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[Continued on next page]

(54) Title: A SYSTEM AND METHOD FOR MULTI-CHANNEL HANDOFF IN A PERSONAL AREA NETWORK

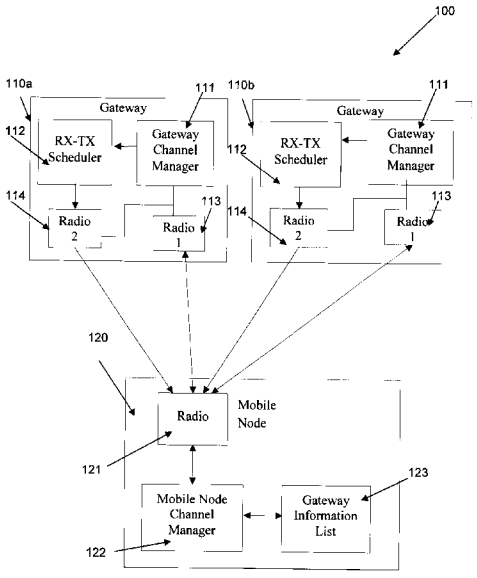

FIG. 1

(57) Abstract: The present invention relates to a system and method for multi-channel handoff in a personal area network. This invention presents a solution for mobile node (120) to get associated with a new gateway (110b) that operates on different channel than the mobile node's current gateway (110a). The mobile node (120) constantly checks the signal strength of the current gateway (110a) that it is associated with and collects channel information from other new gateways (110b). Mobile node (120) disassociates with the current gateway (110a) when its RSSI value dropped below the predefined threshold and associate with new gateway (110b) based on the gateway priority set in its gateway information list (123).

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A SYSTEM AND METHOD FOR MULTI-CHANNEL HANDOFF IN A PERSONAL AREA NETWORK

FIELD OF INVENTION

The present invention relates to a system and method for multi-channel handoff in a personal area network.

BACKGROUND OF THE INVENTION

A personal area network is a network used for communication among computerised devices including telephones and personal digital assistants. IEEE 802.15.4 is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks. IEEE 802.15.4 devices operate on 3 sets of frequency bands; 868 – 868.6 MHz with three communication channels, 902 – 928 MHz with up to thirty channels and 2400 – 2483.5 MHz with sixteen channels. The devices are designed to be low cost, low data rate and low power consumption. Hence, they have tight bandpass requirement on channel filtering and can only listen or communicate using single channel at one time. Devices on distinct channels cannot communicate regardless of physical proximity.

Multiple channels are often available to a set of network deployment during the handoff between two networks. Using same channel on adjacent networks may cause interference on communication between devices. As a result of that, overall network throughput will decrease. To avoid interference, adjacent networks are configured to use different channels. It needs time to scan all possible channels and select a new gateway. A long handoff can happen if nodes move from one network to another that operates on different channels. Nodes are not able to communicate directly with the new gateway as they do not have the new gateway's channel information. This eventually causes the communication to be disrupted.

Recently, IEEE 802.15.4 devices are empowered with IP protocols such as IPv6 Low Power Personal Area Network (6LoWPAN) for mobility management. 6LoWPAN has wide usage on various applications such as for hospital healthcare, military and livestock monitoring. Critical applications such as hospital healthcare are demanding minimal handoff delay of the sensor nodes in monitoring the body condition of the patients as any delay during emergency is a risk for the patients. In

the disaster relief operation, a fast handoff is also needed to save the injured or to evacuate the people from a disaster scene.

Therefore, there is a need to provide a system and method for multi-channel handoff in a personal area network that can reduce the handoff delay.

SUMMARY OF INVENTION

The present invention relates to a system and method for multi-channel handoff in a personal area network. The system comprises of at least two gateways (**110a**, **110b**), and at least one mobile node (**120**). The system is characterized in that each gateway includes at least two radio interfaces (**113**, **114**), wherein a primary radio interface (**113**) is used for communicating with the mobile node (**120**) in a default channel, and wherein a secondary radio interface (**114**) is used for listening for secondary discovery messages sent by the mobile node (**120**) and sending secondary channel acknowledgement messages in respond to secondary discovery messages to the at least one mobile node (**120**); an Rx-Tx (receiving mode – transmission mode) scheduler (**112**) for selecting and scheduling a channel from all available channels except the default channel for the secondary radio interface (**114**); and a gateway channel manager (**111**) for informing the Rx-Tx scheduler (**112**) a selected default channel for the primary radio interface (**113**).

Preferably, the at least one mobile node (**120**) includes radio interface (**121**) for interacting messages with the gateways (**110**) which includes sending secondary discovery messages and receiving secondary channel acknowledgement messages; mobile node channel manager (**122**) for calculating the Received Signal Strength Indicator (RSSI) of the secondary channel acknowledgement messages; and gateway information list (**123**) for storing information received from the gateways (**110**).

Preferably, the information in the gateway information list (**123**) includes the gateway identification (ID), gateway source address, gateway channel, RSSI of the received secondary channel acknowledgement messages and the priority level of the gateways (**110**).

A method for multi-channel handoff from a current gateway (**110a**) to a new gateway (**110b**) in a personal area network is characterized by the steps of switching from one channel to another channel to listen for a secondary discovery message sent in all channels except for a default channel by a secondary radio interface (**114**) of a new gateway (**110b**), and communicating with the mobile node (**120**) in a default channel by a primary radio interface (**113**); multicasting the secondary discovery message in its default channel by a mobile node (**120**); sending the secondary channel acknowledgement messages by the new gateway (**110b**); receiving the secondary channel acknowledgement message from the new gateway (**110b**) by the mobile node (**120**); extracting gateway information based on the secondary channel acknowledgement message; storing gateway information based on the secondary channel acknowledgement message in a gateway information list (**123**) of the mobile node (**120**); and selecting and associating to the new gateway (**110b**) based on its gateway information list (**123**) for the handoff process.

Preferably, the method for the secondary radio interface (**114**) at the gateway (**110**) to listen for secondary discovery messages is characterized by the steps of determining a channel to be the default channel by the gateway channel manager (**111**); informing the Rx-Tx scheduler (**112**) the selected default channel number; selecting and scheduling a channel from the available channels except the default channel for the secondary radio interface (**114**) by the Rx-Tx scheduler (**112**); listening for secondary discovery messages on the selected channel in a periodical scheduled manner for duration of T; switching from receiving mode to transmission mode if the secondary radio interface (**114**) receives a secondary discovery message; replying k number of secondary channel acknowledgement messages to the mobile node (**120**); switching from transmission mode to receiving mode; and repeating the steps of selecting and scheduling a channel for the secondary radio interface (**114**) until switching from transmission mode to receiving mode for all channels except the default channel.

Preferably, the method for the mobile node (**120**) to multicast secondary discovery message to the new gateway (**110b**) is characterized by the steps of checking the Received Signal Strength Indicator (RSSI) of the mobile node (**120**) with the current gateway (**110a**); and multicasting the secondary discovery message for the duration of T * n, where T is duration for secondary radio interface (**114**) listens to

each selected channel, and n is number of channels listened by secondary radio interface (**114**) for a channel rotation.

Preferably, if the mobile node (**120**) does not receive the secondary channel acknowledgement messages from new gateways (**110b**) within that time, the mobile node (**120**) consumes the normal operation for a predetermined duration before it triggers next secondary discovery message multicasting.

Preferably, the method of receiving the secondary channel acknowledgement messages from the new gateway (**110b**) by the mobile node (**120**) is characterized by the steps of receiving the secondary channel acknowledgement messages from the secondary radio interface (**114**) of the new gateway (**110b**); extracting information by the mobile node (**120**); removing the least priority entry from gateway information list (**123**) if the number of entries in list exceeds the limitation; adding new entry into the gateway information list (**123**) if the new gateway ID is found; updating the gateway information list (**123**) every time the mobile node (**120**) receives a secondary channel acknowledgement message from the existing gateway ID; and prioritizing the gateways (**110**) according to the information stored in the gateway information list (**123**), wherein the higher the RSSI of the received secondary channel acknowledgement message, the higher the priority level of the gateway (**110**) will be.

Preferably, the information extracted by the mobile node (**120**) includes the gateway identification (ID), gateway source address, gateway channel, RSSI of the received secondary channel acknowledgement messages and the priority level of the gateways (**110**).

Preferably, if the extracted gateway ID is an existing gateway ID as in the gateway information list (**123**), the mobile node (**120**) processed the received secondary channel acknowledgement messages by the steps of updating the gateway information list (**123**) with the RSSI of the received secondary channel acknowledgement messages; and prioritizing the gateways (**110**) according to the information stored in the gateway information list (**123**), wherein the higher the RSSI of the received secondary channel acknowledgement message, the higher the priority level of the gateway (**110**) will be.

Preferably, the method of selecting and associating to the new gateway (**110b**) for the handoff process is characterized by the steps of checking the RSSI value with respect to the current gateway (**110a**); selecting new gateway (**110b**) based on the gateway information list (**123**) if its current RSSI value is below a predetermined threshold; and performing association process with the new gateway (**110b**); checking if the new selected gateway (**110b**) uses the same channel as the previous association channel; performing node association using the current channel if the gateway (**110b**) uses the same channel as the mobile node (**120**) previous association channel; switching to the new gateway (**110b**) channel by the mobile node (**120**) if the gateway (**110b**) uses a different channel from the previous association channel; and associating to the new gateway (**110b**) using the new channel by the mobile node (**120**).

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

FIG. 1 illustrates a system (**100**) for multi-channel handoff in a personal area network.

FIG. 2 illustrates a flow chart of a method for multi-channel handoff according to an embodiment of the present invention.

FIG. 3 illustrates a flow chart of the substeps for the secondary radio interface (**114**) at the gateway (**110**) to listen for secondary discovery messages on all the channels.

FIG. 4 illustrates a flow chart of the substeps for the mobile nodes (**120**) to multicast secondary discovery messages to request for new gateway channel information.

FIG. 5 illustrates a flow chart of the substeps for the mobile nodes (**120**) to process the received secondary channel acknowledgement messages.

FIG. 6 illustrates a flow chart of the substeps for the mobile nodes (**120**) to associate with a new gateway (**110b**).

DESCRIPTION OF THE PREFFERED EMBODIMENT

A preferred embodiment of the present invention will be described herein below with reference to the accompanying drawings. In the following description, well known functions or constructions are not described in detail since they would obscure the description with unnecessary detail.

Reference is made initially to **FIG. 1**, which illustrates a system (**100**) for multi-channel handoff in a personal area network. The system (**100**) comprises of at least two gateways (**110**) and at least one mobile node (**120**). The mobile node (**120**) is connected to a current gateway (**110a**) and when its Received Signal Strength Indicator (RSSI) falls below a predetermined threshold, the mobile node (**120**) attempts to handoff its connection to a new gateway (**110b**).

Each gateway (**110**) comprises of a gateway channel manager (**111**), an Rx-Tx scheduler (**112**) and at least two radio interfaces (**113**, **114**). The gateway channel manager (**111**) is used to inform the Rx-Tx scheduler (**112**) a selected default channel for the primary radio interface (**113**). It is connected to the primary radio interface (**113**) and the Rx-Tx scheduler (**112**). The Rx-Tx scheduler (**112**) is used to select and schedule a channel from all available channels except the default channel for the secondary radio interface (**114**). The Rx-Tx scheduler (**112**) is connected to the gateway channel manager (**111**) and the secondary radio interface (**114**). The function of the primary radio interface (**113**) of the gateway (**110**) is to communicate with the mobile node (**120**) in a default channel, whereas the secondary radio interface (**114**) is to listen for a secondary discovery message sent by the mobile node (**120**) in all channels except for the default channels and sending secondary channel acknowledgement messages in respond to secondary discovery messages to the mobile node (**120**).

The mobile node (**120**) comprises of a radio interface (**121**), a mobile node channel manager (**122**) and a gateway information list (**123**). The radio interface (**121**) is used to interact messages with the gateways which includes sending secondary discovery messages and receiving secondary channel acknowledgement messages. The radio interface (**121**) is connected to a mobile node channel manager (**122**) that is used to calculate the RSSI of the secondary channel acknowledgement

messages. The mobile node channel manager (**122**) is connected to a gateway information list (**123**). The gateway information list (**123**) is used to store information received from the gateways (**110**) such as the gateway identification (ID), gateway source address, gateway channel, RSSI of the received secondary channel acknowledgement messages and the priority level of the gateways (**110**).

Referring now to **FIG. 2**, it shows a method for multi-channel handoff in a personal area network according to an embodiment of the present invention. Initially, the secondary radio interface (**114**) at the new gateway (**110b**) switches from one channel to another channel in order to listen for a secondary discovery message in all channels except for the default channel and the primary radio interface (**113**) of the current gateway (**110a**) communicates with the mobile node (**120**) in a default channel as in step **200**. Next, the mobile node (**120**) multicasts the secondary discovery message in its default channel if its RSSI is below a predetermined threshold to perform handoff with the new gateway (**110b**) as in step **300**. After multicasting the secondary discovery message, the mobile node (**120**) receives secondary channel acknowledgement message from the new gateway (**110b**). It extracts the gateway information based on the secondary channel acknowledgement message received from the new gateway (**110b**) and stores them in the gateway information list (**123**) of the mobile node (**120**) as in step **400**. Finally, the mobile node (**120**) selects and associates to the new gateway (**110b**) based on its gateway information list (**123**) for the handoff process as in step **500**.

Step **200** is further described in **FIG. 3** wherein initially, the gateway channel manager (**111**) determines the best channel from administratively network configuration to be the default channel as in step **201**. In step **202**, the gateway channel manager (**111**) then informs the Rx-Tx scheduler (**112**) the selected default channel number for the primary radio interface (**113**). To eliminate interference between the primary radio interface (**113**) and the secondary radio interface (**114**), the Rx-Tx scheduler (**112**) selects and schedules a channel for the secondary radio interface (**114**) from all the available channels except the default channel as in step **203** and **204**. Thereon, the secondary radio interface (**114**) listens for secondary discovery messages on the selected channels in a periodical scheduled manner for duration of T as in step **205**.

If during the duration of T, the secondary radio interface **(114)** checks on any message received as in step **206**. If the secondary radio interface **(114)** receives any message that is not the secondary discovery message, it discards the message as in step **207**. On the other hand, if the received message is the secondary discovery message, the secondary radio interface **(114)** switches from Rx (receiving mode) to Tx (transmission mode) as in step **208**. It replies k number of secondary channel acknowledgement messages to the mobile node **(120)** as in step **209**. After sending, the secondary radio interface **(114)** then switches from Tx to Rx mode as in step **210** before it consults Rx-Tx Scheduler **(112)** for the next channel number. Rx-Tx Scheduler **(112)** selects a channel from the list of available channels in sequential manner so that secondary radio interface **(114)** switches to the selected channel. The secondary radio interface **(114)** continues listening for the secondary discovery message on each selected channel for duration of T. The Rx-Tx scheduler (**112**) and the secondary radio interface (**114**) repeat the processes of channel setting and secondary discovery message listening for all the available channels except for the default channel in a sequential manner. They keep on repeating the process after finishing the cycle as shown in steps **205** to **210**.

Referring now to **FIG. 4**, there is shown a flow chart of substeps for the step **300**, wherein the mobile node (**120**) multicasts the secondary discovery message in its default channel to request for the new gateway (**110b**) channel information. If the RSSI of a mobile node (**120**) with the current gateway (**110a**) is below a predetermined threshold, the mobile node (**120**) multicasts secondary discovery messages to request for new gateway (**110b**) information as in decision **301** and step **302**. Mobile node multicasts the secondary discovery message for the duration of T * n as in step **302**, where T is duration for secondary radio interface (**114**) listens to each selected channel, and n is number of channels listened by secondary radio interface (**114**) for a channel rotation.

In that duration of time, if the mobile node (**120**) receives the secondary channel acknowledgement message from the new gateway (**110b**) as shown in decision **303**, the method proceeds to step **400** for processing the received secondary channel acknowledgement message. However, if the mobile node (**120**) doesn't receive any secondary channel acknowledgement message within that time, it is depicted in step **304** that the mobile node (**120**) consumes the IEEE 802.15.4

normal operation for a predetermined duration before it triggers next secondary discovery message multicasting.

FIG. 5 illustrates a flow chart of substeps of step **400** for the mobile nodes (**120**) to process the received secondary channel acknowledgement message. Upon receiving the secondary channel acknowledgement message from the secondary radio interface (**114**) of the new gateway (**110b**) as in step **401**, the mobile node (**120**) extracts information such as the gateway ID, gateway source address and gateway channel as in step **402**. Decision **403** and step **404** show that the least priority entry from gateway information list (**123**) will be removed if the number of entries in list exceeds the limitation. This step can ensure that the mobile node (**120**) does not keep the obsolete gateway information in the gateway information list (**123**).

If the extracted gateway ID is an existing gateway ID as in the gateway information list (**123**), the mobile node (**120**) updates the RSSI of the received secondary channel acknowledgement message to the corresponding gateway entry as indicated in step **407**. On the other hand, in decision **405** and step **406**, if new gateway ID is found, mobile node (**120**) adds new entry into the gateway information list (**123**). The information stored in the gateway information list (**123**) includes gateway ID, gateway source address, gateway channel, RSSI of received secondary channel acknowledgement message and the priority of each channel.

Based on the information stored in the gateway information list (**123**), the mobile node (**120**) prioritizes the gateways (**110**) as in step **408**. The priority of each gateway (**110**) is based on the RSSI of the received secondary channel acknowledgement message, whereby the higher the RSSI, the higher the priority level of the gateway (**110**) will be. After prioritizes the gateways **(110)** as in step **408**, mobile node goes to step **500** for selecting and associating to the new gateway (**110b**).

Referring now to **FIG. 6**, it illustrates a flow chart of a subprocess for the mobile nodes (**120**) to associate with a new gateway (**110b**) after disassociating from the current gateway (**110a**). In step **501**, the mobile node (**120**) checks its RSSI value with respect to the current gateway (**110a**). If its current RSSI value is below a predetermined threshold, the mobile node (**120**) selects a new gateway (**110b**) based

on the gateway information list (**123**) as in decision **502** and step **503**. Based on the gateway information list (**123**), mobile node (**120**) determines the first priority gateway (**110**) for it to associate with. If the new gateway (**110b**) is using the same channel as the current gateway (**110a**), the mobile node (**120**) immediately performs association process with the new gateway (**110b**) as in decision **504** and step **505**. However, if both are using different channels, the mobile node (**120**) is switched to the channel used by the new gateway (**110b**) before it performs the association process with the new gateway (**110b**) as in decision **504** and steps **506** to **507**.

While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specifications are words of description rather than limitation and various changes may be made without departing from the scope of the invention.

CLAIMS

1. A system (**100**) for multi-channel handoff in a personal area network comprises of:
   a) at least two gateways (**110a**, **110b**), and
   b) at least one mobile node (**120**);
   wherein the system is characterized in that:
   each gateway includes:
   i. at least two radio interfaces (**113**, **114**), wherein a primary radio interface (**113**) is used for communicating with the mobile node (**120**) in a default channel, and wherein a secondary radio interface (**114**) is used for listening for secondary discovery messages sent by the mobile node (**120**) and sending secondary channel acknowledgement messages in respond to secondary discovery messages to the at least one mobile node (**120**);
   ii. an Rx-Tx (receiving mode – transmission mode) scheduler (112) for selecting and scheduling a channel from all available channels except the default channel for the secondary radio interface (**114**); and
   iii. a gateway channel manager (**111**) for informing the Rx-Tx scheduler (**112**) a selected default channel for the primary radio interface (**113**).

2. The system (**100**) as claimed in claim **1**, wherein the at least one mobile node (**120**) includes:
   a) radio interface (**121**) for interacting messages with the gateways (**110**) which includes sending secondary discovery messages and receiving secondary channel acknowledgement messages;
   b) mobile node channel manager (**122**) for calculating the Received Signal Strength Indicator (RSSI) of the secondary channel acknowledgement messages; and
   c) gateway information list (**123**) for storing information received from the gateways (**110**).

3. The system (**100**) as claimed in claim **2**, wherein the information in the gateway information list (**123**) includes the gateway identification (ID),

gateway source address, gateway channel, RSSI of the received secondary channel acknowledgement messages and the priority level of the gateways (**110**).

4. A method for multi-channel handoff from a current gateway (**110a**) to a new gateway (**110b**) in a personal area network is characterized by the steps of:
   a) switching from one channel to another channel to listen for a secondary discovery message sent in all channels except for a default channel by a secondary radio interface (**114**) of a new gateway (**110b**), and communicating with the mobile node (**120**) in a default channel by a primary radio interface (**113**);
   b) multicasting the secondary discovery message in its default channel by a mobile node (**120**);
   c) sending the secondary channel acknowledgement messages by the new gateway (**110b**);
   d) receiving the secondary channel acknowledgement message from the new gateway (**110b**) by the mobile node (**120**);
   e) extracting gateway information based on the secondary channel acknowledgement message;
   f) storing gateway information based on the secondary channel acknowledgement message in a gateway information list (**123**) of the mobile node (**120**); and
   g) selecting and associating to the new gateway (**110b**) based on its gateway information list (**123**) for the handoff process.

5. The method as claimed in claim **4**, wherein the step of switching from one channel to another channel to listen for a secondary discovery message sent includes:
   a) determining a channel to be the default channel by the gateway channel manager (**111**);
   b) informing the Rx-Tx scheduler (**112**) the selected default channel number;
   c) selecting and scheduling a channel from the available channels except the default channel for the secondary radio interface (**114**) by the Rx-Tx scheduler (**112**);

d) listening for secondary discovery messages on the selected channel in a periodical scheduled manner for duration of T;

e) switching from receiving mode to transmission mode if the secondary radio interface (**114**) receives a secondary discovery message;

f) replying k number of secondary channel acknowledgement messages to the mobile node (**120**);

g) switching from transmission mode to receiving mode; and

h) repeating the step **(c)** to **(g)** for all channels except the default channel.

6. The method as claimed in claim **4**, wherein the step of multicasting the secondary discovery message in its default channel by a mobile node (**120**) includes:

a) checking the Received Signal Strength Indicator (RSSI) of the mobile node (**120**) with the current gateway (**110a**);and

b) multicasting the secondary discovery message for the duration of T * n, where T is duration for secondary radio interface (**114**) listens to each selected channel, and n is number of channels listened by secondary radio interface (**114**) for a channel rotation.

7. The method as claimed in claim **6**, wherein if the mobile node (**120**) does not receive the secondary channel acknowledgement messages from new gateways (**110b**) within that time, the mobile node (**120**) consumes the normal operation for a predetermined duration before it triggers next secondary discovery message multicasting.

8. The method as claimed in claim **4**, wherein the step of receiving the secondary channel acknowledgement messages by the new gateway (**110b**) includes:

a) receiving the secondary channel acknowledgement messages from the secondary radio interface (**114**) of the new gateway (**110b**);

b) extracting information by the mobile node (**120**);

c) removing the least priority entry from gateway information list (**123**) if the number of entries in list exceeds the limitation;

d) adding new entry into the gateway information list (**123**) if the new gateway ID is found;

e) updating the gateway information list (**123**) every time the mobile node (**120**) receives a secondary channel acknowledgement message from the existing gateway ID; and

f) prioritizing the gateways (**110**) according to the information stored in the gateway information list (**123**), wherein the higher the RSSI of the received secondary channel acknowledgement message, the higher the priority level of the gateway (**110**) will be.

9. The method as claimed in claim **8**, wherein the information extracted includes the gateway identification (ID), gateway source address, gateway channel, RSSI of the received secondary channel acknowledgement messages and the priority level of the gateways (**110**).

10. The method as claimed in claim **8**, wherein if the extracted gateway ID is an existing gateway ID as in the gateway information list (**123**), the mobile node (**120**) processed the received secondary channel acknowledgement messages by the steps of:

a) updating the gateway information list (**123**) with the RSSI of the received secondary channel acknowledgement messages; and

b) prioritizing the gateways (**110**) according to the information stored in the gateway information list (**123**), wherein the higher the RSSI of the received secondary channel acknowledgement message, the higher the priority level of the gateway (**110**) will be.

11. The method as claimed in claim **4**, wherein the step of selecting and associating to the new gateway (**110b**) for the handoff process includes:

a) checking the RSSI value with respect to the current gateway (**110a**);

b) selecting new gateway (**110b**) based on the gateway information list (**123**) if its current RSSI value is below a predetermined threshold; and performing association process with the new gateway (**110b**);

c) checking if the new selected gateway (**110b**) uses the same channel as the previous association channel;

d) performing node association using the current channel if the gateway (**110b**) uses the same channel as the mobile node (**120**) previous association channel;

e) switching to the new gateway (**110b**) channel by the mobile node (**120**) if the new gateway (**110b**) uses a different channel from the previous association channel; and

f) associating to the new gateway (**110b**) using the new channel by the mobile node (**120**).

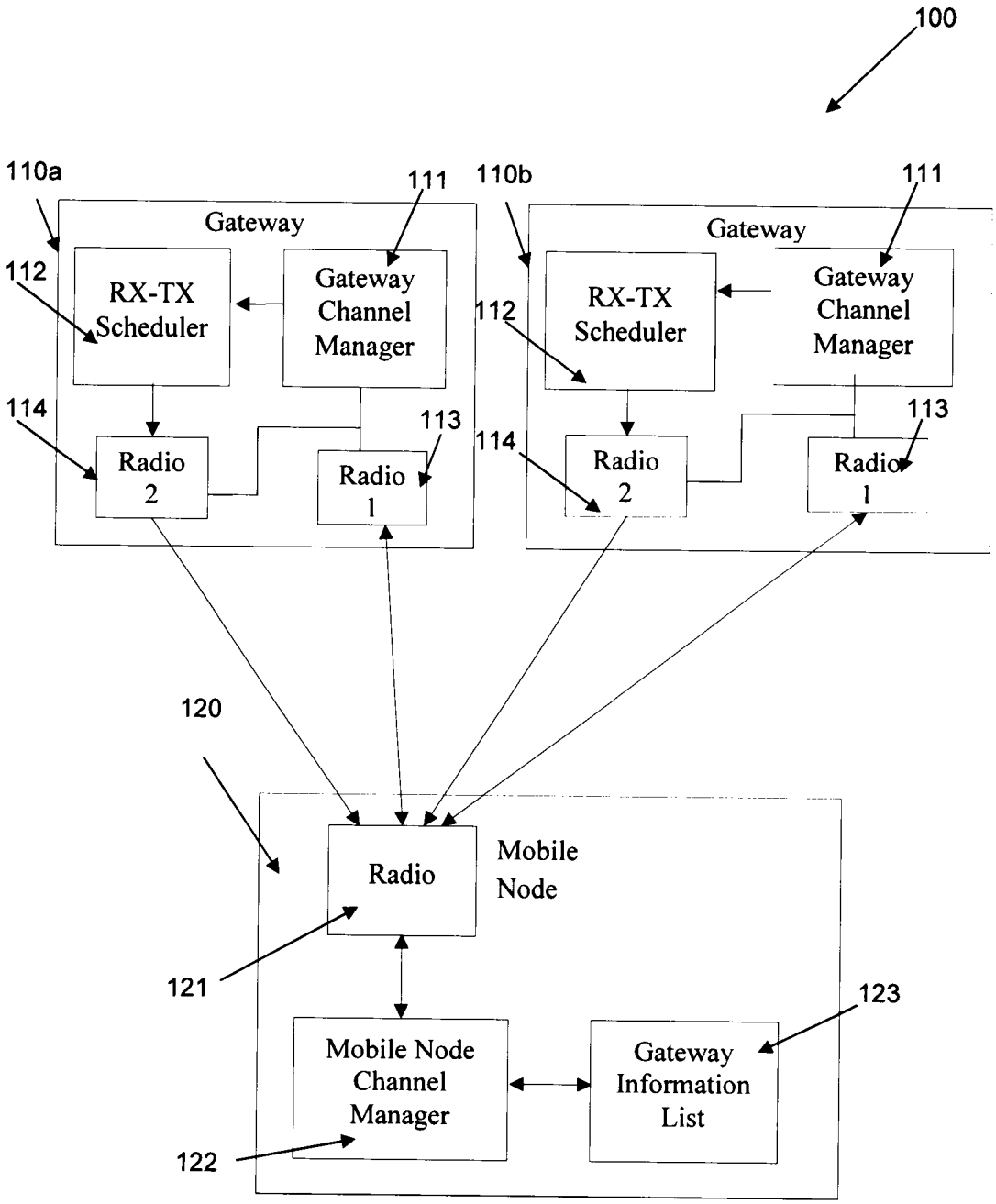
100
110a
111
110b
111
Gateway
Gateway
112
RX-TX Scheduler
Gateway Channel Manager
112
RX-TX Scheduler
Gateway Channel Manager
114
113
114
113
Radio 2
Radio 1
Radio 2
Radio 1
120
Radio
Mobile Node
121
123
Mobile Node Channel Manager
Gateway Information List
122

FIG. 1

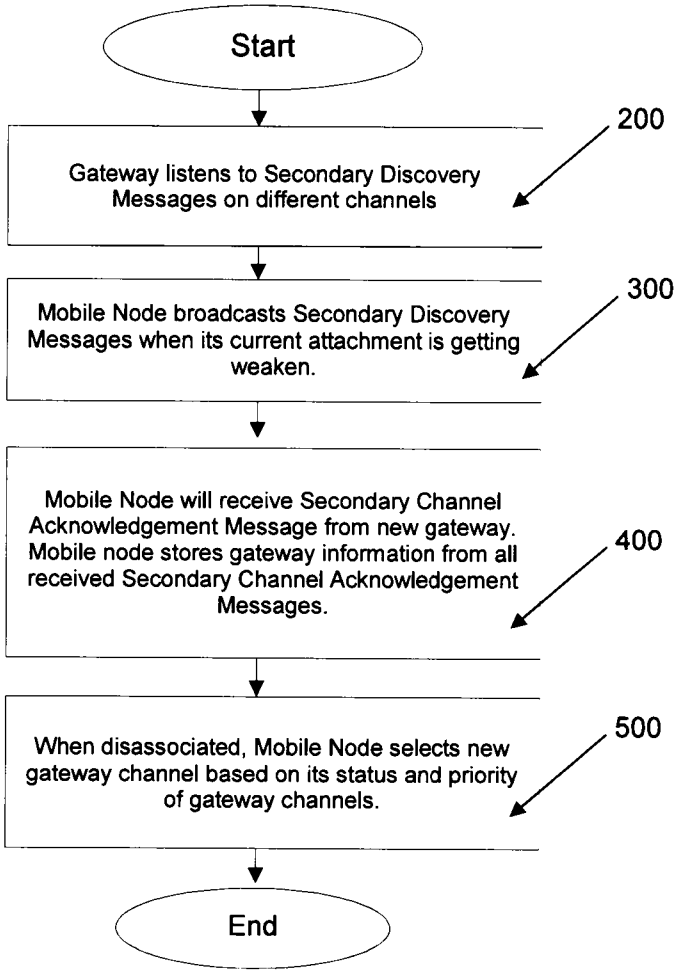
Start
Gateway listens to Secondary Discovery Messages on different channels
200
Mobile Node broadcasts Secondary Discovery Messages when its current attachment is getting weaken.
300
Mobile Node will receive Secondary Channel Acknowledgement Message from new gateway. Mobile node stores gateway information from all received Secondary Channel Acknowledgement Messages.
400
When disassociated, Mobile Node selects new gateway channel based on its status and priority of gateway channels.
500
End

FIG. 2

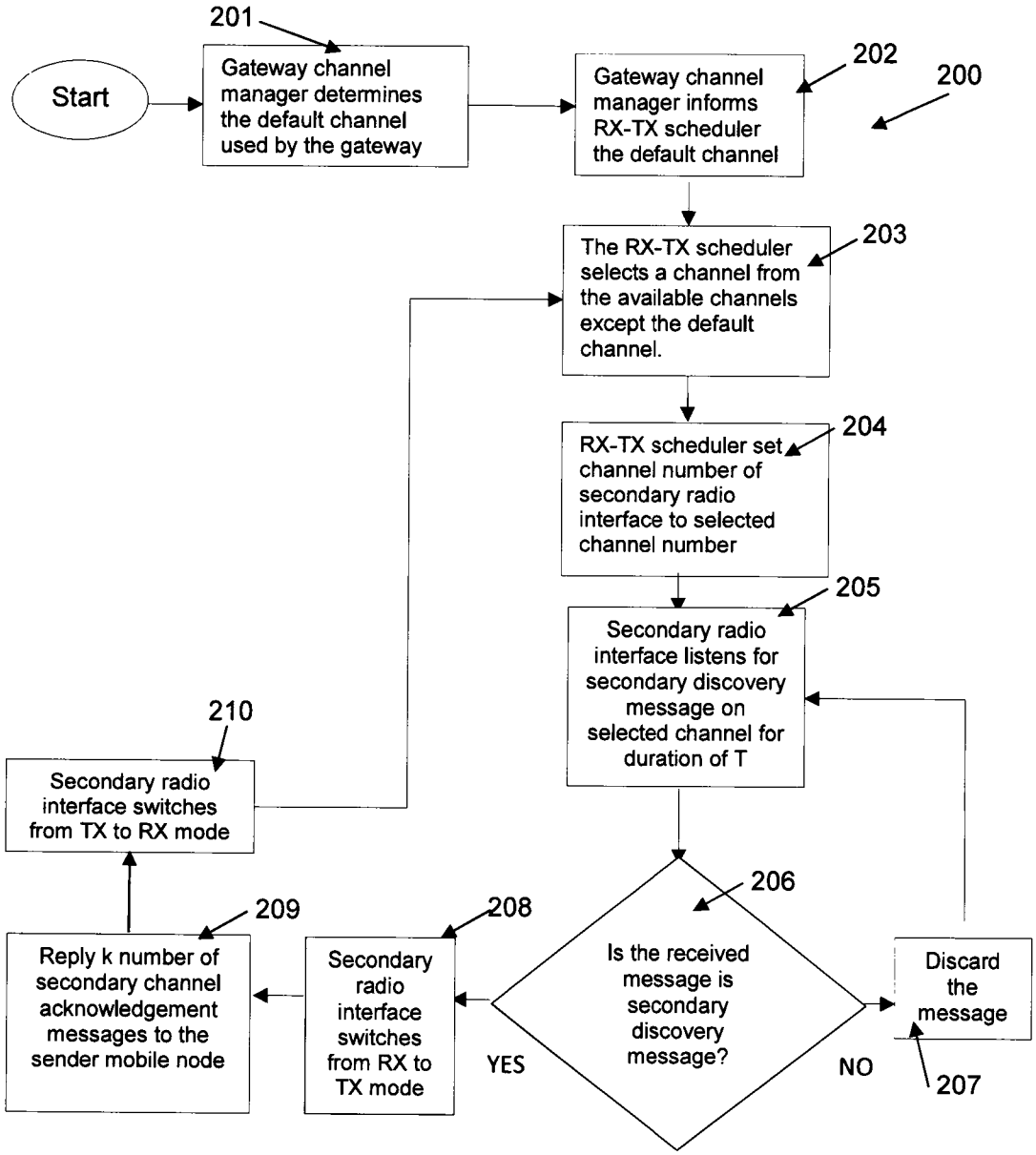
Start
201
Gateway channel manager determines the default channel used by the gateway
202
200
Gateway channel manager informs RX-TX scheduler the default channel
203
The RX-TX scheduler selects a channel from the available channels except the default channel.
204
RX-TX scheduler set channel number of secondary radio interface to selected channel number
205
Secondary radio interface listens for secondary discovery message on selected channel for duration of T
206
Is the received message is secondary discovery message?
YES
NO
208
Secondary radio interface switches from RX to TX mode
209
Reply k number of secondary channel acknowledgement messages to the sender mobile node
210
Secondary radio interface switches from TX to RX mode
Discard the message
207

FIG. 3

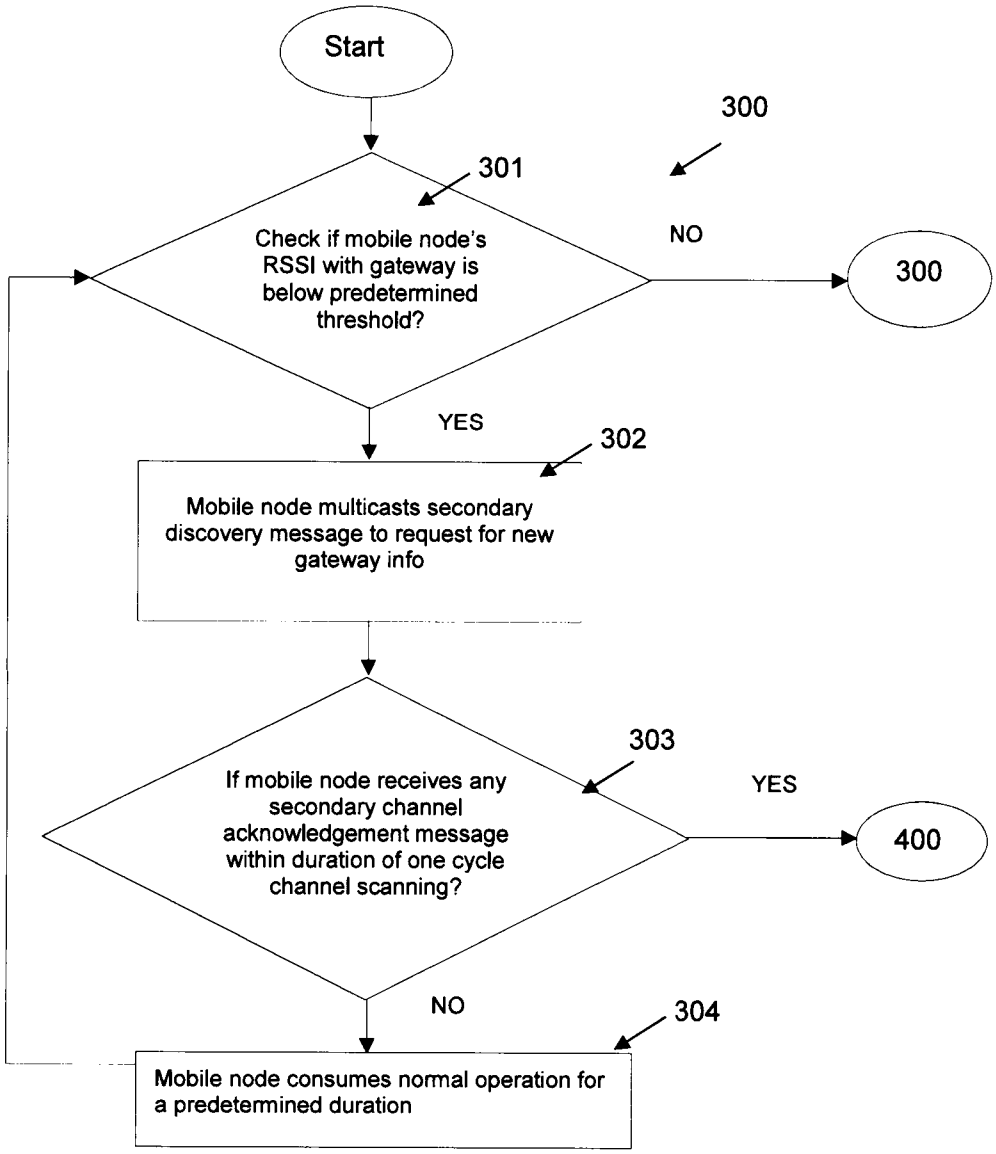
Start
300
301
Check if mobile node's RSSI with gateway is below predetermined threshold?
NO
300
YES
302
Mobile node multicasts secondary discovery message to request for new gateway info
303
If mobile node receives any secondary channel acknowledgement message within duration of one cycle channel scanning?
YES
400
NO
304
Mobile node consumes normal operation for a predetermined duration

FIG. 4

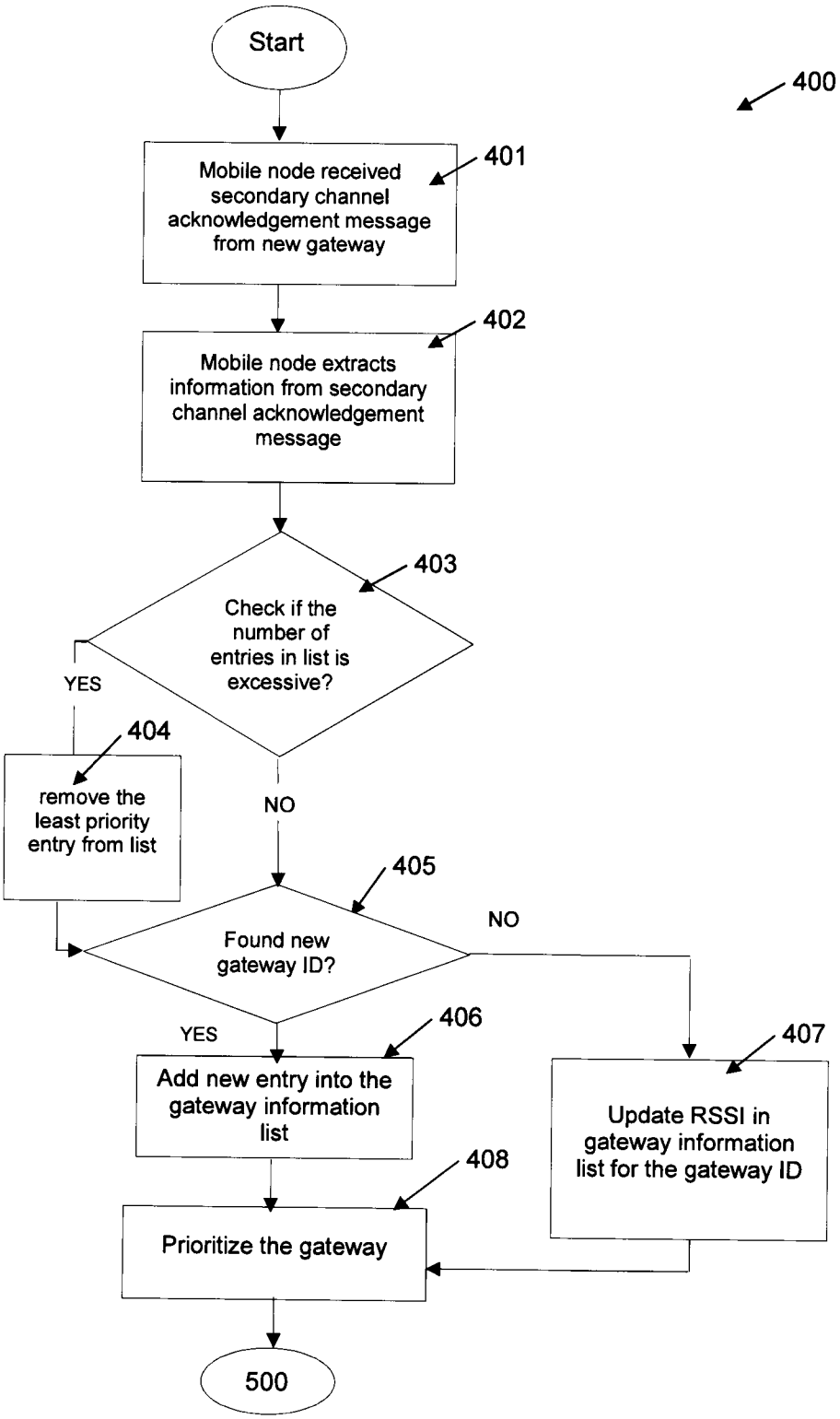
Start
400
Mobile node received secondary channel acknowledgement message from new gateway
401
Mobile node extracts information from secondary channel acknowledgement message
402
Check if the number of entries in list is excessive?
403
YES
NO
remove the least priority entry from list
404
Found new gateway ID?
405
NO
YES
Add new entry into the gateway information list
406
Update RSSI in gateway information list for the gateway ID
407
Prioritize the gateway
408
500

FIG. 5

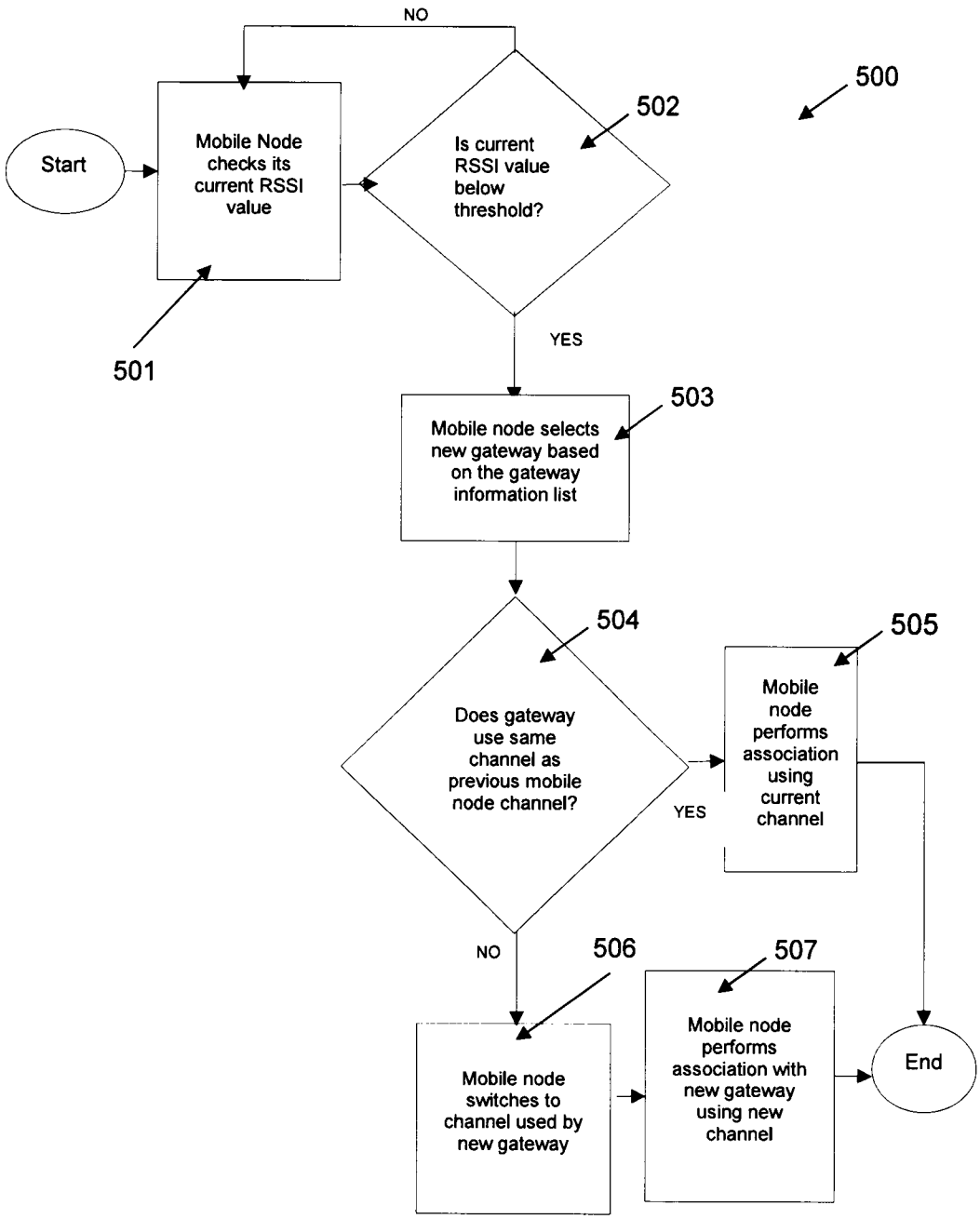
NO
500
502
Start
Mobile Node checks its current RSSI value
Is current RSSI value below threshold?
501
YES
503
Mobile node selects new gateway based on the gateway information list
504
505
Does gateway use same channel as previous mobile node channel?
Mobile node performs association using current channel
YES
NO
506
507
Mobile node switches to channel used by new gateway
Mobile node performs association with new gateway using new channel
End

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/MY2014/000084

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04W36/18
ADD.

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2008/062933 A1 (LIU YONGQIANG [CN] ET AL) 13 March 2008 (2008-03-13) paragraphs [0002], [0045], [0049]	1-11
A	EP 1 760 947 A2 (SAMSUNG ELECTRONICS CO LTD [KR]) 7 March 2007 (2007-03-07) paragraphs [0002] - [0020], [0062]	1-11
A	US 8 351 952 B1 (WOLEBEN SAMUEL M [US]) 8 January 2013 (2013-01-08) abstract	1-11
A	US 2003/129982 A1 (PERINI PATRICK [US]) 10 July 2003 (2003-07-10) abstract	1-11

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
4 November 2014	12/11/2014

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
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