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(54) **SYSTEM AND METHOD FOR CONFIGURING DEVICE CONNECTIONS IN AN EXTENDED NETWORK ENVIRONMENT**

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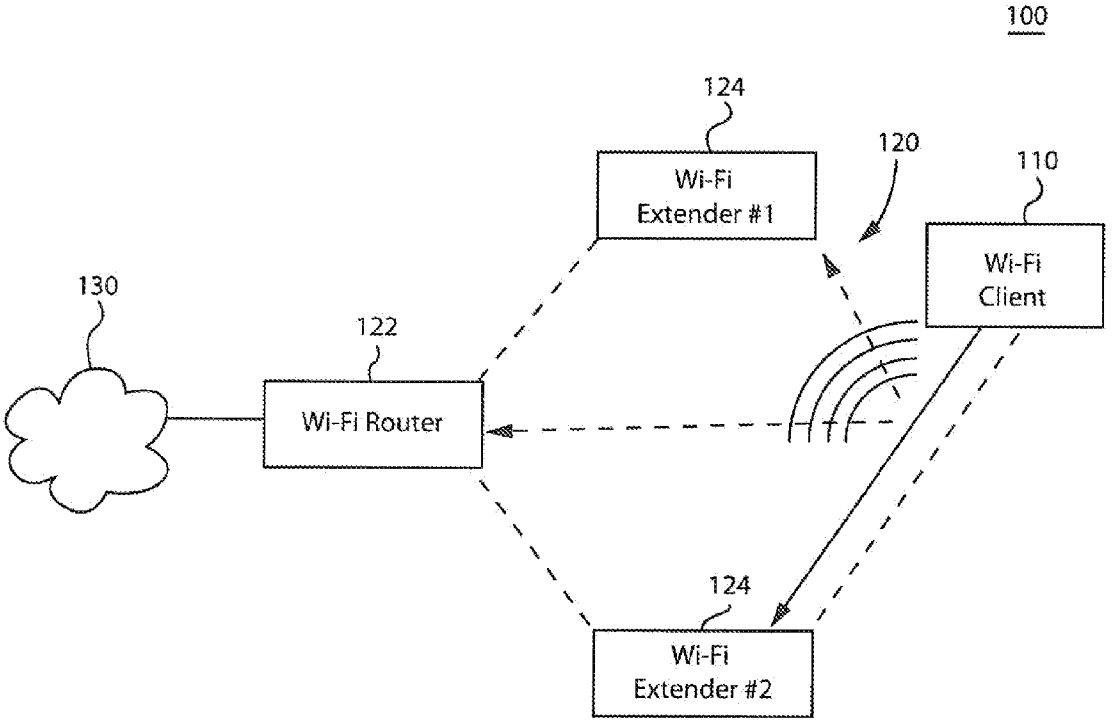
USPC **370/329**; 370/328

(57) **ABSTRACT**

An extended network is configured to implement an extended management function to identify a wireless access device providing a highest quality wireless connection to a wireless device. The extended network includes a gateway wireless access device configured to enable communication between the extended network and an external network, at least one additional wireless access device in the extended network, and at least one wireless device having a wireless connection to a least one of an additional wireless access device and the gateway wireless access device. At least one wireless access device includes a processor executing the extended management function to identify the wireless access device providing the highest quality wireless connection based on wireless connection quality information transmitted from each wireless access device.



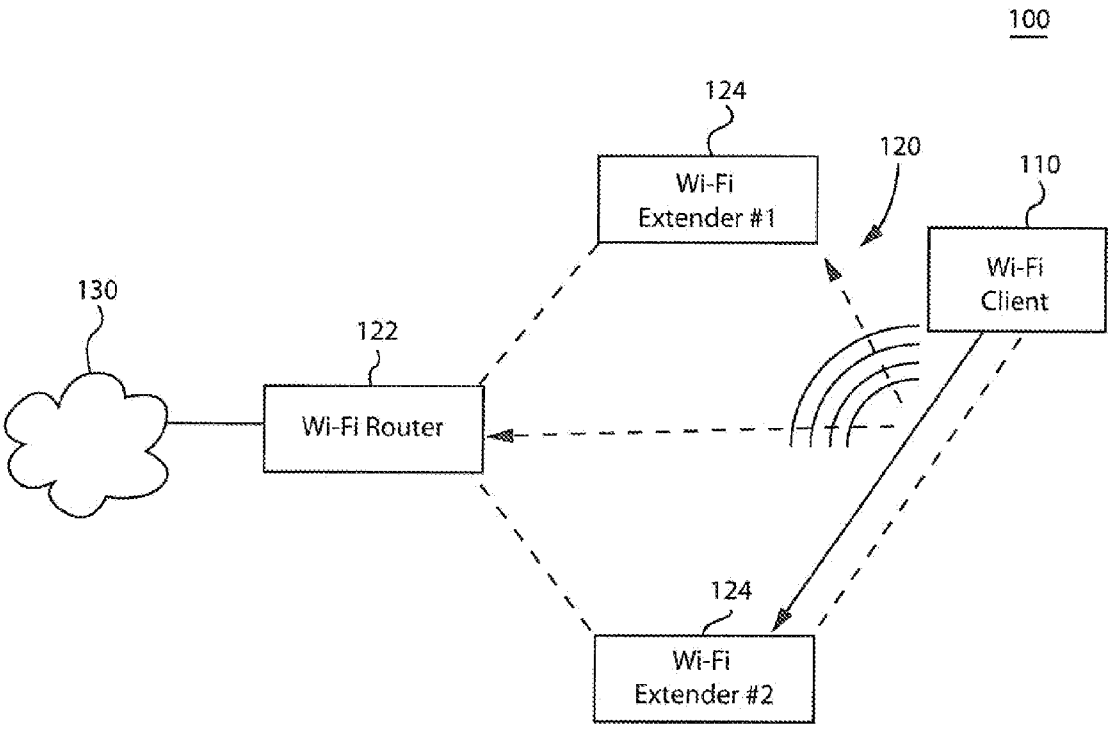

100
124
Wi-Fi
Extender #1
120
110
Wi-Fi
Client
130
122
Wi-Fi Router
124
Wi-Fi
Extender #2

FIG. 1

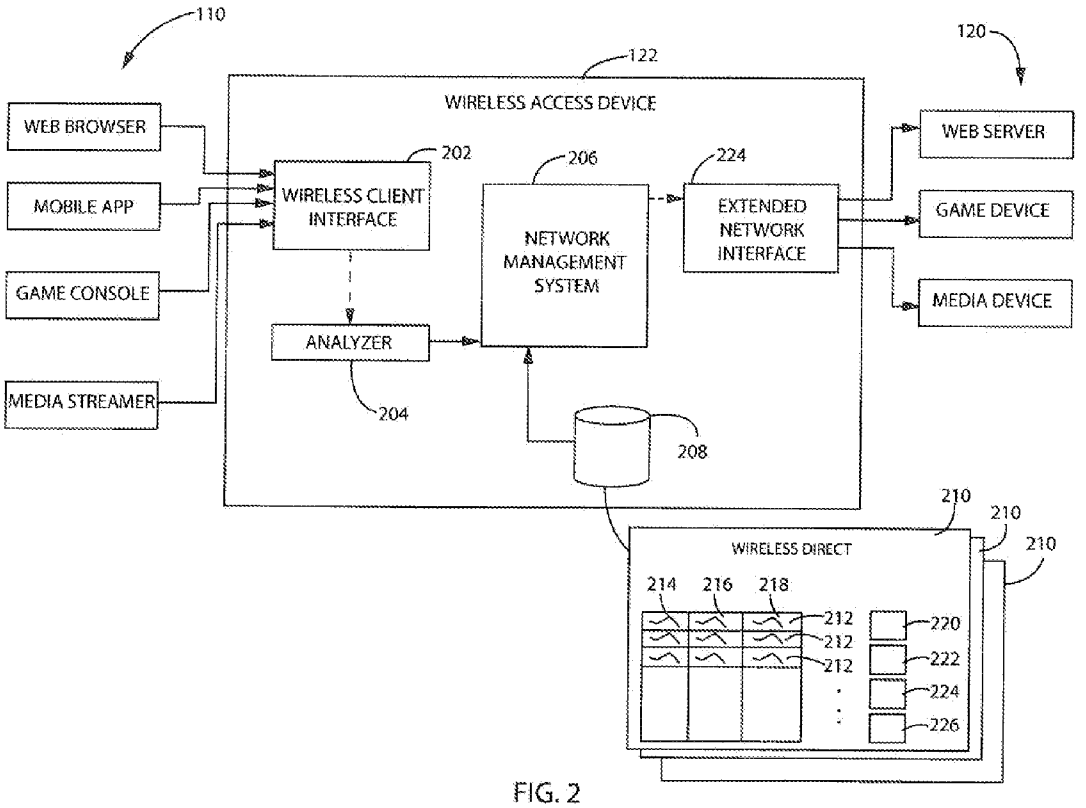

110
120
122
WIRELESS ACCESS DEVICE
WEB BROWSER
MOBILE APP
GAME CONSOLE
MEDIA STREAMER
WIRELESS CLIENT INTERFACE
202
206
224
NETWORK MANAGEMENT SYSTEM
EXTENDED NETWORK INTERFACE
WEB SERVER
GAME DEVICE
MEDIA DEVICE
ANALYZER
204
208
210
210
210
WIRELESS DIRECT
214
216
218
212
212
212
220
222
224
226

FIG. 2

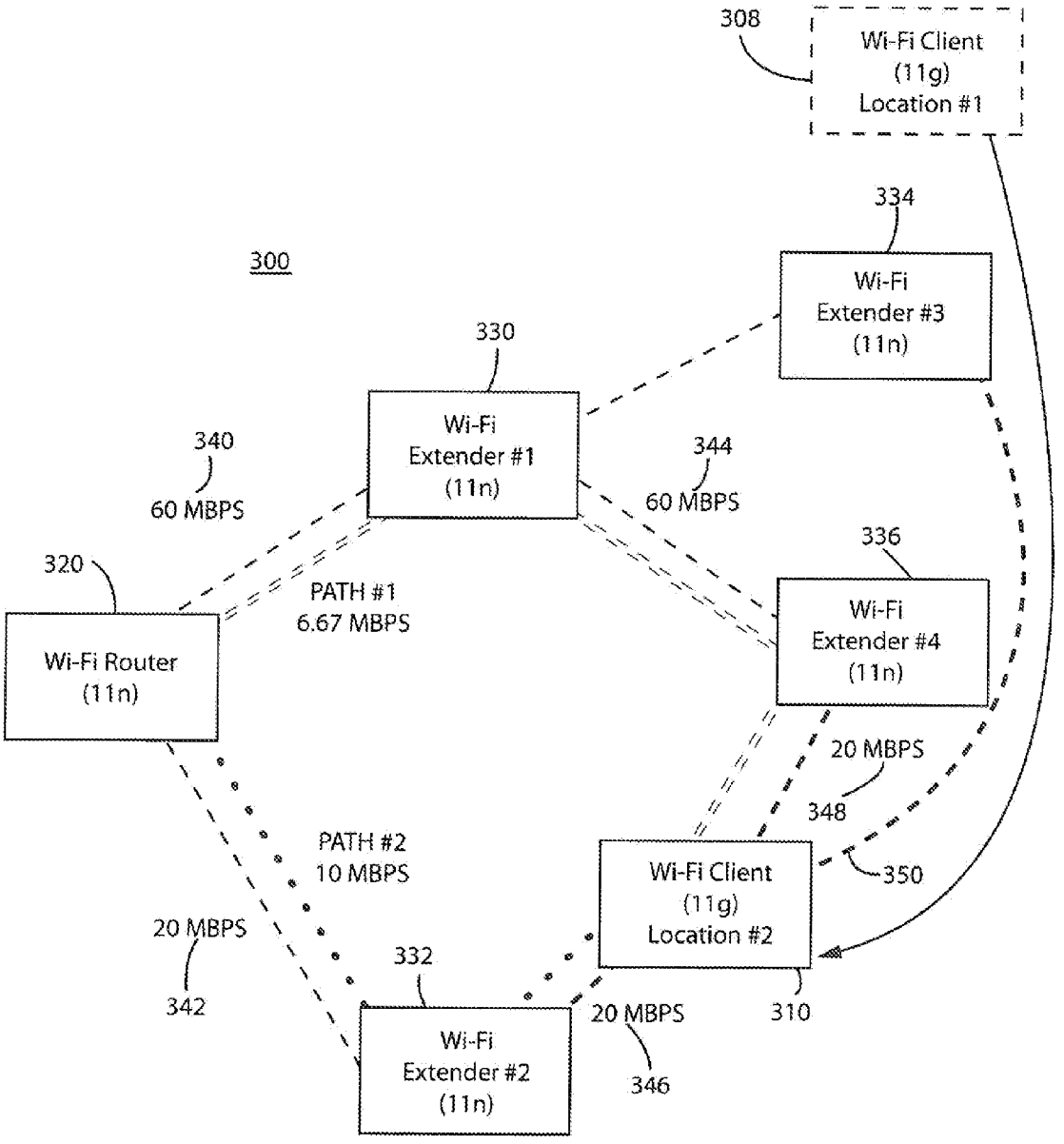

308
Wi-Fi Client
(11g)
Location #1
334
300
Wi-Fi
Extender #3
(11n)
330
Wi-Fi
Extender #1
(11n)
340
60 MBPS
344
60 MBPS
336
320
PATH #1
6.67 MBPS
Wi-Fi Router
(11n)
Wi-Fi
Extender #4
(11n)
20 MBPS
348
PATH #2
10 MBPS
350
Wi-Fi Client
(11g)
Location #2
20 MBPS
342
332
20 MBPS
310
Wi-Fi
Extender #2
(11n)
346

FIG. 3A

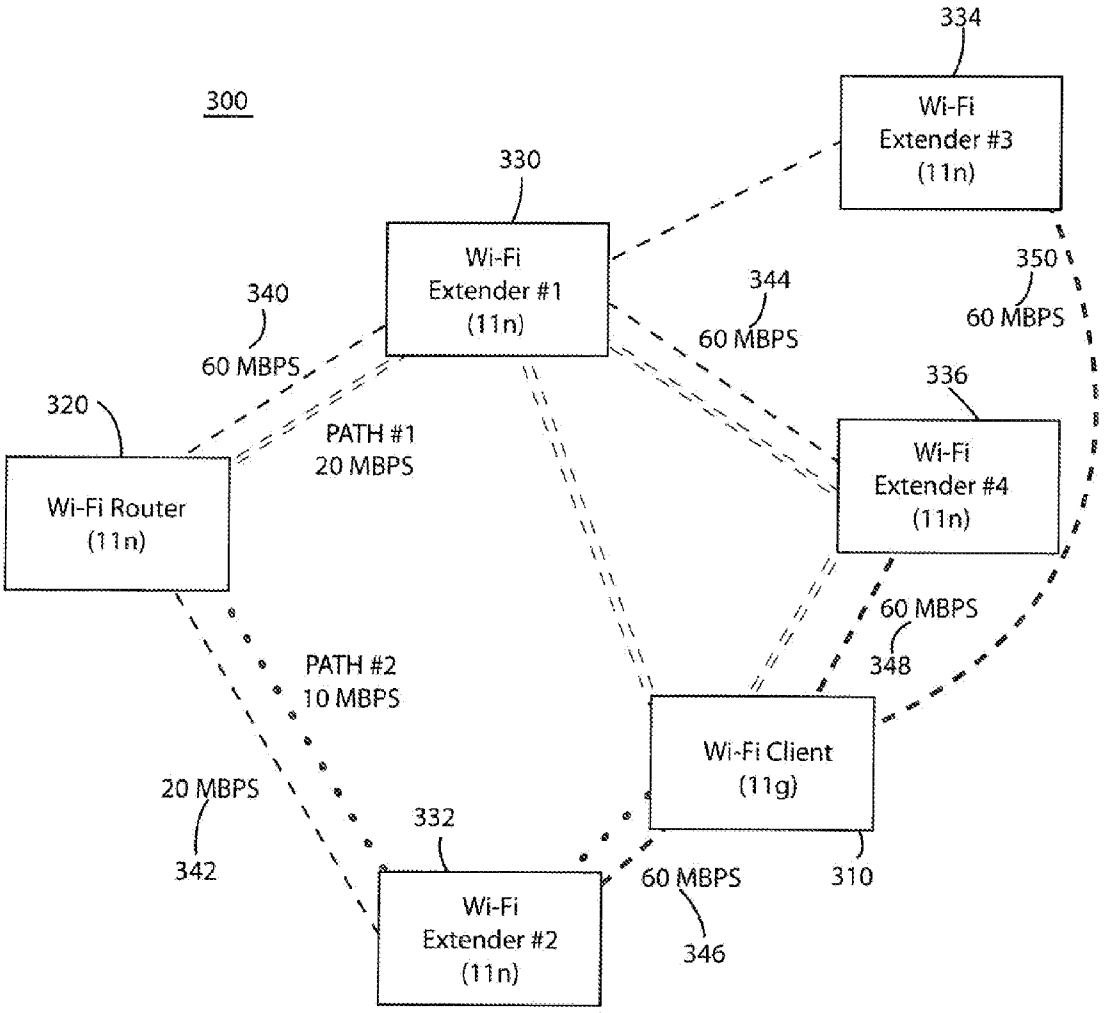

300
334
Wi-Fi
Extender #3
(11n)
330
Wi-Fi
Extender #1
(11n)
340
60 MBPS
344
60 MBPS
350
60 MBPS
320
Wi-Fi Router
(11n)
PATH #1
20 MBPS
336
Wi-Fi
Extender #4
(11n)
60 MBPS
348
PATH #2
10 MBPS
Wi-Fi Client
(11g)
20 MBPS
342
332
Wi-Fi
Extender #2
(11n)
60 MBPS
346
310

FIG. 3B

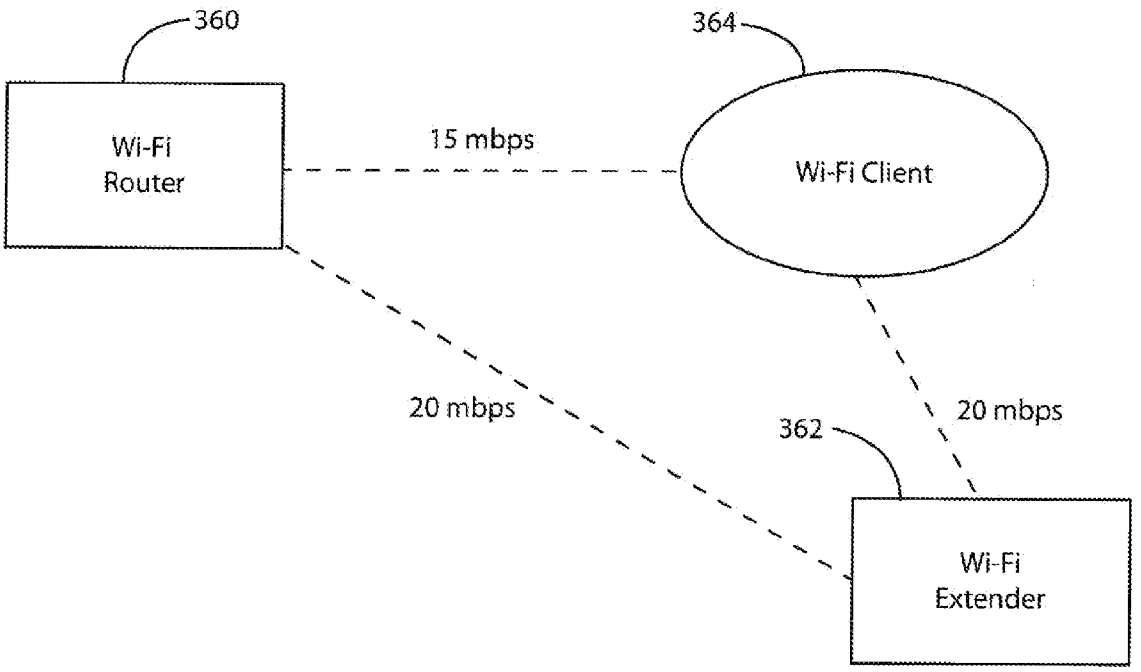

360
364
Wi-Fi
Router
15 mbps
Wi-Fi Client
20 mbps
20 mbps
362
Wi-Fi
Extender

FIG. 3C

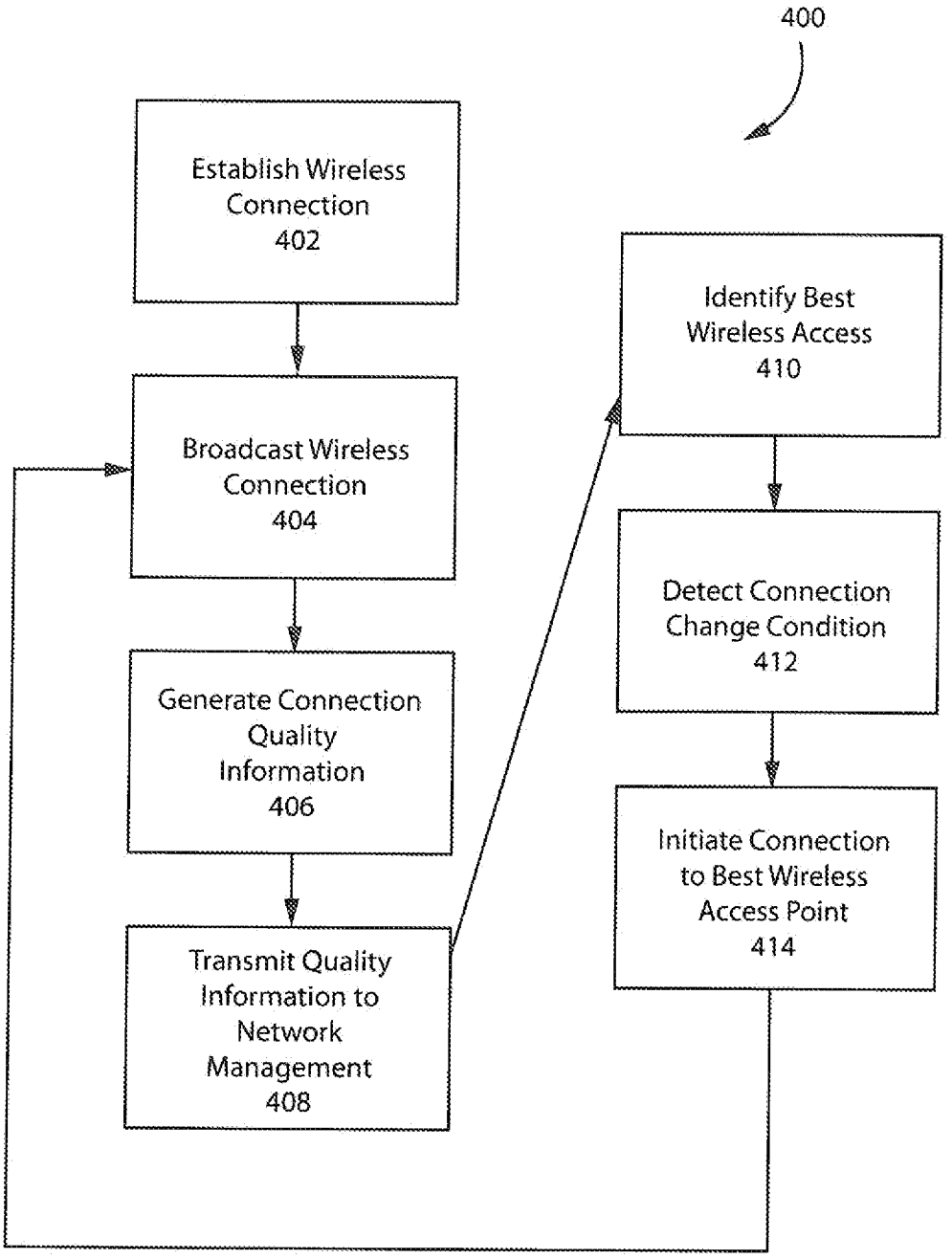

400
Establish Wireless Connection 402
Broadcast Wireless Connection 404
Generate Connection Quality Information 406
Transmit Quality Information to Network Management 408
Identify Best Wireless Access 410
Detect Connection Change Condition 412
Initiate Connection to Best Wireless Access Point 414

FIG. 4

SYSTEM AND METHOD FOR CONFIGURING DEVICE CONNECTIONS IN AN EXTENDED NETWORK ENVIRONMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] None.

FIELD OF INVENTION

[0002] This invention generally relates to the field of providing a network connection between a network device and one of a plurality of wireless access devices in a network environment and more particularly to a system and method for providing a network connection between a network device and one of a plurality of wireless access devices based on the detection of an alternative access point providing one or more advantages over a current access point.

BACKGROUND OF THE INVENTION

[0003] In computer networking, a wireless access device (WAP) is a device that allows wireless devices to connect to a wired or wireless network using a wireless communication protocol, such as Wi-Fi or Bluetooth. The wireless access device typically connects to or is implemented as a component of a muter connected to a wired external network, such as a local network or the Internet. A wireless access device connected to or implemented with a router is referred to as a WiFi router. A network device connected to an external network is referred to as a "gateway," while a wireless access device connected to an external network may be referred to as a "gateway wireless access device" or a "gateway." So a "gateway" device referenced in this document can have a wireless interface or have no wireless interface, but it is a device connecting the internal network and the external network.

[0004] Wireless access devices utilize a wireless connection between the wireless device and the wireless access device to transfer data. The area in which a wireless connection between the wireless device and the wireless access device can be established and maintained is the wireless coverage area or simply the "coverage area." HOW ever, even within the coverage area, the speed at which the data is transferred is dependent on the quality of the wireless connection. A high quality wireless connection relies on multiple different wireless connection quality factors. For example, the quality of a wireless connection may be determined based on the signal strength that exists between the wireless access device and the wireless device. Additionally, the quality of a wireless connection may depend upon communication capability of the devices, determined by the wireless technology implemented on each device. For example, different devices implement different communication protocols, have different processing power, have different antenna configurations, etc. Users and provider of wireless access device continuously strive to maximize the quality of their wireless connection, particularly when using data intensive applications such as video streaming, telephony applications, etc.

[0005] Often, the area where a user wishes to use his or her wireless device is larger than the area providing a high quality wireless connection to the wireless access device. For example, the signal strength decreases based on the distance between the wireless access device and the wireless device. Additionally, certain areas that would otherwise receive a high quality wireless connection are subject to interference that reduces the quality of the wireless connection. Accordingly, users may add additional wireless access devices to their network, such as a WiFi extender, to increase the area where the user can maintain a high quality wireless connection.

[0006] WiFi extenders typically are similar to wireless access devices, but do not include an integral router connected to the external network. Instead, WiFi extenders typically rely on wired or wireless connections to the WiFi router to connect to the external network. The coverage area in which a user can connect to at least one wireless access device is considered the "extended network environment." A network including both a gateway wireless access device and one or more extender wireless access devices is referred to as an "extended network."

[0007] A WiFi extender is a wireless access device for wireless devices to connect to a network. Additionally, the WiFi extender acts as a wireless device to connect to another wireless access device in order to connect to a network. The "another wireless access device" may also be referred to as an "upstream wireless access device". Usually, a WiFi extender uses a single radio frequency device component to connect to both the wireless devices and the upstream wireless access device. Further, in order to avoid had performance, the radio frequency device has to work in the same frequency to connect to the wireless devices as well as to connect to the upstream wireless access device. In such a usage, when a wireless device transmits or receives data from the upstream wireless access device, the transmission between the upstream wireless access device and the WiFi extender and the transmission between the WiFi extender and the wireless device share the same frequency. Assuming there is no other usage on this frequency, the two transmissions must divide the time of using the frequency and so the end to end throughput is not as high as the wireless device can see from its connection to the WiFi extender. For example, if the speed between the wireless device and the WiFi extender and between the WiFi extender and the upstream wireless access device are the same like 100 mbps, then the speed for transmitting data between the wireless device and the upstream wireless access device is cut in half, like to become around 50 mbps.

[0008] Typically, wireless devices establish a connection with a single wireless access device in an extended network based on a determination of which wireless access device will provide the highest quality wireless connection. The single wireless access device having a wireless connection to the wireless device is referred to herein as a "current wireless access device." Once established, this wireless connection is maintained between the wireless access device and the wireless device until the connection is lost or degrades below a threshold quality level. The connection may be lost or degraded when the wireless device moves out of range of the wireless access device, moves to a location where there is interference, etc. Thereafter, the wireless device will attempt to establish a new wireless connection; again with whichever wireless access device will provide the highest quality wireless connection.

[0009] However, wireless devices often are transported to various areas within a coverage area covered by multiple wireless access devices without ever losing their connection to their current wireless access device. Because of variations in the quality of the wireless connection within the coverage

area, users may not always be connected to the wireless access device that will provide the highest quality wireless connection. For example, a wireless device user connected to a first wireless access device may move to location that is remote from that wireless access device (although still maintaining a wireless connection), but is very close to a second wireless access device (that would provide a higher quality wireless connection at the new location). As a result, the wireless device will receive a signal that is weaker than optimal.

[0010] In a home network, there is a router or gateway that connects the internal network, the home network, and the external network, the Internet. For a home network where there is more than one wireless access device for a wireless device to reach the gateway or the external network, almost no wireless device knows which wireless access device can give it better connection to the network. This is because a wireless device does not know which access device has a better connection to the router/gateway and the interpretation of speed for different access devices could be different. For example, when a client sees one connection of 10 mbps from one access device and one connection of 7 mbps from another access device. If the 10 mbps connection is from a gateway, then it is a better connection than the other. If the 10 mbps connection is from an extender, as elaborated in [0007], the connection speed from the wireless device to the gateway (the upstream access device) could be just 5 mbps, and so the 7 mbps direct connection to the gateway is actually the better connection. In a general way, a home network has a tree topology. The root is the router/gateway, the nodes are extenders, and the leaves are wireless devices or wired devices. The whole tree is connected to the Internet through the router/gateway at the root. There could be multiple extenders connecting to the router/gateway directly and there could be extenders connecting to an upstream extender and then connecting to the router/gateway indirectly. For a wireless device, the connection quality provided by each node in the tree, including the root if it is a gateway wireless access device, is determined by not only the node's signal strength to the device, the wireless capability of the node . . . but also the connection quality between the node and the root.

[0011] What is needed is a system and method for configuring wireless connections in an extended network environment that optimizes connection quality to a wireless device in the coverage area. What is further needed is such a system and method configured to continuously monitor wireless connections between a wireless device and a plurality of wireless access devices to optimize the quality of a wireless connection to the wireless device.

SUMMARY

[0012] A wireless access device may be configured to determine wireless connection quality information for a wireless device in comparison to at least one other wireless access device. To achieve this functionality, a wireless access device can monitor all packets sent from the wireless device at a certain time for a certain period, even when the wireless device is not connected to the wireless access device or the wireless packets are not intentionally transmitted to the wireless access device. Advantageously, each wireless access device can contribute to the process of identifying the wireless access device providing the highest quality wireless connection based on wireless connection quality information transmitted by or exchanged among the wireless access devices.

[0013] According to one embodiment of the invention, a network device is configured to facilitate wireless connection management in an extended wireless network. The network device includes a network device input connected at least indirectly to an internal network and configured to communicate a plurality of packets to and from at least one computer system, a network device output connected at least indirectly to an external network and configured to communicate the plurality of packets to and from at least one computer system. The network device could also be a device that includes a network device input connected directly to one or more wireless devices or wireless access devices and configured to communicate a plurality of packets to and from at least one computer system, a network device output connected at least indirectly to a network and configured to communicate the plurality of packets to and from at least one computer system (the network device input and the network device output could actually use the same hardware device). In addition, such a network device also includes a computer processor configured to execute steps stored in non-volatile memory. The computer processor is configured to receive packets from a wireless device, identify the wireless device within a table of wireless devices communicating with at least one wireless access device in an extended wireless network, and generate wireless connection quality information for the wireless device specific to the wireless access device that received the packets based on the received packets and based on the knowledge of the network topology related information.

[0014] In one embodiment, the computer processor is further configured to transmit the wireless connection quality information and partial network topology information to other wireless access devices in the network.

[0015] In another embodiment, the computer processor is further configured to exchange wireless connection quality information and partial network topology information with a plurality of other network devices and to identify a network device in the extended network providing the highest quality wireless connection for the wireless device. The processor may be further configured to exchange messages with other network devices to initiate a connection between the wireless device and the network device having the highest wireless connection quality.

[0016] In another aspect, the wireless connection quality that is detected includes at least one of a wireless signal strength, a connection capability, a utilization status and a connection patch quality.

[0017] According to another aspect of the invention, an extended network configured to implement an extended management function to identify a wireless access device providing a highest quality wireless connection to a wireless device. The extended network includes a gateway configured to enable communication between the extended network and an external network, at least two wireless access devices in the extended network (one could be the gateway if it is a gateway wireless access device), and at least one wireless device having a wireless connection to a least one of the wireless access devices. The wireless access device includes a processor executing the extended management function to identify the wireless access device providing the highest quality wireless

connection based on wireless connection quality information and topology information exchanged among the wireless access devices.

[0018] According to yet another aspect, a computer implemented method for identifying a wireless access device providing a highest quality wireless connection to a wireless device is described. The method includes monitoring the relative signal strength of packets at a plurality of wireless access devices in an extended network from a wireless device having a current wireless connection to a current wireless access device in the plurality of wireless access devices and generating wireless connection quality information at each wireless access device in the plurality of wireless access devices describing the quality of a wireless connection between the wireless device and the wireless access device.

[0019] Other features and advantages of the invention will become apparent to those skilled in the art upon review of the following detailed description, claims and drawings in which like numerals are used to designate like features.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Preferred exemplary embodiments of the invention are illustrated in the accompanying drawings in which like reference numerals represent like parts throughout, and in which:

[0021] FIG. **1** schematically illustrates an extended networking environment for communicating information between a wireless device and a plurality of wireless access devices, according to an exemplary embodiment;

[0022] FIG. **2** illustrates an embodiment of the gateway wireless access device of FIG. **1**, configured to implement an extended network management function, shown in greater detail, according to an exemplary embodiment;

[0023] FIGS. **3**A-**3**C are schematic illustrations of an extended networking environment including a plurality of wireless access devices configured to implement an extended network management function, according to an exemplary embodiment; and

[0024] FIG. **4** is a flowchart illustrating a method for configuring device connections in an extended network environment, according to an exemplary embodiment.

[0025] Before the embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein are for the purpose of description and should not be regarded as limiting. The use of "including" and "comprising" and variations thereof is meant to encompass the items listed thereafter and equivalents thereof as well as additional items and equivalents thereof.

DETAILED DESCRIPTION

[0026] Referring now to FIG. **1**, a networking environment **100** for communicating information between at least one wireless device **110** and an external network **130** through an extended network **120** is shown. The extended network includes at least a gateway wireless access device **122** and one or more extended wireless access devices **124**. The extended network **120** may further be utilized for communicating information with one or more additional wireless devices (not shown) connected with a wireless access device of the extended network **120**.

[0027] Extended network **120** is a local area network configured to provide wireless communication of information with a plurality of devices and applications in relatively close proximity to each other, such as within a home, school, office building, etc. Wireless devices or "wi-fi clients" **110** communicating through extended network **120** may include a web application running on a personal computing device such as a desktop computer, a laptop computer, a tablet, etc, a smartphone, a game device, or a streaming media player. The web application may include a web browsing application, a video player application, a telephony application, a video telephony application, etc. It should be understood that although specific devices and applications are described, these are merely provided as examples. Any or all of these or other wireless devices **110** could be present in a given extended network **120**.

[0028] The gateway wireless access device **122** of extended network **120** is a type of network device that manages the flow of data between extended network **120** and the external network **130**. Gateway wireless device may comprise, for example, a router, a switch, or a gateway. Functionality described herein as being associated with gateway wireless access device **122** may be implemented using one or more devices. For example, gateway wireless access device **122** may be configured to include a router in communication with a network switch, either of which can be configured to perform some or all of the functions described herein.

[0029] When a data packet is received at either gateway wireless access device **122** or an extended wireless access device **124**, an additional or second type of network device, the wireless access device reads address information in the packet to determine its ultimate destination. In a packet-switched network, a "router" is a device which receives packets on one or more input interfaces and which outputs those packets on one of a plurality of output interfaces so as to move those packets within the network from a source device to a destination device. Each packet includes header information, which indicates the destination device in either extended network **120** or external network **130**. Additional information is provided by the physical layer to the device which receives a packet directly and that information can further include wireless connection quality information, described in detail below with reference to FIG. **2**. The router includes routing information, which associates an output interface with information about the destination device. The router can also perform other operations on packets, such as rewriting the packets' headers according to their routing protocol, or encapsulating the packets om a first routing protocol to a second routing protocol.

[0030] Gateway wireless access device **122** may be a gateway device that provides an exclusive communication channel between extended network **120** and external network **130**. Accordingly, packets transmitted by extended wireless access devices **124** and/or wireless devices using extended network **120**, can be viewed using the gateway wireless access device **122**. Gateway wireless access device **122** and extended wireless access device **124** may further be configured to generate wireless connection quality information transmitted to a certain wireless access device (**122** or **124**) or exchanged among wireless access devices (**122** and **124**), as described below in further detail. Accordingly, some or all wireless access device

(**122** and/or **124**) are further configured to implement an extended network management function for configuring device connections in an extended network environment, as described in detail below with reference to FIG. **2**.

[0031] External network **130** may be a wide area telecommunication network covering a broad area, such as the Internet. External network **130** may be connected to network device **120** using a wired or wireless connection. For example, gateway wireless access device **122** may be connected to the external network **130** via a high-bandwidth connection such as a cable modern, a Digital Subscriber Line (DSL) modern, or a 3G/4G Long Term Evolution (LTE) modern connection to send and receive data with systems through external network **130**.

[0032] External network **130** allows communication with one or more of a plurality of external systems including, for example an external web site, an external computing system, and/or an external database. These systems and applications may be accessible using an Internet Protocol address provided by any of the wireless devices on extended network **120** and used by network device **120** to determine a destination for data transmitted to and/or from extended network **120** to external network **130**.

[0033] In operation, each wireless access device **122**, **124** in extended network **120** is configured to monitor, store, and/or report wireless connection quality information. The wireless connection quality information may be generated at the wireless access device **122** or **124** and/or included in packet headers received at the wireless access device. For example, each access point is configured to monitor the link rate of packets sent from the wireless device **110** and to check the signal strength it receives for those packets, no matter which wireless access device the packets are intentionally transmitted to. Accordingly, each wireless access device can provide wireless connection quality information indicating signal strength from the wireless device **110** and corresponding link rate for packets from the wireless device.

[0034] Each wireless access device **122** or **124** in extended network **120** may be further configured to periodically review the wireless connection between the wireless access device and any wireless devices communicating with the wireless access device. The connection check may be performed periodically such as every 5 seconds, based on a reported connection issue, such as an unusually slow connection, etc. A wireless access device can send and receive wireless connection information and a partial network topology with other wireless access devices periodically in an attempt to identify a better connection for a wireless device. In addition, a wireless access device can also monitor an existing connection to identify if the connection with a wireless device becomes bad. If the connection does become bad, the wireless access device starts looking for another wireless access device in the extended network that can provide better a better connection for the wireless device.

[0035] The wireless connection quality information received from the wireless device **110** may be stored in a memory of the wireless access device **122** or **124** and/or forwarded to a central repository, such as the memory for gateway wireless access device **122**. The wireless connection quality information may be either a simple value, such as a connection speed, or a number of different values, such as connection speed and other quality information for the extended network **120**, including the quality for connections between two wireless access devices, for example, for the connection between the gateway wireless access device **122** and an extended wireless access device **124**. The wireless connection quality information may be forwarded when it is received, may be periodically forwarded in a batch operation, may be aggregated to provide wireless connection quality information over a defined period of time, etc. Advantageously, the stored wireless connection quality information may be used to determine the particular wireless access device **122** or **124** that can provide the highest quality wireless connection to the wireless device **110** at any particular time. Using the network management system described herein, extended network **120** may be configured to utilize any tree topology including a gateway wireless access device **122** as a root, such as a hub/star configuration, a cascaded configuration, etc.

[0036] For example, in a tree topology, the extended network is configured in a tree topology including a gateway device as a root, one or more wireless access devices as nodes in the tree, and a wireless device as a leaf. The network tree topology can have several levels and each level can have several nodes. A node or a wireless access device connects to the network by connecting to its upstream node or wireless access device. A wireless access device can connect to its upstream node in any of a variety of different ways, for example through a wired connection (e.g. Ethernet, and the wireless access device is a Wi-Fi AP), through a wireless connection (e.g. Wi-Fi, and the wireless access device is a Wi-Fi extender), etc. in addition, a wireless access device may be configured to have only one wireless interface where it performs multiplexing on the single wireless interface and uses the same wireless to connect to the extended network as well as to wireless devices. One example of such a device is a Wi-Fi single-band extender.

[0037] Although the wireless device **110** will be connected to a single wireless access device **122** or **124** through an existing wireless connection, designated as the "current wireless access device." Establishing a wireless connection may include performance of a handshake protocol and the exchange of data packets as is well known in the art. Once a wireless connection is established, the wireless access device establishing the connection is considered the current wireless access device. Although connected with the current wireless access device, each wireless access device **122** or **124** on extended network **120** is configured to receive any packets transmitted to the current wireless access device from the wireless device **110** and store the observed quality information of these packets independent of whether the wireless access device is providing the wireless connection to the wireless device. Depending on the location/position of each access device relative to the wireless device, the observed signal strength at each access device for a packet from the wireless device (to the current access device) is different. In contrast, in a typical wireless network, this information would be discarded as packets from devices that are not transmitted to a wireless access device were dropped by that wireless access device.

[0038] Referring now to FIG. **2**, a gateway wireless access device **122** or simply "gateway" configured to implement an extended network management function as described herein is shown in greater detail, according to an exemplary embodiment. Although gateway **122** is shown in FIG. **2** as including specific components in an exemplary configuration, it is important to recognize that gateway **122** may include more, fewer, and/or a different configuration of components to

implement the functions described herein. Further, although the functionality described herein is described as being implemented on a gateway device, the extended network management function can be implemented on a gateway device **122** and/or an extender access device **124**. In addition, an implementation may be centralized on one device or distributed among a plurality of devices. For simplicity, the functionality will be described herein below with reference to implementation on a gateway **122**.

[0039] The functional components (not shown) of gateway **122** may be implemented using hardware including a processing unit, a system memory, and a system bus that couples various system components, including the system memory, to the processing unit. The system bus may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. Further, the described components may be implemented using hardware and/or software.

[0040] The processing unit may be any type of computer processor configured to implement the functionality described herein including the steps of identifying advertising content requests in network packets transmitted through gateway **122**. The processing unit may be any type of processor, such as a MIPS processor.

[0041] The system memory of gateway **122** includes computer storage media in the form of volatile and/or nonvolatile memory such as read only memory (ROM) and random access memory (RAM). A basic input/output system (BIOS), containing the basic routines that help to transfer information between elements within gateway **122**, such as during start-up or networking operations, is typically stored in ROM. RAM typically contains data and/or program modules that are immediately accessible to and/or presently being operated on by the processing unit. The gateway **122** may also include other removable/non-removable, volatile/nonvolatile computer storage media, such as flash memory. Although gateway **122** is shown and described herein as including memory, gateway **122** may alternatively be implemented to store information in a network storage device.

[0042] Although gateway wireless access device **122** may be any of a variety of types of network devices, for clarity access point **122** is further described herein as a router type network device. Gateway wireless access device **122** includes a wireless client interface **202**, a wireless connection analyzer **204**, an extended network management system **206**, an extended network management table **208**, and an extended network interface **224**. Although network device **122** is shown as including, a number of functional embodiments represented as separate components, it should be understood that the same functional component may be used to implement one or more of the functional embodiments.

[0043] Wireless client interface **202** is an input/output port receiving/transmitting packets from/to the wireless devices **110**. Extended network interface **224** is an input/output port receiving/transmitting packets from/to the extended network **120**. Extended network interface **224** connects the access device to the extended network. Extended network interface **224** can be an Ethernet port, a wireless transmitter, or another device for receiving/transmitting packets from/to extended network **120**. The physical device for the wireless client interface **202** and the extended network interface **224** can be the same. A simple extended access device **124** can be configured to have only one network interface (a wireless interface) such that both wireless client interface and extended network interface are through the only network interface.

[0044] Wireless connection analyzer **204** is a software component configured to analyze and determine wireless connection quality between the wireless access device **122** and a wireless device. Although shown specifically within gateway wireless access device **122**, a wireless connection analyzer **204** is implemented in the extended network **120** on the wireless access devices **122** and **124** in the network. Accordingly, each wireless access device **122**, **124** in the extended network is configured to be able to obtain information used to determine the wireless connection quality between that wireless access device and the wireless devices within the extended network **120**.

[0045] The wireless connection analyzer **204** associated with each wireless access device **122**, **124** is configured to generate a wireless connection quality table entry to be stored in an extended network management table **208**. The specific data used to generate the wireless connection quality table information is described, in further detail below with reference to the extended network management table **208**. The analyzer **204** may generate the table entry based on information received from the wireless device in packet headers, based on data received from components in the wireless access device, such as a signal strength detection system (not shown), based on data received from other wireless access devices in the extended network, etc.

[0046] Each wireless connection analyzer **204** is further configured to generate the wireless connection quality table entry for each wireless device **110** associated with any wireless access device on the extended network. The analyzer **204** associated with each wireless access device **122** or **124** can be configured to generate the table entry independent of whether the associated wireless access device is connected to the wireless device **110**, being used in the connection path to gateway wireless access device **122**, etc. The analyzer **204** associated with each wireless access device **122** or **124** can be further configured to generate the wireless connection quality table entry for each other wireless access device **122** or **124** that connects to it.

[0047] Extended network management system **206** is a software application implemented in a root or central wireless access device for an extended network, such as gateway wireless access device **122**. In an alternative embodiment, network management system **206** may be implemented as a distributed system in a plurality of wireless access devices. Management system **206** is configured to implement a management protocol in the extended mesh network to determine the wireless access device that can provide the highest quality wireless connection to a wireless device at any particular time. Accordingly, management system **206** is configured to store and maintain the extended network management table **208** based on connection quality data received by the wireless access devices in the network and exchanged among wireless access devices in the network. Table **208** may also be generated to include data connection quality data generated locally at each wireless access device **122** or **124**.

[0048] Extended network management table **208** is generated and stored with the memory of gateway **122** and/or any other wireless access device. Table **208** includes a unique wireless access device record **210** for each wireless access device **122**, **124** communicating through the extended network **120**. Each record **210** includes a plurality of wireless connection quality table entries **212**, one for each wireless

device in the extended network **120**. Accordingly, table **208** may be stored and maintained in memory remote from device **122**, such as would be implemented in a cloud computing environment.

[0049] Each wireless connection quality table entry **212** in the network management table **208** is specific to the wireless connection between one wireless access device **122** or **124** and one wireless device **110**. Accordingly, table entries **212** include a wireless access device identifier **214**, a signal strength data field **216**, and a wireless capability field **218** for the wireless device **110**. Each wireless access device record **210** for a wireless access device **122**, **124** includes a utilization status data field **220** for each wireless band (e.g., 2.4 GHz, 5 GHz), a noise field **222** for each wireless band, a wireless capability field **224** for the wireless access device, and a connection path quality data field **226** describing the connection path for each wireless access device **124** in the path to the gateway wireless access device **122**, (i.e., determined by the connection quality between any two contiguous wireless access devices on the path between the current wireless access device and the gateway wireless access device **122**). For the gateway wireless access device **124**, this field is set to the highest value in the extended network **120**.

[0050] According to a specific implementation, table **208** includes one record **210** for each wireless access device in the extended network. In each record for an access device, there is a table for the wireless clients connected to that access device. Each table entry **212** corresponds to a wireless client connected to the access device. Some fields (**214**, **216**, **218**) are associated with a table entry since they are specific to a wireless client, while other fields (**220**, **222**, **224**) are associated with a record since they are not specific to a wireless client but are specific to a wireless access device.

[0051] Extended network management system **206** is configured to identify the wireless access device that can provide the highest quality wireless connection with a wireless device at any given time. According to exemplary embodiment, management system **206** identifies highest-quality wireless connection based on at least the capability of the wireless device **110**, the capability of the gateway wireless access device **122**, and the capability of each wireless access device **122**, **124** in the extended network **120**, the path quality from the wireless access device to the gateway, etc.

[0052] Referring now also to FIG. **3**A, a schematic illustration of an exemplary extended wireless network **300** network topology including a wireless device **310**, a gateway wireless access device **320** in the form of a router, and extended wireless access devices **330**-**336** is illustrated. The network topology may be generated based on exchanged messages communicated between the components of network **300**. Each message may include a partial network topology based on the messages received by the component that is transmitting the topology.

[0053] Extended wireless network **300** further includes a representation of connection speed **340**~**350** between wireless communication elements within the extended network **300**. Accordingly, the connection speed **340** between gateway wireless access device **320** and a first extended wireless access device **330** is 60 Mega bits per second (Mbps), while the connection speed **342** between gateway wireless access device **320** and a second wireless access device **332** is 20 Mbps. The connection speed is dependent on several factors, including at least the hardware and software installed on each endpoint (i.e. the connection type and the capability of each endpoint) and the distance between the endpoints if it's a wireless connection.

[0054] Where wireless device or "Wi-Fi client" **310** is positioned at a first location **308** as shown in ghost form in FIG. **3**A, the wireless device **310** may be already connected to the extended wireless access device **334**. The wireless connection is designated as **350**. However, management system **206** will continually evaluate available wireless connections while the wireless device **310** is moving.

[0055] For example, when the wireless device **310** moves to the second location depict in FIG. **3**A, (location #2), the wireless connections **350** becomes weak and the wireless device **310** may suffer from the weak wireless connection. Dependent on the wireless device **310**'s implementation, wireless device **310** may determine if the wireless device **310** needs to try to a different wireless access device to get a better connection based on any of a variety of factors. Such continuous searching for an optimal connection is referred to as roaming in the wireless environment. For example, some implementations are configured to use the existing connection to avoid disruption until that connection is too weak to maintain the connection. The weak wireless connection **350** may be identified by the wireless access devices **334** based on detected poor signal strength between the wireless access device **334** and the wireless device **310**. The poor signal strength information may be communicated among the wireless access devices and the management system **206** implemented by each wireless access device **122**, **124** will put the poor signal strength information in its table as discussed above.

[0056] Further, at the second location, wireless device **310** may have a good wireless connection if it connects to wireless access device **336** or wireless access device **332**. This can be detected by the wireless access device **332**, **336** by monitoring the signal strength from all the wireless packets sent from the wireless device **310**, even if the packets are not transmitted to the wireless access device **332**, **336** intentionally. Accordingly, management system **206** is configured to check if the wireless access device **332** or **336** can provide a better connection to the wireless device **310**. Generally, the connection speed for a wireless device **310** to the gateway wireless access device **320** is determined by determining the lowest speed among all links (between any two contiguous devices) in the connection path between that wireless device and the gateway wireless access device **320**, divided by the number of links between the gateway wireless access device **320** and the wireless device the network device **310**. Accordingly, at the second location, the lowest speed in the connection path through wireless access device **336** (path#1) is 20 Mbps, and the connection speed for path#1 is 20 Mbps divided by the three links, which gets 6.67 Mbps. In contrast, while the lowest speed in the connection path through wireless access device **332** (path#2) is also 20 Mbps, the connection speed for path#2 is 20 Mbps divided by the two links, which gets 10.0 Mbps. Accordingly, management system **206** will initiate a wireless connection between the wireless access device **332** and the wireless device **310** based on the higher 10.0 Mbps connection speed.

[0057] However, referring now to FIG. **3**B, where if the wireless device **310** is capable of creating connections with a higher speed to the wireless access device **332** and **336**, and the connection speed **346** and **348** for the wireless connection between wireless device **310** and wireless access device **332**,

336 is both 60 Mbps. The higher speed of the link will result in a higher connection speed for the path#1 and the consequent connection speed is 60 Mbps divided by 3, which gets 20.0 Mbps. However the connection speed for the path#2 remains at 10 Mbps, even the connection speed **346** has been increased to 60 mbps. That is due to the connection **342** now becomes the bottleneck of the path#2 and that keeps the connection speed for path#2 on 10 Mbps. Accordingly, management system **206** will initiate a wireless connection between the wireless access device **336** and the wireless device **310** based on the higher 20.0 Mbps link rate.

[0058] Referring now to FIG. **3**C, a schematic illustration of another exemplary extended wireless network **300** including a wireless device **364**, a gateway wireless access device **360** in the form of a router, and an extended wireless access devices **362** is illustrated. If the wireless device **364** connects to the wireless access device **362**, the connection speed between the wireless device **364** and the gateway wireless access device **360** is 20 mbps divided by 2, which is 10 Mbps. If the wireless device **364** connects to the gateway wireless access device **360** directly, the connection speed is 15 Mbps. The management system **206** will consider the wireless access device **360** provides a better connection for the wireless device **364**, even though, from the wireless device **364**'s point of view, the wireless access device **362** provides a better connection. As shown in FIG. **3**C, in a wireless extended network, a wireless device has multiple wireless access devices to connect to and a wireless access device that has stronger signal may not be a better choice to provide a faster connection speed to the gateway device.

[0059] Referring now to FIG. **4**, a flowchart **400** illustrating a method for implementing the extended network management system **100** of FIG. **1** to identify a high quality wireless connection for a wireless device **110** is shown, according to an exemplary embodiment. Although flowchart **400** includes multiple steps performed in a defined order, the functions described herein can be performed using more, less and/or a different ordering of steps.

[0060] In a first step **402**, wireless device **110** (FIG. **1**) creates a wireless connection with one wireless access device **122** or **124** in the extended network **120**. The wireless connection may be created based on an initial use of the wireless device **110**, based on establishment of a new connection following a loss in connection, based on a specific elapsed time, etc. Establishing a wireless connection may include performance of a handshake protocol and the exchange of data packets as is well known in the art. Once a wireless connection is established, the wireless access device establishing the connection is considered the current wireless access device.

[0061] In a step **404**, upon establishment of the wireless connection, the current wireless access device, including at least gateway wireless access device **122** and possibly additionally including one or more extended wireless access devices **124**, is configured to transmit the establishment of the wireless connection and the identity of the wireless device to other access devices within the extended network **120**.

[0062] In a step **406**, each wireless access device in extended network **120** that is within wireless range of the wireless device **110** will begin receiving data packets from the wireless device **110** based on the wireless connection to the current wireless access device. Generally, wireless access devices in extended network **120** other than the current wireless access device will not process the data packets transmitted to the current wireless access device they typically discard those packets. However, based on the received data packets, each wireless access device in extended network **120** is configured to generate wireless connection quality information describing a real or theoretical wireless connection between that wireless access device and the wireless device **110**. Step **406** may be performed for an indefinite time or a defined period of time, such as 3 seconds.

[0063] In a step **408**, each wireless access device having wireless connection quality information for wireless device **110** exchanges the generated information with each other wireless access device in the extended network **120**, and those information is kept in a repository such as network management table **208** and/or network management system **206**, described above with reference to FIG. **2**. According to an exemplary embodiment, the repository could be located in the memory of any wireless access device **122** or **124**, such as table **210** of FIG. **2**.

[0064] In a step **410**, the gateway wireless access device **122** or the current wireless access device **122** or **124** analyzes the received wireless connection quality information to identify the wireless access device that can provide the highest quality wireless connection to the wireless device **110**. It is important to recognize that the highest quality connection may vary dependent upon the intended use of the wireless connection. For example, if wireless device **110** is utilized to implement an IP telephony application, a link rate may be the primary factor in identifying a high quality wireless connection. Alternatively, if wireless device **110** does not include the capability to manage an excess amount of dropped packets, the wireless connection quality may be identified based on the fewest number of dropped packets.

[0065] In a step **412**, a wireless access device **122** or **124** that does centralized control or the current wireless access device identifies any change in the condition of the wireless connection to the current wireless access device. The connection check may be performed using the method described above with reference to FIG. **1**. Alternatively, the central control wireless access device **122** or **124** or the current wireless access device may be configured to periodically determine whether to change the wireless connection from the current wireless access device to a new wireless access device based on a determination that the new wireless access device can provide a higher quality wireless connection and the connection transfer will not disrupt the applications running on the wireless device **110**.

[0066] In a step **414**, a wireless connection is established to the wireless access device providing the highest quality wireless connection. The connection may be established based on a message transmitted from the central control wireless access device **122** or **124** to the new wireless access device. Alternatively, the connection may be established based on a determination made at the current wireless access device. In either event, the resulting "current" wireless access device may be the same wireless access device to which the wireless device **110** was connected prior to the connection query of step **410** or a different wireless access device. The process then returns to step **404**, where the steps **404**-**414** are repeated on an ongoing basis.

[0067] When a wireless device **110** is joining an extended network **120** (that is, during the step **402**), similar mechanism can also be used to determine the best wireless access device **122** or **124** for the wireless device **110**. When a wireless device **110** attempts to join a network, it usually sends out

some packets to discover the environment and it has to send out a request packet for joining a network. By observing the signal strength from these packets and examining the packet contents, a wireless access device **122** or **124** can estimate the connection quality if the wireless device **110** connects to it. Furthermore, a wireless access device **122** or **124** can estimate the data transmission speed between the wireless device **110** and the gateway wireless device **122** if the wireless device **110** reaches the gateway wireless device **122** through it.

[0068] According to an alternative embodiment, network management system **206** may be implemented as a distributed management system, such that an embodiment of the network management system **206** is resident in every wireless access device within extended network **120**. In such a system, wireless access devices exchange information with each other and each wireless access device is aware of which wireless access device can provide the highest quality wireless connection to the wireless device **110**.

[0069] Certain terminology is used herein for purposes of reference only, and thus is not intended to be limiting. For example, terms such as "network device" refer to any system or device receiving and retransmitting information packets in a computer network.

[0070] References to "a server" and "a processor" can be understood to include one or more controllers or processors that can communicate in a stand-alone and/or a distributed environment(s) and can thus be configured to communicate via wired or wireless communications with other processors, where such one or more processor can be configured to operate on one or more processor-controlled devices that can be similar or different devices. Furthermore, references to memory, unless otherwise specified, can include one or more processor-readable and accessible memory elements and/or components that can be internal to the processor-controlled device, external to the processor-controlled device, and can be accessed via a wired or wireless network. It should be understood that a computer program may embrace constituent programs and that multiple programs may be implemented as a single or multiple programs.

[0071] Various features of the invention are set forth in the following claims. It should be understood that the invention is not limited in its application to the details of construction and arrangements of the components set forth herein. The invention is capable of other embodiments and of being practiced or carried out in various ways. Variations and modifications of the foregoing are within the scope of the present invention. It also being understood that the invention disclosed and defined herein extends to all alternative combinations of two or more of the individual features mentioned or evident from the text and/or drawings. All of these different combinations constitute various alternative aspects of the present invention. The embodiments described herein, explain the best modes known for practicing the invention and will enable others skilled in the art to utilize the invention.

What is claimed is:

1. A network device configured to facilitate wireless connection management in an extended wireless network, comprising:

a network device input connected at least indirectly to an internal network and configured to communicate a plurality of data packets to and from at least one computer system;

a network device output connected at least indirectly to an external network and configured to communicate the plurality of data packets to and from at least one computer system; and

a computer processor configured to execute steps, including

receiving packets from a wireless device,

identifying the wireless device within a table of wireless devices connected to a wireless access device in an extended wireless network,

generating wireless connection quality information for the wireless device specific to the wireless access device.

2. The network device of claim **1**, wherein the computer processor is further configured to transmit the wireless connection quality information to other wireless access devices in the extended network.

3. The network device of claim **1**, wherein the computer processor is further configured to receive wireless connection quality information from a plurality of other network devices and to identify network device in the extended network providing the highest quality wireless connection for the wireless device.

4. The network device of claim **3**, wherein the processor is further configured to initiate a wireless connection between the network device having the highest wireless connection quality and the wireless device.

5. The network device of claim **4**, wherein the processor is further configured to initiate the wireless connection with the network device having the highest wireless connection quality based on a connection check between the network device and the wireless device.

6. The network device of claim **1**, wherein the wireless connection quality information includes at least one of a wireless signal strength, a connection capability, a utilization status, a network topology, and a connection patch quality.

7. An extended network configured to implement an extended management function to identify a wireless access device providing a highest quality wireless connection to a wireless device, comprising:

a gateway device configured to enable communication between the extended network and an external network;

at least two wireless access devices in the extended network; and

at least one wireless device having a wireless connection to a least one of the wireless access devices,

wherein the gateway device and/or wireless access devices include a processor executing the extended management function to identify the wireless access device providing the highest quality wireless connection based on wireless connection quality information transmitted by or exchanged among the wireless access devices.

8. The extended network of claim **7**, wherein the extended network is configured in a tree topology including a gateway device as a root, one or more wireless access devices as nodes in the tree, and a wireless device as a leaf.

9. The extended network of claim **7**, wherein each wireless access device is configured to generate wireless connection quality information for received packets from the wireless device in consideration and to transmit the wireless connection quality information to one or more wireless access devices in the extended network.

10. The extended network of claim **7**, wherein at least one wireless access device is configured to initiate a connection

between the wireless access device having the highest quality wireless connection for the wireless device and the wireless device.

11. The extended network of claim **10**, wherein at least one wireless access device is further configured to initiate the connection to the wireless access device having the highest wireless connection quality based on a connection check between at least one the wireless device and the wireless device.

12. The extended network of claim **10**, wherein the current wireless access device is further configured to check the connection quality for the wireless device on a periodic interval.

13. The extended network of claim **7**, wherein the wireless connection quality includes at least one of a wireless signal strength, a noise level, a connection capability for a wireless device, a connection capability for a wireless access device, an extended network topology, a utilization status and a connection path quality.

14. The connection quality of claim **13**, wherein the connection path quality for a wireless device is the connection quality between the wireless device and the gateway device.

15. The extended network of claim **10**, wherein a first wireless access device is further configured to initiate the connection between the wireless access device having the highest wireless connection quality and the wireless device based on a connection check between at least one wireless access device and the wireless device, wherein the wireless access device having the highest wireless connection quality may be the first wireless access device.

16. A computer implemented method for identifying a wireless access device providing a highest quality wireless connection to a wireless device, comprising

receiving data at a plurality of wireless access devices in an extended network from a wireless device having a current wireless connection to a current wireless access device amongst the plurality of wireless access devices; and

generating wireless connection quality information at each wireless access device in the plurality of wireless access devices describing the quality of a wireless connection between the wireless device and the wireless access device generating the quality information.

17. The method of claim **16**, further including transmitting or exchanging the wireless connection quality information from a wireless access device to/with other wireless access devices in the extended network.

18. The method of claim **17**, wherein at least one wireless access device is configured to initiate a wireless connection between the wireless access device having the highest quality wireless connection for the wireless device and the wireless device.

19. The method of claim **18**, wherein at least one wireless access device is further configured to initiate the wireless connection with the wireless device having the highest wireless connection quality based on a connection check between at least one wireless access device and the wireless device.

20. The method of claim **16**, wherein the wireless connection quality includes at least one of a wireless signal strength, a noise level, a connection capability for a wireless device, a connection capability for a wireless access device, an extended network topology, a utilization status and a connection patch quality.

21. The method of claim **17**, wherein a first wireless access device is further configured to initiate the wireless connection between the wireless access device having the highest wireless connection quality and the wireless device based on a connection check between at least one wireless access device and the wireless device, wherein the wireless access device having the highest wireless connection quality may be the first wireless access device.

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