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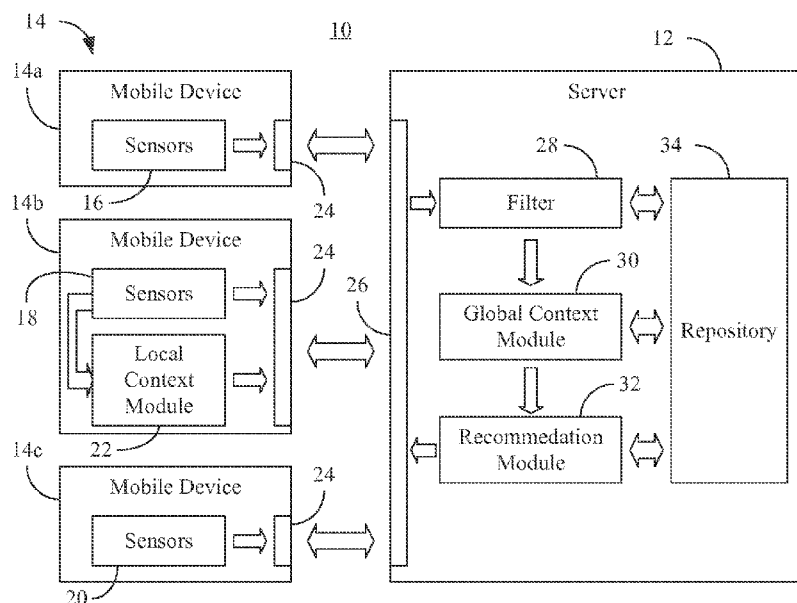
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(54) Title: CLOUD-AWARE COLLABORATIVE MOBILE PLATFORM POWER MANAGEMENT USING MOBILE SENSORS

**FIG. 1**

(57) Abstract: Methods and systems may provide for accumulating sensor-based information from a plurality of mobile devices and identifying context information in the sensor-based information, wherein the context information is relevant to a particular mobile device in the plurality of mobile devices. Additionally, an operational recommendation may be sent to the particular mobile device based on the context information. In one example, the operational recommendation identifies one or more of a power management action, a performance management action, a wireless interface selection and a wireless access point selection.

**CLOUD-AWARE COLLABORATIVE MOBILE PLATFORM POWER
MANAGEMENT USING MOBILE SENSORS**

BACKGROUND

5

Technical Field

Embodiments generally relate to the collaborative operational management of mobile platforms. More particularly, embodiments relate to using sensor-based information from a plurality of mobile devices to collaboratively manage the power and performance settings of individual mobile devices.

Discussion

Modern mobile devices may conduct performance and power management activities based on conditions detected locally at the mobile device. For example, when a user of a mobile device visits a new location, the mobile device may independently scan/probe wireless channels and/or interfaces in order to determine the availability of an Internet connection. Such an approach may yield sub-optimal power efficiency and can result in reduced battery life.

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BRIEF DESCRIPTION OF THE DRAWINGS

The various advantages of the embodiments of the present invention will become apparent to one skilled in the art by reading the following specification and appended claims, and by referencing the following drawings, in which:

FIG. 1 is a block diagram of an example of a collaborative operational management architecture according to an embodiment;

FIG. 2 is a flowchart of an example of a method of operating a server according to an embodiment;

FIG. 3 is a flowchart of an example of a method of managing wireless connections on a mobile device according to an embodiment; and

FIG. 4 is a graphical illustration of an example of a set of wireless connection context information according to an embodiment.

DETAILED DESCRIPTION

FIG. 1 shows an architecture 10 in which a server 12 accumulates sensor-based

information from a plurality of mobile devices 14 (14a-14c), identifies global context information in the sensor-based information, and sends operational recommendations to particular (e.g., individual and/or specific) mobile devices 14 based on the context information. The mobile devices 14 (e.g., clients) may include, but are not limited to, 5 notebook computers, smart tablets, personal digital assistants (PDAs), mobile Internet devices (MIDs), wireless smart phones, image capture devices, media players, etc., wherein the illustrated mobile devices 14 may be operated and/or owned by different users who may or may not be affiliated with one another.

In the illustrated example, the mobile devices 14 include one or more sensors from 10 which the sensor-based information originates. For example, a first mobile device 14a may include sensors 16, a second mobile device 14b may include sensors 18, and a third mobile device 14c may include sensors 20. The sensors 16, 18, 20 might include, for example, accelerometers, gyroscopes, proximity sensors, ambient light sensors, digital compasses, global positioning system (GPS) sensors, battery life sensors (e.g., current, voltage and/or 15 charge level sensors), wireless network controllers, and so forth, wherein the individual mobile devices 14 may have different sensor configurations as well as different communication capabilities from one another. Thus, the first mobile device 14a may send a different type of sensor-based information than the second mobile device 14b and/or the third mobile device 14c, the second mobile device 14b may send a different type of sensor-based information than the first mobile device 14a and/or the third mobile device 14c, and 20 so forth.

The sensor-based information may include raw sensor data such as, for example, received signal strength (RSS) data, accelerometer data, wireless access point (AP) identifier data, battery life data, and so forth. The sensor-based information may also 25 include device-generated local context information from, for example, a local context module 22 of the second mobile device 14b. For example, the local context module 22 may be configured to determine whether the second mobile device 14b is relatively stationary and report that information to the server 12 as local context information. The local context information may also include other information such as the geographic location (e.g., place 30 of business, street address, etc.) of the mobile device 14b, user requests/settings, and so forth.

In the illustrated example, the mobile devices 14 send the sensor-based information to the server 12 via network interfaces 24 (e.g., network controller, communications physical layer/PHY, antenna structure, etc.) and an appropriate network infrastructure (not

shown). The network infrastructure may incorporate technology such as, for example, cellular telephone (e.g., Wideband Code Division Multiple Access/W-CDMA (Universal Mobile Telecommunications System/UMTS), CDMA2000 (IS-856/IS-2000), etc.), WiFi (Wireless Fidelity, e.g., Institute of Electrical and Electronics Engineers/IEEE 802.11-
5 2007, Wireless Local Area Network/LAN Medium Access Control (MAC) and PHY Specifications), 4G LTE (Fourth Generation Long Term Evolution), Bluetooth (e.g., IEEE 802.15.1-2005, Wireless Personal Area Networks), WiMax (e.g., IEEE 802.16-2004, LAN/MAN Broadband Wireless LANS), GPS, spread spectrum (e.g., 900 MHz), near field communications (NFC), and/or other radio frequency (RF) telephony technology.

10 The illustrated server 12 includes a network interface 26 (e.g., network controller, communications PHY, antenna structure) configured to accumulate the sensor-based information from the mobile devices 14 and a global context module 30 to identify global and/or local context information in the sensor-based information, wherein the context information may be relevant to one or more of the mobile devices 14. For example, sensor-
15 based information such as a wireless AP identifier obtained from a WiFi sensor of the third mobile device 14c might be associated with a location that is near (e.g., geographically relevant to) a street address obtained from the local context module 22 of the second mobile device 14b, wherein the wireless AP identifier, the street address and/or the geographic relationship between the two may be considered context information. Other
20 types of context information may also be determined based on, for example, wireless connectivity, battery life, etc.

The server 12 may also include a recommendation module 32 to send operational recommendations to particular mobile devices 14 based on the context information identified by the global context module 30. Thus, in the example of the second mobile
25 device 14b and the third mobile device 14c providing geographically relevant information, the recommendation module 32 might recommend that the second mobile device 14b attempt to access the wireless AP identified by the third mobile device 14c. Of particular note is that such a recommendation may be especially useful if the second mobile device 14b has reported that its WiFi throughput and/or RSS is relatively low and the third mobile
30 device has reported that its WiFi throughput and/or RSS is relatively high, wherein greater throughput may result in better performance as well as enhanced power efficiency.

Indeed, the second mobile device 14b may be using a different network controller altogether (e.g., third generation/3G controller) that might provide sub-optimal performance and/or power efficiency compared to the WiFi wireless AP link identified by

the third mobile device 14c. Thus, the illustrated example obviates any need for the mobile devices 14 to continuously scan/probe each wireless controller, interface and/or AP to determine the wireless configuration that provides the best performance. Other types of operational recommendations such as, for example, other power management actions (e.g., suggestion to visit nearby charging stations), performance management actions, (e.g., suggestion to activate/deactivate various radios and/or software applications) wireless interface selections, and so forth, may also be generated by the recommendation module 32. One or more the mobile devices 14 may also have local recommendation modules to generate operational recommendations from raw sensor data and/or context information.

The illustrated server 12 also includes a filter module 28 to filter out (e.g., remove) a portion of the sensor-based information (e.g., to obtain a reduced set of sensor-based information) and a cloud repository 34 to store the reduced set of sensor based-information for future use, indexing and/or searching. The removed portion of the sensor-based information may be determined to be redundant, obsolete and/or otherwise unnecessary, wherein the filtering determination may be made based on various requirements from other components of the server 12 such as, for example, the global context module 30 (e.g., processing overhead limitations), recommendation module 32 (e.g., processing overhead limitations) and/or repository 34 (e.g., storage limitations).

In one example, the architecture 10 includes logic that at least partially includes hardware logic. In such a case, the hardware logic may be implemented in the server 12 as, for example, the network interface 26, the global context module 30, the recommendation module 32 and/or the filter module 28. Additionally, the hardware logic may be implemented in one or more of the mobile devices 14 as, for example, the network interfaces 24, the local context module 22 and/or sensor interfaces.

Turning now to FIG. 2, a method 36 of operating a server such as, for example, the server 12 (FIG. 1), is shown. The method 36 may be implemented as a set of logic instructions stored in a machine- or computer-readable storage medium such as random access memory (RAM), read only memory (ROM), programmable ROM (PROM), firmware, flash memory, etc., in configurable logic such as, for example, programmable logic arrays (PLAs), field programmable gate arrays (FPGAs), complex programmable logic devices (CPLDs), in fixed-functionality logic hardware using circuit technology such as, for example, application specific integrated circuit (ASIC), complementary metal oxide semiconductor (CMOS) or transistor-transistor logic (TTL) technology, or any combination thereof. For example, computer program code to carry out operations shown

in the method 36 may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages.

5 Illustrated processing block 38 provides for accumulating sensor-based information from a plurality of mobile devices, wherein the sensor-based information may include raw sensor data, device-generated context information, and so forth. In one example, the raw sensor data includes, for example, RSS data, accelerometer, wireless AP identifier data, battery life data, and so forth. Block 38 may also involve filtering out a portion of the
10 sensor-based information to obtain a reduced set of sensor-based information and/or storing the reduced set of sensor-based information to a cloud repository. Context information may be identified in the sensor-based information at block 40, wherein the context information can be identified based on location, wireless connectivity, battery life, etc. In one example, the context information is identified in the reduced set of sensor-based
15 information resulting from one or more filtering operations, as already noted.

Illustrated block 42 provides for sending an operational recommendation to one or more particular mobile devices based on the context information. The operational recommendation may identify, for example, a power management action, a performance management action, a wireless interface selection, a wireless AP selection, and so forth,
20 wherein the receiving mobile device may determine whether to implement the recommendation. The operational recommendation may be pushed to the mobile device (e.g., initiated by the server) or pulled by the remote device (e.g., initiated by the mobile device). The determination as to whether to implement the recommendation may involve prompting a user of the mobile device for authorization, consulting one or more user
25 preferences, automatically implementing the recommendation, or any combination thereof.

FIG. 3 shows a method 44 of managing wireless connections on a mobile device such as, for example, one or more of the mobile devices 14 (FIG. 1), already discussed. The method 44 may be implemented as a set of logic instructions stored in a machine- or computer-readable storage medium such as RAM, ROM, PROM, firmware, flash memory,
30 etc., in configurable logic such as, for example, PLAs, FPGAs, CPLDs, in fixed-functionality logic hardware using circuit technology such as, for example, ASIC, CMOS or TTL technology, or any combination thereof. Illustrated processing block 46 provides for reporting and/or sending sensor-based information to a server, wherein a determination may be made at block 48 as to whether a location change has taken place at the mobile

device. The determination at block 48 may take into consideration, for example, RSS data, wireless AP identifier data, accelerometer data, compass data, and so forth.

If a location change is detected, block 50 may request a wireless interface recommendation from the server, wherein a wireless interface may be chosen at block 52 based on the recommendation. If, on the other hand, no location change is detected at block 48, illustrated block 54 determines whether throughput (e.g., uplink/transmitting and/or downlink/receiving) is below a threshold value. If so, block 50 may request a wireless interface recommendation from the server, wherein a wireless interface may be chosen at block 52 based on the recommendation. Thus, the illustrated approach enhances performance by leveraging sensor-based information from the cloud whenever movement conditions or throughput conditions indicate that such information may be useful.

FIG. 4 shows a graphical illustration 56 of a set of wireless connection context information. In the illustrated example, a first region 58 of the illustration 56 shows uplink and downlink throughput for a WiFi interface as well as a 3G interface in a first geographic location. Similarly, a second region 60 shows uplink and downlink throughput for WiFi and 3G interfaces in a second geographic location. Thus, the first region 58 and the second region 60 may be populated from sensor-based information accumulated from mobile devices when the mobile devices are present in those locations. Additionally, a third region 62 of the illustration 56 shows uplink and downlink throughput for WiFi and 3G interfaces for a particular mobile device, wherein a wireless interface recommendation may be made to the mobile device corresponding to the third region 62 based on the sensor-based information reflected in the first region 58 and the second region 60.

For example, the server might recommend that the mobile device either switch from the 3G interface to the WiFi interface (because the WiFi interface currently has more throughput) and/or move to the first geographic location and use the WiFi interface to achieve even greater throughput. Therefore, context information from not only local sensor data, but also sensor data from other mobile devices can be very useful in obtaining optimal wireless performance and power efficiency for a given location and time.

Thus, techniques described herein may leverage sensor information available in mobile platforms/devices for power management as well as performance management. Mobile applications and services may generate and consume high volumes of sensor information on a regular basis, and techniques described herein can reuse that information to optimize power management policies rather than immediately discarding it. Moreover, techniques may take advantage of the relatively high computing capability of cloud

computing architectures by opportunistically sending sensor data to the cloud for processing (e.g., aggregation, filtering, fusion, decision making, etc.). Such an approach may eliminate high energy overhead associated with the processing.

5 Additionally, a recommendation module can formulate optimal power management policies that are tailored to specific devices, locations, times, and so forth. Indeed, many different algorithms such as, for example, collaborative/context-based filters and/or case-based reasoning, may enable users to select the optimal operational settings. The techniques may be considered collaborative in the sense that the recommendation module may use not only the local sensor-based information of a particular mobile device, but may
10 suggest operational management policies based on statistical results obtained from analyzing large-scale sensor/context data from other mobile devices.

Embodiments may therefore include a system having a network interface to accumulate sensor-based information from a plurality of mobile devices, and a context module to identify context information in the sensor-based information. The context
15 information may be relevant to a particular mobile device in the plurality of mobile devices, wherein a recommendation module can send an operational recommendation to the particular mobile device based at least in part on the context information.

Embodiments may also include a non-transitory computer readable storage medium comprising a set of instructions which, if executed by a processor, cause a computer to
20 accumulate sensor-based information from a plurality of mobile devices. In addition, the instructions, if executed, may also cause a computer to identify context information in the sensor-based information, wherein the context information is to be relevant to a particular mobile device in the plurality of mobile devices. The instructions, if executed, may also cause a computer to send an operational recommendation to the particular mobile device
25 based on the context information.

Embodiments may also include a mobile device having one or more local sensors and a sensor interface to obtain sensor-based information from the one or more local sensors. Additionally, the mobile device may include a network interface to send the sensor-based information to a server and receive an operational recommendation from the
30 server, wherein the operational recommendation is to include first context information associated with sensor-based information from one or more additional mobile devices.

Embodiments may also include a non-transitory computer readable storage medium comprising a set of instructions which, if executed by a mobile device, cause the mobile device to obtain sensor-based information from one or more local sensors of the mobile

device. In addition, the instructions, if executed, may also cause the mobile device to send the sensor-based information to a server, and receive an operational recommendation from the server, wherein the operational recommendation is to include context information associated with sensor-based information from one or more additional mobile devices.

5 Embodiments of the present invention are applicable for use with all types of semiconductor integrated circuit (“IC”) chips. Examples of these IC chips include but are not limited to processors, controllers, chipset components, programmable logic arrays (PLAs), memory chips, network chips, systems on chip (SoCs), SSD/NAND controller ASICs, and the like. In addition, in some of the drawings, signal conductor lines are
10 represented with lines. Some may be different, to indicate more constituent signal paths, have a number label, to indicate a number of constituent signal paths, and/or have arrows at one or more ends, to indicate primary information flow direction. This, however, should not be construed in a limiting manner. Rather, such added detail may be used in connection with one or more exemplary embodiments to facilitate easier understanding of a circuit.
15 Any represented signal lines, whether or not having additional information, may actually comprise one or more signals that may travel in multiple directions and may be implemented with any suitable type of signal scheme, e.g., digital or analog lines implemented with differential pairs, optical fiber lines, and/or single-ended lines.

 Example sizes/models/values/ranges may have been given, although embodiments of
20 the present invention are not limited to the same. As manufacturing techniques (e.g., photolithography) mature over time, it is expected that devices of smaller size could be manufactured. In addition, well known power/ground connections to IC chips and other components may or may not be shown within the figures, for simplicity of illustration and discussion, and so as not to obscure certain aspects of the embodiments of the invention.
25 Further, arrangements may be shown in block diagram form in order to avoid obscuring embodiments of the invention, and also in view of the fact that specifics with respect to implementation of such block diagram arrangements are highly dependent upon the platform within which the embodiment is to be implemented, i.e., such specifics should be well within purview of one skilled in the art. Where specific details (e.g., circuits) are set
30 forth in order to describe example embodiments of the invention, it should be apparent to one skilled in the art that embodiments of the invention can be practiced without, or with variation of, these specific details. The description is thus to be regarded as illustrative instead of limiting.

 The term “coupled” may be used herein to refer to any type of relationship, direct or

indirect, between the components in question, and may apply to electrical, mechanical, fluid, optical, electromagnetic, electromechanical or other connections. In addition, the terms “first”, “second”, etc. are used herein only to facilitate discussion, and carry no particular temporal or chronological significance unless otherwise indicated.

5 Those skilled in the art will appreciate from the foregoing description that the broad techniques of the embodiments of the present invention can be implemented in a variety of forms. Therefore, while the embodiments of this invention have been described in connection with particular examples thereof, the true scope of the embodiments of the invention should not be so limited since other modifications will become apparent to the
10 skilled practitioner upon a study of the drawings, specification, and following claims.

CLAIMS

We claim:

1. A system comprising:
a network interface to accumulate sensor-based information from a plurality of mobile
5 devices;
a context module to identify context information in the sensor-based information,
wherein the context information is to be relevant to a particular mobile device in the
plurality of mobile devices; and
a recommendation module to send an operational recommendation to the particular
10 mobile device based on the context information.

2. The system of claim 1, wherein the operational recommendation is to identify one
or more of a power management action, a performance management action, a wireless
interface selection and a wireless access point selection.

3. The system of claim 1, wherein the context information is to be identified based
on one or more of a location, a wireless connectivity and a battery life of the particular
mobile device.

4. The system of claim 1, wherein the sensor-based information is to include raw
sensor data.

5. The system of claim 4, wherein the raw sensor data is to include one or more of
received signal strength (RSS) data, accelerometer data, wireless access point identifier
25 data and battery life data.

6. The system of claim 1, wherein the sensor-based information is to include device-
generated context information.

7. The system of any one of claims 1 to 6, further including a filter module to filter
out a portion of the sensor-based information to obtain a reduced set of sensor-based
information, wherein the context information is to be identified in the reduced set of
sensor-based information.

8. The system of claim 7, further including a cloud repository, wherein the filter module is to store the reduced set of sensor-based information to the cloud repository.

5 9. A non-transitory computer readable storage medium comprising a set of instructions which, if executed by a processor, cause a computer to:

accumulate sensor-based information from a plurality of mobile devices;

identify context information in the sensor-based information, wherein the context information is to be relevant to a particular mobile device in the plurality of mobile

10 devices; and

send an operational recommendation to the particular mobile device based on the context information.

10. The medium of claim 9, wherein the operational recommendation is to identify

15 one or more of a power management action, a performance management action, a wireless interface selection and a wireless access point selection.

11. The medium of claim 9, wherein the context information is to be identified based on one or more of a location, a wireless connectivity and a battery life of the particular

20 mobile device.

12. The medium of claim 9, wherein the sensor-based information is to include raw sensor data.

13. The medium of claim 12, wherein the raw sensor data is to include one or more of received signal strength (RSS) data, accelerometer data, wireless access point identifier data and battery life data.

14. The medium of claim 9, wherein the sensor-based information is to include

30 device-generated context information.

15. The medium of any one of claims 9 to 14, wherein the instructions, if executed, cause a computer to

filter out a portion of the sensor-based information to obtain a reduced set of sensor-based information, wherein the context information is to be identified in the reduced set of sensor-based information.

5 16. The medium of claim 15, wherein the instructions, if executed, cause a computer to store the reduced set of sensor-based information to a cloud repository.

 17. A local mobile device comprising:

 one or more local sensors;

10 a sensor interface to obtain sensor-based information from the one or more local sensors; and

 a network interface to send the sensor-based information to a server and receive an operational recommendation from the server, wherein the operational recommendation is to include first context information associated with sensor-based information from one or more additional mobile devices.

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 18. The local mobile device of claim 17, wherein the operational recommendation is to identify one or more of a power management action, a performance management action, a wireless interface selection and a wireless access point selection.

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 19. The local mobile device of claim 17, wherein the sensor-based information from the one or more local sensors is to include raw sensor data.

 20. The local mobile device of claim 19, wherein the raw sensor data is to include one or more of received signal strength (RSS) data, accelerometer data, wireless access point identifier data and battery life data.

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 21. The local mobile device of claim 17, further including a context module to identify second context information associated with raw sensor data from the one or more local sensors, wherein the second context information is to be sent to the server.

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 22. The local mobile device of any one of claims 17 to 21, wherein the sensor-based information from the one or more local sensors and the sensor-based information from the one or more additional mobile devices are to be different types of information.

23. A non-transitory computer readable storage medium comprising a set of instructions which, if executed by a processor, cause a local mobile device to:
obtain sensor-based information from one or more local sensors of the local mobile
5 device;
send the sensor-based information to a server; and
receive an operational recommendation from the server, wherein the operational recommendation is to include context information associated with sensor-based information from one or more additional mobile devices.

10 24. The medium of claim 23, wherein the operational recommendation is to identify one or more of a power management action, a performance management action, a wireless interface selection and a wireless access point selection.

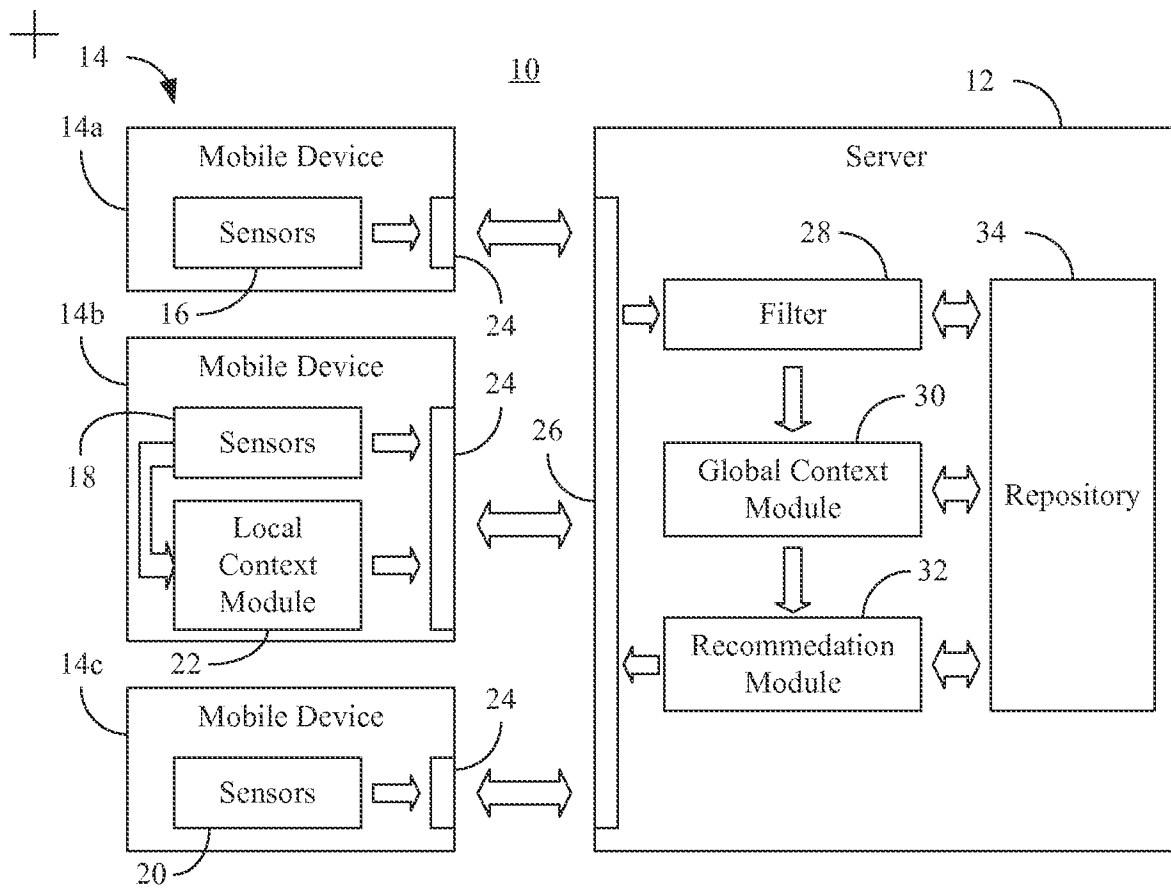
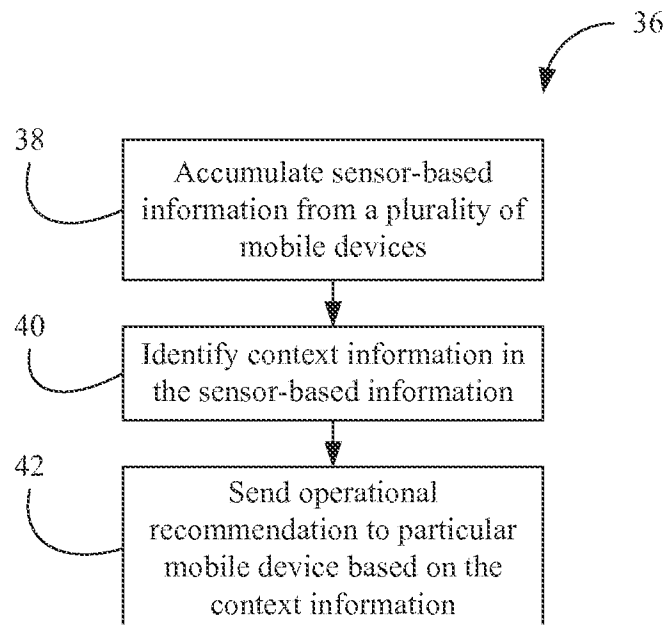
15 25. The medium of claim 23, wherein the sensor-based information from the one or more local sensors is to include raw sensor data.

20 26. The medium of claim 25, wherein the raw sensor data is to include one or more of received signal strength (RSS) data, accelerometer data, wireless access point identifier data and battery life data.

27. The medium of claim 23, wherein the sensor-based information from the one or more local sensors is to include device-generated context information.

25 28. The medium of any one of claims 23 to 27, wherein the sensor-based information from the one or more local sensors and the sensor-based information from the one or more additional mobile devices are to be different types of information.

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**FIG. 1****FIG. 2**

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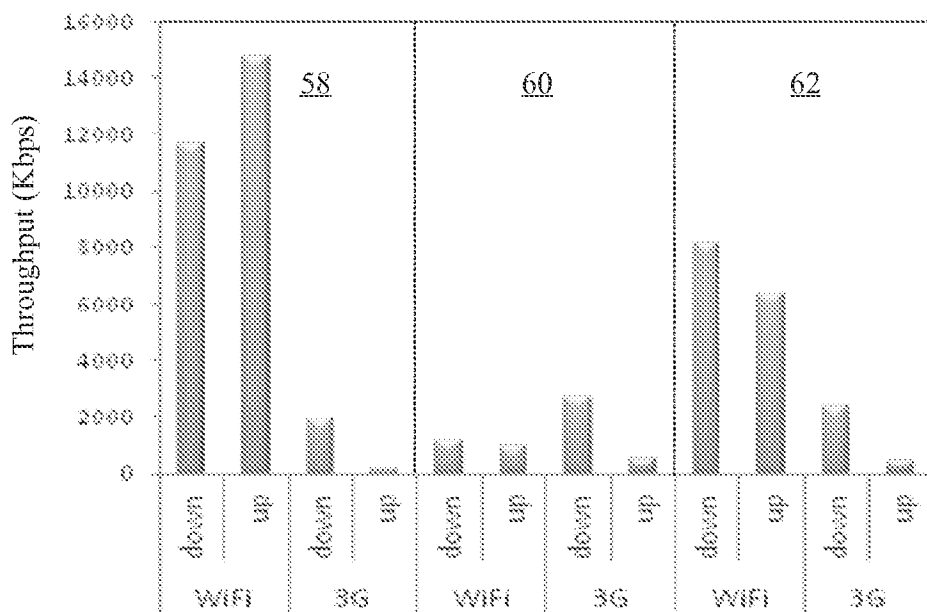
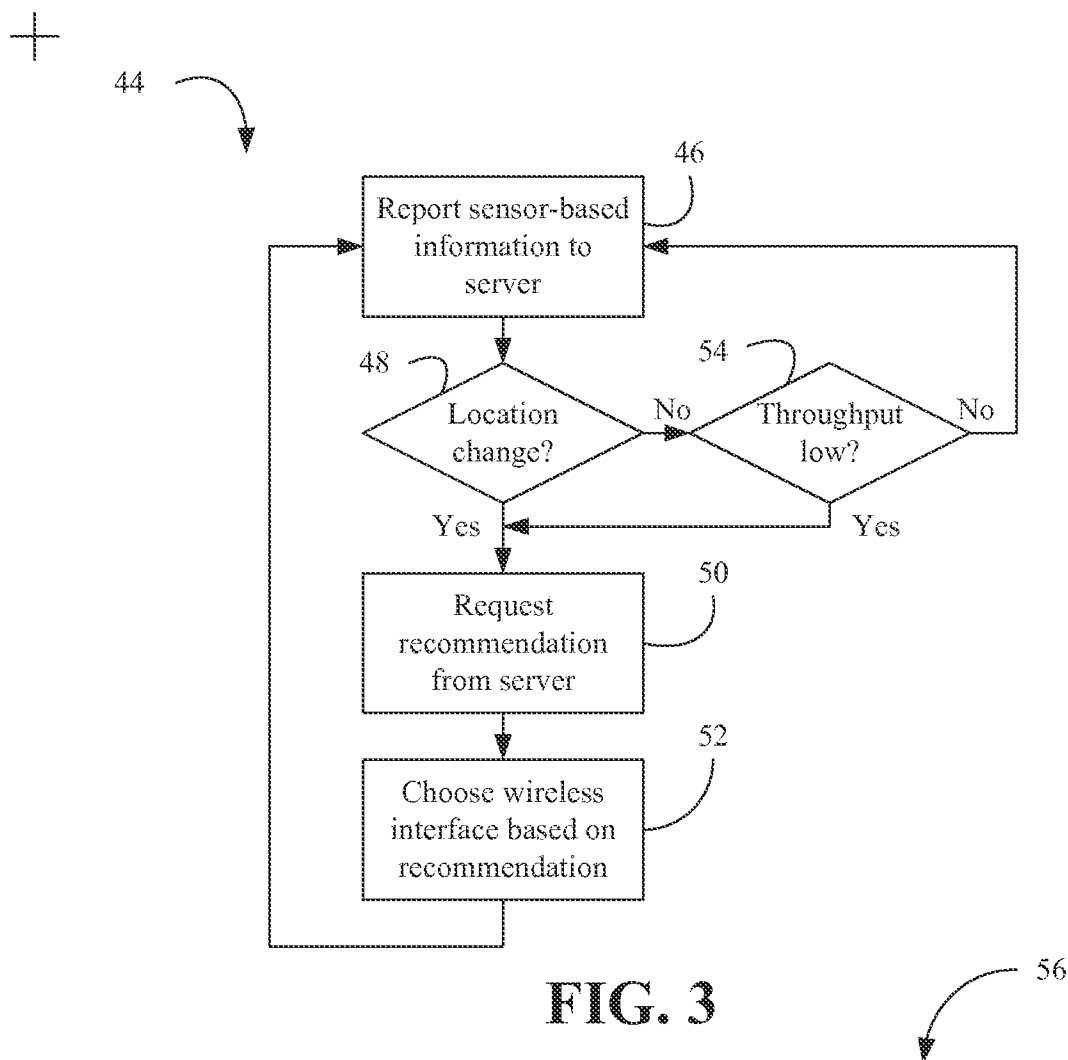


FIG. 4

A. CLASSIFICATION OF SUBJECT MATTER**H04W 52/04(2009.01)i, H04W 24/00(2009.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W 52/04; G06F 15/16; G01S 19/47; H04W 8/00; H04W 24/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & Keywords: sensor , context information , mobile

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2012-0033654 A1 (ROHIT SATISH KALBAG) 09 February 2012 See abstract; paragraph [4]; claims 1-21 and figures 1-3.	1-28
A	US 8284100 B2 (HARRY VARTANIAN et al.) 09 October 2012 See claims 1-18 and figures 1-5.	1-28
A	US 2012-0124136 A1 (HYUN KI KIM et al.) 17 May 2012 See claims 1-15 and figures 1-3.	1-28



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search

20 August 2013 (20.08.2013)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

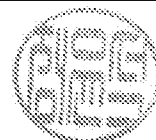
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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