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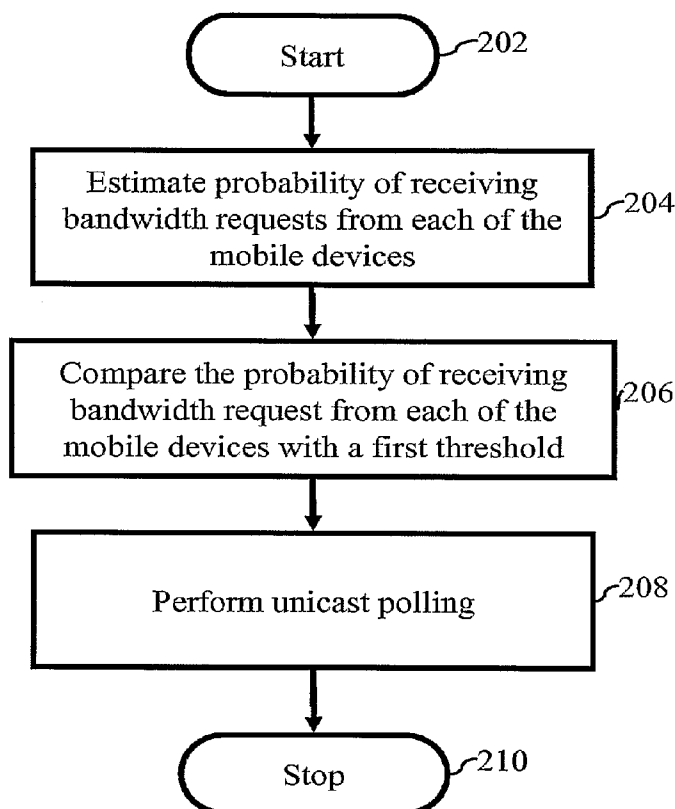
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(54) Title: METHOD AND SYSTEM FOR SELECTING POLLING STRATEGY IN COMMUNICATION NETWORKS



(57) Abstract: A method and system for selecting polling strategy in communication network (100) is disclosed. The method includes estimating (204) probability of receiving bandwidth requests from each of the mobile devices. The method also includes performing (208) unicast polling for a first set of mobile devices. The probability of receiving bandwidth requests from the first set of mobile devices is greater than a first threshold.

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METHOD AND SYSTEM FOR SELECTING POLLING STRATEGY IN COMMUNICATION NETWORKS

FIELD OF THE INVENTION

[0001] This invention relates generally to communication networks, and more particularly, to a method and system for selecting a polling strategy in a communication network.

BACKGROUND OF THE INVENTION

[0002] With an increase in the need for communication and information exchange, communication networks are becoming increasingly popular. Communication networks enable users to share resources and communicate amongst themselves. There are different types of communication networks, for example, mobile communication networks and computer networks. Typically, a mobile communication network includes, at least one base station and one or more mobile devices. Some examples of mobile devices include mobile phones, personal digital assistants, laptop computers, messaging devices. Mobile devices in a mobile communication network communicate with each other through base stations. A base station can poll the mobile devices for bandwidth requests. The base station can poll mobile devices using unicast polling, multicast polling and broadcast polling. Polling is a control method that can be used in a mobile communication network, in which a base station continuously inquires whether mobile devices in the mobile communication network have any data or information to send. In unicast polling, ask mobile devices in the mobile communication network are polled individually. In multicast polling, mobile devices in the mobile communication network are polled in

multicast groups. In broadcast polling, all the mobile devices in the mobile communication network are polled simultaneously. In response to the multicast and broadcast polling, more than one mobile device can request for bandwidth.

[0003] A method by which mobile devices in a communication network are polled plays an important role in optimizing the throughput of the base station. Therefore, an appropriate polling strategy must be selected to optimize throughput of the base station.

BRIEF DESCRIPTION OF THE FIGURES

[0004] The accompanying figures where like reference numerals refer to identical or functionally similar elements throughout the separate views and which together with the detailed description below are incorporated in and form part of the specification, serve to further illustrate various embodiments and to explain various principles and advantages all in accordance with the present invention.

[0005] **FIG. 1** illustrates an exemplary communication network, in accordance with an embodiment of the present invention;

[0006] **FIG. 2** is a flow diagram illustrating a method for selecting a polling strategy, in accordance with an embodiment of the present invention;

[0007] **FIG. 3** illustrates a block diagram of a base station, in accordance with an embodiment of the present invention; and

[0008] **FIG. 4 and 5** is a flow diagram illustrating a method for selecting a polling strategy, in accordance with another embodiment of the present invention.

DETAILED DESCRIPTION

[0009] In an embodiment, a method for polling mobile devices in a communication network is provided. The method includes estimating probability of receiving bandwidth requests from each of the mobile devices. The method further includes performing unicast polling for a first set of mobile devices. The probability of receiving the bandwidth requests from each mobile device in the first set of mobile devices is greater than a first threshold. In another embodiment, the mobile devices are polled in the decreasing order of the probabilities of receiving the bandwidth requests from them.

[0010] In another embodiment, a method for polling mobile devices in a communication network is provided. The method includes estimating probability of receiving bandwidth requests from each of the mobile devices and performing unicast polling for a first set of mobile devices. The probability of receiving the bandwidth requests from each mobile device in the first set of mobile devices is greater than a first threshold. Further, the method includes estimating number of backlogged mobile devices in the communication network. The method also includes performing broadcast polling when the number of backlogged mobile devices is less than a second threshold. In addition, the method includes performing multicast polling when the number of backlogged mobile devices are greater than the second threshold.

[0011] In yet another embodiment, a base station is provided. The base station includes a control unit and a transceiver. The control unit selects a polling strategy based on number of backlogged mobile devices in a communication network or the probability with which the bandwidth requests are received from each of the mobile

devices. Further, the transceiver polls mobile devices in the communication network based on the polling strategy.

[0012] Before describing in detail the particular method and system for selecting a polling strategy for mobile devices in a communication network in accordance with various embodiments of the present invention, it should be observed that the present invention resides primarily in combinations of method steps and apparatus components related to method and system for selecting polling strategy in the communication network. Accordingly, the apparatus components and method steps have been represented where appropriate by conventional symbols in the drawings, showing only those specific details that are pertinent to understanding the present invention so as not to obscure the disclosure with details that will be readily apparent to those of ordinary skill in the art having the benefit of the description herein.

[0013] In this document, relational terms such as first and second, and the like may be used solely to distinguish one entity or action from another entity or action without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising," or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article, or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. An element preceded by "comprises ... a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article, or apparatus that comprises the element.

Since passive antenna is generally equally effective in reception as it is in radiation, of balanced reciprocity, in the text although not explicitly stated, that the word radiation implies including reception.

[0014] The term “another,” as used in this document, is defined as at least a second or more. The term “includes” as used herein, is defined as comprising.

[0015] **FIG. 1** illustrates an exemplary communication network **100**, in accordance with an embodiment of the present invention. Examples of the communication network **100** include, but are not limited to, IEEE 802.16-based broadband wireless access network, an Advanced Mobile Phone Systems (AMPS) network, a Global System for Mobile Communications (GSM) network, a Digital Cellular Systems (DCS) network, and a Universal Mobile Telecommunication Systems (UMTS) network. The communication network **100** includes a base station **102** and mobile devices, for example, a mobile device **104**, a mobile device **106**, a mobile device **108**, and a mobile device **110**. Examples of mobile devices **104**, **106**, **108**, and **110** include, but are not limited to, cellular phones, laptop computers, Personal Digital Assistants (PDAs) and messaging devices. The mobile devices **104**, **106**, **108**, and **110** communicate with each other through the base station **102**.

[0016] **FIG. 2** is a flow diagram illustrating a method for selecting a polling strategy, in accordance with an embodiment of the present invention. Polling is a control method that can be used in a mobile communication network, in which a base station continuously inquires whether mobile devices in the mobile communication network have any data or information to send. After initiating the process at step **202**, probability with which bandwidth requests are received from each of the mobile

devices is estimated, at step **204**. In an embodiment, the base station **102** can estimate the probability with which the bandwidth requests are received from each of the mobile devices. At step **206**, the probability with which the bandwidth requests are received from each of the mobile devices is compared with a first threshold. If at step **206**, it is determined that the probability of receiving the bandwidth requests from each mobile device in a first set of mobile devices is greater than the first threshold then, at step **208**, unicast polling is performed for the first set of mobile devices. In an embodiment, the mobile devices in the first set of mobile devices are polled in the decreasing order of the probability of receiving the bandwidth requests from them. In an embodiment, the unicast polling can also be performed by the base station **102**. In an embodiment, the first threshold can be equal to maximum throughput for the slotted ALOHA protocol. Details regarding the slotted ALOHA can be found in a research paper titled 'ALOHA Packet System with and without Slots and Capture' published in the ACM SIGCOMM Computer Communication Review, Volume 5, Issue 2, pp. 28 – 42, in 1975. For slotted ALOHA protocol, the throughput is equal to an attempt rate 'G' divided by the exponential function of the attempt rate ' e^G '. Maximum throughput for slotted ALOHA protocol occurs when the attempt rate is '1'. As a result, the maximum throughput for slotted ALOHA protocol is equal to ' e^{-1} ', or '0.37'. Similarly, the maximum throughput for slotted ALOHA can be calculated using following equations:

$$T = G \times e^{-G} ;$$

where,

T is the throughput for the slotted ALOHA protocol; and

'G' is the attempt rate;

For maximum throughput, $G = 1$.

Therefore, maximum throughput is given by the following equation:

$$T_{\max} = e^{-1}; \text{ or}$$

$$T_{\max} \approx 0.37; \quad (1)$$

where, $T_{\max}$ is the maximum throughput.

Equation (1) shows that the maximum throughput for the slotted ALOHA protocol is '0.37' or thirty seven percent. As a result, unicast polling is performed for a mobile device if the probability of receiving bandwidth requests from the mobile device is greater than 37%. Further, in this case, it is not possible to achieve a higher throughput using broadcast polling or multicast polling. Thereafter, the process terminates at step 210.

[0017] FIG. 3 illustrates a block diagram of the base station 102, in accordance with an embodiment of the present invention. The base station 102 includes a control unit 302 and a transceiver 304. The control unit 302 selects a polling strategy, based on the number of backlogged mobile devices in a communication network or probability with which the bandwidth requests are received from each of the mobile

devices. Examples of polling strategies include, but are not limited to, unicast polling, multicast polling and broadcast polling. The transceiver **304** polls mobile devices in the communication network based on the polling strategy selected by the control unit **302**. The control unit **302** includes a processor **306**. The processor **306** can determine the number of backlogged mobile devices in the communication network, the probability of receiving bandwidth requests from each of the mobile devices, number of multicast groups in the communication network, or the number of backlogged mobile devices in each multicast group. Mobile devices that have bandwidth requests to transmit are termed as backlogged mobile devices.

[0018] FIG. 4 and 5 is a flow diagram illustrating a method for selecting a polling strategy, in accordance with another embodiment of the present invention. After initiating the process at step **402**, number of backlogged mobile devices in the communication network is estimated, at step **404**. In an embodiment, the base station **102** can estimate the number of backlogged mobile devices in the communication network **100**. In an embodiment, the number of backlogged mobile devices in the communication network is estimated using Rivest's pseudo-Bayesian algorithm. At step **406**, number of multicast groups in the communication network are determined. In an embodiment, the number of multicast groups can be taken to be directly proportional to the number of mobile devices in the communication network and inversely proportional to a second threshold. In another embodiment, the number of multicast groups is equal to the ceiling of the number of mobile devices in the communication network divided by the second threshold. The ceiling rounds off a real number 'X' to a smallest integer greater than or equal to 'X'. For example, ceiling rounds off '2.3' to '3'. In this embodiment, if the number of mobile devices in

the communication network is '1511' and the value of second threshold is '512', then the number of multicast group is given by the ceiling of '1511' divided by '512', which is equal to '3'. Similarly, the number of multicast group can be calculated using the following equation:

$$m = \left\lceil \frac{n}{t} \right\rceil;$$

where,

'm' is the number of multicast groups;

'n' is the number of mobile devices in the communication network;

't' is the maximum number of mobile devices allowed in a multicast group; and

$\left\lceil \right\rceil$ represents a ceiling function.

[0019] In an embodiment, the second threshold can be the maximum number of backlogged mobile devices allowed in a multicast group. At step 408, the backlogged mobile devices in the communication network 100 are assigned to the multicast groups. In an embodiment, each multicast group can be assigned approximately equal number of mobile devices. In this embodiment, first a minimum number of mobile devices are assigned to each multicast group. The minimum number of mobile devices in each multicast group is equal to a quotient of the number of mobile devices in the communication network divided by the number of multicast groups. The quotient is the integral part of the result of dividing one integer by another integer. For example, the quotient of '14' divided by '4' is '3'. In this embodiment, if number

of mobile devices in a communication network is '1511' and the number of multicast groups are '3', the minimum number of mobile devices in each of the multicast group is equal to quotient of '1511' divided by '3', which is '503'. As a result, each of the '3' multicast groups will have at least '503' mobile devices.

[0020] The remaining number of mobile devices are then calculated and assigned to the multicast groups. The remaining number of mobile devices are calculated based on a modulo function. The modulo function is applied on number of mobile devices and the number of multicast groups. The modulo function determines a remainder when one number is divided by another. For example, '14' modulo '3' is equal to '2'. In this embodiment, the number of remaining mobile devices is equal to '1511' modulo '3', which is equal to '2'. Further, the remaining mobile devices are assigned to '1511' modulo '3' multicast groups of the number of multicast groups. As a result, the number of mobile devices in each of the '3' multicast group is equal to '504', '504' and '503' respectively. In another embodiment, second threshold number of mobile devices are assigned to the multicast groups until mobile devices, which are less than or equal to the second threshold are assigned to a last multicast group. For example, if the number of mobile devices in the communication network is '1511' and the second threshold is '512', then two multicast groups are assigned '512' mobile devices and the remaining '487' mobile devices are assigned to the third multicast group. As a result, the '3' multicast groups will have '512', '512' and '487' mobile devices respectively.

[0021] At step 410, probability with which bandwidth requests are received from each of the mobile devices is estimated. At step 412, it is determined whether

the probability of receiving the bandwidth requests from each of the mobile devices is less than a first threshold. In an embodiment, the first threshold can be equal to maximum throughput for the slotted ALOHA protocol. As explained in conjunction with **FIG. 2**, maximum throughput for the slotted ALOHA protocol is approximately equal to '0.37' or thirty seven percent. If at step **412**, it is determined that the probability of receiving bandwidth requests from each mobile device in a first set of mobile devices is greater than the first threshold, then at step **414**, unicast polling is performed for the first set of mobile devices. If at step **412**, it is determined that the probability with which the bandwidth requests are received from each of the mobile devices is less than the first threshold, then step **502** is performed. At step **502**, the number of backlogged mobile devices in the communication network is compared with the second threshold. If at step **502**, it is determined that the number of backlogged mobile devices in the communication network is less than the second threshold then, at step **504**, broadcast polling is performed. In an embodiment, the broadcast polling is performed by the base station **102**. In this embodiment, the second threshold is the maximum number of backlogged mobile devices that can be polled using the broadcast polling to provide a maximum throughput. For example, if the second threshold is '512' and the number of mobile devices that request for bandwidth is '400', then broadcast polling is performed.

[0022] If at step **502**, it is determined that the number of backlogged mobile devices in the communication network is greater than the second threshold then, at step **506**, multicast groups are prioritized. This means that in case the number of backlogged mobile devices in the communication network is greater than the second threshold, as a result, the base station cannot perform broadcast polling to serve the

bandwidth requests. In this case, as described above, the number of backlogged mobile devices in the communication network are divided into multicast groups and multicast polling is used. In an embodiment, at step **506**, the multicast groups are prioritized based on the number of backlogged mobile devices present in a multicast group. For example, a multicast group having maximum number of backlogged mobile devices has the highest priority, and can be polled first. In another embodiment, there is a scheduling algorithm that decides on the multicast group to be polled. For example, this scheduling algorithm can be based on a fairness criterion. In an embodiment, the fairness criterion is such that a minimal amount of bandwidth is allocated to all mobile devices in the communication network. At step **508**, multicast polling is performed. In an embodiment, the multicast group with the highest priority will be polled first. Thereafter, the process terminates at step **510**.

[0023] Various embodiments, as described above, provide a method and system for selecting a polling strategy in a communication network. The polling strategy is selected based on the number of backlogged mobile devices in the network or the probability with which the bandwidth request is transmitted. By selecting an appropriate polling strategy the throughput of a base station in a communication network can be optimized. In an embodiment, a method for grouping the mobile devices in multicast groups is provided. The multicast groups are formed to optimize throughput of the base station during multicast polling.

[0024] In the foregoing specification, the invention and its benefits and advantages have been described with reference to specific embodiments. However, one of ordinary skill in the art appreciates that various modifications and changes can

be made without departing from the scope of the present invention as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present invention. The benefits, advantages, solutions to problems, and any element(s) that may cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements of any or all the claims. The invention is defined solely by the appended claims including any amendments made during the pendency of this application and all equivalents of those claims as issued.

WHAT IS CLAIMED IS:

1. A method for polling mobile devices in a communication network, the method comprising:
 - estimating probability of receiving bandwidth requests from each of the mobile devices; and
 - performing unicast polling for a first set of mobile devices, wherein the probability of receiving the bandwidth requests from each mobile device in the first set of mobile devices is greater than a first threshold.
2. The method as recited in claim 1 further comprising:
 - estimating number of backlogged mobile devices in the communication network;
 - performing broadcast polling when the number of backlogged mobile devices are less than a second threshold; and
 - performing multicast polling when the number of backlogged mobile devices are greater than the second threshold.
3. The method as recited in claim 2, wherein estimating the number of backlogged mobile devices comprises applying Rivest's pseudo-Bayesian algorithm.
4. The method as recited in claim 2, wherein performing the multicast polling comprises:

determining number of multicast groups, wherein the number of multicast groups are directly proportional to number of mobile devices in the communication network and inversely proportional to the second threshold; and assigning the mobile devices to the multicast groups.

5. The method as recited in claim 4 further comprising prioritizing the multicast groups.

6. A method for polling mobile devices in a communication network, the method comprising:

estimating probability of receiving bandwidth requests from each of the mobile devices;

performing unicast polling for a first set of mobile devices, wherein the probability of receiving the bandwidth requests from each mobile device in the first set of mobile devices is greater than a first threshold;

estimating number of backlogged mobile devices in the communication network;

performing broadcast polling when the number of backlogged mobile devices is less than a second threshold; and

performing multicast polling when the number of backlogged mobile devices is greater than the second threshold.

7. The method as recited in claim 6, wherein estimating the number of backlogged mobile devices comprises applying Rivest's pseudo-Bayesian algorithm.

8. The method as recited in claim 6, wherein performing the multicast polling comprises:

determining number of multicast groups, wherein the number of multicast groups is directly proportional to number of mobile devices in the communication network and inversely proportional to the second threshold; and

assigning the mobile devices to the multicast groups.

9. The method as recited in claim 8 further comprising prioritizing the multicast groups.

10. A base station comprising:

a control unit capable of selecting a polling strategy based on one of number of backlogged mobile devices in a communication network and probability with which bandwidth requests are received from each of the mobile devices; and

a transceiver capable of polling mobile devices in the communication network based on the polling strategy.

11. The base station as recited in claim 10, wherein the control unit comprises a processor capable of determining at least one of number of multicast groups, the number of backlogged mobile devices, number of backlogged mobile devices in a multicast group, and the probability with which the bandwidth requests are received from each of the mobile devices.

12. The base station as recited in claim 10, wherein the polling strategy is selected from a group comprising broadcast polling, multicast polling, and unicast polling.

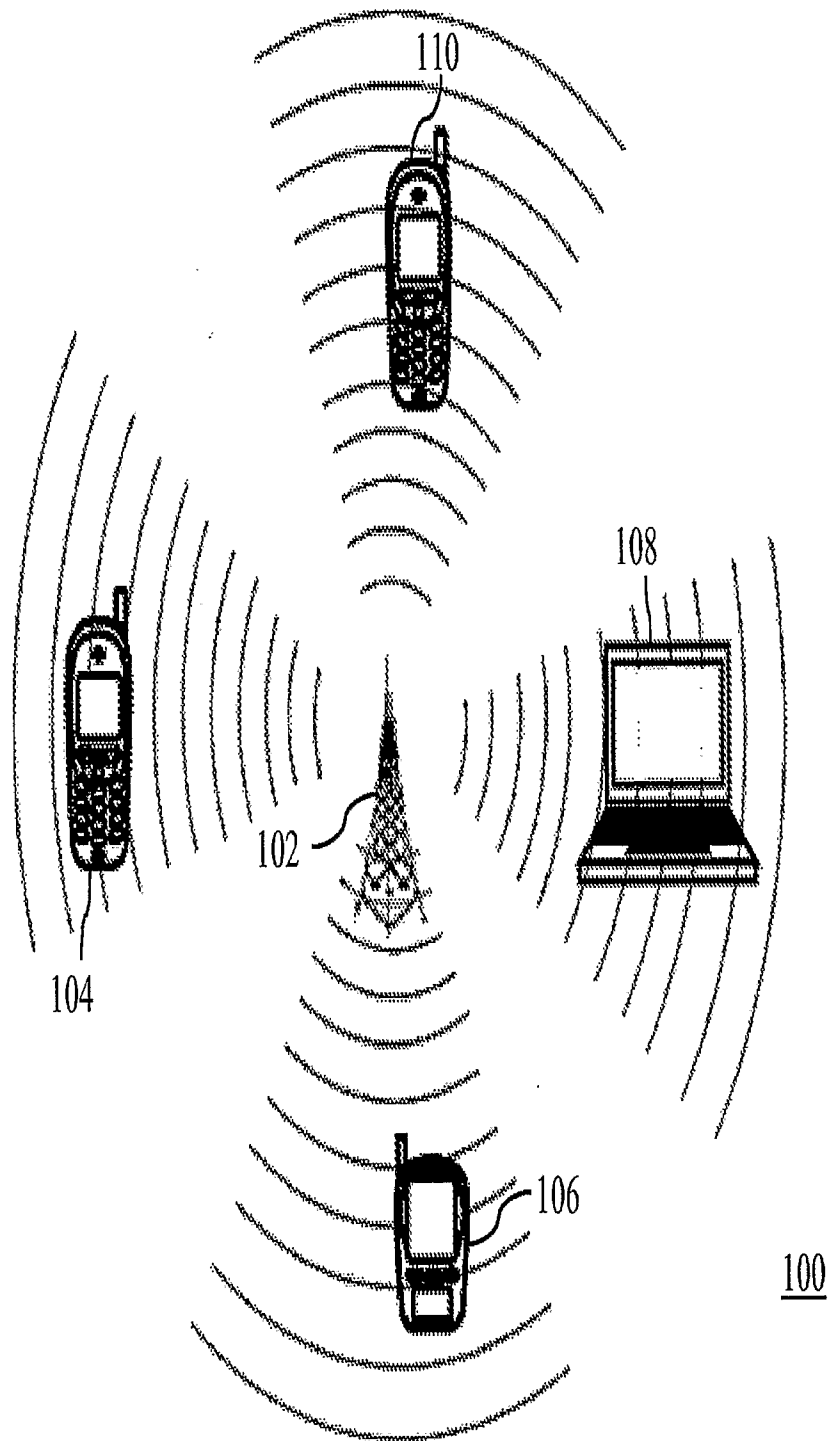


FIG. 1

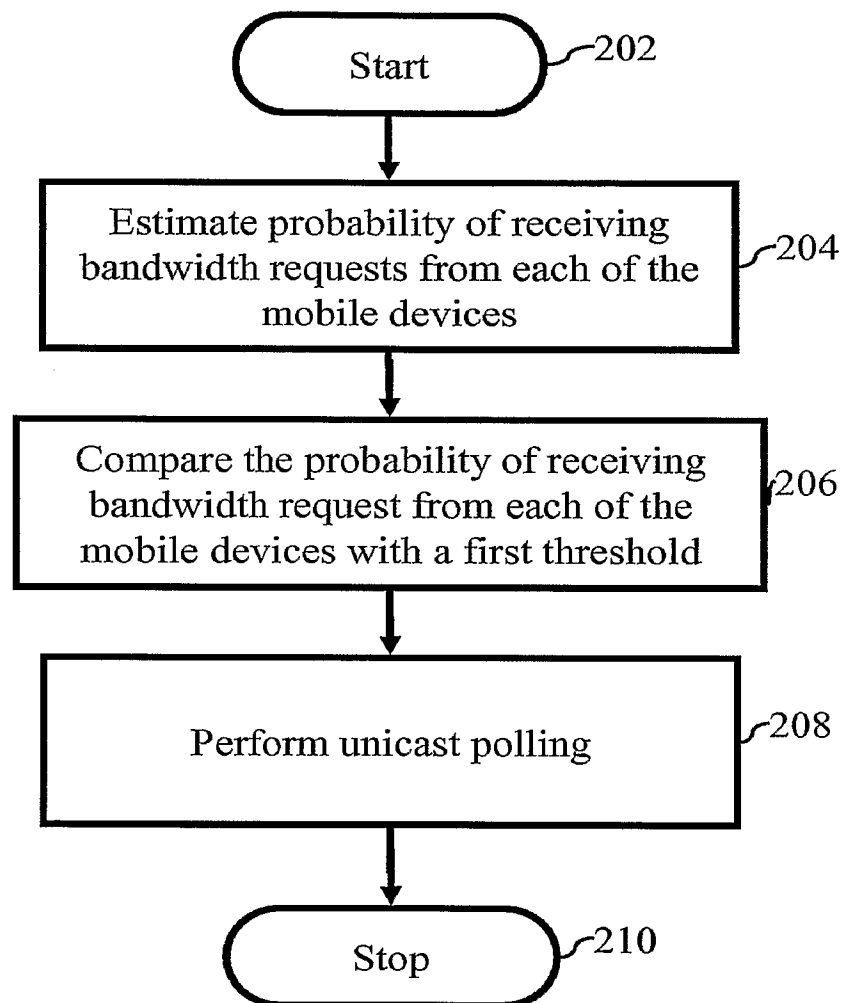


FIG. 2

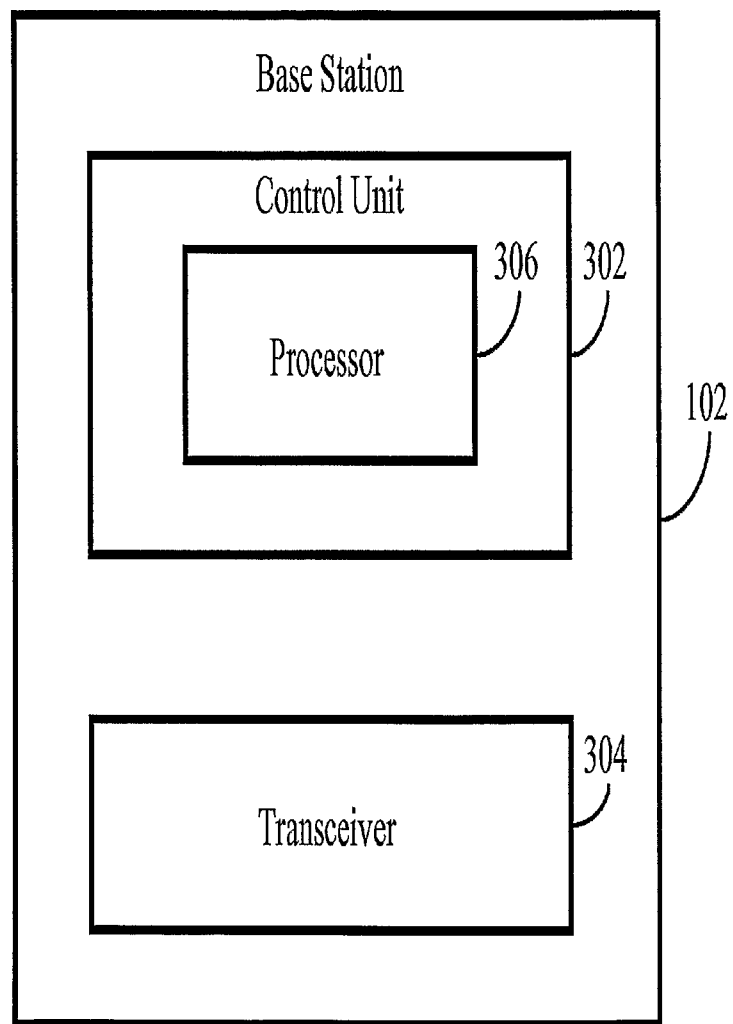


FIG. 3

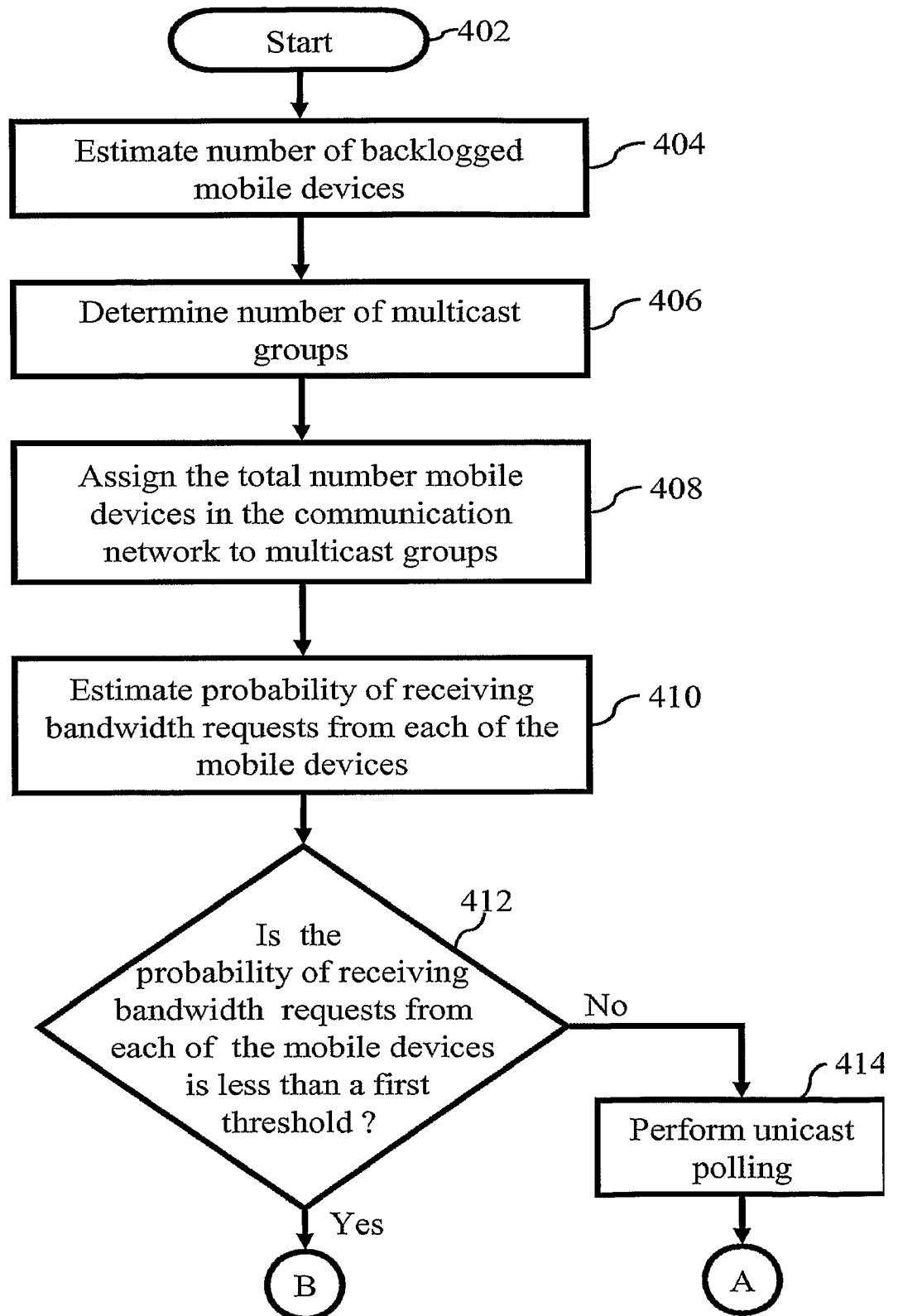


FIG. 4

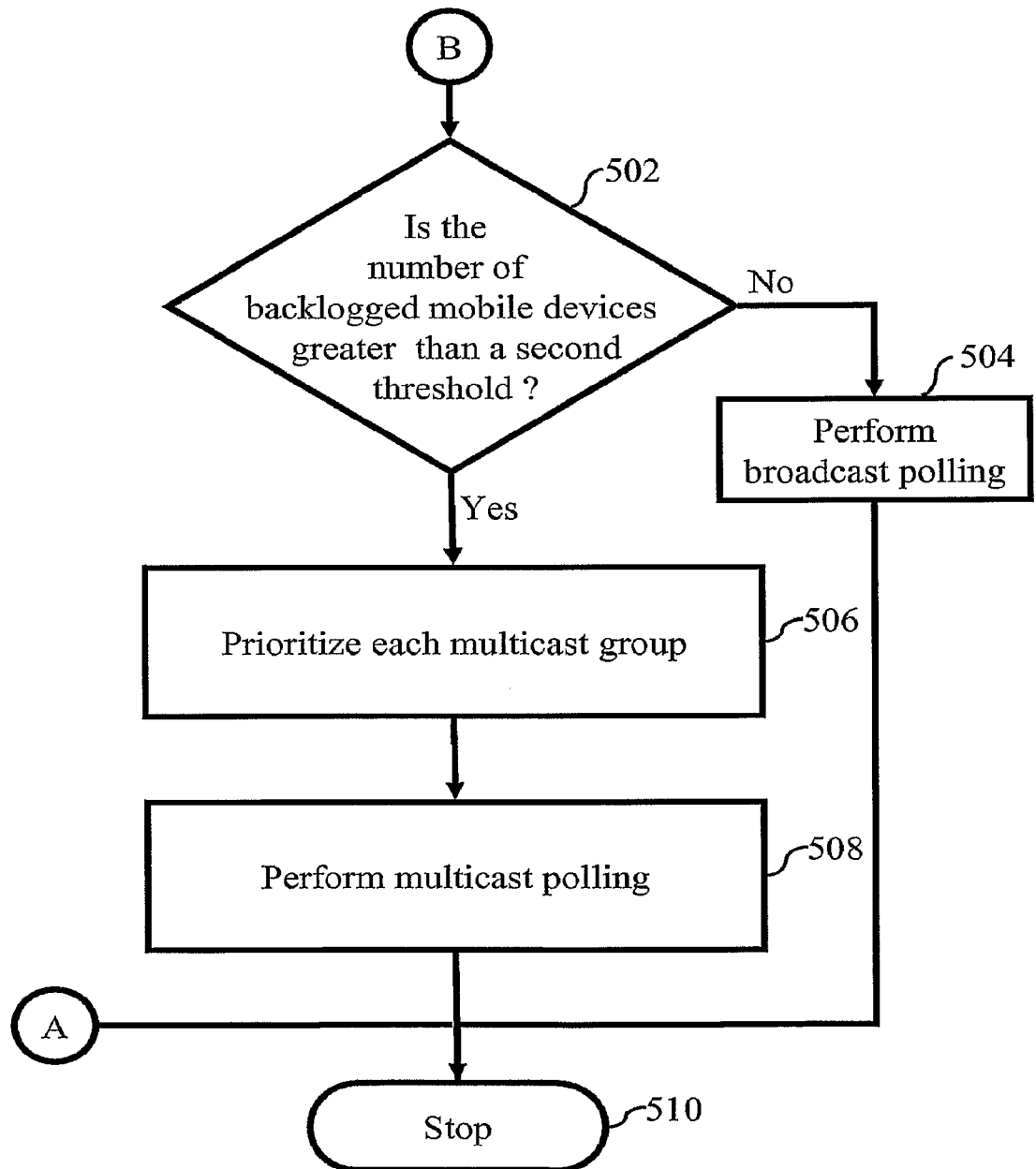


FIG. 5