateway/router **300** and wireless devices (establish WiFi networks). The first WiFi interface **320** may be to establish a WiFi network operating at a first frequency (e.g., 5 GHz network pursuant to IEEE 802.11a) and the second WiFi interface **330** may be to establish a WiFi network operating at a second frequency (e.g., 2.4 GHz network pursuant to IEEE 802.11b,g). According to one embodiment, it is possible that a single chip includes multiple antennas and can provide communications at different frequencies (e.g., 2.4 and 5 GHz network pursuant to IEEE 802.11n). The wireless devices may utilize the gateway/router **300** to communicate with other wireless devices within the location or may use it as an access point to connect to the Internet via the broadband network **140**.

[0037] The wired interface **340** is to provide wired communications between the gateway/router **300** and other devices. The other devices may be computing devices using the gateway/router **300** to communicate with wireless devices within the location or access the Internet via the broadband network **140**. The other devices may be network extenders that extend the range of the wireless network within the location. The wired interface **340** may include a connector (e.g., coaxial, Ethernet, USB) to receive an appropriate cable and associated protocols for receiving and transmitting data thereover.

[0038] The processor **350** is to control the operation of the gateway/router **300**. The processor **350** is to execute computer-executable instructions (e.g., software, apps). The computer executable instructions, when executed, may cause the processor **350** to control the operations of the gateway/router **300** and perform various functions including, but not limited to, network configuration, network and device parameter definition, activity monitoring and analysis (e.g., statistics, analytics), device and network trend generation, potential issue prediction, and adjusting network parameters, device connectivity, and/or device operations as required. Some of the functions performed by the processor **350** are based on data that is collected about the network and the devices connected thereto. In addition to controlling the operation of the gateway/router **300**, the processor **350** may also control the operation of the network.

[0039] The memory **360** is to store the computer-executable instructions and/or other data. The other data may include, for example, configuration data (e.g., wireless network topology), connectivity data (e.g., wireless devices actively connected to the wireless network, signal strength of connected devices, congestion of access points), activity data (e.g., bandwidth utilized by wireless device, tasks being performed) and/or trend data calculated (e.g., when/where the wireless devices will connect, when/what activities the wireless devices will perform). The gateway/router **300** may receive data related to what is connected to the network extenders from the network extenders. The data may be received from the network extenders, for example, when wireless devices connect or disconnect from the network extenders, when the wireless devices communicate with the broadband network **140** which requires communications with the gateway/router **300** and/or at defined intervals (e.g., every few seconds).

[0040] The memory **360** may be located on the processor **350** and/or may be separate from the processor **350**. The memory **360** storing the computer-executable instructions may be computer-readable memory so that the processor **350** can read and execute the computer-executable instructions.

[0041] The memory **360** may be supplemented with external memory that may be located in other access points, in a STB or any other device having storage that is connected to the wireless network and/or in the cloud.

[0042] The user interface **370** may include, for example, lights to provide a user an indication about the operational status thereof. The user interface **370** may also include, for example, switches, buttons or the like to enable the user to, for example, power on/off and/or reset the gateway/router **300**.

[0043] As described above with respect to FIG. **3**, the processor **350** may gather/generate the usage, performance, statistics, analytics, trend and/or issue prediction information. Alternatively, at least some subset of the information may be generated by a service provider. The service provider may maintain one or more servers in the cloud that receive the data collected from the gateway/router **300** and process the data to generate the usage, performance, statistics, analytics, trend and/or issue prediction information. The data may be forwarded from the gateway/router **300** at, for example, defined intervals (e.g., every night, once a week), when trouble shooting is required and/or when the user opens the user interface. Alternatively, the server may be capable of retrieving the data from the gateway/router **300** when, for example, they need to troubleshoot the wireless network, recommend changes/upgrades to the wireless network (e.g., to handle problems or optimize performance and/or cost) and/or perform maintenance on the wireless network. According to one embodiment, the information may be generated as a collaboration between the processor **350** and the cloud server for the service provider.

[0044] As noted above, the WiFi network may provide for the ability to define priorities for wireless devices that will be connected thereto. The priorities may include various levels, for example, high, medium and low. Each priority level may have defined service levels associated therewith. For example, a high priority device may be defined as a device that should be given priority to all other devices. A high priority device may be such that actions should be taken to ensure that it does not lose connectivity, have processing slowed, or have any impact on a user experience. A low priority device may be defined as a device that can have service interrupted, have processing slowed and have actions taken that may affect the user experience (e.g., quick change in video quality that is visible, change from video call to voice call) in order to preserve service for higher priority devices. A middle priority device may be defined therebetween the high and low priority devices.

[0045] The WiFi network (e.g., gateway/router **300**) may utilize the priorities for the wireless devices that may connect to the network as well as the parameters that were defined and/or the trends generated about the wireless devices to control the operation of the network so as to provide better performance thereof (act as a network controller). Specifically, the WiFi network may operate so as to provide the best performance possible to the priority devices. The processor **350** may perform these network controller functions.

[0046] The priorities and the trends (e.g., when wireless devices will likely enter/exit the network, functions they are likely to perform) may be utilized to predict when the trends applied to current conditions may cause congestion on an access point and therefore potential performance issues. Preemptive actions may be taken to avoid the predicted congestion and/or to make adjustments when congestion happens that have the least affect, specifically the least affect on priority devices. The actions that may be taken include restricting access to an access point, routing devices to other access points, switching devices to different frequencies, gradually adjusting the bit rate of an adaptive bit rate stream, rescheduling background tasks (e.g., uploading or downloading content), and/or lowering service levels (e.g., converting video call to voice call).

[0047] The actions taken may be to access points that are about to become congested and/or are about to receive a priority wireless device. As a priority wireless device may need to travel through one or more access points to get to a destination access point, actions may need to be taken on several access points. For example, if the priority device needs to travel through a first access point before it gets to a second access point (cannot connect directly to second access point), adjustments may need to be made to both access points. According to one embodiment, the first access point may be adjusted first followed by adjustments to the second access point. The identification of an access point being a leaf node (only transitioning wireless devices with one other access point) may be utilized in determining which access point to make adjustments to.

[0048] FIG. **4** illustrates an example process flow for controlling a WiFi network to limit performance issues caused by congestion **400**. Parameters about the WiFi network may be defined **410**. The parameters may include, for example, a description of what access points are included and how they are connected to one another (network topology), location layout, access point connectivity (leaf node or not), and the frequency bands supported by the access points. Parameters about the wireless devices that connect to the WiFi network may be defined **420**. The parameters may include, for example, priority level (e.g., high, medium, low), preferred access point, frequency bands supported, preferred frequency band, possible activities, preferred activities, bandwidth requirements, connection times, activity times and movement within the location.

[0049] The WiFi network may monitor the activities of the wireless devices connected to the network **430**. The monitored activities may include, for example, wireless device connectivity (e.g., when and where wireless devices connect), wireless device activity (e.g., activities performed and times the activities are performed), bandwidth usage (e.g., amount and time), and wireless device movement (e.g., when and where wireless devices switch between access points). The monitored activity may be processed to generate trends for the wireless devices **440**. The trends may include likely times that wireless device will be connected to network and which access points on the network, likely activities performed by wireless devices and times associated therewith, likely bandwidth usage and times associated therewith, likely movement patterns between access points and times associated therewith.

[0050] The trends may be applied to current network activity to predict congestion and possible performance issues with the network **450**. Network topology, location layout, access point connectivity and other parameters may also be considered when predicting congestion and possible performance issues. The prediction of performance issues may flag issues with priority wireless devices. The predicted issues may include, for example, loss of bandwidth, reduction in signal strength, slower processing, drop in bit rate, reduction in service, loss of service, change in connectivity and loss of connectivity. The network may take preemptive action to reduce or eliminate the predicted issues **460**. The preemptive actions may be to ensure that performance issues do not affect priority devices. The preemptive actions may be taken on non-priority devices. The preemptive actions may include, for example, routing wireless devices (e.g., non-priority devices) to other access points if the other access points are within range, changing frequency bands for wireless devices if supported, reducing the bit rate (e.g., slowly reducing the rate to limit the ability of the user to notice), reducing service (e.g., changing video call to voice call), delaying activities, restricting activities and restricting access.

[0051] The method **400** is in no way intended to be limited to the illustrated processes. Rather, additional processes can be added, processes can be combined, processes can be deleted, processes can be modified and/or the order of the processes can be modified without departing from the current scope. Computer-executable instructions (e.g., software, apps) may be stored on a computer-readable storage medium (e.g., **360**). The computer-executable instructions when executed by a processor (e.g., **350**) may cause the processor to perform the method **400**.

[0052] FIGS. **5**A-C illustrate examples of utilizing priorities and trends to predict congestion on access points on a WiFi network and making changes to avoid. FIGS. **5**A-C are the network configurations and connections of FIGS. **2**A-C with adjustments made to account for the actions that are predicted to occur based on trends. FIG. **5**A illustrates an example where based on captured trends, it is predicted that

the dad's phone **270** and the work laptop **275** (shaded gray to indicate the prediction) will be added to the network via the gateway/router **200**. The work laptop **275** is designated as a priority device. The addition of these devices **270**, **275** is predicted to cause congestion for the gateway/router **200** and may cause performance issues for the devices connected thereto including the priority device **275**. Accordingly, actions are taken to ensure that the work laptop **275** does not have any service issues when it attempts to connect thereto. The actions may include, for example, changing a video call to a voice call on the first kid phone **250**, switching the second kid phone **255** to a different frequency band (e.g., changing from 5G to 2.4G if supported and priority device **275** requires/desires 5G), routing the toy **260** to the second extender **220** (assuming can connect thereto), and gradually reducing the bit rate of the adaptive bit rate content that is being streamed on the iPad® **240** so that the change top the quality of the video is not obvious.

[0053] FIG. **5**B illustrates an example where based on trends it is predicted that the iPad® **240** is to be moved from the lower level to the main level (transition from the second network extender **220** to the gateway/router **200**) and the kids phones **250**, **255** are to be moved from the lower level to the upper level (transition from the second network extender **220** to first network extender **210** via the gateway/router **200**). The devices **240**, **250**, **255** that are predicted to be moving are shaded gray. The work laptop **275** and the second kid phone **255** are designated as priority devices. The movement of the iPad® **240** and the phones **270**, **275** either to, or through, the gateway/router **200** is predicted to cause congestion for the gateway/router **200** and may cause performance issues for the devices connected thereto including the priority devices **255**, **275**. Accordingly, actions may be taken to ensure that the work laptop **275** and the second kid phone **255** do not have any service issues during the predicted movement. The actions may include, for example, changing a video call to a voice call on the first kid phone **250** (either before or during the transition of access points), delaying the transfer of the iPad® **240** to the gateway/router **200** (assuming can still connect thereto when device moved to main level), routing the toy **260** to the second extender **220** (assuming can connect thereto), routing the mom's phone **235** to the first extender **210** (assuming can connect thereto), and delaying the downloading of material on the home laptop **245**.

[0054] In this embodiment, it is predicted that when the kids phones **250**, **255** continue their movement to the upper level that there are no congestion/performance issues associated with the first extender **210** so no changes are required for the second phase of the movement/transition. If there were predicted issues on the first extender **210** appropriate actions could be taken there as well. As there are no predicted congestion/performance issues, the first kid phone **250** may be changed back to a video call if it had been changed to a voice call before or during the transition from the lower level.

[0055] FIG. **5**C illustrates an example where based on trends it is predicted the mom's phone **235** is going to engage in a video call and the iPad® **240** is going to start streaming content (shaded gray to indicate the prediction). The work laptop **275** is designated as a priority device. The increase in the activity on the mom's phone **235** and the iPad® **240** is predicted to cause the gateway/router **200** to become congested and may cause performance issues with the devices connected thereto including the priority device **275**. Accordingly, actions may be taken to ensure that the work laptop **275** does not have any service issues during the predicted changes in activities. The actions may include, for example, routing the toy **260** to the second extender **220** (assuming can connect thereto), delaying the uploading of material on the home laptop **245** and either preventing the streaming of content on the iPad® **240** or routing the iPad® **240** to the first extender **210** (assuming can connect thereto).

[0056] Although the disclosure has been illustrated by reference to specific embodiments, it will be apparent that the disclosure is not limited thereto as various changes and modifications may be made thereto without departing from the scope. Reference to "one embodiment" or "an embodiment" means that a particular feature, structure or characteristic described therein is included in at least one embodiment. Thus, the appearances of the phrase "in one embodiment" or "in an embodiment" appearing in various places throughout the specification are not necessarily all referring to the same embodiment.

[0057] The various embodiments are intended to be protected broadly within the spirit and scope of the appended claims.

We claim:

1. A method for using trends to predict potential issues and take actions to avoid the potential issues or limit impact thereof, the method comprising

monitoring activities of wireless devices connected to a wireless network;

processing the monitored activities to develop trends for the wireless devices;

predicting potential issues with the wireless network based on current network activities and predicted activities based on the developed trends; and

taking actions to avoid the potential issues or reduce impact of the potential issues.

2. The method of claim **1**, wherein the monitoring activities include monitoring at least some subset of when the wireless devices are connected to the wireless network, what activities the wireless devices perform, when the activities are performed, what access points the wireless devices are connected when the activities are performed, and bandwidth utilized by the wireless devices during the activities.

3. The method of claim **2**, wherein the trends include at least some subset of likely time when the wireless devices connect to the wireless network and the access points associated therewith, likely activities performed by the wireless devices and times and access points associated therewith, likely bandwidth usage and times and access points associated therewith, and likely movement patterns between access points and times associated therewith.

4. The method of claim **1**, wherein the predicting potential issues includes predicting congestion for an access point, wherein the congestion could result in at least some subset of bandwidth limitations, reduction in signal strength, reduction in bit rate, change in connectivity, loss of connectivity, and connectivity restrictions.

5. The method of claim **1**, wherein the taking actions includes modifying the activities of one or more wireless devices.

6. The method of claim **5**, wherein the modifying activities include at least some subset of restricting connectivity to prevent congestion, changing access point connectivity for one or more wireless devices that have sufficient signal

strength available at other access points, limit and/or modify functions performed by one or more wireless devices connected to the access point, slowly modify bit rate for one or more wireless devices connected to the access point, changing frequency band to other frequency band for one or wireless devices that support other frequency band, delaying or restricting certain activities for one or more wireless devices and restricting access to the access point.

7. The method of claim **1**, wherein the taking actions includes modifying the activities of one or more wireless devices to prevent any performance degradation to high priority wireless devices.

8. The method of claim **1**, further comprising identifying parameters associated with the wireless devices that connect to the wireless network.

9. The method of claim **8**, wherein the identifying parameters includes identifying high priority wireless devices.

10. A device for using trends to predict potential issues and take actions to avoid the potential issues or limit impact thereof, the device comprising:

a wireless interface to communicate with one or more wireless devices;

a processor communicatively coupled to a memory for storing network configuration information, wherein the network configuration information includes network topology and wireless device parameters; and

a computer-readable storage medium to store instructions that when executed by the processor cause the processor to:

monitor activities of wireless devices connected to a wireless network;

process the monitored activities to develop trends for the wireless devices;

predict potential issues with the wireless network based on current network activities and predicted activities based on the developed trends; and

take actions to avoid the potential issues or reduce impact of the potential issues.

11. The device of claim **10**, wherein when the instructions are executed they cause the processor to monitor at least some subset of when the wireless devices are connected to the wireless network, what activities the wireless devices perform, when the activities are performed, what access points the wireless devices are connected when the activities are performed, and bandwidth utilized by the wireless devices during the activities.

12. The device of claim **11**, wherein when the instructions are executed they cause the processor to identify trends including at least some subset of likely time when the wireless devices connect to the wireless network and the access points associated therewith, likely activities performed by the wireless devices and times and access points associated therewith, likely bandwidth usage and times and access points associated therewith, and likely movement patterns between access points and times associated therewith.

13. The device of claim **10**, wherein when the instructions are executed they cause the processor to predict congestion for an access point, wherein the congestion could result in at least some subset of bandwidth limitations, reduction in signal strength, reduction in bit rate, change in connectivity, loss of connectivity, and connectivity restrictions.

14. The device of claim **10**, wherein when the instructions are executed they cause the processor to modify the activities of one or more wireless devices to avoid the potential issues or reduce impact of the potential issues.

15. The device of claim **10**, wherein when the instructions are executed they cause the processor to modify the activities of one or more wireless devices to prevent any performance degradation to high priority wireless devices.

16. A non-transitory computer-readable storage medium containing stored instructions that when executed by a processor cause the processor to use trends to predict potential issues and take actions to avoid the potential issues or limit impact thereof by:

monitoring activities of wireless devices connected to a wireless network;

processing the monitored activities to develop trends for the wireless devices;

predicting potential issues with the wireless network based on current network activities and predicted activities based on the developed trends; and

taking actions to avoid the potential issues or reduce impact of the potential issues.

17. The non-transitory computer-readable storage medium of claim **16**, wherein when the instructions are executed they cause the processor to

monitor at least some subset of when the wireless devices are connected to the wireless network, what activities the wireless devices perform, when the activities are performed, what access points the wireless devices are connected when the activities are performed, and bandwidth utilized by the wireless devices during the activities; and

identify trends including at least some subset of likely time when the wireless devices connect to the wireless network and the access points associated therewith, likely activities performed by the wireless devices and times and access points associated therewith, likely bandwidth usage and times and access points associated therewith, and likely movement patterns between access points and times associated therewith.

18. The non-transitory computer-readable storage medium of claim **16**, wherein when the instructions are executed they cause the processor to predict congestion for an access point, wherein the congestion could result in at least some subset of bandwidth limitations, reduction in signal strength, reduction in bit rate, change in connectivity, loss of connectivity, and connectivity restrictions.

19. The non-transitory computer-readable storage medium of claim **16**, wherein when the instructions are executed they cause the processor to modify the activities of one or more wireless devices to avoid the potential issues or reduce impact of the potential issues.

20. The non-transitory computer-readable storage medium of claim **16**, wherein when the instructions are executed they cause the processor to modify the activities of one or more wireless devices to prevent any performance degradation to high priority wireless devices.

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