US 20090022068A1

(19) **United States**

(12) **Patent Application Publication**

(10) **Pub. No.: US 2009/0022068 A1**

(43) **Pub. Date: Jan. 22, 2009**

Iyer et al.

(54) **DELEGATED NETWORK CONNECTION MANAGEMENT AND POWER MANAGEMENT IN A WIRELESS DEVICE**

(75) Inventors: **Mahesh D. Iyer**, Sunnyvale, CA (US); **Venkat B. Rao**, Sunnyvale, CA (US)

Correspondence Address:
STERNE, KESSLER, GOLDSTEIN & FOX P.L. L.C.
1100 NEW YORK AVENUE, N.W.
WASHINGTON, DC 20005 (US)

(73) Assignee: **Broadcom Corporation**, Irvine, CA (US)

(21) Appl. No.: **12/216,889**

(22) Filed: **Jul. 11, 2008**

Related U.S. Application Data

(60) Provisional application No. 60/929,888, filed on Jul. 16, 2007, provisional application No. 61/046,170, filed on Apr. 18, 2008.

Publication Classification

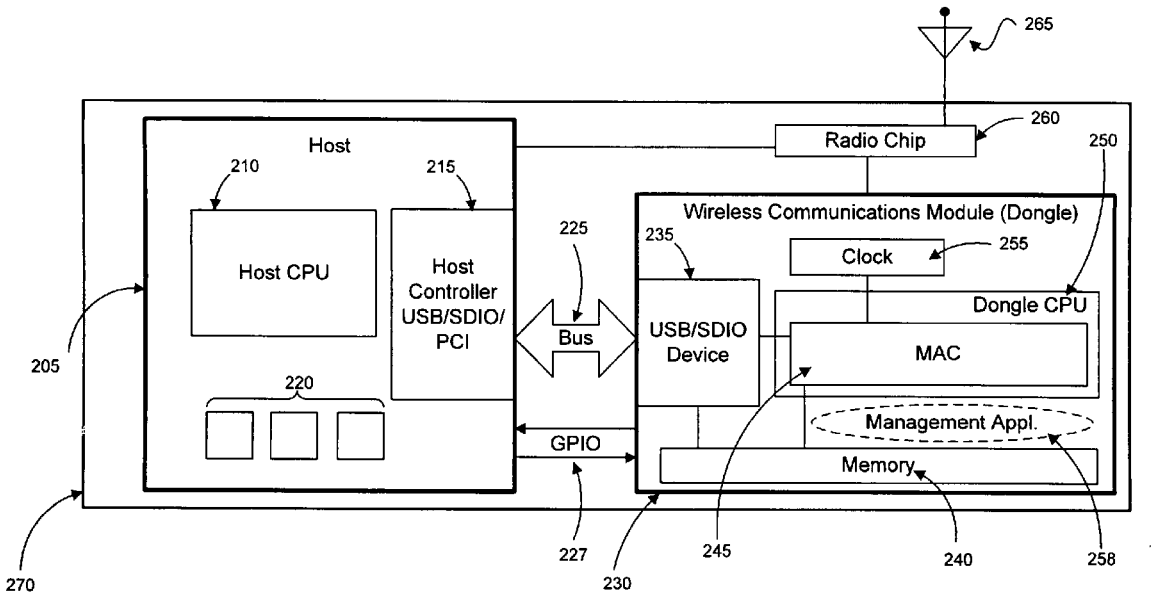
(51) **Int. Cl.**
H04L 12/28 (2006.01)

(52) **U.S. Cl.** **370/254**

(57) **ABSTRACT**

A method and system for advanced media access control delegated from a host device, such as a WiFi device, to a smart wireless communications module. In an embodiment, the host signals to the wireless module a list of one or more preferred networks. The wireless module offloads from the host the processing required to scan for the preferred network (s), as well as possibly other management tasks. The wireless communications module may automatically reassign the network connection from an existing network to a preferred network, or may report to the host when a preferred network is discovered. In either case, the wireless communications module may monitor the wireless environment, and scan for preferred networks, in parallel with maintaining an existing connection. The method and system allows rapid adaptation to a changing network environment, and enables lower system power consumption by distributing management functions between the host and the lower-powered wireless communications module.

Exemplary Wireless Device



[0059] According to embodiments of the present invention, power consumption of a wireless communications device, such as the exemplary wireless device of FIG. 1 (element 110) and FIG. 2 (discussed below), can be lowered by distributing management functions between a host module with a primary processor and a wireless communications module with a secondary processor. In an embodiment, the wireless communications module may perform network discovery and connection management functions. Offloading these tasks from the primary processor of the host module to the secondary processor of the wireless communications module can be used to lower power consumption. In particular, the host module may use a lower power mode or be turned off altogether for periods of time, resulting in lower overall system power consumption.

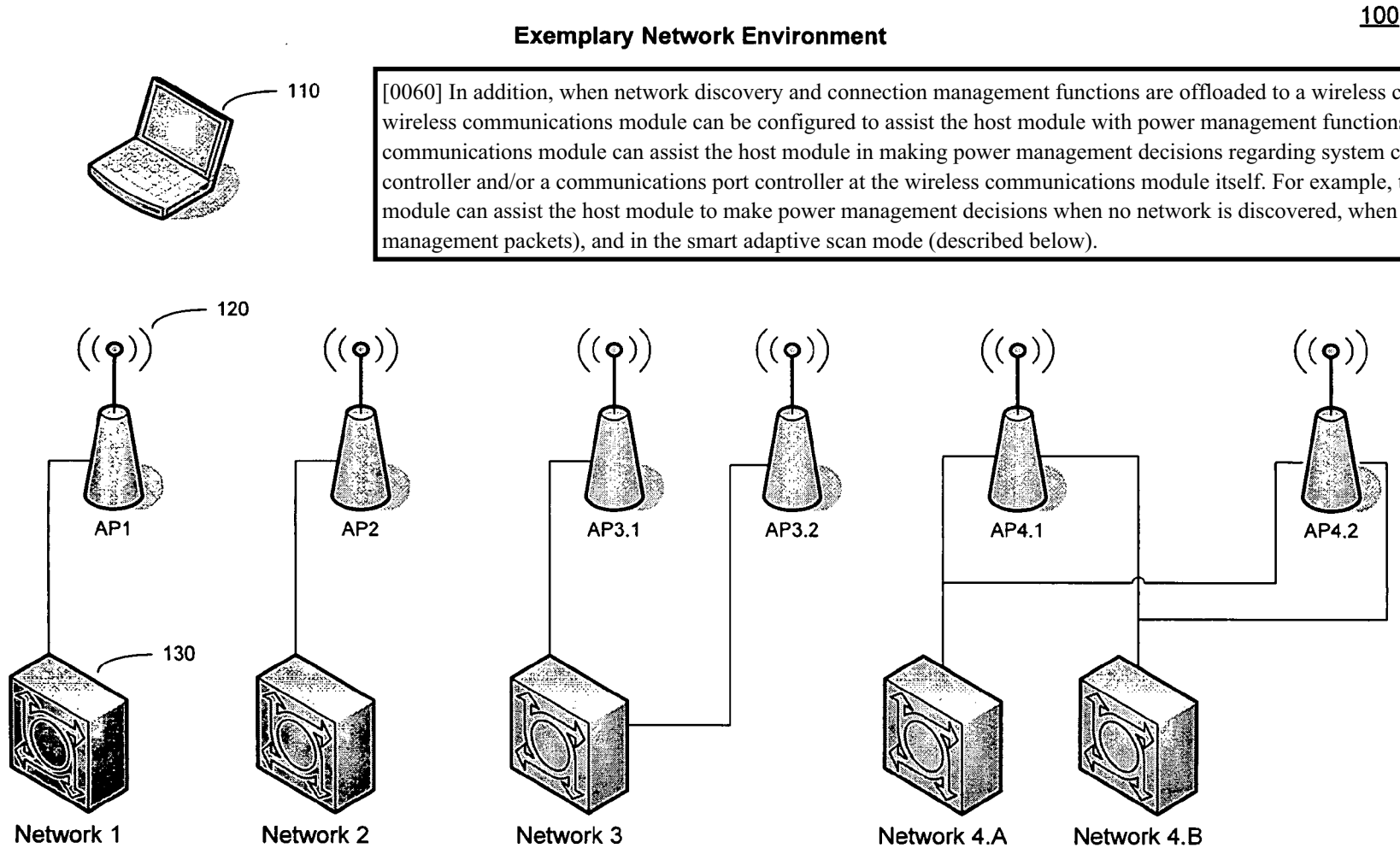
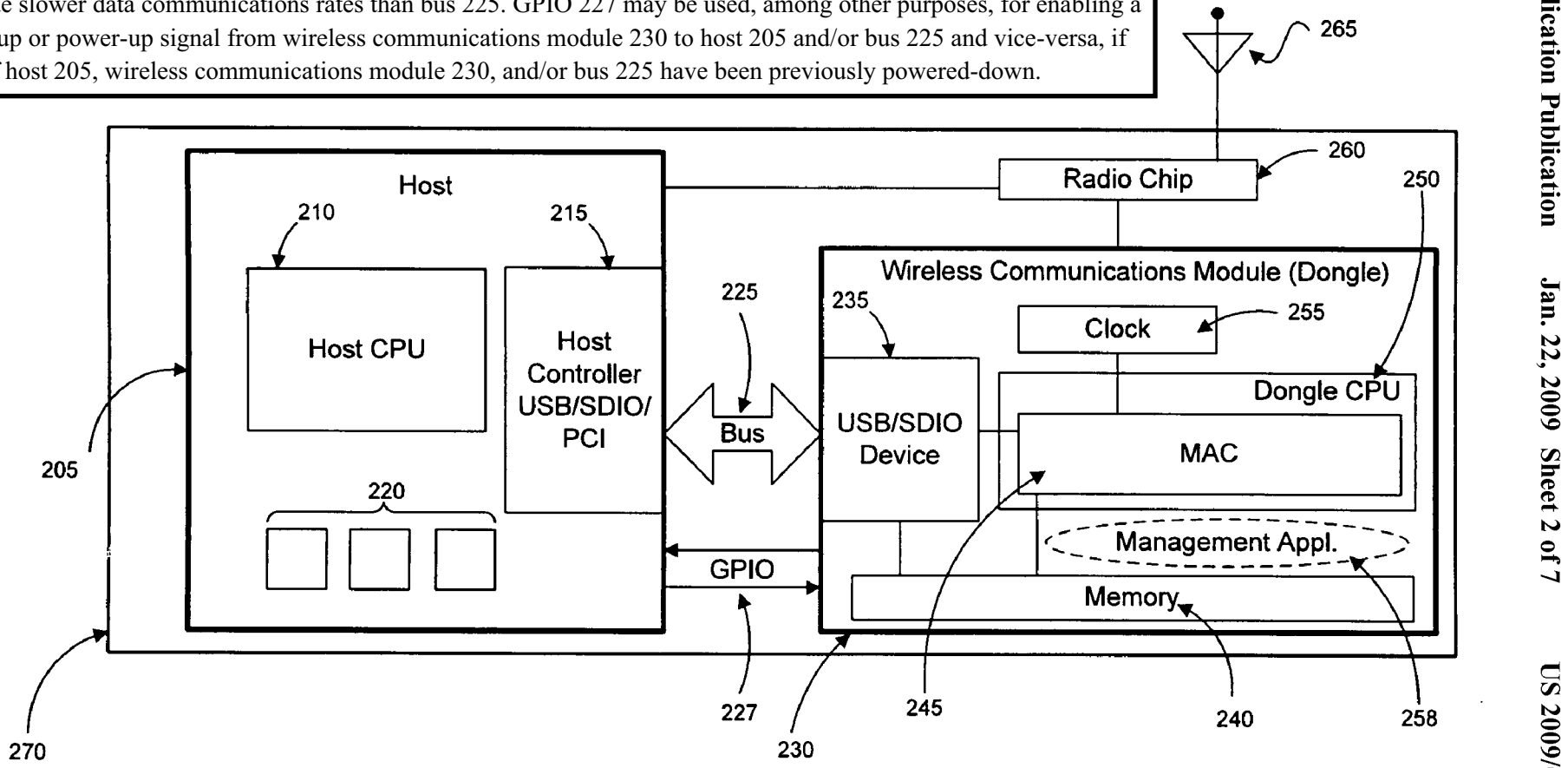


FIG. 1

[0060] In addition, when network discovery and connection management functions are offloaded to a wireless communications module, the wireless communications module can be configured to assist the host module with power management functions. In particular, the wireless communications module can assist the host module in making power management decisions regarding system components, including a host bus controller and/or a communications port controller at the wireless communications module itself. For example, the wireless communications module can assist the host module to make power management decisions when no network is discovered, when no data is available (excluding management packets), and in the smart adaptive scan mode (described below).

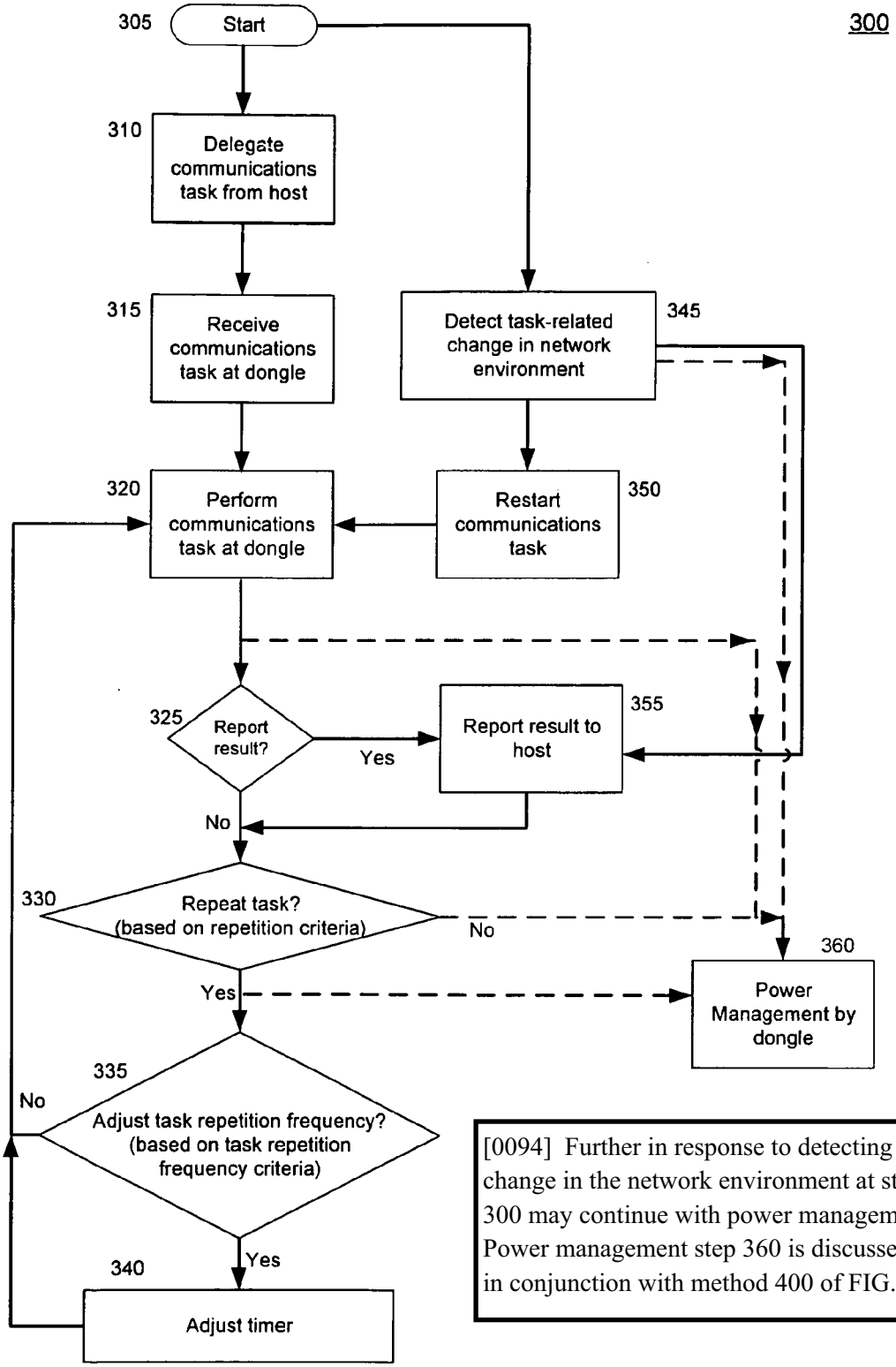
[0061] Further, offloading network discovery and connection management functions to the wireless communications module allows higher-level applications running on the primary processor to quickly switch between networks, when necessary. In an embodiment, a "background scan" is used at the wireless communications module even when the system is associated with a network, so that the overall system (that is, the wireless device) always has full awareness of all available network connections.

[0062] FIG. 2 is a block diagram of an exemplary wireless device 110, which may for example be a WiFi device or a WiFi enabled device, a Bluetooth or Bluetooth enabled device, a cell phone, or other wireless device. Exemplary wireless device 110 may comprise an exemplary host device 205 and an exemplary wireless communications module 230 which may also be known as exemplary dongle 230. Host 205 and wireless communications module 230 are coupled by an exemplary bus 225. Bus 225 enables signal and data communications between host 205 and wireless communications module 230. Host 205 and wireless communications module 230 may also be coupled by an exemplary general purpose input/output (GPIO) connection 227, which may use less power than bus 225, and possibly provide slower data communications rates than bus 225. GPIO 227 may be used, among other purposes, for enabling a wake-up or power-up signal from wireless communications module 230 to host 205 and/or bus 225 and vice-versa, if any of host 205, wireless communications module 230, and/or bus 225 have been previously powered-down.



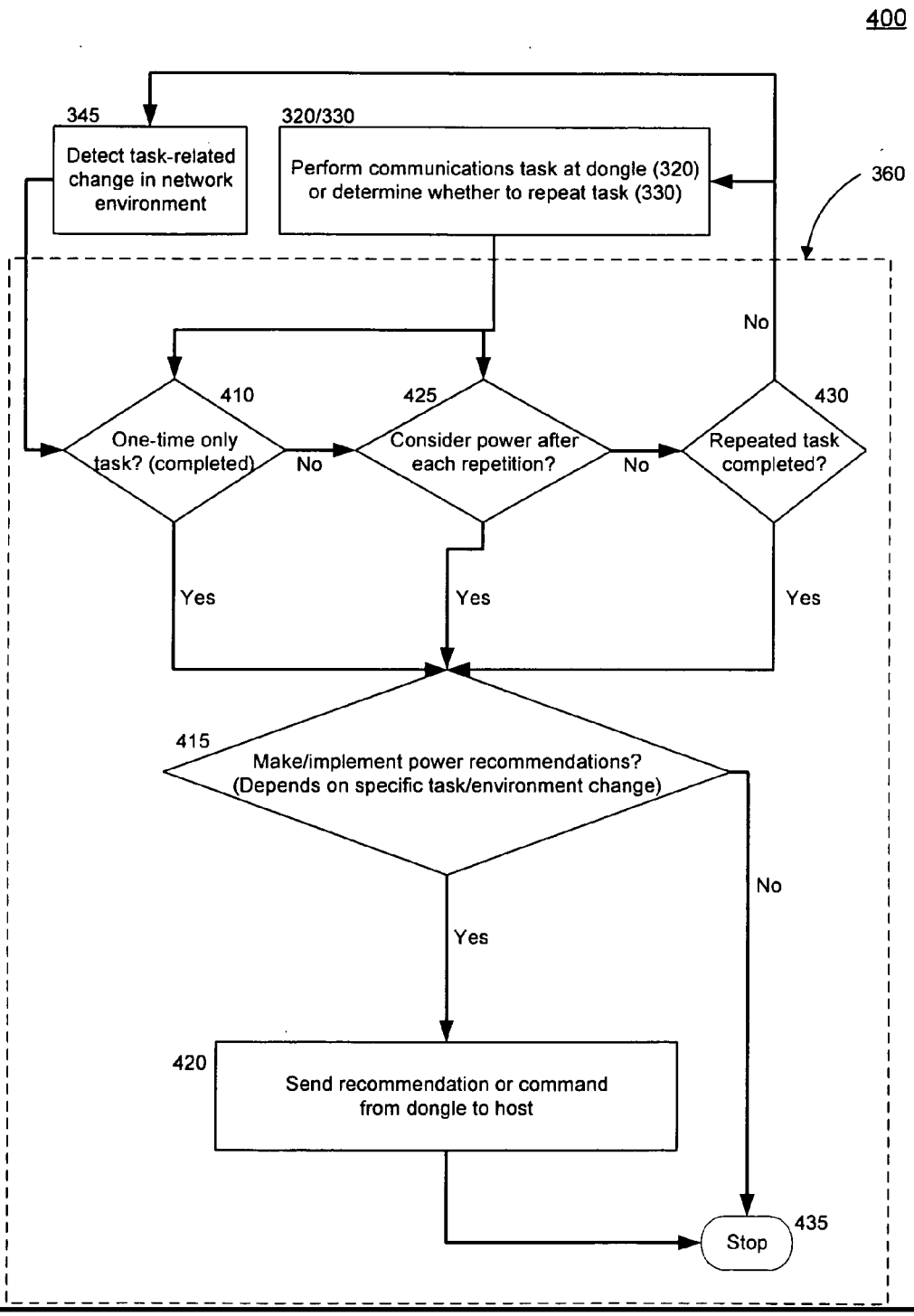
[0072] In an embodiment of the present system and method, MAC 245 or dongle CPU 250 are specifically configured to be electronics which draws less power than host CPU 210 of host 205. For example, in one embodiment of the present system and method, dongle CPU 250 may be implemented with a microprocessor which is less complex or has a simpler architecture than host CPU 210. For example, dongle CPU 250 may be smaller in physical size, have fewer transistors, have smaller on-board cache memory and/or fewer cache levels, have fewer pipelines, have a narrower internal bus width, have fewer microprocessor cores, or have other architectural and design differences as compared with host CPU 210. The different architecture results in overall reduced power consumption for dongle CPU 250 as compared with host CPU 210 based on suitable comparisons (for example, a comparison of the power consumed by each CPU when performing the same, substantially similar, or analogous processing tasks).

[0080] FIG. 3 illustrates an exemplary general method 300 for network connection and power management on a wireless device 110 which employs a wireless communications module 230 coupled with a host 205.



[0094] Further in response to detecting a task-related change in the network environment at step 345, method 300 may continue with power management step 360. Power management step 360 is discussed further below in conjunction with method 400 of FIG. 4.

FIG. 3



[0108] At step 415 a determination is made as to whether a power recommendation should be made or whether a power policy should be implemented. The exact decision will depend upon a specific task and a specific environmental change. For example, if the task is to detect that no network connection is available after a period of time in which there has been a network connection available, the power policy or power recommendation may be to power down certain chips which support communications tasks. Similarly, if a determination is made that a network connection is now available after a period of time when a network connection was not available, the power policy or power recommendation may be to deliver power or increase power delivery to certain components which perform certain communications task.

[0121] FIG. 5 is a flowchart of an exemplary method 500 for network scanning and association according to an embodiment of the present invention. A preferred network scan includes scanning for networks 130 from a list of preferred networks, where the list of preferred networks may be defined or configured by the host module. Exemplary method 500 is performed by wireless communications module 230.

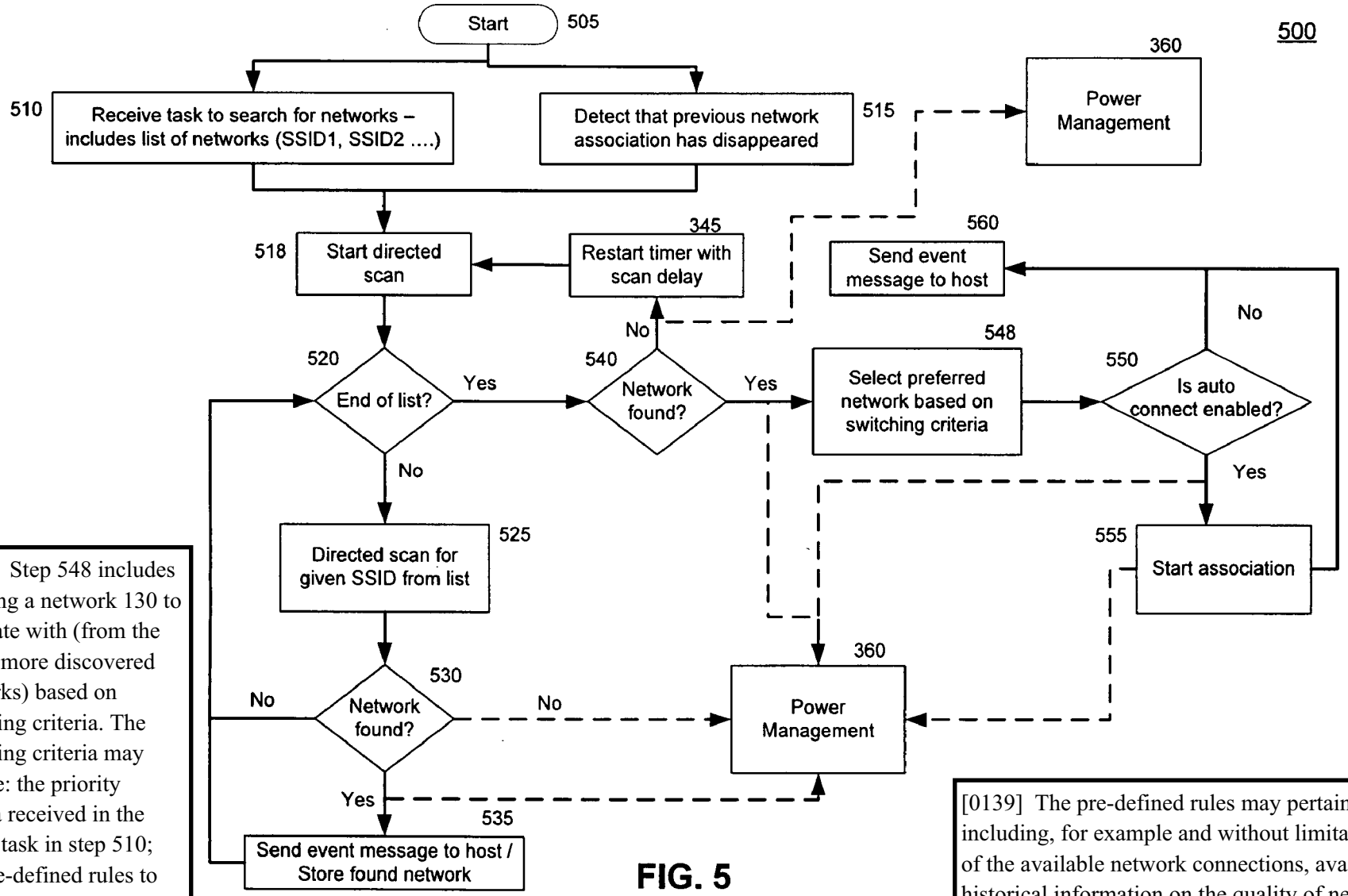


FIG. 5

[0136] Step 548 includes selecting a network 130 to associate with (from the one or more discovered networks) based on switching criteria. The switching criteria may include: the priority criteria received in the search task in step 510; and pre-defined rules to control the switching of the system between networks 130.

[0139] The pre-defined rules may pertain to any number of factors including, for example and without limitation: the quality or speed of the available network connections, available battery power, historical information on the quality of network connections, connection security level, and other factors. Such rules may be defined in whole or in part by rules built into a non-volatile memory 240 of wireless communications module 230....

[0144] FIG. 6 is a flowchart of an exemplary method 600 for background network scanning and association according to an embodiment of the present invention. A background scan may be used by a management application 258 at wireless communications module 230 to continue to scan for networks even when wireless device 110 is associated with a network 130. This allows management application 258 to automatically switch between networks 130 based on switching criteria (for example, the ordered preference list, other network preference criteria, signal strength, link speed, network, security, and/or other criteria) set by host 205. Further, this allows management application 258 to report to host 205 the availability of networks 130 (both from within or outside the preferred list of networks) or the disappearance of networks 130 from the preferred list, thereby enabling host 130 to make intelligent network association decisions.

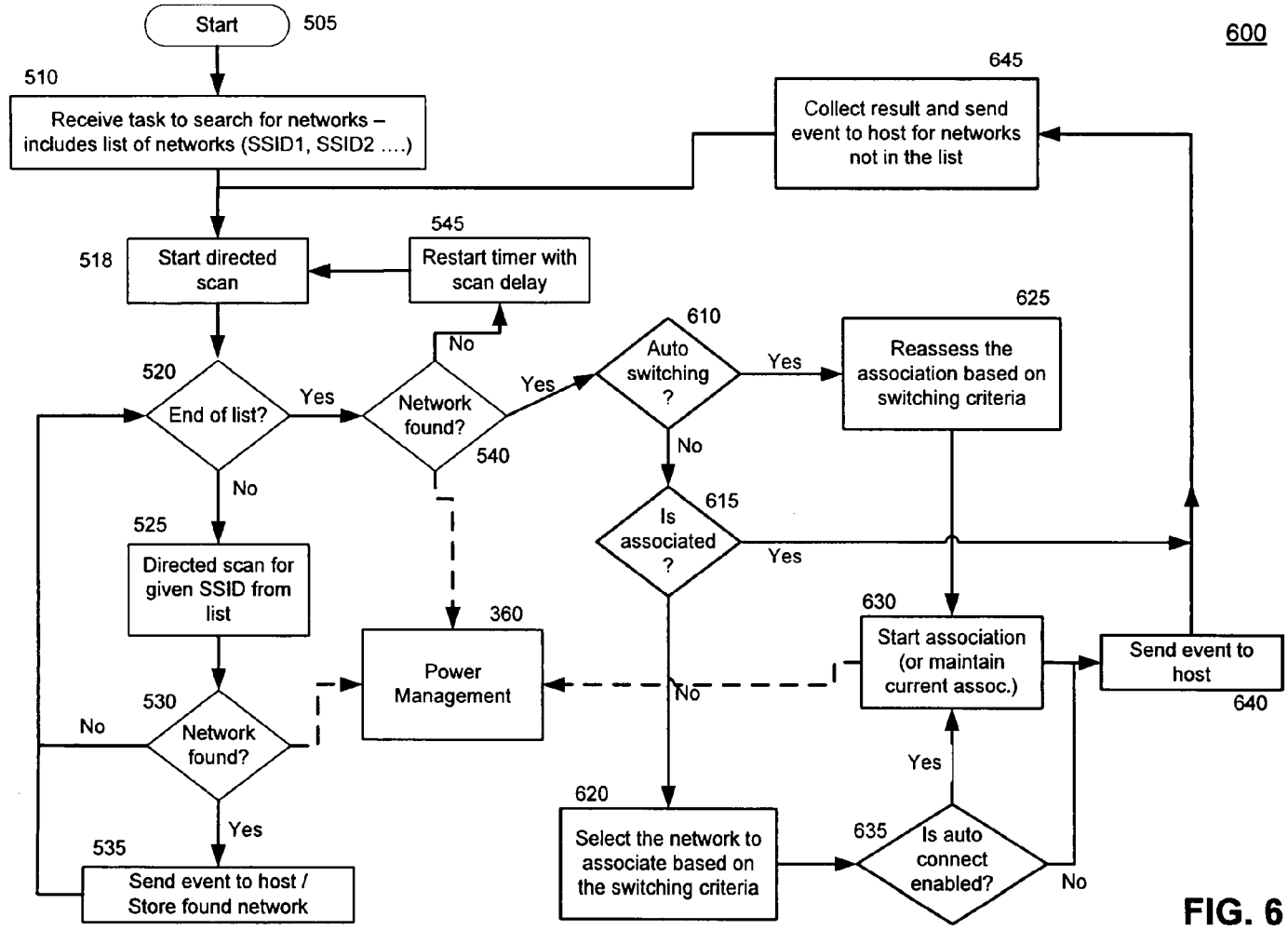


FIG. 6

[0174]According to further embodiments of the present invention, the management application at wireless communications module 230 enables an adaptive scanning algorithm, which may enables wireless system 110 to conserve energy. In a scanning algorithm embodiment 700, illustrated in FIG. 7, adaptive scanning algorithm 700 includes performing directed network scans according to adaptively variable frequencies. (The term "frequency", as used in the present context, refers to a "frequency in time" of performing a step or action pertaining to network scanning, and not "frequency" as a "measure of repetitions of cycles of a radio wave".)

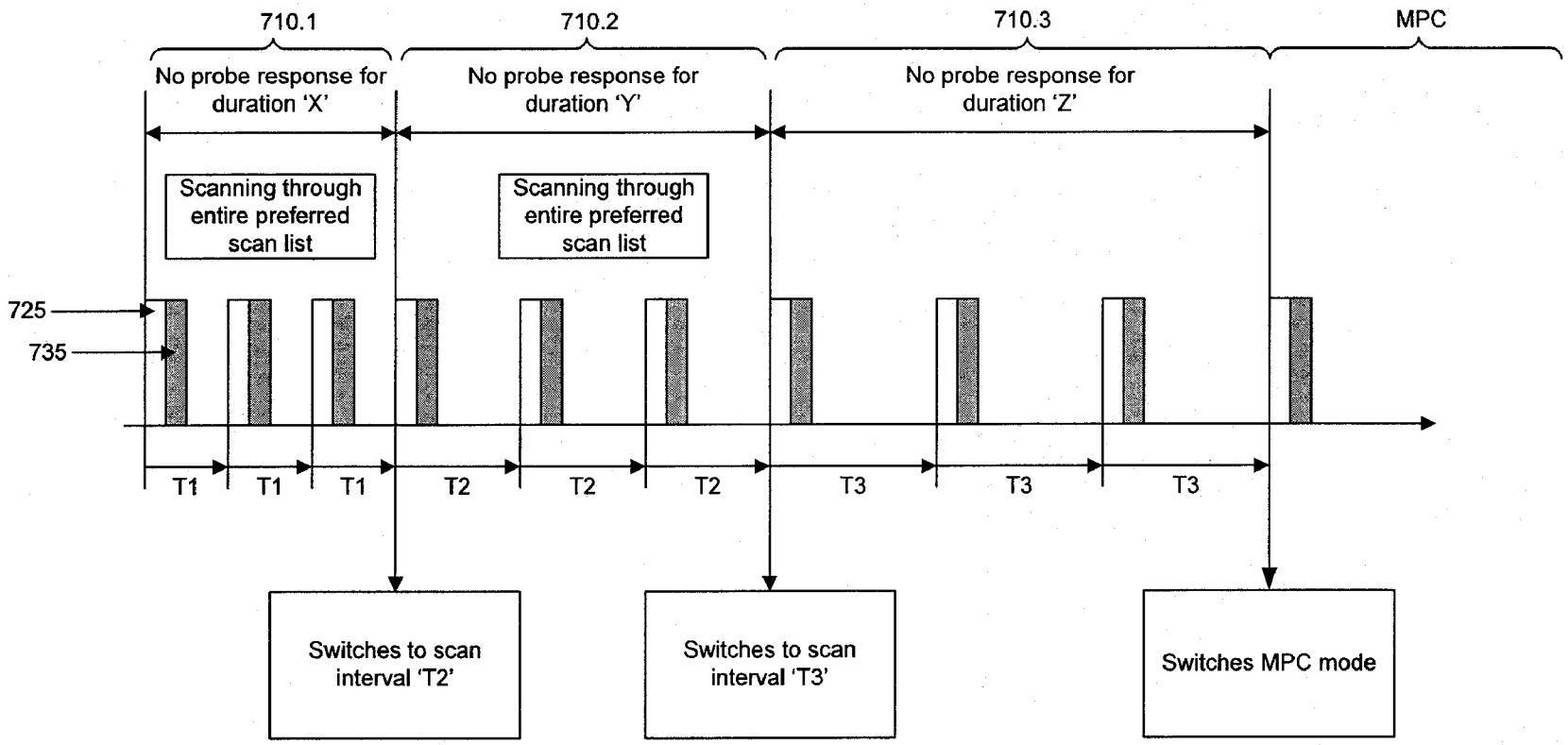


FIG. 7

DELEGATED NETWORK CONNECTION MANAGEMENT AND POWER MANAGEMENT IN A WIRELESS DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This patent application claims the benefit of U.S. Provisional Patent Application No. 60/929,888, filed Jul. 16, 2007, entitled "Low Powered 802.11 Wireless Device," and also claims the benefit of U.S. Provisional Patent Application No. 61/046,170, filed Apr. 18, 2008, entitled "Delegated Network Connection Management And Power Management In A Wireless Device," both of which are incorporated herein by reference in their entirety.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates generally to wireless communications. It relates further to advanced media access control (MAC) capabilities and also to power management in a wireless communications device.

[0004] 2. Background Art

[0005] Wireless communications systems, such as wireless-enabled laptop computers, PDAs, portable music players, portable televisions, personal digital assistants (PDAs), WiFi cards, cell phones, and similar mobile digital devices and mobile analog devices pose multiple challenges for design engineers and users alike.

[0006] For all portable electronic devices, and for wireless devices in particular, power management is a concern as battery life is always limited. Reduced power consumption means longer battery life and better system performance. Even routine management of an existing network connection can be a significant drain on battery power. Further, maintaining optimum network connections and other network management tasks can consume substantial battery power.

[0007] Users in a wireless environment are typically mobile, and so may come in and out of range of wireless access points (APs). Not all APs may support the connections desired by a user, and not all APs provide optimal access (such as high speed wireless links). In addition, other environmental factors, such as a constantly changing multipath environment, may also influence the quality and availability of network connections. Therefore, establishing, maintaining, and optimizing network connections is an ongoing task with significant power demands. For example, if a network connection is lost altogether, substantial power may be consumed simply by continuing to monitor a "dead" network environment, and further power may be consumed by actively sending probes into the network environment to reestablish the connection as quickly as possible.

[0008] As another example, if a user is currently linked to a network via a low speed or low quality network connection, a better network connection should be established as soon as it is available. Similarly, a user may be seeking to use a preferred network connection, but may also be willing to use alternative network connections until a preferred network connection becomes available. This may therefore entail searching for the preferred network connection even while an existing network connection is in place.

[0009] A closely related challenge lies in maintaining awareness of the network environment. Wireless hardware benefits from knowing the speed and quality of network connections. The wireless hardware and wireless user may benefit from learning of the availability of alternative or additional network connections, apart from a connection the user may have at the current moment. Maintaining this wireless environmental awareness again places significant power demands on the system.

[0010] A further challenge is to provide optimized network connectivity and communications management, including reduced power consumption, while not overly taxing the resources of a primary processor of the wireless communications system. Excessive use of a primary processor for network connectivity support may degrade other aspects of system performance.

[0011] What is needed, then, is a system and method in a wireless device for advanced wireless network discovery while minimizing system power consumption. Furthermore, it should also provide for advanced management and maintenance of network connections, that simultaneously provides robust, intelligent connection management, and minimizes the impact on a primary processor of the wireless communications system.

BRIEF SUMMARY

[0012] The embodiments described herein meet the above-identified needs by providing a system and method for advanced network connection management with lower power consumption. In particular, the configuration described herein distributes network management functions between a host device and a dedicated wireless communications module. In an embodiment, the wireless communications module provides network discovery and connection management functions, relieving the host module of some or all of these responsibilities. This may result in lower system power consumption, more advanced network management features, and more effective use of a processor or processors on the host device. In particular, the host device can use a lower power mode or turn off when not required to support communications functions, resulting in lower overall system power consumption.

BRIEF DESCRIPTION OF THE DRAWINGS/FIGURES

[0013] The features and advantages of the present invention will become more apparent from the detailed description set forth below when taken in conjunction with the drawings in which like reference numbers indicate identical or functionally similar elements. Additionally, the left-most digit of a reference number identifies the drawing in which the reference number first appears (for example, an element labeled **310** typically first appears in the drawing labeled FIG. **3**).

[0014] FIG. **1** illustrates an exemplary network environment.

[0015] FIG. **2** illustrates an exemplary wireless host coupled with an exemplary wireless communications module according to an embodiment of the present invention.

[0016] FIG. **3** is a flowchart of an exemplary process for delegating communications tasks from a wireless host to a wireless communications module according to an embodiment of the present invention.

[0017] FIG. **4** is a flowchart of an exemplary power management process associated with delegating communications tasks from a wireless host to a wireless communications module according to an embodiment of the present invention.

[0018] FIG. **5** is a flowchart of an exemplary process for network scanning and association according to an embodiment of the present invention.

[0019] FIG. **6** is a flowchart of an exemplary process for background network scanning and association according to an embodiment of the present invention.

[0020] FIG. **7** illustrates an exemplary adaptive scanning algorithm according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

1. INTRODUCTION

[0021] The present invention is directed to a system and method for advanced media access control delegated in part or in whole from a host device to a wireless communications module. The following detailed description of the present invention refers to the accompanying drawings that illustrate exemplary embodiments consistent with this invention. Other embodiments are possible, and modifications may be made to the embodiments within the spirit and scope of the invention. Therefore, the detailed description is not meant to limit the invention. Rather, the scope of the invention is defined by the appended claims.

2. DEFINITIONS

[0022] The following definitions characterize some features, properties, components, behaviors, elements, or functions of the systems or methods discussed in this document. Further defining aspects or characteristics may be introduced in the detailed discussion in remaining portions of this document. In addition, elements so defined may have additional features, properties, components, behaviors, elements, or functions which are not enumerated in this document, but which may be familiar to those skilled in the relevant arts.

[0023] Some systems or methods may be defined or characterized here in whole or in part by exemplary instances of such systems or methods (for example, by a particular exemplary type of wireless device, such as an 802.11 enabled device, a personal digital assistant, etc.). It should be understood, however, that such systems or methods may encompass other specific instances or embodiments not listed in the definitions below or elsewhere herein.

[0024] Wireless device—The terms "wireless device", "wireless communications device", "wireless communications system", and "wireless system" are used synonymously herein. These terms may typically refer to a self-contained, fully-featured portable device used for processing, transmitting, and/or receiving voice, music, other sounds, still images, video, text, e-mail, Web page content, digital documents, a variety of other digital files, and other data or content matter of interest. Other synonymous terms which may be used in the art include "mobile digital device" and "mobile analog device".

[0025] Such devices may include, for example and without limitation, 802.11 enabled devices in general, laptop computers, portable music players, portable televisions, personal digital assistants (PDAs), and similar devices. Devices using other wireless communications protocols, such as Bluetooth or any of several cell phone communications protocols are also wireless devices within the scope of the present system and method. Such devices include some mobile phones, laptop computers, GPS devices, wireless video game consoles, and cell phones.

[0026] Such devices may be principally dedicated to communications, or may be principally dedicated to a variety of other data processing tasks but have enabled within a capability for wireless communications (for example, laptop computers, portable music players). Wireless devices typically have a host CPU, which may be configured to support in whole in or in part the communications tasks of the wireless device, but at a minimum is generally capable of supporting higher level network management tasks associated with media access control (MAC) services. Wireless devices may or may not have a radio chip for actual modulation, demodulation, transmission, and reception of the radio frequency (RF) waves used to carry wireless signals; in some cases, they may depend on a wireless communications module (defined below) for a radio chip.

[0027] In some cases, the terms "wireless device", "wireless communications system", or "wireless system" may refer to a built-in or removable component part of a larger device, wherein the component part is dedicated to providing wireless communications capabilities and services. For example, a WiFi card, which may be attached to a USB port or inserted into a PCMCIA slot of a laptop computer, may be regarded as a "wireless device" or "wireless communications system".

[0028] As used in this document, the terms "wireless device", "wireless communications device", "wireless communications system", or "wireless system" will have a component referred to in this document as a "host" or "host device", defined further immediately below. A wireless device may also have a component referred to in this document as a "wireless communications module" or a "dongle", also defined further below.

[0029] "Wireless device" and synonymous terms may refer to a device which operates without the wireless communications module of the present invention. "Wireless device" and synonymous terms may also refer to a device which incorporates the wireless communications module of the present invention. For example, a WiFi card or a PDA, without the wireless communications module of the present invention may be considered a wireless device. Also, a WiFi card or a PDA with the wireless communications module of the present invention may be considered a wireless device.

[0030] Host/Host device—The terms "host", "wireless host", and "host device" are used synonymously herein to refer to a wireless device, as defined immediately above, which specifically does not include the wireless communications module of the present invention. However, a host device may be coupled or be capable of being coupled to a wireless communications module.

[0031] For example, a WiFi enabled cell phone or a PDA with an SDIO slot for accepting a variety of adapters may be

[0215] According to embodiments of the present invention, several power management functions can be implemented based on the above described functions and events. For example, when the host **205** receives a 'no network found' or a 'no data available' event from the wireless communications module **230**, host **205** can instruct the wireless communications module **230** through out-of-band GPIO **227** to shut down its bus device (e.g., USB/SDIO Device in FIG. **2**). The host **205** can further shut down its own bus controller. Subsequently, when any of the bus devices (host bus controller **215** or wireless communications module bus device **235**) wants to communicate over the bus **225**, it uses the out-of-band GPIO **227** to indicate this desire to communicate to the other side and to wake up the bus.

10. CONCLUSION

[0216] As will be appreciated by persons skilled in the relevant art(s), the system(s) and method(s) described here represent only one possible embodiment of the present invention. Many of the elements described herein could, in alternative embodiments of the present invention, be configured differently within the scope and spirit of the present invention. In addition, additional elements, or a different organization of the various elements, could still implement the overall effect and intent of the present system and method. Therefore, the scope of the present invention is not limited by the above disclosure and detailed embodiments described therein, but rather is determined by the scope of the appended claims.

What is claimed is:

1. In a communications system comprising a host and a wireless communications module coupled to said host, a method for network discovery and connection management comprising:
- delegating from a processor of said host a communications task, wherein said communications task comprises at least one of:
  - a task to automate an establishment of a network connection;
  - a task to optimize a network connection; and
  - a task to report on a network environment;
- receiving at said wireless communications module said communications task; and
- performing at said wireless communications module said communications task.

2. The method of claim **1**, wherein said task further comprises:
- a list comprising:
  - a plurality of alternative networks; and
  - a criteria for prioritizing said networks;
- a second task to search said network environment for at least an available network of said plurality of networks; and
- a third task to establish said network connection with a highest priority network of said at least an available network, wherein said highest priority network of said at least an available network is a preferred network.

3. The method of claim **2**, further comprising:
- receiving said task at said wireless communications module;
- searching said network environment via said wireless communications module for said preferred network; and
- establishing via said wireless communications module said connection with said preferred network.

4. The method of claim **1**, further comprising performing said communications task at said wireless communications module in parallel with maintaining an existing network connection via said wireless communications module.

5. The method of claim **4**, further comprising:
- defining in said communications task a preferred network connection; and
- monitoring said network environment for said preferred network connection while maintaining said existing network connection.

6. The method of claim **5**, further comprising switching said network connection to said preferred network upon a detection of said preferred network.

7. The method of claim **1**, further comprising delegating from the processor of said host a communications task of determining at least one of a communications event or a communications status.

8. The method of claim **7**, wherein said at least one of said communications status or said communications event comprises at least one of:
- an existing network connection is found;
- said existing network is not found
- a preferred network is found;
- said preferred network is not found;
- a data packet is found;
- said data packet is not found;
- a management packet is found; or
- said management packet is not found.

9. The method of claim **7**, further comprising signaling the host with the at least one of the communications status or the communications event.

10. The method of claim **1**, further comprising periodically performing said communications task.

11. The method of claim **10**, further comprising adjusting a timing between repetitions of said periodic communications task.

12. The method of claim **11**, further comprising adjusting said timing in conformance with a detected condition of said network environment.

13. The method of claim **12**, further comprising adjusting said timing in conformance with a detection that a current network connection is not found and a preferred network connection is not found.

14. The method of claim **1**, further comprising:
- defining in said communications task a specified network condition; and
- notifying said host module when said specified condition is detected by said wireless communications module.

15. The method of claim **1**, further comprising:
- defining in said communications task a specified network condition and a specified response; and
- automatically performing said specified response by said wireless communications module when said specified network condition is detected by said wireless communications module.

16. The method of claim **1**, further comprising configuring said wireless communications module to store a data pertaining to a detected condition of said network environment.

17. The method of claim **1**, further comprising:
- defining in said communications task a network condition filter criteria; and
- reporting from said wireless communications module to said host a detected network condition which conforms to said filter criteria.

18. The method of claim 1, further comprising:
configuring said wireless communications module to recognize a network condition not requiring support from said host; and
in response to said network condition sending a power-consumption reduction command from said wireless communications module to at least one of said host, a processor of said host, a bus of said host, and a radio chip associated with said host.

19. A system for media access control, said system receiving a delegated communications task from a host device, comprising:
a media access control (MAC) device constructed and arranged to receive said delegated communications task;
said MAC device further constructed and arranged to manage a process of network discovery and network connection management according to said delegated communications task, said delegated communications task comprising at least one of:
a task to automate an establishment of a network connection;
a task to optimize a network connection; and
a task to report on a network environment.

20. The system of claim 19, wherein said MAC device comprises a processor and a memory in communication with said processor, said memory storing a plurality of processing instructions for directing the processor to manage the network environment according to said delegated communications task.

21. The system of claim 19, wherein said MAC device is constructed and arranged to consume less power to perform said communications task than a power required by a processor of said host device to perform said communications task.

22. The system of claim 19, wherein said MAC device is further constructed and arranged to perform said delegated communications task in parallel with maintaining an existing network connection.

23. The system of claim 19, wherein said MAC device is further constructed and arranged to periodically perform said communications task.

24. The system of claim 19, wherein said MAC device is further constructed and arranged to adjust a timing between repetitions of said periodic communications task in conformance with a detected condition of said network environment.

25. The system of claim 19, wherein:
said host device comprises at least one of a processor, a radio chip, and a bus; and
said MAC device is configured and arranged that upon a determination of a lack of network connectivity said MAC device issues a sleep command to at least one of said processor, said radio chip, or said bus.

26. A system for media access control, comprising:
a host module constructed and arranged to delegate a communications task; and
a media access control (MAC) device coupled to said host module;
said MAC device constructed and arranged to receive said delegated communications task;
said MAC device further constructed and arranged to manage a process of network discovery and network connection management according to said delegated communications task;
wherein said host module switches to a low power mode after offloading said delegated communications task to said MAC device.

27. The system of claim 26, wherein said host module comprises a first processor, wherein said MAC device is constructed and arranged to consume less power to perform said communications task compared to a power required by said first processor to perform said communications task.

28. In a communications system comprising a host and a wireless communications module coupled to said host, a method for network discovery and connection management comprising:
delegating from a processor of said host a communications task, wherein said communications task comprises at least one of:
a task to automate an establishment of a connection to a preferred network;
a task to detect a preferred network; and
a task to automatically switch a network connection to a preferred network;
receiving at said wireless communications module said communications task; and
performing at said wireless communications module said communications task.

29. In a communications system comprising a host and a wireless communications module coupled to said host, a method for network discovery and connection management comprising:
delegating from a processor of said host a communications task;
receiving at said wireless communications module said communications task; and
performing at said wireless communications module said communications task.

30. The method of claim 29, wherein the step of delegating the communications task from the processor of the host communications module comprises at least one of:
delegating a task to automate an establishment of a network connection;
delegating a task to optimize a network connection; and
delegating a task to report on a network environment.

31. The method of claim 29, wherein the step of delegating the communications task from the processor of the host communications module comprises at least one of:
delegating a task to automate an establishment of a connection to a preferred network;
delegating a task to detect a preferred network; and
delegating a task to automatically switch a network connection to a preferred network.

32. A system for media access control, said system receiving a delegated communications task from a host device, comprising:
a media access control (MAC) device constructed and arranged to receive said delegated communications task;
said MAC device further constructed and arranged to manage a process of network discovery and network connection management according to said delegated communications task.

* * * * *