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(54) **MULTI-MODE METHODS AND DEVICES
UTILIZING BATTERY POWER LEVEL FOR
SELECTION OF THE MODES**

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H04B 1/40 (2006.01)

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

CPC **H04W 52/0261** (2013.01); **H04W 52/0277**
(2013.01); **H04B 1/406** (2013.01)

USPC **455/574**; 455/552.1; 455/553.1;
455/404.1; 455/343.5

(58) **Field of Classification Search**

USPC 455/500, 552.1, 553.1, 574,
455/343.1–343.5, 404.1, 521

See application file for complete search history.

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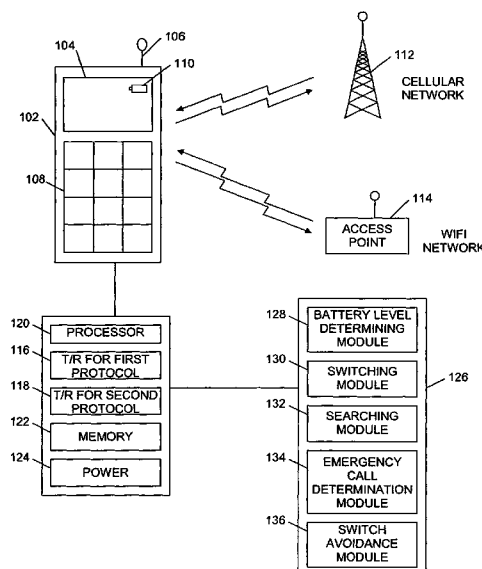
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(57) **ABSTRACT**

A battery-powered wireless communication device monitors
battery power level and switches from operation pursuant to a
first wireless communication protocol to a second communi-
cation protocol in the event that the battery power level has
dropped to a predetermined threshold while operating in idle
mode or in active mode.

18 Claims, 5 Drawing Sheets



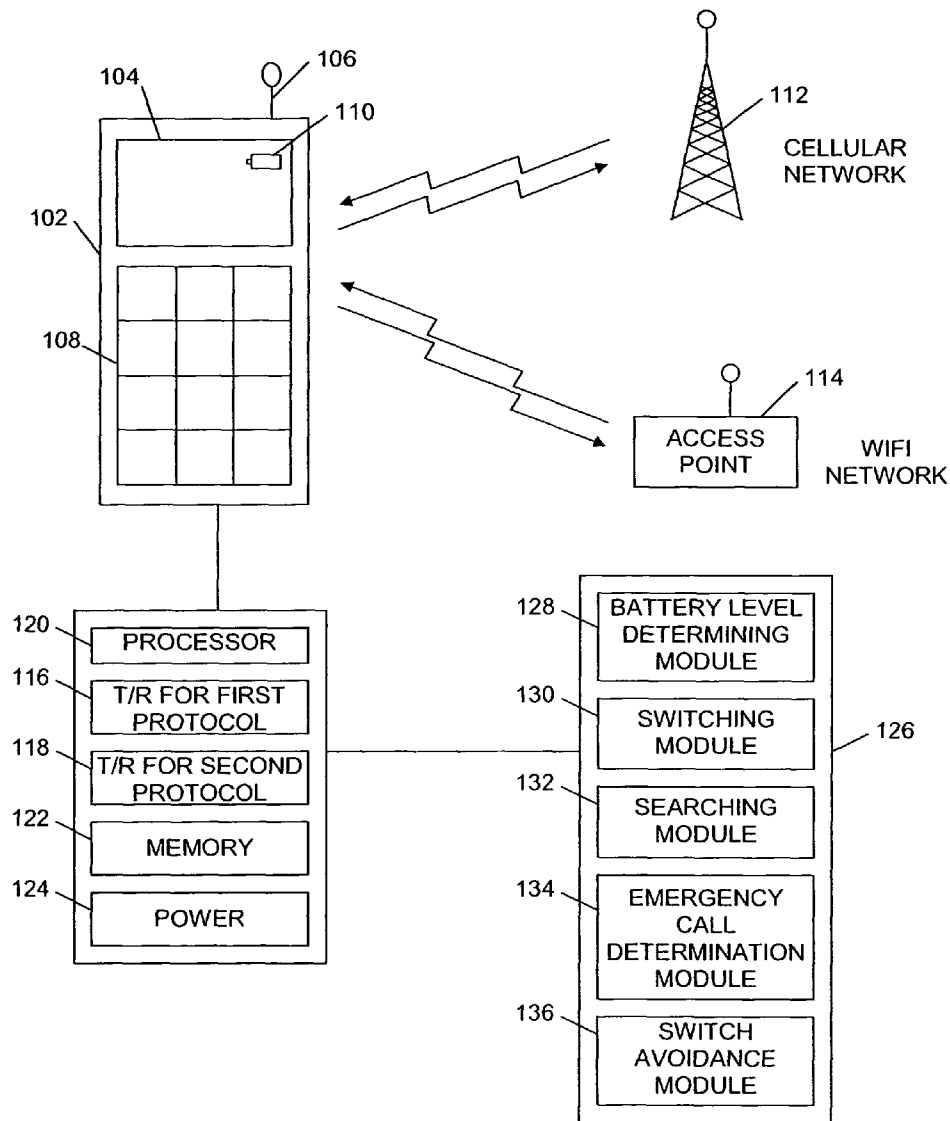


FIG. 1

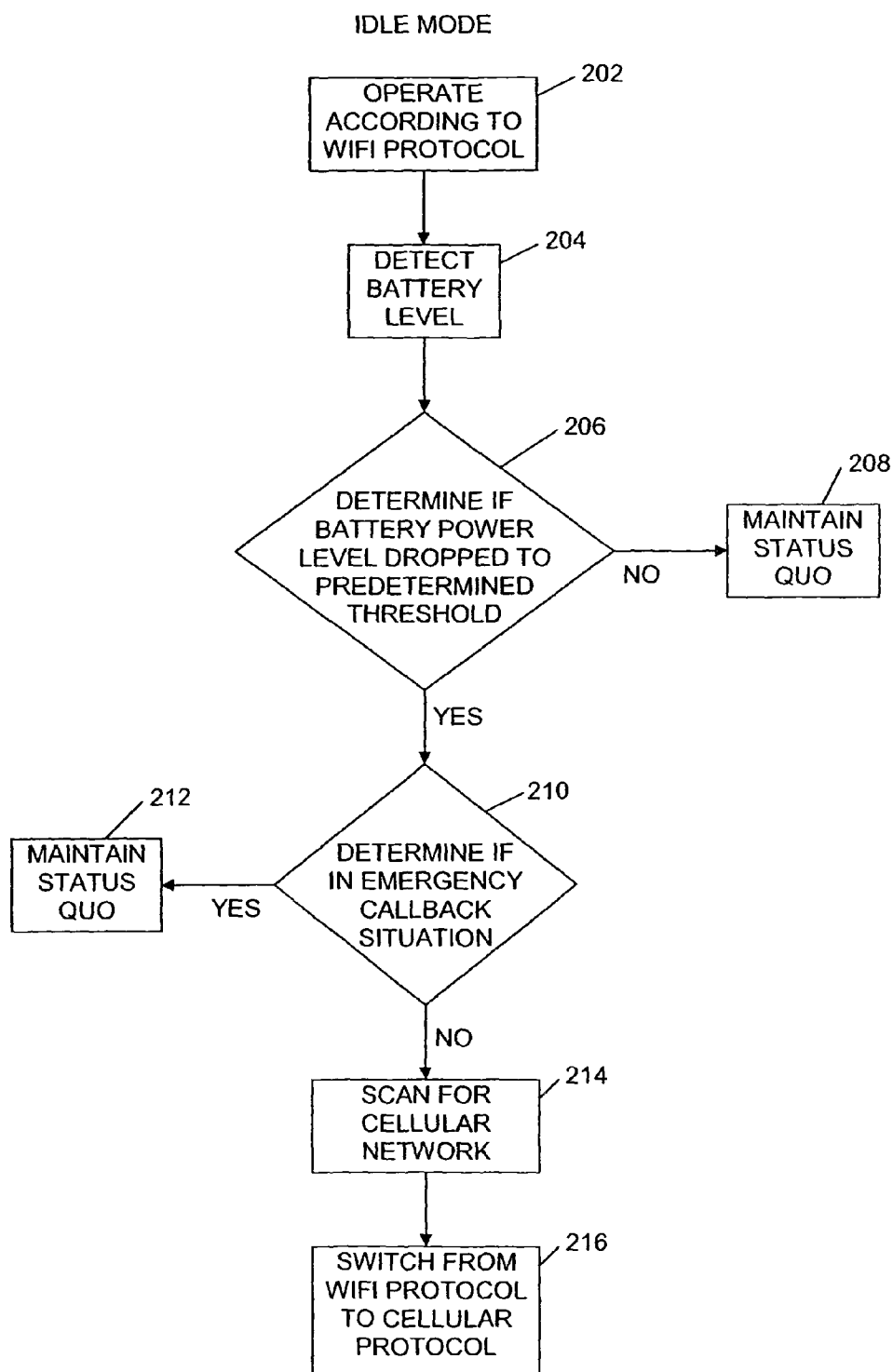


FIG. 2

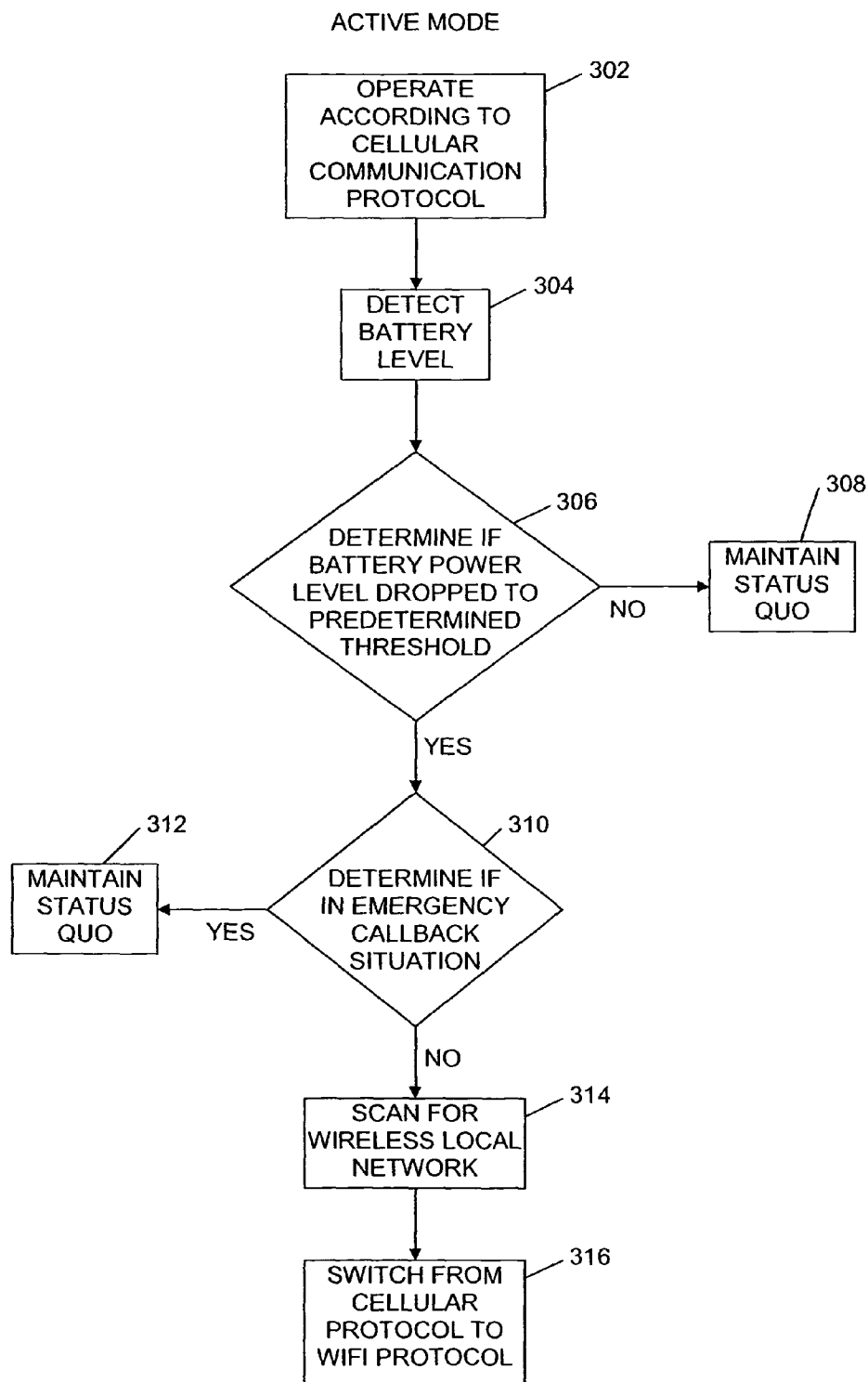


FIG. 3

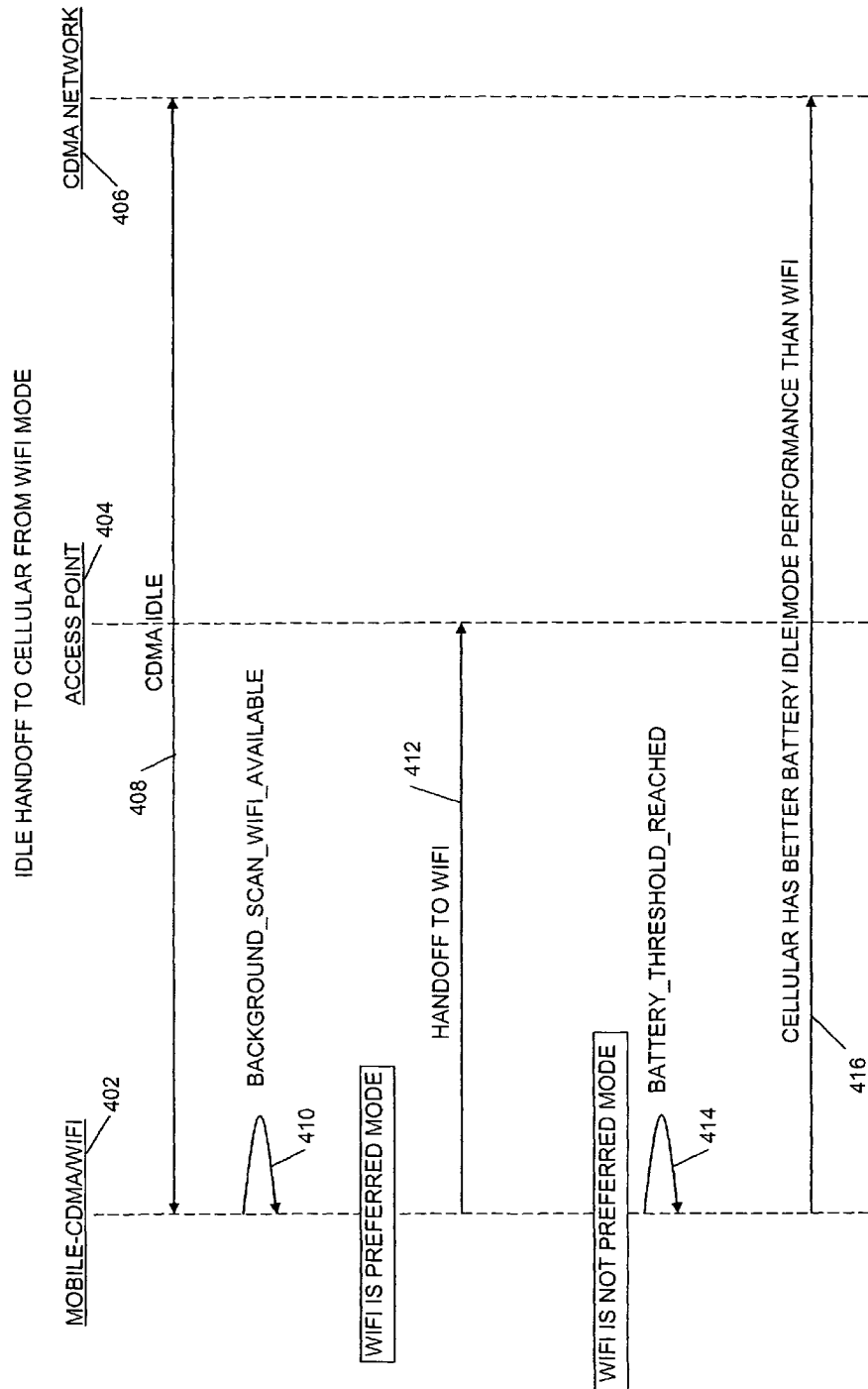


FIG. 4

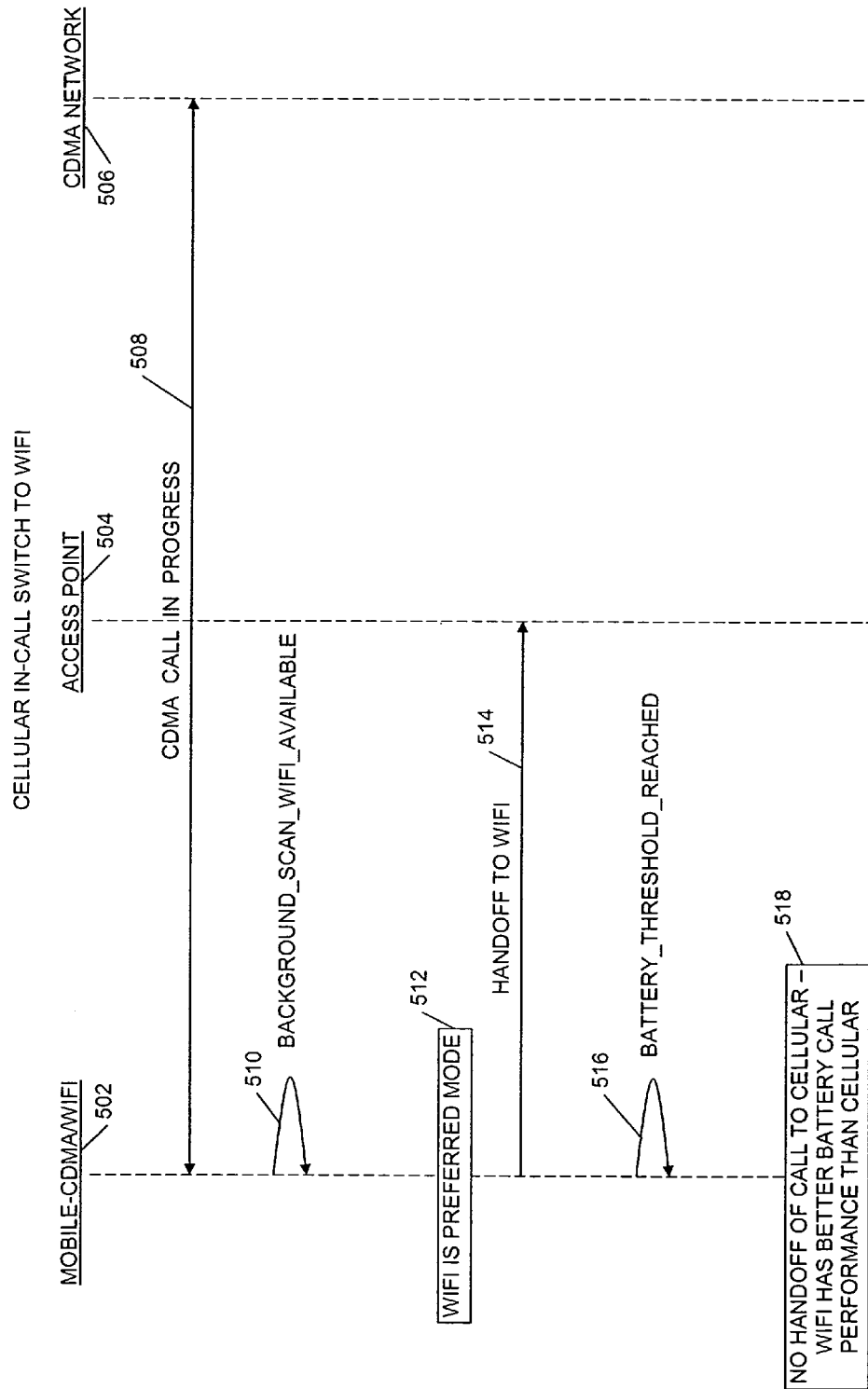


FIG. 5

1

MULTI-MODE METHODS AND DEVICES UTILIZING BATTERY POWER LEVEL FOR SELECTION OF THE MODES

FIELD OF THE DISCLOSURE

The present disclosure relates generally to wireless communications, and more particularly to switching between modes in multi-mode wireless communication devices based on different criteria, for example, based on a battery power level and/or the cost of service.

BACKGROUND

Mobile communication devices such as battery powered cellular telephones can be equipped with multiple transceivers. In addition to communicating pursuant to traditional communication protocols such as CDMA and GSM, mobile communication devices may also communicate using non-cellular protocols. For example, mobile communication devices are often enabled with a Bluetooth transceiver and/or a local area network (LAN) transceiver. For communications pursuant to Wireless Fidelity (WIFI) or wireless local area network (WLAN) protocols, mobile communication devices can be equipped with a WIFI transceiver in addition to CDMA and GSM transceivers or other wireless transceiver.

Dual-mode communication devices can leverage the ubiquity of cellular networks (e.g., GSM and CDMA) with the high performance and low operational costs of local-area WIFI networks. The dual-mode roaming capability allows wireless handsets to utilize cellular or WIFI networks to place and receive calls and to provide Internet access for email and Web surfing while the device is in an active mode (in call).

The various aspects, features and advantages of the present disclosure will become more fully apparent to those having ordinary skill in the art upon careful consideration of the following Detailed Description thereof with the accompanying drawings described below. The drawings may have been simplified for clarity and are not necessarily drawn to scale.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a wireless communication system.

FIG. 2 is a flow chart illustrating the operation of a mobile communication device in idle mode.

FIG. 3 is a flow chart illustrating the operation of a mobile communication device in active mode.

FIG. 4 is a signal flow diagram of a mobile communication device in idle mode operating pursuant to a WIFI protocol.

FIG. 5 is a signal flow diagram of a mobile communication device in active mode operating pursuant to a cellular communication protocol.

DETAILED DESCRIPTION

In one embodiment, a battery-powered multimode wireless communication device that operates pursuant to first and second communication modes switches from the first active communication mode so that the device operates to the second active communication mode in the event that battery power level drops to a predetermined threshold while operating pursuant in the first active communication mode. In one embodiment, the device switches from operation on a cellular communication protocol while in a call to operation on a wireless local area network protocol in the event that the battery power level drops to the predetermined threshold. The wireless communication device may also perform a partial

2

switch of the operation of certain functions to the other transceiver. For example, a video stream could be handed over from a first transceiver to another transceiver while a voice call is maintained on the first transceiver.

The switching process can be transparent to the user. Alternatively, the device may prompt the user with a request for instructions so that the user may choose to switch from one mode to the other. In some applications, an emergency call takes priority over any benefits that may be obtained by switching protocols. In these embodiments there is no switching between protocols during the emergency call. An emergency call can be identified, for example, by the telephone number input to the mobile communication device.

In another embodiment, the device hands off a function performed on the wireless communication device to an external device wherein the external device performs the function performed on the wireless communication device. For example, the device could connect to an external audio device, e.g., a sound system, or to an external video system, e.g., a laptop or an external monitor, using a Bluetooth or through an Internet Protocol connection when the battery threshold is reached, thus reducing power consumption associated with performing the function on the wireless communication device.

FIG. 1 illustrates a mobile communication device, some of its components, and two networks that operate pursuant to different communication protocols. More than two different communication protocols are within the scope of this discussion as well. The device 102 can have a display 104, an antenna 106, a keypad for input 108, and a battery usability icon 110 on the display. The mobile communication device 102 represents a wide variety of communication devices that have been developed for use within various networks. Such handheld communication devices include, for example, cellular telephones, messaging devices, mobile telephones, personal digital assistants (PDAs), notebook or laptop computers incorporating communication modems, mobile data terminals, application specific gaming devices, video gaming devices incorporating wireless modems, and the like. Any of these portable wireless communication devices may be referred to as a mobile station or user equipment. It is understood that any and all mobile wireless communication devices are within the scope of this discussion.

FIG. 1 depicts the mobile communication device 102 configured to communicate with two networks, a cellular network 112 and a WIFI network through its access point 114. The networks typically communicate in accordance with different communication protocols. The cellular network protocol may be for example, CDMA, GSM, and/or W-CDMA or some other cellular communication protocol. Exemplary WIFI network protocols include but are not limited to IEEE 802.11/802.16. Other protocols are within the scope of this disclosure. A multi-mode mobile communication device may include a plurality of transceivers for receiving and transmitting pursuant to the different protocols. A first transceiver for communication pursuant to a first protocol 116 and a second transceiver for communication pursuant to a second protocol 118 are shown. In other embodiments, the first and second transceivers could be different incarnations of a single transceiver, for example, a software-defined radio transceiver. In this disclosure the terms "first protocol" and "second protocol" are used interchangeably. It is clear from the context whether the first protocol refers to, for example, a WIFI protocol, and the second protocol refers to, for example, cellular protocol. It is also understood that the mobile device may communicate via more than two transceivers.

3

The mobile communication device is further configured with a processor **120**, memory **122**, and a power source **124**, such as a battery. Instruction modules **126** can include instructions that are in hardware and/or software. The operations of the instruction modules will be described in detail in reference to the flow charts and signal flow diagrams discussed below. Briefly, the modules can include a battery power level determination module **128** coupled to the battery and a switching module **130** that switches the device **102** from operation via the first communication protocol transceiver **116** to operation via the second communication protocol transceiver **118**, for example, in the event that the battery power level drops to a predetermined threshold while operating via the first communication transceiver. The modules can further include a searching module **132** for searching for service on a different network in the event that the battery power level drops to the predetermined threshold. The modules can further include an emergency call determination module **134** for determining whether the device is in an emergency call activation state, and a switch avoidance module **136** operable for when the device is in an emergency call activation state to avoid breaking emergency communication.

A dual or multi-mode device **102** may operate in either idle mode or active mode. As mentioned above, there are at least two situations, in accordance with this disclosure, that the battery longevity may be improved in the event that communication over an alternative network is available. In idle mode, where it is determined that battery power level has dropped to a predetermined threshold while operating pursuant to a first communication protocol, the device switches to operation pursuant to a second communication protocol. Also, in active mode, where it is determined that battery power level has dropped to a predetermined threshold while operating pursuant to a first communication protocol, the device switches to operation pursuant to a second communication protocol.

In some embodiments, in active mode, a cellular communication may cost more than a WIFI communication. Therefore, it may be more cost effective to maintain communication with a WIFI service provider when possible due to air time fees. However, once a call over the WIFI service is completed, the device may operate pursuant to the WIFI protocol while in an idle mode. When the device operates pursuant to the WIFI protocol in idle mode, the drain on the battery power level can be greater than were the device to operate pursuant to a cellular communication protocol.

FIG. 2 is a flow chart illustrating the operation of a mobile communication device in idle mode. As described above, the device may operate pursuant to a first protocol **202**, here a WIFI protocol, while in idle mode. More generally, however, the first protocol may be any other communication protocol. The battery level of the device may be monitored, at **204**, either periodically or constantly. At **206**, a query is made to determine whether the battery power level has dropped to a predetermined threshold. If there is no determination that the battery power level has dropped to a predetermined threshold while operating pursuant to the first communication protocol, here a WIFI protocol, in idle mode, the device maintains its operation in pursuant to the first protocol **208**.

FIG. 2 further illustrates that when in idle mode and operating pursuant to the first protocol, the device can determine if the device is in an emergency call situation **210**. In such an event, the device may not switch from the first communication protocol to the second communication protocol in the event that the battery power level drops to the predetermined threshold. Accordingly, the device may maintain the status quo at **212**. For example, if the battery-powered multimode wireless communication device were in an emergency call

4

situation, an emergency service provider such as the police or fire department may receive the mobile communication device's telephone number by, for example, a caller ID, and may try to return a call to the mobile communication device.

In an emergency call situation, it may be beneficial that during an emergency call back period, the mobile communication device should be able to receive a callback from the Public Safety Answering Point (PSAP) pursuant to the same communication protocol from which the call was made.

Therefore when the battery power level drops to a predetermined threshold, there may be sufficient battery usability to sustain a short cellular call during an emergency callback period. Once the battery reaches this state, the device may indicate, for example, on its display, that multimedia and other battery intensive operations should be avoided. Alternatively, the device may automatically shut down ancillary activity. The predetermined battery power threshold can be calibrated to sustain the power necessary to receive a callback during a callback period or may be calibrated according to a different standard.

After the query of the battery power level while in idle mode, the device operating pursuant to the first protocol, here, a WIFI network protocol, may begin scanning for service pursuant to a second protocol, here, a cellular network in the event that the battery power level has dropped to the predetermined threshold **214**. The device may then switch from the first wireless communication protocol so that the device can operate in accordance with the second communication protocol **216** in the event that the battery power level has dropped to the predetermined threshold in idle mode. Accordingly, some battery usability may be prolonged.

FIG. 3 is a flow chart illustrating operation of a mobile communication device in an active mode. As described above, the device may be operating pursuant to a first protocol **302**, here a cellular communication protocol while in the active mode. The battery level of the device may be monitored, at **304**, periodically or constantly. A query can be made whether the battery power level has dropped to a predetermined threshold, at **306**. If there is no determination that the battery power level has dropped to a predetermined threshold while operating pursuant to the first communication protocol, here a cellular protocol, in the active mode, the device can maintain its operation pursuant to the first protocol, at **308**.

The switch in either the idle mode or the active mode can be made automatically or by response of the user to a prompt of the device. In FIG. 1, the battery icon **110** on the display may provide an indication that the switch from a first communication protocol to a second communication protocol may be made. It is understood that any type of prompt to switch protocols when the battery power drops to a predetermined level is within the scope of this discussion.

FIG. 3 further shows that when in active mode and operating pursuant to the first protocol, the device can determine if the device is in an emergency callback situation **310**. In the event that the battery power level drops to the predetermined threshold during an emergency call, the device does not switch from the first communication protocol to the second protocol. Accordingly, the device may maintain the status quo, at **312**, when in an emergency callback situation.

After the query for the battery power level in the active mode, the device operating pursuant to the first protocol, here, cellular network protocol, begins scanning for service pursuant to a second protocol, here, a WIFI network protocol in the event that the battery power level has dropped to the predetermined threshold at **314**. The device then switches from the first wireless communication protocol so that the device is operating in accordance with the second communication pro-

5

tol, at 316, in the event that the battery power level has dropped to the predetermined threshold while operating pursuant to the first communication protocol in the active mode. Accordingly, the battery usability may be prolonged.

The scan rate may also be based on the battery power level. In the event the battery power level has dropped to a predetermined threshold, that is the same as that which is described above, or different from that which is described above, the scan rate for service pursuant to a second protocol may be slowed to conserve power.

FIG. 4 is a signal flow diagram of a mobile communication device in idle mode. The device 402, the WLAN access point 404, and the cellular network 406 are depicted therein. The device can be in an idle state pursuant to a first communication protocol, in this example, a cellular network protocol 408. The device can perform a background scan for a WIFI access point 410 to establish communication under a second protocol, in this example, a WIFI communication protocol. If the WIFI access point is found, there may be a switch from the cellular network to the WIFI access point when the device is in the idle state 412. However, in the event that the battery power level drops to a determined threshold level 414, the device can switch in its idle state so that it is operating pursuant to a cellular communication protocol 416. Accordingly, battery usability may be prolonged.

FIG. 5 is a signal flow diagram of a mobile communication device in an active mode. The device 502, the WLAN access point 504, and the cellular network 506 are depicted therein. A cellular network call is in progress at 508. At 510, the device may perform a background scan to see if WIFI is available. If available, wherein WIFI is the preferred mode 512, there is a hand-off to the WIFI access point of a call in progress 514. If it is determined that the battery power level has dropped to a predetermined threshold level at 516, the active call state can remain with the WIFI access point at 518 since the WIFI communication protocol can have a better battery in-call performance than does a call over a cellular network. Accordingly, the battery usability may be prolonged.

Since it has been found that in an idle state, less power is consumed when operating pursuant to a cellular communication protocol than when operating pursuant to a WIFI communication protocol, the device may increase its longevity based on current battery consumption if the device were to switch from the more consumptive to the less consumptive communication protocols. The same can be true in the active state, though the relationship is reversed.

While the present disclosure and the best modes thereof have been described in a manner establishing possession by the inventors and enabling those of ordinary skill in the art to make and use the same, it will be understood and appreciated that there are equivalents to the exemplary embodiments disclosed herein and that modifications and variations may be made thereto without departing from the scope and spirit of the inventions, which are to be limited not by the exemplary embodiments but by the appended claims.

What is claimed is:

1. A method in a battery-powered multimode wireless communication device that operates pursuant to a first communication protocol and a second communication protocol, the method comprising:

determining whether a battery power level has dropped to a predetermined threshold while operating pursuant to the first communication protocol in idle mode; and

switching from the first communication protocol so that the device is operating in accordance with the second communication protocol in the event that the battery power

6

level has dropped to the predetermined threshold while operating pursuant to the first communication protocol in idle mode,

the first communication protocol is a wireless local area network protocol and the second communication protocol is a cellular communication protocol,

switching from the first communication protocol includes switching to the cellular communication protocol in the event that the battery power level has dropped to the predetermined threshold.

2. The method of claim 1, operating pursuant to the first communication protocol in idle mode includes operating in a mode during which the device is not in a call.

3. The method of claim 2, beginning scanning for service on a cellular network in the event that the battery power level has dropped to the predetermined threshold.

4. A battery-powered multimode wireless communication device that operates pursuant to a first communication protocol and a second communication protocol, comprising:

a battery power level determination module coupled to the battery; and

a switching module that switches from operation on a first communication protocol transceiver to operation on a second communication protocol transceiver in the event that the battery power level drops to a predetermined threshold while operating the first communication transceiver in an idle mode,

the first communication protocol transceiver is a local area network protocol transceiver,

the switching module switching from operation on the first communication protocol transceiver to operation on the second communication protocol transceiver in the event that the battery power level drops to the predetermined threshold while operating the first communication transceiver in the idle mode.

5. The device of claim 4, the second communication protocol transceiver is a cellular transceiver, the switching module switching from operation on the first communication protocol transceiver to operation on the second communication protocol transceiver in the event that the battery power level drops to the predetermined threshold while operating the first communication transceiver in the idle mode.

6. The device of claim 4, the device further comprising a searching module for searching for service on a cellular network in the event that the battery power level drops to the predetermined threshold while operating the first communication transceiver in the idle mode.

7. The device of claim 4 further comprising:

an emergency call determination module for determining whether the device is in an emergency call activation state when the device is in idle mode pursuant to the first communication protocol; and

a switch avoidance module operable when the device is in an emergency call activation state to avoid breaking emergency communication.

8. A method in a battery-powered multimode wireless communication device that operates pursuant to a first active communication mode and a second active communication mode, the method comprising:

determining whether a battery power level has dropped to a predetermined threshold while operating pursuant to the first active communication mode;

switching from operation of the wireless communication device in the first active communication mode to operation in the second active communication mode in the event that the battery power level drops to the predeter-

7

mined threshold while operating pursuant in the first active communication mode; and

not switching from the first active communication mode to the second active communication mode in the event that the battery power level drops to the predetermined threshold if the wireless communication device is in an emergency call.

9. The method of claim 8, switching from the first active communication mode includes switching from operation on a cellular communication protocol while in a call to operation on a wireless local area network protocol in the event that the battery power level drops to the predetermined threshold.

10. The method of claim 9, switching from the first active communication mode includes handing off a function performed on the wireless communication device to an external device wherein the external device performs the function performed on the wireless communication device.

11. The method of claim 9, searching for service on the wireless local area network in the event that the battery power level drops to the predetermined threshold while operating pursuant to the cellular communication protocol in the active mode.

12. A battery-powered multimode wireless communication device that operates pursuant to a first communication protocol and a second communication protocol, comprising:
a battery power level determination module coupled to the battery; and

a switching module that switches from operation on a first communication protocol transceiver to operation on a second communication protocol transceiver in the event that the battery power level drops to a predetermined threshold while operating the first communication transceiver in an active mode;

an emergency call determination module for determining whether the device is in an emergency call activation state when the device is in active mode on the first communication protocol transceiver;

a switch avoidance module operable to avoid breaking emergency communication when the device is in an emergency call activation state.

13. The device of claim 12, the first communication protocol transceiver is a cellular communication protocol transceiver, the switching module switching from operation on the first communication protocol transceiver to operation on the second communication protocol transceiver in the event that the battery power level drops to the predetermined threshold while operating the first communication transceiver in the active mode.

14. The device of claim 12, the second communication protocol transceiver is a local area network protocol transceiver, the switching module switching from operation on the first communication protocol transceiver to operation on the second communication protocol transceiver in the event that

8

the battery power level drops to the predetermined threshold while operating the first communication transceiver in the active mode.

15. The device of claim 12, the first communication protocol transceiver is a cellular communication protocol transceiver, the device further comprising: a searching module for searching for service on a wireless local area network in the event that the battery power level drops to the predetermined threshold while operating pursuant to an active mode.

16. The device of claim 12 further comprising:

an emergency call determination module for determining whether the device is in an emergency call activation state when the device is in active mode pursuant to the second communication protocol;

a switch avoidance module operable when the device is in an emergency call activation state to avoid breaking emergency communication.

17. A battery-powered multimode wireless communication device that operates pursuant to a first communication protocol and a second communication protocol, comprising:
a battery power level determination module coupled to the battery; and

a switching module that switches from operation on a first communication protocol transceiver to operation on a second communication protocol transceiver in the event that the battery power level drops to a predetermined threshold while operating the first communication transceiver in an idle mode,

the second communication protocol transceiver is a cellular transceiver, the switching module switching from operation on the first communication protocol transceiver to operation on the second communication protocol transceiver in the event that the battery power level drops to the predetermined threshold while operating the first communication transceiver in the idle mode.

18. A battery-powered multimode wireless communication device that operates pursuant to a first communication protocol and a second communication protocol, comprising:
a battery power level determination module coupled to the battery;

a switching module that switches from operation on a first communication protocol transceiver to operation on a second communication protocol transceiver in the event that the battery power level drops to a predetermined threshold while operating the first communication transceiver in an idle mode;

an emergency call determination module for determining whether the device is in an emergency call activation state while operating the first communication transceiver in the idle mode; and

a switch avoidance module operable to avoid breaking emergency communication when the device is in an emergency call activation state.

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