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(54) MAKING ROAMING DECISIONS BASED ON ASSOCIATION QUALITIES BETWEEN WIRELESS DEVICES AND WIRELESS ACCESS POINTS

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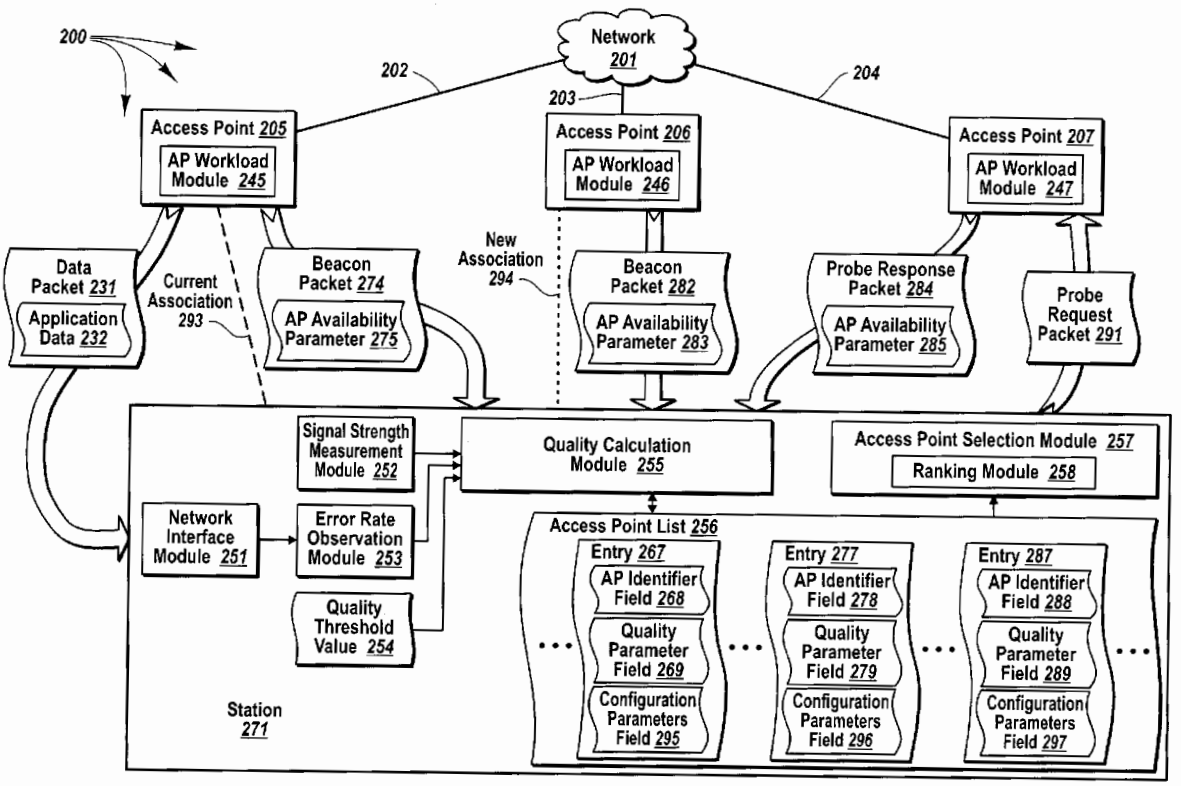
(57) ABSTRACT

The principles of the present invention provides for making roaming decisions based on association qualities between a wireless device and one or more wireless access points. From time to time, the wireless device updates a current association quality for a current wireless access point, for example, based on relative signal strength, observed error rates, and current wireless access point workload. Similarly, the wireless device updates association qualities for any other wireless access points the wireless device can communicate with. If the current association quality falls below a quality threshold, the wireless device roams to attempt to associate with another wireless access point. The wireless device ranks compatibly configured wireless access points based at least in part on corresponding association qualities. The wireless device can attempt to associate with higher ranked wireless access points before lower ranked wireless access points.



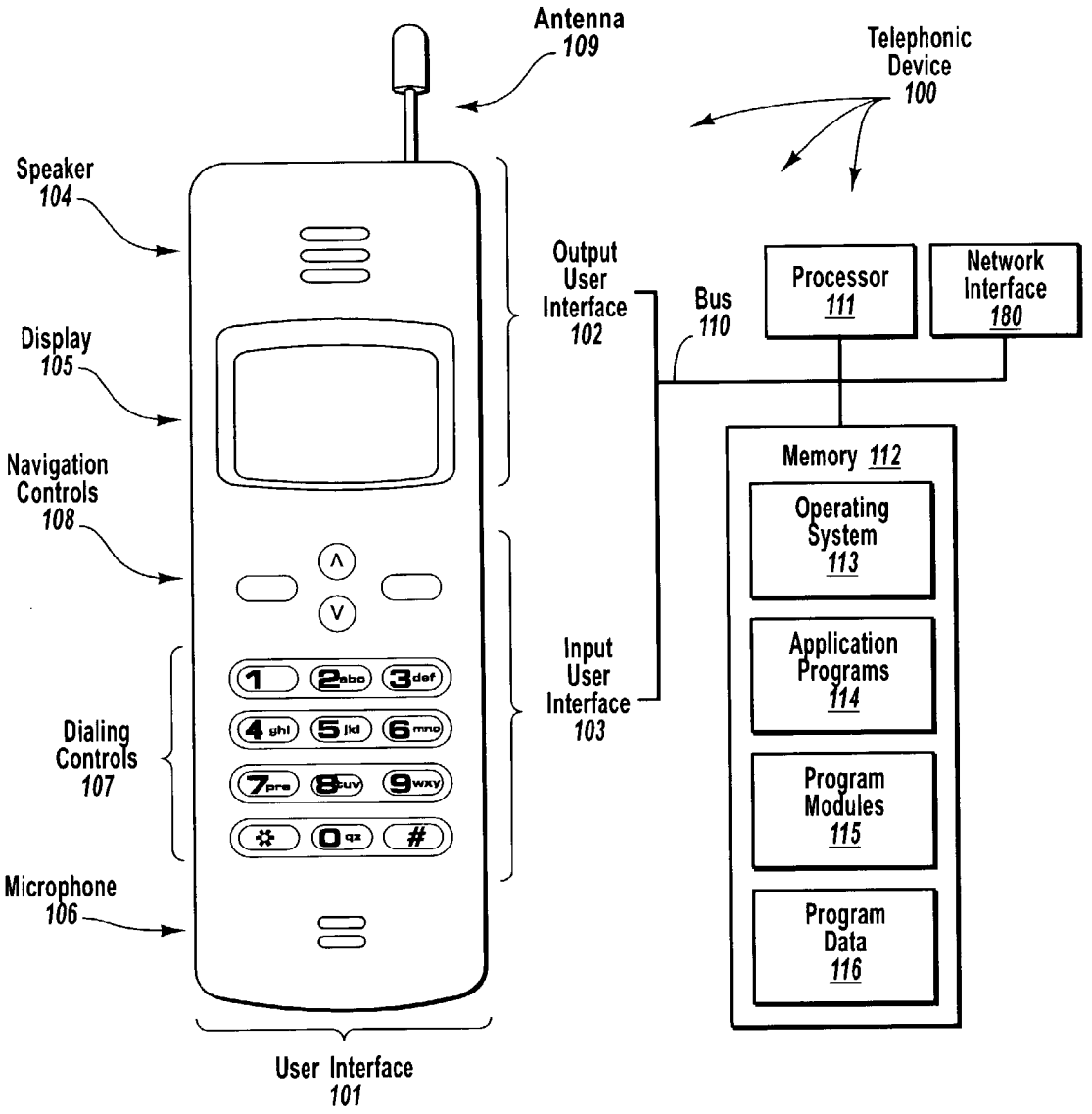

Antenna
109
Telephonic
Device
100
Speaker
104
Display
105
Navigation
Controls
108
Dialing
Controls
107
Microphone
106
Output
User
Interface
102
Input
User
Interface
103
Bus
110
Processor
111
Network
Interface
180
Memory 112
Operating
System
113
Application
Programs
114
Program
Modules
115
Program
Data
116
User Interface
101

Fig. 1

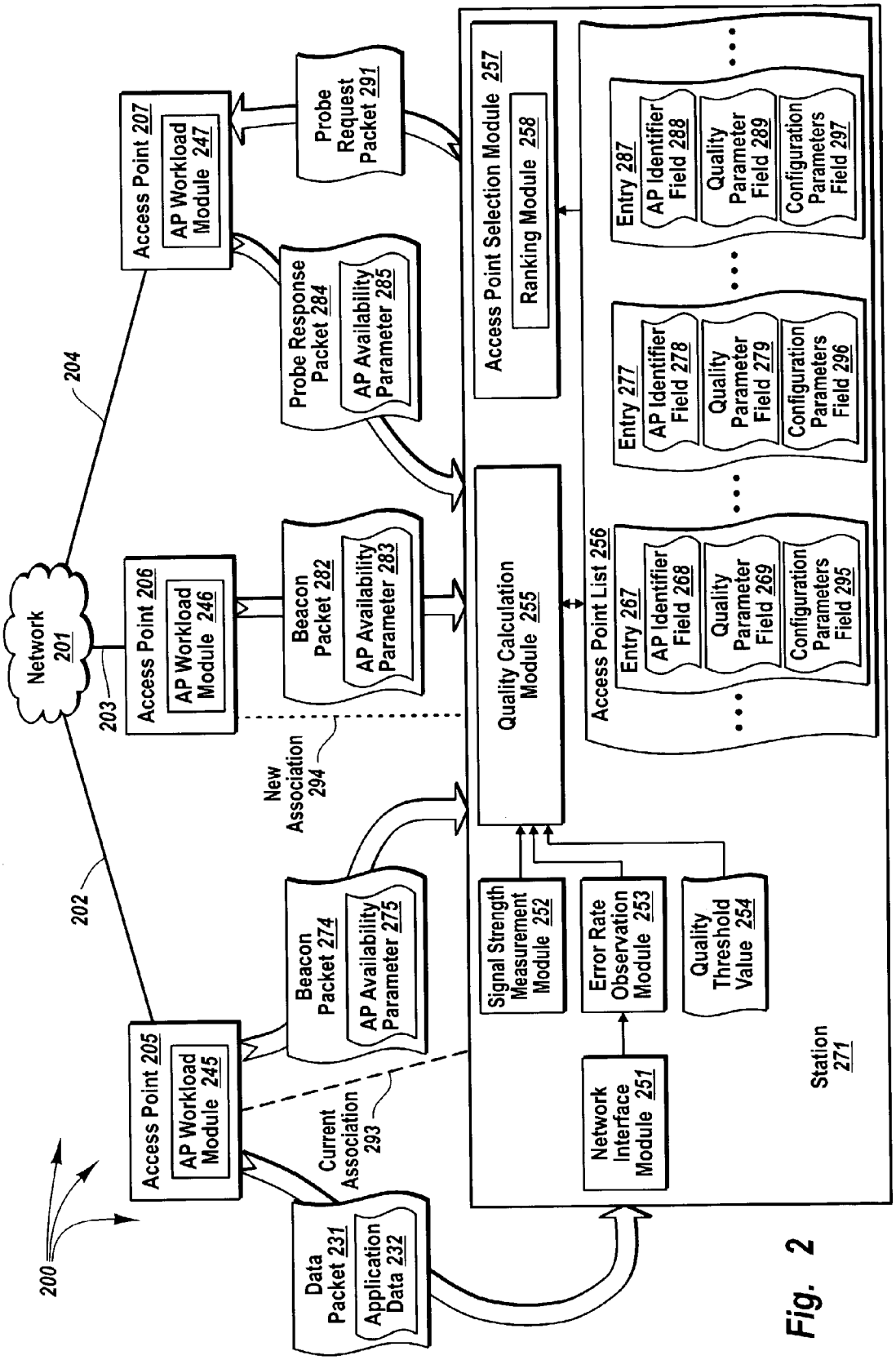

Network 201
Access Point 207
AP Workload Module 247
Access Point 206
AP Workload Module 246
Access Point 205
AP Workload Module 245
Probe Request Packet 291
Probe Response Packet 284
AP Availability Parameter 285
Beacon Packet 282
AP Availability Parameter 283
Beacon Packet 274
AP Availability Parameter 275
Data Packet 231
Application Data 232
New Association 294
Current Association 293
200
202
203
204
Access Point Selection Module 257
Ranking Module 258
Quality Calculation Module 255
Access Point List 256
Entry 287
AP Identifier Field 288
Quality Parameter Field 289
Configuration Parameters Field 297
Entry 277
AP Identifier Field 278
Quality Parameter Field 279
Configuration Parameters Field 296
Entry 267
AP Identifier Field 268
Quality Parameter Field 269
Configuration Parameters Field 295
Signal Strength Measurement Module 252
Error Rate Observation Module 253
Quality Threshold Value 254
Network Interface Module 251
Station 271

Fig. 2

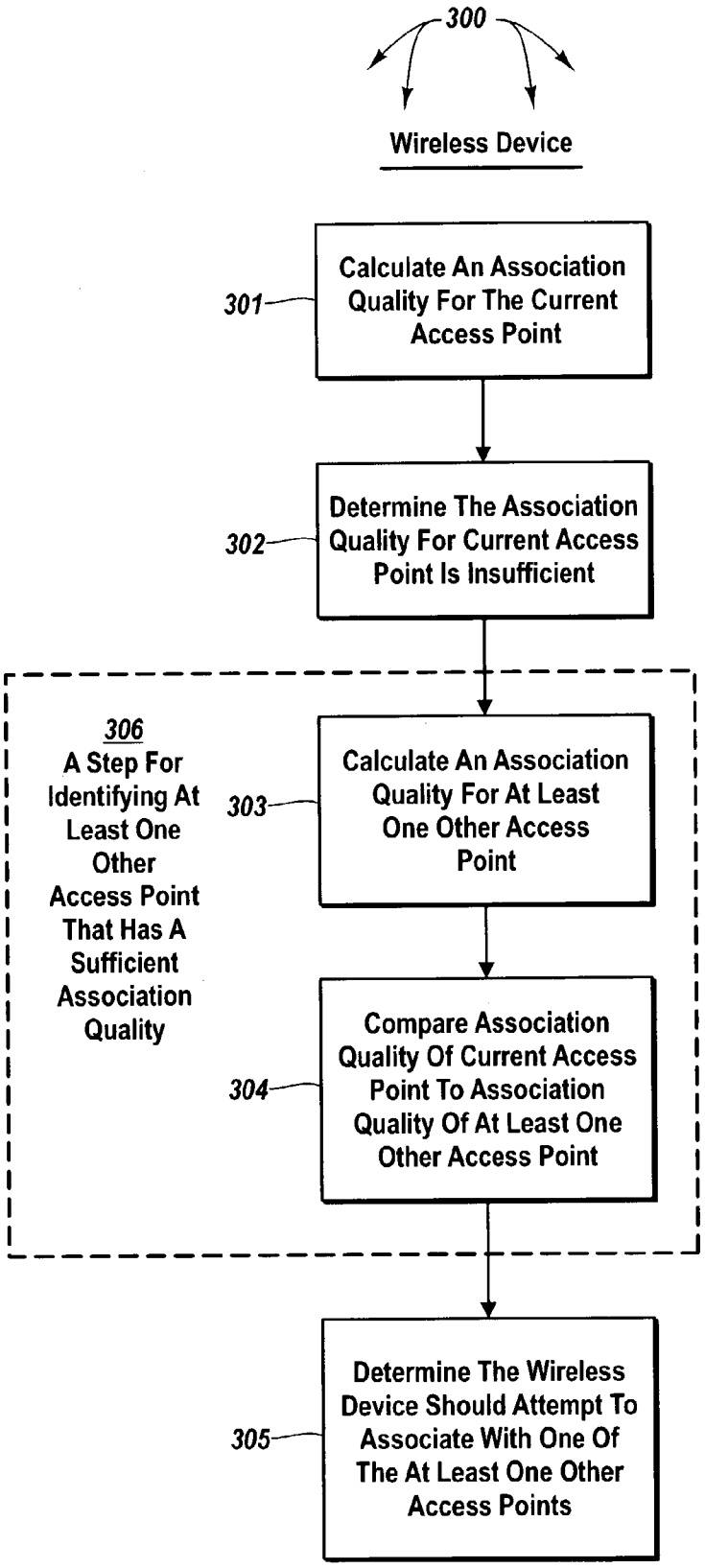

300
Wireless Device
301
Calculate An Association Quality For The Current Access Point
302
Determine The Association Quality For Current Access Point Is Insufficient
306
A Step For Identifying At Least One Other Access Point That Has A Sufficient Association Quality
303
Calculate An Association Quality For At Least One Other Access Point
304
Compare Association Quality Of Current Access Point To Association Quality Of At Least One Other Access Point
305
Determine The Wireless Device Should Attempt To Associate With One Of The At Least One Other Access Points

Fig. 3

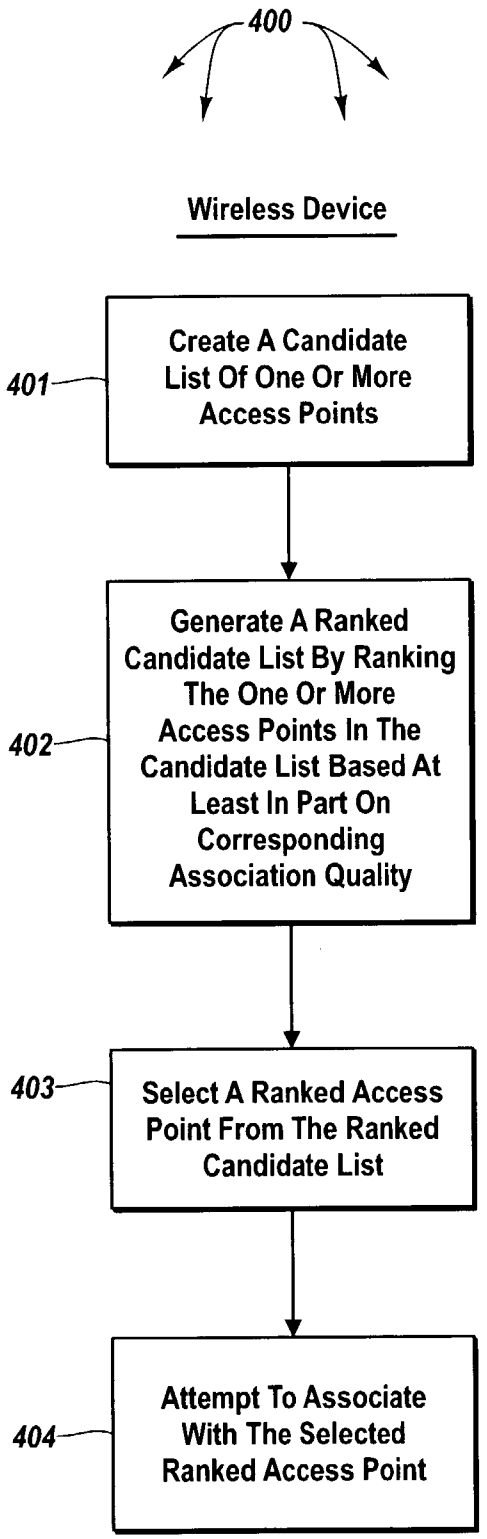

400
Wireless Device
401
Create A Candidate List Of One Or More Access Points
402
Generate A Ranked Candidate List By Ranking The One Or More Access Points In The Candidate List Based At Least In Part On Corresponding Association Quality
403
Select A Ranked Access Point From The Ranked Candidate List
404
Attempt To Associate With The Selected Ranked Access Point

Fig. 4

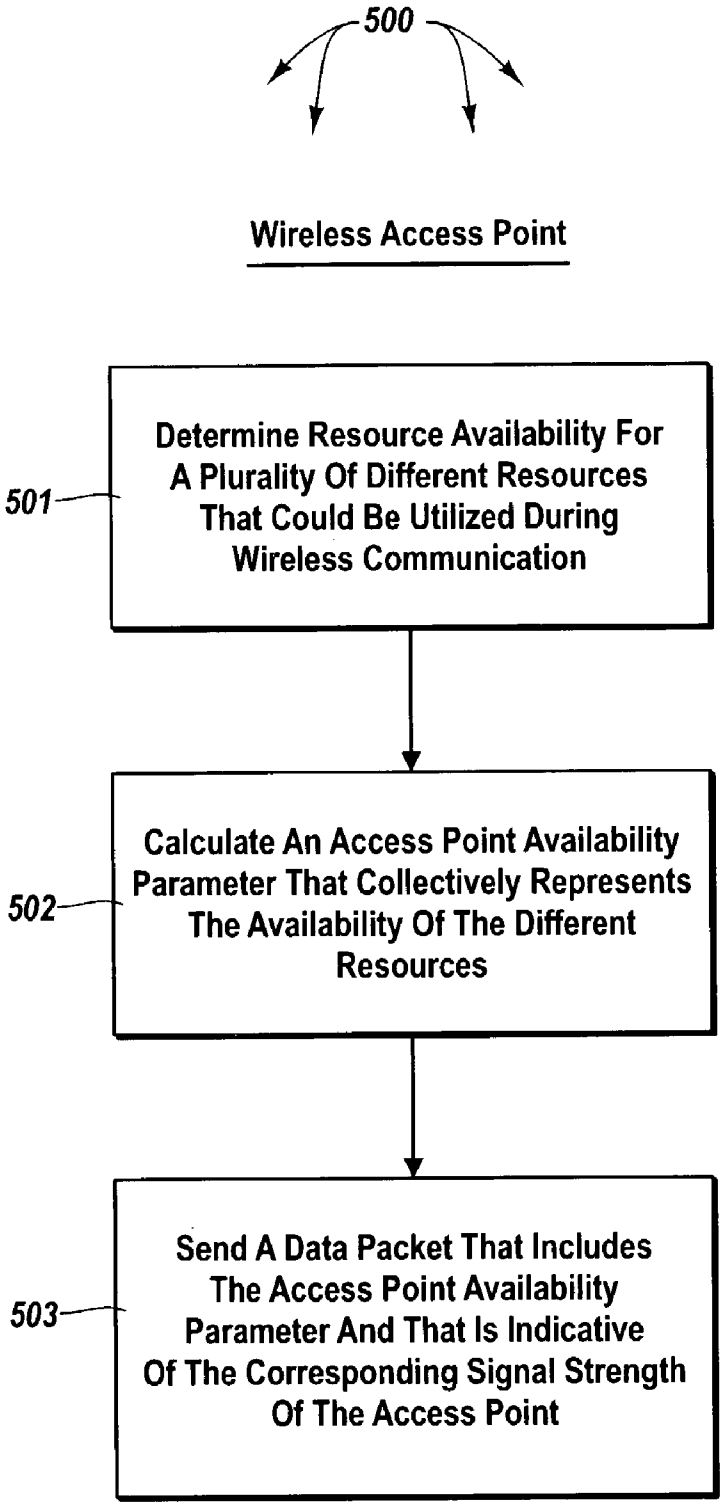

500
Wireless Access Point
501
Determine Resource Availability For A Plurality Of Different Resources That Could Be Utilized During Wireless Communication
502
Calculate An Access Point Availability Parameter That Collectively Represents The Availability Of The Different Resources
503
Send A Data Packet That Includes The Access Point Availability Parameter And That Is Indicative Of The Corresponding Signal Strength Of The Access Point

Fig. 5

MAKING ROAMING DECISIONS BASED ON ASSOCIATION QUALITIES BETWEEN WIRELESS DEVICES AND WIRELESS ACCESS POINTS

BACKGROUND OF THE INVENTION

[0001] 1. The Field of the Invention

[0002] The present invention relates to wireless networks, and more specifically, to a wireless device making roaming decisions based on association qualities between the wireless device and one or more wireless access points.

[0003] 2. Background and Relevant Art

[0004] Computer systems and related technology affect many aspects of society. Indeed, the computer system's ability to process information has transformed the way we live and work. Computer systems now commonly perform a host of tasks (e.g., word processing, scheduling, and database management) that prior to the advent of the computer system were performed manually. More recently, computer systems have been coupled to one another to form both wired and wireless computer networks over which the computer systems can communicate electronically to share data. As a result, many tasks performed at a computer system (e.g., voice communication, accessing electronic mail, electronic conferencing, web browsing) include electronic communication with one or more other computer systems via wired and/or wireless computer networks.

[0005] For example, a number of computer systems can be coupled to a data hub through corresponding wired connections (e.g., category 5 cable) to form a wired network (e.g., an Ethernet segment). Similarly, a number of wireless computer systems (commonly referred to as "stations") can be coupled to a wireless access point ("AP") through corresponding wireless connections (e.g., resulting from appropriate communication between radio transmitters and receivers) to form a wireless network (e.g., an IEEE 802.11 network). Further, a data hub and/or an AP can be connected to other data hubs, APs, or other network devices, such as routers, gateways, and switches to form more complex networks (including both wired and wireless connections).

[0006] Many wireless network environments include a plurality of stationary access points that provide mobile stations with access to a wired network. A mobile station can associate with one of the access points to gain access to the resources on the wired network. For example, a mobile station can associate with an access point that provides access (potentially through one or more other wired components) to the Internet. Once associated, the mobile station and the access point can wirelessly communicate. Accordingly, the access point essentially operates as an intermediary that compatibly translates wireless communication (e.g., IEEE 802.11) into wired communication (e.g., Ethernet) and vice versa.

[0007] However, due to changed conditions, for example, when the mobile station is blocked from a current access point by physical barriers, when the current access point malfunctions, or when the mobile station moves from the vicinity/coverage of the current access point to another access point, communication between the mobile station and the current access point may be degraded or even lost Communication is lost when the signal strength of the access point drops below the receive sensitivity threshold of the mobile station's network interface and thus the mobile station can not receive packets from the current access point. The mobile station may also have a roaming threshold at or near the receive sensitivity threshold.

[0008] When signal strength drops below the roaming threshold, the mobile station may attempt to identify other access points that can provide access to the same wired network (commonly referred to as "roaming"). If other access points are identified, the mobile device can attempt to establish a new association with one of the other access points. However, aside from signal strength dropping below a roaming threshold, few, if any, other events typically cause a mobile station to roam. Thus, a mobile station may maintain an association with an access point even though communication with the access point is substantially degraded and other access points are potentially be available.

[0009] When a mobile station does roam, the mobile station typically identifies access points based almost solely on the access points being able to provide access the same wired network. However, aside from being able to provide access to the same wired network, mobile stations do not typically distinguish between access points. Accordingly, a mobile station typically does not consider the appropriateness of connections that would result from associating with different access points. For example, a mobile station may associate with an access point that provides a connection having increased latency and/or reduced bandwidth, even though other access points could provide connections with reduced latency and/or increased bandwidth. Therefore, it would be advantageous if stations determined when to roam and when to associate with an access point in a more intelligent manner.

BRIEF SUMMARY OF THE INVENTION

[0010] The foregoing problems with the prior state of the art are overcome by the principles of the present invention, which are directed towards methods, systems, computer program products, and data structures for making roaming decisions based on association qualities between a wireless device and one or more wireless access points. A wireless local area network environment includes a wireless device and a number of wireless access points. The wireless device is associated with a current wireless access point from among the plurality of wireless access points such that the wireless device communicates with the current wireless access point to access resources (files, Web pages, etc).

[0011] The wireless device calculates an association quality for the current wireless access point based on a plurality of association parameters relevant to the quality of the current association. Some association parameters can be calculated from measurements taken at the wireless device. For example, the wireless device can calculate relative signal strength and an error rate corresponding to the current wireless access point by measuring data packets received from the current wireless access point. Other association parameters can be received from a providing wireless access point (e.g., the current wireless access point).

[0012] A providing wireless access point determines resource availability for a number of different resources, such as, for example, radio frequency ("RF") resources, memory resources, and processor resources, that are poten-

tially utilized during wireless communication with the providing wireless access point. The providing wireless access point calculates an AP availability parameter that collectively represents the availability of the number of different resources. The providing wireless access point sends a management packet (e.g., a beacon or probe response packet) that contains the AP availability parameter and that is also indicative of the corresponding signal strength of the providing wireless access point.

[0013] The wireless device determines that the association quality for the current wireless access point is insufficient, such as, for example, when the association quality for the current wireless access point drops below a specified quality threshold value. The wireless device calculates an association quality for at least one other wireless access point based on relative signal strength associated with and AP availability parameters contained in received beacon packets or probe response packets. The wireless device compares the association quality of the current wireless access point to the association quality of the at least one other wireless access point.

[0014] It may be that the wireless device maintains an access point list of wireless access points and corresponding access point association quality values. The wireless device can compare the corresponding access point association quality values to the association quality of the current wireless access point and/or the specified quality threshold value. The wireless device determines that the wireless device should attempt to associate with one of the at least one other wireless access points based on the comparison. For example, the wireless device may identify one or more other wireless access points that have a corresponding association quality above the specified quality threshold value. Accordingly, a wireless device can determine when to roam based on the quality of an association with a current wireless access point, even before signal strength drops below a roaming threshold.

[0015] The wireless device creates a candidate list containing one or more wireless access points from the access point list. The candidate list can include wireless access points that match a configuration requested by the wireless device. For example, the wireless device may request to communicate with a wireless access point that has a particular Service Set Identifier ("SSID"), that is operating in infrastructure mode, and/or that has Wired Equivalent Privacy ("WEP") encryption enabled. The wireless device generates a ranked candidate list by ranking the one or more wireless access points in the candidate list based at least in part on corresponding association quality.

[0016] The wireless device can identify any wireless access points from the candidate list that have an association quality equal to or greater than the quality threshold value (hereinafter referred to as "sufficient access points"). The wireless device can then randomly rank the sufficient access points relative to one another such that each sufficient access point is ranked differently than the other sufficient access points. This reduces thrashing and greediness since the wireless access point with the highest association quality is not always ranked first. The wireless device can then append any wireless access points from the candidate list that have an association quality less than the quality threshold value (hereinafter referred to as "insufficient access points") to the list. The wireless device can rank the insufficient access points randomly or can rank the insufficient access points based solely on association quality.

[0017] The wireless device selects a ranked wireless access point from the ranked candidate list. For example, the wireless device can select the highest ranked wireless access point from the ranked candidate list. The wireless device attempts to associate with the selected ranked wireless access point. If the wireless device can not associate with the selected ranked wireless access point, the wireless device selects another ranked wireless access point (e.g., the second highest ranked wireless access point). The wireless device then attempts to associate with the other ranked wireless access point. The wireless device can continue to select ranked wireless access points until an association is established or the ranked candidate list is exhausted. Accordingly, a wireless device associates with a wireless access point based the quality of an association with the wireless access point.

[0018] Additional features and advantages of the invention will be set forth in the description that follows, and in part will be obvious from the description, or may be learned by the practice of the invention. The features and advantages of the invention may be realized and obtained by means of the instruments and combinations particularly pointed out in the appended claims. These and other features of the present invention will become more fully apparent from the following description and appended claims, or may be learned by the practice of the invention as set forth hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] In order to describe the manner in which the above-recited and other advantages and features of the invention can be obtained, a more particular description of the invention briefly described above will be rendered by reference to specific embodiments thereof which are illustrated in the appended drawings. Understanding that these drawings depict only typical embodiments of the invention and are not therefore to be considered to be limiting of its scope, the invention will be described and explained with additional specificity and detail through the use of the accompanying drawings in which:

[0020] **FIG. 1** illustrates a suitable operating environment for the principles of the present invention.

[0021] **FIG. 2** illustrates an example network architecture that facilitates making roaming decisions based on an association quality between a wireless device and an access point in accordance with the principles of the present invention.

[0022] **FIG. 3** illustrates an example flowchart of a method for determining whether a wireless device should roam in accordance with the principles of the present invention.

[0023] **FIG. 4** illustrates an example flowchart of a method for identifying a new access point for a wireless device to attempt to associate with in accordance with the principles of the present invention.

[0024] **FIG. 5** illustrates an example flowchart of a method for indicating the availability of an access point to wirelessly communicate with a wireless device in accordance with the principles of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0025] The principles of the present invention provides for making roaming decisions based on association qualities between a wireless device and one or more wireless access points. A wireless device is associated with a current wireless access point. From time to time, the wireless device updates a current association quality for the current wireless access point, for example, based on relative signal strength, observed error rates, and access point resource availability. The current wireless access point can provide a corresponding access point availability parameter, which represents access point resource availability in beacon and/or probe response packets. The wireless device also updates association qualities for any other access points the wireless device can communicate with. If the current association quality (i.e., the association quality with the current access point) falls below a quality threshold value, the wireless device roams to attempt to associate with another wireless access point. The wireless device ranks compatibly configured access points based at least in part on corresponding association qualities. The wireless device can attempt to associate with higher ranked access points before lower ranked access points.

[0026] Embodiments within the scope of the present invention include computer-readable media for carrying or having computer-executable instructions or data structures stored thereon. Such computer-readable media may be any available media, which is accessible by a general-purpose or special-purpose computer system. By way of example, and not limitation, such computer-readable media can comprise physical storage media such as RAM, ROM, EPROM, CD-ROM or other optical disk storage, magnetic disk storage or other magnetic storage devices, or any other media which can be used to carry or store desired program code means in the form of computer-executable instructions, computer-readable instructions, or data structures and which may be accessed by a general-purpose or special-purpose computer system.

[0027] When information is transferred or provided over a network or another communications connection (either hardwired, wireless, or a combination of hardwired or wireless) to a computer system, the connection is properly viewed as a computer-readable medium. Thus, any such connection is properly termed a computer-readable medium. Combinations of the above should also be included within the scope of computer-readable media. Computer-executable or computer-readable instructions comprise, for example, instructions and data which cause a general-purpose computer system or special-purpose computer system to perform a certain function or group of functions. The computer-executable or computer-readable instructions may be, for example, binaries, intermediate format instructions such as assembly language, or even source code.

[0028] In this description and in the following claims, a "computer system" is defined as one or more software modules, one or more hardware modules, or combinations thereof, that work together to perform operations on electronic data. For example, the definition of computer system includes the hardware modules of a personal computer, as well as software modules, such as the operating system of the personal computer. The physical layout of the modules is not important. A computer system may include one or more computers coupled via a network. Likewise, a computer system may include a single physical device (such as a mobile phone or Personal Digital Assistant "PDA") where internal modules (such as a processor and memory) work together to perform operations on electronic data.

[0029] Those skilled in the art will appreciate that the invention may be practiced in network computing environments with many types of computer system configurations, including hubs, routers, wireless access points ("APs"), wireless stations, personal computers, laptop computers, hand-held devices, multi-processor systems, microprocessor-based or programmable consumer electronics, network PCs, minicomputers, mainframe computers, mobile telephones, PDAS, pagers, and the like. The invention can also be practiced in distributed system environments where local and remote computer systems, which are linked (either by hardwired, wireless, or a combination of hardwired and wireless connections) through a network, both perform tasks. In a distributed system environment, program modules may be located in both local and remote memory storage devices.

[0030] **FIG. 1** and the following discussion are intended to provide a brief, general description of a suitable computing environment in which the invention may be implemented. Although not required, the invention will be described in the general context of computer-executable instructions, such as program modules, being executed by computer systems. Generally, program modules include routines, programs, objects, components, data structures, and the like, which perform particular tasks or implement particular abstract data types. Computer-executable instructions, associated data structures, and program modules represent examples of the program code means for executing acts of the methods disclosed herein.

[0031] With reference to **FIG. 1**, a suitable operating environment for the principles of the invention includes a general-purpose computer system in the form of a telephonic device **100**. Telephonic device **100** includes a user interface **101** for allowing a user to input information through an input user interface **103**, and review information presented at an output user interface **102**. For example, the output user interface **102** includes a speaker **104** for presenting audio information to the user, as well as a display **105** for presenting visual information to the user. Although not required, telephonic device **100** may also have an antenna **109**.

[0032] The input user interface **103** may include a microphone **106** for inputting audio information into telephonic device **100**. In addition, the input user interface **103** includes dialing controls **107** represented by 12 buttons through which a user may enter information. Input user interface **103** also includes navigation control buttons **108** that assist the user in navigating through various entries and options listed on display **105**.

[0033] Although the user interface **101** has the appearance of a mobile telephone, the unseen features of the user interface **101** may allow for complex and flexible general-purpose processing capabilities. For example, the telephonic device **100** also includes processor **111**, network interface **180**, and memory **112** that are connected to each other and to the user interface **101** via system bus **110**. The memory

112 generally represents a wide variety of volatile and/or non-volatile memories and may include types of memory previously discussed. However, the particular type of memory used in the telephonic device **100** is not important to the present invention. Program code means comprising one or more program modules may be stored in memory **112**. The one or more program modules may include an operating system **113**, one or more application programs **114**, other program modules **115**, and program data **116**.

[**0034**] Telephonic device **100** is connectable to networks, such as, for example, an office-wide or enterprise-wide computer network, an intranet, and/or the Internet. Telephonic device **100** can wirelessly exchange data with external sources, such as, for example, remote computer systems and/or remote databases over such a network. Telephonic device **100** includes network interface **180** that can, when appropriate, interoperate with antenna **109** to receive data from external sources and/or transmit data to external sources.

[**0035**] While **FIG. 1** represents a suitable operating environment for the present invention, the principles of the present invention may be employed in any system that is capable of, with suitable modification if necessary, implementing the principles of the present invention. The environment illustrated in **FIG. 1** is illustrative only and by no means represents even a small portion of the wide variety of environments in which the principles of the present invention may be implemented.

[**0036**] For example, embodiments of the present invention may also be practiced with a laptop computer. The laptop computer can include a user input interface that receives information from an input device such as, for example, a keyboard, microphone, or mouse. The laptop computer can also include a video output interface that provides a video output signal to an integrated or external video display device, such as, for example, a color or monochrome computer monitor. The laptop computer can also include an audio output interface that provides an audio output signal to external audio output devices, such as, for example, speakers.

[**0037**] The laptop computer can also include a magnetic hard disk drive for reading from and writing to a magnetic hard disk. A magnetic hard disk drive and magnetic hard disk can provide nonvolatile storage of computer-executable instructions, data structures, program modules, and other data for the laptop computer. For example, a magnetic hard disk can store one or more program modules including an operating system, application programs, and program data.

[**0038**] The laptop computer can be connectable to networks, such as, for example, an office-wide or enterprise-wide computer network, an intranet, and/or the Internet. The laptop computer can wirelessly exchange data with external sources, such as, for example, remote computer systems and/or remote databases over such a network. The laptop computer can include a network interface, through which the laptop computer receives data from external sources and/or transmits data to external sources.

[**0039**] Modules of the present invention, as well as associated data can be stored and accessed from any of the computer-readable media associated with telephonic device **100** (or a laptop computer). For example, portions of such modules and portions of associated program data may be included in operating system **113**, application programs **114**, program modules **115**, and/or program data **116**, for storage in system memory **112**. When a mass storage device, such as, for example, a magnetic hard disk, is coupled to telephonic device **100** (or a laptop computer), such modules and associated program data may also be stored at the mass storage device. In a networked environment, program modules depicted relative to telephonic device **100** (or a laptop computer), or portions thereof, can be stored in remote memory storage devices, such as, for example, system memory and/or mass storage devices associated with a remote computer system. Execution of such modules may be performed in a distributed environment as previously described.

[**0040**] **FIG. 2** illustrates an example network architecture **200** that facilitates making roaming decisions based on association qualities between a wireless device and one or more wireless access points. Network architectures **200** includes access points **205**, **206** and **207** that are connected to network **201** by corresponding links **202**, **203**, and **204** respectively. Access points **205**, **206**, and **207** can be wireless access point computer systems that provide associated wireless devices with access to resources included in network **201**. An access point computer system can be a special-purpose computer system that provides an interface between wireless devices and resources of a wired network. Alternatively, an access point computer system can be a general-purpose computer system provides that provides an interface between wireless devices and resources of a wired network and potentially also performs other functions not related to providing wireless devices with access to wired resources. It may be that an access point computer system occasionally provides an interface between wireless devices and resources of a wired network (as opposed to continuously providing an interface). For example, a PDA with wireless capabilities may provide an interface between wireless devices and resources of a wired network when the PDA is docked in a docking station that has a wired connection. Alternately, when the PDA is not docked in the docking station, the PDA may provide an interface between a wireless device and resources that are reachable via a wireless network.

[**0041**] Network **201** can be a Local Area Network ("LAN"), a Wide Area Network ("WAN"), or even the Internet. Accordingly, access points **205**, **206**, and **207** can forward data received from an associated wireless device to a resource in network **201**. On the other hand, access points **205**, **206**, and **207** can also forward data received from a resource in network **201** to an associated wireless device. Network architecture **200** can include other stations (not shown) and other access points (not shown) that can each potentially communicate with station **271** and access points **205**, **206**, and **207**.

[**0042**] Access points **205**, **206**, and **207** include AP workload modules **245**, **246**, and **247** respectively. Generally, an AP workload module calculates an AP availability parameter that represents the availability of a corresponding access point to wirelessly communicate. An AP workload module can measure the availability (or usage) of resources, such as, for example, radio frequency ("RF") resources, memory resources, processor resources, etc., at an access point. From the measurements, the AP workload a module can calculate

an AP availability parameter that collectively represents the availability of access point resources. An access point can include an AP availability parameter and one or more AP configuration parameters in a beacon packet or probe response packet that is sent to a wireless device.

[**0043**] Network architecture **200** also includes station **271**, which can be a wireless station computer system that accesses network **201** via an associated wireless access point computer system. Station **271** includes quality calculation module **255**. Quality calculation module **255** can receive one or more inputs corresponding to an association with an access point. Signal strength measurement module **252** can measure the signal strength either passively or actively. For passive measurement, for example, signal strength measurement module **252** can measure the signal strength associated with a data packet received from an access point and provide the measured signal strength to quality calculation module **255**. For active measurement, for example, signal strength measurement module **252** may send a null data packet to an access point and measures the signal strength associated with the acknowledge control packet (ACK) sent back by the access point. Error rate observation module **253** can measure an error rate associated with data packets received at network interface module **251** and provide the observed error rate to quality calculation module **255**. An access point can also provide an AP availability parameter to quality calculation module **255**. From received inputs, quality calculation module **255** can generate an association quality for a corresponding access point.

[**0044**] Station **271** can maintain access point list **256**, which includes entries for access points that are in communication with station **271**. From time to time, station **271** can update entries for access points contained in access point list **256**. Each entry in access point list **256** includes an AP identifier field, a quality parameter field, and an AP configuration parameters field. An AP identifier field can store an AP identifier value that is used by station **271** to identify an access point. An AP identifier field can store a network address value, such as, for example, a Media Access Control ("MAC") address, that is essentially unique to an access point.

[**0045**] A quality parameter field can store an association quality value for a corresponding access point identified by an AP identifier. For example, quality parameter field **269** can store an association quality value for the access point identified by an AP identifier stored in AP identifier field **268**. An AP configuration parameters field can store AP configuration parameter values (e.g., Basic Service Set ("BSS") Type, Service Set Identifiers ("SSIDs"), supported data rates, privacy settings, etc.) for a corresponding access point identified by an AP identifier. For example, AP configuration parameters field **295** can store configuration parameter values for the access point identified by an AP identifier stored in AP identifier field **268**. A series of three periods (i.e., an ellipsis) within access point list **256** indicates that other entries may be included between the depicted entries.

[**0046**] Station **271** also includes access point selection module **257**, which can identify an access point that station **271** should attempt to associate with (e.g., when station **271** is roaming). Access point selection module **257** can retrieve entries from access point list **256**. Based on association quality values and AP configuration values in retrieved entries, access point selection module **257** can determine if any access points are suitable for association with station **271**. Ranking module **258** can rank suitable entries based at least in part on association quality values. Ranking module **258** can also use random multipliers to reduce the chance of access points with higher association qualities always being ranked higher. Accordingly, both thrashing between access points and greediness can be reduced.

[**0047**] As represented by current association **293** (the dashed line), station **271** is currently associated with access point **205**. Thus, station **271** communicates with resources included in network **201** through access point **205** and resources included in network **201** communicate with station **271** through access point **205**. Accordingly, data packets containing application data (Web pages, electronic mail messages, etc.) can be transferred between station **271** and access point **205**. For example, data packet **231**, which contains application data **232**, is transferred from access point **205** to station **271**.

[**0048**] **FIG. 3** illustrates an example flowchart of a method **300** for determining whether a wireless device should roam in accordance with the principles of the present invention. The method **300** will be discussed with respect to the station and access points depicted in network architecture **200**. The method **300** includes an act of calculating an association quality for the current access point (act **301**). Act **301** can include a wireless device calculating an association quality for a current wireless access point based on a plurality of parameters relevant to the quality the current association. For example, station **271** can calculate an association quality for access point **205** based on parameters relevant to the quality of current association **293**. Some parameters may be generated at station **271**, while others are received from access points.

[**0049**] For example, signal strength measurement module **252** can measure the signal strength associated with packets, such as, for example, data packet **231** and beacon packet **274**, received from access point **205**. Signal strength measurement module **252** can measure the energy at an antenna utilized by station **271** to receive packets. Absolute signal strength, measured in milliwatts ("mW") or decibel milliwatts ("dBm"), may be specific to the data rate at which a packet is received. Thus, a comparison of absolute signal strength values for different data rates may not have significant meaning. For example, comparing an absolute signal strength measured for data transferred at 2 Megabits per second ("Mbps") to an absolute signal strength measured for data transferred to 5.5 Megabits per second ("Mbps") may not have significant meaning.

[**0050**] Accordingly, absolute signal strengths can be normalized such that signal strength values of different data rates can be meaningfully compared. A Received Signal Strength Indicator ("RSSI") is a relative measurement that can be used to compare signal strengths for different data rates. Signal strength measurement module **252** can provide normalized values, such as, for example, RSSIs, to quality calculation module **252**.

[**0051**] Further, error rate observation module **253** can observe error rates for data packets received from a current access point, such as, for example, access point **205**. Network interface module **251** can generate error rate statistics

as data packets are received from a current access point, such as, for example, from access point **205**. Error rate observation module **253** can query network interface module **251** for error rate statistics corresponding to the current access point and can provide queried error rate statistics to quality calculation module **255**.

[**0052**] Access point **205** can also provide an AP availability parameter and one or more AP configuration parameters to station **271**. Referring now to **FIG. 5**, **FIG. 5** illustrates an example flowchart of a method **500** for indicating the availability of an access point to wirelessly communicate with a wireless device in accordance with the principles of the present invention. The method **500** will be discussed with respect to the station and access points depicted in network architecture **200**. The method **500** includes an act of determining resource availability for a plurality of different resources that could be utilized during wireless communication (act **501**). Act **501** can include a providing wireless access point determining resource availability for a plurality of different resources that are potentially utilized during wireless communication with a wireless device.

[**0053**] For example, access point **205** can determine the availability of resources that are potentially utilized when wirelessly communicating with station **271**. AP workload module **245** can make appropriate availability measurements to determine availability values for resources. For example, AP workload module **245** can measure RF usage of the underlying wireless channel (e.g., an IEEE 802.11 channel in the 2.4 GHz or 5 GHz spectrum) currently being utilized by access point **205**. From measured RF usage, AP workload module **245** can calculate an RF availability value (a percentage or an absolute value) that represents available RF resources (e.g., by subtracting RF usage from total available RF resources).

[**0054**] AP workload module **245** can also measure memory usage of access point **205**. From measured memory usage, AP workload module **245** can calculate a memory availability value (a percentage or an absolute value) that represents available memory resources. AP workload module **245** can also measure processor usage of access point **205**. From measured processor usage, AP workload module **245** can calculate a processor availability value (a percentage or an absolute value) that represents available processor resources. AP workload module **245** can calculate the availability of other resources in a similar manner.

[**0055**] Still referring to **FIG. 5**, the method **500** includes an act of calculating an access point availability parameter that collectively represents the availability of access point resources (act **502**). Act **502** can include a providing access point calculating an access point availability parameter that collectively represents the availability of the providing wireless access point's different resources. For example, AP workload module **245** can calculate AP availability parameter **275** that collectively represents the availability of RF resources, memory resources, and processor resources at access point **205**.

[**0056**] AP workload module **245** can calculate AP availability parameter **275** based on weighted values. When the availability of a particular resource has increased importance, AP workload module **245** can weight the corresponding value so that the corresponding value has an increased affect on an access point availability parameter. For example, when RF resources at access point **205** have increased importance, an RF availability value can be weighted to have an increased affect on AP availability parameter **275**. On the other hand, when the availability of a particular resource has decreased importance, AP workload module **245** can weight the corresponding value so that the corresponding value has a reduced affect on an access point availability parameter. For example, when processor resources at access point **205** have decreased importance, a processor availability value can be weighted to have a reduced affect on AP availability parameter **275**.

[**0057**] Still referring to **FIG. 5**, the method **500** includes an act of sending a data packet that includes the access point availability parameter and that is indicative of the corresponding signal strength of the access point (act **503**). Act **503** can include a providing wireless access point sending a management packet that includes the access point availability parameter (and potentially one or more AP configuration parameters) to a wireless device, the data packet also being indicative of the corresponding signal strength of the providing wireless access point. For example, access point **205** can send beacon packet **274**, which includes AP availability parameter **275**, to station **271**. From beacon packet **274**, signal strength measurement module **252** can measure the signal strength associated with access point **205**.

[**0058**] Based on received signal strength measurements, error rate observations, and an AP availability parameter, quality calculation module **255** can calculate a current association quality value for access point **205**. Quality calculation module **255** can store the current association quality value in an entry of access point list **256**. For example, it may be that entry **267** corresponds to access point **205**. Accordingly, an AP identifier identifying access point **205** may be stored in AP identifier field **268** and AP configuration parameter values for access point **205** may be stored in AP configuration parameters field **295**. When a current quality association value is calculated for access point **205**, the current quality association value can be stored in quality parameter field **269** (potentially overwriting a previously calculated quality association value). Since quality association values are calculated from a plurality of relevant measurements, a wireless device can make more intelligent roaming decisions.

[**0059**] Returning back to **FIG. 3**, the method **300** includes an act of determining the association quality for the current access point is insufficient (act **302**). Act **302** can include the wireless device determining that the association quality for the current wireless access point is insufficient. For example, station **271** can determine that the association quality value for access point **205** is insufficient. Quality calculation module **255** can retrieve a current quality association value corresponding to access point **205** (e.g., stored in quality parameter field **269**) from access point list **256**. Alternately, quality calculation module **255** may use a recently calculated current quality association value that has not yet been stored in access point list **256**.

[**0060**] Quality calculation module **255** compares the current quality association value to quality threshold value **254**. When the retrieved current quality association value is greater than or equal to quality threshold value **254**, current association **293** is viewed as being sufficient. When current association **293** is sufficient, station **271** can maintain current

association **293**, even if associations with other access points might provide increased association quality. Accordingly, the greediness of station **271** is potentially reduced. That is, station **271** does not always attempt to associate with an access point having increased association quality.

[**0061**] On the other hand, when the current quality association value is less than quality threshold value **254**, current association **293** is viewed as being insufficient. When current association **293** is insufficient, station **271** may roam to attempt to associate with a different access point. A quality threshold value is configurable such that a user or system administrator can set a desired quality threshold to appropriately suit particular network environments.

[**0062**] The method **300** includes a functional, result-oriented step for identifying a least one other wireless access point that has a sufficient association quality (step **306**). Step **306** can include any corresponding acts for identifying a least one other access point that has a sufficient association quality. However, in the illustrated example of **FIG. 3**, step **306** includes a corresponding act of calculating an association quality for at least one other access point (act **303**.) Act **303** can include the wireless device calculating an association quality for at least one of the other wireless access points included in the plurality of wireless access points.

[**0063**] For example, station **271** can calculate association quality values for other access points in network architecture **200**, such as, for example, access points **206** and **207**. Station **271** can receive beacon and/or probe response packets that contain AP availability parameters (and potentially one or more AP configuration parameters) from other access points. Upon receiving beacon and/or probe response packets, signal strength measurement module **252** can measure a signal strength associated with the received beacon and/or probe response packets. For example, signal strength measurement module **252** can measure the signal strength associated with access point **206** when beacon packet **282** is received at station **271**. Accordingly, beacon packet **282** may provide station **271** with all the information for calculating an association quality value for access point **206**.

[**0064**] Access points can be configured to automatically send beacon packets at specified intervals. As beacon packets are received from an access point, quality calculation module **255** can calculate a new quality association value for the access point. Quality calculation module **255** can update entries in access point list **256** by storing new quality association values in corresponding quality parameter fields. For example, it may be that entry **277** corresponds to access point **206**. Accordingly, an AP identifier identifying access point **206** may be stored in AP identifier field **278** and AP configuration parameters for access point **206** may be stored in AP configuration parameters field **296**. When a new association quality value is calculated for access point **206**, the new quality association value can be stored in quality parameter field **279** (potentially overwriting a previously calculated quality association value).

[**0065**] It may be that station **271** is to calculate an association quality value for an access point at some time between beacon packets. Accordingly, station **271** can send a probe request packet to an access point to request an AP availability parameter. For example, station **271** can send probe request packet **291** to access point **207**. In response, access point **207** can send probe response packet **284**, which contains AP availability parameter **286** (and potentially one or more AP configuration parameters), back to station **271**. Signal strength measurement module **252** can measure the signal strength associated with access point **207** when probe response packet **284** is received at station **271**. Accordingly, probe request packet **284** may provide station **271** with all the information for calculating an association quality value for access point **206**.

[**0066**] Quality calculation module **255** can calculate a new quality association value for access point **207**. Quality calculation module **255** can update an entry in access point list **256** by storing a new quality association value in a corresponding quality parameter field. For example, it may be that entry **287** corresponds to access point **207**. Accordingly, an AP identifier identifying access point **207** may be stored in AP identifier field **288** and AP configuration parameters for access point **207** may be stored in AP configuration parameters field **297**. When a new quality association value is calculated for access point **207**, the new quality association value can be stored in quality parameter field **289** (potentially overwriting a previously calculated quality association value).

[**0067**] The step **306** also includes a corresponding act of comparing association quality of the current access point to the association quality of at least one other access point (act **304**). Act **304** can include the wireless device comparing the association quality of the current wireless access point to the association quality of the at least one of the other wireless access points. For example, station **271** can compare the association quality of access point **205** to the association qualities of access points **206** and **207**. Quality calculation module **255** can retrieve appropriate quality association values from access point list **256** and compare the values.

[**0068**] Based on association quality value comparisons, station **271** may determine that station **271** should not attempt to associate with a different access point. For example, it may be that no other access point has an association quality value greater than the association quality value for access point **205**. Accordingly, station **271** may maintain current association **293** (even if current association **293** is insufficient) when no other access points could provide increased quality.

[**0069**] On the other hand, station **271** may determine that station **271** should attempt to associate with a different access point. The method **300** includes an act of determining that the wireless device should attempt to associate with one of the at least one other access points (act **305**). Act **305** can include the wireless device determining that the wireless device should attempt to associate with one of the at least one of the other wireless access points based on the comparison. For example, based on comparisons of quality association values for access points **205**, **206**, and **207**, station **271** may determine that station **271** should attempt to associate with an access point other than access point **205**. Station **271** may make such a determination when the association quality value for access point **205** is less than the association quality value for access point **206** and/or access point **207**. Accordingly, station **271** can roam to attempt to identify a new access point that can provide increased quality.

[**0070**] **FIG. 4** illustrates an example flowchart of a method **400** for identifying a new access point for a wireless

device to attempt to associate with in accordance with the principles of the present invention. The method **400** will be discussed with respect to the station and access points depicted in network architecture **200**.

[**0071**] The method **400** includes an act of creating a candidate list of one or more access points (act **401**). Act **401** can include a wireless device creating a candidate list of one or more wireless access points from among a plurality of wireless access points. For example, access point selection module **257** can create a candidate list of one or more wireless access points from network architecture **200**, such as, for example, access points **205**, **206**, and **207**. Access point selection module **257** can create a candidate list based on the configuration of access points.

[**0072**] Access point selection module **257** can check AP configuration parameter values (e.g., previously received in beacon and/or probe response packets) stored in AP configuration parameters fields to identify access points that are appropriately configured for communicating with station **271**. When an appropriately configured access point is identified, the access point can be selected for inclusion in the candidate list. For example, access point selection module **257** may check configuration parameter values contained in configuration parameters field **279** to determine if access point **206** is appropriately configured for communicating with station **271**.

[**0073**] Configuration parameters can include BSS type, such as, for example, independent or infrastructure mode, SSID, basic service set identifier ("BSSID"), supported data rate set, privacy settings (e.g., support for Wired Equivalent Privacy ("WEP") encryption), short preamble requirement, modulation requirement, channel agility requirement. Access point selection module **257** can identify access points matching a configuration that promotes appropriate communication with station **271**. For example, access point selection module **257** can identify one or more access points that match a requested data rate and privacy setting for station **271**. Access point selection module **257** can select the one or more identified access points for inclusion in the candidate list.

[**0074**] Access point selection module **257** does not select access points that are not appropriately configured to communicate with station **271**. For example, when station **271** does not support short preamble matching, desired modulation, or channel agility, access point selection module **257** does not select access points that require those features. Matching SSIDs and BSSIDs can include byte for byte comparisons to determine if a requested SSID or BSSID matches an SSID or BSSID advertised by an access point. For example, access point selection module **257** can compare an SSID requested by station **271** to an SSID advertised by access point **207** (e.g., stored in AP configuration parameters field **297**). When the SSID matches, access point selection module **257** may select access point **207** for inclusion in the candidate list. On the other hand, when the SSID does not match, access point selection module **257** does not select access point **207** for inclusion in the candidate list.

[**0075**] The method **400** includes an act of generating a ranked candidate list by ranking the one or more wireless access points in the candidate list (act **402**). Act **402** can include the wireless device generating a ranked candidate list by assigning a corresponding rank to each wireless access point in the candidate list. For example, ranking module **258** can assign corresponding ranks to access points **205**, **206**, and **207**. A corresponding rank for each wireless access point can be calculated at least in part based on an association quality between a wireless access point and a wireless device.

[**0076**] For example, access point selection module **257** can identify any access points from among access points **205**, **206**, and **207** that have an association quality value equal to or greater than the quality threshold value (hereinafter referred to as "sufficient access points"). Ranking module **258** can then randomly rank the sufficient access points relative to one another such that each sufficient access point is ranked differently than the other sufficient access points. Ranking module **258** can arrange the sufficient access points in a ranked candidate list based on rank. This reduces thrashing and greediness since, due to the randomness, the access point with the highest association quality value is not always ranked first.

[**0077**] Ranking module **258** can then append any access points from among access points **205**, **206**, and **207** that have an association quality value less than the quality threshold value (hereinafter referred to as "insufficient access points") to the ranked candidate list. Ranking module **258** can rank the insufficient access points randomly or can rank the insufficient access points based solely on association quality. However, it may be that the lowest ranked sufficient access point is ranked higher than the highest ranked insufficient access point. Thus, there is an increased likelihood of station **271** becoming associated with a sufficient access point.

[**0078**] In some embodiments, sufficient access points are included in a sufficient candidate sub-list and insufficient access points are included in an in insufficient candidate sub-list. Equation 1 can be used to appropriately weight sufficient access points included in a sufficient candidate sub-list in accordance with the principles of the present invention.

$$W_i = \frac{(Q_i - DesiredQualityThreshold + c)}{\sum_i (Q_i - DesiredQualityThreshold + c)} \qquad \text{EQUATION 1}$$

[**0079**] Within Equation 1, i is i-th (i=1, 2, . . . , n) access point in the sufficient candidate sub-list, Q_i is the association quality value for the i-th access point, c is a constant. The constant c gives access points with lower association quality values some chance to be placed higher in a ranked candidate list. For each access point, W equals a representative fraction of the sum of all calculated values. For example, it may be that DesriredQualityThreshold has a value of 4 and c has a value of 2. Further, access point **205** (a first access point, i=1) may have a Q value 5, access point **206** (a second access point, i=2) may have a Q value 9, and access point **207** (a third access point, i=3) may have a Q value 7. Accordingly, access point **205** would have a W_1 value of 3/15, access point **205** would have a W_2 value of 7/15, and access point **205** would have a W_3 value of 5/15

[**0080**] Equation 2 can be used to appropriately assign a probability for each weighted sufficient access point in accordance with the principles of the present invention.

$$P_0 = 0 \qquad \text{EQUATION 2}$$

$$P_i = \sum_{k=1}^{i} W_k$$

[0081] Referring to the immediate preceding example involving access points **205**, **206**, and **207**, access point **205** would have a P_1 value of 3/15 (i.e., W_1), access point **206** would have a P_2 value of 10/15 (i.e., W_1+W_2), and access point **207** would have a P_3 value of 15/15 (i.e., $W_1+W_2+W_3$). A uniform distributed random number r, between 0 and 1 is generated for each access point. When $P_{i-} \leqq r < P_i$, the i-th access point is moved to a ranked list access points. For example, a random number of 0.5 would result in access point **206** (the second access point, i=2) being moved to a ranked list of access points. That is, $3/15 \leqq 0.5 < 10/15$.

[0082] After the sufficient access points are included in the ranked candidate list, any insufficient access points can be appended to the ranked candidate list. The method **400** includes an act of selecting a ranked access point from the ranked candidate list (act **403**). Act **403** can include the wireless access point selecting a ranked wireless access point from the ranked candidate list. For example, access point selection module **257** can select a ranked access point from the ranked candidate list for station **271**. It may be that access point selection module **257** selects a highest ranked access point first.

[0083] The method **400** includes an act of attempting to associate with the selected ranked access point (act **404**). Act **404** can include the wireless device attempting to associate with the selected ranked wireless access point. For example, station **271** can attempt to associate with access point **206**. When the association is successful, new association **294** (the dotted line) is established. Station **271** then communicates with resources included in network **201** through access point **206**.

[0084] If the station **271** can not associate with the selected ranked access point, station **271** selects another ranked access points (e.g., the second highest ranked access point). Station **271** then attempts to associate with the other ranked access point. For example, if station **217** is unable to associate with access point **206**, station **217** can then attempt to associate with access point **207**. Station **271** can continue to select ranked access points until an association is established (which may result in a current association being maintained). Accordingly, a wireless device associates with a new wireless access point in an intelligent manner that reduces thrashing and greediness.

[0085] The present invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The described embodiments are to be considered in all respects only as illustrative and not restrictive. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description. All changes, which come within the meaning and range of equivalency of the claims, are to be embraced within their scope.

What is claimed and desired secured by United States Letters Patent is:

1. In a wireless local area network environment that includes a plurality of wireless access points and a wireless device that is currently associated with a current wireless access point from among the plurality of wireless access points, a method for determining whether the wireless device should roam to associate with another of the wireless access points, the method comprising the following performed by the wireless device:

an act of calculating an association quality for the current wireless access point based on a plurality of parameters relevant to the quality of the current association;

an act of determining that the association quality for the current wireless access point is insufficient;

an act of calculating an association quality for at least one of the other wireless access points of the plurality of wireless access points;

an act of comparing the association quality of the current wireless access point to the association quality of the at least one of the other wireless access points; and

an act of determining that the wireless device should attempt to associate with one of the at least one of the other wireless access points.

2. The method as recited in claim 1, wherein the act of calculating an association quality for the current wireless access point comprises an act of calculating an association quality based on the signal strength of the current wireless access point.

3. The method as recited in claim 1, wherein the act of calculating an association quality for the current wireless access point comprises an act of calculating an association quality based on the available resources at the current wireless access point.

4. The method as recited in claim 3, wherein an act of calculating an association quality based on the availability resources at the current wireless access point comprises an act of calculating an association quality based on radio frequency availability.

5. The method as recited in claim 3, wherein an act of calculating an association quality based on the availability resources at the current wireless access point comprises an act of calculating an association quality based on processor availability.

6. The method as recited in claim 3, wherein an act of calculating an association quality based on the availability resources at the current wireless access point comprises an act of calculating an association quality based on memory availability.

7. The method as recited in claim 3, wherein an act of calculating an association quality based on the availability resources at the current wireless access point comprises an act of calculating an association quality based on an access point availability parameter that collectively represents the availability of a plurality of different wireless access point resources.

8. The method as recited in claim 1, wherein the act of calculating an association quality for the current wireless access point comprises an act of calculating an association quality based an error rate of data packets sent from the current wireless access point.

9. The method as recited in claim 1, wherein the act of determining that the association quality for the current wireless access point is insufficient comprises an act of detecting that the association quality for the current wireless access point is below a quality threshold value.

10. The method as recited in claim 1, wherein the act of calculating an association quality for at least one of the other wireless access points of the plurality of wireless access points comprises an act of calculating an association quality for at least one of the other wireless access points based on the on the available resources at the at least one of the other wireless access points.

11. The method as recited in claim 1, wherein the act of calculating an association quality for at least one of the other wireless access points of the plurality of wireless access points comprises an act of calculating an association quality for at least one of the other wireless access points based on the on the signal strength of the at least one of the other wireless access points.

12. The method as recited in claim 1, wherein the act of comparing the association quality of the current wireless access point to the association quality of the at least one of the other wireless access points comprises an act of comparing an association quality value for the current wireless access points to an association quality value for at least one of the other wireless access points.

13. The method as recited in claim 1, wherein the act of determining that the wireless device should attempt to associate with one of the at least one of the other wireless access points comprises an act of the wireless device roaming.

14. The method as recited in claim 1, further comprising:

an act of storing the calculated association quality for the current wireless access point in a corresponding entry of an access point list.

15. The method as recited in claim 1, further comprising:

an act of storing the calculated association qualities for the at least one of the other wireless access point in corresponding entries of an access point list.

16. The method as recited in claim 1, further comprising:

an act of receiving a packet from the current wireless access point that includes an access point availability parameter.

17. The method as recited in claim 16, wherein the act of receiving a packet from the current wireless access point that includes an access point availability parameter comprises an act of receiving a packet that includes one or more access point configuration parameters.

18. In a wireless local area network environment that includes a plurality of wireless access points and a wireless device that is currently associated with a current wireless access point from among the plurality of wireless access points, a method for determining whether the wireless device should roam to associate with another of the wireless access points, the method comprising the following performed by the wireless device:

an act of calculating an association quality for the current wireless access point based on a plurality of parameters relevant to the quality of the current association;

an act of determining that the association quality for the current wireless access point is insufficient;

a step for identifying that at least one of the other wireless access points has a sufficient association quality;

an act of determining that the wireless device should attempt to associate with one of the at least one other wireless access points.

19. In a wireless local area network environment that includes a plurality of wireless access points and a wireless device that is associated with a current access point from among the plurality of wireless access points, a method for identifying a new access point for the wireless device to attempt to associate with when the association quality for the current access point is insufficient, the method comprising the following performed by the wireless device:

an act of creating a candidate list of one or more wireless access points from among the plurality of wireless access points, the candidate list including wireless access points that have a configuration appropriate for communicating with the wireless device;

an act of generating a ranked candidate list by assigning a corresponding rank to each wireless access point in the candidate list, the corresponding rank for each wireless access point being calculated at least in part based on an association quality between the access point and the wireless device;

an act of selecting a ranked wireless access point from the ranked candidate list; and

an act of attempting to associate with the selected ranked wireless access point.

20. The method as recited in claim 19, wherein the act of creating a candidate list of one or more wireless access points from among the plurality of wireless access points comprises an act of identifying wireless access points that are operating in infrastructure mode.

21. The method as recited in claim 19, wherein the act of creating a candidate list of one or more wireless access points from among the plurality of wireless access points comprises an act of identifying wireless access points having a service set identifier matching a service set identifier requested by the wireless device.

22. The method as recited in claim 19, wherein the act of creating a candidate list of one or more wireless access points from among the plurality of wireless access points comprises an act of identifying wireless access points having a data rate value matching a data rate value requested by the wireless device.

23. The method as recited in claim 19, wherein the act of creating a candidate list of one or more wireless access points from among the plurality of wireless access points comprises an act of identifying wireless access points having a privacy settings matching that match privacy settings requested by the wireless device.

24. The method as recited in claim 23, wherein the act of identifying wireless access points having a privacy settings matching that match privacy settings requested by the wireless device comprise an act of identifying a wireless access point that supports Wired Equivalent Privacy encryption.

25. The method as recited in claim 19, wherein the act of creating a candidate list of one or more wireless access points from among the plurality of wireless access points comprises an act of retrieving one or more entries from an access points list.

26. The method as recited in claim 19, wherein the act of generating a ranked candidate list by assigning a corresponding rank to each wireless access point in the candidate list comprises an act of identifying wireless access points that have a corresponding association quality above a quality threshold value.

27. The method as recited in claim 19, wherein the act of generating a ranked candidate list by assigning a corresponding rank to each wireless access point in the candidate list comprises an act of randomly assigning ranks to wireless access points having a corresponding association quality above a quality threshold value.

28. The method as recited in claim 19, wherein the act of selecting a ranked wireless access point from the ranked candidate list comprises an act of selecting the highest ranked wireless access point.

29. The method as recited in claim 19, wherein the act of attempting to associate with the selected ranked wireless access point comprises an act of wirelessly communicating with the selected ranked wireless access point.

30. The method as recited in claim 19, further comprising:

an act of retrieving association qualities for wireless access points from corresponding entries in an access point list.

31. In a wireless local area network environment that includes a plurality of wireless access points and a wireless device that is associated with a current access point from among the plurality of wireless assess points, a method for indicating resource availability to the wireless device, the method comprising the following performed by a providing wireless access point from among the plurality of wireless access points:

an act of determining resource availability for a plurality of different resources that could be utilized during wireless communication with the wireless device;

an act of calculating an access point availability parameter that collectively represents the availability of the providing wireless access point's different resources; and

an act of sending a packet that includes the access point availability parameter to the wireless device, the packet also being indicative of the corresponding signal strength of the providing wireless access point.

32. The method as recited in claim 31, wherein the act of determining resource availability for a plurality of different resources comprises an act of determining radio frequency availability.

33. The method as recited in claim 31, wherein the act of determining resource availability for a plurality of different resources comprises an act of determining memory availability.

34. The method as recited in claim 31, wherein the act of determining resource availability for a plurality of different resources comprises an act of determining processor availability.

35. The method as recited in claim 31, wherein an act of sending a packet that includes the access point availability parameter to the wireless device comprises an act of sending a packet that includes one or more access point configuration parameters.

36. The method as recited in claim 31, wherein an act of sending a packet that includes the access point availability parameter to the wireless device comprises an act of sending a beacon packet.

37. The method as recited in claim 31, wherein an act of sending a packet that includes the access point availability parameter to the wireless device comprises an act of sending a probe response packet.

38. A computer program product for use in a wireless local area network environment that includes a plurality of wireless access points and a wireless device that is currently associated with a current wireless access point from among the plurality of wireless access points, the computer program produce for implementing a method for determining whether the wireless device should roam to associate with another of the wireless access points, the computer program product comprising one or more computer-readable media having stored thereon computer executable instructions that, when executed by a processor, cause the wireless device to perform the following:

calculate an association quality for the current wireless access point based on a plurality of parameters relevant to the quality of the current association;

determine that the association quality for the current wireless access point is insufficient;

calculate an association quality for at least one of the other wireless access points of the plurality of wireless access points;

compare the association quality of the current wireless access point to the association quality of the at least one of the other wireless access points; and

determine that the wireless device should attempt to associate with one of the at least one of the other wireless access points based on the comparison.

39. The computer program product as recited in claim 38, wherein the one or more computer-readable media include system memory.

40. A computer program product for use in a wireless local area network environment that includes a plurality of wireless access points and a wireless device that is associated with a current access point from among the plurality of wireless access points, the computer program product for implementing a method for identifying a new access point for the wireless device to attempt to associate with when the association quality for the current access point is insufficient, the computer program product comprising one or more computer-readable media having stored thereon computer executable instructions that, when executed by a processor, cause the wireless device to perform the following:

create a candidate list of one or more wireless access points from among the plurality of wireless access points, the candidate list including wireless access points that have a configuration appropriate for communicating with the wireless device;

generate a ranked candidate list by assigning a corresponding rank to each wireless access point in the candidate list, the corresponding rank for each wireless access point being calculated at least in part based on an association quality between the wireless access point and the wireless device;

select a ranked wireless access point from the ranked candidate list; and

attempt to associate with the selected ranked wireless access point.

41. The computer program product as recited in claim 40, wherein the one or more computer-readable media include system memory.

42. A computer program product for use in a wireless local area network environment that includes a plurality of wireless access points and a wireless device that is associated with a current access point from among the plurality of wireless assess points, the computer program produce for implementing a method for indicating resource availability to the wireless device, the computer program product comprising one or more computer-readable media having stored thereon computer executable instructions that, when executed by a processor, cause a providing access point from among the plurality of wireless access points to perform the following:

determine resource availability for a plurality of different resources that could be utilized during wireless communication with the wireless device;

calculate an access point availability parameter that collectively represents the availability of the providing wireless access point's different resources; and

send a packet that includes the access point availability parameter to the wireless device, the data packet also being indicative of the corresponding signal strength of the providing wireless access point.

43. The computer program product as recited in claim 42, wherein the one or more computer-readable media include system memory.

44. In a wireless device, one or more computer-readable media having stored thereon a data structure for representing an entry in an access point list, the data structure comprising the following:

an access point identifier field representing an access point identifier for identifying a wireless access point that can wirelessly communicate with the wireless device;

a quality parameter field representing an association quality value that indicates the association quality between the wireless device and the wireless access point identified in the access point identifier field; and

an AP configuration parameters field representing one or more configuration values that indicate the configuration of the wireless access point identified in the access point identifier field.

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