

Rank load: Each node/access point 104 in the mesh network 106 measures its respective utilization rate according to equation (8) and exchanges this information with other network nodes. Each AP 104 can then identify a bottleneck node along its route to the mesh gateway 102. When the client 110 scans the AP, the AP reports this parameter to the client. Based on this parameter, client 110 can assign a rating to each AP 104, which is the AP with the smallest bottleneck utilization along its backhaul route. It should be noted that node utilization, rather than link utilization, is used as an indication of AP load. This is because, in order to load balance the network 106, it is necessary to consider the total traffic through one node instead of just the traffic on a particular link.

The advantage of specifying a rating based on these metrics is that it allows abstraction of the underlying metrics. Regardless of the metric used, system 100 can simply use the ranking to calculate the final AP score. This allows system 100 to use more relevant metrics for different measurement purposes. For example, system 100 can use throughput to estimate channel quality between an AP and a client while using node utilization to estimate network load.

The Rank AP and Rank path are designed to maximize client throughput and therefore provide optimal end-to-end performance. With these two ratings, the client 110 can select an AP that has the best estimated throughput between the client and the AP and has the best path in terms of backhaul performance. However, by considering the utilization of a single mesh node, the Rank load metric is directed to achieving consistent traffic distribution in the mesh backhaul. Combining these ratings allows the client 110 to select the best AP that is both the purpose of providing the best end user experience while achieving the load balancing destination service in the mesh backhaul wireless network 106. The following equation is used to combine these parameters and calculate the final AP score:

$$\text{AP score} = \omega_1 \times (\text{Rank AP} + \text{Rank path}) + \omega_2 \times \text{Rank load} \quad (9)$$

Where ω_1 and ω_2 are the weights assigned to each item, and take values in the range 0 to 1. Assigning different weights to two items allows the system 100 to achieve a balance between the two opposite goals of always choosing the best end-to-end throughput and balancing traffic across the mesh.

According to another embodiment depicted in FIG. 5A, a method 500 of selecting an AP for accessing the wireless network 106 for the mobile client 110 based on the quality and load characteristics of the wireless network is provided. In particular, for each AP detected by the AP scanning process, the client 110 collects and calculates information on the connection quality and load characteristics of the various paths through the wireless network 106 (502). The client 110 then ranks (504) all detected APs based on the connection quality and load characteristics and calculates a score (506) for each detected AP from the resulting ranking. Finally, client 110 selects an AP based on the score to access wireless network 106 (508).

FIG. 5B depicts another embodiment of an AP selection method 500. As shown in FIG. 5B, the client device 110 first scans for available APs by using an AP scanning process, and selects the top three APs based on signal strength measurements. Thereafter, client 110 obtains individual measurements associated with each AP. Then, using these measurements, the client device 110 can rank each AP and finally estimate the AP score using equation (9). Once the client calculates the above AP score for each AP, the client 110 can make an association decision.

According to another embodiment, when client 110 is connected to wireless network 106, it periodically scans the channel and obtains a new set of measurements for each of the three metrics from the neighboring AP. Based on these new measurements, client 110 can update its AP score and switch to the new AP based on the new score.

Implementation details

mobile client

2B depicts a schematic diagram of the structure of the mobile client 110. These structures can be applied to any mobile platform.

In one embodiment, the structure depicted in Figure 2B can be implemented as a middleware program. Advantages of such implementation include (i) application transparency, (ii) no system upgrade or painful recompilation, and (iii) each use or interaction across different components (eg, sensor hardware). Figure 2B depicts four main components that provide the various functions described above.

Mobility module 284: Mobility module (MM) 284 periodically monitors the motion of the mobile client based on samples of the sensor or accelerometer. The MM 284 periodically turns on the accelerometer for a predetermined period of time (eg, 1 second on, 4s off). Based on the collected samples, the MM 284 uses Goertzel signal processing techniques to classify the behavior of mobile users.

Scan module 285: Scan module (SM) 285 is directed to performing periodic and on-demand AP scan tasks. When the SM 285 gets a disconnect notification from the underlying wireless network interface card, it calculates and uses the optimal scanning frequency based on at least the measured AP node density and client motion

described above. Next, the SM 285 triggers an on-demand scan in the connected state. Whenever other modules request a scan, it first checks for the most recent scan result. If there is a cached result, the SM 285 passes it to the requesting module. Otherwise, it immediately triggers a new AP scanning process.

Association Module 286: Association Module (AM) 286 includes network monitoring and AP selection functionality as described above. For network monitoring, the AM 286 uses network status information that is available from the wireless node. It first sends a path status request message to a group of APs selected from the scan based on the RSS information. Each AP replies to the client with path network information from the mobile client to the gateway. This monitoring and messaging technology has been implemented in the OLSR plugin running on the mobile client. The AM 286 exchanges this information between mesh nodes using existing OLSR control messages. Such information exchange can also be made available using the IEEE 802.11k protocol, such as the non-patent entitled "Load balancing in WLANs through IEEE 802.11k mechanisms" by EG Villegas et al., Proc. of the IEEE ISCC, 2006. This document is hereby incorporated by reference in its entirety. When the client performs the AP selection process, it simply sends a GET query message to the desired AP.

Migration module 287: Migration Module (MI) 287 performs preemptive migration of AP associations as described above. Even when the mobile client connects to an AP, the MI 287 dynamically changes the migration trigger threshold by using the client's motion information and AP density. In addition, MI 287 also dynamically adapts the migration threshold considering AP density and average RSS. As the mobile client moves around, the MI 287 uses historical AP density data to calculate an average of the nearest AP densities. Then, if the density and RSS increase, the MI 287 lowers the migration threshold for the client 110 to find a better AP, and vice versa.

Mesh router

In order to collect certain network statistics for AP selection from the mesh AP, the first metric is the modified cumulative path performance for each AP. In one embodiment, the underlying OLSR routing protocol is implemented in each AP. The cumulative ETX value of each AP-to-mesh gateway path described in equation (7) is provided by the routing protocol and integrated with the channel information for each node. Each mesh AP can then calculate the modified ETX value for its own path to the gateway node and enable the client device to obtain this value during the AP scan phase. When the link quality changes, or if the routing protocol selects a new path, the AP can calculate a new modified ETX value.

To estimate node utilization, one implementation provides a modified Madwifi driver for each AP. Each AP keeps track of the total number of bytes transmitted by that AP to all its neighbors and keeps track of the maximum amount of data (capacity) that the AP can transmit to its neighbors at any given time. Modify the OLSR TC message to add a field that carries the utilization value for each node, thereby avoiding the overhead of

transmitting additional packets. In this manner, each AP receives utilization information for all other APs in the mesh network 106. Then, based on equation (8), each mesh node can estimate bottleneck utilization for its own path to mesh gateway 102. It also enables the client to obtain this information and use this information to estimate the Rank load metric.

The last metric that needs to be provided is the channel quality between the client and the AP. In one embodiment, it is assumed that most of the traffic flows in the downlink direction from the mesh gateway to the client because most of the servers currently reside on the external wired network. In this embodiment, only the downlink channel quality between the AP and the client is estimated. To do this, use the estimated throughput metric. As mentioned above, each mesh AP keeps track of its own utilization, and therefore also knows the current transfer rate between itself and the client.

Once these two parameters are provided, the mobile client calculates the estimated throughput in the downlink direction and uses it to classify the AP for its client-to-AP link performance.

According to this embodiment, in order to obtain the necessary information to determine the AP score from the wireless AP, a customized OLSR plug-in is implemented on each AP and keep track of all data measured by that AP. Upon receiving a GET request from the mobile client, each AP's OLSR plugin responds with the measured statistics.

Performance evaluation

This section describes various experiments designed to evaluate the system 100 depicted in FIG. For the purposes of evaluation only, various implementations of the system in accordance with the above-described exemplary embodiments are provided herein, and thus should in no way be used to limit the scope of the invention.

Experimental establishment

The outdoor test rig illustrated in Figure 11 was constructed in a forest reserve that spans 2,000 acres of wilderness and hilly terrain. The test bed supports real-time traffic and is actively used by several researchers. It consists of 34 mesh nodes (access points) located in 31 physical locations. It can be seen that the average number of APs is 8 and the transmission range of the AP is 300 m.

The nodes in the mesh network are built using the Soekris net4826 embedded motherboard. Each node has 266 MHz of 586 processors, 128 MB of SDRAM, and flash storage from 64 MB to 256 MB. For wireless devices, each motherboard is equipped with two Atheros 802.11b/g Mini-PCI cards. A radio operating on the 802.11b/g standard can use three non-overlapping channels. All nodes run a custom Linux distribution using kernel 2.6.28 with a modified wireless device driver. Use the OLSR routing protocol.

The indoor test rig is deployed inside the office building and consists of 15 APs across two floors. Each grid includes an OpenWRT-based Cambria GW2358-4 motherboard, a 667MHz Intel XScale processor, 128MB of RAM and 32MB of flash memory. Each wireless node supports two radios based on the Atheros chipset, which runs an open source Madwifi wireless device driver. A radio on each node is configured in an ad-hoc mode, thereby forming a mesh backhaul. These radios use an 802.11a modulation strategy. Another radio on each node is configured as an AP (thus providing client access) and uses an 802.11g modulation strategy. Different channels are assigned to different APs to minimize interference. A wireless node also acts as a mesh gateway 102 that is connected to an external network. The default rate adaptation technique available in the OLSR routing protocol with ETX metrics and in the Madwifi driver is used in the test bed.

Experimental result

Efficiency of disconnection sensing: The performance of the disconnection sensing technique depicted in Figure 4B was measured at an outdoor test rig. During the experiment, the mobile client moved for 10 minutes around different areas of behavior (ie, standing, walking) and measured the number of scans triggered by the mobile client. For comparison, the number of scans is also measured while changing the threshold of the threshold-based periodic policy.

Figure 12A depicts a performance comparison between the adaptive triggering of the disconnected AP sensing and the fixed periodic AP scanning depicted in Figure 4B with respect to the average power consumption of the scanning process and the detection of the available AP delay. During the experiment, based on the estimated AP density, the threshold distance (d_{th}) for the adaptation trigger was set to 71 m. The trigger intervals for fixed frequency triggering are set to 10s, 20s, 30s, and 60s, respectively. As shown in the figure, the adaptive trigger saves scan energy consumption by up to 60% compared to a fixed frequency trigger with a 30s trigger interval, while keeping the AP detection delay at the same level as the fixed frequency trigger. This benefit is provided by combining motion information in adjusting the trigger interval (or frequency). In particular, each client 110 calculates an optimal scan frequency based on the distance traveled by the mobile user. If the distance does not increase, the mobile client suppresses the scan, saving energy. At the same time, when the mobile client travels a distance greater than the threshold, it triggers an AP scan to detect the access opportunity, thereby reducing the detection delay.

The effectiveness of connecting AP sensing

The validity of the connection mode provided by system 100 is further evaluated. When the mobile client connected to the indoor wireless network moves around a track in the indoor test rig for 6 minutes, including 3 minutes of walking and 3 minutes of standing, the total energy consumption per minute is measured from the connected mode. For comparison, the energy consumption of a traditional fixed threshold system and a benchmark system (labeled "Oracle") was also measured. Three different fixed thresholds, -55dBm, -75dBm, and -95dBm, are set for the fixed threshold triggering technique. In an Oracle system, the mobile device is configured to scan the channel every two seconds to provide very fine-grained measurements and to determine the best AP based on the scan results throughout the experiment. The selected AP is used as the best choice and ignores the scan overhead.

Figure 12B shows the average energy consumption per minute for migration. As shown in the figure, when the client moves around (sports scene), the adaptation threshold technique as described above saves energy by 47% compared to the migration of a fixed threshold. This is primarily because the adaptation threshold technique suppresses unnecessary scanning when the mobile client is stationary. Furthermore, while saving energy for scanning, the adaptive thresholding technique still achieves almost the same level of RSS from associated APs throughout the experiment. Table 1 further shows that for different thresholds, the RSS implemented by the adaptation threshold technique is close to the RSS of the "Oracle" technology. For stationary (fixed) scenarios, the adaptive thresholding technique also achieves a similar level of RSS while reducing energy consumption by 34%.

Table 1: Comparison of RSS implemented between fixed threshold sensing and motion sensing sensing

[image]

Dynamically sense the effectiveness of the trigger threshold

Figure 12C illustrates the effectiveness of a threshold adaptive strategy based on AP density. In the experiment, the mobile client was carried by users walking around (indoor and outdoor) locations, with local AP density varying from 5 to 25. First, use a fixed set of RSS thresholds. Count the number of scans triggered by the mobile client and compare the average RSS implemented by the mobile client to the "Oracle" technology, assuming that Oracle technology always chooses the best AP without any overhead. This figure clearly shows the trade-off between RSS and scan overhead. For the same experimental setup, the AP density-based threshold adaptive

strategy made a good trade-off, with 94.4% of RSS while scanning 16 times because it was able to dynamically adapt the threshold based on local AP density.

AP selection strategy assessment

To further evaluate the AP selection strategy, a separate experiment was performed. The experiment demonstrates how the AP selection strategy utilizes link quality information that can be obtained from the underlying routing protocol as described above and incorporates load balancing in the AP selection process.

In the experiment, the client device scans for available APs and requests a modified cumulative ETX value for that AP to the path of the mesh gateway 102 from each available AP. This value is then used by the client as an indicator of the backhaul path performance between the AP and the gateway node. In order to estimate the quality of the link between itself and the AP, the client also obtains an estimated downlink throughput value from each AP. Both of these values are passively measured by the mesh AP as described above, so no client resources are used. By combining the two pieces of data, the client makes the final AP selection decision.

Figure 13 illustrates the CDF of throughput achieved by the client device at two different locations in the test bed utilizing the AP selection strategy ("throughput + ETX based AP selection") described herein. The figure also shows client throughput for the case where only the estimated client-to-AP link throughput is used for AP selection ("throughput-based AP selection"). The throughput increase is because system 100 incorporates path ETX, which considers the performance of mesh backhaul wireless network 106 in the AP selection process. A similar improvement was observed during the round trip time of the client device, as shown in FIG.

One point that should be pointed out from Figure 5 is that we have implemented performance similar to the scenario in which traditional active policies are used to estimate mesh backhaul performance based on AP selection strategies that utilize routing protocol metrics. This confirms the fact that the link quality metrics that can be obtained from the underlying routing protocol can be used to estimate the mesh backhaul performance.

As shown in equation (9), the two weights ω_1 and ω_2 are used to balance between throughput and load balancing in AP selection. Figure 15 shows the network throughput values for different combinations of these two weights. As shown in Fig. 15, when ω_1 is set to 0, the network performance is degraded. In this case, the client will choose the AP with the lowest bottleneck utilization along its backhaul path, regardless of the throughput that can be achieved on that path. In terms of throughput, the best performance is achieved when ω_2 is set to zero. However, this also achieves the worst performance in terms of minimizing bottleneck utilization in the mesh backhaul. As the value of ω_1 increases, an improvement in performance is observed because it gives

the "throughput" component a higher weight. However, this also leads to an increase in bottleneck network utilization, resulting in an uneven distribution of traffic in the network. Therefore, the two weights ω_1 and ω_2 can be adjusted to match the target network performance and design requirements.

To evaluate the impact of load characteristics on AP selection, an experiment was performed in which values 0.6 and 0.4 were assigned to ω_1 and ω_2 , respectively, because these values provide a way to achieve higher client throughput and minimize network bottleneck utilization. The best balance.

To test the AP selection techniques described herein, new clients are introduced into the network in the indoor test bed at varying locations. The number of new clients varies from 1 to 5. Figure 16 illustrates the performance of an AP selection policy when considering and not considering the load characteristics of the backhaul wireless network 106. It is observed that if there is load balancing, the overall network performance is significantly better, and a more balanced traffic distribution in the mesh backhaul is achieved.

The AP selection technique was further tested on an outdoor test bench. In addition to the background traffic already in the network, two clients are introduced, which generate UDP traffic at a constant rate of 3 Mbps. Figure 17 shows the network performance of a client with a varying number of clients. Similarly, incorporating load characteristics into AP selection provides significant improvements in throughput and round-trip latency.

In order to evaluate the impact of the AP selection strategy on user traffic, the following experiments were further carried out on an outdoor test rig.

Specifically, the two clients generate background UDP traffic at a constant rate of 3 Mbps. A third client is introduced to transmit UDP data to a server attached to the gateway node at a constant rate of 3 Mbps. During the duration of the experiment, the server used the tcpdump tool to collect network traces. A fourth client is then introduced in the network that uses the traditional active AP selection policy and the AP selection policy described herein. Figure 18 shows the impact of an active policy on existing user throughput. The TCP upload and download tests performed by the new client adversely affect the throughput of existing customers. Compared to the AP policy described herein, when the newly introduced client uses the traditional active policy, the packet loss of the client currently connected to the network is an average of 3.9%.

While the invention has been particularly shown and described with reference to the preferred embodiments

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CLAIMS CN102907141

1.

A method of providing a wireless connection to a mobile client, the method comprising:

The access point (110A-C) scanning process is periodically triggered to monitor the access point density of the wireless network (106);

The frequency of the trigger is adjusted in response to changes in the density of the access points.

2.

The method of claim 1 further comprising:

The frequency of the trigger is reduced in response to a decrease in the density of the access point.

3.

The method of claim 1 or 2, further comprising:

The frequency of the trigger is increased in response to an increase in the density of the access point.

4.

The method of any one of claims 1 to 3, further comprising:

Monitoring at least one movement of the mobile client; and

The frequency of the trigger is adjusted in response to the at least one motion of the mobile client.

5.

The method of claim 4 further comprising:

Determining a speed of the at least one movement of the mobile client; and

The frequency of the trigger is increased in response to the increase in speed.

6.

The method of claim 5 further comprising:

In response to the decrease in speed, the frequency of the trigger is reduced.

7.

A method as claimed in claim 5 or claim 6, wherein the movement of the mobile client is detected by an accelerometer placed in the mobile client.

8.

The method of any of claims 1 to 7, further comprising:

Detecting one or more access points in the area in which the mobile client is located (104);

Monitoring at least the link quality and load characteristics of the wireless network; and

In response to at least the link quality and load characteristics of the wireless network, one of the detected one or more access points is selected to connect the mobile client to the wireless network.

9.

The method of any of claims 1 to 8, wherein the wireless network is a wireless mesh network comprising a plurality of access points, wherein another network entity is connected to one of the plurality of access points, and wherein Each of the detected one or more access points is associated with a path connecting the corresponding access point and the another network entity over the wireless mesh network, each path having a plurality of accesses selected from the plurality of access points One or more nodes of the point;

The method further includes:

Determining connection quality and load characteristics of each path associated with each of the detected one or more access points over the wireless mesh network;

The access point is selected based on the connection quality and load characteristics of the path.

10.

The method of claim 9 further comprising:

And locating the detected one or more access points based on the detected connection quality and load characteristics of the associated path of the one or more access points through the wireless mesh network; and

According to the ranking, an access point is selected.

11.

A computer readable medium having stored thereon computer readable code, when the code is executed by one or more digital processors, instructing the one or more digital processors to provide a wireless connection to a mobile client, The computer readable code includes:

An instruction for periodically triggering an access point scanning process to monitor the access point density of

the wireless network; and

An instruction to adjust the frequency of the trigger in response to a change in the density of the access point.

12.

The computer readable medium of claim 11 further comprising:

An instruction for monitoring at least one motion of the mobile client; and

An instruction to adjust the frequency of the trigger in response to the change in the at least one motion of the mobile client.

13.

The computer readable medium of claim 11 or 12, the computer code further comprising:

An instruction for receiving a motion signal from an accelerometer placed in a mobile client; and

An instruction for determining at least one motion of the mobile client from the motion signal.

14.

The computer readable medium according to any one of claims 11 to 13, the computer code further comprising:

An instruction for detecting one or more access points in an area in which the mobile client is located;

An instruction for measuring at least link quality and load characteristics of a wireless network; and

Configuring to select one of the detected one or more access points to connect the mobile client to the wireless network based on at least the link quality and load characteristics of the wireless network to maximize end-to-end performance of the wireless connection Instructions.

15.

A mobile client (110A-C) for connecting to a wireless network (106) via one or more access points (104), comprising:

a scanning module (247) configured to periodically trigger an access point scanning process to monitor an access point density of the wireless network;

The adjustment module is configured to adjust the frequency of the trigger in response to a change in the density of the access points.

16.

The mobile client of claim 15 further comprising:

a sensor (262) configured to generate a motion signal indicative of at least one motion of the mobile client; and

a mobility monitor (246) configured to monitor at least one motion of the mobile client by the motion signal,

The adjustment module is further configured to adjust a frequency of the trigger in response to a change in the at least one motion of the mobile client.

17.

A mobile client according to claim 15 or 16, further comprising an association module (248) configured to monitor at least link quality and load characteristics of the wireless network, and according to at least said link of the wireless network Quality and Load Characteristics An access point (104) is selected to connect the mobile client (110A-C) to the wireless network to maximize end-to-end performance of the wireless connection.

18.

The mobile client of any one of claims 15 to 17, wherein the scanning module (247) is further configured to monitor a received signal strength of a wireless signal received by the mobile client,

The mobile client further includes:

The migration module (287) is configured to migrate the mobile client from the first access point to the second in response to at least one of a change in motion of the mobile client, a change in access point density, and a change in received signal strength Access Point.

19.

A system (100) for providing a mobile client (110A-C) with a wireless connection to a wireless network (106), the system comprising:

Multiple access points (104) distributed in the wireless network (106); and

A mobile client (110A-C) configured to periodically trigger an access point scanning process to monitor an access point density within an area in which the mobile client is located, the mobile client further configured to The frequency of the trigger is adjusted in response to changes in the density of the access points.

20.

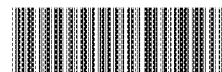
The system of claim 19, wherein the mobile client (110A-C) is configured to monitor at least one motion of the mobile client and is configured to adjust the frequency of the trigger in response to a change in motion of the mobile client.

21.

A system as claimed in claim 19 or 20, wherein each of the plurality of access points (104) is configured to measure at least link quality and load characteristics of the wireless network and is configured to indicate the link Measurements of quality and load characteristics are sent to the mobile client (110A-C).

22.

A system according to any one of claims 19 to 21, wherein the mobile client (110A-C) is configured to receive measurements of the link quality and load characteristics, and when the mobile client detects the wireless network (106) When the one or more access points (104) are configured, the mobile client is configured to select one of the detected one or more access points based on the measurement of the link quality and load characteristics of the wireless network One to maximize the end-to-end performance of the wireless connection.



(12) 发明专利申请

(10) 申请公布号 CN 102907141 A

(43) 申请公布日 2013.01.30

(21) 申请号 201180024785.0

(51) Int. Cl.

(22) 申请日 2011.06.01

H04W 48/16(2006.01)

(30) 优先权数据

12/793,387 2010.06.03 US

(85) PCT申请进入国家阶段日

2012.11.19

(86) PCT申请的申请数据

PCT/EP2011/002721 2011.06.01

(87) PCT申请的公布数据

WO2011/151071 EN 2011.12.08

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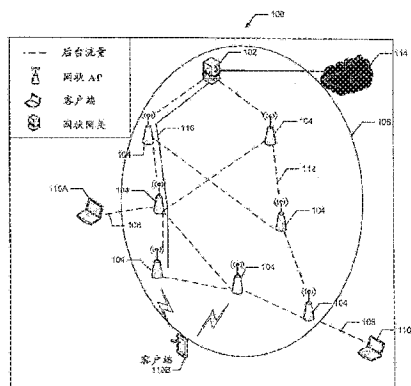
权利要求书 3 页 说明书 27 页 附图 17 页

(54) 发明名称

把移动客户端连接到无线网络的方法、装置与系统

(57) 摘要

本公开涉及把移动客户端连接到无线网络的方法、装置与系统。用于把移动客户端连接到无线网络的方法包括周期性地触发接入点扫描过程，以便监视无线网络的接入点密度。触发的频率是响应于接入点密度的变化来调整的。



1. 一种为移动客户端提供无线连接的方法,所述方法包括:
周期性地触发接入点(110A-C)扫描过程,以便监视无线网络(106)的接入点密度;及
响应于接入点密度的变化,调整触发的频率。
2. 如权利要求1所述的方法,还包括:
响应于接入点密度的减小,降低触发的频率。
3. 如权利要求1或2所述的方法,还包括:
响应于接入点密度的增加,提高触发的频率。
4. 如权利要求1至3中任一项所述的方法,还包括:
监视移动客户端的至少一种运动;及
响应于移动客户端的所述至少一种运动,调整触发的频率。
5. 如权利要求4所述的方法,还包括:
确定移动客户端的所述至少一种运动的速度;及
响应于所述速度的增加,提高触发的频率。
6. 如权利要求5所述的方法,还包括:
响应于所述速度的减小,降低触发的频率。
7. 如权利要求5或6所述的方法,其中移动客户端的运动是由放在移动客户端中的加速计检测的。
8. 如权利要求1至7中任一项所述的方法,还包括:
检测移动客户端所处的区域中的一个或多个接入点(104);
监视无线网络的至少链路质量和负载特性;及
响应于无线网络的至少所述链路质量和负载特性,从检测到的一个或多个接入点中选择一个接入点来把移动客户端连接到无线网络。
9. 如权利要求1至8中任一项所述的方法,其中无线网络是包括多个接入点的无线网状网络,其中另一网络实体连接到这多个接入点中的一个,并且其中检测到的一个或多个接入点中的每一个都与通过无线网状网络连接对应接入点和所述另一网络实体的路径关联,每条路径都具有选自所述多个接入点的一个或多个节点;
所述方法还包括:
确定通过无线网状网络的与检测到的一个或多个接入点中的每一个关联的每条路径的连接质量和负载特性;
根据所述路径的连接质量和负载特性来选择接入点。
10. 如权利要求9所述的方法,还包括:
基于检测到的一个或多个接入点的通过无线网状网络的关联路径的连接质量与负载特性,给所述检测到的一个或多个接入点分级;及
根据所述分级,选择接入点。
11. 一种在其上存储了计算机可读代码的计算机可读介质,当所述代码被一个或多个数字处理器执行时,指示所述一个或多个数字处理器为移动客户端提供无线连接,所述计算机可读代码包括:
用于周期性地触发接入点扫描过程,以便监视无线网络的接入点密度的指令;及
用于响应于接入点密度的变化,调整触发的频率的指令。

12. 如权利要求 11 所述的计算机可读介质,所述计算机代码还包括:

用于监视移动客户端的至少一种运动的指令;及

用于响应于移动客户端的所述至少一种运动中的变化,调整触发的频率的指令。

13. 如权利要求 11 或 12 所述的计算机可读介质,所述计算机代码还包括:

用于从放在移动客户端中的加速计接收运动信号的指令;及

用于从所述运动信号确定移动客户端的至少一种运动的指令。

14. 如权利要求 11 至 13 中任一项所述的计算机可读介质,所述计算机代码还包括:

用于检测移动客户端所处的区域中的一个或多个接入点的指令;

用于测量无线网络的至少链路质量和负载特性的指令;及

用于根据无线网络的至少所述链路质量和负载特性,选择检测到的一个或多个接入点中的一个以把移动客户端连接到无线网络,从而最大化无线连接的端到端性能的指令。

15. 一种用于通过一个或多个接入点(104)连接到无线网络(106)的移动客户端(110A-C),包括:

扫描模块(247),被配置成周期性地触发接入点扫描过程,以便监视无线网络的接入点密度;及

调整模块,被配置成响应于接入点密度的变化来调整触发的频率。

16. 如权利要求 15 所述的移动客户端,还包括:

传感器(262),被配置成生成指示移动客户端的至少一种运动的运动信号;及

移动性监视器(246),被配置成通过所述运动信号监视移动客户端的至少一种运动,

其中,所述调整模块还被进一步配置成响应于移动客户端的所述至少一种运动的变化来调整触发的频率。

17. 如权利要求 15 或 16 所述的移动客户端,还包括关联模块(248),所述关联模块被配置成监视无线网络的至少链路质量和负载特性,并且根据无线网络的至少所述链路质量和负载特性选择一个接入点(104)以把移动客户端(110A-C)连接到无线网络,从而最大化无线连接的端到端性能。

18. 如权利要求 15 至 17 中任一项所述的移动客户端,其中所述扫描模块(247)还被进一步配置成监视由移动客户端接收到的无线信号的接收信号强度,

所述移动客户端还包括:

迁移模块(287),被配置成响应于移动客户端的运动中的变化、接入点密度的变化和接收信号强度的变化中的至少一个,把移动客户端从第一接入点迁移到第二接入点。

19. 一种为移动客户端(110A-C)提供到无线网络(106)的无线连接的系统(100),所述系统包括:

分布在无线网络(106)中的多个接入点(104);及

移动客户端(110A-C),被配置成周期性地触发接入点扫描过程,以便监视所述移动客户端所处的区域内的接入点密度,所述移动客户端还被进一步配置成响应于接入点密度的变化来调整触发的频率。

20. 如权利要求 19 所述的系统,其中移动客户端(110A-C)被配置成监视移动客户端的至少一种运动,并且被配置成响应于移动客户端的运动的变化来调整触发的频率。

21. 如权利要求 19 或 20 所述的系统,其中多个接入点(104)中的每一个都被配置成测

量无线网络的至少链路质量和负载特性,并且被配置成把指示所述链路质量和负载特性的测量发送给移动客户端(110A-C)。

22. 如权利要求 19 至 21 中任一项所述的系统,其中移动客户端(110A-C)被配置成接收所述链路质量和负载特性的测量,并且当移动客户端检测到无线网络(106)的一个或多个接入点(104)时,所述移动客户端被配置成根据无线网络的所述链路质量和负载特性的测量,选择检测到的一个或多个接入点中的一个,从而最大化无线连接的端到端性能。

把移动客户端连接到无线网络的方法、装置与系统

技术领域

[0001] 本发明总体上涉及无线联网而且尤其涉及用于为移动客户端提供无线连接从而优化节能、无线接入机会和端到端性能的方法、装置与系统。

背景技术

[0002] 随着启用互联网的移动设备越来越流行以及使用中的移动网络应用的过剩,智能电话上的数据消费在过去的几年中猛涨。许多载体都报告了移动数据流量的惊人增长。尽管,在包括美国在内的国家中,定价收费计划(flat rate plan)有助于伴随着最大数据限制,但是遍布全球的用户仍然继续加入基于用量的计划。

[0003] 基于 Wi-Fi 的无线网状网络给出了高带宽,而且常常比较便宜,对于移动互联网用户来说是另一种选择,而且对于服务提供商来说也是卸载移动数据流量的一个不错的选择。为了令人满意的用户体验,像对延迟敏感的 IP 电话的移动互联网应用需要担保具有无线覆盖的区域内的无缝连接性。但是,由于因为用户移动性所需的重新连接及 Wi-Fi 网络的短传输范围,这是移动电话的电池难以负担的。具体而言,为了最大化 Wi-Fi 机会的使用,移动主机必须(i)频繁地扫描 ISM 频谱带,来获得可用 Wi-Fi 网络的列表,(ii)主动地探查无线链路,以便识别最好的接入网络或者接入点(AP),及(iii)抢先地(proactively)把他们当前的关联迁移到提供高吞吐量的其它 AP。所有这些任务对于移动主机的电池寿命和连接性都是关键性的。

[0004] 对于最大化 Wi-Fi 使用对电池受限的移动客户端的利用率,有几个固有的挑战。Wi-Fi 网络的周期性扫描可以帮助识别可用的网络。确定优化电池寿命和 Wi-Fi 连接机会的最优扫描频率是具有挑战性的。现有蜂窝服务提供商所提供的蜂窝辅助的基于距离的扫描要忍受蜂窝信号的不可预测性或者手机信号塔变化的密度。有些现有的设备使用基于接收信号强度(RSS)的扫描,这种方法在触发 AP 扫描时依赖于固定的阈值,不够灵活,以至于不能利用由无线网状网络提供的多变的 Wi-Fi 接入机会。还有一些现有的设备利用基于历史的扫描和关联控制,这需要能量密集的计算与位置跟踪。

[0005] 在无线网状网络(WMN)中,移动客户端能够从属于该网络的多个移动 AP 收到信号而且能够选择其中一个 AP 来接入 WMN。因此,期望选择为移动客户端提供最佳用户体验或性能的 AP。现有的系统主要利用基于信号强度的机制来给 AP 分级,其中移动客户端与在该客户端提供最大接收信号强度(RSS)的 AP 关联。

[0006] 但是,仅仅根据信号强度选择 AP 会造成选定 AP 上拥塞的增加,由此对终端用户导致差的性能。而且,信号强度不是无线网络中信道状况的准确指示。因此,即使从一个 AP 接收到的信号强度高,这也可能没有正确地指示该 AP 当前的性能级别。

发明内容

[0007] 本发明的一个目标是克服以上提到的缺陷。

[0008] 本发明提供了用于为移动客户端提供无线连接的方法。该方法包括周期性地触发

接入点扫描过程,从而监视无线网络的接入点密度,并且响应接入点密度的变化来调整触发的频率。

[0009] 该方法还可以包括响应接入点密度的减小而降低触发频率的步骤和 / 或响应于接入点密度的增加而提高触发频率的步骤。

[0010] 有利地,该方法可以包括监视移动客户端的至少一种运动并且响应于该移动客户端的至少一种运动来调整触发频率的步骤。

[0011] 优选地,该方法包括确定移动客户端的至少一种运动的速度;及响应于所述速度的提高而提高触发频率的步骤。

[0012] 在一种优选实施方式中,该方法包括响应于速度的减小而降低触发频率的步骤。

[0013] 优选地,该方法包括通过放在移动客户端中的加速计检测移动客户端的运动的步骤。

[0014] 有利地,该方法还包括步骤:

[0015] 检测移动客户端所处的区域内的一个或多个接入点;

[0016] 监视无线网络的至少链路质量和负载特性;

[0017] 响应于无线网络的至少所述链路质量和负载特性,从检测到的一个或多个接入点中选择一个接入点,以把移动客户端连接到无线网络。

[0018] 在一种优选实施方式中,无线网络是包括多个接入点的无线网状网络,其中另一网络实体连接到所述多个接入点中的一个,而且其中所检测到的一个或多个接入点中的每一个都与通过无线网状网络连接对应接入点和另一网络实体的路径关联,每条路径都具有选自所述多个接入点的一个或多个节点;

[0019] 该方法还包括:

[0020] 确定通过无线网状网络的与检测到的一个或多个接入点中的每一个关联的每条路径的连接质量和负载特性;

[0021] 根据路径的连接质量与负载特性选择接入点。

[0022] 优选地,该方法包括步骤:

[0023] 基于其通过无线网状网络的关联路径的连接质量与负载特性给检测到的一个或多个接入点分级;及

[0024] 根据所述分级选择接入点。

[0025] 还通过其上存储了计算机可读代码的计算机可读介质来解决以上提到的技术问题,当所述代码被一个或多个数字处理器执行时,指示这一个或多个数字处理器为移动客户端提供无线连接,所述计算机可读代码包括:

[0026] 周期性地触发接入点扫描过程,从而监视无线网络的接入点密度的指令;及

[0027] 响应于接入点密度的变化来调整触发频率的指令。

[0028] 优选地,所述计算机代码还包括:

[0029] 监视移动客户端的至少一种运动的指令;及

[0030] 响应于移动客户端的至少一种运动的变化来调整触发频率的指令。

[0031] 有利地,所述计算机代码还可以包括:

[0032] 从放在移动客户端中的加速计接收运动信号的指令;及

[0033] 从所述运动信号确定移动客户端的至少一种运动的指令。

- [0034] 在一种优选实施方式中,所述计算机代码还包括:
- [0035] 检测移动客户端所处的区域内的一个或多个接入点的指令;
- [0036] 测量无线网络的至少链路质量与负载特性的指令;及
- [0037] 根据无线网络的至少链路质量和负载特性选择检测到的一个或多个接入点中的一个以便把移动客户端连接到无线网络的指令,从而最大化无线连接的端到端性能。
- [0038] 进一步由通过一个或多个接入点连接到无线网络的移动客户端来解决以上提到的技术问题。该移动客户端包括:
- [0039] 扫描模块,被配置成周期性地触发接入点扫描过程,从而监视无线网络的接入点密度;及
- [0040] 调整模块,被配置成响应于接入点密度的变化来调整触发的频率。
- [0041] 优选地,所述移动客户端还包括:
- [0042] 传感器,被配置成生成指示该移动客户端的至少一种运动的运动信号;及
- [0043] 移动性监视器,被配置成通过所述运动信号监视移动客户端的至少一种运动,
- [0044] 其中,调整模块还被配置成响应于移动客户端的至少一种运动的变化来调整触发的频率。
- [0045] 有利地,所述移动客户端可以包括关联模块,该模块被配置成监视无线网络的至少链路质量和负载特性,并且根据无线网络的至少所述链路质量和负载特性选择一个接入点,以把移动客户端连接到无线网络,从而最大化无线连接的端到端性能。
- [0046] 优选地,扫描模块被配置成监视由移动客户端接收到的无线信号的接收信号强度,其中移动客户端还可以包括:
- [0047] 迁移模块,该模块被配置成响应于移动客户端的运动的变化、接入点密度的变化和接收信号强度的变化中的至少一个而把移动客户端从第一接入点迁移到第二接入点。
- [0048] 进一步通过为移动客户端提供到无线网络的无线连接的系统来解决以上提到的技术问题。该系统包括:
- [0049] 在无线网络中分布的多个接入点;及
- [0050] 移动客户端,被配置成周期性地触发接入点扫描过程,从而监视该移动客户端所处的区域内的接入点密度,该移动客户端还被配置成响应于接入点密度的变化而调整触发的频率。
- [0051] 优选地,移动客户端被配置成监视该移动客户端的至少一种运动并且被配置成响应于该移动客户端运动的变化而调整触发的频率。
- [0052] 有利地,所述多个接入点中的每一个都被配置成测量无线网络的至少链路质量和负载特性,并且被配置成把指示所述链路质量和负载特性的测量发送到移动客户端。
- [0053] 在一种优选实施方式中,移动客户端被配置成接收链路质量和负载特性的测量,而且,当移动客户端检测到无线网络的一个或多个接入点时,该移动客户端被配置成根据无线网络的链路质量和负载特性的测量,选择检测到的一个或多个接入点中的一个,从而最大化无线连接的端到端性能。

附图说明

- [0054] 图1绘出了其中实践本发明各种实施方式的无线网络环境;

- [0055] 图 2A 绘出了图 1 所示移动客户端的一种实施方式的示意图；
- [0056] 图 2B 绘出了图 1 所示移动客户端的另一种实施方式的示意图；
- [0057] 图 3 绘出了图 1 所示无线接入点的一种实施方式的示意图；
- [0058] 图 4A 绘出了用于在移动客户端触发接入点感测过程的方法的流程图；
- [0059] 图 4B 示出了当移动客户端从无线网络断开时触发接入点感测过程的方法的另一种实施方式；
- [0060] 图 4C 绘出了当移动客户端连接到无线网络时触发接入点感测过程的方法的另一种实施方式；
- [0061] 图 5A 绘出了选择接入图 1 中所绘无线网络的接入点的方法的流程图；
- [0062] 图 5B 示出了图 4B 中所绘方法的另一种实施方式；
- [0063] 图 6 绘出了具有可调触发间隔 T_s 的周期性接入点扫描的功耗；
- [0064] 图 7 绘出了固定阈值接入点扫描与可适配阈值 AP 扫描之间的性能比较；
- [0065] 图 8A 绘出了当移动客户端移动时由接入点扫描过程检测到的新接入点的平均个数；
- [0066] 图 8B 绘出了在不同的运动行为下以 20% 的占空比从移动客户端的一种实施方式上的内置加速计收集到的数据样本；
- [0067] 图 8C 绘出了根据本发明的测量结果,该结果显示 AP 到达间隔时间被准确地近似为指数分布；
- [0068] 图 9A 绘出了根据本发明的适于移动客户端运动速度及 AP 密度的最优扫描间隔 (T_s)；
- [0069] 图 9B 绘出了根据本发明的作为对于各个概率值 ξ 的平均 AP 密度的函数的 AP 扫描的阈值距离；
- [0070] 图 9C 绘出了当与具有固定触发间隔 (T_s) 的传统固定频率触发比较时,由根据本发明的基于运动的扫描所提供的节能；
- [0071] 图 10 绘出了根据本发明的由链路带宽的被动探查估计所提供的准确度；
- [0072] 图 11 绘出了用于实践本发明实施方式的室外试验台拓扑结构；
- [0073] 图 12A 绘出了与传统的固定频率扫描相比,由本发明一种实施方式提供的性能改进；
- [0074] 图 12B 绘出了与传统的固定频率扫描相比,由本发明一种实施方式提供的节能；
- [0075] 图 12C 绘出了具有不同阈值的、基于密度的扫描的性能；
- [0076] 图 13 绘出了与传统的接入点选择策略相比,由本发明一种实施方式提供的吞吐量改进；
- [0077] 图 14 绘出了与传统的接入点选择策略相比,由本发明一种实施方式提供的往返延迟改进；
- [0078] 图 15 绘出了根据本发明的权重值 w_1 和 w_2 对吞吐量性能的影响；
- [0079] 图 16 绘出了当移动客户端的个数变化时,由在室内试验台实践的本发明一种实施方式所提供的吞吐量与往返延迟性能；
- [0080] 图 17 绘出了当移动客户端的个数变化时,由在室外试验台实践的本发明一种实施方式所提供的吞吐量与往返延迟性能；及

[0081] 图 18 绘出了传统 AP 选择策略对网络吞吐量的影响。

具体实施方式

[0082] 在有些实施方式中,本发明提供了为移动客户端最大化无线接入机会,同时提供最优节能的接入点感测(扫描)技术。不像依赖昂贵的定位机制(例如, GPS)或者 war-driving (战争驾驶)的现有系统,本发明提供了放在移动客户端中的低功率传感器,来最大化无线网络的使用。本发明还提供了为移动客户端选择接入点以便最大化端到端性能,从而提供最优的用户体验的 AP 选择技术。

[0083] 根据另一种实施方式,所述方法包括检测移动客户端所处的区域内的一个或多个接入点、监视无线网络的至少链路质量和负载特性,并且响应于无线网络的至少所述链路质量与负载特性,从检测到的一个或多个接入点中选择一个接入点,以把移动客户端连接到无线网络,从而最大化无线连接的端到端性能。

[0084] 根据一些备选实施方式,提供了其上存储了计算机可读代码的计算机可读介质。当所述计算机可读代码被一个或多个数字处理器执行时,指示这一个或多个数字处理器为移动客户端提供无线连接。所述计算机可读代码包括周期性地触发用于监视无线网络的接入点密度的接入点扫描过程的指令和用于响应于接入点密度的变化而调整触发频率从而最大化移动客户端的节能与接入机会的指令。

[0085] 根据另一种实施方式,所述计算机代码还包括用于检测移动客户端所处区域内的一个或多个接入点的指令、用于测量无线网络的至少链路质量和负载特性的指令及用于根据无线网络的至少所述链路质量与负载特性而从检测到的一个或多个接入点选择一个接入点以便把移动客户端连接到无线网络从而最大化无线连接的端到端性能的指令。

[0086] 在还有一些备选实施方式中,提供了通过一个或多个接入点连接到无线网络的移动客户端。所述移动客户端包括被配置成周期性地触发用于监视无线网络接入点密度的接入点扫描过程的扫描模块、被配置成响应于接入点密度的变化而调整触发频率从而最大化移动客户端的节能与接入机会的调整模块。

[0087] 在另一种实施方式中,移动客户端包括关联模块,该模块被配置成监视无线网络的至少链路质量和负载特性,并且根据无线网络的至少所述链路质量与负载特性而选择一个接入点,以把移动客户端连接到无线网络,从而最大化无线连接的端到端性能。

[0088] 根据还有一些备选实施方式,提供了把移动客户端连接到无线网络的系统。该系统包括分布在无线网络中的多个接入点和被配置成周期性地触发用于监视移动客户端所处的区域内的接入点密度的接入点扫描过程的移动客户端。该移动客户端还被配置成响应于接入点密度的变化而调整触发的频率。

[0089] 在另一种实施方式中,多个接入点中的每一个都被配置成测量无线网络的至少链路指令与负载特性,并且被配置成把指示所述链路质量和负载特性的测量发送到移动客户端。

[0090] 在还有另一种实施方式中,移动客户端被配置成接收链路质量与负载特性的测量,而且,当移动客户端检测到无线网络的一个或多个接入点时,该移动客户端被配置成根据无线网络的链路质量与负载特性的测量而选择检测到的一个或多个接入点中的一个。

[0091] 本发明的各种实施方式将参考附图来描述,其中相同的标号在几个视图中始终代

表相同的部分和组件。对各种实施方式的参考不限制本发明的范围,本发明的范围只能由所附权利要求的范围来限制。另外,本说明书中所阐述的任何例子都不意图是限制性的,而仅仅是阐述所保护发明的许多可能实施方式中的一些。其中,本发明可以体现为方法或设备。相应地,本发明可以采取完全硬件实施方式、完全软件实施方式或者结合软件与硬件方面的实施方式。因此,以下具体描述不应当从限制的角度来理解。

[0092] 在整个本说明书与权利要求中,除非上下文明确地另外指出,否则以下术语都采用在此明确关联的意义。如在此所使用的,短语“在一种实施方式中”不一定指同一实施方式,尽管也可能是这样。如在此所使用的,除非上下文明确地另外指出,否则术语“或者”是包含性的“或者”运算符,而且等同于术语“和/或”。除非上下文明确地另外指出,否则术语“部分地基于”、“至少部分地基于”或者“基于”不是排他的而且允许基于没有描述的附加因素。此外,在整个本说明书中,“一个”和“这个”的意义包括复数含义。“在...中(in)”的意义包括“在...中”和“在...上(on)”。

[0093] 简言之,提供了用于把移动客户端连接到无线网络的方法、装置与系统。在这里,无线网络包括,但不限于,Wi-Fi 网络、蓝牙网络、WiMAX 网络或者遵循例如 IEEE 802.11 的工业标准的任何无线网络,其中 IEEE 802.11 在此全部引入作为参考。可替换地,无线网络可以通过多个接入点提供数据通信的专有网络。

[0094] 总的来说,在此所述的方法通过考虑移动客户端的运动和行为及该移动客户端传输范围内接入点的密度,提供了接入点感测过程(例如,扫描与关联)。

[0095] 特别地,移动客户端周期性地扫描信道,来发现可用的无线接入点。因为无线接入机会受空间变化的影响,诸如移动客户端的运动和接入点密度,所以接入点感测过程的扫描频率是基于空间变化来适配的,以便节约能量并最大化接入机会。为移动客户端提供用于感测接入点的接入点密度和细粒度的移动性信息,从而维持最佳节能和无线接入机会。

[0096] 此外,所述方法还通过优化权衡度量(trade-off metric)来提供能量高效的接入点感测,其中权衡度量可以定义为花在经无线网络发现和通信上的能量与传送到移动客户端的全部位之比。

[0097] 另外,由于无线接入机会的不均衡本质,在此所述的方法使用关于接入网络状况的信息及给定位置的 AP 密度,这允许移动客户端发现新的接入点,Wi-Fi 网络。例如,在其中无线接入点密集分布的、具有高平均接收信号强度(RSS)的高度密集区域内,移动客户端可以提高迁移阈值,来发现更好的 AP,而在稀疏分布的区域内,它们可以降低迁移阈值,以避免迁移开销。在这里,也称为切换的迁移是指当满足某些条件时从现有接入点断开移动客户端并把该移动客户端与另一个接入点连接的过程。

[0098] 移动客户端包括,但不限于,具有接入无线网络的能力的便携式计算机、蜂窝电话、PDA 和智能电话。所述方法包括周期性地触发用于监视无线网络接入点密度的接入点扫描过程并且响应于接入点密度的变化而调整触发的频率,从而最大化移动客户端的节能和接入机会。

[0099] 说明性的运行环境

[0100] 图 1 示出了其中可以实践本发明的环境的一种实施方式的部件。实践本发明不一定需要所有的部件,而且在不背离本发明主旨或范围的情况下可以对部件的布置和类型进行变化。如所示出的,图 1 的系统 100 包括包含多个接入点 104 的无线网络 106 及一个或

多个移动客户端 110A-C。在某种实施方式中,无线网络 106 还包括把无线网络 106 连接到外部网络 114 的边缘网关 102,其中的外部网络 114 诸如互联网、局域网/广域网、电话网络或者蜂窝网络。

[0101] 总的来说,接入点 104 是经无线链路 112 互连的,每条链路都可以包括一条或多条以不同传输频率,诸如 900MHz 或者 2.5GHz,为中心的无线信道。每条链路 112 可以在一条或多条无线信道上提供单向或双向的数据传输。此外,当数据从一个接入点传输到另一个接入点时,数据通过无线网络 106 穿过诸如路径 116 的无线路径,其中无线网络 106 是由一个或多个接入点(节点)形成的。如图 1 中所示,作为无线网络路径的示例性实施方式的路径 116 可以包括一个或多个跳,每个跳由沿该路径的一对相邻节点定义。数据可以在同一无线信道上传输通过整个无线路径。可替换地,用于传输数据的无线信道沿无线路径从一跳到下一跳可以是不同的。

[0102] 除了与由接入点 104 所提供的那些类似的功能之外,边缘网关 102 还提供到外部网络 114 的接口。这些接口提供了地址变换和数据转换与封装,这在本领域中是众所周知的。

[0103] 当诸如 110A-C 的移动客户端进入接入点 104 的传输范围内时,接入点 104 可以在无线客户端与无线网络 106 之间提供无线连接 108。一旦进行了最初的连接,接入点可能需要来自无线客户端的认证。一旦该移动客户端得到了认证,它就被允许在无线网络 106 中移动,而无需另外的认证。

[0104] 移动客户端 110A-C 中的每一个都被配置成周期性地扫描在无线信号的传输范围内的区域,以便确定在该传输范围内是否有任何接入点。移动客户端可以选择所检测到的接入点中的一个来接入无线网络 106。当移动客户端移动时,网络拓扑结构改变或者环境改变,移动客户端可以从一个接入点迁移到另一个接入点。

[0105] 总的来说,移动客户端 110 实际上可以包括能够经诸如无线网络 110 等的网络接收数据的任何移动计算设备。这种设备包括便携式设备,诸如蜂窝电话、智能电话、射频(RF)设备、红外线设备、个人数字助理(PDA)、手持式电脑、膝上型电脑、可佩戴式电脑、平板电脑、结合以上一种或多种设备的集成设备,等等。

[0106] 说明性移动客户端设备 110A、110B 和 110C

[0107] 图 2A 示出了可以包括在实现本发明的系统 100 中的移动客户端设备 200 的一种实施方式。设备 200 可以包括比图 2A 中所示部件更多或更少的部件。但是,所示出的部件足以实现用于实践本发明的说明性实施方式。例如,设备 200 可以代表图 1 移动客户端 110A、110B 和 110C 中的至少一个的一种实施方式。

[0108] 如图中所示出的,设备 200 包括经总线 224 与大容量存储器 230 通信的处理单元(CPU)222。设备 200 还包括电源 226、一个或多个网络接口 250、音频接口 252、显示器 254、键区 256、照明器 258 及输入/输出接口 260。电源 226 为设备 200 供电。充电或非充电电池可以用于供电。电力还可以由外部电源提供,诸如补充电池和/或给电池充电的 AC 适配器或者充电底座。

[0109] 设备 200 可以直接地或者经有线/无线网络接口 250 与另一个计算设备通信。网络接口 250 包括电路,该电路用于把设备 200 耦合到一个或多个网络,而且是为了与一种或多种通信协议与技术一起使用而构建的,其中的通信协议与技术包括,但不限于,全球

移动通信系统(GSM)、码分多址(CDMA)、时分多址(TDMA)、用户数据报协议(UDP)、传输控制协议 / 互联网协议(TCP/IP)、SMS、通用分组无线业务(GPRS)、WAP、超宽带(UWB)、IEEE 802.11Wi-Fi、IEEE 802.16 全球微波接入互操作性(WiMAX)、SIP/RTP 或者多种其它无线通信协议中的任意一种。网络接口 250 有时候称为收发器、收发设备或者网络接口卡(NIC)。

[0110] 音频接口 252 布置成产生和接收音频信号,诸如人的声音。例如,音频接口 252 可以耦合到扬声器和麦克风,使得可以与其他人通话和 / 或生成对某种动作的音频确认。显示器 254 可以是液晶显示器(LCD)、气体等离子体、发光二极管(LED) 或者与计算设备一起使用的任何其它类型的显示器。显示器 254 还可以包括布置成从诸如触控笔或者人的手指的对象接收输入的触敏屏幕。

[0111] 键区 256 可以包括布置从用户接收输入的任何输入设备。例如,键区 256 可以包括按钮数字拨号盘,或者键盘。键区 256 还可以包括与选择和发送图像关联的命令按钮。照明器 258 可以提供状态指示和 / 或提供光。照明器 258 可以在特定的时间段内或者响应于事件而保持活动状态。例如,当照明器 258 处于活动状态时,它可以从背后照亮键区 256 上的按钮并且在设备带电的时候一直处于这种状态。此外,当执行特定的动作时,诸如拨打另一个设备时,照明器 258 可以按各种模式从背后照亮这些按钮。照明器 258 还可以使位于设备透明或半透明外壳中的光源响应于动作而照亮。

[0112] 设备 200 还包括用于与外部设备,诸如头戴式耳机,通信的输入 / 输出接口 260。输入 / 输出接口 260 可以利用一种或多种通信技术,诸如 USB、红外线、Bluetooth™ 等。

[0113] 就能力与特征来说,设备 200 范围一般很广泛。例如,手机可以具有数字键区和几行单色 LCD 显示器,在上面只能显示文字。在另一个例子中,启用万维网的移动设备,诸如 PDA,可以具有触敏屏幕、触控笔和几行彩色 LCD 显示器,在其中既可以显示文字又可以显示图形。在再一个例子中,启用多媒体的移动设备,诸如膝上型电脑 110A,可以包括诸如视频播放应用的多媒体应用,其被配置成通过诸如彩色 LCD 或 LED 屏幕或者麦克风的多媒体接口来渲染图像、视频流、音频信号等。在再一个例子中,设备 200 还可以包括被配置成接收和显示图形、文字、多媒体等的浏览器应用,该浏览器应用实际上可以采用任何基于万维网的语言,包括无线应用协议消息(WAP)等。例如,使浏览器应用能够采用手持设备标记语言(HDML)、无线标记语言(WML)、WMLScript、JavaScript、标准通用标记语言(SMGL)、超文本标记语言(HTML)、可扩展标记语言(XML) 等来显示和发送信息。

[0114] 如图 2 中所绘出的,设备 200 还包括用于监视由于用户运动,诸如行走、跑步或者骑自行车,造成的移动客户端的运动的传感器 262。总的来说,传感器 262 可以生成反映移动客户端的运动的信号。传感器 262 可以把信号转换成数字数据,然后该数字数据存储在存储器的数据存储部分 244 中或者提供给用于实践本发明的 CPU 222。传感器 262 可以采取许多形式的加速计而且通常嵌入在移动客户端中。

[0115] 设备 200 还包括被配置成从由传感器 262 生成的数据中检测移动客户端的运动的移动性监视器 246。例如,移动性监视器 246 可以把数据分成包括行走、跑步和骑自行车的多个类并且基于分类的运动数据计算移动设备的行进距离。

[0116] 设备 200 还包括扫描模块 247,该模块可以周期性地触发接入点扫描过程,来检测当前在传输范围内是否有和有多少接入点。

[0117] 设备 200 还包括接入点关联模块 248,该模块可以选择接入点,以把移动客户端连

接到无线网络 106。接入点关联模块 248 可以基于各种标准,诸如无线网络 106 的链路质量和负载特性,来选择接入点。关联模块 248 还可以基于类似的标准提供移动客户端从一个接入点到另一个接入点的迁移。

[0118] 在图 2A 中,移动性监视器 246、扫描模块 247 和接入点关联模块 248 是作为包括存储在存储器的应用部分 242 中的计算机可读代码的一个或多个计算机程序来实现的。这些计算机程序可以由诸如 C、C++、Java 等的编程语言来实现。

[0119] 可替换地,以上所述的各种模块也可以作为硬件模块来实现,如图 2B 中所绘出的。在这种实施方式中,也可以用于移动客户端 110 的设备 280 包括用户接口 281、存储器 282、CPU 283、传感器 288、网络接口 289 及附加的移动性监视器 284、扫描模块 285、关联模块 286 和迁移模块 287。根据这种实施方式,这些模块是包括一个或多个电路的硬件部件,其中的电路可以是专用电路或者通用的可编程逻辑设备。

[0120] 说明性网络节点 104

[0121] 图 3 示出了可以用在图 1 无线网络 106 中的接入点 300 的一种实施方式。接入点 300 可以包括比所示出部件更多或更少的部件。但是,所示出的部件足以公开用于实践本发明的说明性实施方式。

[0122] 具体而言,网络设备 300 包括处理单元 312、大容量存储器及一个或多个网络接口单元 310A、310B 和 310C (统称为“无线接口单元 310”),所有这些部件都经总线 322 彼此通信。大容量存储器通常包括 RAM 316、ROM 332 及一个或多个永久性大容量存储设备,例如硬盘驱动器、磁带驱动器、光驱和 / 或软盘驱动器。大容量存储器存储用于控制接入点 300 操作的操作系统 320。任何通用操作系统都可以采用。还提供了用于控制网络设备 300 的低层操作的基本输入 / 输出系统 (“BIOS”) 318。

[0123] 如图 3 中所说明的,网络设备 300 还可以经无线网络接口单元 310A、310B 和 310C 与其它接入点 104 或者移动客户端 110 通信,其中无线网络接口单元 310A、310B 和 310C 是为了与包括 TCP/IP、Wi-Fi、蓝牙等在内的各种通信协议一起使用而构建的。无线网络接口单元 310A、310B 和 310C 有时候称为无线收发器、收发设备或者网络接口卡 (NIC)。无线单元 310A、310B 和 310C 中的每一个可以在相同或不同的频率范围工作,诸如 900MHz、2.5GHz 或者 5GHz。

[0124] 当无线接口单元 310 与另一个接入点 104 通信时,它充当网络路由器,用于把数据路由通过无线网络 106。另一方面,当无线接口单元 310 与移动客户端 110 通信时,它充当接入点,以让连接的移动客户端接入无线网络 106。因此,通过无线接口单元 310A、310B 和 310C,设备 300 可以同时充当无线路由器和接入点。

[0125] 如上所述的大容量存储器说明了另一种类型的计算机可读介质,即,计算机存储介质。如在此所使用的,这种计算机可读存储介质指物理的有形设备。计算机可读存储介质可以包括以任何方法或技术实现的、用于信息存储的易失性、非易失性、可拆卸和不可拆卸的介质,其中的信息诸如计算机可读指令、数据结构、程序模块或者其它数据。计算机可读存储介质的例子包括 RAM、ROM、EEPROM、闪存存储器或者其它存储器技术、CD-ROM、数字多用盘 (DVD) 或者其它光学存储器、盒式磁带、磁带、磁盘存储器或者其它磁性存储设备,或者可以用于存储期望信息而且可以由计算设备访问的任何其它物理设备。

[0126] RAM 316 可以包括一个或多个数据存储,其中,该数据存储可以被接入点 300 用于

存储应用 350 和 / 或其它数据。RAM 316 还可以用于存储数据库信息。大容量存储器还存储程序代码与数据。一个或多个应用 350 加载到大容量存储器中并且由中央处理单元 312 在操作系统 320 上运行。应用的例子包括链路质量监视器 354 和利用率监视器 356、可定制的用户接口程序、IPSec 应用、加密程序、安全程序,等等。

[0127] 链路质量监视器 354 和利用率监视器 356 的操作将在下文中进一步描述。

[0128] 系统 100 的广义操作

[0129] 由于接入点 (AP) 的无计划部署及其小的覆盖范围,移动用户频繁地从 AP 断开,而且因此需要主动地发现无线接入机会。即使在给定的区域内存在许多开放的无线 AP 104,也存在覆盖区域的黑点或者在某些位置吞吐量对于令人满意的用户体验而言不是很好。为了发现无线接入机会,移动客户端 110A、110B 和 110C (统称为“移动客户端 110”)周期性地触发接入点扫描过程。

[0130] 但是,接入点扫描消耗移动客户端 110 中大量的能量。图 6 示出了 GOOGLE G1 电话中 Wi-Fi 扫描过程的功耗。图 6 中所示出的数据是利用 Agilent 34410A 数字万用表以每秒 20 个样本在实验中测量出来的。在实验过程中,所有其它的应用和后台服务都关掉了,因此在数据中反映了 AP 扫描过程的能量消耗。如图中所示出的,AP 扫描是能量昂贵的,大约每次扫描 1.1J (即,00mW $\times$ 1.3 秒),这主要是因为它需要扫描 ISM 信道的完整集合并且从所有的相邻 AP 接收多个信标。由于其高能耗,因此扫描过程是周期性触发的,这导致能耗尖峰。每两个尖峰之间的时间间隔 T_s 是由触发的频率确定的。

[0131] 根据本发明的一种实施方式,为了最大化节能(即,降低能耗),同时维持无线接入机会(即,降低扫描错误),提供了基于各种条件,诸如接入点的密度或移动客户端的运动,来调整触发频率的方法。

[0132] 在另一种实施方式中,当移动客户端 110A-C 暴露给多个接入点 104 时,本发明还提供了估计网络状况来选择最佳 AP 的方法。这也导致能量高效的数据传输。特别地,为了提供估计和关联选择,系统 100 允许移动客户端 110A-C 收集关于无线最后一跳(即,客户端到 AP)和网状回程(AP 到网关)状况的信息。由于大量的数据包被发送到 AP 和从 AP 发送,因此利用主动探查策略的现有技术是能量密集的。不像现有技术,系统 100 中的移动客户端 110A-C 被允许利用从 AP 104 收集到的数据来监视网络状况,而不用主动提供。

[0133] 在连接上的时候,移动主机将经历链路状况波动,尤其是对于无线最后一跳,而且他们会遭受 AP 感测的错误触发(例如,位于多个 AP 边界中的移动主机)。即使在没有用户移动的情况下,无线最后一跳的状况也会随用户的运动或者新的障碍而波动。这往往造成 AP 感测被触发多于其应该被触发的次数,从而导致频繁的网络探查和重新关联。AP 感测的反应性触发可以节省关联的开销,但延迟的感测会增加遗漏的机会。

[0134] 根据另一种实施方式,系统 100 提供了基于移动客户端的触发概率(P_{scan})及接收信号强度(RSS)阈值来触发 AP 扫描的机制。触发概率是响应于移动客户端的运动来更新的。RSS 阈值是响应于 AP 的密度来更新的。基于触发概率的触发减少了由于衰落引起的 RSS 波动所造成的错误触发。

[0135] 在具有密集部署的无线 AP 和高平均 RSS 的区域内,移动客户端 110 抢先地感测新的和 / 或更好的无线接入机会并且执行迁移,来提高数据传输中的能量效率和端到端性能。

[0136] 不像只在接收信号强度(RSS)低于某个预定阈值时才触发感测与迁移的现有系统,移动客户端 110A-C 响应于移动客户端的运动和诸如 AP 密度的网络状况而触发感测与迁移。在本发明的一种实施方式中,用于触发迁移的阈值是响应于运动和 AP 密度中的至少一个来适配的。阈值可以持续地或者以离散的值适配。

[0137] 图 7 说明了系统 100 的实施方式与使用固定 RSS 阈值的现有系统的实施方式的迁移性能之间的比较。在此所示的实施方式使用两个离散的值(-75dBm 和 -85dBm)来适配 RSS 阈值,而固定阈值系统使用 -75dBm 作为 RSS 阈值。在所述示例性实施方式中,RSS 阈值针对不同的 AP 密度(高和低密度)而被改变。移动客户端只在来自当前 AP 的 RSS 变得低于 RSS 阈值时才触发迁移。图 7 示出了当移动客户端在室内试验台周围移动时来自关联 AP 的平均 RSS,其中该试验台具有高 AP 密度区域 712 和低 AP 密度区域 714。如图中所示出的,在高 AP 密度区域 712,常规系统和系统 100 的示例性实施方式都用较小的迁移开销产生了较高的可实现用户 RSS。另一方面,在低 AP 密度区域 714,由于增加的迁移次数,使用高阈值(-75dBm)的常规系统导致显著的能量成本和中断,而具有可适配 RSS 阈值的系统 100 的示例性实施方式可以用由于减少的迁移次数而造成的显著较小的能量成本实现了相对高的 RSS。

[0138] 根据如图 2A 和 2B 中所绘出的实施方式,为移动客户端 200 提供了各种模块,以在无线网络 106 的多个无线接入点 104 上扫描、探查、关联和迁移,从而最大化无线接入机会,同时节省每位的能量成本。

[0139] 具体而言,为了发现无线接入机会,移动客户端 200 使用从放在其上的低功率传感器,诸如加速计,提取的细粒度运动信息。这种以移动为中心的移动性检测有助于避免触发昂贵的位置跟踪或者战争驾驶。移动客户端 200 提供了断开感测过程,当移动客户端 200 从任何 AP 断开时,该过程调整 AP 扫描频率,从而以降低的能量成本最大化网络机会的发现。移动客户端 200 还提供了连接感测过程,该过程抢先地识别并把移动客户端从一个接入点迁移到另一个接入点,来最大化无线接入机会。还有,移动客户端 200 既使用网络状况信息又使用运动信息来减少错误的关联/迁移触发。

[0140] 移动客户端 200 可以在许多不同的平台上实现,其中的平台诸如利用 GOOGLE 的 G1 Android 开发手机(ADP)的 Android 框架或者 Apple 的 iPhone 或者微软的 Windows Phone 等。根据另一种实施方式,图 2A-B 中所绘出的模块可以实现为利用来自位于移动客户端 200 中的低功率传感器的信息并与其它部件交互的中间件程序。

[0141] 当被移动客户端 200 执行时,所述程序主要在三方面对始终开启的无线连接性提供了能量效率的改进。首先,传感器辅助的自适应 AP 扫描减少了扫描的次数,同时显著减少了遗漏的接入机会。第二,网络感知的关联控制节省了探查开销,而且进一步提高了 AP 选择的准确性。第三,基于移动性的自适应迁移帮助移动客户端 110 投机地确定最优迁移时间。

[0142] 在这个程序的指示下,移动客户端 200 通过以下特征提供了能量高效的 AP 发现。

[0143] 运动感知的接入点感测:移动客户端 200 收集关于其自己的物理运动的信息并且把这种信息与网络状况组合,来优化 AP 感测频率或者定时并且触发或者抑制 AP 感测操作。

[0144] 低功率传感器的使用:不像基于 GPS 或手机信号塔 ID 的现有运动检测方法,该现有方法通常是能源密集的或者要忍受不准确,移动客户端 200 使用板载的低功率传感器,

诸如加速计,来推断运动并确定触发点。

[0145] 在连接或断开时的感测:移动客户端 200 不仅在其从网络断开的时候识别无线接入机会,而且在其连到现有接入点的时候也抢先地搜寻更好的接入机会。

[0146] 动态的 AP 感测:移动客户端 200 在空间上监视无线接入机会的不均匀性,并且动态地改变其感测参数,来提高网络机会的发现并提高能量效率。

[0147] 能量高效的接入点感测

[0148] 如以上所指出的,移动客户端 110 相对于无线网络 106 的物理位置和运动影响连接机会的发现。图 8A 示出了当携带移动客户端的用户沿市区路边站立、行走和跑步五分钟时经 AP 扫描检测到的新 AP 的平均数。如图中所示,增加移动性转变成所发现的无线接入机会的较高数量(即,在一个时间帧内在一个区域内检测到的 AP 数量)。在一种实施方式中,移动客户端 200 自适应地依赖其运动而改变其感测频率。例如,当移动客户端 110 的板载传感器 262 或者 288 检测到其用户没有移动时,AP 感测被较不频繁地触发或者当移动客户端没有连接到任何无线网络时甚至被抑制。当传感器 262 或者 288 检测到用户走过一个具有密集 AP 分布的区域时,就更经常地触发 AP 感测过程。

[0149] 在另一种实施方式中,用户移动性是由板载传感器以能量高效的方式监视的。此外,由板载传感器检测到的运动信息实时地变得可用于检测接入机会。特别地,传感器 262 或者 288 包括检测用户运动的低功耗加速计传感器。这种低功耗加速计类似于在诸如 Apple 的 iPhone 和 GOOGLE 的 G1 手机的现有系统中可以获得的那些。与能耗高的 GPS 传感器相比,低功耗的加速计对于正确操作而言需要的能量少得多。此外,在监视客户端 110 的运动期间,传感器 262 或者 288 不需要外部信息,诸如蜂窝无线电或者蓝牙信号,由此提供了包括可控制性、准确性和较少功耗在内的几个好处。

[0150] 在运行中,移动性监视器 246 或者 284 周期性地监视加速计值并且把给定时刻用户的行为分成诸如行走、跑步或站立的类。这种基于行为的移动性估计允许移动客户端基于传感器读数推断有意义的用户行为,包括站立、行走、跑步、骑自行车和开车。

[0151] 图 8B 说明了从 GOOGLE G1 电话收集到的基于加速计的行为分类的示例性实施方式。当把移动客户端放在口袋中并且执行不同的行为(例如,站立、行走和跑步)时,由移动性监视器 246 或者 284 计算运动矩阵(x, y, z),其中 x、y 和 z 代表基于加速计样本的沿三个轴的加速计值。特别地,加速计是周期性开启的(例如,开 1 秒关 4 秒)并且计算在该时间间隔内获得的样本的平均值。如图中所示,由移动性监视器 246 或 284 生成的运动估计准确地检测出了用户的行为。在另一种实施方式中,用户行为分类是基于在美国数学月刊 1958 年第 65 卷第 34-35 页上 G. Goertzel 所写的、标题为“An algorithm for the evaluation of finite trigonometric series”的非专利文献中描述的 Goertzel 方法提供的,该文献在此全部引入作为参考。

[0152] 根据图 4A 中所绘出的另一种实施方式,提供了把移动客户端连接到无线网络的方法 400。在这种实施方式中,移动客户端周期性地触发接入点发送过程,该过程用于监视无线网络的接入点密度(402 和 404)。在每个感测间隔内,移动客户端都进一步测量其运动(406)。然后,基于移动客户端的运动和 AP 密度动态地调整频率(感测间隔),从而最大化节能和无线接入机会(408)。当每个发送过程完成时,移动客户端确定是否有任何 AP 可用(410)。如果没有 AP 可用,移动客户端就继续下一个触发循环。相反,如果至少有一个 AP

可用,移动客户端就选择一个 AP,来接入无线网络(412),然后继续下一个触发循环。可替换地,在步骤 412,如果当前移动客户端连到一个 AP,那么该移动客户端就确定是否有必要迁移,来最大化端到端性能。如果满足迁移条件,移动客户端就从现有的 AP 迁移到选定的 AP。

[0153] 根据另一种实施方式,移动客户端 110 在断开和连接模式下运行。基于运行模式,移动客户端 110 触发如图 4B 和 4C 中所示的不同 AP 感测过程。

[0154] 断开模式下的接入点感测

[0155] 当从无线网络 106 断开时,扫描模块 247 或 285 周期性地触发移动客户端 110 执行 AP 扫描过程,来发现任何接入选项。AP 扫描过程有利地使用来自无线网络的统计性观察。基于在过去的时间窗口中获得的扫描结果,移动客户端 110 可以估计局部 AP 密度并且适配扫描间隔 T_s (或者触发频率),从而最小化检测可用无线接入点中的延迟,同时减少扫描次数,由此最大化节能。

[0156] 在设计提供以上所讨论的优点的扫描技术时,对于无线网络状况的行为作出两个假设。首先,AP 分布遵循点泊松过程,该过程具有平均密度 ρ ,即,每平方米 AP 的个数,如在斯坦福大学技术报告 2009 年 2 月由 D. Qiu 等人所写的、标题为“Physical Pseudo RandomFunction in Radio Frequency Sources for Security”的非专利文献中所描述的,该文献在此全部引入作为参考。

[0157] 第二,如在 2008 年 4 月 Proc. of IEEE Infocom 上由 W. Wang 等人所写的、标题为“Joint Effects of Radio Channels and Node Mobility on Link Dynamics in Wireless Networks”的非专利文献中所描述的,该文献在此全部引入作为参考,假设客户端到 AP 的连接寿命,即,客户端与 AP 之间物理距离小于有效传输范围的时间跨度,可以近似为指数分布,即, $T_l \sim \exp\left(\frac{v}{R}\right)$, 其中 v 是移动客户端的平均速度,而 R 是 AP 的公用传输范围,假设所述 AP 的公用传输范围是本领域中众所周知的单位圆盘模型。

[0158] 给定这些假设,导出新 AP 的平均到达率。考虑以平均速度 v 移动的移动客户端。然后,在时间段 (t_1, t_2) 内被移动主机覆盖的预期面积近似为 $2Rv(t_2 - t_1)$ 。然后,根据泊松分布的 AP 的假设,新 AP 的平均到达率为 $\lambda \approx 2Rv\rho$, 其中 ρ 是平均 AP 密度。

[0159] 图 8C 示出了 AP 到达间隔时间的累积分布函数(CDF)。该图清楚地指示这个函数可以近似为指数分布,由此确认以上讨论过的假设。经验与近似曲线之间的间隙可以如下解释。在实践当中,AP 可以高度聚集而且可能不精确地遵循泊松分布。移动客户端运动测量的不规律性也会造成这种间隙。基于所述假设,接入点的可用性可以建模为 Markov 模型,该模型具有两个状态,即,断开(D)和连接(C)状态。断开状态意味着没有移动客户端 110 可以连接的可用 AP,否则它将连上。应当指出,根据所述假设,AP 到达与离开速率分别是作为 $\lambda = 2Rv\rho$ 和 $\mu = \frac{v}{R}$ 给出的。因而,对于这种两态模型的状态过渡概率可以容易地作为 $\lambda_d = \lambda$ 和 $\lambda_c = \frac{(\mu - \lambda)\lambda}{\mu}$ 导出,其中 λ_d 和 λ_c 分别是 $D \rightarrow C$ 和 $C \rightarrow D$ 的状态过渡概率。

[0160] 最优扫描间隔(频率)

[0161] 基于上面的连接性模型,可以确定最小化遗漏的无线接入机会同时最大化用于最优节能的扫描间隔的最优扫描间隔(T_s)。遗漏的接入机会定义为没有被移动客户端 110 检

测到的接入机会的次数的平均分数。

[0162] 特别地,对于遗漏的无线接入机会,考虑从无线网络 106 断开并且以间隔 T_s 周期性地扫描频谱的移动客户端 110。令 $T_{m,d}(T_s)$ 表示利用扫描间隔 T_s 的遗漏的机会(直到找到可用的 AP)。于是,可以示为:

$$[0163] \quad T_{m,d}(T_s) = \frac{\lambda_d}{\lambda_d + \lambda_c} (1 - e^{-(\lambda_d + \lambda_c)T_s}) \quad (1)$$

[0164] 其中, $\lambda_d = 2R\bar{v}\rho$ 而 $\lambda_c = 2R\bar{v}\rho(1 - 2R^2\rho)$ 。

[0165] 为此,令 $T_{m,d}(t)$ 表示时间段 $(\tau, \tau+t)$ 内(按时间)的平均遗漏 AP 连接机会。当在时刻 τ 没有可用的 AP 时,连接(即,AP 关联)的机会只在时间段 t 内有可用 AP 到达的时候才发生。因此,对于时间段 $(\tau, \tau+t)$,遗漏机会的预期数量可以表达为:

$$[0166] \quad T_{m,d}(t) = t \int_0^\infty f_c(x) dx + \int_0^t f_c(x)(x + T_{m,d}(t-x)) dx$$

[0167] 类似地,

$$[0168] \quad T_{m,d}(t) = \int_0^t f_d(x) T_{m,d}(t-x) dx$$

[0169] 通过采用拉普拉斯变换,遗漏机会的预期数量 $T_{m,d}$ 可以在频率域内求解,即,

$$[0170] \quad T_{m,d}(s) = \frac{F_d^*(s)T_{m,d}(s)}{E[T_c]}$$

$$[0171] \quad T_{m,d}(s) = \frac{f_c^*(0) - f_c^*(s)}{s^2} + f_c^*(s)T_{m,d}(s)$$

$$[0172] \quad T_{m,d} = f_{m,d}(s)T_{m,d}(s)$$

[0173] 基于这些拉普拉斯变换,预期的遗漏机会 $T_{m,d}(s)$ 如下给出:

$$[0174] \quad T_{m,d}(s) = \frac{F_d(s)}{E[T_d]s^2} \cdot \frac{f_c^*(0) - f_c^*(s)}{1 - f_c^*(s)f_d^*(s)} \quad (2)$$

[0175] 对于指数分布的连接和断开周期是如下给出的:

$$[0176] \quad f_c(t) = \lambda e^{-\lambda t} \text{ 和 } f_d(t) = \mu e^{-\mu t}.$$

[0177] 于是,拉普拉斯变换如下给出:

$$[0178] \quad f_c^*(s) = \frac{\lambda}{\lambda + s} \text{ 和 } f_d^*(s) = \frac{\mu}{\mu + s}$$

[0179] 把这些替换到公式(2)中并采用逆拉普拉斯变换,就产生了公式(1)。

[0180] 公式(1)指示遗漏的机会随着增加的扫描间隔 T_s 而增加。从这个公式,遗漏的接入机会显示出如下行为:

$$[0181] \quad \text{当 } t \rightarrow \infty \text{ 时, } T_{m,d}(T_s) \rightarrow \frac{E[T_c]}{E[T_c] + E[T_d]}$$

[0182] 这种确认显示,随着扫描间隔增加,移动客户端遗漏检测所有的接入机会。应当指出,在所述分析当中,假设扫描过程是脉动的,因此由于扫描造成的遗漏的接入机会可以忽略。

[0183] 基于这种分析,可以确定最优扫描间隔(T_s),来最小化花在 AP 扫描上的能量与扫描间隔 T_s 内总传输位之比。在这里,假设用于数据传输的能耗是可以忽略的。当移动客户端 110 以固定的间隔 T_s 扫描 AP 时,它检测到接入机会的时间分数是 $1 - T_d - T_{m,d}(T_s)$, 其中

$T_d = \frac{\lambda_d}{\lambda_d + \lambda_s}$ 是处于断开状态的平均分数。于是, 最优扫描间隔如下给出:

$$[0184] \quad T_s^* = \arg \min_{0 < T_s \leq T_{\max}} \frac{E_{\text{scan}}}{T_s (1 - T_d - T_{m,d}(T_s)) E[R]}, \quad (3)$$

[0185] 其中, $T_{\max}$ 是最大扫描间隔, 这是一个预先确定的参数。例如, 对于运行延迟敏感应用 (例如, IP 电话) 的移动客户端, $T_{\max}$ 可以设成一个小的值, 反之亦然。在公式 (3) 中, 预期的可实现数据率表示为 $E[R]$ 而且它依赖于与客户端关联的 AP。AP 关联策略在本申请中稍后进一步具体描述。

[0186] 以下, 进一步示出最小化公式 (3) 的最优扫描间隔为:

$$[0187] \quad T_s^*(\bar{v}, \rho) = \left[\frac{1}{4R\bar{v}\rho(1-R^2\rho)} \right]^+ \quad (4)$$

[0188] 其中, $\bar{v}$ 是平均速度, ρ 是平均 AP 密度, 而 R 是 AP 的传输范围 (例如, 200m)。

[0189] 为此, 指示 $G(T_s) = \frac{E_{\text{scan}}}{T_s (1 - T_d - T_{m,d}(T_s)) E[R]}$ 是公式 (***) 中的目标函数, 即, 花

在扫描每个传输的数据位上的能量。假设用于扫描的能耗 E_{scan} 和平均可实现的数据率 $E[R]$ 作为常量给出, 找出公式 (3) 中最优扫描间隔 T_s^* 的过程等同于找出最大化 $G(T_s)$ 的 T_s , 这可以如下找出:

$$[0190] \quad \frac{\partial G(T_s)}{\partial T_s} = \frac{E_{\text{scan}}}{T_s^2 (1 - T_d - T_{m,d}(T_s)) E[R]} = 0$$

$$[0191] \quad \Rightarrow \lambda_d \left(\frac{1}{\lambda_d + \lambda_s} - T_d \right) e^{-(\lambda_d + \lambda_s) T_s} = 0$$

[0192] 很显然, 在 $(0, \frac{1}{\lambda_d + \lambda_s})$ 中 $G(T_s)$ 是 T_s 的单调递增函数。因此, T_s 的最优值是作为

$T_s^* = \frac{1}{\lambda_d + \lambda_s}$ 给出的。

[0193] 因此, 公式 (4) 随后进行。

[0194] 公式 (4) 暗示最优扫描周期依赖于移动客户端的平均移动速度 ($\bar{v}$) 和平均 AP 密度 (ρ)。例如, 当用户快速移动时, AP 到达率 (λ_d) 将增加, 并且鼓励用户更频繁地扫描, 预期快点检测到可用的 AP, 反之亦然。图 9A 示出了在假设 AP 的传输范围 $R=200\text{m}$ 的情况下用于不同用户速度的最优扫描间隔 (T_s^*)。

[0195] 接入点感测

[0196] 根据一种实施方式, 基于以上进行的分析提供了基于运动的 AP 扫描方法。在这种实施方式中, AP 扫描是基于从上次扫描开始移动客户端 110 行进的距离来触发的。不是依赖于像 GPS 那样的功率昂贵的位置跟踪系统, 这个距离可以利用上述运动感测技术来估计。具体而言, 行进的距离可以估计为:

$$[0197] \quad \hat{d} \approx \sum_{k \in K} n_k \times v_k$$

[0198] 其中, K 是可以基于如上所述的加速计读数来分类的用户行为的集合, v_k 是对应于行为 $k \in K$ 的平均速度。在每次 AP 扫描之后, 行进距离都重新设置成零, 使得系统中的不准确性不会累积。

[0199] 根据另一种实施方式,当移动客户端 110 行进超过一个阈值距离 d_{th} 时触发 AP 扫描过程,这个阈值距离 d_{th} 被定义为用户为了以概率 ξ (在 0 到 1 的范围内)找出至少一个可用 AP 所需移动的最小距离,即,

$$[0200] \quad 1 - \text{Poi}(n_{ap} = 0) \geq \xi$$

$$[0201] \quad \Leftrightarrow e^{-2\rho R d_{th}} \geq 1 - \xi$$

$$[0202] \quad \Leftrightarrow d_{th} \geq -\frac{\ln(1-\xi)}{2\rho R} = -\frac{\pi R \ln(1-\xi)}{2E[n_{ap}]} \quad (5)$$

[0203] 其中, n_{ap} 是由前一次扫描检测到的可用 AP 的个数。最后一个公式是基于关系 $E[n_{ap}] \approx \pi R^2 \rho$ 和 $E[n_{ap}]$, 这可以利用本领域中众所周知的指数加权的移动平均(EWMA)来估计。图 9B 示出了公式(5)中用于不同 AP 密度的阈值距离。例如,如果 AP 的平均数是 2 而且 ξ 设置成 0.3,则阈值距离为 56m。

[0204] 对于运行在如图 4B 中所示的断开模式下的移动客户端,在包括三个顺序周期的每个时期(epoch)中作出扫描决定。首先,在运动估计周期(T_m)内,移动客户端以给定占空比的比率开启加速计(例如,每 10 秒开启 1 秒)。一旦移动主机估计出用户行为,它就更新距离($\hat{d}$)并且决定是否在扫描决定周期(T_d)内触发 AP 扫描。一旦它检测到一组 AP,它就基于选择标准选择一个 AP 并且与选定的 AP 关联,否则它将更新 AP 密度并重复该过程。

[0205] 为了理解距离阈值对能耗的影响,分析在检测到 AP 之前固定周期和基于运动的触发方法所需的扫描次数。在基于运动的触发方法中,AP 扫描只有当移动主机移动某个距离的时候才触发,而固定周期的触发方法是以预定的时间间隔触发 AP 扫描。

[0206] 固定周期触发方法所需的扫描次数如下给出:

[0207]

$$n_{scan}^F = \frac{1}{T_s} \left[t_{still} + \sum_{k \in K} \frac{d_k}{v_k} \right]$$

[0208] 而基于运动的触发方法所需的扫描次数如下给出:

[0209]

$$n_{scan}^M = \left\lceil \frac{\hat{d}}{d_{th}} \right\rceil$$

[0210] 其中, t_{still} 是用户静止不动的时间量,而 $d = \sum_{k \in K} d_k$ 是直到检测到新 AP 时所行进的距离,而且其中 d_k 是行为 k (例如,行走或跑步)所行进的距离。

[0211] 图 9C 示出了当移动客户端 110 重复行走和暂停(静止不动)直到找出可用 AP 时的扫描总数。假设 AP 离断开点的距离为 $d=500m$ 而且 $d_{th}=80m$ 。该图显示,由于移动客户端多次保持静止不动,因此用于固定周期触发所需的扫描次数增加。相反,基于运动的触发不受静止不动时间的影响,因为它只在移动客户端的运动超过阈值距离时才触发扫描。应当指出,当用户在行走时,运动算法每 $\frac{d_{th}}{v_{max}} \approx 38.5s$ 触发一次扫描。

[0212] 连接模式下的接入点感测

[0213] 图 4C 描述了当移动客户端运行在连接模式下时控制扫描、探查和迁移的 AP 感测方法。

[0214] 为了利用多样的 Wi-Fi 接入机会,感测过程自适应地基于利用移动平均值估计出的局部 AP 密度来改变 RSS 阈值。当 AP 密度高时,通过设置高 RSS 阈值,移动客户端 110 变

得更加主动地触发 AP 扫描过程,从而预期以扫描开销为代价找出更好的 AP。为了避免即使在移动客户端静止不动时也会由于衰退引起 RSS 波动所造成的高错误触发率,移动客户端基于其运动以概率方式触发扫描。具体而言,基于移动客户端从最近一次扫描开始所行进的距离(d),触发概率(即,图 4C 中的行 18 的 P_{scan})增加。在这里,在我们的实验中, Δ 设置成 0.1 而且单位距离(d_{unit})是 10 米。

[0215] 一旦触发了感测,如果移动客户端经扫描发现了任何可用的 AP,就与所述可用 AP 中提供最高估计带宽的一个 AP 关联。相反,如果没有发现可用的 AP,该移动客户端就切换到图 4B 中所绘出的断开模式。

[0216] 根据这种实施方式,当移动客户端当前连接到无线网络 106 的一个 AP 时,它仍然抢先地搜寻其它的或者更好的无线接入机会,以维持连接性。例如,当移动用户在市区内行走时,其中存在许多的接入点而且它们的性能是不均匀的。于是,移动客户端可以按能量高效的方式识别并使用(或者迁移到)这种机会。

[0217] 连接模式下的 AP 感测过程包括三个主要部分(即,扫描、探查和选择)。具体而言,为了在最小化错误触发的同时利用多样的接入机会,扫描触发阈值(接收信号强度阈值)是基于移动客户端的运动或运动历史和局部的 AP 密度来动态适配的。例如,当用户静止不动时,即使 RSS 由于暂时链路质量的变化而为低,移动客户端也避免触发 AP 感测过程。但是,当移动客户端已经移动了某个距离(例如,20m)时,它不仅观察到降级的 RSS 而且预期找出更多的 AP,因而触发 AP 感测过程。

[0218] 接入点选择

[0219] 一旦移动主机经扫描找出了一组可用的 AP,它就根据基于性能的 AP 选择策略选择其中一个 AP,其中基于性能的 AP 选择策略设法为移动客户端提供最优的端到端吞吐量性能。接入点选择是由关联模块 248 或者 286 提供的。

[0220] 总的来说,移动客户端 110 通过利用在网络中可以获得的质量和负载信息来估计端到端带宽。在无线网状网络中,移动主机可以实现的吞吐量依赖于客户端到 AP 的链路和网状回程链路的质量。在这里,客户端到 AP 的链路的质量更依赖于用户的移动性,而网状回程性能与网络流量状况紧密关联。因此,分别估计最后一跳(客户端到 AP 的链路)和网状回程的可用带宽。EAB 是通过识别沿从客户端到网状网关的路径的瓶颈链路来估计的。具体而言,每个 AP 和网状路由器周期性地测量它们呼出链路的可用带宽,而且每个 AP 收集沿从它自己到网关的路径所测量到的信息,然后导出 EAB。然后,这种信息交给移动客户端,便于选择最佳 AP 来关联。

[0221] 网状回程的可用带宽的估计

[0222] 为了避免附加的测量开销,AP 感测以被动的方式使用现有的测量结果。

[0223] 考虑链路 i 并且用 m 表示用于下游流量的源节点。然后,节点 m 可以通过被动地监视测量周期($t, t+T$)内包传输时间(t_{tx})、链路忙时间(t_{busy})和链路空闲时间(t_{idle})来估计链路 i 上可用的通信时间(airtime),其中 $T = t_{tx} + t_{busy} + t_{idle}$ 。于是,链路 i 上可用的带宽可以估计为:

$$[0224] \quad AB_i = \left(1 - \frac{t_{tx} + t_{busy}}{T}\right) \cdot R_{m,i}$$

[0225] 其中, $R_{m,i}$ 是节点 m 可以在链路 i 上支持的最大数据传输速率,这可以通过执行简

单的校准实验来计算一个先验值。以上计算出的估计可用带宽包括运行在同一信道上的相邻链路之间的信道竞争的影响。每个网状节点都通过采取移动平均来保持更新可用的链路带宽。

[0226] 客户端到 AP 的链路的可用带宽估计

[0227] 接下来,为了计算可用的客户端到 AP 带宽, AP 保持估计它们自己的链路利用率为:

$$[0228] \quad U_a(t,t+T) = \frac{1}{T} \sum_{c \in C} \frac{L_{a,c}(t,t+T)}{R_{a,c}}$$

[0229] 其中, C 是与 AP a 关联的客户端集合, $L_{a,c}$ 是由用户 $c \in C$ 在 AP a 上生成的负载(即,流量),而 $R_{a,c}$ 是用户 c 的最大可实现发送率(当不存在竞争时)。AP 可以通过监视每秒传输到与其关联的每个客户端的字节总数来估计负载 $L_{a,c}$ 。在这里,利用率 U_a 可以解释为用于为关联到该 AP 的现有客户端服务的 AP 容量部分的估计。由此,剩余容量可用于新的客户端 n,这由下式给出:

$$[0230] \quad AB_{a,n} = (1-U_a) \times R_{a,n}$$

[0231] 其中, $R_{a,n}$ 是 AP a 与新客户端之间的传输速率,这可以在 AP 扫描过程中估计。

[0232] 图 10 示出了与利用 Thrulay 的方法测量的实际带宽(用点线表示)相比,为单跳、两跳、三跳和四跳连接估计的可用链路带宽(用实线表示),其中 Thrulay 的方法可以在 <http://shlang.com/thrulay> 获得,该文献在此全部引入作为参考。图 10 指示简单的估计方法提供了合理的准确结果,只有少于 10% 的误差,同时消除了主动探查的需求(及其开销)。

[0233] 基于链路质量和负载平衡的接入点选择

[0234] 根据另一种实施方式,移动客户端 110 把回程无线网络 106 的链路质量和负载平衡都考虑进接入点选择策略。

[0235] 具体而言,有三个单独的测量成分结合到 AP 选择策略中,包括:

[0236] 客户端 110 与每个可用 AP 之间的信道质量;

[0237] 如果客户端 110 试图接入外部网络 114 的话,是无线网络 106 中期望的 AP 与网状网关 102 之间的回程路径的性能,或者,如果客户端试图接入无线网络 106 中另一个网络实体的话,是无线网络 106 中期望的 AP 与另一个接入点之间的回程路径的性能;及

[0238] 无线网络 106 的负载特性的信息。

[0239] 到网关节点有更拥塞路由的接入点应当由 AP 选择策略给予较低的优先级,其中拥塞路由不是总能由性能或质量参数反映出来。

[0240] 以下描述假设移动客户端 110 通过边缘网关 102 寻求到外部网络 114 的网络连接。AP 选择技术可以容易地适配为接入无线网络 106 中的内部网络实体。

[0241] 为了基于回程无线网络 106 的性能及负载特性选择 AP,客户端 110 被配置成估计它自己与可用 AP 之间的信道状况及网状回程 106 中的网络性能。此外,客户端 110 尽可能高效地收集所需信息,同时引入尽可能少的开销。测量过程应当既不显著影响网络资源,又不导致客户端设备的过多能耗。另一方面,为了负载平衡网络流量和避免拥塞,无线网络 106 本身便于 AP 选择过程,由此提高整体网络性能和利用率。

[0242] 在一种实施方式中,由客户端 110 检测到的 AP 为客户端提供反映它们到网状网关

102 的路由性能的链路质量信息。为了避免实现测量框架的开销,可以从底层路由协议获得的链路质量度量用于这个目的。此外,为了避免不均衡的负载分布和路由拥塞,网络负载信息进一步结合到决策制定过程中。这两个因素与客户端到 AP 链路的信道质量一起由每个客户端 110 在作出 AP 选择决定之前考虑。这种方法也得到可以在 <http://www.ietf.org/rfc/rfc3626.txt> 上获得的新推出的 IEEE 802.11k 草案的支持,该草案在此全部引入作为参考。另外,对于多无线电多信道无线网状网络,信道分集的影响也结合到 AP 选择过程中。

[0243] 如图 1 中所绘出的,在利用所述 AP 扫描方法扫描并检测到可用的 AP 之后,新的客户端 110B 需要与 AP 的几个可能选择中的一个关联。从终端用户的角度来看,可以提供最佳端到端吞吐量或延迟的 AP 将是最佳选择。但是,从网络 106 的角度来看,还期望跨网络 106 均衡地分布网络流量(或者负载),以实现更好的网络利用率。为了帮助客户端作出正确的决定,网络 106 为客户端 110B 提供必要的度量,诸如客户端预期的吞吐量、可用回程路径的负载及其它。基于这些,客户端设备 110B 计算与每个 AP 关联的得分,这个得分指示如果客户端 110B 与那个 AP 关联的话可以实现的预期性能的测量。然后,客户端 110B 利用这种得分给各个 AP 分级并与最佳可用 AP 关联。

[0244] 在这种实施方式中,每个 AP 只让客户端设备可以获得必需的网络统计数据,而且把最终的 AP 选择决定留给客户端。不像现有系统,在这种实施方式中网络 106 没有提供关联控制,其中网络 106 不决定客户端 110B 可以与哪个 AP 关联,或者强制客户端 110B 为了搜索更好的 AP 而漫游。

[0245] AP 选择技术有以下特征:

[0246] 网络辅助的 AP 选择:在通常是无线网状网络的无线网络 106 中,每个客户端 110 需要注意网状回程的状况,以便作出可靠的 AP 选择决定。不是让客户端 110 通过执行端到端的主动探查来获得这种信息,这从网络资源和能耗来说都是非常昂贵的,而是系统 100 利用网络 106 向客户端提供必需的信息。

[0247] 低开销的网络监视:为了降低与测量相关的开销,网络 106 执行被动测量,来收集必需的信息。然后,对于分布式的 AP 选择策略,这种信息在各个网状节点或 AP 之间交换,或者报告给集中式的控制器。

[0248] 网状回程中的负载平衡:诸如估计的吞吐量、包丢失率及其它的几个度量用于估计网状回程的性能。但是,这种度量通常趋于选择具有较高吞吐量的 AP,这导致网状网络中不均衡的流量分布并且降低整体的系统性能。在此所述的 AP 选择技术在 AP 选择过程中结合了某种形式的负载平衡度量。

[0249] 跳计数与信道分集的影响:为了正确地把网状回程的性能结合到 AP 选择过程中,要考虑跳的个数和信道分集对用户性能的影响。在此所述的 AP 选择度量说明了这两个参数。

[0250] 根据另一种实施方式,当执行 AP 选择时,新的客户端 110B 确定各种度量,这些度量指示回程无线网络 106 的连接性能与负载特性。这些度量包括客户端与 AP 之间的无线链路的信道质量度量、AP 与边缘网关之间的回程路由的性能度量及回程无线网络的负载平衡度量。这些度量中的每一个都在下文进一步描述。

[0251] 客户端与 AP 之间的信道质量

[0252] 这个度量指示客户端设备 110B 与网状 AP 之间第一无线跳的性能。在一种实施方

式中,假设大部分流量是在下行链路方向从网状 AP 流到客户端。由此,只估计从 AP 到客户端的下行链路信道质量。可替换地,下行链路和上行链路信道质量可以都考虑。

[0253] 总的来说,客户端 110B 与期望的 AP 之间的链路质量是通过估计的吞吐量度量来测量的。具体而言,考虑具有与其关联的一组客户端 U 的 AP a。令 $L_{a,u}$ 是由每个客户端 $u \in U$ 每个单位时间在 AP a 上生成的负载。如果 $R_{a,u}$ 是每个客户端实现的最大传输速率,则 AP a 的利用率定义为:

[0254] 对于所有的 $u \in U$, $\mu_a = \sum (L_{a,u}/R_{a,u})$ 。

[0255] 这个利用率是对用于为现有客户端服务的 AP 容量部分的估计。由此,剩余容量可用于新的客户端 110B,而且可以用于估计 AP 和该客户端之间的下行链路吞吐量。如果 R 指示 AP 与新客户端之间的传输速率,则估计的下行链路吞吐量由下式给出:

[0256] $\text{Thr}_{\text{downlink}} = (1 - \mu_a) \times R$ (6)

[0257] 在扫描过程中,对应的 AP 使得这个值可以让客户端 110B 获得。

[0258] AP 与网关之间回程路由的性能

[0259] 系统 110 提供了网络性能度量,该度量指示网状回程网络 106 中客户端流的性能。通过结合这个度量,系统 100 考虑如下情况:其中即使客户端到 AP 链路良好但该 AP 与网关节点之间的路由可能遭受差的链路质量,并由此给对应的 AP 分配低优先级。

[0260] 不像依赖于涉及可能不利地影响终端用户性能的额外测量与通信开销的测量框架的现有策略,系统 100 利用用于无线网状网络 106 的底层路由协议,所述底层路由协议已经采用了某种形式的链路质量估计。例如,这个度量可以是在 <http://www.ietf.org/rfc/rfc3626.txt> 可以获得的最优链路状况路由协议 (OLSR) 中的预期发送计数 (ETX) 度量或者 IEEE 802.11s 标准中推荐的通信时间度量,所述文档和标准在此全部引入作为参考。当网络 106 把这些度量暴露给客户端 110 时,客户端可以利用无线网络 106 估计回程路径的性能并且把它结合到 AP 选择过程中。

[0261] 在一种实施方式中,无线网络 106 利用 OLSR 路由协议并且把 ETX 度量暴露给客户端设备 110。每个 AP 都保持对用于其到网关节点的路由的累积路径 ETX 值的跟踪。此外,为了包括信道分集,修改累积的 ETX。如图 1 中所示,对于通过无线网络 106 的路径 116,累积的 ETX 定义如下:

[0262]
$$ETX_P = (N/N_j) \times \sum_{i=1}^N ETX_i$$
 (7)

[0263] 其中, N 是 P 上的跳的总数,而 N_j 是由路径 P 上的跳所使用的不同信道的数量。分数 N/N_j 充当分配给每条路径的权重。如果两条路径具有相同个数的跳,那么具有更好信道分集的路径将给予较低的权重。这是因为,如果沿一条路径的多个跳在同一条信道上,那么同时只能有一跳可以访问该信道。由此,即使个别链路可能具有好的 ETX 值,但那条路径的有效吞吐量将降低。这种路径的累积 ETX 值被处罚以较大的权重。可替换地,无线网络 106 可以使用具有已经包括了信道分集信息的度量的路由协议,诸如在 2004 年的移动计算与网络国际年会第 114-128 页上 R. Draves 等人所写的、标题为“Routing in Multi-Radio, Multi-Hop Wireless Mesh Networks”的非专利文献中描述过的加权累积预期传输时间 (WCETT),该文献在此全部引入作为参考。

[0264] 负载特性度量

[0265] 网络 106 中的不同 AP 为客户端 110 提供不同分级的性能。偏好为客户端提供较高吞吐量路径的 AP 的现有系统在网状网络中造成负载不平衡。为了避免这种负载不平衡，系统 100 使用节点利用率作为无线网络 106 中网络负载的一个指示。对于 AP 与网关 102 之间的给定路径，估计瓶颈跳。

[0266] 具体而言，考虑具有 n 个回程链路的网状节点（接入点） m 。令 $L_{m,i}$ 是由节点 m 在链路 i 上每单位时间生成的负载，而且 $C_{m,i}$ 是最大传输容量。于是，节点 m 的利用率定义为：

$$[0267] \quad \mu_m = \sum_{i=1}^n (L_{m,i} / C_{m,i})$$

[0268] 依赖于那个节点的当前调制率， $C_{m,i}$ 对于每个节点是常量。通过执行简单的校准实验，计算先验值。 $L_{m,i}$ 是通过监视由该节点当前传输的数据总量来估计的。无线网络 106 中的每个节点关于时间保持其各自利用率值的移动平均值。现在，对于通过无线网络 106 的给定路径 116，假定为每一跳都分配了 k 条可用信道中的一条。于是， U_j 定义为：

$$[0269] \quad U_j = \sum \mu_i \quad 1 \leq j \leq k$$

[0270] 跳 i 在信道 j 上。

[0271] 因而， U_j 是路径 116 上在同一信道 j 上的所有节点的利用率的总和。于是，对于路径 116，我们把瓶颈利用率定义为：

$$[0272] \quad \text{对于所有的 } j \in (1 \dots k) \quad U_p = \max U_j \quad (8)$$

[0273] 因而，如果一条路径上不同的跳使用不同的信道，那么具有最大利用率的跳将是瓶颈跳。但是，如果一条路径上的多个跳使用同一条信道，那么这些跳上的传输将彼此干扰（除了非常长的跳的情况之外）。在这种情况下，客户端 110 总加该路径上处于同一信道上的所有跳的单个利用率。具有最低瓶颈利用率 U_p 的路径将给予最高优选，因为这将有助于实现更负载平衡的网络。

[0274] AP 选择得分

[0275] 一旦确定了度量，客户端 110 就把以上三个参数结合到单个得分当中，基于这个得分，客户端可以给不同 AP 分级并作出决定。每个客户端 110 都使用以下三个分级，这三个分级与要测量的三个参数关联。

[0276] Rank_{AP} ：对于客户端检测的每个 AP，客户端根据估计出的来自每个 AP 的下行链路吞吐量给它分配一个分级。给可以提供最大下行链路吞吐量的 AP 分配最高分级。下行链路吞吐量的估计既涉及 AP 上的负载又涉及当前信道的状况或链路质量（就所使用的传输速率而言）。由此，其提供对下行链路信道质量的准确估计。

[0277] $\text{Rank}_{\text{path}}$ ：对于每个 AP，客户端 110 还将获得从该 AP 到网状网关的回程路径的性能。在这种实施方式中，这个性能是基于在公式 (7) 中描述过的修改后的 ETX 度量的值。通过选择具有最低累积路径 ETX 值的 AP，客户端 110B 有效地选择具有高吞吐量回程路由的 AP。这种方法允许客户端 110 独立于路由协议来选择回程性能参数。例如，如果底层协议使用某个其它的链路质量度量，诸如在 IEEE 802.11s 协议中推荐的通信时间度量，那么每个 AP 可以计算把用户流量从 AP 传输到网状网关所需的累积通信时间并且把它报告给客户端 110。

[0278] $\text{Rank}_{\text{load}}$ ：网状网络 106 中的每个节点 / 接入点 104 根据公式 (8) 测量其各自的利

用率并且与其它网络节点交换这个信息。然后,每个 AP 104 可以识别沿其到网状网关 102 的路由的瓶颈节点。当客户端 110 扫描 AP 时,AP 把这个参数报告给客户端。基于这个参数,客户端 110 可以给每个 AP 104 指定一个分级,最佳 AP 是沿其回程路由具有最小瓶颈利用率的那个 AP。应当指出,节点利用率而不是链路利用率用作 AP 负载的指示。这是因为,为了负载均衡网络 106,需要考虑通过一个节点的全部流量而不是仅仅一条特定链路上的流量。

[0279] 基于这些度量指定分级的优点是它允许底层度量的抽象。不管使用什么度量,系统 100 都可以简单地使用所述分级来计算最终的 AP 得分。这使得系统 100 可以使用更多的相关度量用于不同的测量目的。例如,系统 100 可以使用吞吐量来估计 AP 与客户端之间的信道质量,同时使用节点利用率来估计网络负载。

[0280] Rank_{AP} 和 $\text{Rank}_{\text{path}}$ 针对最大化客户端的吞吐量,并因此提供最佳的端到端性能。利用这两个分级,客户端 110 可以选择在该客户端与 AP 之间具有最佳估计吞吐量及在回程性能方面具有最佳路径的 AP。但是,通过考虑单个网状节点的利用率, $\text{Rank}_{\text{load}}$ 度量针对实现网状回程中一致的流量分布。组合这些分级允许客户端 110 选择既为提供最佳终端用户体验的目的同时又实现网状回程无线网络 106 中负载均衡的目的服务的最佳 AP。以下等式用于组合这些参数并且计算最终的 AP 得分:

$$[0281] \quad \text{AP}_{\text{score}} = \omega_1 \times (\text{Rank}_{\text{AP}} + \text{Rank}_{\text{path}}) + \omega_2 \times \text{Rank}_{\text{load}} \quad (9)$$

[0282] 其中, ω_1 和 ω_2 是分配给每个项的权重,并且取范围 0 至 1 内的值。给两个项分配不同的权重允许系统 100 实现总是选择在端到端吞吐量方面最佳的 AP 和跨网状网络平衡流量的两个对立目的之间的平衡。

[0283] 根据图 5A 中所绘出的另一种实施方式,提供了基于无线网络的连接质量和负载特性为移动客户端 110 选择 AP 以接入无线网络 106 的方法 500。特别地,对于由 AP 扫描过程检测到的每个 AP,客户端 110 收集并计算通过无线网络 106 的各条路径的连接质量和负载特性的信息(502)。然后,客户端 110 基于所述连接质量和负载特性给所有检测到的 AP 分级(504)并且从结果得到的分级给每个检测到的 AP 计算得分(506)。最后,客户端 110 基于所述得分选择一个 AP 来接入无线网络 106 (508)。

[0284] 图 5B 绘出了 AP 选择方法 500 的另一种实施方式。如图 5B 中所示,客户端设备 110 首先通过使用 AP 扫描过程扫描可用的 AP,并且基于信号强度测量选择最上面的三个 AP。其后,客户端 110 获得与每个 AP 关联的各个测量。然后,利用这些测量,客户端设备 110 可以给每个 AP 分级,并且最终利用公式(9)估计 AP 得分。一旦客户端为每个 AP 计算出了上面的 AP_{score} ,客户端 110 就可以做出关联决定。

[0285] 根据另一种实施方式,当客户端 110 连接到无线网络 106 时,它周期性地扫描信道并且从相邻 AP 为三个度量中的每一个获得一组新的测量。基于这些新的测量,客户端 110 可以更新其 AP 得分并且基于新的得分切换到新的 AP。

[0286] 实现细节

[0287] 移动客户端

[0288] 图 2B 绘出了移动客户端 110 的结构的示意图。这些结构可以适用于任何移动平台。

[0289] 在一种实施方式中,图 2B 中所绘出的结构可以实现为中间件程序。这种实现的优

点包括(i)应用透明性,(ii)不需要系统升级或者令人痛苦的重新编译及(iii)跨不同部件(例如,传感器硬件)的每次使用或交互。图 2B 绘出了提供上述各种功能的四个主要部件。

[0290] 移动性模块 284:移动性模块(MM) 284 基于传感器或加速计的样本周期性地监视移动客户端的运动。MM 284 周期性地开启加速计预先确定的时期(例如,1 秒开启,4s 关闭)。基于所收集的样本,MM 284 应用 Goertzel 信号处理技术给移动用户的行为分类。

[0291] 扫描模块 285:扫描模块(SM) 285 针对执行周期性和按需的 AP 扫描任务。当 SM 285 从底层的无线网络接口卡得到断开通知时,它基于至少上述测量到的 AP 节点密度和客户端运动来计算并使用最优扫描频率。接下来,SM 285 在连接状态下触发按需扫描。无论什么时候当其它模块请求扫描时,它首先检查最近的扫描结果。如果存在高速缓冲的结果,SM 285 就把它传递给发出请求的模块。否则,它立即触发新的 AP 扫描过程。

[0292] 关联模块 286:关联模块(AM) 286 包括如上所述的网络监视和 AP 选择功能性。对于网络监视,AM 286 使用可以从无线节点获得的网络状况信息。它首先把路径状况请求消息发送给基于 RSS 信息从扫描选择出的一组 AP。每个 AP 用从移动客户端到网关的路径网络信息给客户端答复。这种监视与消息递送技术已经在运行在移动客户端上的 OLSR 插件中实现了。AM 286 利用现有的 OLSR 控制消息在网状节点之间交换这种信息。这种信息交换还可以利用 IEEE 802.11k 协议变得可用,如在 2006 年 Proc. of the IEEE ISCC 上由 E. G. Villegas 等人所写的、标题为“Load balancing in WLANs through IEEE 802.11k mechanisms”的非专利文献中所描述的,该文献在此全部引入作为参考。当客户端执行 AP 选择过程时,它简单地把 GET 查询消息发送到期望的 AP。

[0293] 迁移模块 287:迁移模块(MI) 287 执行如上所述的 AP 关联的抢先迁移。即使当移动客户端连接到一个 AP 时,MI 287 也通过使用客户端的运动信息和 AP 密度动态地改变迁移触发阈值。此外,MI 287 还考虑 AP 密度和平均 RSS 来动态地适配迁移阈值。在移动客户端四处移动的时候,MI 287 利用历史 AP 密度数据计算最近 AP 密度的平均值。然后,如果密度和 RSS 增加,MI 287 就降低用于客户端 110 找出更好 AP 的迁移阈值,反之亦然。

[0294] 网状路由器

[0295] 为了从网状 AP 收集用于 AP 选择的某些网络统计数据,第一个度量是用于每个 AP 的修改后的累积路径性能。在一种实施方式中,在每个 AP 中实现底层 OLSR 路由协议。在公式(7)中所描述的每个 AP 到网状网关的路径的累积 ETX 值是由路由协议提供的并且与用于每个节点的信道信息集成。然后,每个网状 AP 可以为其自己到网关节点的路径计算修改后的 ETX 值,并且使得在 AP 扫描阶段客户端设备可以获得这个值。当链路质量变化时,或者如果路由协议选择了新的路径,AP 可以计算新的修改后的 ETX 值。

[0296] 为了估计节点利用率,一种实施方式为每个 AP 提供了修改后的 Madwifi 驱动器。每个 AP 保持跟踪由那个 AP 传输到其所有邻居的字节总数并且保持跟踪该 AP 在任何给定时刻可以传输到其邻居的最大数据量(容量)。修改 OLSR TC 消息,添加一个携带用于每个节点的利用率值的字段,由此避免传输额外的包的开销。以这种方式,每个 AP 都接收网状网络 106 中所有其它 AP 的利用率信息。然后,基于公式(8),每个网状节点可以为其自己到网状网关 102 的路径估计瓶颈利用率。还使得客户端可以获得这个信息并且将该信息用于估计 $\text{Rank}_{\text{load}}$ 度量。

[0297] 需要提供的最后一个度量是客户端与 AP 之间的信道质量。在一种实施方式中,假设大部分流量在从网状网关到客户端的下行链路方向流动,因为大部分服务器当前都驻留在外部的有线网络上。在这种实施方式中,只估计 AP 和客户端之间的下行链路信道质量。为此,使用估计的吞吐量度量。如上面所提到的,每个网状 AP 都保持跟踪其自己的利用率,而且因此还知道它自己与客户端之间的当前传输速率。

[0298] 一旦提供了这两个参数,移动客户端就计算下行链路方向中的估计吞吐量,并且用它来针对其客户端到 AP 链路性能给 AP 分级。

[0299] 根据这种实施方式,为了从无线 AP 获得确定 AP_{score} 的必要信息,在每个 AP 上实现定制的 OLSR 插件,并且保持跟踪由那个 AP 测量的所有数据。一从移动客户端接收到 GET 请求,每个 AP 的 OLSR 插件就利用测量到的统计数据响应。

[0300] 性能评估

[0301] 这部分描述被设计成评估图 1 中所绘系统 100 的各种实验。仅仅是为了评估,在这里提供了根据上述示例性实施方式的系统的多种实现,而且因此决不当用于限制本发明的范围。

[0302] 实验建立

[0303] 图 11 中所说明的室外试验台是在森林保护区中构建的,跨越 2000 英亩的荒野和丘陵地形。试验台支持实时流量而且被几个研究人员积极地使用。它包括位于 31 个物理地点的 34 个网状节点(接入点)。可见 AP 的平均数是 8 而且 AP 的传输范围是 300m。

[0304] 网状网络中的节点是利用 Soekris net4826 嵌入式主板建立的。每个节点具有 266MHz 的 586 处理器、128MB 的 SDRAM 和从 64MB 到 256MB 变化的闪存储存器。对于无线设备,每个主板配备有两个 Atheros 802.11b/g Mini-PCI 卡。以 802.11b/g 标准运行的无线电设备可以使用三条不重叠的信道。所有节点都利用具有修改后的无线设备驱动器的内核 2.6.28 运行定制的 Linux 分布。使用 OLSR 路由协议。

[0305] 室内试验台部署在办公大楼内部并且由跨两层的 15 个 AP 组成。每个网格都包括基于 OpenWRT 的 Cambria GW2358-4 主板、667MHz 的 Intel XScale 处理器、128MB 的 RAM 和 32MB 的闪存。每个无线节点都支持基于 Atheros 芯片集的两个无线电设备,所述芯片集运行开放源码的 Madwifi 无线设备驱动器。每个节点上的一个无线电设备被配置成 ad-hoc 模式,由此形成网状回程。这些无线电设备使用 802.11a 调制策略。每个节点上的另一个无线电设备被配置成 AP (因此提供客户端接入) 并且使用 802.11g 调制策略。不同的信道分配给不同的 AP,以最小化干扰。一个无线节点还充当连接到外部网络的网状网关 102。在试验台中使用具有 ETX 度量的 OLSR 路由协议和 Madwifi 驱动器中可以获得的缺省速率自适应技术。

[0306] 实验结果

[0307] 断开感测的效率:在图 4B 中所绘出的断开感测技术的性能是在室外试验台测量的。在实验过程中,移动客户端以不同的行为(即,站立、行走)比在断开的区域周围移动 10 分钟,并且测量由移动客户端触发的扫描次数。为了比较,还在改变基于阈值的周期性策略的阈值的同时测量扫描的次数。

[0308] 图 12A 绘出了就扫描过程的平均能耗与检测可用 AP 的延迟而言,图 4B 中所绘断开 AP 感测的适配触发与固定周期的 AP 扫描之间的性能比较。在实验过程中,基于估计的

AP 密度,用于适配触发的阈值距离(d_{th})设置成 71m。用于固定频率触发的触发间隔分别设置成 10s、20s、30s 和 60s。如图中所示,与具有 30s 触发间隔的固定频率触发相比,适配触发节省扫描能耗多达 60%,同时保持 AP 检测延迟与所述固定频率触发在相同的水平。这个好处是通过在调整触发间隔(或者频率)中结合运动信息来提供的。具体而言,每个客户端 110 基于移动用户行进的距离计算最优的扫描频率。如果距离不增加,移动客户端就抑制扫描,从而节省能量。同时,当移动客户端行进了大于阈值的距离时,它触发 AP 扫描,来检测接入机会,由此降低检测延迟。

[0309] 连接 AP 感测的有效性

[0310] 进一步评估由系统 100 提供的连接模式的有效性。当连接到室内无线网络的移动客户端在室内试验台中的某个轨道周围移动 6 分钟时,其中包括 3 分钟的行走和 3 分钟的站立,从连接模式测量每分钟的总能耗量。为了比较,还测量了传统固定阈值系统和基准(benchmark)系统(标记为“Oracle”)的能耗。为固定阈值触发技术分别设置了三个不同的固定阈值, -55dBm、-75dBm 和 -95dBm。在 Oracle 系统中,移动设备被配置成每两秒钟扫描信道,用于提供非常细粒度的测量并基于在整个实验过程中的扫描结果确定最佳 AP。选定的 AP 用作最佳选择并且忽略扫描开销。

[0311] 图 12B 示出了每分钟用于迁移的平均能耗。如图中所示,当客户端四处移动时(运动场景),与固定阈值的迁移相比,如上所述的适配阈值技术节省能量达 47%。这主要是因为适配阈值技术抑制了当移动客户端静止不动时不必要的扫描。此外,在节省用于扫描的能量的同时,适配阈值技术仍然在整个实验过程中实现了几乎相同水平的来自关联 AP 的 RSS。表 1 进一步显示,对于不同的阈值,由适配阈值技术实现的 RSS 接近“Oracle”技术的 RSS。对于静止不动(固定)场景,适配阈值技术也实现了相似水平的 RSS,同时降低能耗达 34%。

[0312] 表 1 :固定阈值感测与运动感知感测之间实现的 RSS 比较

[0313]	阈值 (dBm)	Oracle	实现的	比率 (%)
	-55 (固定的)	-60.86	-63.70	95.3
	-75 (固定的)	-61.56	-64.98	94.4
	-95 (固定的)	-61.04	-68.76	87.4
	-55 (运动)	-59.48	-61.04	97.4
	-75 (运动)	-59.51	-64.23	92.1
	-95 (运动)	-63.28	-71.91	86.4

[0314] 动态感测触发器阈值的有效性

[0315] 图 12C 示出了基于 AP 密度的阈值自适应策略的有效性。在实验中,移动客户端被在(室内和室外)各个地点周围行走的用户携带,其中局部 AP 密度从 5 个到 25 个变化。首先,使用一组固定的 RSS 阈值。计数由移动客户端触发的扫描次数并且把由移动客户端实现的平均 RSS 与“Oracle”技术进行比较,假设 Oracle 技术总是没有任何开销地选择最佳 AP。该图清楚地显示出了 RSS 与扫描开销之间的权衡。对于相同的实验设置,基于 AP 密度

的阈值自适应策略做了良好的权衡,在扫描 16 次的同时具有 94.4% 的 RSS,这是因为它基于局部 AP 密度动态适配阈值的能力。

[0316] AP 选择策略的评估

[0317] 为了进一步评估 AP 选择策略,进行单独的实验。实验展示了 AP 选择策略如何如上所述利用可以从底层路由协议获得的链路质量信息并且在 AP 选择过程中结合负载平衡。

[0318] 在实验中,客户端设备扫描可用的 AP,并且从每个可用的 AP 请求那个 AP 到网状网关 102 的路径的修改后的累积 ETX 值。然后,这个值由客户端用作该 AP 与网关节点之间回程路径性能的指示器。为了估计其自己与 AP 之间的链路的质量,客户端还从每个 AP 获得估计的下行链路吞吐量值。这两个值都是如上所述由网状 AP 被动测量的,因此,不使用任何的客户端资源。通过组合这两块数据,客户端作出最终的 AP 选择决定。

[0319] 图 13 示出了由客户端设备在试验台中两个不同位置利用在此所述的 AP 选择策略(“基于吞吐量+ETX 的 AP 选择”)实现的吞吐量的 CDF。该图还示出了用于只有估计的客户端到 AP 链路的吞吐量用于 AP 选择(“基于吞吐量的 AP 选择”)的情况下的客户端吞吐量。吞吐量增加是因为系统 100 结合了路径 ETX,其中该路径 ETX 在 AP 选择过程中考虑了网状回程无线网络 106 的性能。在客户端设备的往返时间内观察到了类似的改进,如图 14 中所示。

[0320] 从图 5 中应当指出的一点是我们基于利用路由协议度量的 AP 选择策略实现了与其中传统主动策略用于估计网状回程性能的场景类似的性能。这确证了可以从底层路由协议获得的链路质量度量可以用于估计网状回程性能的事实。

[0321] 如公式(9)中所示,两个权重 ω_1 和 ω_2 用于在 AP 选择中的吞吐量和负载平衡之间平衡。图 15 示出了用于这两个权重的不同组合的网络吞吐量值。如图 15 中所示,当 ω_1 设置成 0 时,网络性能降级。在这种情况下,客户端将沿其回程路径选择具有最小瓶颈利用率的 AP,而不管在那条路径上可以实现的吞吐量。就吞吐量而言,最佳性能是在 ω_2 设置成 0 时实现的。但是,这也实现了就最小化网状回程中瓶颈利用率而言的最差性能。随着 ω_1 值的增加,观察到了性能的改进,因为它给予“吞吐量”成分较高的权重。但是,这也导致瓶颈网络利用率的增加,从而导致网络中流量的不均衡分布。因此,这两个权重 ω_1 和 ω_2 可以调整,来与目标网络性能和设计需求相配。

[0322] 为了评估负载特性对 AP 选择的影响,进行一个实验,其中值 0.6 和 0.4 分别分配给 ω_1 和 ω_2 ,因为这些值提供了实现较高客户端吞吐量与最小化网络瓶颈利用率之间的最佳平衡。

[0323] 为了测试在此所述的 AP 选择技术,新的客户端在变化的位置引入到室内试验台中的网络中。新客户端的个数从 1 到 5 变化。图 16 示出了考虑和没有考虑回程无线网络 106 的负载特性时的 AP 选择策略的性能。观察到,如果有负载平衡,整体的网络性能显著更好,同时实现了网状回程中更均衡的流量分布。

[0324] 进一步在室外试验台测试 AP 选择技术。除网络中已有的后台流量之外,再引入两个客户端,其以 3Mbps 的恒定速率生成 UDP 流量。图 17 示出了具有变化个数的客户端的网络性能。同样,把负载特性结合到 AP 选择中在吞吐量和往返延迟方面都提供了显著的改进。

[0325] 为了评估 AP 选择策略对用户流量的影响,进一步在室外试验台进行以下实验。

[0326] 具体而言,两个客户端以 3Mbps 的恒定速率生成后台 UDP 流量。引入第三个客户端,以 3Mbps 的恒定速率向附连到网关节点的服务器传输 UDP 数据。在实验持续时间内,在服务器利用 tcpdump 工具收集网络踪迹。然后,在网络中引入第四个客户端,该客户端使用传统的主动 AP 选择策略和在此所述的 AP 选择策略。图 18 示出了主动策略对现有用户吞吐量的影响。由新客户端执行的 TCP 上载和下载测试不利地影响了现有客户的的吞吐量。相对于在此所述的 AP 策略,当新引入的客户端使用传统的主动策略时,当前连接到网络的客户端的包丢失平均多了 3.9%。

[0327] 尽管本发明已经特别示出并且参考其优选实施方式进行了描述,但是本领域技术人员将理解,在不背离本发明主旨与范围的情况下,可以对其进行形式和细节的各种变化。

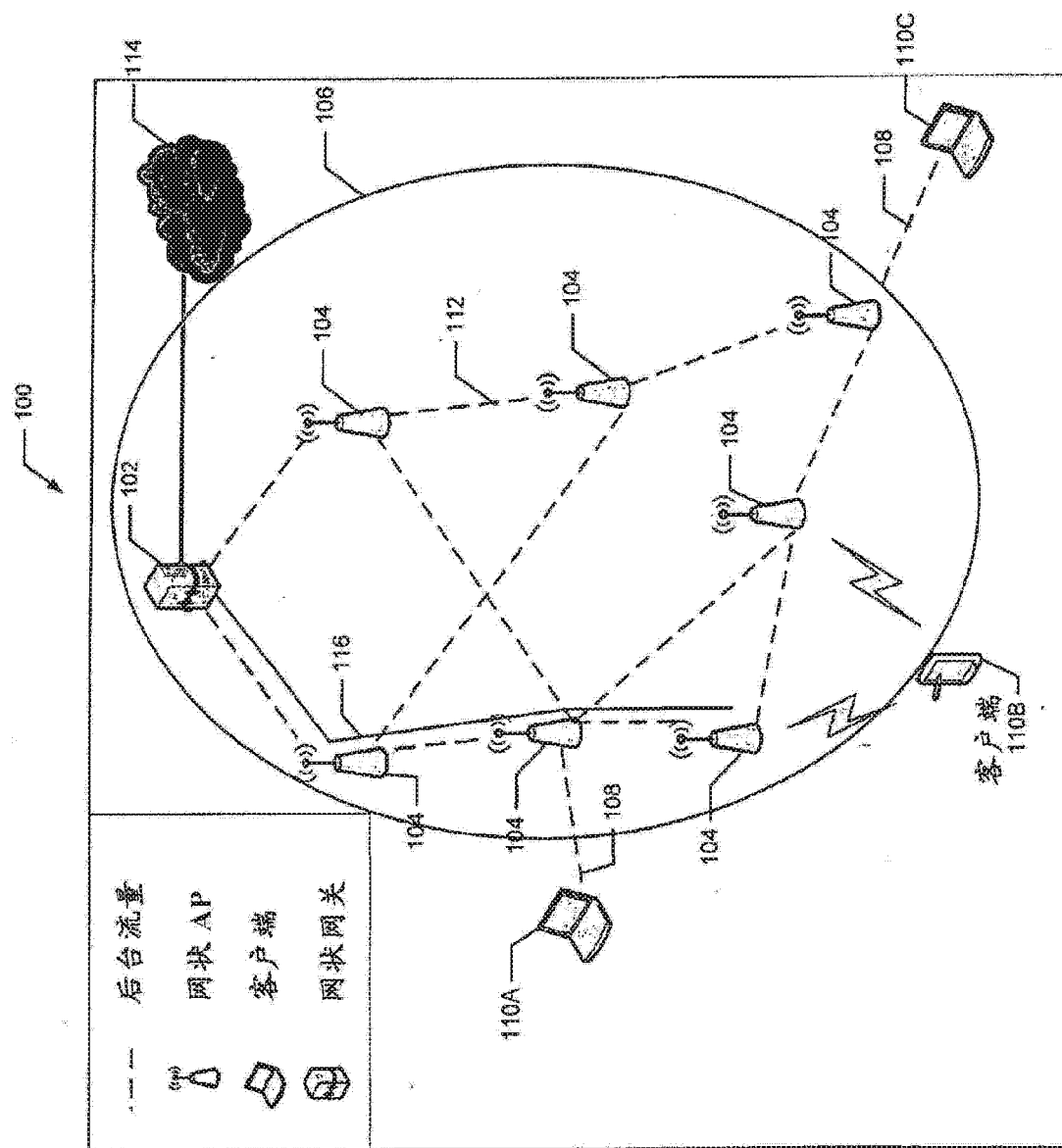


图 1

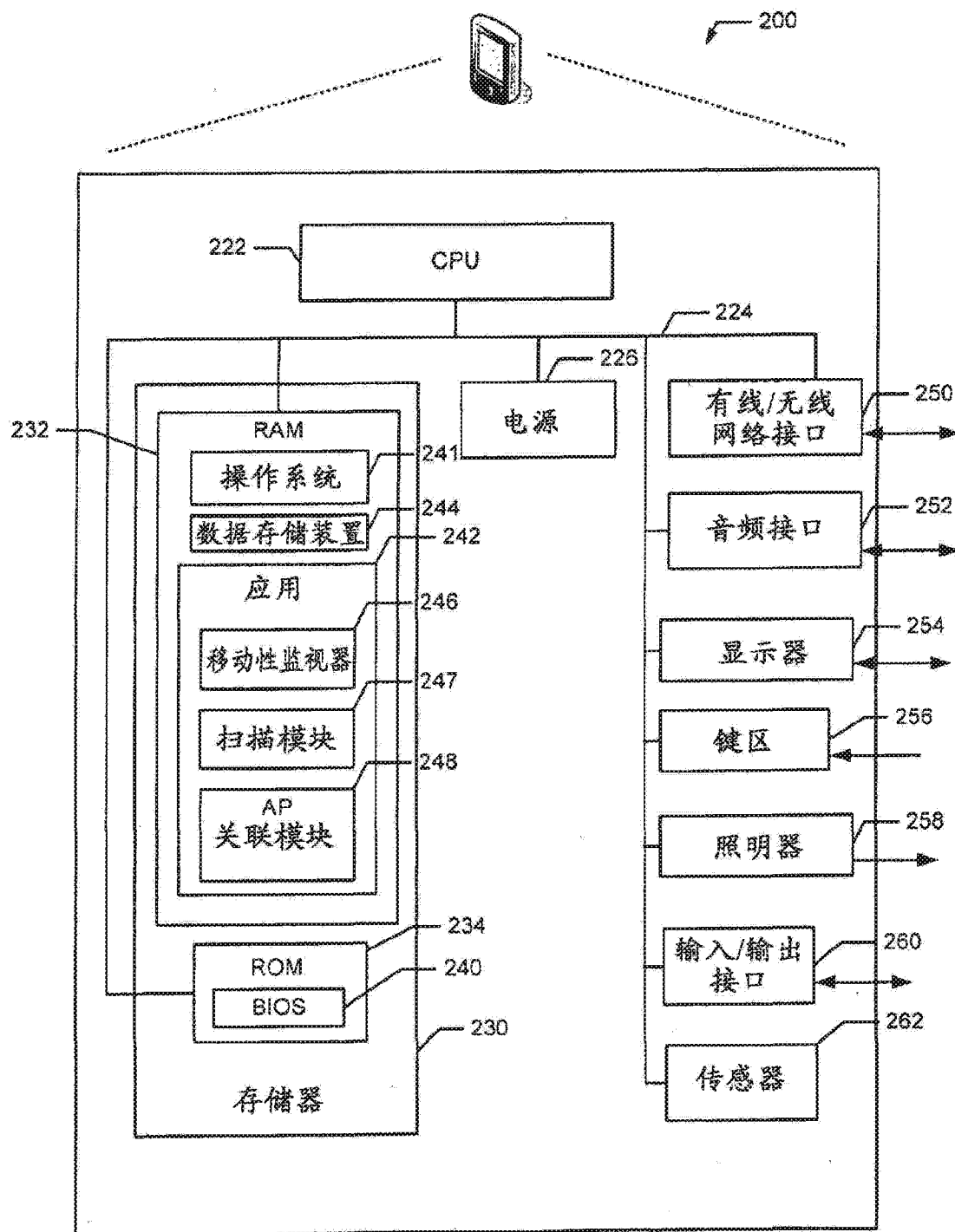


图 2A

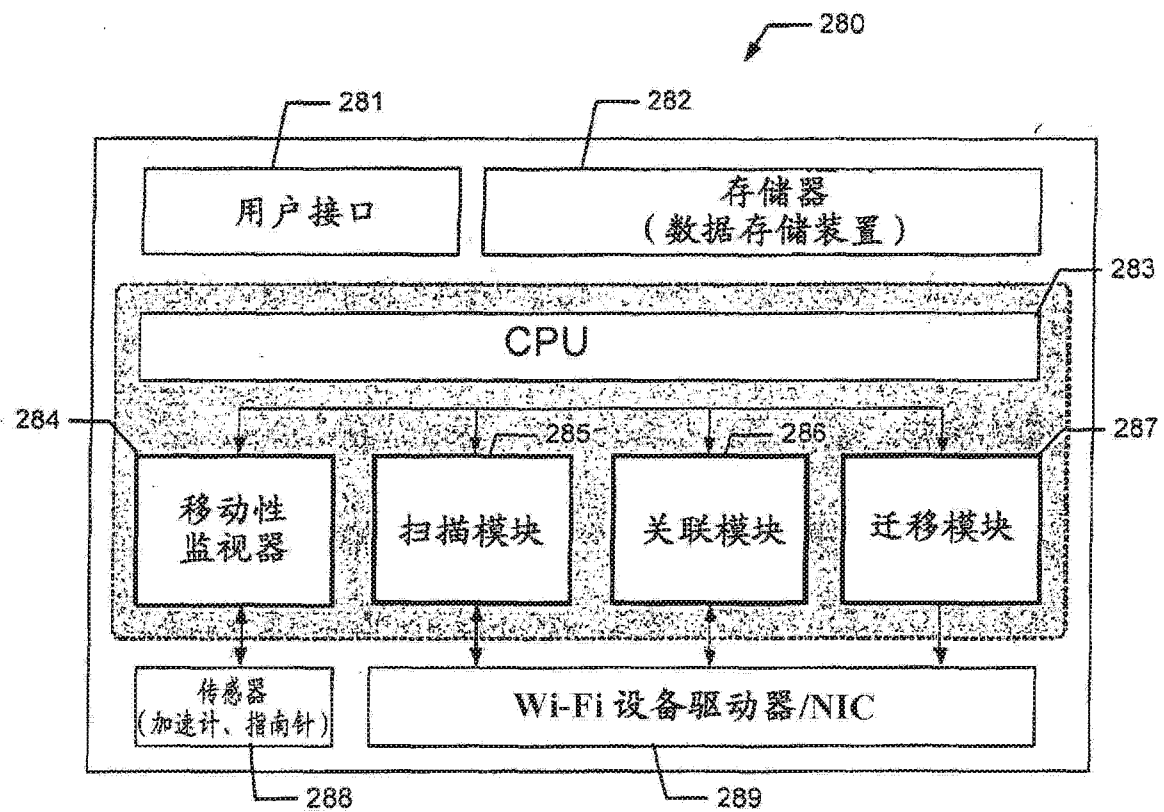


图 2B

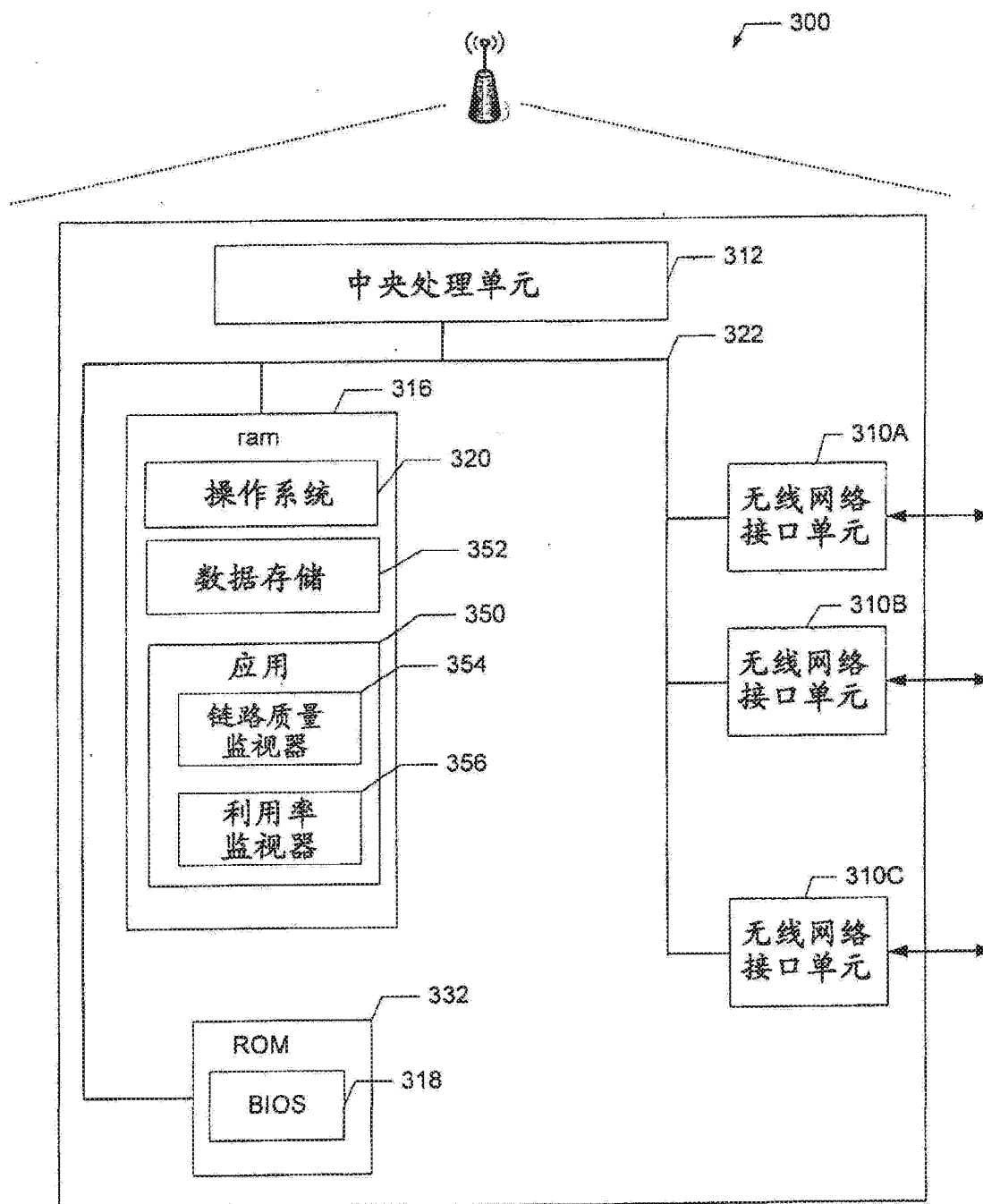


图 3

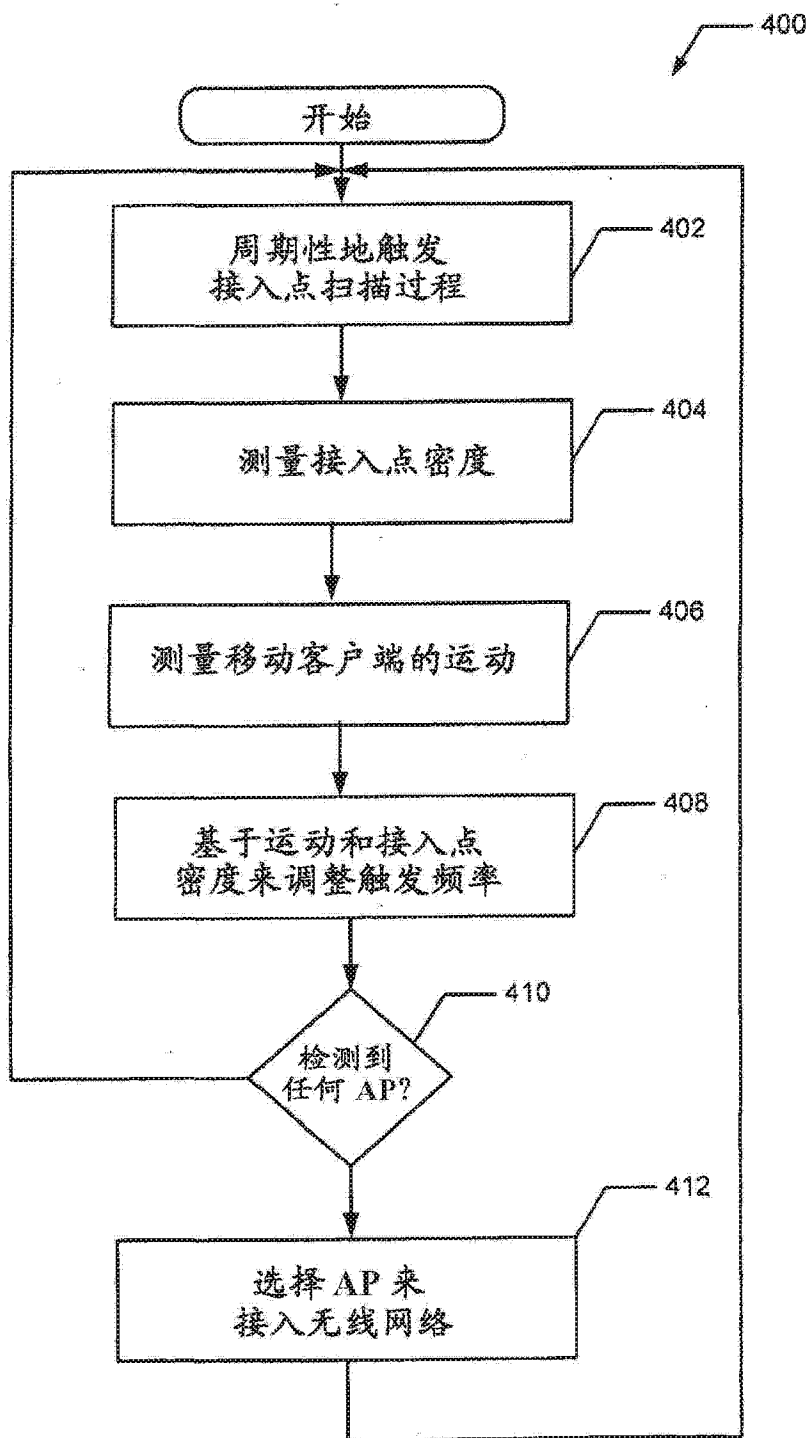


图 4A

断开期间的感测

- (1) 运动估计阶段 (T_m)
 - 1: 开启加速计 1s 并估计用户行为
 - 2: 利用公式 (4) 更新行进距离 ($\hat{d}$)
 - (2) 扫描决定阶段 (T_d)
 - 3: if ($\hat{d} > d_{th}$) then // d_{th} 是利用公式 (5) 计算的
 - 4: 执行 Wi-Fi 扫描
 - 5: $\Omega \leftarrow$ 通过扫描检测到的 AP 集合
 - 6: 重新设置距离: $\hat{d} \leftarrow 0$
 - 7: end if
 - (3) 关联 (或者更新) 阶段 (T_a)
 - 8: 利用 EWMA 更新 AP 的平均数 $E[n_{ap}]$ 并且更新 d_{th}
 - 9: if $|\Omega| \neq 0$ then
 - 10: for each AP $i \in \Omega$ do
 - 11: 计算端到端带宽
 - 12: end for
 - 13: 与提供最高端到端带宽的 AP 关联
 - 14: else
 - 15: Go to (1)
 - 16: end if
-

图 4B

 连接期间的感测

(1) 迁移控制过程

```

1: if  $RSS < RSS_{thr}$  then
2:   if  $rnd() < P_{scan}$  then
3:     执行 AP 扫描
4:     利用 EWMV 更新 AP 密度
5:     if  $|\Omega| > 0$  then
6:       为最上面的三个 AP 估计端到端带宽
7:       与最佳 AP 关联
8:     else
9:       进入断开模式 (算法 1)
10:    end if
11:  end if
12: end if
  
```

(2) 阈值适配过程

```

13: 重新设置阈值:  $RSS_{thr} \leftarrow RSS_{base} + \text{平均 AP 密度}$ 
14: for each 运动估计周期 do
15:   基于加速计读数估计用户运动
16:   if 存在运动 then
17:     更新估计的行进距离  $\hat{d}$ 
18:      $P_{scan} = 0.1 + \min \{ \lfloor \frac{\hat{d}}{d_{unit}} \rfloor \times \Delta, 0.9 \}$ 
19:   end if
20: end for
  
```

图 4C

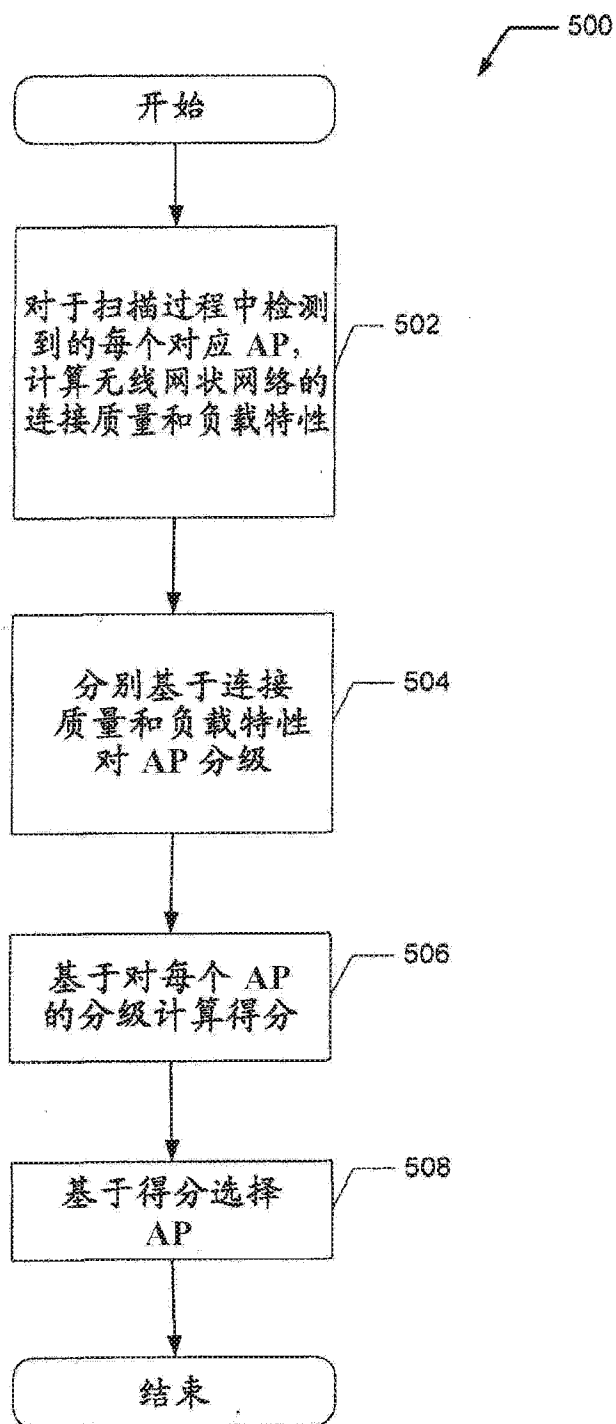


图 5A

接入点选择

```

AP ← ap_scan()
FOR EACH  $ap \in AP$ 
    RankAP = get_ap_info(ap)
    Rankpath = get_path_info(ap)
    Rankload = get_load_info(ap)
    APscore =  $\omega_1 \times (\text{Rank}_{AP} + \text{Rank}_{path}) + \omega_2 \times \text{Rank}_{load}$ 
END FOR
与具有最佳 APscore 的 ap 关联

```

```

Function get_ap_info(ap)

```

```

     $\mu \leftarrow$  信道利用率

```

```

    C ← 容量

```

```

    Return  $(1 - \mu) \times C$ 

```

```

Function get_path_info(ap)

```

```

    Return ETXpath

```

```

Function get_load_info(ap)

```

```

    FOR EACH 沿从 ap 到网关的路径 P 的 node

```

```

        Return 具有最大利用率的 node

```

```

    END FOR

```

图 5B

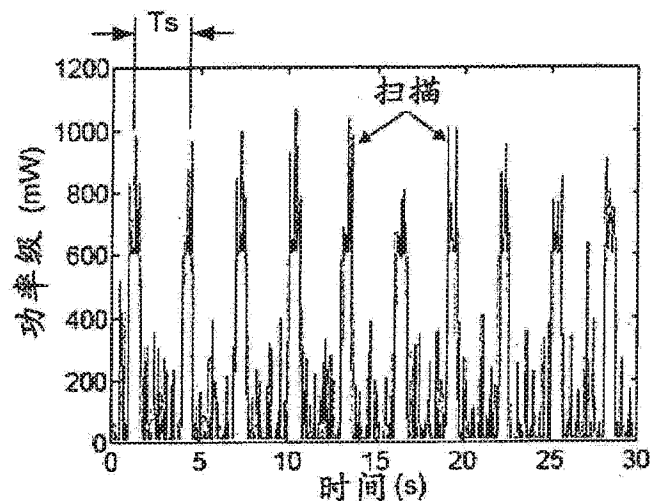


图 6

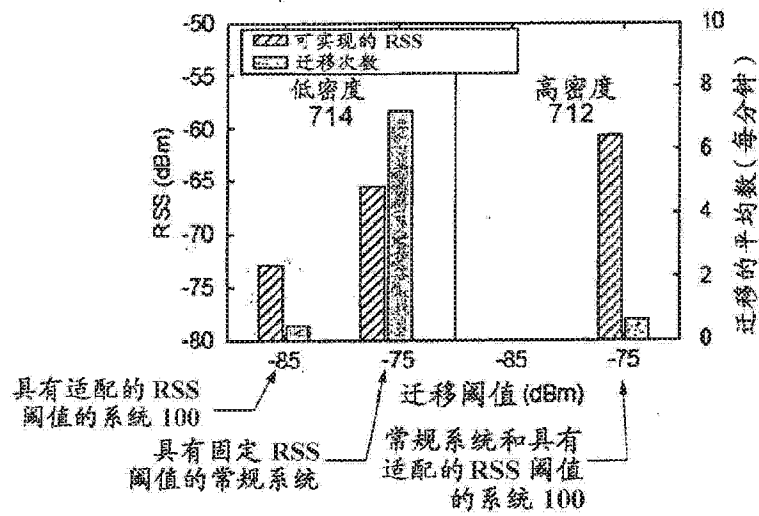


图 7

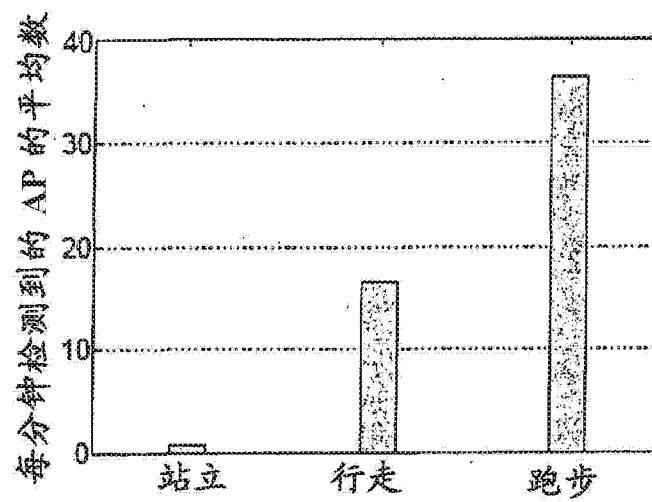


图 8A

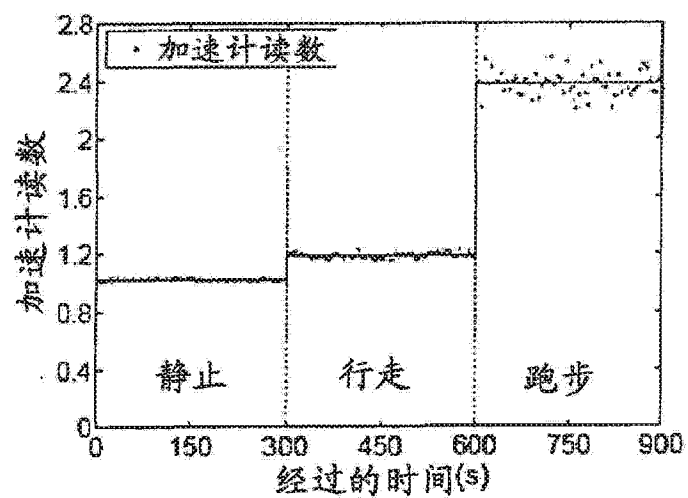


图 8B

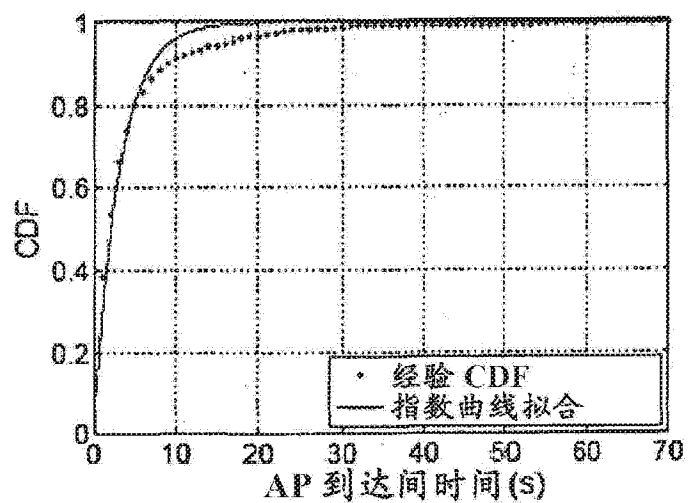


图 8C

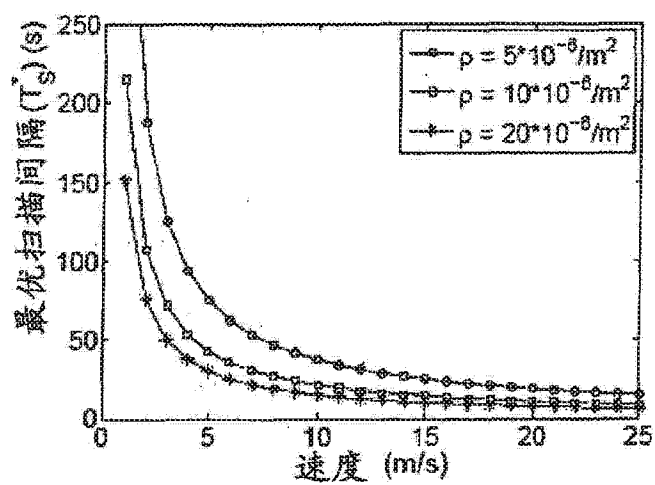


图 9A

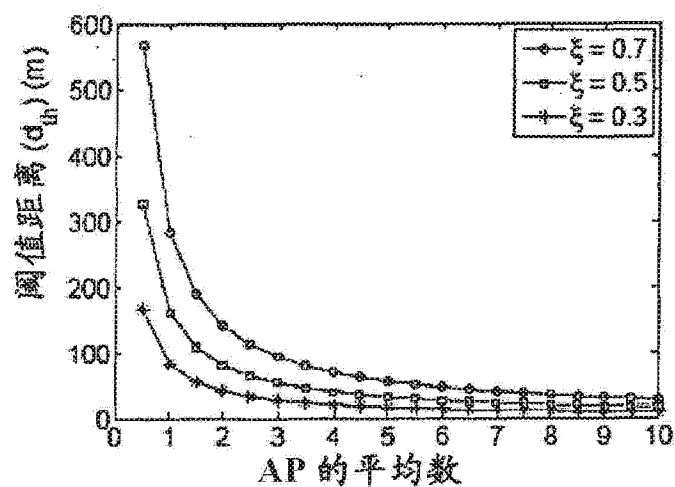


图 9B

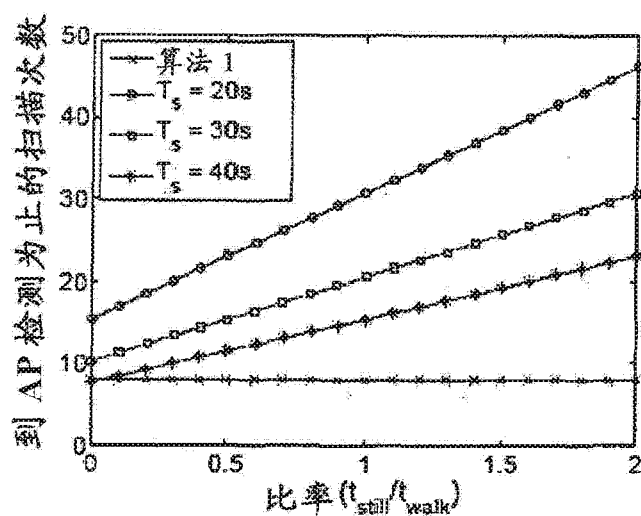


图 9C

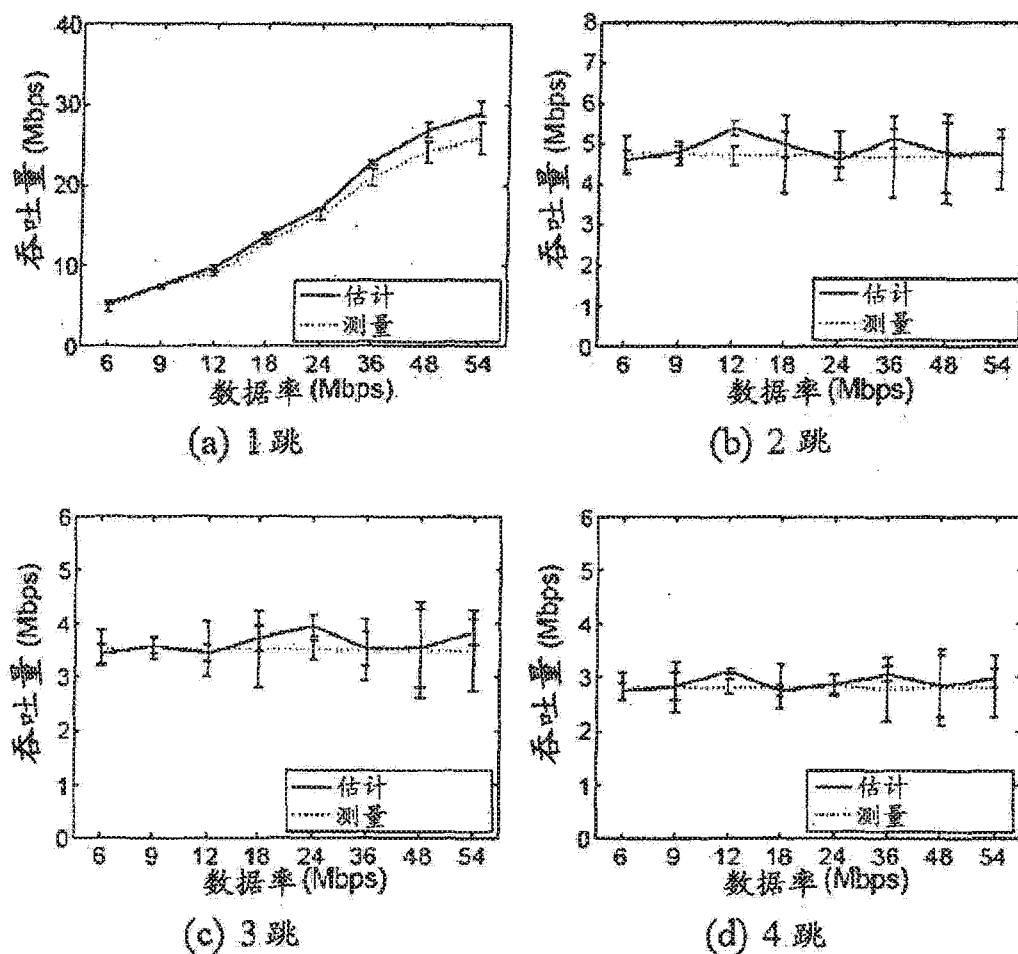


图 10

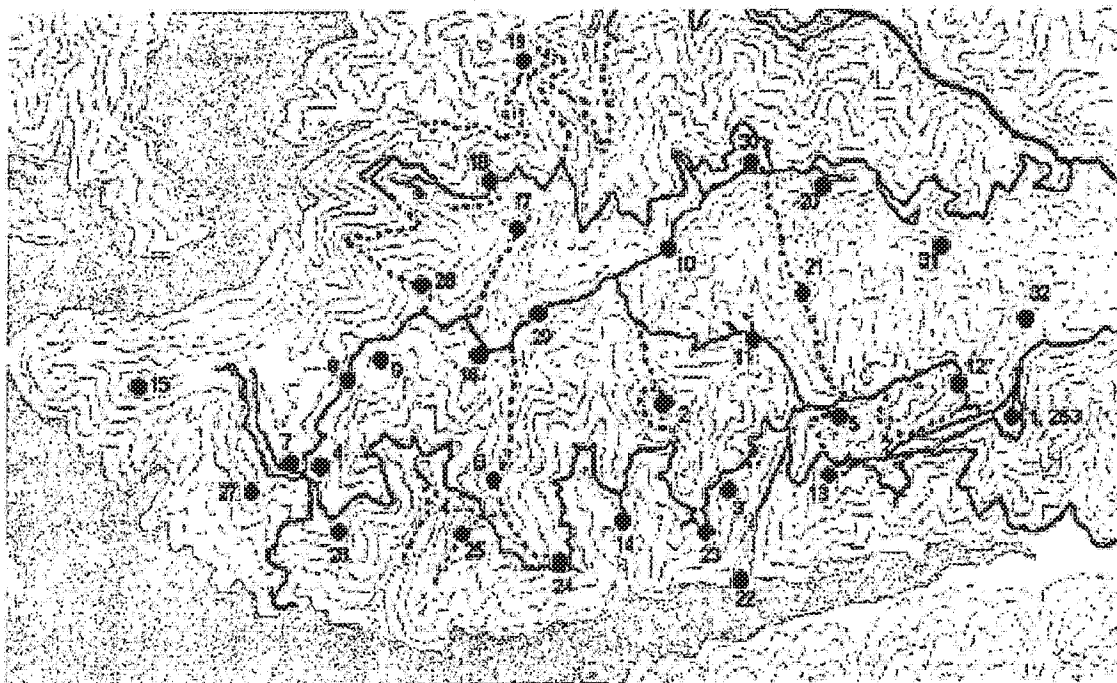


图 11

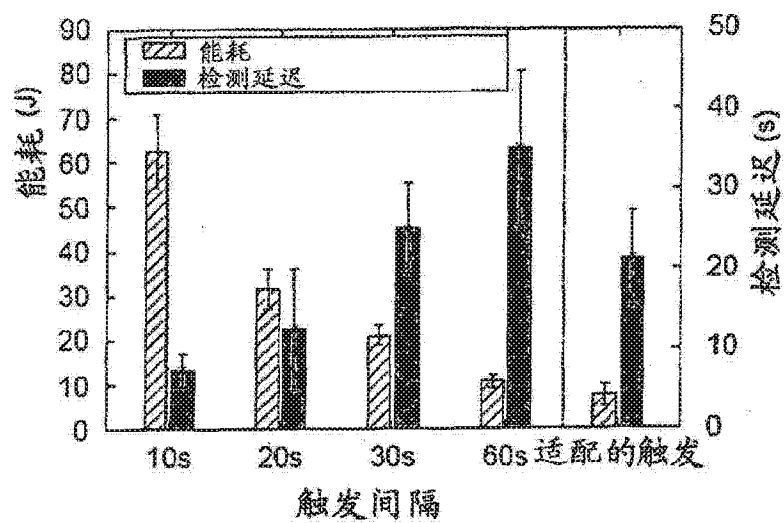


图 12A

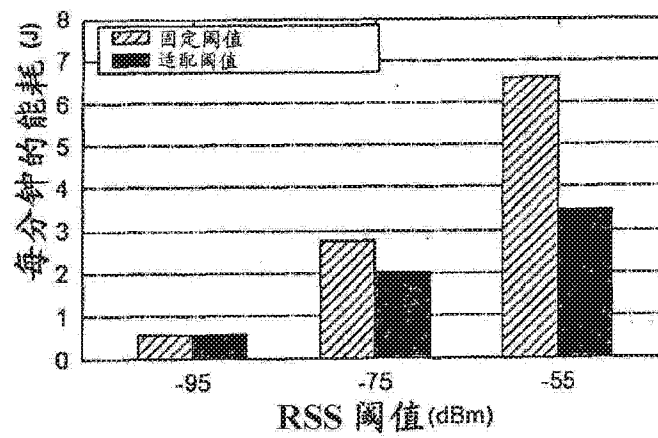


图 12B

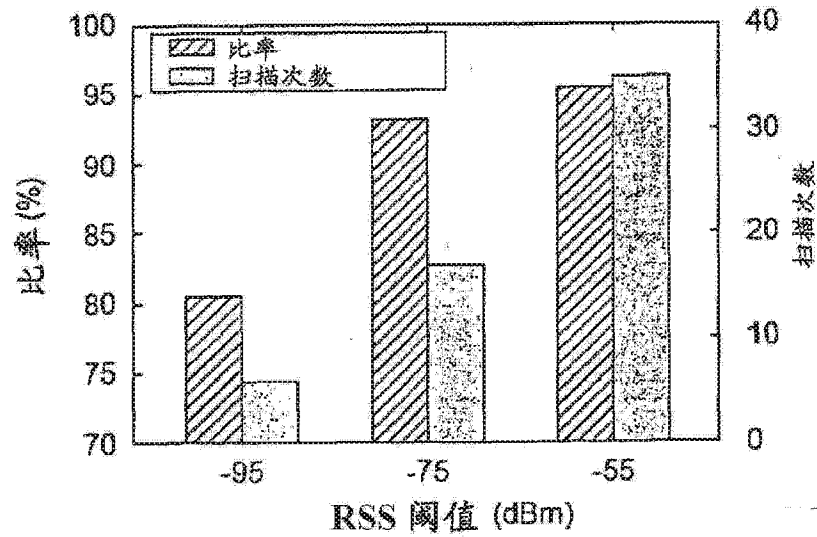


图 12C

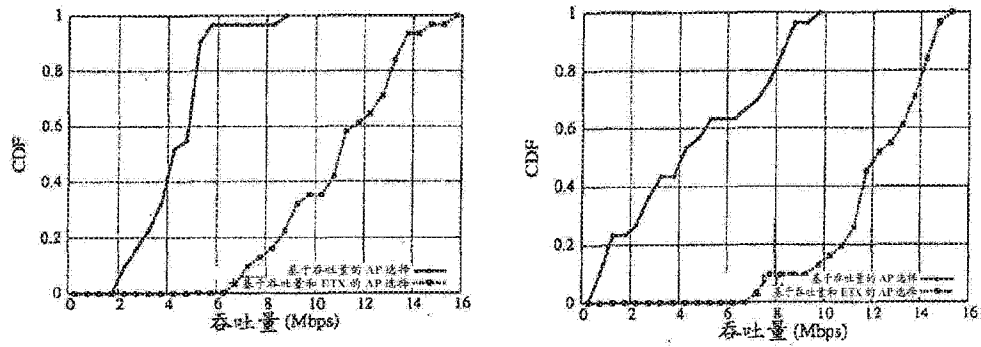


图 13

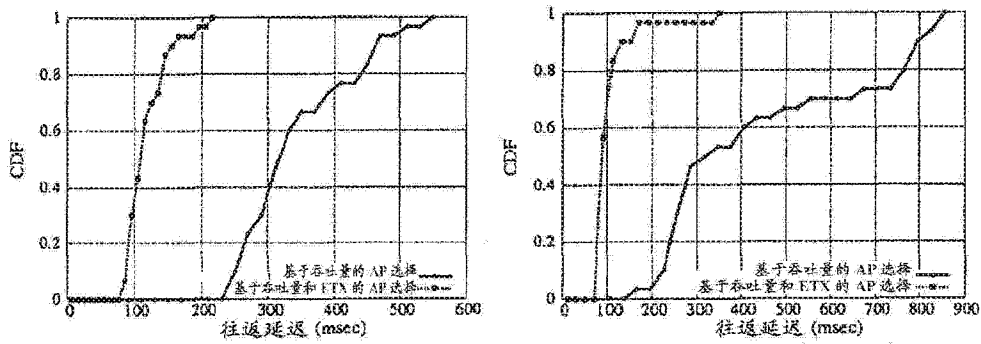


图 14

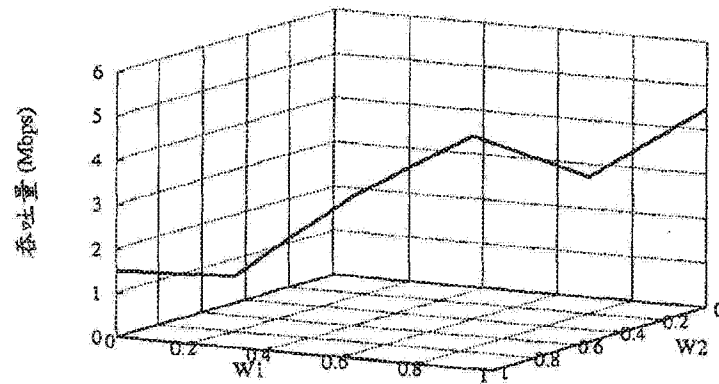


图 15

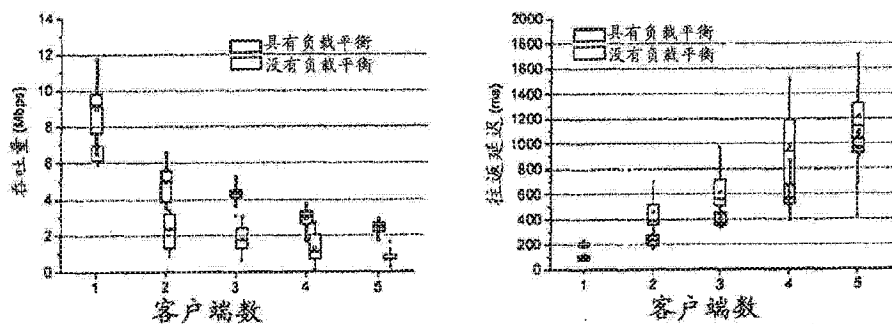


图 16

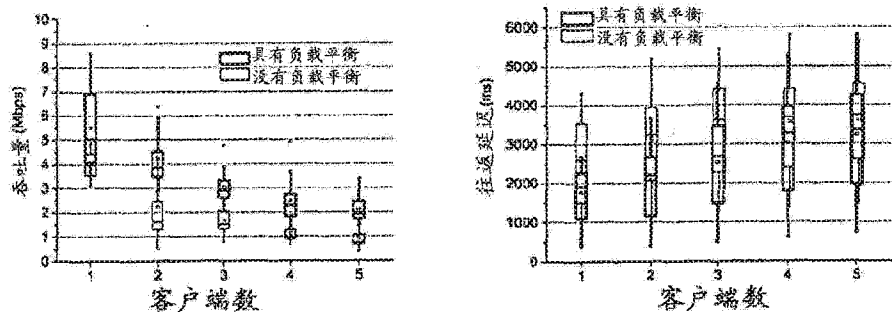


图 17

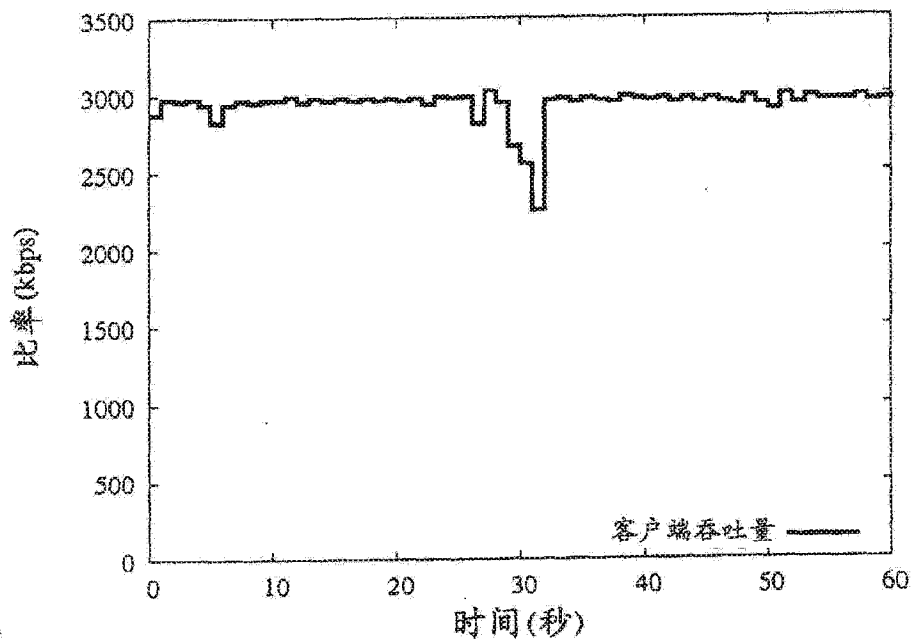


图 18



Espacenet

Bibliographic data: CN104301957 (A) — 2015-01-21

Method and device for controlling terminal to actively roam

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Classification: - international: *H04W36/08; H04W36/30*
- cooperative: H04W36/30 (CN); H04W52/245 (CN); Y02D70/14 (EP)

Application number: CN201410500088 20140925 Global Dossier

Priority number (s): CN201410500088 20140925

Also published as: CN104301957 (B)

Abstract of CN104301957 (A)

The invention discloses a method for controlling a terminal to actively roam. The method is applied to an access controller (AC) in a wireless local area network system and comprises the steps that when the average signal strength of an STA on a first access point (AP) connected with the STA is not larger than a first preset value and the average signal strength of the STA on other APs is not smaller than a second preset value, the first AP is informed to reduce emission power for the STA, meanwhile, a second AP is pushed to the STA, the second preset value is larger than the first preset value, and the second AP is the AP where the average signal strength, not smaller than the second preset value, of the STA on the other APs is the maximum. The invention further discloses a device for controlling the terminal to actively roam. According to the method and device, a client side can fast roam from the AP with poor signals to the AP with good signals.

Notice

This translation is machine-generated. It cannot be guaranteed that it is intelligible, accurate, complete, reliable or fit for specific purposes. Critical decisions, such as commercially relevant or financial decisions, should not be based on machine-translation output.

DESCRIPTION CN104301957

The invention discloses a method for controlling active roaming of a terminal, which is applied to an access controller AC in a wireless local area network system, and the method comprises: when the STA is on the first access point AP with which the connection is established, the average signal strength is not greater than a first predetermined value, and the average signal strength of the STA on the other AP is not less than a second predetermined value; notifying the first AP to reduce the transmit power for the STA, and pushing the second AP to the STA, where The second predetermined value is greater than the first predetermined value, and the second AP is an AP whose average signal strength of the STA on other APs is not less than the average signal strength of the second predetermined value. The invention also discloses an apparatus for controlling active roaming of a terminal. By adopting the invention, the client can roam from the poor signal AP to the AP with better signal as soon as possible.

Method and device for controlling terminal active roaming

Technical field

The present invention relates to the field of network communication technologies, and in particular, to a method and apparatus for controlling active roaming of a terminal.

Background technique

In a wireless network such as a WLAN, it is generally implemented by a wireless access point (AP) and a wireless access controller (AC). In this AC+AP networking mode, the AP is a wireless transceiver device that is

responsible for converting data received from a wired network (such as the Internet) into wireless signal transmission, converting the received wireless signal into data and forwarding it to the data. Wired network. The AC completes the functions of authentication/configuration/data forwarding for wireless users and plays a centralized control role.

FIG. 1 is a schematic diagram of a typical wireless network networking structure. As shown in FIG. 1, an AC is connected to multiple APs of AP1 to AP4, and a terminal (STA) is connected to the AC through an access point AP. In the process of STA accessing the network, it is necessary to first find an available network, and then decide which AP to access the AC according to certain factors. Obviously, the right to choose this is STA. The choice of most STAs is based on signal strength.

The working mechanism of STA determines that there are many STAs in which the initial STA is connected to AP1, and then the STA moves. When it moves to the position of the dotted frame as shown in Figure 1, the STA is away from AP 1 Farther away, the signal is weaker, and the distance from AP 2 is closer, the signal is stronger, but the STA is still stubbornly connected to AP1 and will not actively roam to AP 2.

Due to the implementation of the wireless terminal manufacturer, this situation is very common in the real network. The drawback is obvious: the client is connected to the AP 1, the signal is weak, and there are a large number of low-speed retransmission messages, so that the users of the wireless network The experience speed is getting worse. We can call such a STA as a weak client.

The existing solution generally activates the AP to disconnect from the STA when the AC senses that the STA is weak, and causes the STA to rescan the network and select a better AP access signal. Obviously, the shortcomings of the prior art are obvious: this can cause the user's network interruption time to be too long.

Summary of the invention

It is an object of the present invention to provide a method and apparatus for controlling active roaming of a terminal, which enables the client to roam from an AP with a poor signal to an AP with a better signal as soon as possible.

To achieve the above object, the present invention provides a method for controlling active roaming of a terminal, which is applied to an access controller AC in a wireless local area network system, and the method includes:

When the average signal strength of the terminal STA on the first access point AP with which the connection is established is not greater than the first predetermined value, and the average signal strength of the STA on the other AP is not less than the second predetermined value;

Notifying the first AP to reduce the transmit power for the STA, and pushing the second AP to the STA, where the second predetermined value is greater than a first predetermined value, and the second AP is the STA on the other AP The average signal strength is not less than the AP with the highest average signal strength in the second predetermined value.

In order to achieve the above object, the present invention further provides an apparatus for controlling active roaming of a terminal, which is applied to an access controller AC in a wireless local area network system, and the apparatus includes:

a determining unit, configured to determine an average signal strength of the terminal STA on the AP, where an average signal strength of the STA on the first access point AP with which the STA establishes a connection is not greater than a first predetermined value, and an average of the STA on other APs When the signal strength is not less than the second predetermined value, the processing unit is instructed to perform processing;

a processing unit, configured to notify the first AP to reduce the transmit power for the STA, and push the second AP to the STA, where the second predetermined value is greater than a first predetermined value, and the second AP is the STA The average signal strength on other APs is not less than the AP with the highest average signal strength in the second predetermined value.

In summary, in the embodiment of the present invention, when the AC senses that a weak client exists and knows that the network has a better signal, the AP that reports the poor network reduces the transmission power for the weak client, and simultaneously weakens the weak client. The client pushes a better signal network, so that the weak client actively reselects the network and actively roams from the poor signal network to the better signal network. Compared with the prior art, the weak client can be transferred from the poor signal network to the better signal network as soon as possible.

DRAWINGS

FIG. 1 is a schematic structural diagram of a typical wireless network networking.

FIG. 2 is a schematic flowchart of a method for controlling active roaming of a terminal according to an embodiment of the present invention.

FIG. 3 is a flowchart of establishing a connection with an AP in an active scanning mode of the STA.

FIG. 4 is a flow chart of establishing a connection with an AP in a STA passive scanning mode.

FIG. 5 is a schematic structural diagram of an apparatus for actively roaming a control terminal applied to the foregoing method according to an embodiment of the present invention.

detailed description

In order to make the objects, the technical solutions and the advantages of the present invention more comprehensible, the embodiments of the present invention will be further described in detail below with reference to the accompanying drawings.

2 is a schematic flowchart of a method for controlling active roaming of a terminal according to an embodiment of the present invention, which is applied to an AC in a wireless local area network system, and the method includes:

Step 201: Determine an average signal strength of the terminal STA on the AP, where an average signal strength of the STA on the first access point AP that establishes a connection with the STA is not greater than a first predetermined value, and an average signal strength of the STA on other APs Not less than the second predetermined value;

Step 202: Notify the first AP to reduce the transmit power for the STA, and push the second AP to the STA, where the second predetermined value is greater than a first predetermined value, and the second AP is the STA in the other The average signal strength on the AP is not less than the AP with the highest average signal strength in the second predetermined value.

In this way, the control of the AC is used to notify the first AP to reduce the transmit power for the STA, so that the STA disconnects the connection with the first AP, and directly pushes the second AP with a better signal to the STA, so that the STA scans as soon as possible. The second AP saves the scanning time of the STA and ensures that the STA roams from the first AP to the second AP as soon as possible.

The method for pushing the second AP to the STA may include: informing the second AP to unicast multiple probe response messages to the STA in the beacon period.

Alternatively, the method for pushing the second AP to the STA may further include: informing the second AP to unicast a plurality of Beacon messages to the STA during the beacon period.

Preferably, when the STA has not established a connection with the second AP within a predetermined period, the first AP is again notified to reduce the transmission power for the STA until the STA establishes a connection with the second AP. Here, the predetermined period is generally defined as a certain number of beacon periods.

Preferably, when performing step 202, the AC may further notify the first AP to reject the probe request message of the STA within a predetermined period of reducing the transmit power for the STA.

That is, the method of the present invention controls the first AP and the second AP by using the AC, so as to achieve the purpose of helping the STA to actively roam from the first AP to the second AP.

In a wireless network, each AP may transmit data packets to and from multiple STAs. Each AP periodically detects the signal strength of each STA to send data packets, and each STA sends a data packet to the AP. Average signal strength. Therefore, the first AP obtains the average signal strength of the STAs with which the connection is established, and then notifies the AC, and the other APs also notify the AC after obtaining the average signal strength value of the STA. The AC defines a first predetermined value and a second predetermined value, the second predetermined value being greater than the first predetermined value. If the average signal strength R1 of the STA on the first AP is not greater than the first predetermined value, and the average signal strength on the other AP is not less than the second predetermined value, the STA is considered to be weak on the first AP. The signal on the other AP is strong. At this time, the AC notifies the first AP to reduce the transmit power for the STA, and at the same time, selects the second AP to push to the STA. The second AP is an AP whose average signal strength on the other AP is not smaller than the average signal strength in the second predetermined value. Therefore, the STA that establishes the connection with the first AP is triggered to reselect the network, so that the STA establishes a connection with the second AP with the better signal found during the

rescanning process.

The following is a brief introduction of how the STA establishes a connection between the STA and the STA in active scan mode and passive scan mode.

FIG. 3 is a flowchart of establishing a connection with an AP in an active scanning mode of the STA.

Step 301: The STA sends a Probe Request message to the AP by using a broadcast.

Step 302: The STA receives a probe response (Probe Response) packet of the AP, to obtain wireless network information.

Step 303: The STA sends an authentication request (Authentication Request) to the AP to request an authentication permission.

Step 304: The STA receives an authentication response (Authentication Response) packet of the AP.

Step 305: The STA further sends an association request (Association Request) message to the AP.

Step 306: The AP sends back an association response (Association Response) message to the STA.

At this point, the STA establishes a connection with the AP.

FIG. 4 is a flow chart of establishing a connection with an AP in a STA passive scanning mode.

First, the AP periodically sends a beacon packet to the STA, so that the STA scans the best AP, and then initiates an authentication request to the AP.

Step 401: After scanning the AP to the AP, the STA sends an authentication request (Authentication Request) to

the AP to request an authentication permission.

Step 402: The STA receives an authentication response (Authentication Response) packet of the AP.

Step 403: The STA sends an association request (Association Request) message to the AP.

Step 404: The AP sends back an association response (Association Response) message to the STA.

At this point, the STA establishes a connection with the AP.

It can be seen from the descriptions of FIG. 3 and FIG. 4 that during the rescanning process, the STA establishes a connection with other APs with better signals, such as the second AP, in an active scanning manner or a passive scanning manner.

The AC may be configured to enable the STA to actively roam to the second AP with a better signal, and may push the second AP to the STA. The embodiment of the present invention may have two implementation schemes: the first scheme, the second AP is notified to the second AP during the beacon period. The STA sends a probe response packet, so that the STA establishes a connection with the second AP, that is, actively roams from the first AP to the second AP. The second solution is to notify the second AP to increase the sending of the Beacon packet, that is, to notify the second AP to unicast multiple beacons to the STA in the beacon period. The message is such that the STA establishes a connection with the second AP, that is, actively roaming from the first AP to the second AP.

Of course, the two schemes may be combined to notify the second AP to send multiple probe response packets to the STA in a beacon period. Meanwhile, the second AP is notified to the STA in the beacon period. Multiple beacon messages are sent unicast.

In order to clearly illustrate the present invention, a specific scenario will be described below. The schematic diagram of the wireless network networking structure of FIG. 1 is taken as an example for description.

1)

After a STA accesses AP1, it becomes weak due to the location mobile access signal and becomes a weak client.

2)

The AC obtains the average signal strength of the STA on each AP, and the AP1 detects that the average signal strength of the STA is R1 and notifies the AC, and the AP2 detects that the average signal strength of the STA is R2. The AC is notified, and the AP3 notifies the AC after detecting that the average signal strength of the STA is R3, and the AP4 notifies the AC after detecting that the average signal strength of the STA is R4.

The AC judges that $R1 \leq$ the first predetermined value, and determines that R3 and R2 are respectively greater than or equal to the second predetermined value, and after $R2 > R3$, the AC notifies AP1 to perform steps 3) and 4), and notifies AP2 to perform steps 5) and 6).

3)

The AC notifies AP1 to reduce the transmit power for the STA. The level of the transmit power reduction is reduced by 2 units in 10 Beacon periods, so that AP1 sends a message to the STA with the reduced transmit power in 10 Beacon periods. For example, 1 Beacon period = 100ms, then 10 Beacon period = 1000ms; 1 unit = 1db = 1mw, then 2 units = 2mw. In this way, the AC reduces the transmit power of AP1 by 2 mw, and AP1 sends a message to the STA by reducing the transmit power after 2 mw. After the transmit power of AP1 is reduced, the signal becomes worse for the STA, so that the STA disconnects from AP1, so that the STA actively searches for the AP. If the STA does not actively roam to AP2 within 10 Beacon periods, the transmit power of AP1 is further reduced by 2 units, and the packet is sent to the STA with the transmit power after the lowering again in the next 10 Beacon periods until the STA Scan for a better AP and actively roam to the AP.

4)

The AC notifies the AP1 that it does not respond to the probe request message sent by the STA to the STA within a predetermined period of reducing the transmit power for the STA, which will speed up the STA disconnecting from the AP1 and actively roaming as soon as possible.

5)

The AC notifies AP2 to continuously send unicast two probe response messages to the STA during each Beacon period.

In this way, the STA will be able to select AP2 faster and actively roam to AP2. To make the interval for sending probe response packets more uniform, the time for sending probe response packets in this scenario is as follows: After AP1 reduces the transmit power, if any Beacon period starts, the time is T, and the time is over. The point is T1, then the time points for sending 2 probe response messages are $T + (T1 - T)/4$, $T1 - (T1 - T)/4$, respectively: 1/4 time point in a Beacon period And send a probe response message at the 3/4 time point of a Beacon period.

6)

The AC notifies AP2 to unicast two Beacon packets to the STA during each Beacon period. On the basis of the normal broadcast of the Beacon packet, the AP2 is required to increase the transmission of the Beacon packet and unicast to the STA, so that the STA can select the AP2 and actively roam to the AP2. To make the time interval for sending Beacon packets more uniform, the time for sending Beacon packets in this scenario can be: For any Beacon period, the starting time is T, and the ending time is T1. The time of the added Beacon packet is $T + (T1 - T)/2$, that is, one Beacon packet is sent at 1/2 of the Beacon period.

In summary, through the control of the AC, the AP2 actively pushes its own network connection to the weak client, and the AP1 network has become basically unavailable for the weak client, thereby realizing the STA active roaming.

Based on the same inventive concept, the present invention also provides an apparatus for controlling active roaming of a terminal. Referring to FIG. 5, FIG. 5 is a schematic structural diagram of an apparatus for actively roaming a control terminal applied to the foregoing method according to an embodiment of the present invention. The device is applied to an AC in a wireless local area network system, including:

The determining unit 501 is configured to determine an average signal strength of the terminal STA on the AP, where an average signal strength of the STA on the first access point AP that establishes a connection with the STA is not greater than a first predetermined value, and the STA is on another AP. When the average signal strength is not less than the second predetermined value, the processing unit is instructed to perform processing;

The processing unit 502 is configured to notify the first AP to reduce the transmit power for the STA, and push the second AP to the STA, where the second predetermined value is greater than a first predetermined value, and the second AP is the The average signal strength of the STA on other APs is not less than the AP with the highest average signal strength in the second predetermined value.

The processing unit 502 is further configured to: when the STA has not established a connection with the second AP within a predetermined period, notify the first AP to reduce the transmit power for the STA, until the STA and the second The AP establishes a connection.

The processing unit 502 is further configured to notify the first AP to reject the probe request message of the STA within a predetermined period of reducing the transmit power for the STA.

When the processing unit 502 pushes the second AP to the STA, the processing unit 502 is specifically configured to: notify the second AP to unicast multiple probe response messages to the STA in the beacon period.

When the processing unit 502 pushes the second AP to the STA, the processing unit 502 is specifically configured to: notify the second AP to unicast a plurality of beacon messages to the STA within the beacon period.

The technical solution provided by the invention brings the following advantages:

1. When a weak client exists, the AC helps it to actively roam to a better AP, which eliminates the existence of weak clients in the network and greatly improves the performance of the entire network.

Second, improve the network experience of weak client users, so that they can be connected to the AP with the best signal at any time.

The above is only the preferred embodiment of the present invention and is not intended to limit the scope of the present invention. Any modifications, equivalent substitutions, improvements, etc. made within the spirit and scope of the present invention are intended to be included within the scope of the present invention.

Notice

This translation is machine-generated. It cannot be guaranteed that it is intelligible, accurate, complete, reliable or fit for specific purposes. Critical decisions, such as commercially relevant or financial decisions, should not be based on machine-translation output.

CLAIMS CN104301957

1.

A method for controlling active roaming of a terminal is applied to an access controller AC in a wireless local area network system, and the method includes:

When the average signal strength of the terminal STA on the first access point AP with which the connection is established is not greater than the first predetermined value, and the average signal strength of the STA on the other AP is not less than the second predetermined value;

Notifying the first AP to reduce the transmit power for the STA, and pushing the second AP to the STA, where the second predetermined value is greater than a first predetermined value, and the second AP is the STA on the other AP The average signal strength is not less than the AP with the highest average signal strength in the second predetermined value.

2.

The method according to claim 1, wherein when the STA has not established a connection with the second AP within a predetermined period, the first AP is again notified to reduce the transmission power for the STA until the STA Establish a connection with the second AP.

3.

The method of claim 2, further comprising: notifying the first AP to reject the probe request message in response to the STA within a predetermined period of reducing the transmit power for the STA.

4.

The method of claim 1, wherein the method of pushing a second AP to the STA comprises: notifying the second AP to unicast a plurality of probe response messages to the STA during a beacon period.

5.

The method of claim 1, wherein the method of pushing a second AP to the STA comprises: notifying the second AP to unicast a plurality of beacon messages to the STA during a beacon period.

6.

A device for controlling active roaming of a terminal is applied to an access controller AC in a wireless local area network system, and the device includes:

a determining unit, configured to determine an average signal strength of the terminal STA on the AP, where an average signal strength of the STA on the first access point AP with which the STA establishes a connection is not greater than a first predetermined value, and an average of the STA on other APs When the signal strength is not less than the second predetermined value, the processing unit is instructed to perform processing;

a processing unit, configured to notify the first AP to reduce the transmit power for the STA, and push the second AP to the STA, where the second predetermined value is greater than a first predetermined value, and the second AP is the STA The average signal strength on other APs is not less than the AP with the highest average signal strength in the second predetermined value.

7.

The apparatus according to claim 6, wherein the processing unit is further configured to: when the STA has not established a connection with the second AP within a predetermined period, notify the first AP to lower the target again. The transmit power of the STA until the STA establishes a connection with the second AP.

8.

The apparatus according to claim 7, wherein the processing unit is further configured to notify the first AP to reject the probe request message of the STA within a predetermined period of reducing the transmit power for the STA.

9.

The device according to claim 6, wherein the processing unit, when pushing the second AP to the STA, is specifically configured to: notify the second AP to unicast multiple probe responses to the STA during the beacon period. Message.

10.

The device according to claim 6, wherein the processing unit, when pushing the second AP to the STA, is specifically configured to: notify the second AP to unicast the plurality of beacons to the STA in the beacon period. Message.



(12) 发明专利申请



(10) 申请公布号 CN 104301957 A

(43) 申请公布日 2015.01.21

(21) 申请号 201410500088.3

(22) 申请日 2014.09.25

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(51) Int. Cl.

H04W 36/08 (2009.01)

H04W 36/30 (2009.01)

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(54) 发明名称

一种控制终端主动漫游的方法及装置

(57) 摘要

本发明公开了一种控制终端主动漫游的方法,应用于无线局域网系统中的接入控制器 AC,该方法包括:当 STA 在与其建立连接的第一接入点 AP 上的平均信号强度不大于第一预定值,且该 STA 在其它 AP 上的平均信号强度不小于第二预定值时;通知所述第一 AP 降低针对该 STA 的发射功率,同时向该 STA 推送第二 AP,其中,所述第二预定值大于第一预定值,所述第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP。本发明还公开了一种控制终端主动漫游的装置。采用本发明能够使客户端尽快从信号较差 AP 漫游到信号较好的 AP。

判断终端 STA 在 AP 上的平均信号强度,当终端 STA 在与其建立连接的第一接入点 AP 上的平均信号强度不大于第一预定值,且该 STA 在其它 AP 上的平均信号强度不小于第二预定值时

通知所述第一 AP 降低针对该 STA 的发射功率,同时向该 STA 推送第二 AP,其中,所述第二预定值大于第一预定值,所述第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP

1. 一种控制终端主动漫游的方法,应用于无线局域网系统中的接入控制器 AC,该方法包括:

当终端 STA 在与其建立连接的第一接入点 AP 上的平均信号强度不大于第一预定值,且该 STA 在其它 AP 上的平均信号强度不小于第二预定值时:

通知所述第一 AP 降低针对该 STA 的发射功率,同时向该 STA 推送第二 AP,其中,所述第二预定值大于第一预定值,所述第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP。

2. 如权利要求 1 所述的方法,其特征在于,当所述 STA 在预定周期内还未与第二 AP 建立起连接,则再次通知所述第一 AP 降低针对该 STA 的发射功率,直至该 STA 与第二 AP 建立连接。

3. 如权利要求 2 所述的方法,其特征在于,该方法还包括:通知第一 AP 在降低针对该 STA 的发射功率的预定周期内,拒绝响应该 STA 的探测请求报文。

4. 如权利要求 1 所述的方法,其特征在于,所述向该 STA 推送第二 AP 的方法包括:通知第二 AP 在信标周期内,向该 STA 单播多个探测响应报文。

5. 如权利要求 1 所述的方法,其特征在于,所述向该 STA 推送第二 AP 的方法包括:通知第二 AP 在信标周期内,向该 STA 单播多个信标报文。

6. 一种控制终端主动漫游的装置,应用于无线局域网系统中的接入控制器 AC,该装置包括:

判断单元,用于判断终端 STA 在 AP 上的平均信号强度,当 STA 在与其建立连接的第一接入点 AP 上的平均信号强度不大于第一预定值,且该 STA 在其它 AP 上的平均信号强度不小于第二预定值时,指示处理单元进行处理;

处理单元,用于通知所述第一 AP 降低针对该 STA 的发射功率,同时向该 STA 推送第二 AP,其中,所述第二预定值大于第一预定值,所述第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP。

7. 如权利要求 6 所述的装置,其特征在于,所述处理单元,还用于当所述 STA 在预定周期内还未与第二 AP 建立起连接时,则再次通知所述第一 AP 降低针对该 STA 的发射功率,直至该 STA 与第二 AP 建立连接。

8. 如权利要求 7 所述的装置,其特征在于,所述处理单元,还用于通知第一 AP 在降低针对该 STA 的发射功率的预定周期内,拒绝响应该 STA 的探测请求报文。

9. 如权利要求 6 所述的装置,其特征在于,所述处理单元在向该 STA 推送第二 AP 时,具体用于:通知第二 AP 在信标周期内,向该 STA 单播多个探测响应报文。

10. 如权利要求 6 所述的装置,其特征在于,所述处理单元在向该 STA 推送第二 AP 时,具体用于:通知第二 AP 在信标周期内,向该 STA 单播多个信标报文。

一种控制终端主动漫游的方法及装置

技术领域

[0001] 本发明涉及网络通信技术领域,特别涉及一种控制终端主动漫游的方法及装置。

背景技术

[0002] 在无线网络如 WLAN 的组网中,一般通过无线接入点 (AP) 和无线接入控制器 (AC) 实现。在这种 AC+AP 的组网模式中, AP 是一个无线收发设备,负责将从有线网络 (例如 Internet) 接收到的数据转换成无线信号发送,将接收到的无线信号转换成数据并转发到有线网络。而 AC 完成对无线用户的认证 / 配置 / 数据转发等功能,起到集中控制的作用。

[0003] 图 1 为现有典型无线网络组网结构示意图,如图 1 所示,该无线网络中,一台 AC 与 AP1 ~ AP4 多台 AP 相连,终端 (STA) 通过接入点 AP 连接到 AC。在 STA 接入网络的过程中需要首先寻找可用网络,然后根据某些因素决定选择从哪个 AP 接入 AC。很显然,这个选择的权利在于 STA,目前绝大多数 STA 的选择依据是信号强度。

[0004] STA 这样的工作机制,就决定了有很多的 STA 存在如下的情况,初始 STA 连接在 AP1 上,然后 STA 进行了移动,当它移动到如图 1 所示虚线框位置,此时 STA 距离 AP 1 较远了,信号较弱,而距离 AP 2 的距离却较近,信号较强,但是此 STA 依然固执的连接在 AP1 上,不会主动漫游到 AP 2 上。

[0005] 由于无线终端厂家的实现,这种情况在现实网络中非常普遍,这样的弊端显而易见:此客户端连接在 AP 1 上,信号较弱,会有大量的低速重传报文,使无线网络的用户体验速度变差,我们可以称这样的 STA 为弱客户端。

[0006] 现有的方案一般都是在 AC 感知到这个 STA 很弱的时候,就主动使 AP 断开和这个 STA 的连接,促使 STA 重新扫描网络,选择信号更好的 AP 接入。很显然,现有技术的缺点很明显:这会造成用户的网络中断时间过长。

发明内容

[0007] 本发明的目的在于提供一种控制终端主动漫游的方法及装置,能够使客户端尽快从信号较差的 AP 漫游到信号较好的 AP。

[0008] 为实现上述发明目的,本发明提供了一种控制终端主动漫游的方法,应用于无线局域网系统中的接入控制器 AC,该方法包括:

[0009] 当终端 STA 在与其建立连接的第一接入点 AP 上的平均信号强度不大于第一预定值,且该 STA 在其它 AP 上的平均信号强度不小于第二预定值时;

[0010] 通知所述第一 AP 降低针对该 STA 的发射功率,同时向该 STA 推送第二 AP,其中,所述第二预定值大于第一预定值,所述第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP。

[0011] 为实现上述发明目的,本发明还提供了一种控制终端主动漫游的装置,应用于无线局域网系统中的接入控制器 AC,该装置包括:

[0012] 判断单元,用于判断终端 STA 在 AP 上的平均信号强度,当 STA 在与其建立连接的

第一接入点 AP 上的平均信号强度不大于第一预定值,且该 STA 在其它 AP 上的平均信号强度不小于第二预定值时,指示处理单元进行处理;

[0013] 处理单元,用于通知所述第一 AP 降低针对该 STA 的发射功率,同时向该 STA 推送第二 AP,其中,所述第二预定值大于第一预定值,所述第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP。

[0014] 综上所述,本发明实施例在 AC 感知到弱客户端存在,并且知道有信号更好的网络的时候,通过通知信号较差网络的 AP 降低针对该弱客户端的发射功率,同时向该弱客户端推送信号较好的网络,以使弱客户端主动重新选择网络,主动从信号较差网络漫游到信号较好网络。与现有技术相比,能够使弱客户端尽快从信号较差网络转移到信号较好网络。

附图说明

[0015] 图 1 为现有典型无线网络组网结构示意图。

[0016] 图 2 为本发明实施例控制终端主动漫游的方法流程示意图。

[0017] 图 3 为 STA 主动扫描方式下与 AP 建立连接的流程图。

[0018] 图 4 为 STA 被动扫描方式下与 AP 建立连接的流程图。

[0019] 图 5 为本发明实施例中应用于上述方法的控制终端主动漫游的装置结构示意图。

具体实施方式

[0020] 为使本发明的目的、技术方案及优点更加清楚明白,以下参照附图并举实施例,对本发明方案作进一步地详细说明。

[0021] 图 2 为本发明实施例控制终端主动漫游的方法流程示意图,应用于无线局域网系统中的 AC,该方法包括:

[0022] 步骤 201、判断终端 STA 在 AP 上的平均信号强度,当 STA 在与其建立连接的第一接入点 AP 上的平均信号强度不大于第一预定值,且该 STA 在其它 AP 上的平均信号强度不小于第二预定值时;

[0023] 步骤 202、通知所述第一 AP 降低针对该 STA 的发射功率,同时向该 STA 推送第二 AP,其中,所述第二预定值大于第一预定值,所述第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP。

[0024] 这样,通过 AC 的控制,通知第一 AP 降低针对该 STA 的发射功率,以致使 STA 断开与第一 AP 的连接,同时直接将信号较好的第二 AP 推送给 STA,使得 STA 尽快扫描到第二 AP,节省了 STA 的扫描时间,确保 STA 尽快从第一 AP 漫游到第二 AP。

[0025] 其中,向该 STA 推送第二 AP 的方法可以包括:通知第二 AP 在信标周期内,向该 STA 单播多个探测响应报文。

[0026] 或者,向该 STA 推送第二 AP 的方法还可以包括:通知第二 AP 在信标周期内,向该 STA 单播多个信标(Beacon)报文。

[0027] 优选地,当所述 STA 在预定周期内还未与第二 AP 建立起连接,则再次通知所述第一 AP 降低针对该 STA 的发射功率,直至该 STA 与第二 AP 建立连接。这里,预定周期一般定义为一定个数信标周期。

[0028] 优选地,在执行步骤 202 时,AC 还可以通知第一 AP 在降低针对该 STA 的发射功率

的预定周期内,拒绝响应该 STA 的探测请求报文。

[0029] 也就是说,本发明的方法通过 AC 分别对第一 AP 和第二 AP 进行控制,从而达到帮助 STA 从第一 AP 主动漫游到第二 AP 的目的。

[0030] 在无线网络中,每个 AP 可以会与多个 STA 之间进行数据包的传输,每个 AP 会周期性检测各个 STA 向其发送数据包的信号强度,得到每个 STA 向该 AP 发送数据包的平均信号强度。因此,第一 AP 得到与其建立有连接的 STA 的平均信号强度为 R1 后通知 AC,其它 AP 得到该 STA 的平均信号强度值后也通知 AC。AC 定义第一预定值和第二预定值,第二预定值大于第一预定值。如果该 STA 在第一 AP 上的平均信号强度 R1 不大于第一预定值,且在其它 AP 上的平均信号强度不小于第二预定值时,则认为 STA 在第一 AP 上的信号较弱,在其它 AP 上的信号较强,此时 AC 通知第一 AP 降低针对该 STA 的发射功率,同时,选择第二 AP 推送给该 STA。其中,第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP。从而触发与第一 AP 建立有连接的 STA 重新选择网络,使得 STA 在重新扫描过程中,与所发现的信号较好的第二 AP 建立连接。

[0031] 下面简单介绍一下 STA 在主动扫描方式下和被动扫描模式下,AP 与 STA 如何建立连接。

[0032] 图 3 为 STA 主动扫描方式下与 AP 建立连接的流程图。

[0033] 步骤 301、STA 通过广播向 AP 发送探测请求 (Probe Request) 报文;

[0034] 步骤 302、STA 接收 AP 的探测响应 (Probe Response) 报文,来获取无线网络信息;

[0035] 步骤 303、STA 向 AP 发送认证请求 (Authentication Request) 请求认证许可;

[0036] 步骤 304、STA 接收到 AP 的认证响应 (Authentication Response) 报文;

[0037] 步骤 305、STA 再向 AP 发起连接请求 (Association Request) 报文;

[0038] 步骤 306、AP 向 STA 回送一个连接响应 (Association Response) 报文。

[0039] 至此,STA 与 AP 建立起连接。

[0040] 图 4 为 STA 被动扫描方式下与 AP 建立连接的流程图。

[0041] 首先,AP 周期性向 STA 发送信标 Beacon 报文,以使 STA 扫描到最佳 AP,从而向该 AP 发起认证请求;

[0042] 步骤 401、STA 扫描到 AP 后,向 AP 发送认证请求 (Authentication Request) 请求认证许可;

[0043] 步骤 402、STA 接收到 AP 的认证响应 (Authentication Response) 报文;

[0044] 步骤 403、STA 再向 AP 发起连接请求 (Association Request) 报文;

[0045] 步骤 404、AP 向 STA 回送一个连接响应 (Association Response) 报文。

[0046] 至此,STA 与 AP 建立起连接。

[0047] 根据图 3 和图 4 的描述可以看出,STA 在重新扫描的过程中,就会以主动扫描方式或者被动扫描方式,与信号较好的其它 AP,例如第二 AP,建立起连接。

[0048] AC 为帮助 STA 主动漫游到信号更好的第二 AP,可以向该 STA 推送第二 AP,本发明实施例可以有两种实现方案;第一种方案,通知第二 AP 在信标周期内向该 STA 发送探测响应报文,以使 STA 与第二 AP 建立起连接,即从第一 AP 主动漫游到第二 AP。第二种方案,在第二 AP 正常广播发 Beacon 报文的基础上,通知第二 AP 增加 Beacon 报文的发送,即通知第二 AP 在信标周期内,向该 STA 单播多个信标报文,以使 STA 与第二 AP 建立起连接,即从第

一 AP 主动漫游到第二 AP。

[0049] 当然,也可以将这两种方案结合即:通知第二 AP 在信标周期内,向该 STA 单播发送多个探测响应报文;同时,通知第二 AP 在信标周期内,向该 STA 单播发送多个信标报文。

[0050] 为清楚说明本发明,下面列举具体场景进行说明。仍然以图 1 的无线网络组网结构示意图为例进行说明。

[0051] 1) 一个 STA 接入 AP1 之后,由于位置移动接入信号就比较弱,变成了一个弱客户端。

[0052] 2) AC 通过获取该 STA 在每个 AP 上的平均信号强度,其中,AP1 检测到该 STA 在其上的平均信号强度为 R1 后通知 AC, AP2 检测到该 STA 在其上的平均信号强度为 R2 后通知 AC, AP3 检测到该 STA 在其上的平均信号强度为 R3 后通知 AC, AP4 检测到该 STA 在其上的平均信号强度为 R4 后通知 AC。AC 判断 $R1 \leq$ 第一预定值,同时确定 R3, R2 分别大于等于第二预定值,且 $R2 > R3$ 后,AC 通知 AP1 执行步骤 3) 和 4),通知 AP2 执行步骤 5) 和 6)。

[0053] 3) AC 通知 AP1 降低针对该 STA 的发射功率,发射功率降低的级别是 10 个 Beacon 周期内降低 2 个单位,以使 AP1 在 10 个 Beacon 周期内以降低后的发射功率向该 STA 发送报文。举例来说,1 Beacon 周期 = 100ms,则 10 Beacon 周期 = 1000ms;1 单位 = 1db = 1mw,则 2 单位 = 2mw。这样,AC 将 AP1 的发射功率降低 2mw,AP1 以降低 2mw 之后的发射功率向该 STA 发送报文。AP1 的发射功率降低之后,对于 STA 来说,信号就会变得更差,以致 STA 断开与 AP1 的连接,这样,STA 就会主动搜索 AP。如果该 STA 在 10 个 Beacon 周期内还没有主动漫游到 AP2,则会将 AP1 的发射功率继续降低 2 个单位,在下 10 个 Beacon 周期内以再次降低之后的发射功率向 STA 发送报文,直至 STA 扫描到信号更好的 AP 并主动漫游到该 AP。

[0054] 4) AC 通知 AP1 在降低针对该 STA 的发射功率的预定周期内,不再响应 STA 向其发送的探测请求报文,这样将加快 STA 断开与 AP1 的连接并尽快主动漫游。

[0055] 5) AC 通知 AP2 在每个 Beacon 周期内,向该 STA 连续单播发送 2 个探测响应报文。这样,STA 将能够更快选择 AP2 并主动漫游到 AP2。为使探测响应报文发送的时间间隔更加均匀,本场景中发送探测响应报文的时间计算方法为:假设 AP1 降低发射功率以后,假如任意一个 Beacon 周期,开始的时间点为 T,结束的时间点为 T1,那么发送 2 个探测响应报文的时间点分别为 $T + (T1 - T) / 4$ 、 $T1 - (T1 - T) / 4$,即分别为:在一个 Beacon 周期的 1/4 时间点上,以及在一个 Beacon 周期的 3/4 时间点上发送探测响应报文。

[0056] 6) AC 通知 AP2 在每个 Beacon 周期内,向该 STA 单播发送 2 个 Beacon 报文。这样,在 AP2 正常广播发 Beacon 报文的基础上,要求 AP2 增加 Beacon 报文的发送,且单播发送至该 STA,从而使该 STA 能够更快选择 AP2 并主动漫游到 AP2。为使 Beacon 报文发送的时间间隔更加均匀,本场景中发送 Beacon 报文的时间计算方法可以为:对于其中的任意一个 Beacon 周期,开始的时间点为 T,结束的时间点为 T1,那么发送增加的 Beacon 报文的时间点为 $T + (T1 - T) / 2$,即在一个 Beacon 周期的 1/2 时间点上再发送 1 个 Beacon 报文。

[0057] 综上,通过 AC 的控制,AP2 主动将自己的网络连接推送给了这个弱客户端,同时 AP1 的网络对于此弱客户端来说已经基本变得不可用,从而实现了 STA 主动漫游。

[0058] 基于同样的发明构思,本发明还提出一种控制终端主动漫游的装置,参见图 5,图 5 为本发明具体实施例中应用于上述方法的控制终端主动漫游的装置结构示意图。该装置应用于无线局域网系统中的 AC,包括:

[0059] 判断单元 501,用于判断终端 STA 在 AP 上的平均信号强度,当 STA 在与其建立连接的第一接入点 AP 上的平均信号强度不大于第一预定值,且该 STA 在其它 AP 上的平均信号强度不小于第二预定值时,指示处理单元进行处理;

[0060] 处理单元 502,用于通知所述第一 AP 降低针对该 STA 的发射功率,同时向该 STA 推送第二 AP,其中,所述第二预定值大于第一预定值,所述第二 AP 为该 STA 在其它 AP 上的平均信号强度不小于第二预定值中平均信号强度最大的 AP。

[0061] 所述处理单元 502,还用于当所述 STA 在预定周期内还未与第二 AP 建立起连接时,则再次通知所述第一 AP 降低针对该 STA 的发射功率,直至该 STA 与第二 AP 建立连接。

[0062] 所述处理单元 502,还用于通知第一 AP 在降低针对该 STA 的发射功率的预定周期内,拒绝响应该 STA 的探测请求报文。

[0063] 所述处理单元 502 在向该 STA 推送第二 AP 时,具体用于:通知第二 AP 在信标周期内,向该 STA 单播多个探测响应报文。

[0064] 所述处理单元 502 在向该 STA 推送第二 AP 时,具体用于:通知第二 AP 在信标周期内,向该 STA 单播多个信标报文。

[0065] 本发明提供的技术方案,会带来如下好处:

[0066] 一、当弱客户端存在时,AC 帮助其发生主动漫游到信号更好的 AP,即消灭了网络中弱客户端的存在,大大提高了整个网络的性能;

[0067] 二、提高了弱客户端用户的网络体验,使之能够随时都连接在信号最好的 AP 上。

[0068] 以上,仅为本发明的较佳实施例而已,并非用于限定本发明的保护范围。凡在本发明的精神和原则之内,所作的任何修改、等同替换、改进等,均应包含在本发明的保护范围之内。

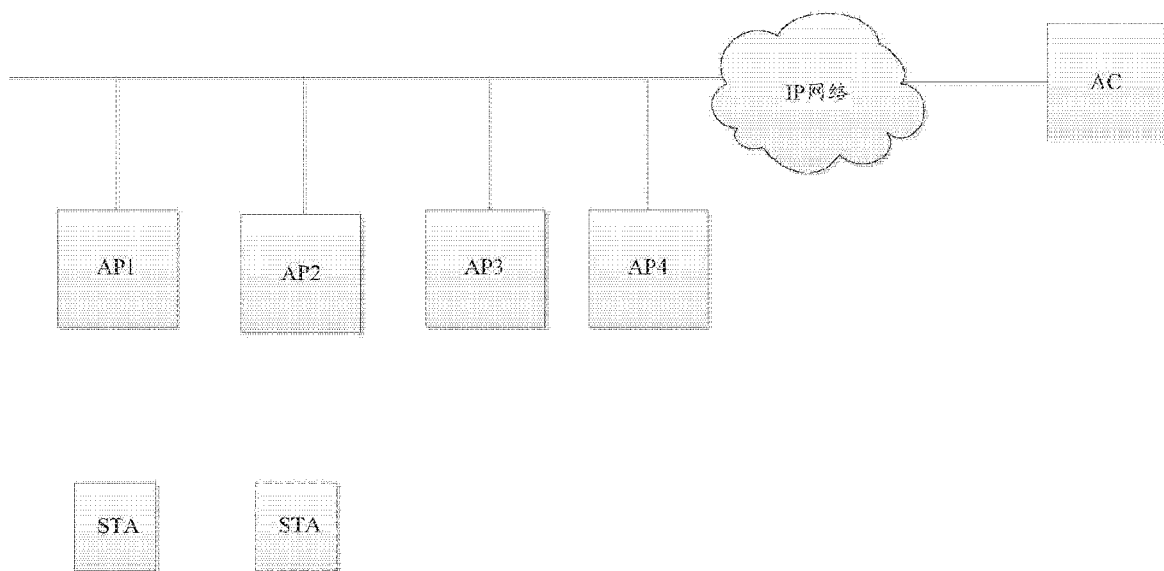


图 1

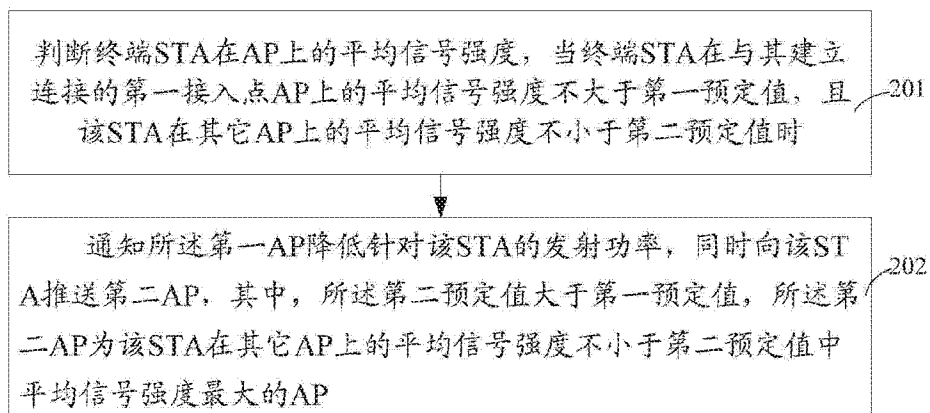


图 2

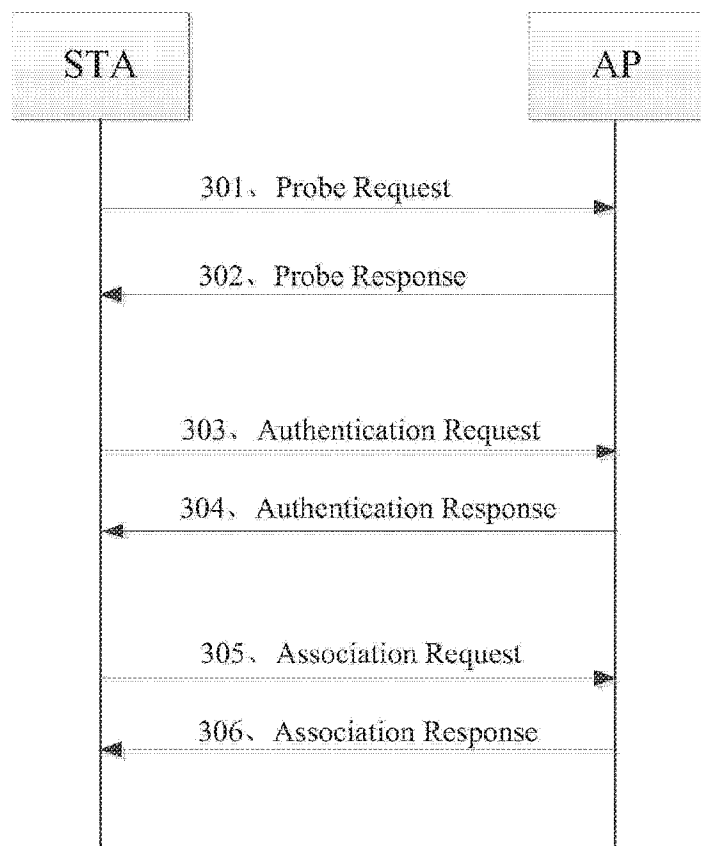


图 3

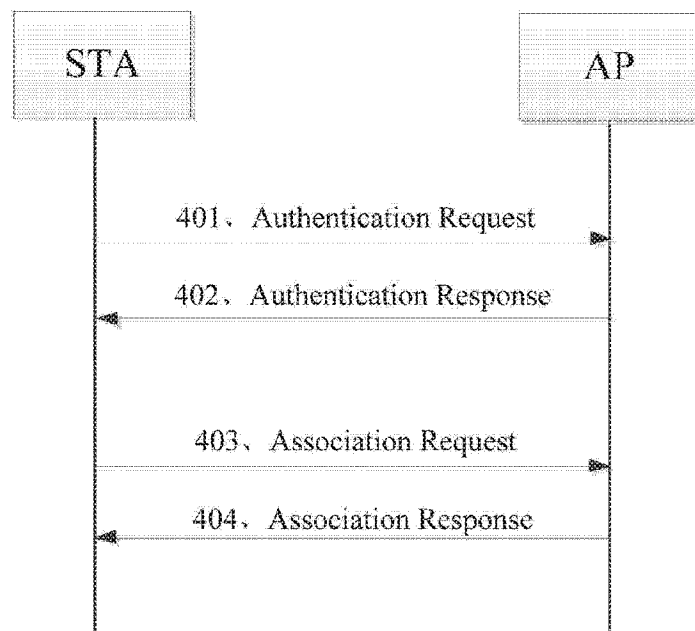


图 4

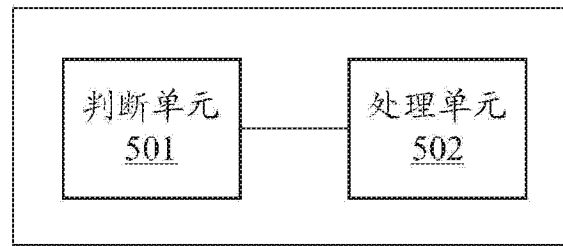
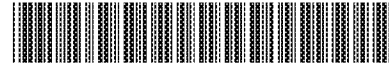


图 5



(11)

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(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
04.03.2015 Bulletin 2015/10

(51) Int Cl.:
H04W 74/08 (2009.01) H04W 72/12 (2009.01)

(21) Application number: 14186014.8

(22) Date of filing: 30.01.2012

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB
GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO
PL PT RO RS SE SI SK SM TR

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(62) Document number(s) of the earlier application(s) in
accordance with Art. 76 EPC:
12153128.9 / 2 621 239

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Remarks:

This application was filed on 23-09-2014 as a
divisional application to the application mentioned
under INID code 62.

(54) Data broadcasting with a prepare-to-broadcast message

(57) Techniques for broadcasting data in a multi-channel network having a control channel and multiple data channels are described. A node wishing to broadcast data may determine a particular data channel from among the multiple data channels, a modulation technique, and a data rate to be utilized to broadcast the data. The broadcasting node may transmit a message over the control channel indicating that the data will be broadcast on the particular data channel using the modulation technique and at the determined data rate. The broadcasting node and a node wishing to receive the data may switch to the particular data channel. The broadcast node may broadcast the data over the particular data channel, while the receiving node may receive the data. After broadcasting the data or a predetermined time period has expired, the broadcasting node and receiving node may switch to the control channel.

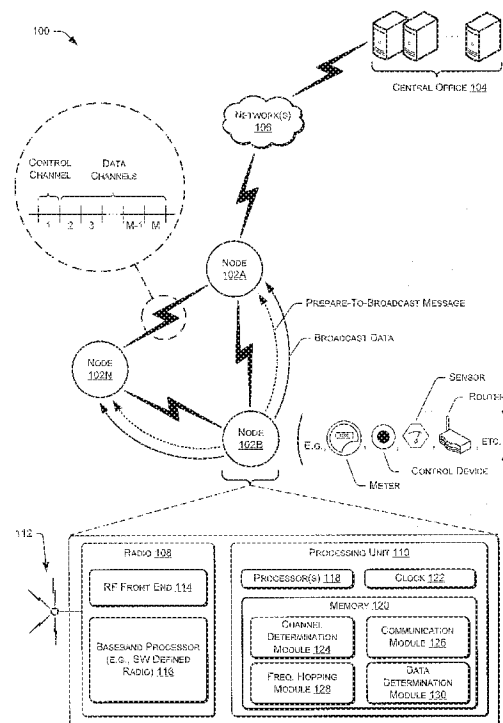


FIG. 1

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Description

DETAILED DESCRIPTION

BACKGROUND

[0001] Communication networks, such as wireless mesh networks, are used to connect a variety of different devices (e.g., nodes). These communication networks often contain multiple different generations of nodes having different characteristics and capabilities.

[0002] Within a communication network, one or more nodes may wish to communicate while a particular node is broadcasting data. Due to a limited number of channels and/or in order to avoid interference, the one or more nodes may be forced to communicate after the particular node finishes broadcasting the data. This waiting period may be lengthened when the particular node broadcasts a large amount of data which requires more communication time. In addition, this waiting period may be lengthened when the particular node broadcasts the data based on a particular modulation technique and/or data rate that requires more communication time.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The detailed description refers to the accompanying figures. In the figures, the left-most digit(s) of a reference number identifies the figure in which the reference number first appears. The use of the same reference numbers in different figures indicates similar or identical items.

FIG. 1 is a schematic diagram of an example architecture of a multi-channel, wireless mesh network in which data can be broadcast among nodes.

FIG. 2 illustrates an example environment for broadcasting data from a broadcasting node to one or more neighboring nodes.

FIG. 3 illustrates an example frequency hopping process which may be utilized in broadcasting data in a multi-channel network.

FIG. 4 illustrates an example prepare-to-broadcast protocol data unit which may be transmitted in a multi-channel network.

FIG. 5 illustrates an example process for transmitting a prepare-to-broadcast message over a control channel indicating that data will be broadcast on a particular data channel, switching to the particular data channel, and broadcasting the data over the particular data channel.

FIG. 6 illustrates an example process for receiving a prepare-to-broadcast message over a control channel indicating data will be broadcast on a particular data channel, switching to the particular data channel, and receiving the data over the particular data channel.

[0004] As discussed above, existing techniques for broadcasting data do not provide an effective way of broadcasting data within a wireless mesh network. For example, existing broadcasting techniques are not well suited to broadcast data in a heterogeneous wireless mesh network in which nodes have differing capabilities.

[0005] This disclosure describes techniques directed to broadcasting data in an efficient manner to one or more nodes of a network. The disclosure introduces a prepare-to-broadcast (PTB) message, to be sent over a control channel to the one or more neighboring nodes. The network may comprise a multi-channel network having a control channel and multiple data channels. In some implementations, a node wishing to broadcast data (e.g., a broadcasting node) may determine a particular data channel of the multiple data channels to be utilized to broadcast data, a particular modulation technique to be utilized, and/or a particular data rate to be utilized. In some instances, the determination is based at least in part on the capabilities of one or more other nodes (e.g., neighboring nodes) within a predetermined proximity to the broadcasting node.

[0006] The broadcasting node may transmit a prepare-to-broadcast (PTB) message over the control channel to the one or more neighboring nodes that are listening on the control channel. As used herein, the term "PTB message" may generally refer to a message that is transmitted before data is broadcast indicating that a node (e.g., the broadcasting node) wishes to broadcast data. The PTB message may also indicate a particular data channel to be utilized to broadcast the data, a modulation technique to be utilized, and/or a data rate (e.g., bit rate) to be utilized. The PTB message may also include information to identify the data that will be broadcast (e.g., a data identifier (ID)). The particular data channel, modulation technique, and/or data rate indicated in the PTB message may comprise a particular data channel, modulation technique, and/or data rate previously determined by the broadcasting node. In some instances, the PTB message is shorter in length than the data. That is, the PTB message includes less bits and/or bytes than the data.

[0007] After the PTB message has been transmitted on the control channel, the broadcasting node and/or the one or more neighboring nodes may switch (e.g., tune, with an RF-receiving radio) to the particular data channel. The broadcasting node may broadcast the data over the particular data channel based at least in part on the modulation technique and/or data rate indicated in the PTB message. Meanwhile, the one or more neighboring nodes may receive the data over the particular data channel. The broadcasting node and/or the one or more neighboring nodes may switch to the control channel after the data has been broadcast and/or a predetermined time period has expired since switching to the particular data channel.

[0008] Use of the PTB message may allow broadcast

of data without receiving any communication from one or more neighboring nodes. For example, a broadcasting node may broadcast the data without knowing whether the one or more neighboring nodes are available to receive the broadcast. Thus, the data may be broadcast without exchanging a request-to-send (RTS) message and/or a clear-to-send (CTS) message between the broadcasting node and the one or more neighboring nodes. Additionally, or alternatively, after the data has been broadcast, the broadcasting node may switch back to the control channel without receiving an acknowledgment message from the one or more neighboring nodes indicating that the data was received.

[0009] The broadcasting techniques are described herein in the context of a utility mesh network including a plurality of nodes. While the techniques are described in the context of a utility mesh network, the techniques may additionally, or alternatively, be applicable to other networks and/or other applications. As such, the nodes may include any device coupled to a communication network and capable of sending and/or receiving data.

[0010] In various embodiments described herein, data may be broadcast in an efficient manner. For example, by employing a multi-channel network having a control channel and multiple data channels, a node may communicate over the control channel while another node broadcasts data over a data channel. In addition, by utilizing multiple data channels, a first node may broadcast data over a first data channel while a second node broadcasts, or otherwise communicates, over a second data channel. This may allow a network to increase data throughput compared to techniques which utilize a single channel. Further, by communicating shorter messages on a control channel and broadcasting longer data (e.g., data frames) on a data channel, more nodes may communicate over the control channel compared to techniques which utilize a single channel for communicating short messages and long data.

[0011] In addition, in some instances, by broadcasting data with a modulation technique and/or data rate that is determined based at least in part on capabilities of one or more nodes neighboring a broadcasting node, the capabilities of the one or more neighboring nodes may be leveraged to decrease a time required to broadcast the data. That is, the data may be broadcast with a modulation technique and/or data rate that requires less communication time from among modulation techniques and/or data rates that are available to the one or more neighboring nodes or that might otherwise be utilized to broadcast the data.

[0012] The sections below are examples provided for the reader's convenience and are not intended to limit the scope of the claims, nor the proceeding sections. Furthermore, the techniques described in detail below may be implemented in a number of ways and in a number of contexts. One example implementation and context is provided with reference to the following figures, as described below in more detail. Additionally, the fol-

lowing implementation and context is meant to be representative of other possible implementations.

EXAMPLE ARCHITECTURE

[0013] FIG. 1 is a schematic diagram of an example architecture 100 of a multi-channel, wireless mesh network in which a PTB message and/or data can be broadcast. The architecture 100 includes a plurality of nodes 102A, 102B, ... 102N (collectively referred to as nodes 102) communicatively coupled to each other via direct communication paths. In this example, N represents a number of nodes in an autonomous routing area (ARA), such as a wide area network (WAN), metropolitan area network (MAN), local area network (LAN), neighborhood area network (NAN), personal area network (PAN), or the like.

[0014] Each direct communication path may represent a plurality of channels over which a node is able to transmit and/or receive a PTB message and/or data. Each of the plurality of channels may be defined by a frequency range which may be the same as or different from frequency ranges of others of the plurality of channels. In some instances, the plurality of channels comprises radio frequency (RF) channels. The plurality of channels may comprise a control channel and multiple data channels. In some instances, the control channel is utilized for communicating one or more PTB messages to nodes to specify one of the multiple data channels, a modulation technique, and/or a data rate to be utilized to broadcast data. Meanwhile, the data channels may be utilized for communicating data. Generally, transmissions on the control channel are shorter relative to transmissions on the data channels.

[0015] Each of the nodes 102 may be implemented as any of a variety of conventional computing devices such as, for example, smart utility meters (e.g., electric, gas, and/or water meters), control devices, sensors (e.g., temperature sensors, weather stations, frequency sensors, etc.), transformers, routers, servers, relays (e.g., cellular relays), switches, valves, combinations of the foregoing, or any device couplable to a communication network and capable of sending and/or receiving data. In some cases, the nodes 102 may include different types of nodes (e.g., smart meters, cellular relays, sensors, etc.), different generations or models of nodes, and/or nodes that otherwise are capable of transmitting on different channels and using different modulation techniques, data rates, protocols, signal strengths, and/or power levels. In these cases, the architecture 100 may represent a heterogeneous network of nodes.

[0016] In the example of FIG. 1, the nodes 102 are also configured to communicate with a central office 104 via an edge device (e.g., cellular relay, cellular router, edge router, DODAG root, etc.) which serves as a connection point of the ARA to a backhaul network(s) 106, such as the Internet. In the example illustrated example, the node 102A serves as a cellular relay to relay communications

from the other nodes 102B-102N of the ARA to and from the central office 104 via the network(s) 106.

[0017] The node 102B is representative of each of the nodes 102 and includes a radio 108 and a processing unit 110. The radio 108 comprises an RF transceiver configured to transmit and/or receive RF signals via one or more of a plurality of channels/frequencies. In some implementations, each of the nodes 102 includes a single radio 108 configured to send and receive data on multiple different channels, such as the control channel and multiple data channels of each communication path. The radio 108 may also be configured to implement a plurality of different modulation techniques, data rates, protocols, signal strengths, and/or power levels.

[0018] In some implementations, the radio 108 utilizes a modulation technique and/or data rate associated with a previously defined standard. The modulation technique and/or data rate may be associated with a standard defined by the Institute of Electrical and Electronics Engineering (IEEE), such as the IEEE 802.11 standard, the IEEE 802.15 standard (e.g., 802.15.4), etc. In one example, the modulation technique and/or data rate are selected from the following non-exhaustive list:

- Frequency Shift Keying (FSK) modulation with a data rate of 50 or 150 kbps; channel spacing of 200 or 400 kHz; and/or a first channel starting at 902.2 or 902.4 MHz. FSK modulation may utilize convolutional code forward error correction (FEC).
- Orthogonal Frequency-Division Multiplexing (OFDM) with physical modulations of binary phase-shift keying (BPSK), quadrature phase-shift keying (QPSK), and/or quadrature amplitude modulation (QAM) (e.g., 16-QAM); a data rate of 50, 100, 200, 300, 400, 600, or 800 kbps; and/or channel spacing of 400 or 800 kHz. OFDM may utilize convolutional FEC with $\frac{1}{2}$ or $\frac{3}{4}$ coding rate.
- Direct-sequence spread spectrum (DSSS) modulation with a physical modulation of offset quadrature phase-shift keying (O-QPSK); a data rate of 31.25, 125, 250, or 500 kbps; and/or channel design based on a previously defined standard, such as the 802.15.4 standard. DSSS may utilize convolutional FEC.

[0019] In further examples, the radio 108 may utilize a customized modulation technique. The customized modulation technique may be associated with a data rate of 6 or 10 kbps.

[0020] In the example of FIG. 1, the radio 108 includes an antenna 112 coupled to an RF front end 114 and a baseband processor 116. The RF front end 114 may provide transmitting and/or receiving functions. The RF front end 114 may include high-frequency analog and/or hardware components that provide functionality, such as tuning and/or attenuating signals provided by the antenna 112 and obtained from one or more of the nodes 102. The RF front end 114 may provide a signal

to the baseband processor 116.

[0021] In one implementation, all or part of the baseband processor 116 may be configured as a software (SW) defined radio. In one example, the baseband processor 116 provides frequency and/or channel selection functionality to the radio 108. For example, the SW defined radio may include mixers, filters, amplifiers, modulators and/or demodulators, detectors, etc., implemented in software executed by a processor or application specific integrated circuit (ASIC) or other embedded computing device(s). The SW defined radio may utilize processor(s) 118 and software defined or stored in memory 120. Alternatively, the baseband processor 116 may be implemented at least in part using analog components.

[0022] The processing unit 110 may include one or more processor(s) 118 communicatively coupled to memory 120. The processing unit 110 may also include a clock 122 configured to provide a clock signal and/or maintain a time. In one example, the clock signal is provided as an input to the processor 118. The clock 122 may also be configured to provide one or more count-up or count-down timers. Such timers may be used in frequency hopping among multiple communication channels.

[0023] The memory 120 may be configured to store one or more software and/or firmware modules, which are executable on the processor(s) 118 to implement various functions. While the modules are described herein as being software and/or firmware executable on a processor, in other embodiments, any or all of the modules may be implemented in whole or in part by hardware (e.g., as an ASIC, a specialized processing unit, etc.) to execute the described functions.

[0024] In the embodiment of FIG. 1, the memory 120 includes a channel determination module 124, a communication module 126, a frequency hopping module 128, and a data determination module 130. The channel determination module 124 may determine a particular data channel from among multiple data channels to be utilized to broadcast data, a modulation technique to be utilized, and/or a data rate to be utilized. The particular data channel, modulation technique, and/or data rate may be output to the communication module 126. In some instances, the channel determination module 124 maintains a location (e.g., frequency or frequency range) of a control channel and/or the multiple data channels. Additionally, or alternatively, the channel determination module 124 may maintain a list of available data channels from among the multiple data channels.

[0025] The communication module 126 may cause switching of a communication channel utilized by the node 102 for communication. For example, the communication module 126 may cause the node 102 to switch from a control channel to a data channel and/or from a data channel to a control channel. That is, the communication module 126 may cause the radio 108 of the node 102 to tune from a frequency associated with a control channel to a frequency associated with a data channel.

In addition, the communication module 126 may cause one or more PTB messages and/or data to be transmitted and/or received on a communication channel (e.g., control channel, data channel). The particular data channel, modulation technique, and/or data rate indicated in the PTB message may comprise a particular data channel, modulation technique, and/or data rate input to the communication module 126 from the channel determination module 124.

[0026] The frequency hopping module 128 may be configured to communicate with the baseband processor 116 and the clock 122. In one example, the frequency hopping module 128 is configured to obtain time information and/or set frequency-hopping timers in the clock 122. Such time information and/or timers will indicate to the frequency hopping module 128 when to "hop" or tune to a different channel or frequency. Additionally, the frequency hopping module 128 may be configured to direct the SW defined radio or other component of the radio 108 to perform the actual frequency changes. Accordingly, the frequency hopping module 128 is able to repeatedly shift between agreed upon frequencies, at agreed upon times and communicate with another node(s) for agreed upon periods of time and in agreed upon protocols.

[0027] The data determination module 130 may determine whether data to be broadcast has already been received. The determination may be based at least in part on a data ID included in a PTB message of the data that will be broadcast. The data determination module 130 may compare this data ID with data IDs associated with other data (e.g., data packets) that have been previously received.

[0028] In some implementations (e.g., when the node is a utility meter), the memory 120 may also include a metrology module configured to collect consumption data of one or more resources (e.g., electricity, water, natural gas, etc.), which may then be transmitted to one or more other nodes 102 for eventual propagation to the central office 104 or another destination.

[0029] The memory 120 may comprise computer-readable media and may take the form of volatile memory, such as random access memory (RAM) and/or non-volatile memory, such as read only memory (ROM) or flash RAM. Computer-readable media includes volatile and non-volatile, removable and non-removable media implemented in any method or technology for storage of information such as computer-readable instructions, data structures, program modules, or other data for execution by one or more processors of a computing device. Examples of computer-readable media include, but are not limited to, phase change memory (PRAM), static random-access memory (SRAM), dynamic random-access memory (DRAM), other types of random access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), flash memory or other memory technology, compact disk read-only memory (CD-ROM), digital versatile disks (DVD) or

other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other non-transmission medium that can be used to store information for access by a computing device. As defined herein, computer-readable media does not include communication media, such as modulated data signals and carrier waves.

[0030] The network(s) 106, meanwhile, represents a backhaul network, which may itself comprise a wireless or a wired network, or a combination thereof. The network(s) 106 may be a collection of individual networks interconnected with each other and functioning as a single large network (e.g., the Internet or an intranet). Further, the individual networks may be wireless or wired networks, or a combination thereof.

[0031] The central office 104 may be implemented by one or more computing devices, such as servers, personal computers, laptop computers, etc. The one or more computing devices may be equipped with one or more processor(s) communicatively coupled to memory. In some examples, the central office 104 includes a centralized meter data management system which performs processing, analysis, storage, and/or management of data received from one or more of the nodes 102. For instance, the central office 104 may process, analyze, store, and/or manage data obtained from a smart utility meter, sensor, control device, router, regulator, server, relay, switch, valve, and/or other nodes. Although the example of FIG. 1 illustrates the central office 104 in a single location, in some examples the central office 104 may be distributed amongst multiple locations and/or may be eliminated entirely (e.g., in the case of a highly decentralized distributed computing platform).

[0032] FIG. 2 illustrates an example environment 200 for broadcasting data from a broadcasting node 202 to one or more neighboring nodes 204A and 204B. The nodes 202-204 may be similar to or the same as the nodes 102 in FIG. 1. The neighboring nodes 204A and 204B may be located within a predetermined proximity to the broadcasting node 202 such that the broadcasting node 202 may communicate with the neighboring nodes 204A and 204B. Although the following description refers to the node 202 as a broadcasting node and the nodes 204A and 204B as nodes that receive the broadcast data, it should be understood that many nodes can function as both a broadcasting node and a receiving node as needed.

[0033] In some instances, the broadcasting techniques described below refer to various layers of the nodes 202, 204A, and 204B that may be based at least in part on the Open Systems Interconnection (OSI) Model or the like. In the OSI Model, the nodes 202, 204A, and 204B may each include a plurality of layers, such as a Physical Layer, a Data Link Layer, and one or more additional layers. In particular implementations, the Data Link Layer includes a Media Access Control (MAC) sub-layer implementing various functionality. Although the following description refers to specific layers for implementing various

functionality, it should be appreciated that the functionality described below may be otherwise implemented by the nodes 202, 204A, and 204B.

[0034] In the example of FIG. 2, a MAC sub-layer of the broadcasting node 202 may receive a command from another layer of the broadcasting node 202 requesting to broadcast data. The command may be received from an upper layer of the broadcasting node 202, that is, a layer that is further removed from a physical layer of the broadcasting node 202 than the MAC sub-layer. In some embodiments, the command may request that the data be broadcast with a specific modulation technique and/or at a data rate. While in other embodiments, the command merely requests that the data be broadcast.

[0035] After receiving the command, the MAC sub-layer of the broadcasting node 202 may determine a particular data channel from among multiple data channels. The determination may be based at least in part on a list of available data channels that are currently available for communication. The list of available data channels may be maintained in memory of a node (e.g., node 202, 204A, and/or 204B) and may be updated based at least in part on communications received from one or more other nodes indicating that a channel may be busy (e.g., utilized for communication) for a period of time. In FIG. 2, the data channel M represents the data channel that is determined for broadcasting the data. In the architecture 100 of FIG. 1, the determination of the particular data channel may be performed by the channel determination module 124.

[0036] The broadcasting node 202 may additionally, or alternatively, determine a particular modulation technique and/or data rate to be utilized for broadcasting the data. When a modulation technique and/or data rate are specified in a command received from an upper layer of the broadcasting node 202, the specified modulation technique and/or data rate are selected for broadcasting the data. However, when a modulation technique and/or data rate are not specified in the command, then the MAC sub-layer of the broadcasting node 202 may determine a modulation technique and/or data rate to be utilized for broadcasting the data. The determination may be based at least in part on capabilities of the nodes 202, 204A, and/or 204B.

[0037] As noted above, the nodes 202, 204A, and/or 204B may comprise different generations and/or types of nodes, such as smart utility meters, sensors, control devices, transformers, routers, servers, relays, switches, valves, or a combination thereof. In this case, the nodes 202, 204A, and/or 204B may employ or be capable of employing different modulation techniques and/or data rates. Such capabilities (e.g., modulation techniques, data rates, etc.) may be determined based on, for example, a previous communication from one or more of the nodes 202, 204A, and/or 204B, other nodes, a central office, and/or other devices.

[0038] Accordingly, in some instances, the broadcasting node 202 may leverage these capabilities by deter-

mining a modulation technique and/or data rate that is common to the nodes 202, 204A, and/or 204B from among a plurality of modulation techniques and/or data rates that are available. The broadcasting node 202 may determine a modulation technique and/or data rate that provides a longest communication range, provides a maximum data rate, and/or is less susceptible to interference from among modulation techniques and/or data rates that are available and/or common to the nodes 202, 204A, and/or 204B.

[0039] After determining the particular data channel, modulation technique, and/or data rate, the broadcasting node 202 may transmit (e.g., an RF broadcast) a PTB message on a control channel. As noted above, the PTB message may indicate the particular data channel, modulation technique, and/or data rate determined to be utilized to broadcast the data. In addition, the PTB message may include a data ID identifying the data to be broadcast.

[0040] The PTB message may be transmitted to one or more neighboring nodes that are listening on the control channel (e.g., the nodes 204A and/or 204B). In some examples, the PTB message is transmitted with the same modulation technique and/or at the same data rate that will be utilized for broadcasting the data. Furthermore, in some examples, the PTB message is transmitted by utilizing an access method, such as the carrier sense multiple access with collision avoidance (CSMA/CA) method. In the example architecture 100 of FIG. 1, the communication module 126 may cause the PTB message to be transmitted.

[0041] In some implementations, the PTB message is transmitted when the PTB message is shorter in length than the data to be broadcast. That is, the PTB message may be transmitted if it includes fewer bits and/or bytes than the data. In such circumstances, a broadcasting node may confirm that the PTB message is shorter in length before transmitting the PTB message. If a number of bits or bytes of the data is greater than or equal to a number of bits or bytes of the PTB message, then the broadcasting node may proceed to transmit the PTB message. When the PTB message is not shorter in length than the data, then the data may be directly transmitted on a control channel and/or data channel without transmitting a PTB message.

[0042] Meanwhile, the one or more neighboring nodes listening on the control channel (e.g., the nodes 204A and/or 204B) may receive the PTB message and determine whether the data has been previously received. In some instances, the one or more neighboring nodes each include a list of data IDs corresponding to data (e.g., data packets) that have been previously received by the node. The list of data IDs may be included in a table. Here, the one or more neighboring nodes may each compare a data ID provided in the PTB message with the list of data IDs. When the comparison indicates that the data ID of the PTB message is not included in the list, then the one or more neighboring nodes may determine that the data to be broadcast has not been previously received. In the

architecture 100 of FIG. 1, the data determination module 130 may determine whether data has been previously received.

[0043] When the data has not been previously received, the one or more neighboring nodes may switch to the particular data channel and begin listening for the data. When the data has been previously received, the one or more neighboring nodes may continue listening on the control channel for other messages. In the architecture 100 of FIG. 1, the communication module 126 may cause the radio 108 to tune the particular data channel.

[0044] The broadcasting node 202 may switch to the particular data channel after transmitting the PTB message. The broadcasting node 202 may then begin broadcasting (e.g., transmitting) the data over the particular data channel based at least in part on the modulation technique and/or data rate previously determined for broadcasting the data. In some instances, the data is broadcast after a predetermined time interval has expired since the PTB message was transmitted. The predetermined time interval may comprise a Short Inter-Frame Space (SIFS) defined by, for example, the IEEE 802.11 and/or 802.15 standard. After the data has been broadcast, the broadcasting node 202 may switch back to the control channel. In the architecture 100 of FIG. 1, the communication module 126 may cause switching (i.e., a change in a tuned frequency) to and from the particular data channel and cause the data to be broadcast.

[0045] The one or more neighboring nodes (e.g., the nodes 204A and/or 204B) may listen on the particular data channel for the data. In some instances, the one or more neighboring nodes may each receive the data over the particular data channel by utilizing the modulation technique and/or data rate specified in the PTB message. The one or more neighboring nodes may each switch back to the control channel after the data has been received. In other instances, the one or more neighboring nodes may not receive the data after a predetermined time period has expired (e.g., a timeout period), and may switch back to the control channel after the predetermined time period has expired.

[0046] As noted above, in some instances, the data is broadcast without receiving any communication from one or more neighboring nodes. For example, the broadcasting node 202 may broadcast the data without knowing whether the one or more neighboring nodes are available to receive the broadcast. That is, the data may be broadcast without exchanging a request-to-send (RTS) message and/or a clear-to-send (CTS) message between the broadcasting node 202 and the one or more neighboring nodes. Additionally, or alternatively, after the data has been broadcast, the broadcasting node 202 may switch back to the control channel without receiving an acknowledgement message from the one or more neighboring nodes indicating that the data was received. The RTS, CTS, and/or acknowledgement messages may be defined in part by a standard, such as the IEEE 802.11

and/or IEEE 802.15 standard.

[0047] In some implementations, the data broadcasting process is repeated a number of times. That is, the PTB message is retransmitted a number of times and the data is rebroadcast after each retransmission of the PTB message. The number of times may be specified by a layer, such as a MAC sub-layer or an upper layer of a node (e.g., a layer above the MAC sub-layer). In instances where the upper layer specifies the number of times to rebroadcast the data, this number may take priority over a number determined and/or specified by the MAC sub-layer. This rebroadcasting process may provide another opportunity for one or more neighboring nodes to receive the PTB message and/or the data, which may not have been received due to, for example, interference and/or a communication that involved the one or more neighboring nodes while the PTB message and/or data was previously transmitted.

EXAMPLE BROADCASTING WITH FREQUENCY HOPPING

[0048] FIG. 3 illustrates an example frequency hopping process 300 which may be utilized in broadcasting data in a multi-channel network. Frequency hopping generally includes the sequential tuning, by one or more nodes, of one or more channels (e.g., a control channel and/or data channel(s)) as a function of time. Moreover, a control channel may be repeatedly redefining from a first channel (e.g., first RF frequency range) at a particular time to a second channel (e.g., second RF frequency range) at a different time, and so on. Because the timing of the hopping is synchronized, nodes are able to move between channels in a harmonized manner—e.g., tuning a same data channel at a same time, transmitting/receiving data for a same period of time, and then tuning a same control channel frequency at the same time, etc.

[0049] To illustrate, in FIG. 3 a control channel 302 is redefined as a function of time such that the control channel 302 is located at a channel 1 at a time t_0 , at a channel 3 at a time t_1 , and at a channel M-1 at a time t_2 . When the control channel 302 is located at a particular channel, then the other channels may comprise data channels. As illustrated, each of the channels 1-M is defined by a frequency range. For instance, the channel 1 is defined between a frequency f_0 and f_1 .

[0050] The example frequency hopping of FIG. 3 may be associated with a frequency hopping sequence. This sequence may be transmitted to one or more nodes of a network that may utilize the channels 1-M. In some instances, the sequence is transmitted from a particular node in the network that will initiate the frequency hopping. The particular node may comprise, for example, a coordinator of the network, such as a PAN coordinator.

[0051] It should be appreciated that the frequency hopping process 300 illustrated in FIG. 3 is an exemplary process, and that the frequency hopping process 300 may be implemented in other manners and/or based on

other hopping sequences. For example, although the frequency hopping of FIG. 3 utilizes a hopping sequence that hops the control channel 302 from channel 1 to channel 3, and then from channel 3 to channel M-1, a different hopping sequence may be utilized to hop the control channel 302 to any of the channels 1-M in any order.

[0052] In one implementation, a node wishing to broadcast data may perform a number of data broadcasts over a number of channel hops. For example, when the control channel 302 is defined at channel 1, the node may transmit a PTB message over the control channel 302 indicating that data will be broadcast on a particular data channel (e.g., any of channels 2-M). The node may then switch (e.g., tune) to the particular data channel and broadcast the data over the particular data channel.

[0053] Thereafter, the node may repeat the data broadcasting process when the control channel 302 is defined at channel 3. That is, when the control channel 302 is located at channel 3, the node may transmit another PTB message over the control channel 302 indicating that the same data will be broadcast on a particular data channel (e.g., any of channels 1, 2, or 4-M). The node may then switch (e.g., tune) to the particular data channel and broadcast the same data over the particular data channel. The data broadcasting process may be repeated any number of times specified by a layer, such as a MAC sub-layer or an upper layer of the node. Between each rebroadcast, the control channel 302 and/or data channel may be frequency hopped to different channels.

[0054] In some instances, this rebroadcasting process may allow the PTB message and/or data to be retransmitted on a different channel than that utilized in a previous transmission. In such instances, this may provide another opportunity for one or more neighboring nodes to receive a PTB message and/or data, which may not have been received due to, for example, interference on a channel utilized in the previous transmission.

EXAMPLE PREPARE-TO-BROADCAST PROTOCOL DATA UNIT

[0055] FIG. 4 illustrates an example prepare-to-broadcast (PTB) protocol data unit (PDU) 400 which may be transmitted in a multi-channel network. This frame example is based on the frame format described in 802.15.4 standard. The term PDU is used to herein to refer generally to any communication, message, or transmission within a communication network, such as that shown in FIG. 1. The term PDU is based, at least in concept, on the OSI Model and may comprise, for example, a bit, a frame, a packet, a segment, etc. In the example of FIG. 4, the prepare-to-broadcast PDU 400 is illustrated in the form of a frame.

[0056] In some instances, one or more layers of the OSI model may be utilized to transmit one or more PDUs between nodes. For example, the data link layer of the OSI model may be utilized to transmit a PDU between two or more of the nodes 102 in the architecture 100. In

particular implementations, the MAC sub-layer of the data link layer may be utilized to transmit a PDU between two or more of the nodes 102. Further, in some implementations, an access method may be utilized to transfer PDUs, such as the carrier sense multiple access with collision avoidance (CSMA/CA) method.

[0057] As discussed above, the PTB frame 400 may be used to inform neighboring nodes that a node wishes to broadcast data. The PTB frame 400 will be described with reference to the example network of architecture 100 of FIG. 1. However, the example PTB frame 400 is not limited to use with the example architecture 100, and may be implemented using other architectures and devices.

[0058] As shown in FIG. 4, the PTB frame includes the following fields: frame control (FC), sequence number, destination personal area network (PAN) identifier, destination address, source PAN identifier, source address, auxiliary security header, payload, and frame check sequence (FCS). Details of the foregoing fields of the 802.15.4-based PTB frame other than the payload are well known to those skilled in the art and are not described in detail herein. The payload of the PTB frame, however, is customized to implement the broadcasting techniques described above, as well as other functionalities. The payload may be variable in size and may include, for example, one or more of the following fields:

- Type: This field indicates a type of the frame, e.g., RTS, CTS, etc. In the example of FIG. 4, this field indicates that the frame is a PTB frame.
- HW: This field indicates a modulation technique and/or data rate that are determined at a broadcasting node and that will be utilized to broadcast data.
- Duration: This field indicates a total expected time for transmitting data frame(s) specified in the PTB frame. The duration may include time to transmit the specified data frames, waiting times such inter-frame spacing (IFS) (e.g., SIFS, DIFS, etc.) between frames, and acknowledgment (ACK) or non-acknowledgement (NACK) responses. The duration field may be used to determine a duration that a node will be busy communicating with another node and therefore unavailable to receive.
- Channel: This field indicates a data channel that will be utilized to broadcast data.
- Data Rate (DR) parameters: This field indicates a data rate to be utilized to broadcast data.
- Data_ID: This field includes an ID of a data PDU (e.g., data packet) to be broadcast. This field may be utilized to, for example, determine if the data PDU to be broadcast has been previously received at a node receiving the PTB frame.

EXAMPLE PROCESSES

[0059] FIGS. 5-6 illustrate example processes 500 and 600 of transmitting or receiving a PTB message over a

control channel indicating that data will be broadcast on a particular data channel and broadcasting or receiving the data over the particular data channel. In FIG. 5, the process 500 may be performed by a node that will transmit a PTB message and/or data. While in FIG. 6, the process 600 may be performed by a node that will receive the PTB message and/or data. However it should be understood that every node can function as both a broadcasting node and a receiving node as needed.

[0060] The processes 500 and 600 (as well as each process described herein) are illustrated as a logical flow graph, each operation of which represents a sequence of operations that can be implemented in hardware, software, or a combination thereof. In the context of software, the operations represent computer-executable instructions stored on one or more computer-readable storage media that, when executed by one or more processors, perform the recited operations. Generally, computer-executable instructions include routines, programs, objects, components, data structures, and the like that perform particular functions or implement particular abstract data types. The order in which the operations are described is not intended to be construed as a limitation, and any number of the described operations can be combined in any order and/or in parallel to implement the process.

[0061] In FIG. 5, the process 500 is performed by a node that will broadcast data. At operation 502, a broadcasting node determines a particular data channel for broadcasting data. At 502, the broadcasting node may also determine a modulation technique and/or a data rate for broadcasting the data. Referring to the example of FIG. 1, the channel determination module 124 may perform the operation 502.

[0062] At operation 504, the broadcasting node transmits a message over a control channel indicating that the data will be broadcast on the particular data channel. The message may comprise a PTB message and may indicate the determined modulation technique and/or data rate to be utilized to broadcast the data. Referring to the example of FIG. 1, the communication module 128 may perform the operation 504.

[0063] At operation 506, the broadcasting node switches (e.g., tunes) to the particular data channel determined in the operation 502. Referring to the example of FIG. 1, the communication module 126 may perform the operation 506. At operation 508, the broadcasting node broadcasts the data over the particular data channel. The data may be broadcast based at least in part on the modulation technique and/or data rate determined in the operation 502. Referring to the example of FIG. 1, the communication module 126 may perform the operation 508.

[0064] At operation 510, the broadcasting node switches to the control channel by tuning a radio of the broadcasting node. The operation 510 may be performed after the data has been broadcast over the particular data channel. Referring to the example of FIG. 1, the communication module 126 may perform the operation 510.

[0065] At operation 512, the control channel and/or data channels are frequency hopped, i.e., their frequency ranges are redefined at periodic intervals. Although the process 500 includes performing the operation 512, in some instances the operation 512 is not performed. Referring again to the example of FIG. 1, the frequency hopping module 128 may perform the operation 512.

[0066] After the broadcasting node has sequentially tuned ("hopped between") the control channel and/or data channels, the broadcasting node may return to the operation 502 and perform the operations 502-512 again (e.g., retransmit PTB message and/or data). Here, the operations 502-512 may utilize, in part, the hopped control channel and/or hopped data channels. The operations 502-512 may be performed a number of times.

[0067] Meanwhile, in FIG. 6, the process 600 is performed by a node that may receive data that is broadcast. At operation 602, a receiving node receives a message over a control channel indicating that the data will be broadcast on a particular data channel. The message may comprise a PTB message and may indicate a modulation technique and/or data rate to be utilized to broadcast the data. Referring to the example of FIG. 1, the communication module 126 may perform the operation 602.

[0068] At operation 604, the receiving node determines whether the data has been previously received. The receiving node may utilize a data ID included in the PTB message to determine whether the data has been previously received. For example, the determination may be based on a comparison of the data ID in the PTB message with data IDs associated with previously received data (e.g., data packets). Referring again to the example of FIG. 1, the data determination module 130 may perform the operation 604 and determine if the data was previously received.

[0069] In some instances, when the data has not been previously received, the receiving node proceeds to operations 606, 608, and/or 610. At operation 606, the receiving node switches to the particular data channel by tuning a radio of the receiving node. At operation 608, the receiving node listens on the particular data channel for the data. At operation 610, the receiving node receives the data over the particular data channel. Referring to the example of FIG. 1, the communication module 126 may perform the operations 606, 608, and/or 610.

[0070] At operation 612, the receiving node switches to the control channel. In some instances, the operation 612 may be performed after the data has been received. In other instances, the operation 612 may be performed after a predetermined time period has expired since switching to the particular data channel. Here, the operation 610 may not be performed. Referring to the example of FIG. 1, the communication module 126 may perform the operation 612.

[0071] In an embodiment there is provided a method implemented in a multi-channel network having a control channel and a plurality of data channels, comprising:

under control of a node configured with computer-executable instructions:

transmitting or receiving, by the node, a message on the control channel indicating: (i) data will be broadcast on a particular data channel of the plurality of data channels, and (ii) a modulation technique of the broadcast;
switching, at the node, to the particular data channel based at least in part on the transmitted or received message;
broadcasting or listening for a broadcast of the data on the particular data channel based at least in part on the modulation technique; and
switching, at the node, to the control channel after the data has been broadcast or a predetermined time period has expired.

[0072] Optionally, the method further comprises:

determining the particular data channel, the modulation technique, and a data rate for broadcasting the data; and
confirming that a number of bits or bytes of the data is greater than a number of bits or bytes of the message, wherein the message indicates that the data will be broadcast on the determined particular data channel with the determined modulation technique and at the determined data rate if the number of bits or bytes of the data is greater than a number of bits or bytes of the message.

[0073] Optionally, the determining includes determining the modulation technique based at least in part on capabilities of other nodes located within a predetermined proximity to the node.

[0074] Optionally, the determined modulation technique comprises a modulation technique that provides a longest communication range from among a plurality of modulation techniques that are available to other nodes located within a predetermined proximity to the node.

[0075] Optionally, the method further comprises:

receiving, at a media access control sub-layer of the node and from another layer of the node, a command requesting to broadcast the data with the modulation technique, and
wherein the modulation technique indicated in the message comprises the modulation technique identified in the command.

[0076] Optionally, the broadcasting or listening for a broadcast of the data includes broadcasting or listening for a broadcast of the data after a predetermined time interval has expired since the message was transmitted or received on the control channel, the predetermined time interval comprising a short inter-frame space.

[0077] Optionally, transmitting or receiving the message includes transmitting the message on the control channel, and

broadcasting or listening for a broadcast of the data includes broadcasting the data on the particular data channel.

[0078] Optionally, transmitting or receiving the message includes receiving the message on the control channel,

broadcasting or listening for a broadcast of the data includes listening for the broadcast of the data on the particular data channel.

[0079] Optionally, the method further comprises:

determining that the data has not been previously received, wherein the switching to the particular data channel includes switching to the particular data channel in response to determining that the data has not been previously received.

[0080] Optionally, the method further comprises:

receiving the data on the particular data channel after switching to the particular data channel, wherein the switching to the control channel includes switching to the control channel after receiving the data on the particular data channel.

[0081] In another embodiment, there is provided one or more computer-readable media storing the computer-executable instructions that, when executed by one or more processors of the node, configure the node to perform the method of any of the preceding embodiments.

[0082] In another embodiment, there is provided a network computing device of a multi-channel network having a control channel and a plurality of data channels, comprising:

one or more processors;
memory communicatively coupled to the one or more processors; and
one or more modules stored in the memory and executable on the one or more processors to perform acts including:

determining (i) a particular data channel from the plurality of data channels for broadcasting data, and (ii) a modulation technique for broadcasting the data;
transmitting a message over the control channel indicating that the data will be broadcast on the particular data channel according to the modulation technique, the data comprising a number of bits or bytes that is greater than a number of bits or bytes of the message;
switching to the particular data channel;
broadcasting the data over the particular data

channel based at least in part on the modulation technique; and
switching to the control channel after the data has been broadcast.

[0083] Optionally, the acts further include:

retransmitting the message over the control channel a predetermined number of times that is specified by an upper layer above a media access control sub-layer of the network computing device; and
rebroadcasting the data over the particular data channel after each retransmission of the message.

[0084] Optionally, the transmitting the message includes transmitting the message over the control channel which is located on a first channel of the network, and the acts further include:

redefining the control channel from the first channel to a second channel of the network; and
retransmitting the message over the control channel when the control channel is redefined to the second channel.

[0085] Optionally, the acts further include:

rebroadcasting the data over a data channel of the plurality of data channels after the control channel has been redefined to the second channel and the message has been retransmitted.

CONCLUSION

[0086] Although embodiments have been described in language specific to structural features and/or methodological acts, it is to be understood that the disclosure is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed herein as illustrative forms of implementing the embodiments.

Claims

1. A network computing device comprising:

one or more processors (118);
memory (120) communicatively coupled to the one or more processors; and
one or more modules stored in the memory (120) and executable by the one or more processors to perform acts comprising:

transmitting or receiving a message via a control channel indicating that data will be broadcast via a particular data channel of a plurality of data channels according to a

modulation technique, the message including fewer bits and/or bytes than the data;
switching to the particular data channel based at least in part on the message;
broadcasting or listening for a broadcast of the data via the particular data channel based at least in part on the modulation technique; and
switching to the control channel after the data has been broadcast or a predetermined time period has expired.

2. The network computing device of claim 1, wherein the acts further comprise:

determining the modulation technique based at least in part on capabilities of other nodes located within a predetermined proximity to the network computing device.

3. The network computing device of claim 1 or claim 2, wherein the modulation technique comprises a modulation technique that provides a longest communication range from among a plurality of modulation techniques that are available to other nodes located within a predetermined proximity to the network computing device.

4. The network computing device of any of claims 1-3, wherein the broadcasting or listening for a broadcast of the data comprises broadcasting the data, without having received a communication from a neighboring node that indicates an availability of the neighboring node to receive the data.

5. The network computing device of any of claims 1-4, wherein the data comprises consumption data of one or more resources.

6. The network computing device of any of claims 1-5, wherein the switching to the control channel comprises switching to the control channel without having received an acknowledgement message indicating that the data was received.

7. The network computing device of any of claims 1-6, wherein the acts further comprise:

determining that the data has not been previously received based at least in part on a data identifier in the message that identifies the data that will be broadcast;
wherein the switching to the particular data channel comprises switching to the particular data channel in response to determining that the data has not been previously received.

8. A method implemented in a multi-channel network

having a control channel and a plurality of data channels, comprising:

under control of a node configured with computer-executable instructions:

determining that a number of bits or bytes of data to be broadcast is greater than a number of bits or bytes of a message;
transmitting (504) the message via the control channel based at least in part on determining that the number of bits or bytes of the data is greater than the number of bits or bytes of the message, the message indicating that the data will be broadcast on a particular data channel of the plurality of data channels;
switching (506) to the particular data channel;
broadcasting (508) the data via the particular data channel; and
switching (510) to the control channel after the data has been broadcast.

9. The method of claim 8, further comprising:

determining a modulation technique for the broadcasting based at least in part on capabilities of other nodes located within a predetermined proximity to the node.

10. The method of claim 9, wherein the modulation technique comprises a modulation technique that provides a longest communication range from among a plurality of modulation techniques that are available to other nodes located within a predetermined proximity to the node.

11. The method of any of claims 8-10, wherein the data is broadcast after a predetermined time interval has expired since the message was transmitted via the control channel, the predetermined time interval comprising a short inter-frame space.

12. The method of any of claims 8-11, further comprising:

retransmitting the message via the control channel a predetermined number of times; and
rebroadcasting the data over the particular data channel after each retransmission of the message.

13. The method of any of claims 8-12, wherein the data comprises consumption data of one or more resources.

14. The method of any of claims 8-13, wherein the

switching to the control channel comprises switching to the control channel without having received an acknowledgement message indicating that the data was received.

15. One or more computer-readable media storing the computer-executable instructions that, when executed by one or more processors of the node, configure the node to perform the method of any of claims 8-14.

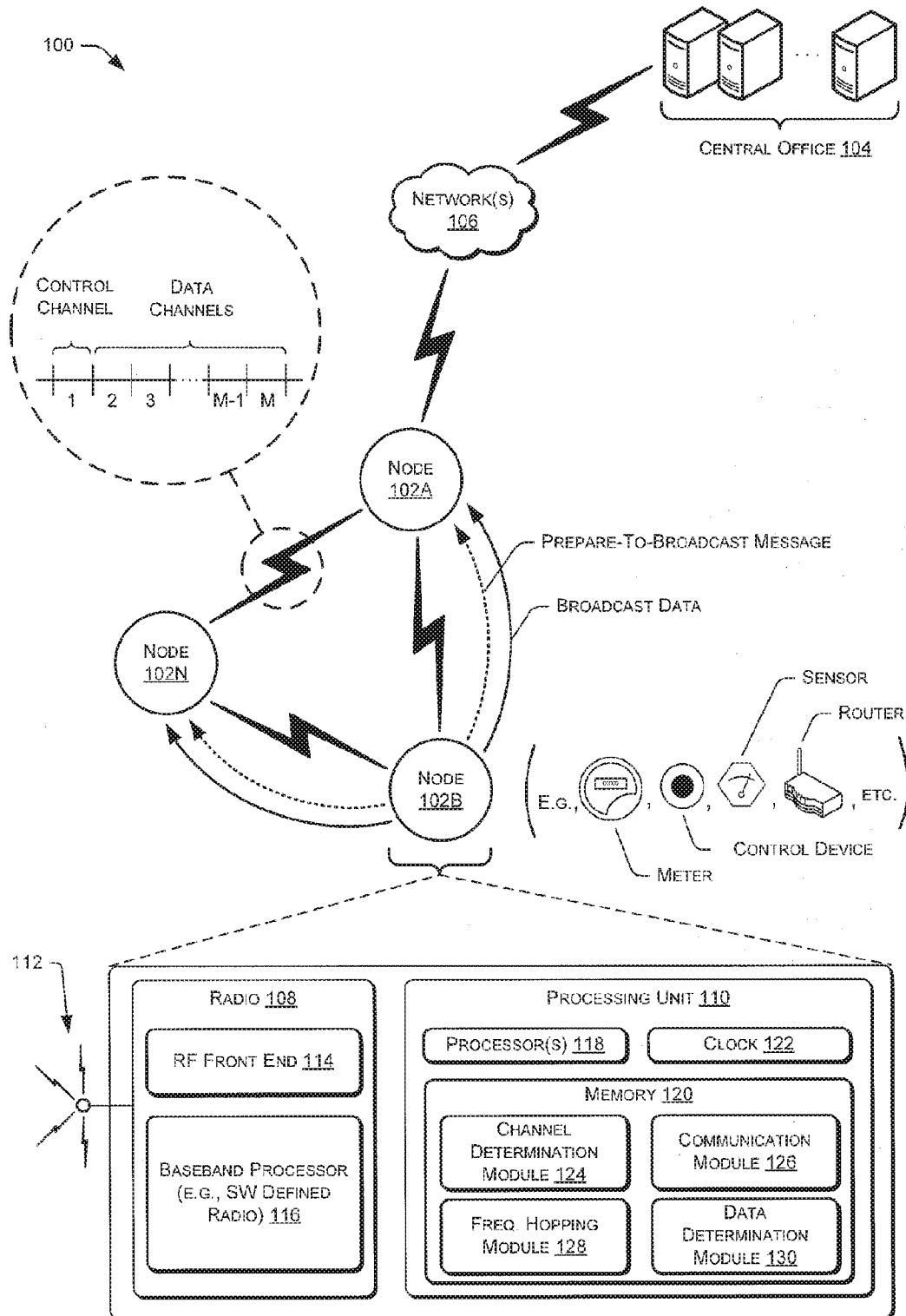
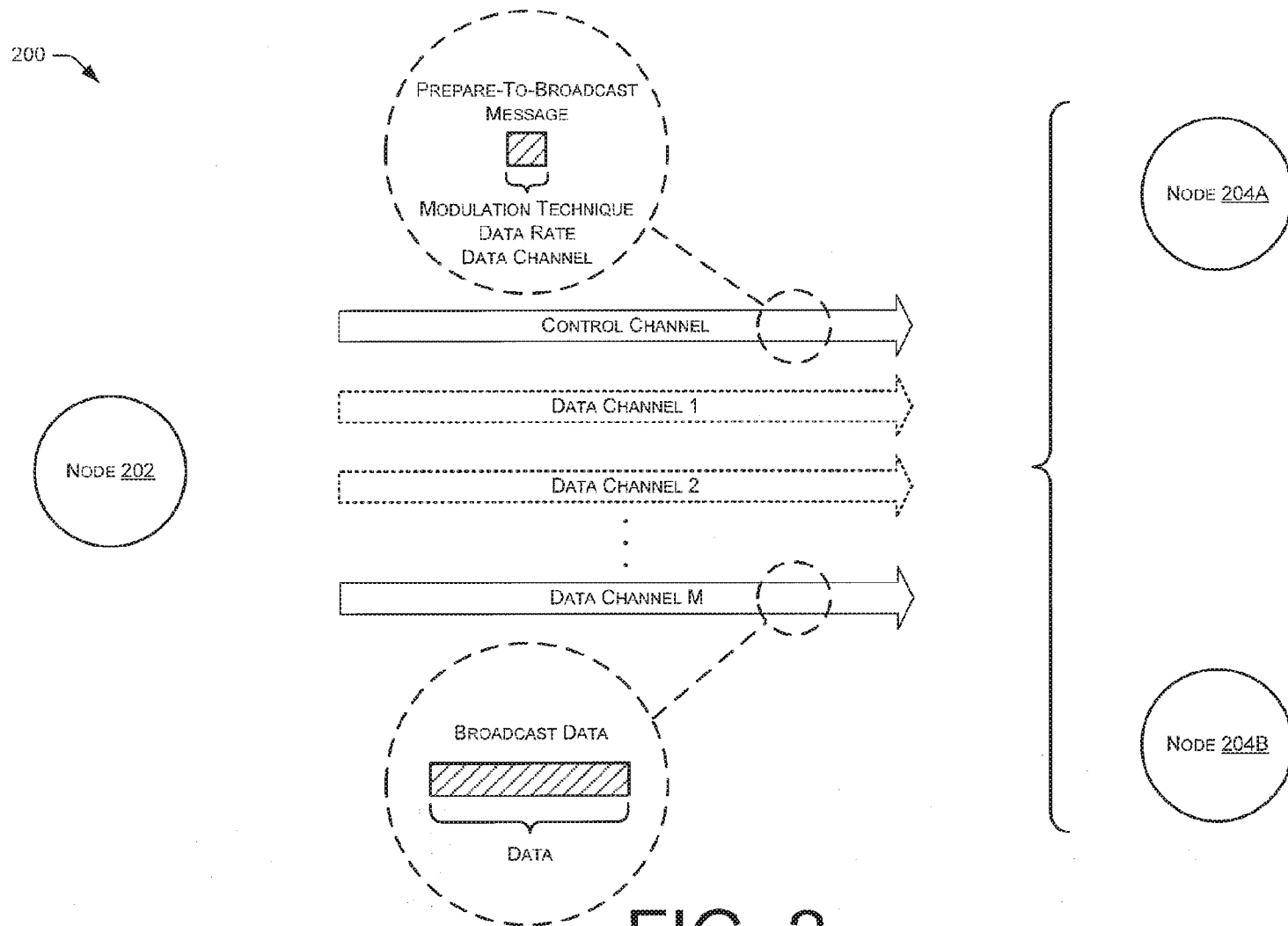


FIG. 1



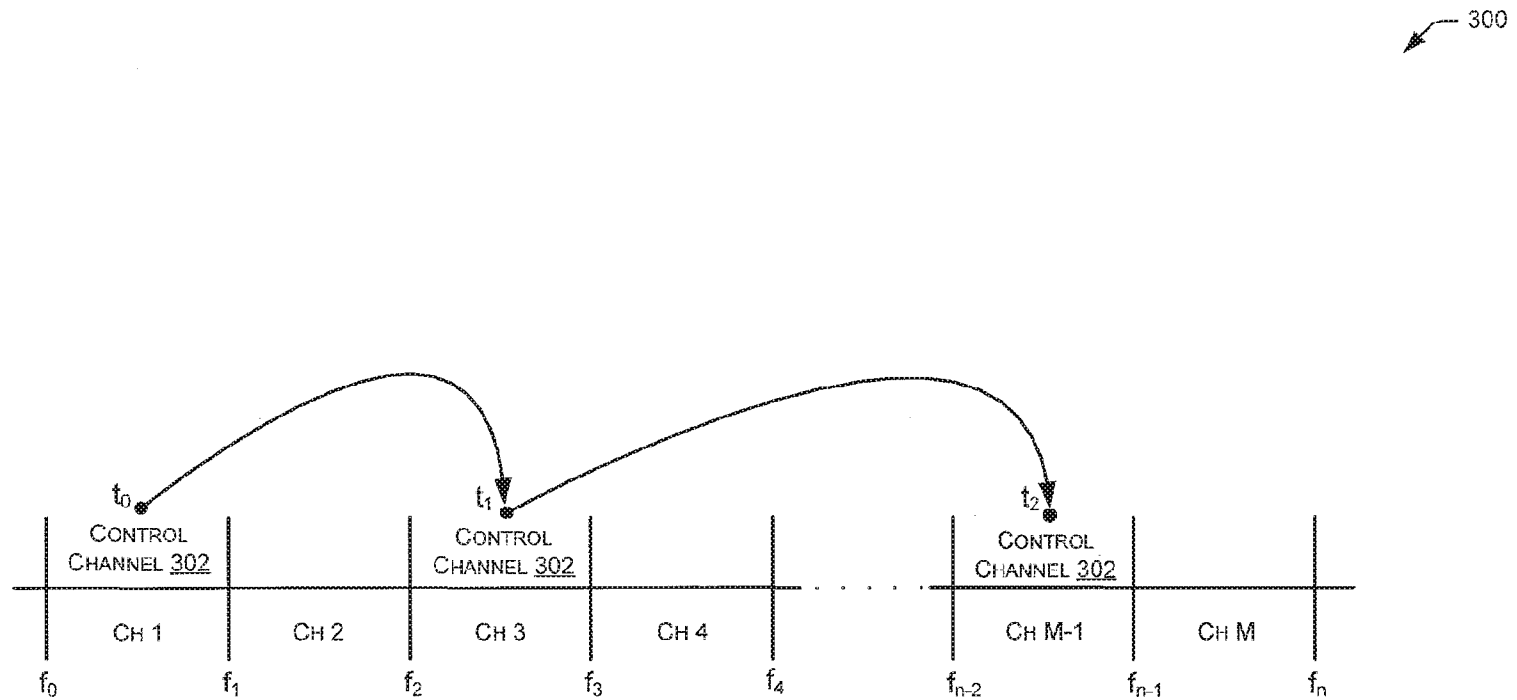


FIG. 3

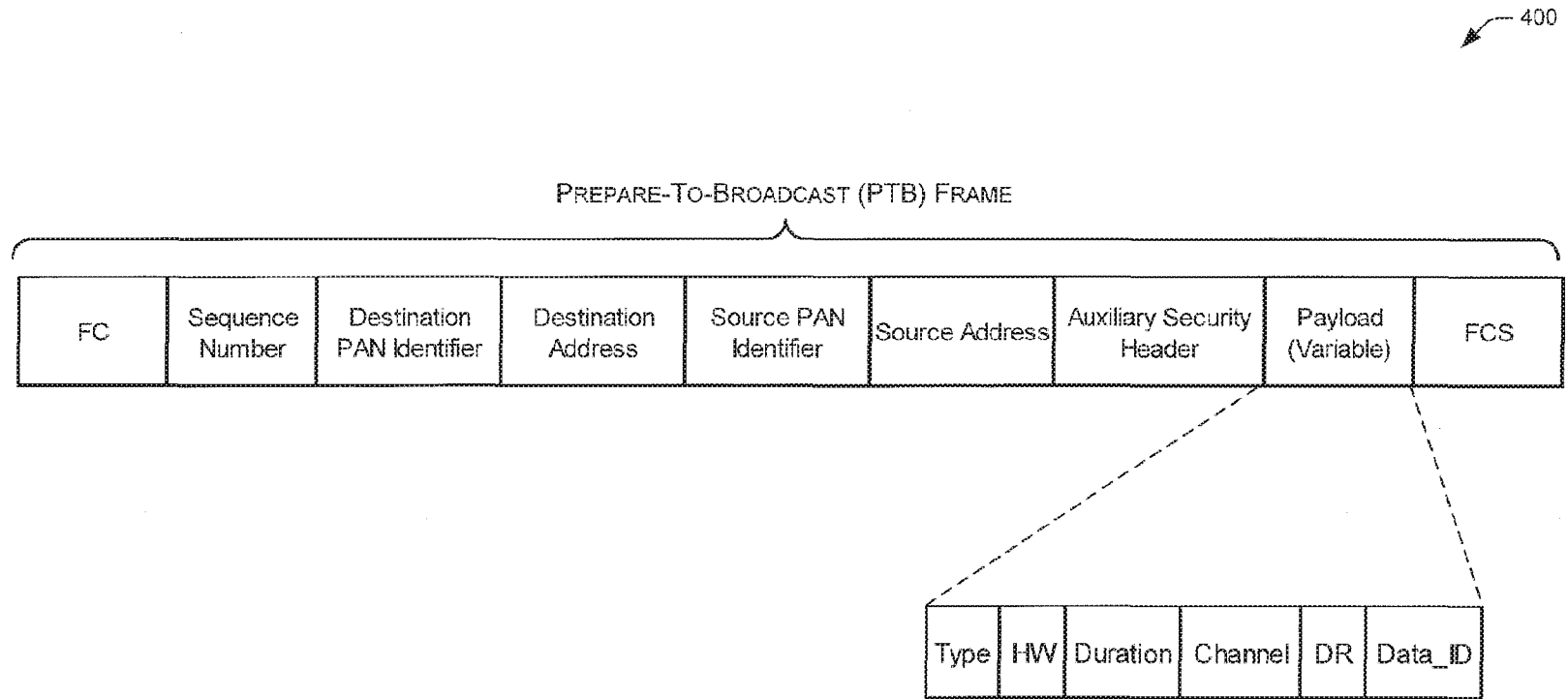


FIG. 4

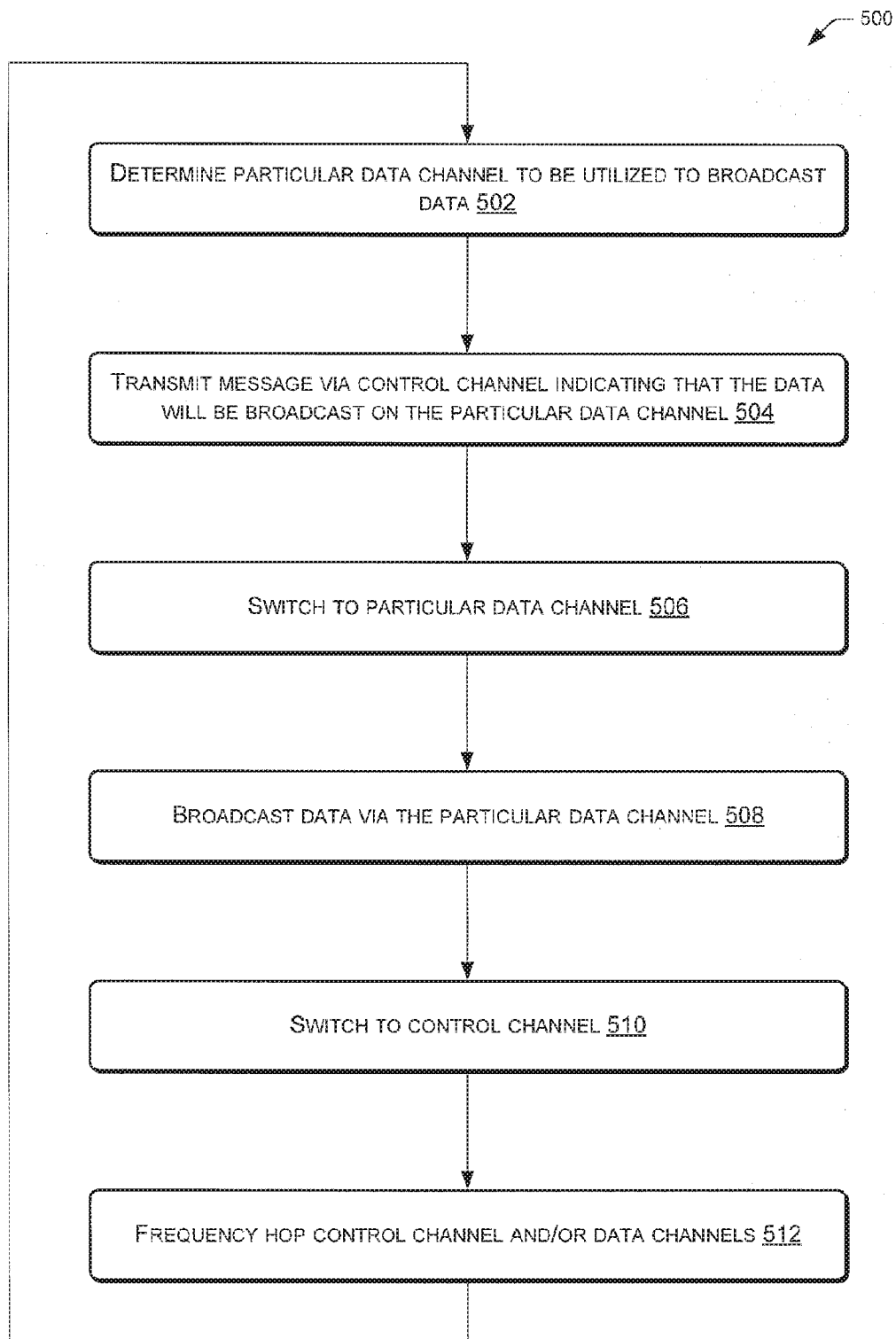


FIG. 5

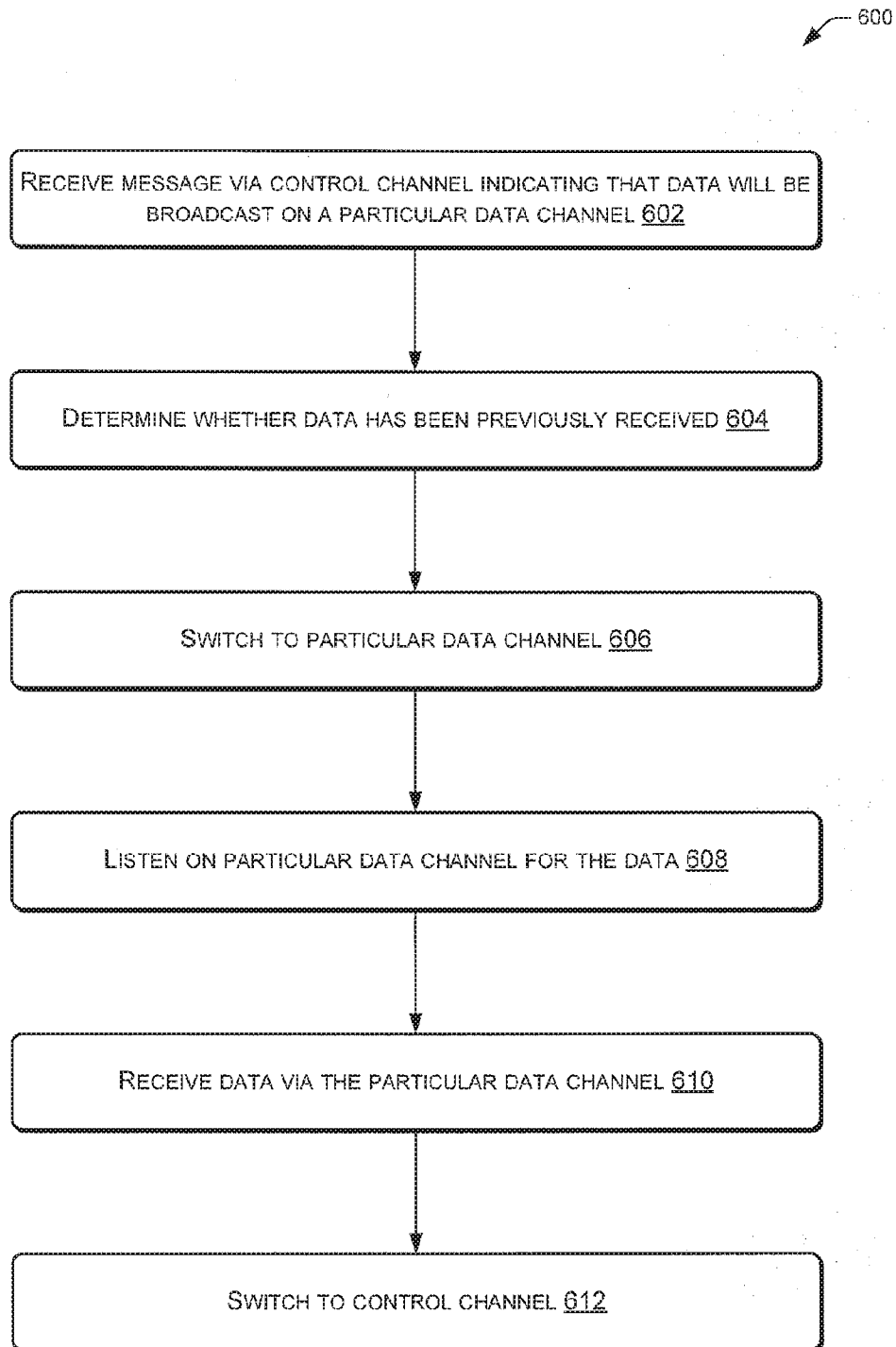


FIG. 6



EUROPEAN SEARCH REPORT

 Application Number
 EP 14 18 6014

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2008/144493 A1 (YEH CHI-HSIANG [CA]) 19 June 2008 (2008-06-19) * the whole document *	1-15	INV. H04W74/08 H04W72/12
X	US 2011/158110 A1 (STACEY ROBERT [US] ET AL) 30 June 2011 (2011-06-30) * the whole document *	1-15	
A	EP 2 384 078 A1 (ALCATEL LUCENT [FR]) 2 November 2011 (2011-11-02) * paragraph [0026] *	5	
A	US 2008/144500 A1 (CHEN YE [US] ET AL) 19 June 2008 (2008-06-19) * paragraph [0007] *	8-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			H04W
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 26 January 2015	Examiner Schneider, Gernot
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EPC FORM 1503 (3.02) (PDA/C01)

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EPC FORM P459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82



Espacenet

Bibliographic data: CN104703193 (A) — 2015-06-10

Mesh network deployment method and mesh network deployment device

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Classification: - international: **H04W16/18**
- cooperative: **H04W16/18 (CN)**

Application number: CN201510131542 20150325 Global Dossier

Priority number (s): CN201510131542 20150325

Also published as: CN104703193 (B)

Abstract of CN104703193 (A)

The invention provides a mesh network deployment method and a mesh network deployment device. The method comprises the steps of selecting a wireless network position m where no access point (AP) is deployed yet by a network deployment unit according to pre-planned wireless network positions for deploying the APs, randomly selecting an AP m from the non-deployed APs, determining the neighbor position list of the position m according to a pre-planned neighbor relation of the wireless network positions, for any neighbor position of the position m, determining whether the AP is already deployed in the neighbor position, and if so, instructing the network deployment personnel to contact the AP m with the AP in the neighbor position, so that the two APs can learn the MAC addresses of each other and add the MAC addresses of each other to own neighbor AP lists, and instructing the network deployment personnel to deploy the AP m to the position m after contacting. According to the mesh network deployment method, the speed and the accuracy of Mesh network deployment are improved.

Notice

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DESCRIPTION CN104703193

The present application proposes a grid network deployment method and apparatus. The method includes: the network deployment unit selects a wireless network location m of the AP that has not yet deployed the AP according to the pre-planned wireless network location where the access point AP is to be deployed; and selects an AP m from the AP that has not yet been deployed; according to the pre-planned A neighbor relationship between each wireless network location, determining a neighbor location list of the location m ; determining, for any neighbor location of the location m , whether an AP has been deployed on the neighbor location, and if so, instructing the network deployment personnel to associate the AP m with the neighbor The AP in the location touches, so that both APs learn the MAC address of the other party, add the MAC address of the other party to the neighbor AP list, and instruct the network deployment personnel to deploy the AP m after the collision. Go to position m . This application improves the speed and accuracy of Mesh network deployment.

Grid network deployment method and device

Technical field

The present application relates to the field of network planning and deployment technologies, and in particular, to a Mesh (mesh) network deployment method, device, and AP (Access Point).

Background technique

A mesh network is a mesh network formed by establishing a wireless connection between an AP and an AP. In a place where the wired network is inconvenient, this networking mode is usually adopted, so that the wireless

WiFi network has a larger coverage and a longer extension. However, compared with the traditional FAT (fat) AP or AC (Access Controller) + FIT (thin) AP network, Mesh network formation is more complicated, time-consuming and laborious. One of the reasons is because the AP and the AP are connected by wireless, and the wireless network signal is affected by the interference signal. If the APs select the neighbor with the strongest signal according to the signal strength of the neighbor, the Mesh network The mesh topology is constantly changing, which is not conducive to the stability of the network.

Therefore, in the actual application process, in order to prevent network topology flapping, in the initial stage of deployment of the mesh network, network planning is usually required, and network deployment is performed according to the network planning.

The existing Mesh network planning content mainly includes:

1)

Record the MAC (Media Access Control) address of each AP;

2)

Plan the wireless network location where APs can be deployed, and set them as: location 1, location 2, location 3, ..., location n;

3)

Planning the neighbor relationship between each wireless network location in 2);

For example, if there are four wireless network locations where APs can be deployed, which are labeled as Location 1, Location 2, Location 3, and Location 4, the neighbor relationship between the four locations is planned as follows:

The neighbors in position 1 are: position 2, position 4;

The neighbors in position 2 are: position 1, position 3;

The neighbors in position 3 are: position 2, position 4;

The neighbors in position 4 are: position 1, position 3.

4)

Plan the wireless network location of each AP.

For example, if there are a total of n wireless network locations that can be deployed in the planned AP, they are marked as: location 1, location 2, location 3, ..., location n , and there are a total of n APs:

Select one AP from any of the n APs, set it to AP 1, and plan AP 1 to position 1.

Select one AP from the remaining $n-1$ APs, set it as AP 2, and plan AP 2 to position 2;

Select one AP from the remaining $n-2$ APs, set it as AP 3, and plan AP 3 to position 3;

.....;

Select one AP from any of the remaining $n-m$ APs, set AP($m+1$), and plan AP($m+1$) to position $m+1$.

.....;

Set the last AP to AP n and plan to position n .

5)

According to the wireless network location planned for each AP in 4), record the correspondence between the MAC address of each AP and its location; and, according to the neighbor relationship between each wireless network location planned in 3), each is obtained. The neighbor AP list of the AP is configured with a neighbor AP list on each AP. The neighbor AP list contains the MAC address of each neighbor AP.

The existing Mesh network deployment process is as follows:

According to the correspondence between the MAC address of each AP recorded in 5) and its location, each AP is deployed to a corresponding wireless network location;

According to the neighbor AP list of each AP recorded in 5), for any AP, configure its neighbor AP list to the AP.

After the Mesh network is deployed, each AP establishes a neighbor relationship with its neighbor APs based on the neighbor AP list. After the neighbor relationship between the APs is established, the Mesh network is successfully established.

Summary of the invention

The present application provides a Mesh network deployment method, device, and AP to improve the deployment speed and accuracy of the Mesh network.

The technical solution of the present application is implemented as follows:

A Mesh network deployment method includes:

The network deployment unit selects a wireless network location of the AP that has not been deployed according to the pre-planned wireless network location of the AP to be deployed, and sets the location to m , $1 \leq m \leq n$, where n is the total number of wireless network locations where the AP is to be deployed;

The network deployment unit arbitrarily selects an AP from the AP that has not been deployed, and sets it as AP m , and determines that the AP m is to be deployed to the location m .

The network deployment unit determines a neighbor location list of the location m according to a pre-planned neighbor relationship between each wireless network location;

For any neighbor location of the location m , the network deployment unit determines whether the AP has been deployed on the neighbor location, and if so, instructs the network deployment personnel to touch the AP m with the AP at the neighbor location, so that the two APs are in the When detecting that the RSSI value of the beacon signal from the other party is greater than the preset first threshold, learn the MAC address of the other party from the beacon signal from the other party, and add the MAC address of the other party to the list of neighbor APs, and indicate the network. The deployer deploys the AP m to location m after the touch.

A Mesh network deployment method includes:

The first AP is powered on, and the automatic neighbor adding mode is started. When receiving the beacon signal sent by other APs, the RSSI value of the signal is detected.

The first AP determines whether the RSSI value is greater than a preset first threshold. If the value is greater than, the MAC address of the other AP is read from the beacon signal, and the MAC address of the other AP is already in the neighbor AP list. If it does not exist, add the MAC address of the other AP to its neighbor AP list.

The first AP is an AP to be deployed to a wireless network location m in the Mesh network, where $1 \leq m \leq n$, where n is the total number of wireless network locations where the AP is to be deployed;

The other AP is an AP that has been deployed in the Mesh network and whose location is pre-planned as the neighbor location of the location m .

Moreover, when the first AP is to be deployed to the wireless network location m , the first AP is instructed by the network deployment unit to instruct the network deployment personnel to touch the first AP with each neighbor AP that has been deployed to the Mesh network.

A Mesh network deployment device includes:

Location and AP selection module: According to the pre-planned wireless network location of the AP to be deployed, select a wireless network location where the AP has not been deployed, and set the location m , $1 \leq m \leq n$, where n is the wireless network location where the AP is to be deployed. Total number; select one AP from the AP that has not yet been deployed, set it to AP m , and determine that AP m should be deployed to

location m;

The deployment indication module: determining a neighbor location list of the location m according to the neighbor relationship between the pre-planned wireless network locations; determining, for any neighbor location of the location m, whether the AP has been deployed in the neighbor location, and if yes, indicating the network The deployer touches the AP m with the AP at the neighbor location, so that the two APs learn from the beacon signal from the other party when detecting that the RSSI value of the beacon signal from the other party is greater than a preset first threshold. The MAC address of the other party is added to the neighbor's AP list, and the network deployer is instructed to deploy the AP m to the location m after the touch.

An AP is located in a mesh network, where the AP is an AP that is to be deployed to a wireless network location m in the mesh network, $1 \leq m \leq n$, where n is the total number of wireless network locations where the AP is to be deployed, and when the AP wants When being deployed to the wireless network location m, the AP is instructed by the network deployment unit to contact the neighboring APs that have been deployed to the Mesh network, and the AP includes:

The signal strength detection module: when the AP is powered on, the automatic neighbor addition mode is activated. When receiving the beacon signal sent by other APs, the RSSI value of the signal is detected, and the other APs are deployed in the Mesh network. And the location where the location is pre-planned as the AP of the neighbor location of the location m;

The neighbor list maintenance module is configured to determine whether the RSSI value is greater than a preset first threshold. If the value is greater than, the MAC address of the other AP is read from the beacon signal, and it is determined whether the MAC address of the other AP exists in the If the neighboring AP list does not exist, the MAC address of the other AP is added to its neighbor AP list.

It can be seen that, in the present application, it is only necessary to pre-plan the wireless network location of the AP to be deployed and the neighbor relationship between the wireless network locations, without recording the correspondence between the AP's MAC address and the wireless network location, and the AP's neighbor AP is not required. The list is pre-configured on the AP; when deploying the Mesh network, you only need to select one AP from the AP that has not been deployed to deploy to any wireless network location where the AP has not been deployed, and only need to be based on the wireless network location. The location of the neighboring network, prompting the network deployer to set the AP on the AP to the AP in the neighboring location where the AP is deployed, so that the AP can automatically add the MAC address of the neighboring AP, which improves the deployment speed and accuracy of the mesh network. And ensure the success of the mesh network networking.

DRAWINGS

FIG. 1 is a flowchart of a method for deploying a mesh network according to an embodiment of the present application;

2 is a flowchart of a method for deploying a mesh network according to another embodiment of the present application;

FIG. 3 is a flowchart of a Mesh network planning method according to an embodiment of the present application;

4 is a flowchart of a method for deploying a mesh network according to another embodiment of the present application;

FIG. 5 is a flowchart of a method for deploying a mesh network according to another embodiment of the present application;

FIG. 6 is a flowchart of error correction processing of a Mesh network deployment according to an embodiment of the present application;

FIG. 7 is a schematic structural diagram of a Mesh network deployment apparatus according to an embodiment of the present disclosure;

FIG. 8 is a schematic structural diagram of an AP according to an embodiment of the present application.

detailed description

The applicant analyzed the existing Mesh network planning and network methods and found that:

You need to manually record the MAC address of each AP and its location. You need to manually record the neighbor AP list of each AP. The neighbor AP list includes the MAC address of each neighbor AP.

1) Network planning and deployment processes are time consuming and labor intensive;

2) The MAC address of the AP is 48 bits. If one bit is recorded incorrectly, the neighbor relationship between the AP and its neighboring APs cannot be established. As a result, the mesh network fails.

3) Since each AP has a fixed location, once the AP is placed in the wrong location, the AP cannot establish a neighbor relationship with its neighbor AP, causing the mesh network to fail.

FIG. 1 is a flowchart of a method for deploying a mesh network according to an embodiment of the present disclosure, and the specific steps are as follows:

Step 101: The network deployment unit selects a wireless network location of the AP that has not been deployed according to the pre-planned wireless network location of the AP to be deployed, and sets the location to m , $1 \leq m \leq n$, where n is the wireless network location where the AP is to be deployed. total.

Step 102: The network deployment unit arbitrarily selects an AP from the AP that has not been deployed, and sets it as AP m , and determines that the AP m is to be deployed to the location m .

Step 103: The network deployment unit determines a neighbor location list of the location m according to a neighbor relationship between the preset wireless network locations.

Step 104: For any neighbor location of the location m , the network deployment unit determines whether the AP has been deployed on the neighbor location, and if yes, instructs the network deployment personnel to touch the AP m with the AP at the neighbor location, so that: When the RSSI (Received Signal Strength Indication) value of the beacon (beacon) signal from the other party is greater than the preset first threshold, the two APs learn the MAC of the other party from the becon signal from the other party. Access Control (Media Access Control) address, and adds the MAC address of the other party to its neighbor AP list, and instructs the network deployer to deploy the AP m to the location m after the touch.

Preferably, in step 104, after the network deployment personnel is instructed to contact the AP on the AP in the neighboring location, the method further includes:

The network deployment unit receives the indication that the AP m input by the network deployer has been deployed to the location m, and adds the location m to the wireless network location list of the deployed AP that is recorded by itself;

In step 101, the network deployment unit selects a wireless network location of the AP that has not yet deployed according to the pre-planned wireless network location of the AP to be deployed, including:

The network deployment unit selects a wireless network location of the AP that has not been deployed according to the pre-planned wireless network location of the AP to be deployed, and the wireless network location list of the deployed AP that is recorded by itself.

Preferably, when the network deployment unit finds that the AP m on the location m is deployed incorrectly, determining a neighbor location list of the location m according to a neighbor relationship between the pre-planned wireless network locations; and,

The network deployment unit determines, according to the recorded wireless network location list of the deployed AP, a neighbor location list of the deployed APs at the location m, and instructs the network deployment personnel to locate the APs on the location m and the neighbor locations of the deployed APs in the location m respectively. Each AP touches, so that: AP m and its neighbor APs mutually delete the MAC address of the other party from its neighbor AP list; and,

When the network deployment unit receives the indication that the AP on the location m input by the network deployer has been deleted, the location m is deleted from the wireless network location list of the deployed AP that is recorded by itself.

FIG. 2 is a flowchart of a method for deploying a mesh network according to another embodiment of the present application, and the specific steps are as follows:

Step 201: The first AP is powered on, and the automatic neighbor adding mode is started. When receiving the

beacon signal sent by other APs, the RSSI value of the signal is detected, where the first AP is a wireless network location to be deployed in the Mesh network. The AP of m , $1 \leq m \leq n$, n is the total number of wireless network locations where the AP is to be deployed, and when the first AP is to be deployed to the wireless network location m , the first AP is instructed by the network deployment unit to be the network deployer. The first AP touches each neighbor AP that has been deployed in the Mesh network.

Step 202: The first AP determines whether the RSSI value is greater than a preset first threshold. If it is greater than, the MAC address of the other AP is read from the beacon signal, and it is determined whether the MAC address of the other AP already exists in its neighbor AP. In the list, if it does not exist, the MAC address of the other AP is added to the neighbor AP list. The other APs are deployed in the Mesh network, and the location is pre-planned as the wireless network location. The AP of the neighbor location.

Preferably, in step 202, after determining whether the MAC address of the other AP is already in the neighbor AP list, the method further includes:

If it already exists, the MAC address of the other AP is deleted from its neighbor AP list.

FIG. 3 is a flowchart of a method for planning a mesh network according to an embodiment of the present disclosure, and the specific steps are as follows:

Step 301: The network planning unit plans and records the wireless network location of the AP to be deployed, and is respectively marked as: location 1, location 2, location 3, ..., location n .

Step 302: The network planning unit plans and records the neighbor relationship between the wireless network locations of each AP to be deployed.

For example, if there are four wireless network locations to be deployed, which are marked as: location 1, location 2, location 3, and location 4, the neighbor relationship between the four locations is planned as follows:

The neighbors in position 1 are: position 2, position 4;

The neighbors in position 2 are: position 1, position 3;

The neighbors in position 3 are: position 2, position 4;

The neighbors in position 4 are: position 1, position 3.

The network planning unit considers the neighbor relationship between the wireless network locations where the APs are to be deployed. After the APs are deployed to various locations, the signal strength between neighboring APs (eg, the stronger the better) and the distance between neighboring APs. (the shorter the better) and so on.

FIG. 4 is a flowchart of a method for deploying a mesh network according to another embodiment of the present application, and the specific steps are as follows:

Step 401: The network deployment unit selects a wireless network location of the AP that has not been deployed according to the pre-planned wireless network location of the AP to be deployed, and the wireless network location list of the deployed AP that is recorded by itself, and sets the location to m , $1 \leq m \leq n$, n is the total number of wireless network locations where the AP is to be deployed.

Step 402: The network deployment unit arbitrarily selects an AP from the AP that has not been deployed, and sets it as AP m , and determines that the AP m is to be deployed to the location m .

Step 403: The network deployment unit determines the neighbor location list of the location m according to the neighbor relationship between the pre-planned wireless network locations, and sets the location k and p .

Step 404: For any neighbor location (location k , p) of the location m , the network deployment unit determines whether the AP has been deployed on the neighbor location, and if so, the network deployment unit instructs the network deployment personnel to locate the AP m and the neighbor location. The AP touches, so that: when detecting that the RSSI value of the beacon signal from the other party is greater than the preset first threshold, the two APs learn the MAC address of the other party from the beacon signal from the other party, and the MAC address of the other party is obtained. Add to the neighbor AP list; when the network deployment unit receives the indication that the AP m input by the network deployer has been deployed to the location m , add the location m to the list of wireless network locations of the deployed APs that are recorded by itself, and instructs the network deployer to deploy the AP m to location m after the touch.

In this step 404, the network deployment unit instructs the network deployment personnel to touch the AP m and the AP in the neighboring location to: instruct the network deployment personnel to arbitrarily select an AP (as AP m) in the AP that has not yet been deployed, and then The AP is touched with an AP (ie, AP k) deployed at location k.

For example, if the AP k has been deployed on the neighboring location k of the location m, the network deployment unit instructs the network deployer to touch the AP m and the AP k; when the network deployer touches the AP m and the AP k, the AP m The beacon (beacon) signal periodically sent by the AP k, and the AP m detects that the RSSI (Received Signal Strength Indication) value of the beacon signal is greater than a preset first threshold, then the beacon signal is The source MAC address, that is, the MAC address of the AP k is added to its neighbor AP list. Similarly, the AP k also receives the beacon signal periodically sent by the AP m. The AP k detects that the RSSI value of the beacon signal is greater than the pre- If the first threshold is set, the source MAC address of the beacon signal, that is, the MAC address of the AP m, is added to the neighbor AP list.

When the network deployer touches AP m and AP k, the AP m is formally deployed to the wireless network location m, and an indication that the AP m has been deployed to the location m is input to the network deployment unit.

If the AP is not deployed on the neighbor location p of the location m, the network deployment unit does not perform any processing at this time.

FIG. 5 is a flowchart of a method for deploying a mesh network according to another embodiment of the present application, and the specific steps are as follows:

In step 501, any AP (set as the first AP) is powered on, and the automatic neighbor addition mode is activated. When receiving the beacon signal sent by the other AP (set to the second AP), the RSSI value of the signal is detected, where The first AP is an AP to be deployed to the wireless network location m in the Mesh network, $1 \leq m \leq n$, where n is the total number of wireless network locations where the AP is to be deployed, and when the first AP is to be deployed to the wireless network location m When the first AP is instructed by the network deployment unit, the network deployment personnel touches the first AP with each neighbor AP that has been deployed to the Mesh network. The second AP is deployed in the Mesh network and its location is An AP that is pre-planned as a neighbor location of the wireless network location m.

Step 502: The first AP determines whether the RSSI value is greater than a preset first threshold. If yes, step 503 is

performed; otherwise, step 506 is performed.

Step 503: The first AP reads the MAC address of the second AP from the beacon signal, and determines whether the MAC address of the second AP is already in the neighbor AP list. If yes, go to step 504; otherwise, go to step 505.

Step 504: The first AP deletes the MAC address of the second AP from its neighbor AP list, and the process ends.

Step 505: The first AP adds the MAC address of the second AP to its neighbor AP list, and the process ends.

Step 506: The first AP does not perform further processing.

In the embodiment of the present application, if the AP deployment error occurs in a certain wireless network location due to various reasons, the network deployment unit performs the error correction processing flow of the Mesh network deployment as shown in FIG. 6, and the specific steps are as follows:

Step 601: The network deployment unit finds that the AP (ie, AP m) in the location m is deployed incorrectly, and determines the neighbor location list of the location m according to the neighbor relationship between the pre-planned wireless network locations.

Step 602: The network deployment unit determines, according to the recorded wireless network location list of the deployed AP, a neighbor location list of the deployed AP in the location m, and instructs the network deployment personnel to locate the AP (ie, AP m) in the location m and the location m respectively. Each AP in the neighboring location of the AP is touched, so that the AP m and its neighbor APs delete each other's MAC address from their neighbor AP list. When the network deployment unit receives the network deployment personnel input. When the AP on the location m has been deleted, the location m is deleted from the list of wireless network locations of the deployed APs that it records.

The neighbor location list of the deployed AP of the location m, that is, all the neighbor locations of the location m, the neighbor location list of the AP has been deployed.

For example, the neighbor location list of the location m includes: location k, p, where the AP k has been

deployed on the location k, and the AP has not been deployed on the location p, then the network deployment unit instructs the network deployment personnel to locate the location m. AP m touches AP k at position k, such that:

The network deployer will remove the AP m from the location m. At this time, because the AP m has been deployed in the location m, the network deployer will receive the AP m deployment error after receiving the above instructions from the network deployment unit. Then, the AP m is touched with the AP k of the location k, and the AP m and the AP k both receive the beacon signal sent by the other party, and the RSSI value of the beacon signal is detected to be greater than the preset first threshold, and the other party is found. If the MAC address is in the neighbor AP list, the MAC address of the peer is deleted from the neighbor AP list. Then, the network deployer puts the AP m back into the unallocated AP and enters the location into the network deployment unit. The indication that the upper AP has been deleted, the network deployment unit deletes the location m from the list of wireless network locations of the deployed APs that it records.

The beneficial technical effects of the embodiments of the present application are as follows:

- a) It is only necessary to pre-plan the location of the wireless network where the AP is to be deployed, without recording the correspondence between the MAC address of the AP and the location of the wireless network, that is, not requiring an AP to be placed on a wireless network location; When you select an AP from an AP that has not been deployed, you can deploy it to a wireless network location where the AP has not been deployed. That is, you do not need to consider the MAC address of the AP when deploying the AP to the wireless network. Therefore, the deployment speed and accuracy of the mesh network are improved, and the mesh network success is ensured.
- 2) It is only necessary to pre-plan the neighbor relationship between the wireless network locations without pre-configuring the AP's neighbor AP list on the AP; and prompting the network deployer to locate the location according to the neighbor location of the wireless network location The AP can be connected to the AP in the neighboring position of the AP. This allows the AP to automatically add the MAC address of the neighboring AP. This improves the deployment speed and accuracy of the Mesh network and ensures the success of the mesh network.
- c) When the AP is found to be deployed incorrectly, it can be automatically and quickly corrected.

FIG. 7 is a schematic diagram of a composition of a Mesh network deployment apparatus according to an embodiment of the present disclosure, which mainly includes: a location, an AP selection module, and a

deployment indication module, where:

Location and AP selection module: According to the pre-planned wireless network location where the access point AP is to be deployed, select a wireless network location where the AP has not been deployed, and set the location m , $1 \leq m \leq n$, n is the wireless to deploy the AP. Total number of network locations; arbitrarily select an AP from the AP that has not yet been deployed, set it to AP m , and determine that AP m should be deployed to location m , and the identifier of AP m (such as: sequence number m) and the identifier of location m (Such as: geographic location) sent to the deployment indicator module.

The deployment indication module is configured to: receive the location and the identifier of the AP m and the identifier of the location m sent by the AP selection module, and determine a neighbor location list of the location m according to the neighbor relationship between the pre-planned wireless network locations; A neighboring location, determining whether the AP has been deployed on the neighboring location, and if so, instructing the network deployment personnel to touch the AP m with the AP at the neighboring location, so that: the two APs detect the beacon signal from the other party. When the RSSI value is greater than the preset first threshold, the MAC address of the other party is learned from the beacon signal from the other party, and the MAC address of the other party is added to the neighbor AP list, and the network deployer is instructed to AP after the touch. m is deployed to location m .

Preferably, the deployment indication module instructs the network deployment personnel to further contact the AP on the AP in the neighboring location, and after receiving the indication that the AP m input by the network deployment personnel has been deployed to the location m , the location m is Join the list of wireless network locations of the deployed APs that have their own records; and,

The location and AP selection module is specifically configured to select a wireless network location of the AP that has not been deployed according to the pre-planned wireless network location of the AP to be deployed, and the wireless network location list of the deployed AP recorded by the deployment indicator module.

Preferably, the apparatus further comprises deploying an error correction module for:

When the AP m deployment error on the location m is found, the neighbor location list of the location m is determined according to the neighbor relationship between the pre-planned wireless network locations;

Determining, according to the list of the wireless network locations of the deployed APs recorded by the

deployment indication module, a list of neighbor locations of the deployed APs at the location m, instructing the network deployer to locate the APs at the location m and the neighbors of the deployed APs at the location m respectively. Each AP touches, so that: AP m and its neighbor APs mutually delete the MAC address of the other party from its neighbor AP list;

When receiving an indication that the AP on the location m entered by the network deployer has been deleted, the location m is deleted from the list of wireless network locations of the deployed AP recorded by the deployment indication module.

FIG. 8 is a schematic diagram of a composition of an AP according to an embodiment of the present disclosure. The AP is located in a mesh network, and the AP is an AP that is to be deployed to a wireless network in the Mesh network, where $1 \leq m \leq n$, where n is to be deployed. The total number of wireless network locations, and when the AP is to be deployed to the wireless network location m, the AP is instructed by the network deployment unit to contact the neighboring APs deployed in the Mesh network by the network deployer. The AP mainly includes: a signal strength detection module and a neighbor list maintenance module, where:

The signal strength detection module: when the AP is powered on, the automatic neighbor addition mode is activated. When receiving the beacon signal sent by other APs, the RSSI value of the signal is detected. The other APs are deployed in the Mesh network. And its location is pre-planned as the AP of the neighbor location of the wireless network location m.

The neighbor list maintenance module determines whether the RSSI value detected by the signal strength detecting module is greater than a preset first threshold. If it is greater than, the MAC address of the other AP is read from the beacon signal received by the signal strength detecting module, and the other AP is determined. Whether the MAC address is already in the neighbor AP list. If it does not exist, the MAC address of the other AP is added to its neighbor AP list.

Preferably, the neighbor list maintenance module further determines whether the MAC address of the other AP is already in the neighbor AP list.

If it already exists, the MAC address of the other AP is deleted from its neighbor AP list.

The above is only the preferred embodiment of the present application, and is not intended to limit the present application. Any modifications, equivalent substitutions, improvements, etc., which are made within the spirit

and principles of the present application, should be included in the present application. Within the scope of protection.

Notice

This translation is machine-generated. It cannot be guaranteed that it is intelligible, accurate, complete, reliable or fit for specific purposes. Critical decisions, such as commercially relevant or financial decisions, should not be based on machine-translation output.

CLAIMS CN104703193

1.

A method for deploying a mesh Mesh network, comprising:

The network deployment unit selects a wireless network location of the AP that has not been deployed according to the pre-planned wireless network location where the access point AP is to be deployed, and sets the location to m , $1 \leq m \leq n$, where n is the wireless network location where the AP is to be deployed. total;

The network deployment unit arbitrarily selects an AP from the AP that has not been deployed, and sets it as AP m , and determines that the AP m is to be deployed to the location m .

The network deployment unit determines a neighbor location list of the location m according to a pre-planned neighbor relationship between each wireless network location;

For any neighbor location of the location m , the network deployment unit determines whether the AP has been deployed on the neighbor location, and if so, instructs the network deployment personnel to touch the AP m with the AP at the neighbor location, so that the two APs are in the When the received signal strength of the beacon signal from the other party is detected, the RSSI value is greater than the preset first threshold, the MAC address of the other party is learned from the becon signal from the other party, and the MAC address of the other party is added to the neighbor AP. In the list, and instruct the network deployer to deploy the AP m to location m after the touch.

2.

The method according to claim 1, wherein the instructing the network deployer to touch the AP m with the AP at the neighboring location further comprises:

The network deployment unit receives the indication that the AP m input by the network deployer has been deployed to the location m, and adds the location m to the wireless network location list of the deployed AP that is recorded by itself;

The network deployment unit selects a wireless network location of the AP that has not yet deployed according to the pre-planned wireless network location where the access point AP is to be deployed, including:

The network deployment unit selects a wireless network location of the AP that has not been deployed according to the pre-planned wireless network location of the AP to be deployed, and the wireless network location list of the deployed AP that is recorded by itself.

3.

The method of claim 2, wherein the method further comprises:

The network deployment unit finds that the AP m in the location m is deployed incorrectly, and determines the neighbor location list of the location m according to the neighbor relationship between the pre-planned wireless network locations;

The network deployment unit determines, according to the recorded wireless network location list of the deployed AP, a neighbor location list of the deployed APs at the location m, and instructs the network deployment personnel to locate the APs on the location m and the neighbor locations of the deployed APs in the location m respectively. Each AP touches, so that: AP m and its neighbor APs mutually delete the MAC address of the other party from its neighbor AP list;

When the network deployment unit receives the indication that the AP on the location m input by the network deployer has been deleted, the location m is deleted from the wireless network location list of the deployed AP that is recorded by itself.

4.

A method for deploying a mesh Mesh network, comprising:

The first access point AP is powered on, and the automatic neighbor adding mode is activated. When receiving the beacon signal sent by the other AP, detecting the received signal strength indicating the RSSI value of the signal;

The first AP determines whether the RSSI value is greater than a preset first threshold. If it is greater than, the medium access control MAC address of the other AP is read from the beacon signal, and it is determined whether the MAC address of the other AP already exists in its neighbor. If the AP list does not exist, add the MAC address of the other AP to its neighbor AP list.

The first AP is an AP to be deployed to a wireless network location m in the Mesh network, where $1 \leq m \leq n$, where n is the total number of wireless network locations where the AP is to be deployed;

The other AP is an AP that has been deployed in the Mesh network and whose location is pre-planned as the neighbor location of the location m .

Moreover, when the first AP is to be deployed to the wireless network location m , the first AP is instructed by the network deployment unit to instruct the network deployment personnel to touch the first AP with each neighbor AP that has been deployed to the Mesh network.

5.

The method according to claim 4, wherein the determining whether the MAC address of the other AP already exists in its neighbor AP list further comprises:

If it already exists, the MAC address of the other AP is deleted from its neighbor AP list.

6.

A mesh Mesh network deployment device, comprising:

Location and AP selection module: According to the pre-planned wireless network location where the access

point AP is to be deployed, select a wireless network location where the AP has not been deployed, and set the location m , $1 \leq m \leq n$, n is the wireless to deploy the AP. Total number of network locations; arbitrarily select an AP from an AP that has not yet been deployed, set it to AP m , and determine that AP m should be deployed to location m ;

The deployment indication module: determining a neighbor location list of the location m according to the neighbor relationship between the pre-planned wireless network locations; determining, for any neighbor location of the location m , whether the AP has been deployed in the neighbor location, and if yes, indicating the network The deployer touches the AP m with the AP at the neighboring location, so that the two APs are from the other party when detecting that the received signal strength indication RSSI value of the beacon signal from the other party is greater than a preset first threshold. The beacon signal learns the MAC address of the other party, adds the MAC address of the other party to its neighbor AP list, and instructs the network deployer to deploy the AP m to the location m after the touch.

7.

The device according to claim 6, wherein the deployment indication module instructs a network deployer to further use the AP m after touching the AP at the neighbor location,

After receiving the indication that the AP m input by the network deployment personnel has been deployed to the location m , the location m is added to the wireless network location list of the deployed AP that is recorded by itself;

And the location and the AP selection module are specifically used,

Select a wireless network location for which the AP has not been deployed, based on the pre-planned wireless network location where the AP is to be deployed, and the list of wireless network locations of the deployed APs recorded by the deployment indicator module.

8.

The apparatus of claim 6 wherein said apparatus further comprises deploying an error correction module for:

When the AP m deployment error on the location m is found, the neighbor location list of the location m is determined according to the neighbor relationship between the pre-planned wireless network locations;

Determining, according to the list of the wireless network locations of the deployed APs recorded by the deployment indication module, a list of neighbor locations of the deployed APs at the location m, instructing the network deployer to locate the APs at the location m and the neighbors of the deployed APs at the location m respectively. Each AP touches, so that: AP m and its neighbor APs mutually delete the MAC address of the other party from its neighbor AP list;

When receiving an indication that the AP on the location m entered by the network deployer has been deleted, the location m is deleted from the list of wireless network locations of the deployed AP recorded by the deployment indication module.

9.

An access point AP is located in a mesh Mesh network, and is characterized in that the AP is an AP to be deployed to a wireless network location m in the Mesh network, $1 \leq m \leq n$, where n is the wireless network location where the AP is to be deployed. The total number of the APs, and when the AP is to be deployed to the wireless network location m, the AP is instructed by the network deployment unit to contact the neighboring APs deployed in the Mesh network. The AP includes:

The signal strength detection module: when the AP is powered on, the automatic neighbor addition mode is activated. When receiving the beacon signal sent by other APs, the received signal strength indication RSSI value of the signal is detected, and the other APs are deployed. An AP to a neighbor location in the Mesh network and whose location is pre-planned as location m;

The neighbor list maintenance module: determining whether the RSSI value is greater than a preset first threshold, and if yes, reading a media access control MAC address of the other AP from the beacon signal, and determining whether the MAC address of the other AP is If it does not exist, the MAC address of the other AP is added to its neighbor AP list.

10.

The AP according to claim 9, wherein the neighbor list maintenance module further determines whether the MAC address of the other AP is already present in its neighbor AP list.

If it already exists, the MAC address of the other AP is deleted from its neighbor AP list.



(12) 发明专利申请

(10) 申请公布号 CN 104703193 A

(43) 申请公布日 2015.06.10

(21) 申请号 201510131542.7

(22) 申请日 2015.03.25

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(51) Int. Cl.
H04W 16/18(2009.01)

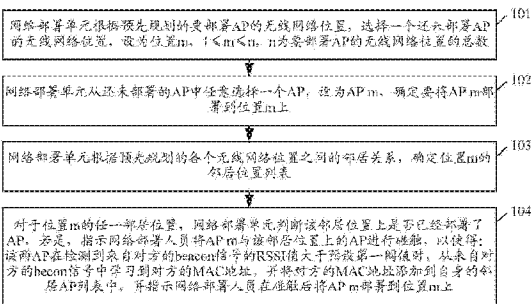
权利要求书3页 说明书8页 附图4页

(54) 发明名称

无线网络部署方法及装置

(57) 摘要

本申请提出无线网络部署方法及装置。方法包括：网络部署单元根据预先规划的要部署接入点 AP 的无线网络位置，选择一个还未部署 AP 的无线网络位置 m ；从还未部署的 AP 中任意选择一个 AP m ；根据预先规划的各个无线网络位置之间的邻居关系，确定位置 m 的邻居位置列表；对于位置 m 的任一邻居位置，判断该邻居位置上是否已经部署了 AP，若是，指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触，以使得：该两 AP 都学习到对方的 MAC 地址，并将对方的 MAC 地址添加到自身的邻居 AP 列表中，并指示网络部署人员在碰触后将 AP m 部署到位置 m 上。本申请提高了 Mesh 网络部署的速度和准确度。



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1. 一种网络 Mesh 网络部署方法, 其特征在于, 包括:

网络部署单元根据预先规划的要部署接入点 AP 的无线网络位置, 选择一个还未部署 AP 的无线网络位置, 设为位置 m , $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数;

网络部署单元从还未部署的 AP 中任意选择一个 AP, 设为 AP m , 确定要将 AP m 部署到位置 m 上;

网络部署单元根据预先规划的各个无线网络位置之间的邻居关系, 确定位置 m 的邻居位置列表;

对于位置 m 的任一邻居位置, 网络部署单元判断该邻居位置上是否已经部署了 AP, 若是, 指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触, 以使得: 该两 AP 在检测到来自对方的信标 beacon 信号的接收信号强度指示 RSSI 值大于预设第一阈值时, 从来自对方的 becon 信号中学习到对方的 MAC 地址, 并将对方的 MAC 地址添加到自身的邻居 AP 列表中, 并指示网络部署人员在碰触后将 AP m 部署到位置 m 上。

2. 根据权利要求 1 所述的方法, 其特征在于, 所述指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触之后进一步包括:

网络部署单元接收到网络部署人员输入的 AP m 已部署到位置 m 上的指示, 则将位置 m 加入自身记录的已部署 AP 的无线网络位置列表中;

所述网络部署单元根据预先规划的要部署接入点 AP 的无线网络位置, 选择一个还未部署 AP 的无线网络位置包括:

网络部署单元根据预先规划的要部署 AP 的无线网络位置, 以及自身记录的已部署 AP 的无线网络位置列表, 选择一个还未部署 AP 的无线网络位置。

3. 根据权利要求 2 所述的方法, 其特征在于, 所述方法进一步包括:

网络部署单元发现位置 m 上的 AP m 部署错误, 则根据预先规划的各个无线网络位置之间的邻居关系, 确定位置 m 的邻居位置列表;

网络部署单元根据记录的已部署 AP 的无线网络位置列表, 确定位置 m 的已部署 AP 的邻居位置列表, 指示网络部署人员将位置 m 上的 AP 分别与位置 m 的已部署 AP 的邻居位置上的各 AP 进行碰触, 以使得: AP m 与自身的各邻居 AP 相互将对方的 MAC 地址从自身的邻居 AP 列表中删除;

当网络部署单元收到网络部署人员输入的位置 m 上的 AP 已删除的指示时, 将位置 m 从自身记录的已部署 AP 的无线网络位置列表中删除。

4. 一种网络 Mesh 网络部署方法, 其特征在于, 包括:

第一接入点 AP 上电, 启动自动邻居添加模式, 当接收到其它 AP 发来的信标 beacon 信号时, 检测该信号的接收信号强度指示 RSSI 值;

第一 AP 判断该 RSSI 值是否大于预设第一阈值, 若大于, 从该 beacon 信号中读取该其它 AP 的媒体接入控制 MAC 地址, 判断该其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中, 若不存在于, 则将该其它 AP 的 MAC 地址添加到自身的邻居 AP 列表中,

所述第一 AP 为要部署到 Mesh 网络中的无线网络位置 m 的 AP, $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数;

且, 所述其它 AP 为已部署到 Mesh 网络中的、且其所在位置被预先规划为位置 m 的邻居位置的 AP;

且,当第一 AP 要被部署到无线网络位置 m 时,第一 AP 被网络部署单元指示网络部署人员将第一 AP 与已部署到 Mesh 网络中的各邻居 AP 进行碰触。

5. 根据权利要求 4 所述的方法,其特征在于,所述判断该其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中之后进一步包括:

若已存在于,则将该其它 AP 的 MAC 地址从自身的邻居 AP 列表中删除。

6. 一种网格 Mesh 网络部署装置,其特征在于,包括:

位置及 AP 选择模块:根据预先规划的要部署接入点 AP 的无线网络位置,选择一个还未部署 AP 的无线网络位置,设为位置 m , $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数;从还未部署的 AP 中任意选择一个 AP,设为 AP m ,确定要将 AP m 部署到位置 m 上;

部署指示模块:根据预先规划的各个无线网络位置之间的邻居关系,确定位置 m 的邻居位置列表;对于位置 m 的任一邻居位置,判断该邻居位置上是否已经部署了 AP,若是,指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触,以使得:该两 AP 在检测到来自对方的信标 beacon 信号的接收信号强度指示 RSSI 值大于预设第一阈值时,从来自对方的 becon 信号中学习到对方的 MAC 地址,并将对方的 MAC 地址添加到自身的邻居 AP 列表中,并指示网络部署人员在碰触后将 AP m 部署到位置 m 上。

7. 根据权利要求 6 所述的装置,其特征在于,所述部署指示模块指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触之后进一步用于,

接收到网络部署人员输入的 AP m 已部署到位置 m 上的指示,则将位置 m 加入自身记录的已部署 AP 的无线网络位置列表中;

且,所述位置及 AP 选择模块具体用于,

根据预先规划的要部署 AP 的无线网络位置,以及部署指示模块记录的已部署 AP 的无线网络位置列表,选择一个还未部署 AP 的无线网络位置。

8. 根据权利要求 6 所述的装置,其特征在于,所述装置进一步包括部署纠错模块,用于:

在发现位置 m 上的 AP m 部署错误时,根据预先规划的各个无线网络位置之间的邻居关系,确定位置 m 的邻居位置列表;

根据部署指示模块记录的已部署 AP 的无线网络位置列表,确定位置 m 的已部署 AP 的邻居位置列表,指示网络部署人员将位置 m 上的 AP 分别与位置 m 的已部署 AP 的邻居位置上的各 AP 进行碰触,以使得:AP m 与自身的各邻居 AP 相互将对方的 MAC 地址从自身的邻居 AP 列表中删除;

当收到网络部署人员输入的位置 m 上的 AP 已删除的指示时,将位置 m 从部署指示模块记录的已部署 AP 的无线网络位置列表中删除。

9. 一种接入点 AP,位于网格 Mesh 网络中,其特征在于,该 AP 为要部署到 Mesh 网络中的无线网络位置 m 的 AP, $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数,且,当该 AP 要被部署到无线网络位置 m 时,该 AP 被网络部署单元指示网络部署人员将该 AP 与已部署到 Mesh 网络中的各邻居 AP 进行碰触,该 AP 包括:

信号强度检测模块:当本 AP 上电时,启动自动邻居添加模式,当接收到其它 AP 发来的信标 beacon 信号时,检测该信号的接收信号强度指示 RSSI 值,所述其它 AP 为已部署到 Mesh 网络中的、且其所在位置被预先规划为位置 m 的邻居位置的 AP;

邻居列表维护模块:判断所述 RSSI 值是否大于预设第一阈值,若大于,从所述 beacon 信号中读取所述其它 AP 的媒体接入控制 MAC 地址,判断所述其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中,若不存在于,则将所述其它 AP 的 MAC 地址添加到自身的邻居 AP 列表中。

10. 根据权利要求 9 所述的 AP,其特征在于,所述邻居列表维护模块判断所述其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中之后进一步用于,

若已存在于,则将所述其它 AP 的 MAC 地址从自身的邻居 AP 列表中删除。

网格网络部署方法及装置

技术领域

[0001] 本申请涉及网络规划部署技术领域,尤其涉及 Mesh(网格)网络部署方法、装置及 AP(Access Point,接入点)。

背景技术

[0002] Mesh 网络是一种完全通过 AP 与 AP 之间建立无线连接,而形成的一种网状网络。在有线网络布网不方便的地方,通常采用这种组网方式,使得无线 WiFi 网络的覆盖范围更大,延伸更长。但是同传统的 FAT(胖)AP 或者 AC(Access Controller,接入控制器)+FIT(瘦)AP 网络相比,Mesh 网络组建更为复杂,费时费力。原因之一是因为 AP 和 AP 之间通过无线连接,而无线网络信号受干扰信号的影响比较大,如果任由各个 AP 按照邻居的信号强度来选择信号最强的邻居进行连接,则 Mesh 网络的网状拓扑时刻处于变化之中,不利于网络的稳定。

[0003] 所以,在实际的应用过程中,为了防止网络拓扑震荡,Mesh 网络在部署初期,通常就要做好网络规划,根据该网络规划进行网络部署。

[0004] 现有的 Mesh 网络规划内容主要包括:

[0005] 1) 记录每个 AP 的 MAC(Media Access Control,媒体接入控制)地址;

[0006] 2) 规划可以部署 AP 的无线网络位置,设分别标记为:位置 1、位置 2、位置 3、……、位置 n;

[0007] 3) 规划 2) 中各个无线网络位置之间的邻居关系;

[0008] 例如,设可以部署 AP 的无线网络位置共有 4 个,分别标记为:位置 1、位置 2、位置 3 和位置 4,则将该 4 个位置之间的邻居关系规划如下:

[0009] 位置 1 的邻居为:位置 2、位置 4;

[0010] 位置 2 的邻居为:位置 1、位置 3;

[0011] 位置 3 的邻居为:位置 2、位置 4;

[0012] 位置 4 的邻居为:位置 1、位置 3。

[0013] 4) 规划每个 AP 的无线网络位置。

[0014] 例如,设 2) 中规划的可以部署 AP 的无线网络位置共 n 个,分别标记为:位置 1、位置 2、位置 3、……、位置 n,设共有 n 个 AP,则:

[0015] 从 n 个 AP 中任意挑选出一个 AP,设为 AP₁,将 AP₁ 规划到位置 1;

[0016] 从剩余的 n-1 个 AP 中任意挑选出一个 AP,设为 AP₂,将 AP₂ 规划到位置 2;

[0017] 从剩余的 n-2 个 AP 中任意挑选出一个 AP,设为 AP₃,将 AP₃ 规划到位置 3;

[0018] ……;

[0019] 从剩余的 n-m 个 AP 中任意任意挑选出一个 AP,设为 AP_(m+1),将 AP_(m+1) 规划到位置 m+1;

[0020] ……;

[0021] 将最后一个 AP,设为 AP_n,规划到位置 n。

[0022] 5) 根据 4) 中为每个 AP 规划的无线网络位置,记录每个 AP 的 MAC 地址与其所在位置的对应关系;同时,根据 3) 中规划的各个无线网络位置之间的邻居关系,得出每个 AP 的邻居 AP 列表,在每个 AP 上配置其邻居 AP 列表,该邻居 AP 列表中包含了:各邻居 AP 的 MAC 地址。

[0023] 现有的 Mesh 网络部署过程如下:

[0024] 根据 5) 中记录的每个 AP 的 MAC 地址与其所在位置的对应关系,将每个 AP 部署到对应的无线网络位置上;

[0025] 根据 5) 中记录的每个 AP 的邻居 AP 列表,对于任一 AP,将其邻居 AP 列表配置到该 AP 上。

[0026] 当 Mesh 网络部署完成后,每个 AP 根据自身配置的邻居 AP 列表,与自己的各邻居 AP 建立邻居关系,AP 之间的邻居关系都建立成功后,Mesh 网络组网成功。

发明内容

[0027] 本申请提供 Mesh 网络部署方法、装置及 AP,以提高 Mesh 网络部署速度和准确度。

[0028] 本申请的技术方案是这样实现的:

[0029] 一种 Mesh 网络部署方法,包括:

[0030] 网络部署单元根据预先规划的要部署 AP 的无线网络位置,选择一个还未部署 AP 的无线网络位置,设为位置 m , $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数;

[0031] 网络部署单元从还未部署的 AP 中任意选择一个 AP,设为 AP m ,确定要将 AP m 部署到位置 m 上;

[0032] 网络部署单元根据预先规划的各个无线网络位置之间的邻居关系,确定位置 m 的邻居位置列表;

[0033] 对于位置 m 的任一邻居位置,网络部署单元判断该邻居位置上是否已经部署了 AP,若是,指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触,以使得:该两 AP 在检测到来自对方的 beacon 信号的 RSSI 值大于预设第一阈值时,从来自对方的 becon 信号中学习对方的 MAC 地址,并将对方的 MAC 地址添加到自身的邻居 AP 列表中,并指示网络部署人员在碰触后将 AP m 部署到位置 m 上。

[0034] 一种 Mesh 网络部署方法,包括:

[0035] 第一 AP 上电,启动自动邻居添加模式,当接收到其它 AP 发来的 beacon 信号时,检测该信号的 RSSI 值;

[0036] 第一 AP 判断该 RSSI 值是否大于预设第一阈值,若大于,从该 beacon 信号中读取该其它 AP 的 MAC 地址,判断该其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中,若不存在于,则将该其它 AP 的 MAC 地址添加到自身的邻居 AP 列表中,

[0037] 所述第一 AP 为要部署到 Mesh 网络中的无线网络位置 m 的 AP, $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数;

[0038] 且,所述其它 AP 为已部署到 Mesh 网络中的、且其所在位置被预先规划为位置 m 的邻居位置的 AP;

[0039] 且,当第一 AP 要被部署到无线网络位置 m 时,第一 AP 被网络部署单元指示网络部署人员将第一 AP 与已部署到 Mesh 网络中的各邻居 AP 进行碰触。

[0040] 一种 Mesh 网络部署装置,包括:

[0041] 位置及 AP 选择模块:根据预先规划的要部署 AP 的无线网络位置,选择一个还未部署 AP 的无线网络位置,设为位置 m , $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数;从还未部署的 AP 中任意选择一个 AP,设为 AP m ,确定要将 AP m 部署到位置 m 上;

[0042] 部署指示模块:根据预先规划的各个无线网络位置之间的邻居关系,确定位置 m 的邻居位置列表;对于位置 m 的任一邻居位置,判断该邻居位置上是否已经部署了 AP,若是,指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触,以使得:该两 AP 在检测到来自对方的 beacon 信号的 RSSI 值大于预设第一阈值时,从来自对方的 becon 信号中学习对方的 MAC 地址,并将对方的 MAC 地址添加到自身的邻居 AP 列表中,并指示网络部署人员在碰触后将 AP m 部署到位置 m 上。

[0043] 一种 AP,位于 Mesh 网络中,该 AP 为要部署到 Mesh 网络中的无线网络位置 m 的 AP, $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数,且,当该 AP 要被部署到无线网络位置 m 时,该 AP 被网络部署单元指示网络部署人员将该 AP 与已部署到 Mesh 网络中的各邻居 AP 进行碰触,该 AP 包括:

[0044] 信号强度检测模块:当本 AP 上电时,启动自动邻居添加模式,当接收到其它 AP 发来的 beacon 信号时,检测该信号的 RSSI 值,所述其它 AP 为已部署到 Mesh 网络中的、且其所在位置被预先规划为位置 m 的邻居位置的 AP;

[0045] 邻居列表维护模块:判断所述 RSSI 值是否大于预设第一阈值,若大于,从所述 beacon 信号中读取所述其它 AP 的 MAC 地址,判断所述其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中,若不存在,则将所述其它 AP 的 MAC 地址添加到自身的邻居 AP 列表中。

[0046] 可见,本申请中,只需预先规划要部署 AP 的无线网络位置以及各无线网络位置之间的邻居关系,而无需记录 AP 的 MAC 地址与无线网络位置的对应关系,且无需将 AP 的邻居 AP 列表预先配置在 AP 上;在部署 Mesh 网络时,只需从还未部署的 AP 中任意选择一个 AP 部署到还未部署 AP 的任一无线网络位置上即可,且只需根据该无线网络位置的邻居位置,提示网络部署人员将该位置上的 AP 与已部署了 AP 的邻居位置上的 AP 即可,从而使得 AP 可以自动添加邻居 AP 的 MAC 地址,提高了 Mesh 网络的部署速度和准确度,且保证了 Mesh 网络组网成功。

附图说明

[0047] 图 1 为本申请一实施例提供的 Mesh 网络部署方法流程图;

[0048] 图 2 为本申请另一实施例提供的 Mesh 网络部署方法流程图;

[0049] 图 3 为本申请一实施例提供的 Mesh 网络规划方法流程图;

[0050] 图 4 为本申请另一实施例提供的 Mesh 网络部署方法流程图;

[0051] 图 5 为本申请另一实施例提供的 Mesh 网络部署方法流程图;

[0052] 图 6 为本申请实施例提供的 Mesh 网络部署纠错处理流程图;

[0053] 图 7 为本申请实施例提供的 Mesh 网络部署装置的组成示意图;

[0054] 图 8 为本申请实施例提供的 AP 的组成示意图。

具体实施方式

[0055] 申请人对现有的 Mesh 网络规划和网络方法进行分析发现：

[0056] 需要手工记录每个 AP 的 MAC 地址及其所在位置的对应关系，同时需要手工记录每个 AP 的邻居 AP 列表，其中，邻居 AP 列表中包括：各邻居 AP 的 MAC 地址，则：

[0057] 1) 网络规划和部署过程既费时又费力；

[0058] 2) 由于 AP 的 MAC 地址为 48bit，一旦有 1 个 bit 记录错误，就会导致该 AP 与其邻居 AP 之间无法建立邻居关系，导致 Mesh 网络组网失败；

[0059] 3) 由于每个 AP 都有固定的位置，因此，一旦哪个 AP 放错位置，就会导致该 AP 无法与其邻居 AP 建立邻居关系，导致 Mesh 网络组网失败。

[0060] 图 1 为本申请一实施例提供的 Mesh 网络部署方法流程图，其具体步骤如下：

[0061] 步骤 101：网络部署单元根据预先规划的要部署 AP 的无线网络位置，选择一个还未部署 AP 的无线网络位置，设为位置 m ， $1 \leq m \leq n$ ， n 为要部署 AP 的无线网络位置的总数。

[0062] 步骤 102：网络部署单元从还未部署的 AP 中任意选择一个 AP，设为 AP m ，确定要将 AP m 部署到位置 m 上。

[0063] 步骤 103：网络部署单元根据预先规划的各个无线网络位置之间的邻居关系，确定位置 m 的邻居位置列表。

[0064] 步骤 104：对于位置 m 的任一邻居位置，网络部署单元判断该邻居位置上是否已经部署了 AP，若是，指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触，以使得：该两 AP 在检测到来白对方的 beacon（信标）信号的 RSSI（Received Signal Strength Indication，接收信号强度指示）值大于预设第一阈值时，从来自对方的 becon 信号中学习对方的 MAC（Media Access Control，媒体接入控制）地址，并将对方的 MAC 地址添加到自身的邻居 AP 列表中，并指示网络部署人员在碰触后将 AP m 部署到位置 m 上。

[0065] 优选地，步骤 104 中，指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触之后进一步包括：

[0066] 网络部署单元接收到网络部署人员输入的 AP m 已部署到位置 m 上的指示，则将位置 m 加入自身记录的已部署 AP 的无线网络位置列表中；且，

[0067] 步骤 101 中，网络部署单元根据预先规划的要部署 AP 的无线网络位置，选择一个还未部署 AP 的无线网络位置包括：

[0068] 网络部署单元根据预先规划的要部署 AP 的无线网络位置，以及自身记录的已部署 AP 的无线网络位置列表，选择一个还未部署 AP 的无线网络位置。

[0069] 优选地，当网络部署单元发现位置 m 上的 AP m 部署错误时，根据预先规划的各个无线网络位置之间的邻居关系，确定位置 m 的邻居位置列表；且，

[0070] 网络部署单元根据记录的已部署 AP 的无线网络位置列表，确定位置 m 的已部署 AP 的邻居位置列表，指示网络部署人员将位置 m 上的 AP 分别与位置 m 的已部署 AP 的邻居位置上的各 AP 进行碰触，以使得：AP m 与自身的各邻居 AP 相互将对方的 MAC 地址从自身的邻居 AP 列表中删除；且，

[0071] 当网络部署单元收到网络部署人员输入的位置 m 上的 AP 已删除的指示时，将位置 m 从自身记录的已部署 AP 的无线网络位置列表中删除。

[0072] 图 2 为本申请另一实施例提供的 Mesh 网络部署方法流程图，其具体步骤如下：

[0073] 步骤 201:第一 AP 上电,启动自动邻居添加模式,当接收到其它 AP 发来的 beacon 信号时,检测该信号的 RSSI 值,其中,第一 AP 为要部署到 Mesh 网络中的无线网络位置 m 的 AP, $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数,且,当第一 AP 要被部署到无线网络位置 m 时,第一 AP 被网络部署单元指示网络部署人员将第一 AP 与已部署到 Mesh 网络中的各邻居 AP 进行碰触。

[0074] 步骤 202:第一 AP 判断该 RSSI 值是否大于预设第一阈值,若大于,从该 beacon 信号中读取该其它 AP 的 MAC 地址,判断该其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中,若不存在于,则将该其它 AP 的 MAC 地址添加到自身的邻居 AP 列表中,其中,其它 AP 为已部署到 Mesh 网络中的、且其所在位置被预先规划为无线网络位置 m 的邻居位置的 AP。

[0075] 优选地,步骤 202 中,判断该其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表之后进一步包括:

[0076] 若已存在于,则将该其它 AP 的 MAC 地址从自身的邻居 AP 列表中删除。

[0077] 图 3 为本申请一实施例提供的 Mesh 网络规划方法流程图,其具体步骤如下:

[0078] 步骤 301:网络规划单元规划并记录要部署 AP 的无线网络位置,设分别标记为:位置 1、位置 2、位置 3、……、位置 n 。

[0079] 步骤 302:网络规划单元规划并记录各个要部署 AP 的无线网络位置之间的邻居关系。

[0080] 例如,设要部署 AP 的无线网络位置共有 4 个,分别标记为:位置 1、位置 2、位置 3 和位置 4,则将该 4 个位置之间的邻居关系规划如下:

[0081] 位置 1 的邻居为:位置 2、位置 4;

[0082] 位置 2 的邻居为:位置 1、位置 3;

[0083] 位置 3 的邻居为:位置 2、位置 4;

[0084] 位置 4 的邻居为:位置 1、位置 3。

[0085] 网络规划单元在规划要部署 AP 的无线网络位置之间的邻居关系要考虑:AP 部署到各个位置上之后,邻居 AP 之间的信号强度(如:越强越好)、邻居 AP 之间的距离(越短越好)等。

[0086] 图 4 为本申请另一实施例提供的 Mesh 网络部署方法流程图,其具体步骤如下:

[0087] 步骤 401:网络部署单元根据预先规划的要部署 AP 的无线网络位置,以及自身记录的已部署 AP 的无线网络位置列表,选择一个还未部署 AP 的无线网络位置,设为位置 m , $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数。

[0088] 步骤 402:网络部署单元从还未部署的 AP 中任意选择一个 AP,设为 AP m ,确定要将 AP m 部署到位置 m 上。

[0089] 步骤 403:网络部署单元根据预先规划的各个无线网络位置之间的邻居关系,确定位置 m 的邻居位置列表,设为位置 k 、 p 。

[0090] 步骤 404:对于位置 m 的任一邻居位置(位置 k 、 p),网络部署单元判断该邻居位置上是否已经部署了 AP,若是,网络部署单元指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触,以使得:该两 AP 在检测到来自对方的 beacon 信号的 RSSI 值大于预设第一阈值时,从来自对方的 beacon 信号中学习到对方的 MAC 地址,并将对方的 MAC 地址添加到自身的邻居 AP 列表中;当网络部署单元接收到网络部署人员输入的 AP m 已部署到位置 m 上的指

示时,将位置 m 加入自身记录的已部署 AP 的无线网络位置列表中,并指示网络部署人员在碰触后将 AP m 部署到位置 m 上。

[0091] 本步骤 404 中,网络部署单元指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触具体为:指示网络部署人员在还未部署的 AP 中任意选择一个 AP(作为 AP m),然后将该 AP 与位置 k 上部署的 AP(即 AP k)进行碰触。

[0092] 例如:位置 m 的邻居位置 k 上已经部署了 AP k ,则网络部署单元指示网络部署人员将 AP m 与 AP k 进行碰触;当网络部署人员将 AP m 与 AP k 进行碰触时,AP m 会收到 AP k 周期性发出的 beacon(信标)信号,AP m 检测到该 beacon 信号的 RSSI(Received Signal Strength Indication,接收信号强度指示)值大于预设第一阈值,则将该 beacon 信号的源 MAC 地址,即 AP k 的 MAC 地址添加到自身的邻居 AP 列表中;同样地,AP k 也会同时收到 AP m 周期性发出的 beacon 信号,AP k 检测到该 beacon 信号的 RSSI 值大于预设第一阈值,则将该 beacon 信号的源 MAC 地址,即 AP m 的 MAC 地址添加到自身的邻居 AP 列表中。

[0093] 当网络部署人员将 AP m 与 AP k 碰触完毕时,会将 AP m 正式部署到无线网络位置 m 上,并向网络部署单元输入 AP m 已部署到位置 m 上的指示。

[0094] 位置 m 的邻居位置 p 上还未部署 AP,则网络部署单元此时不作任何处理。

[0095] 图 5 为本申请另一实施例提供的 Mesh 网络部署方法流程图,其具体步骤如下:

[0096] 步骤 501:任一 AP(设为第一 AP)上电,启动自动邻居添加模式,当接收到其它 AP(设为第二 AP)发来的 beacon 信号时,检测该信号的 RSSI 值,其中,第一 AP 为要部署到 Mesh 网络中的无线网络位置 m 的 AP, $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数,且,当第一 AP 要被部署到无线网络位置 m 时,第一 AP 被网络部署单元指示网络部署人员将第一 AP 与已部署到 Mesh 网络中的各邻居 AP 进行碰触,第二 AP 为:已部署到 Mesh 网络中的、且其所在位置被预先规划为无线网络位置 m 的邻居位置的 AP。

[0097] 步骤 502:第一 AP 判断该 RSSI 值是否大于预设第一阈值,若是,执行步骤 503;否则,执行步骤 506。

[0098] 步骤 503:第一 AP 从该 beacon 信号中读取第二 AP 的 MAC 地址,判断第二 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中,若是,执行步骤 504;否则,执行步骤 505。

[0099] 步骤 504:第一 AP 将第二 AP 的 MAC 地址从自身的邻居 AP 列表中删除,本流程结束。

[0100] 步骤 505:第一 AP 将第二 AP 的 MAC 地址添加到自身的邻居 AP 列表中,本流程结束。

[0101] 步骤 506:第一 AP 不作进一步处理。

[0102] 本申请实施例中,若由于种种原因导致某一无线网络位置上的 AP 部署错误,则此时网络部署单元进行如图 6 所示的 Mesh 网络部署纠错处理流程,其具体步骤如下:

[0103] 步骤 601:网络部署单元发现位置 m 上的 AP(即 AP m)部署错误,则根据预先规划的各个无线网络位置之间的邻居关系,确定位置 m 的邻居位置列表。

[0104] 步骤 602:网络部署单元根据记录的已部署 AP 的无线网络位置列表,确定位置 m 的已部署 AP 的邻居位置列表,指示网络部署人员将位置 m 上的 AP(即 AP m)分别与位置 m 的已部署 AP 的邻居位置上的各 AP 进行碰触,以使得:AP m 与自身的各邻居 AP 相互将对方的 MAC 地址从自身的邻居 AP 列表中删除;当网络部署单元收到网络部署人员输入的位置 m

上的 AP 已删除的指示时,将位置 m 从自身记录的已部署 AP 的无线网络位置列表中删除。

[0105] 位置 m 的已部署 AP 的邻居位置列表,即位置 m 的所有邻居位置中,已经部署了 AP 的邻居位置列表。

[0106] 例如:位置 m 的邻居位置列表中包含:位置 k 、 p ,其中,位置 k 上已部署了 AP k ,位置 p 上则还未部署 AP,则:网络部署单元指示网络部署人员将位置 m 上的 AP m 与位置 k 上的 AP k 进行碰触,这样:

[0107] 网络部署人员就会将 AP m 从位置 m 上取走(此时,由于 AP m 已经部署在位置 m 上,则网络部署人员收到网络部署单元的上述指示后就会得知 AP m 部署错误),然后将 AP m 与位置 k 的 AP k 进行碰触,则,AP m 、AP k 都会接收到对方发来的 beacon 信号,且检测到 beacon 信号的 RSSI 值大于预设第一阈值,且发现对方的 MAC 地址位于自身的邻居 AP 列表中,则将对方的 MAC 地址从自身的邻居 AP 列表中删除;然后,网络部署人员会将 AP m 放回未部署 AP 中,并向网络部署单元输入位置 m 上的 AP 已删除的指示,网络部署单元将位置 m 从自身记录的已部署 AP 的无线网络位置列表中删除。

[0108] 本申请实施例的有益技术效果如下:

[0109] 一) 只需预先规划要部署 AP 的无线网络位置,而无需记录 AP 的 MAC 地址与无线网络位置的对应关系,即,不要求某个 AP 必须放置到某个无线网络位置上;在部署 Mesh 网络时,只需从还未部署的 AP 中任意选择一个 AP 部署到还未部署 AP 的一个无线网络位置上即可,即,在将 AP 部署到无线网络位置上时,无需考虑 AP 的 MAC 地址,从而提高了 Mesh 网络的部署速度和准确度,且保证了 Mesh 网络组网成功。

[0110] 二) 只需预先规划各无线网络位置之间的邻居关系,而无需将 AP 的邻居 AP 列表预先配置在 AP 上;只需根据该无线网络位置的邻居位置,提示网络部署人员将该位置上的 AP 与已部署了 AP 的邻居位置上的 AP 即可,从而使得 AP 可以自动添加邻居 AP 的 MAC 地址,从而提高了 Mesh 网络的部署速度和准确度,且保证了 Mesh 网络组网成功。

[0111] 三) 当发现 AP 部署错误时,可以自动、快速纠错。

[0112] 图 7 为本申请实施例提供的 Mesh 网络部署装置的组成示意图,其主要包括:位置及 AP 选择模块和部署指示模块,其中:

[0113] 位置及 AP 选择模块:根据预先规划的要部署接入点 AP 的无线网络位置,选择一个还未部署 AP 的无线网络位置,设为位置 m , $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数;从还未部署的 AP 中任意选择一个 AP,设为 AP m ,确定要将 AP m 部署到位置 m 上,将 AP m 的标识(如:序号 m)和位置 m 的标识(如:地理位置)发送给部署指示模块。

[0114] 部署指示模块:接收位置及 AP 选择模块发来的 AP m 的标识和位置 m 的标识,根据预先规划的各个无线网络位置之间的邻居关系,确定位置 m 的邻居位置列表;对于位置 m 的任一邻居位置,判断该邻居位置上是否已经部署了 AP,若是,指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触,以使得:该两 AP 在检测到来自对方的 beacon 信号的 RSSI 值大于预设第一阈值时,从来自对方的 becon 信号中学习对方的 MAC 地址,并将对方的 MAC 地址添加到自身的邻居 AP 列表中,并指示网络部署人员在碰触后将 AP m 部署到位置 m 上。

[0115] 优选地,部署指示模块指示网络部署人员将 AP m 与该邻居位置上的 AP 进行碰触之后进一步用于,接收到网络部署人员输入的 AP m 已部署到位置 m 上的指示,则将位置 m 加入自身记录的已部署 AP 的无线网络位置列表中;且,

[0116] 位置及 AP 选择模块具体用于,根据预先规划的要部署 AP 的无线网络位置,以及部署指示模块记录的已部署 AP 的无线网络位置列表,选择一个还未部署 AP 的无线网络位置。

[0117] 优选地,该装置进一步包括部署纠错模块,用于:

[0118] 在发现位置 m 上的 AP m 部署错误时,根据预先规划的各个无线网络位置之间的邻居关系,确定位置 m 的邻居位置列表;

[0119] 根据部署指示模块记录的已部署 AP 的无线网络位置列表,确定位置 m 的已部署 AP 的邻居位置列表,指示网络部署人员将位置 m 上的 AP 分别与位置 m 的已部署 AP 的邻居位置上的各 AP 进行碰触,以使得:AP m 与自身的各邻居 AP 相互将对方的 MAC 地址从自身的邻居 AP 列表中删除;

[0120] 当收到网络部署人员输入的位置 m 上的 AP 已删除的指示时,将位置 m 从部署指示模块记录的已部署 AP 的无线网络位置列表中删除。

[0121] 图 8 为本申请实施例提供的 AP 的组成示意图,该 AP 位于 Mesh 网络中,且该 AP 为要部署到 Mesh 网络中的无线网络位置 m 的 AP, $1 \leq m \leq n$, n 为要部署 AP 的无线网络位置的总数,且,当该 AP 要被部署到无线网络位置 m 时,该 AP 被网络部署单元指示网络部署人员将该 AP 与已部署到 Mesh 网络中的各邻居 AP 进行碰触,该 AP 主要包括:信号强度检测模块和邻居列表维护模块,其中:

[0122] 信号强度检测模块:当本 AP 上电时,启动自动邻居添加模式,当接收到其它 AP 发来的 beacon 信号时,检测该信号的 RSSI 值,其中,其它 AP 为已部署到 Mesh 网络中的、且其所在位置被预先规划为无线网络位置 m 的邻居位置的 AP。

[0123] 邻居列表维护模块:判断信号强度检测模块检测的 RSSI 值是否大于预设第一阈值,若大于,从信号强度检测模块接收到的 beacon 信号中读取该其它 AP 的 MAC 地址,判断该其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中,若不存在于,则将该其它 AP 的 MAC 地址添加到自身的邻居 AP 列表中。

[0124] 优选地,邻居列表维护模块判断该其它 AP 的 MAC 地址是否已存在于自身的邻居 AP 列表中之后进一步用于,

[0125] 若已存在于,则将该其它 AP 的 MAC 地址从自身的邻居 AP 列表中删除。

[0126] 以上所述仅为本申请的较佳实施例而已,并不用以限制本申请,凡在本申请的精神和原则之内,所做的任何修改、等同替换、改进等,均应包含在本申请保护的范围之内。

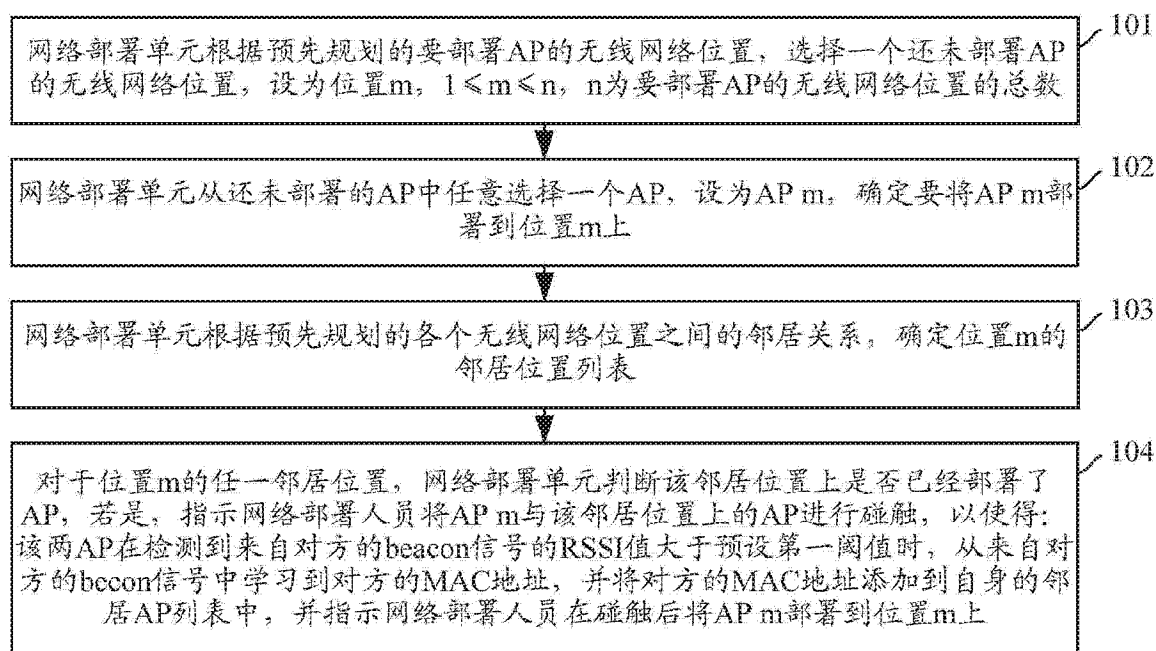


图 1

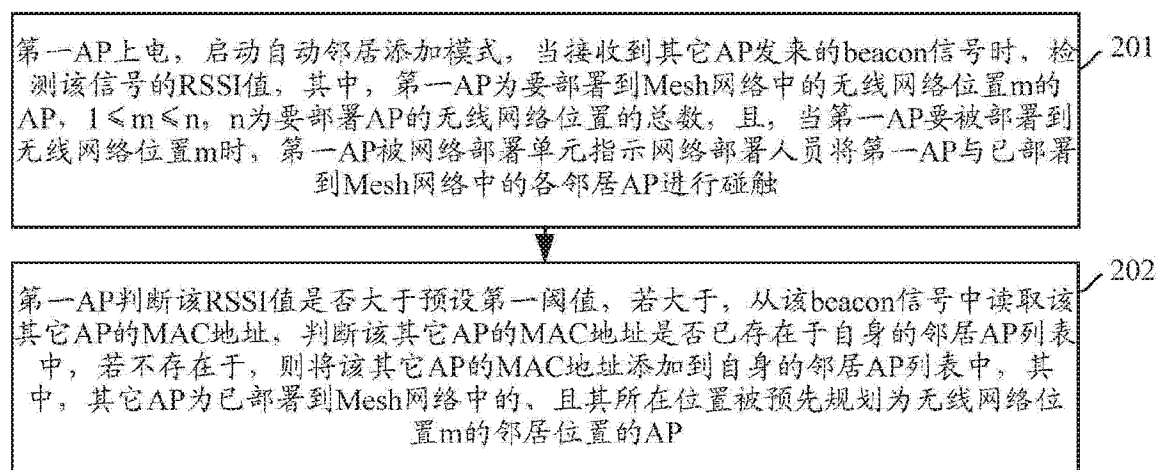


图 2

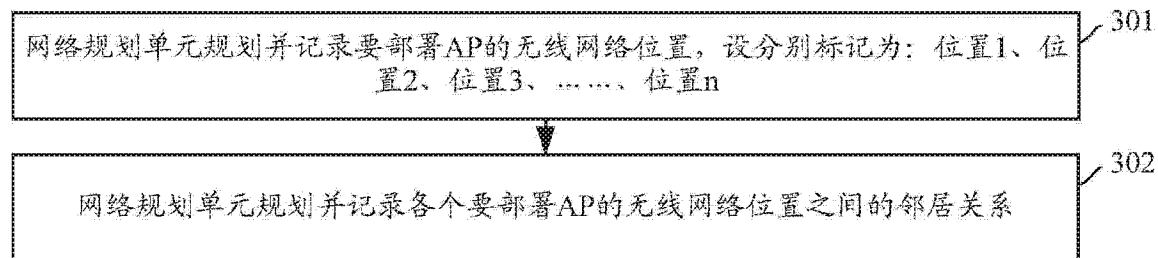


图 3

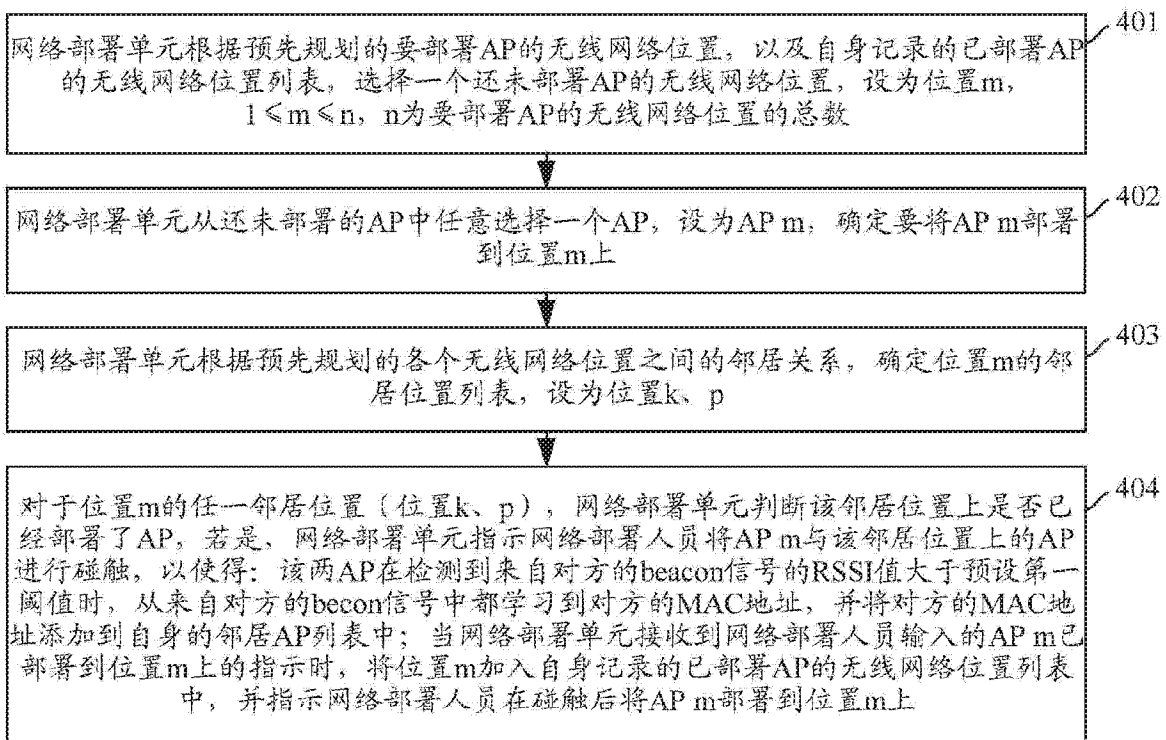


图 4

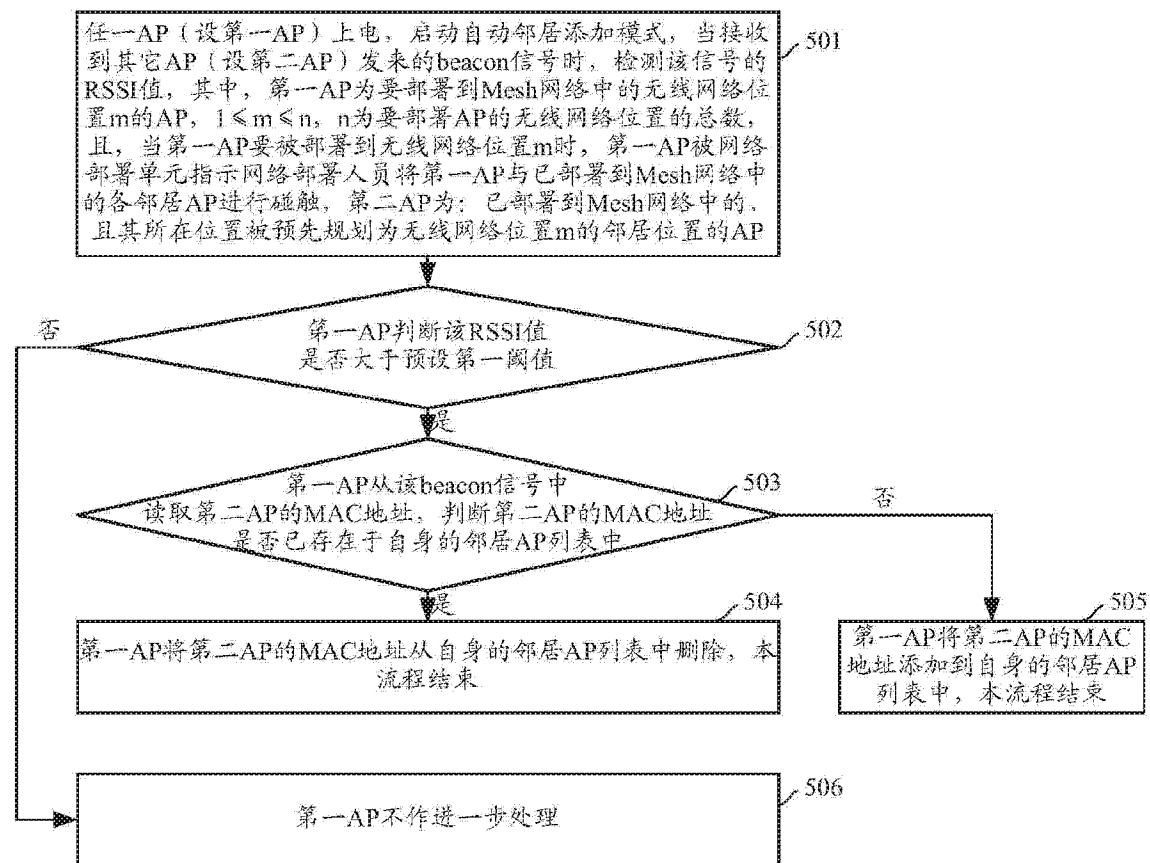


图 5

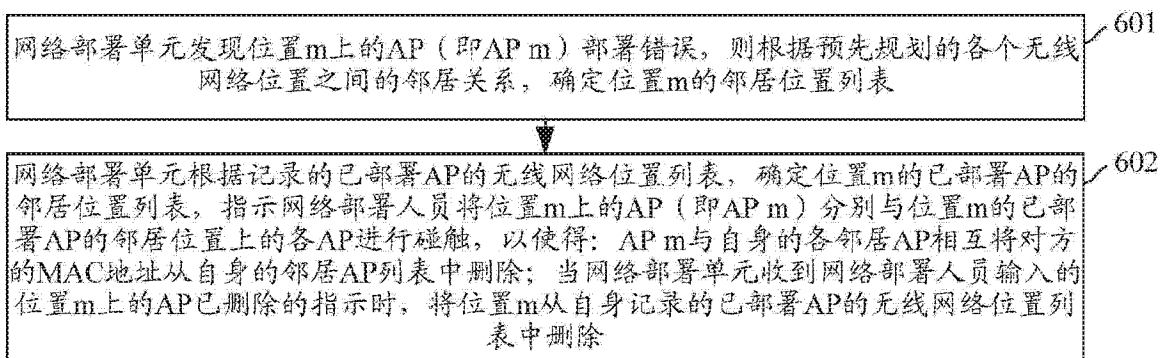


图 6

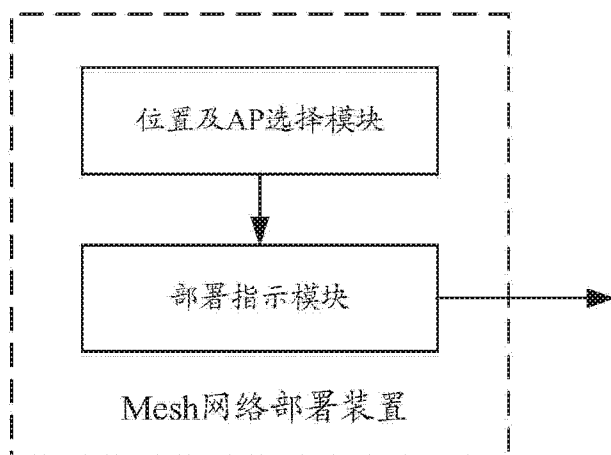


图 7

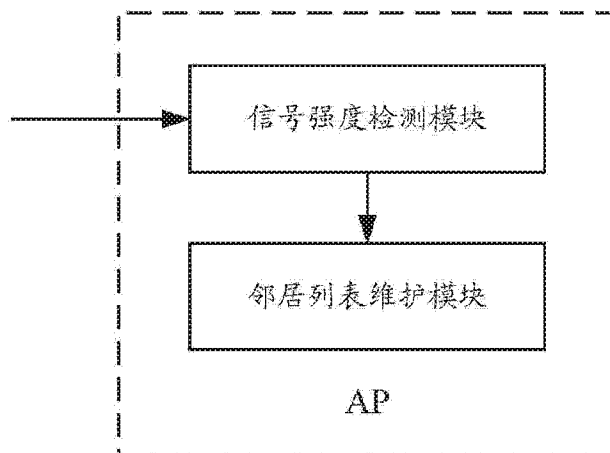


图 8



Espacenet

Bibliographic data: CN104756474 (A) — 2015-07-01

Method and system for performance estimation of a communication link

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Classification: - international: H04L12/24; H04M11/06; H04M3/22
- cooperative: H04L41/142 (KR); H04L43/0811 (KR); H04L43/0847 (KR); H04L43/10 (EP, KR, US); H04L43/12 (EP, US); H04M11/062 (EP, KR, US); H04M3/2209 (EP, US); H04W24/08 (US); H04L41/142 (EP, US); H04L41/16 (EP, US); H04L43/0811 (EP, US); H04L43/0847 (EP, US); H04L43/0852 (EP, US); H04L43/087 (EP, US)

Application number: CN20128075813 20120713 Global Dossier

Priority number(s): WO2012US46810 20120713

Also published as: CN104756474 (B) AU2012384930 (A1) AU2016204112 (A1) AU2016204112 (B2) BR112015000810 (A2) CA2879060 (A1) CA2879060 (C) CN110266565 (A) EP2873223 (A1) JP2015530774 (A) KR101677404 (B1) KR20150039198 (A) US10375590 (B2) US2016007218 (A1) WO2014011191 (A1) less

Abstract of CN104756474 (A)

Described is a method for performance estimation of a communication device. The method comprises: executing active probing to determine active probing data; reading operational data which includes data related to channel and its noise condition and counter values related to user data traffic between the communication device and another communication device, wherein the operational data is relevant to the current settings of the communication device; and training a performance estimation algorithm

for the communication device according to the active probing data and the operational data.

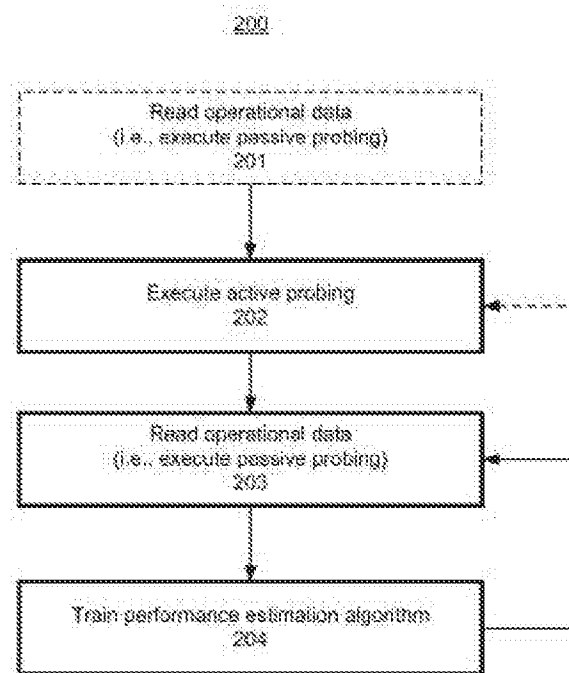


FIG. 2

Notice

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CLAIMS CN104756474

1.

A method for performance estimation of a communication device, the method comprising:

Perform proactive detection to determine active probing data;

Reading operational data, the operational data including data related to noise conditions of the channel and the channel, and counter values associated with user data traffic between the communication device and another communication device, wherein the operational data is Related to the current settings of the communication device;

And performing a performance estimation algorithm on the communication device according to the active probe data and the operation data.

2.

The method of claim 1 further comprising: reading the operational data prior to performing the active probing.

3.

The method of claim 1 wherein the reading of the operational data is performed during execution of the active probe or after performing the active probe.

4.

The method of claim 1 wherein training the performance estimation algorithm comprises updating the performance estimation algorithm as a function of one or more indicators, the one or more indicators comprising at least one of:

Times of Day,

One week,

Type of communication device,

Manufacturer and model of the equipment,

The characteristics of the device,

firmware,

The backbone is limited,

User's network usage style,

RF characteristics including at least one of signal power, path loss, noise level, frequency band, and mode of operation,

Environmental statistics, or

Data relating to operation of a communication device adjacent to the communication device, wherein the data comprises at least one of an interference channel and an interference level.

5.

The method of claim 1 wherein performing active probing comprises:

Transmitting active probe data from the communication device to another communication device;

Waiting for a predetermined time before reading the operational data.

6.

The method of claim 1 wherein performing active probing comprises:

Transmitting active probe data from the communication device to another communication device;

A report is received that represents the amount or data of data received by the other communication device.

7.

The method of claim 1 wherein performing active probing comprises:

Transmitting traffic from the communication device to another communication device;

Record the measured data associated with the transmitted service.

8.

The method of claim 1 further comprising:

At least one of throughput, connectivity, delay, jitter, or error rate of the communication device is calculated using active probe data for training the performance estimation algorithm.

9.

The method of claim 1 wherein performing active probing is performed less frequently than performing passive

probing.

10.

The method of claim 1 further comprising:

The active probe data and the read operational data are sent to the server before, during, and/or after the active probe is performed.

11.

The method of claim 10 wherein said server trains said communication device with said performance estimation algorithm based on active probe data from said communication device and other communication devices and said manipulated operational data.

12.

The method of claim 11 wherein said server applies a machine learning algorithm to train said performance estimation algorithm for said communication device.

13.

The method of claim 1 wherein said communication device comprises at least one of:

Access point (AP);

Base station

Wireless local area network (LAN) device;

Digital Subscriber Line Access Multiplexer (DSLAM);

Gateway

Performance enhancement device;

Digital Subscriber Line (DSL) Customer Premises Equipment (CPE) modem;

In-home power line equipment;

Home Phone Line Network Alliance (HPNA) based device;

In-home coaxial cable distribution equipment;

G.hn (Global Home Networking Standard) compatible device;

Metering communication equipment within the home;

An in-home device communicably coupled to the LAN;

Wireless femtocell base station;

Wireless WiFi compatible base station;

Wireless mobile device repeater;

Wireless mobile device base station;

a node in an ad hoc network/mesh network;

Set-top box (STB) / set-top unit (STU) customer electronics;

TV that supports Internet Protocol (IP);

IP-enabled media player;

IP-enabled game console;

Ethernet gateway

a computing device connected to the LAN;

a computer peripheral connected to an Ethernet;

a router connected to an Ethernet;

a wireless bridge connected to the Ethernet;

a bridge connecting Ethernet; and

A network switch that connects to an Ethernet.

14.

A system comprising:

An optimization center communicatively coupled to one or more communication devices, wherein the one or more communication devices are operable to:

Perform proactive detection to determine active probing data;

Reading operational data, the operational data including data related to noise conditions of the channel and the channel, and counter values associated with user data traffic between the communication device and another communication device, wherein the operational data is Related to the current settings of the communication device;

And performing a performance estimation algorithm on the communication device according to the active probe data and the operation data.

15.

The system of claim 14, wherein the optimization center is implemented as a server or implemented as a communication device from the one or more communication devices.

16.

The system of claim 14 wherein said one or more communication devices are operative to read operational data prior to performing active probing.

17.

The system of claim 14 wherein said one or more communication devices are operative to read operational data during execution of active probing or after performing active probing.

18.

The system of claim 14 wherein said one or more communication devices are operative to train said performance estimation algorithm, said one or more, by updating said performance estimation algorithm as a function of one or more indicators The indicator includes at least one of the following:

Times of Day,

One week,

Type of communication device,

Manufacturer and model of the equipment,

The characteristics of the device,

firmware,

The backbone is limited,

User's network usage style,

RF characteristics including at least one of signal power, path loss, noise level, frequency band, and mode of operation,

Environmental statistics, or

Data relating to operation of a communication device adjacent to the communication device, wherein the data comprises at least one of an interference channel and an interference level.

19.

The system of claim 14 wherein said one or more communication devices are operable to perform active probing by:

Transmitting active probe data from the communication device to another communication device;

Waiting for a predetermined time before reading the operational data.

20.

The system of claim 14 wherein said one or more communication devices are operable to perform active probing by:

Transmitting active probe data from the communication device to another communication device;

A report is received that represents the amount or data of data received by the other communication device.

21.

The system of claim 14 wherein said one or more communication devices are operable to perform active probing by:

Transmitting traffic from the communication device to another communication device;

Record the measured data associated with the transmitted service.

22.

The system of claim 14 wherein said one or more communication devices are operative to calculate throughput, connectivity, delay, jitter of said communication device using active probe data for training said performance estimation algorithm Or at least one of the error rates.

23.

The system of claim 14 wherein said one or more communication devices are operable to perform active probing less often than performing passive probing.

24.

The system of claim 14 wherein said one or more communication devices are operable to:

The active probe data and the read operational data are sent to the server before, during, and/or after the active probe is performed.

25.

The system of claim 24 wherein said server is operative to train said performance estimation algorithm for said communication device based on active probe data and said manipulated data from said communication device and other communication devices.

26.

The system of claim 25 wherein said server is operative to apply a machine learning algorithm to train said performance estimation algorithm.

27.

The system of claim 14 wherein said communication device comprises at least one of:

Access point (AP);

Base station

Wireless local area network (LAN) device;

Digital Subscriber Line Access Multiplexer (DSLAM);

Gateway

Performance enhancement device;

Digital Subscriber Line (DSL) Customer Premises Equipment (CPE) modem;

In-home power line equipment;

Home Phone Line Network Alliance (HPNA) based device;

In-home coaxial cable distribution equipment;

G.hn (Global Home Networking Standard) compatible device;

Metering communication equipment within the home;

An in-home device communicably coupled to the LAN;

Wireless femtocell base station;

Wireless WiFi compatible base station;

Wireless mobile device repeater;

Wireless mobile device base station;

a node in an ad hoc network/mesh network;

Set-top box (STB) / set-top unit (STU) customer electronics;

TV that supports Internet Protocol (IP);

IP-enabled media player;

IP-enabled game console;

Ethernet gateway

a computing device connected to the LAN;

a computer peripheral connected to an Ethernet;

a router connected to an Ethernet;

a wireless bridge connected to the Ethernet;

a bridge connecting Ethernet; and

A network switch that connects to an Ethernet.

28.

A machine-readable storage medium for storing machine-executable instructions that, when executed, cause a processor to perform the method of any one of claims 1 to 13.

29.

A method for performance estimation of a communication device, the method comprising:

After performing active probing and passive probing, receiving operational data including a counter value from the communication device, the counter value being related to user data traffic from the communication device to another communication device;

The performance estimation algorithm is trained on the communication device based on the operational data before performing active probing or after performing active probing.

30.

The method of claim 29, further comprising receiving the operational data prior to performing the active probing.

31.

The method of claim 29 wherein the operational data is received during execution of the active probe or after

performing the active probe.

32.

The method of claim 29, wherein training the performance estimation algorithm comprises updating the performance estimation algorithm as a function of one or more indicators, the one or more indicators comprising at least one of:

Times of Day,

One week,

Type of communication device,

Manufacturer and model of the equipment,

The characteristics of the device,

firmware,

The backbone is limited,

User's network usage style,

RF characteristics including at least one of signal power, path loss, noise level, frequency band, and mode of operation,

Environmental statistics, or

Data relating to operation of a communication device adjacent to the communication device, wherein the data

comprises at least one of an interference channel and an interference level.

33.

The method of claim 29 wherein performing active probing comprises:

Transmitting active probe data from the communication device to another communication device;

Waiting for a predetermined time before reading the operational data.

34.

The method of claim 29 wherein performing active probing comprises:

Transmitting active probe data from the communication device to another communication device;

A report is received that represents the amount or data of data received by the other communication device.

35.

The method of claim 29, further comprising:

At least one of throughput, connectivity, delay, jitter, or error rate of the communication device is calculated using active probe data for training the performance estimation algorithm.

36.

The method of claim 29 wherein performing active probing is performed less frequently than performing passive probing.

37.

The method of claim 29, further comprising:

The active probe data and the read operational data are received, the operational data being related to user data

traffic from the communication device prior to performing active probing, during performing proactive probing, and/or after performing proactive probing.

38.

The method of claim 37 wherein training the performance estimation algorithm for the communication device is performed based on active probe data and read operational data from the communication device and other communication devices.

39.

The method of claim 38 wherein training the performance estimation algorithm comprises applying a machine learning algorithm.

40.

The method of claim 38 wherein said communication device comprises at least one of:

Access point (AP);

Base station

Wireless local area network (LAN) device;

Digital Subscriber Line Access Multiplexer (DSLAM);

Gateway

Performance enhancement device;

Digital Subscriber Line (DSL) Customer Premises Equipment (CPE) modem;

In-home power line equipment;

Home Phone Line Network Alliance (HPNA) based device;

In-home coaxial cable distribution equipment;

G.hn (Global Home Networking Standard) compatible device;

Metering communication equipment within the home;

An in-home device communicably coupled to the LAN;

Wireless femtocell base station;

Wireless WiFi compatible base station;

Wireless mobile device repeater;

Wireless mobile device base station;

a node in an ad hoc network/mesh network;

Set-top box (STB) / set-top unit (STU) customer electronics;

TV that supports Internet Protocol (IP);

IP-enabled media player;

IP-enabled game console;

Ethernet gateway

a computing device connected to the LAN;

a computer peripheral connected to an Ethernet;

a router connected to an Ethernet;

a wireless bridge connected to the Ethernet;

a bridge connecting Ethernet; and

A network switch that connects to an Ethernet.

41.

A machine-readable storage medium for storing machine-executable instructions that, when executed, cause a processor to perform the method of any one of the method claims 29-40.

Notice

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CLAIMS CN104756474

1.

A method for performance estimation of a communication device, the method comprising:

Perform proactive detection to determine active probing data;

Reading operational data, the operational data including data related to noise conditions of the channel and the channel, and counter values associated with user data traffic between the communication device and another communication device, wherein the operational data is Related to the current settings of the communication device;

And performing a performance estimation algorithm on the communication device according to the active probe data and the operation data.

2.

The method of claim 1 further comprising: reading the operational data prior to performing the active probing.

3.

The method of claim 1 wherein the reading of the operational data is performed during execution of the active probe or after performing the active probe.

4.

The method of claim 1 wherein training the performance estimation algorithm comprises updating the performance estimation algorithm as a function of one or more indicators, the one or more indicators comprising at least one of:

Times of Day,

One week,

Type of communication device,

Manufacturer and model of the equipment,

The characteristics of the device,

firmware,

The backbone is limited,

User's network usage style,

RF characteristics including at least one of signal power, path loss, noise level, frequency band, and mode of operation,

Environmental statistics, or

Data relating to operation of a communication device adjacent to the communication device, wherein the data comprises at least one of an interference channel and an interference level.

5.

The method of claim 1 wherein performing active probing comprises:

Transmitting active probe data from the communication device to another communication device;

Waiting for a predetermined time before reading the operational data.

6.

The method of claim 1 wherein performing active probing comprises:

Transmitting active probe data from the communication device to another communication device;

A report is received that represents the amount or data of data received by the other communication device.

7.

The method of claim 1 wherein performing active probing comprises:

Transmitting traffic from the communication device to another communication device;

Record the measured data associated with the transmitted service.

8.

The method of claim 1 further comprising:

At least one of throughput, connectivity, delay, jitter, or error rate of the communication device is calculated using active probe data for training the performance estimation algorithm.

9.

The method of claim 1 wherein performing active probing is performed less frequently than performing passive

probing.

10.

The method of claim 1 further comprising:

The active probe data and the read operational data are sent to the server before, during, and/or after the active probe is performed.

11.

The method of claim 10 wherein said server trains said communication device with said performance estimation algorithm based on active probe data from said communication device and other communication devices and said manipulated operational data.

12.

The method of claim 11 wherein said server applies a machine learning algorithm to train said performance estimation algorithm for said communication device.

13.

The method of claim 1 wherein said communication device comprises at least one of:

Access point (AP);

Base station

Wireless local area network (LAN) device;

Digital Subscriber Line Access Multiplexer (DSLAM);

Gateway

Performance enhancement device;

Digital Subscriber Line (DSL) Customer Premises Equipment (CPE) modem;

In-home power line equipment;

Home Phone Line Network Alliance (HPNA) based device;

In-home coaxial cable distribution equipment;

G.hn (Global Home Networking Standard) compatible device;

Metering communication equipment within the home;

An in-home device communicably coupled to the LAN;

Wireless femtocell base station;

Wireless WiFi compatible base station;

Wireless mobile device repeater;

Wireless mobile device base station;

a node in an ad hoc network/mesh network;

Set-top box (STB) / set-top unit (STU) customer electronics;

TV that supports Internet Protocol (IP);

IP-enabled media player;

IP-enabled game console;

Ethernet gateway

a computing device connected to the LAN;

a computer peripheral connected to an Ethernet;

a router connected to an Ethernet;

a wireless bridge connected to the Ethernet;

a bridge connecting Ethernet; and

A network switch that connects to an Ethernet.

14.

A system comprising:

An optimization center communicatively coupled to one or more communication devices, wherein the one or more communication devices are operable to:

Perform proactive detection to determine active probing data;

Reading operational data, the operational data including data related to noise conditions of the channel and the channel, and counter values associated with user data traffic between the communication device and another communication device, wherein the operational data is Related to the current settings of the communication device;

And performing a performance estimation algorithm on the communication device according to the active probe data and the operation data.

15.

The system of claim 14, wherein the optimization center is implemented as a server or implemented as a communication device from the one or more communication devices.

16.

The system of claim 14 wherein said one or more communication devices are operative to read operational data prior to performing active probing.

17.

The system of claim 14 wherein said one or more communication devices are operative to read operational data during execution of active probing or after performing active probing.

18.

The system of claim 14 wherein said one or more communication devices are operative to train said performance estimation algorithm, said one or more, by updating said performance estimation algorithm as a function of one or more indicators The indicator includes at least one of the following:

Times of Day,

One week,

Type of communication device,

Manufacturer and model of the equipment,

The characteristics of the device,

firmware,

The backbone is limited,

User's network usage style,

RF characteristics including at least one of signal power, path loss, noise level, frequency band, and mode of operation,

Environmental statistics, or

Data relating to operation of a communication device adjacent to the communication device, wherein the data comprises at least one of an interference channel and an interference level.

19.

The system of claim 14 wherein said one or more communication devices are operable to perform active probing by:

Transmitting active probe data from the communication device to another communication device;

Waiting for a predetermined time before reading the operational data.

20.

The system of claim 14 wherein said one or more communication devices are operable to perform active probing by:

Transmitting active probe data from the communication device to another communication device;

A report is received that represents the amount or data of data received by the other communication device.

21.

The system of claim 14 wherein said one or more communication devices are operable to perform active probing by:

Transmitting traffic from the communication device to another communication device;

Record the measured data associated with the transmitted service.

22.

The system of claim 14 wherein said one or more communication devices are operative to calculate throughput, connectivity, delay, jitter of said communication device using active probe data for training said performance estimation algorithm Or at least one of the error rates.

23.

The system of claim 14 wherein said one or more communication devices are operable to perform active probing less often than performing passive probing.

24.

The system of claim 14 wherein said one or more communication devices are operable to:

The active probe data and the read operational data are sent to the server before, during, and/or after the active probe is performed.

25.

The system of claim 24 wherein said server is operative to train said performance estimation algorithm for said communication device based on active probe data and said manipulated data from said communication device and other communication devices.

26.

The system of claim 25 wherein said server is operative to apply a machine learning algorithm to train said performance estimation algorithm.

27.

The system of claim 14 wherein said communication device comprises at least one of:

Access point (AP);

Base station

Wireless local area network (LAN) device;

Digital Subscriber Line Access Multiplexer (DSLAM);

Gateway

Performance enhancement device;

Digital Subscriber Line (DSL) Customer Premises Equipment (CPE) modem;

In-home power line equipment;

Home Phone Line Network Alliance (HPNA) based device;

In-home coaxial cable distribution equipment;

G.hn (Global Home Networking Standard) compatible device;

Metering communication equipment within the home;

An in-home device communicably coupled to the LAN;

Wireless femtocell base station;

Wireless WiFi compatible base station;

Wireless mobile device repeater;

Wireless mobile device base station;

a node in an ad hoc network/mesh network;

Set-top box (STB) / set-top unit (STU) customer electronics;

TV that supports Internet Protocol (IP);

IP-enabled media player;

IP-enabled game console;

Ethernet gateway

a computing device connected to the LAN;

a computer peripheral connected to an Ethernet;

a router connected to an Ethernet;

a wireless bridge connected to the Ethernet;

a bridge connecting Ethernet; and

A network switch that connects to an Ethernet.

28.

A machine-readable storage medium for storing machine-executable instructions that, when executed, cause a processor to perform the method of any one of claims 1 to 13.

29.

A method for performance estimation of a communication device, the method comprising:

After performing active probing and passive probing, receiving operational data including a counter value from the communication device, the counter value being related to user data traffic from the communication device to another communication device;

The performance estimation algorithm is trained on the communication device based on the operational data before performing active probing or after performing active probing.

30.

The method of claim 29, further comprising receiving the operational data prior to performing the active probing.

31.

The method of claim 29 wherein the operational data is received during execution of the active probe or after

performing the active probe.

32.

The method of claim 29, wherein training the performance estimation algorithm comprises updating the performance estimation algorithm as a function of one or more indicators, the one or more indicators comprising at least one of:

Times of Day,

One week,

Type of communication device,

Manufacturer and model of the equipment,

The characteristics of the device,

firmware,

The backbone is limited,

User's network usage style,

RF characteristics including at least one of signal power, path loss, noise level, frequency band, and mode of operation,

Environmental statistics, or

Data relating to operation of a communication device adjacent to the communication device, wherein the data

comprises at least one of an interference channel and an interference level.

33.

The method of claim 29 wherein performing active probing comprises:

Transmitting active probe data from the communication device to another communication device;

Waiting for a predetermined time before reading the operational data.

34.

The method of claim 29 wherein performing active probing comprises:

Transmitting active probe data from the communication device to another communication device;

A report is received that represents the amount or data of data received by the other communication device.

35.

The method of claim 29, further comprising:

At least one of throughput, connectivity, delay, jitter, or error rate of the communication device is calculated using active probe data for training the performance estimation algorithm.

36.

The method of claim 29 wherein performing active probing is performed less frequently than performing passive probing.

37.

The method of claim 29, further comprising:

The active probe data and the read operational data are received, the operational data being related to user data

traffic from the communication device prior to performing active probing, during performing proactive probing, and/or after performing proactive probing.

38.

The method of claim 37 wherein training the performance estimation algorithm for the communication device is performed based on active probe data and read operational data from the communication device and other communication devices.

39.

The method of claim 38 wherein training the performance estimation algorithm comprises applying a machine learning algorithm.

40.

The method of claim 38 wherein said communication device comprises at least one of:

Access point (AP);

Base station

Wireless local area network (LAN) device;

Digital Subscriber Line Access Multiplexer (DSLAM);

Gateway

Performance enhancement device;

Digital Subscriber Line (DSL) Customer Premises Equipment (CPE) modem;

In-home power line equipment;

Home Phone Line Network Alliance (HPNA) based device;

In-home coaxial cable distribution equipment;

G.hn (Global Home Networking Standard) compatible device;

Metering communication equipment within the home;

An in-home device communicably coupled to the LAN;

Wireless femtocell base station;

Wireless WiFi compatible base station;

Wireless mobile device repeater;

Wireless mobile device base station;

a node in an ad hoc network/mesh network;

Set-top box (STB) / set-top unit (STU) customer electronics;

TV that supports Internet Protocol (IP);

IP-enabled media player;

IP-enabled game console;

Ethernet gateway

a computing device connected to the LAN;

a computer peripheral connected to an Ethernet;

a router connected to an Ethernet;

a wireless bridge connected to the Ethernet;

a bridge connecting Ethernet; and

A network switch that connects to an Ethernet.

41.

A machine-readable storage medium for storing machine-executable instructions that, when executed, cause a processor to perform the method of any one of the method claims 29-40.



(12) 发明专利申请

(10) 申请公布号 CN 104756474 A

(43) 申请公布日 2015.07.01

(21) 申请号 201280075813.6

H04M 3/22(2006.01)

(22) 申请日 2012.07.13

H04L 12/24(2006.01)

(85) PCT国际申请进入国家阶段日
2015.03.13

(86) PCT国际申请的申请数据
PCT/US2012/046810 2012.07.13

(87) PCT国际申请的公布数据
WO2014/011191 EN 2014.01.16

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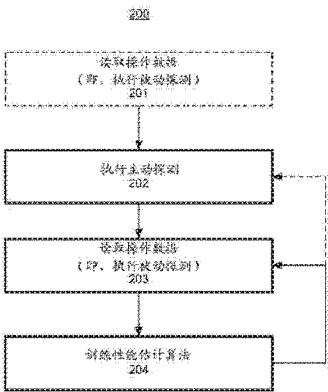
(51) Int. Cl.
H04M 11/06(2006.01)

权利要求书6页 说明书12页 附图4页

(54) 发明名称
用于通信链路性能估计的方法和系统

(57) 摘要

所描述的是一种用于通信设备的性能估计的方法。该方法包括：执行主动探测，以确定主动探测数据；读取操作数据，该操作数据包括与信道及其噪声条件相关的数据以及与该通信设备和另一通信设备之间的用户数据业务相关的计数器值，其中该操作数据与该通信设备的当前设置相关；以及根据该主动探测数据和该操作数据，对该通信设备训练性能估计算法。



CN 104756474 A

1. 一种用于通信设备的性能估计的方法,所述方法包括:
执行主动探测,以确定主动探测数据;
读取操作数据,所述操作数据包括与信道和信道的噪声条件相关的数据以及与所述通信设备和另一通信设备之间的用户数据业务相关的计数器值,其中所述操作数据与所述通信设备的当前设置相关;以及
根据所述主动探测数据和所述操作数据,对所述通信设备训练性能估计算法。
2. 根据权利要求 1 所述的方法,进一步包括:在执行主动探测以前,读取操作数据。
3. 根据权利要求 1 所述的方法,其中读取操作数据是在执行主动探测期间或在执行主动探测以后执行的。
4. 根据权利要求 1 所述的方法,其中训练所述性能估计算法包括:更新所述性能估计算法作为一个或多个指标的函数,所述一个或多个指标包括以下至少之一:
一天的时间,
一周的时间,
通信设备的类型,
设备的制造者及型号,
设备的特性,
固件,
主干局限,
用户的网络使用样式,
包括信号功率、路径损耗、噪声电平、频带和操作模式中至少一个的 RF 特性,
环境统计信息,或
关于与所述通信设备相邻的通信设备的操作的数据,其中所述数据包括干扰信道和干扰电平中至少一个。
5. 根据权利要求 1 所述的方法,其中执行主动探测包括:
将主动探测数据从所述通信设备发送至另一通信设备;以及
在读取操作数据以前等待预定的时间。
6. 根据权利要求 1 所述的方法,其中执行主动探测包括:
将主动探测数据从所述通信设备发送至另一通信设备;以及
接收报告,所述报告表示由所述另一通信设备接收的数据的量或数据。
7. 根据权利要求 1 所述的方法,其中执行主动探测包括:
将业务从所述通信设备发送至另一通信设备;以及
记录与所发送的业务关联的测量的数据。
8. 根据权利要求 1 所述的方法,进一步包括:
使用用于训练所述性能估计算法的主动探测数据,计算所述通信设备的吞吐量、连通性、延迟、抖动或错误率中的至少一个。
9. 根据权利要求 1 所述的方法,其中执行主动探测与执行被动探测相比,执行次数更少。
10. 根据权利要求 1 所述的方法,进一步包括:
在执行主动探测以前、期间和 / 或以后,将所述主动探测数据和所读取的操作数据发

送至服务器。

11. 根据权利要求 10 所述的方法, 其中所述服务器根据来自所述通信设备和其它通信设备的主动探测数据和所读取的操作数据, 对所述通信设备训练所述性能估计算法。

12. 根据权利要求 11 所述的方法, 其中所述服务器应用机器学习算法, 对所述通信设备训练所述性能估计算法。

13. 根据权利要求 1 所述的方法, 其中所述通信设备包括以下至少之一:

接入点 (AP);

基站;

无线局域网 (LAN) 设备;

数字用户线路接入复用器 (DSLAM);

网关;

性能增强设备;

数字用户线路 (DSL) 客户驻地设备 (CPE) 调制解调器;

家庭内电力线设备;

基于家庭电话线网络联盟 (HPNA) 的设备;

家庭内同轴电缆分配设备;

G.hn (全球家庭联网标准) 兼容设备;

家庭内计量通信设备;

与 LAN 可通信地接合的家庭内装置;

无线毫微微蜂窝基站;

无线 WiFi 兼容基站;

无线移动设备中继器;

无线移动设备基站;

自组网 / 网状网内的节点;

机顶盒 (STB) / 机顶单元 (STU) 客户电子设备;

支持互联网协议 (IP) 的电视;

支持 IP 的媒体播放器;

支持 IP 的游戏控制台;

以太网网关;

与 LAN 连接的计算设备;

连接以太网的计算机外围设备;

连接以太网的路由器;

连接以太网的无线桥;

连接以太网的网桥; 以及

连接以太网的网络交换机。

14. 一种系统, 包括:

优化中心, 通信地联接至一个或多个通信设备, 其中所述一个或多个通信设备能操作来;

执行主动探测, 以确定主动探测数据;

读取操作数据,所述操作数据包括与信道和信道的噪声条件相关的数据以及与所述通信设备和另一通信设备之间的用户数据业务相关的计数器值,其中所述操作数据与所述通信设备的当前设置相关;以及

根据所述主动探测数据和所述操作数据,对所述通信设备训练性能估计算法。

15. 根据权利要求 14 所述的系统,其中所述优化中心被实现为服务器或被实现为来自所述一个或多个通信设备中的通信设备。

16. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来在执行主动探测以前读取操作数据。

17. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来在执行主动探测期间或在执行主动探测以后读取操作数据。

18. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来通过更新所述性能估计算法作为一个或多个指标的函数,训练所述性能估计算法,所述一个或多个指标包括以下至少之一:

一天的时间,

一周的时间,

通信设备的类型,

设备的制造者及型号,

设备的特性,

固件,

主干局限,

用户的网络使用样式,

包括信号功率、路径损耗、噪声电平、频带和操作模式中至少一个的 RF 特性,

环境统计信息,或

关于与所述通信设备相邻的通信设备的操作的数据,其中所述数据包括干扰信道和干扰电平中至少一个。

19. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来通过以下步骤,执行主动探测:

将主动探测数据从所述通信设备发送至另一通信设备;以及

在读取操作数据以前等待预定的时间。

20. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来通过以下步骤,执行主动探测:

将主动探测数据从所述通信设备发送至另一通信设备;以及

接收报告,所述报告表示由所述另一通信设备接收的数据的量或数据。

21. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来通过以下步骤,执行主动探测:

将业务从所述通信设备发送至另一通信设备;以及

记录与所发送的业务关联的测量的数据。

22. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来使用用于训练所述性能估计算法的主动探测数据,计算所述通信设备的吞吐量、连通性、延迟、抖动或

错误率中的至少一个。

23. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来比执行被动探测更少次数地执行主动探测。

24. 根据权利要求 14 所述的系统,其中所述一个或多个通信设备能操作来:

在执行主动探测以前、期间和 / 或以后,将所述主动探测数据和所读取的操作数据发送至服务器。

25. 根据权利要求 24 所述的系统,其中所述服务器能操作来根据来自所述通信设备和其它通信设备的主动探测数据和所读取的操作数据,对所述通信设备训练所述性能估计算法。

26. 根据权利要求 25 所述的系统,其中所述服务器能操作来应用机器学习算法,对所述通信设备训练所述性能估计算法。

27. 根据权利要求 14 所述的系统,其中所述通信设备包括以下至少之一:

接入点 (AP);

基站;

无线局域网 (LAN) 设备;

数字用户线路接入复用器 (DSLAM);

网关;

性能增强设备;

数字用户线路 (DSL) 客户驻地设备 (CPE) 调制解调器;

家庭内电力线设备;

基于家庭电话线网络联盟 (HPNA) 的设备;

家庭内同轴电缆分配设备;

G.hn (全球家庭联网标准) 兼容设备;

家庭内计量通信设备;

与 LAN 可通信地接合的家庭内装置;

无线毫微微蜂窝基站;

无线 WiFi 兼容基站;

无线移动设备中继器;

无线移动设备基站;

自组网 / 网状网内的节点;

机顶盒 (STB) / 机顶单元 (STU) 客户电子设备;

支持互联网协议 (IP) 的电视;

支持 IP 的媒体播放器;

支持 IP 的游戏控制台;

以太网网关;

与 LAN 连接的计算设备;

连接以太网的计算机外围设备;

连接以太网的路由器;

连接以太网的无线桥;

连接以太网的网桥；以及
连接以太网的网络交换机。

28. 一种用于存储机器可执行指令的机器可读存储介质，所述机器可执行指令在执行时，引起处理器执行根据方法权利要求 1 至 13 中任一项权利要求所述的方法。

29. 一种用于通信设备的性能估计的方法，所述方法包括：

在执行主动探测和被动探测以后，从所述通信设备接收包括计数器值的操作数据，所述计数器值与从所述通信设备至另一通信设备的用户数据业务相关；以及

在执行主动探测以前或在执行主动探测以后，根据所述操作数据对所述通信设备训练性能估计算法。

30. 根据权利要求 29 所述的方法，进一步包括：在执行主动探测以前，接收操作数据。

31. 根据权利要求 29 所述的方法，其中操作数据是在执行主动探测期间或在执行主动探测以后接收到的。

32. 根据权利要求 29 所述的方法，其中训练所述性能估计算法包括：更新所述性能估计算法作为一个或多个指标的函数，所述一个或多个指标包括以下至少之一：

一天的时间，

一周的时间，

通信设备的类型，

设备的制造者及型号，

设备的特性，

固件，

主干局限，

用户的网络使用样式，

包括信号功率、路径损耗、噪声电平、频带和操作模式中至少一个的 RF 特性，

环境统计信息，或

关于与所述通信设备相邻的通信设备的操作的数据，其中所述数据包括干扰信道和干扰电平中至少一个。

33. 根据权利要求 29 所述的方法，其中执行主动探测包括：

将主动探测数据从所述通信设备发送至另一通信设备；以及

在读取操作数据以前等待预定的时间。

34. 根据权利要求 29 所述的方法，其中执行主动探测包括：

将主动探测数据从所述通信设备发送至另一通信设备；以及

接收报告，所述报告表示由所述另一通信设备接收的数据的量或数据。

35. 根据权利要求 29 所述的方法，进一步包括：

使用用于训练所述性能估计算法的主动探测数据，计算所述通信设备的吞吐量、连通性、延迟、抖动或错误率中的至少一个。

36. 根据权利要求 29 所述的方法，其中执行主动探测与执行被动探测相比，执行次数更少。

37. 根据权利要求 29 所述的方法，进一步包括：

接收所述主动探测数据和所读取的操作数据，所述操作数据与在执行主动探测以前、

在执行主动探测期间和 / 或在执行主动探测以后来自所述通信设备的用户数据业务相关。

38. 根据权利要求 37 所述的方法, 其中对所述通信设备训练所述性能估计算法, 是根据来自所述通信设备和其它通信设备的主动探测数据和所读取的操作数据而执行的。

39. 根据权利要求 38 所述的方法, 其中训练所述性能估计算法包括应用机器学习算法。

40. 根据权利要求 38 所述的方法, 其中所述通信设备包括以下至少之一:

接入点 (AP);

基站;

无线局域网 (LAN) 设备;

数字用户线路接入复用器 (DSLAM);

网关;

性能增强设备;

数字用户线路 (DSL) 客户驻地设备 (CPE) 调制解调器;

家庭内电力线设备;

基于家庭电话线网络联盟 (HPNA) 的设备;

家庭内同轴电缆分配设备;

G.hn (全球家庭联网标准) 兼容设备;

家庭内计量通信设备;

与 LAN 可通信地接合的家庭内装置;

无线毫微微蜂窝基站;

无线 WiFi 兼容基站;

无线移动设备中继器;

无线移动设备基站;

自组网 / 网状网内的节点;

机顶盒 (STB) / 机顶单元 (STU) 客户电子设备;

支持互联网协议 (IP) 的电视;

支持 IP 的媒体播放器;

支持 IP 的游戏控制台;

以太网网关;

与 LAN 连接的计算设备;

连接以太网的计算机外围设备;

连接以太网的路由器;

连接以太网的无线桥;

连接以太网的网桥; 以及

连接以太网的网络交换机。

41. 一种用于存储机器可执行指令的机器可读存储介质, 所述机器可执行指令在执行时, 引起处理器执行根据方法权利要求 29 至 40 中任一项权利要求所述的方法。

用于通信链路性能估计的方法和系统

背景技术

[0001] 执行监视通信链路的性能,例如前摄性地解决和防止用户抱怨、决定何时更新与通信链路关联的硬件、决定何时触发优化算法、验证该优化算法已经提高性能等。

[0002] 可以使用传统测试软件应用程序(如 iperf、netperf、ttcp 等)来评估通信系统性能。这种软件应用程序需要被安装在两个通信设备上,其中一个设备上的应用程序生成并发送测试数据,另一设备上的应用程序接收测试数据。在测试完成后,对数据传输的统计结果进行评估,以评估这两个设备之间的通信链路的性能。

[0003] 本文中的术语“性能”通常指网络吞吐量(例如,TCP/UDP)、延迟、抖动、连通性、错误率、功耗、发射功率等。改善通信系统的性能包括提高该通信系统的吞吐量、降低该通信系统的错误率和延迟、改善(即降低)该通信系统的抖动、降低该通信系统的功耗等。术语“TCP”代表传输控制协议。术语“UDP”指用户数据报协议。

[0004] 然而,通过这种传统测试软件应用程序测试通信系统或网络以估计其性能,对客户的服务是侵入性的。这些传统测试在网络上施加测试业务,该测试业务会对客户的业务产生有害影响。

附图说明

[0005] 根据下面给出的具体实施方式以及根据本公开的各实施例的附图,将更全面地理解本公开的实施例,然而不应认为其将本公开局限于这些特定实施例,而是仅用于说明和理解。

[0006] 图 1 是根据本公开的一个实施例的可操作来评估和改善通信系统性能算法的通信网络。

[0007] 图 2 是根据本公开的一个实施例的用于训练性能算法的流程图。

[0008] 图 3 是根据本公开的一个实施例的用于由服务器对通信设备训练性能算法的流程图。

[0009] 图 4 是根据本公开的一个实施例的具有机器可读存储介质的基于处理器的系统,该机器可读存储介质具有计算机可执行指令,该机器可执行指令可操作来评估和改善通信系统性能算法。

具体实施方式

[0010] 用于测试网络业务的传统方法(对用户网络服务是侵入性的)被称为“主动探测”。本文中术语“主动探测”一般指,通过从一个通信设备经由网络向另一通信设备发送测试样式/数据并然后测量所发送的测试样式的响应,对通信网络进行测试。响应数据在本文中还被称为“主动数据”或“主动测量数据”,其是与通信网络的主动探测关联的数据。

[0011] 诸如 iperf、netperf、ttcp 等之类的传统主动探测软件运行在应用层,其中数据发送应用程序软件和数据接收应用程序软件一起被用于准确地测量这两个发送和接收设备之间的性能。传统的主动探测是准确的,因为实际的测试数据是以与用户业务在该网络

上会发送的方式相同的方式发送的。频繁的主动探测可能干扰用户,因为其可能使用户业务延迟。在不停止用户业务的情况下运行主动探测是可能的,但是这种测量是不准确的,因为测试业务与用户业务相竞争,而且此外主动探测可能因为较低的吞吐量和 / 或较高的延迟而显著地损害用户体验。为了克服这个及其它局限,本文描述用于在不影响客户的业务的条件下测量性能的方法和系统。

[0012] 一种先进的主动探测方法在代理人案号 P067PCT(在 2012 年 7 月 13 日与本申请同时提交的标题为“Method and System for Performance Measurement of a Communication Link(用于通信链路的性能测量的方法和系统)”的 PCT 申请号,通过引用整体并入本文,并且由美国加利福尼亚雷德伍德城 94065 的 ASSIA 公司共同拥有)中描述,能够通过考虑补偿用户业务以及测试业务的操作数据,来避免用户业务问题。

[0013] 用于评估通信链路和 / 或通信设备的性能的另一机制是监视与通信设备关联的操作数据。该操作数据是为几种目的而生成的。例如,有时作为通信设备的正常操作的副产品,生成操作数据。在另一示例中,为了提供与通信设备关联的基本性能或操作信息,生成操作数据。读取或收集这种操作数据对用户网络服务不是侵入性的。这种通信数据(操作数据)的监视或读取在本文中有时被称为“被动探测”。通常,通信设备的操作数据不包含最重要的和高级的性能参数,例如吞吐量或延迟,但是使用操作数据可以进行高级参数的粗略估计。

[0014] 例如,根据典型的操作数据,如分组错误量以及表示每个数据符号正发送多少比特的物理层星座信息,可以粗略地估计吞吐量。然而,这种估计可能是不准确的,因为所使用的操作数据可能不包含关于吞吐量的足够信息,并且因为操作数据和吞吐量之间的关系经常取决于噪声(包括干扰)和在不同位置 and 不同时间快速变化的信道特性。

[0015] 在本公开的实施例中,操作数据与主动探测数据一起被用于获得通信链路性能的可靠估计。在一个实施例中,在使用主动探测数据时,可以一起收集操作数据。包括完整的主动探测数据和操作数据的集合,主动探测数据结果被视为通信链路性能的准确估计,并且被用于训练仅操作数据(operational-data-only)估计算法。

[0016] 在一个实施例中,一旦训练结束并且完全地理解了仅操作数据估计的准确度,就可以用操作数据在不频繁的主动探测(其是侵入性的服务)的情况下对系统进行监视。在一个实施例中,不频繁地调用主动探测,或者甚至根据对准确性能估计的需要以及对为更新仅操作数据估计器而训练数据的需要,动态地调用主动探测。

[0017] 可以以一些不同的方式使用本公开的实施例。例如,在较高层的抽象中,可以从大型(例如,100 个或 100 个以上的形成网络的通信设备)通信网络中收集主动探测和操作数据,并且可以对全部数据执行分析以开发具有良好准确度的被动估计器。在一个实施例中,利用任何众所周知的机器学习技术(例如 SVM(支持矢量机))执行这种被动估计。

[0018] 在另一示例中,在较低层的抽象中,可以针对通信网络中的每个通信链路适应性地调整被动估计器。每个环境是唯一的,并且最好的估计器可以依赖于环境。在一个实施例中,对通信系统中的每个通信设备执行机器学习或任何学习,使得被动估计器提供给定的环境的最佳性能。

[0019] 在一个实施例中,性能估计算法执行如下更新。首先,限定初始步长。如果使用被动数据的吞吐量估计被主动探测数据确定为过低,则与步长成比例地增加该吞吐量估计。

如果使用被动数据的吞吐量数据被主动探测数据确定为过高,则与步长成比例地减少该吞吐量估计。术语“低”和术语“高”指彼此不同的可编制的或预定的阈值。如果吞吐量估计减少并且在下一次迭代时增加,或者如果吞吐量估计增加并且在下一次迭代时减少,则降低步长。

[0020] 在一个实施例中,从计数器(本文中还被称为与通信设备关联的操作计数器)中读取操作数据,操作数据的计数值因成功地传递分组而增加。本文中的术语“成功地”指建议通信设备安全接收分组的指示,安全接收分组通常通过 ACK(确认)消息分组来确认。在另一实施例中,操作数据,如错误计数、重传计数、调制、信号强度等,被用于估计通信链路的吞吐量。

[0021] 在被动探测的过程期间,即在操作数据的读取期间,不中断客户网络服务。操作数据通常是用户可见到的或可访问的数据,并且通常用于通信系统的调试(debug)和基本性能监视,但是通常不用于高级性能估计,因为该数据不是为性能监视而设计的,不携带与性能相关的足够信息,并且没有高准确度的已知估计算法。因此,被动探测自身可能不足以确定通信系统的高级性能,并且操作数据通常包括仅与通信系统的当前性能弱关联的计数器值。

[0022] 本文中的实施例公开一种用于通过将操作数据与主动探测数据一起使用来训练性能估计算法,改善通信设备的性能估计的方法和系统。在一个实施例中,在使用准确的主动探测数据和非入侵的被动探测数据训练性能估计算法以后,对操作数据进行规则的监视并且将操作数据用于准确地更新性能估计,而不中断网络上的客户业务。

[0023] 在一个实施例中,当需要更新性能估计算法时,发起主动探测。然后,通过被动操作探测数据,训练性能估计算法。在另一实施例中,周期性地(即以规则的间隔)发起主动探测,以检查仅使用被动探测数据的性能估计算法是否正以与主动探测数据的算法相当的准确度估计性能。本文中的实施例提供一种用于评估通信设备性能以及用于在对网络用户很少中断或不对用户中断的情况下管理网络系统的有效且几乎非侵入的方法。

[0024] 在下面的描述中,介绍许多细节,以提供本公开的实施例的更全面解释。然而,对本领域技术人员将显而易见的是,本公开的实施例可以在没有这些特定细节的情况下实践。在其它示例中,为了避免使本公开的实施例模糊,以框图形式而不是详细地示出众所周知的结构和设备。

[0025] 注意,在实施例的对应图中,以直线表示信号。一些直线可能较粗,以表示更主要的信号路径,和/或一些直线可能在一端或两端具有箭头,以表示主要信息流向。这样表示的目的不是限制性的。相反,这些直线与一个或多个示例性实施例结合用于帮助电路或逻辑单元的更方便理解。由设计需要或偏好指定的任何被表示的信号实际上可以包括可以沿任一方向传播的一个或多个信号,并且可以以任何适合类型的信号机制来实现。

[0026] 在下面的描述和权利要求中,可以使用术语“联接”和其派生词。本文中的术语“联接”指直接接触(物理地、电气地、磁性地、光学地等)的两个或更多个元件。本文中的术语“联接”还可以指彼此不直接接触但仍彼此配合或相互影响的两个或更多元件。

[0027] 如本文中使用的(除非另外指定),描述普通对象的序数词“第一”、“第二”和“第三”等,仅表示所指的相似对象的不同示例,并且目的不在于表明如此描述的这些对象必须在时间上、在空间上、按等级或以任何其它方式处于特定的顺序。术语“基本上”、“大致”、

“几乎”、“大约”、“接近”及类似术语指位于目标值 $\pm 20\%$ 范围内的量。

[0028] 图 1 是根据本公开的一个实施例的可操作来评估和改善通信系统性能估计算法的通信网络 100。在一个实施例中,该通信网络包括与一个或多个通信设备 103_{1-N} 通信地联接的优化中心 101 (例如,服务器),其中 N 是正整数。在一个实施例中,通信设备 103_2 通过数字用户线路 (DSL) 链路与客户驻地设备 (CPE) 调制解调器 104 联接。在一个实施例中,CPE 调制解调器 104 与接入点 (AP) 105 联接。在一个实施例中,AP 105 联接至一个或多个站点 (STA) 106_{1-M} ,其中 M 是正整数。

[0029] 在一个实施例中,性能估计算法 102 是具有输入变量是被动探测数据的公式。在一个实施例中,性能估计算法 102 与被动探测数据成比例地增加或减少。

[0030] 在一个实施例中,在优化服务器 101 和 / 或通信设备 103_{1-N} 中的一个或多个通信设备上存储用于更新和 / 或提高性能估计算法 102 的指令。尽管图 1 的实施例未示出其它设备 104、105 和 106_{1-M} 包括用于更新和 / 或提高性能估计算法 102 的指令,但在一个实施例中,与网络 (有线或无线) 直接地或间接地联接的任何通信设备可以具有用于更新和 / 或提高性能估计算法 102 的指令。在一个实施例中,可以根据每个通信设备的数据和环境,对该通信设备调整性能估计算法 102。在一个实施例中,对这些通信设备 103_{1-N} 产生的性能估计算法可能是不同的。

[0031] 在一个实施例中,通信设备 103_{1-N} 包括接入点 (AP)、基站、无线局域网 (LAN) 设备、数字用户线路接入复用器 (DSLAM)、网关、性能增强设备、数字用户线路 (DSL) CPE (客户驻地设备) 调制解调器、家庭内电力线设备、基于家庭电话线网络联盟 (HPNA) 的设备、家庭内同轴电缆分配设备、G.hn (全球家庭联网标准) 兼容设备、家庭内计量通信设备、与 LAN 通信地接合的家庭内装置、无线毫微微蜂窝基站、无线 WiFi 兼容基站、无线移动设备中继器、无线移动设备基站、自组网 (ad-hoc) / 网状网内的节点、机顶盒 (STB) / 机顶单元 (STU) 客户电子设备、支持互联网协议 (IP) 的电视、支持 IP 的媒体播放器、支持 IP 的游戏控制台、以太网网关、与 LAN 连接的计算设备、连接以太网的计算机外围设备、连接以太网的路由器、连接以太网的无线桥、连接以太网的网桥以及连接以太网的网络交换机。

[0032] 在一个实施例中,该一个或多个通信设备 103_{1-N} 可操作来执行主动探测,以确定主动探测数据。在该实施例中,该一个或多个通信设备 103_{1-N} 在它们各自的通信链路 107_{1-N} 上将业务输运至优化中心 101。在该实施例中,由该一个或多个通信设备 103_{1-N} 通过通信链路 107_{1-N} 从优化中心 101 接收的响应是主动数据,该主动数据由对应一个或多个通信设备 103_{1-N} 中各自的性能估计算法 102 使用,以训练这些性能估计算法。

[0033] 在一个实施例中,该一个或多个通信设备 103_{1-N} 可操作来通过从一个通信设备向另一通信设备发送主动探测数据,来执行主动探测。例如,通信设备 103_1 通过 DSL 链路向通信设备 106_1 发送探测数据,和 / 或通信设备 103_2 通过 DSL 线路向 CPE 104 发送主动探测数据。在另一示例中,通信设备 106_1 通过包括 107_1 的通信链路向优化中心 101 发送主动探测数据。

[0034] 在一个实施例中,该一个或多个通信设备 103_{1-N} 进一步可操作成在读取包括与通信链路 107_{1-N} 上的用户数据业务相关的计数器值的操作数据以前等待预定的时间。在一个实施例中,该预定的时间位于 0.001 秒至 60 秒的范围内。在其它实施例中,可以使用其它等待时间段。在一个实施例中,该等待时间段可通过软件或硬件来编制。

[0035] 为了不使本公开的实施例模糊,介绍通信设备 103₁、103₂、104 和优化中心 101。相同的介绍适用于其它通信设备。在一个实施例中,通信设备 103₁进一步可操作来接收报告,该报告表示由其它通信设备(例如,优化中心 101 和 / 或通信设备 103₂)接收的数据的量或数据。

[0036] 在一个实施例中,该一个或多个通信设备 103_{1-N}可操作来读取操作数据,该操作数据包括与信道(例如,链路 107_{1-N}、105 和 106_{1-M}之间的链路、103₁和 106_{1-M}之间的链路和 / 或 103₂和 104 之间的 DSL 链路)和其噪声条件相关的数据、与通信设备 103_{1-N}的当前设置相关的数据、以及与通信设备 103_{1-N}和另一通信设备(例如,优化中心 101、105、106_{1-M}、104 等)之间的用户数据业务相关的计数器值,其中该操作数据与通信设备的当前设置相关。这种操作数据的示例是成功发送的分组计数、成功接收的分组计数、ACK 分组计数、错误分组计数、丢弃分组计数、重传计数等。

[0037] 在一个实施例中,该一个或多个通信设备可操作来比执行被动探测更少次数地执行主动探测。例如,每天最多执行 5 次主动探测,因为主动探测是侵入性过程,并且每天执行被动探测 1440 次(例如,每一分钟)。

[0038] 在一个实施例中,该一个或多个通信设备 103_{1-N}可操作为根据主动探测数据和操作数据来训练它们各自的性能估计算法 102。在一个实施例中,该一个或多个通信设备 103_{1-N}可操作来,在执行主动探测以前从与通信链路上的用户数据业务相关的计数器值中读取操作数据(即,被动探测)。例如,链路 107_{1-N}、105 和 106_{1-M}之间的链路、103₁和 106_{1-M}之间的链路和 / 或 103₂和 104 之间的 DSL 链路。

[0039] 在一个实施例中,计数器值包括分组错误计数、分组重传计数、成功的 ACK 消息计数等中至少之一。在一个实施例中,该一个或多个通信设备 103_{1-N}可操作来在执行主动探测期间或在执行主动探测以后读取操作数据(即,执行被动探测)。

[0040] 性能估计算法的准确度可能取决于用户业务样式的特性以及噪声和信道环境的特性。在环境中,噪声和信道可能频繁地改变。在另一环境中,噪声和信道可能十分不频繁地改变。在又一环境中,噪声和信道可能频繁地改变,但主要仅在两个状态之间改变。

[0041] 在一个实施例中,可以适应性地调整每个设备的性能估计算法 102。在一个实施例中,该一个或多个通信设备 103_{1-N}可操作来通过更新性能估计算法 102 作为一个或多个指标的函数,对性能估计算法 102 进行训练,一个或多个指标包括以下至少之一:一天的时间、一周的时间、通信设备的类型、设备的制造者和型号、设备特性、固件、主干局限、用户的网络使用样式、包括信号功率、频带和操作模式中至少之一的射频(RF)特性、环境统计信息、或关于与通信设备相邻的通信设备的操作的数据,其中该数据包括干扰信道和干扰水平中至少之一。

[0042] 在一个实施例中,该一个或多个通信设备 103_{1-N}可操作来使用用于训练性能估计算法的主动探测数据,计算通信设备 103_{1-N}的吞吐量。在一个实施例中,该一个或多个通信设备 103_{1-N}可操作来发送主动探测数据并且通过通往优化中心 101(例如,服务器)的通信链路 107_{1-N}读取操作数据,其中该操作数据在执行主动探测以前、在执行主动探测期间和 / 或在执行主动探测以后与来自该一个或多个通信设备 103_{1-N}的数据业务相关。在一个实施例中,优化中心 101 可操作来根据主动探测数据对该通信设备训练性能估计算法 102,并且从该一个或多个通信设备 103_{1-N}读取操作数据。

[0043] 在一个实施例中,优化中心 101 可操作来应用机器学习算法,以训练该通信设备的性能估计算法。在该实施例中,准确的主动探测数据与被动探测数据一起用于机器学习,并且相应地确定仅使用被动数据作为输入的性能估计算法 102。

[0044] 例如,优化中心 101 (或者任何其它通信设备) 可以应用以下中的一个或多个:决策树学习、关联规则学习、人工神经网络学习算法、遗传编程算法、归纳逻辑编程方法、支持向量机方法、聚类、基于贝叶斯网络的概率图模型、强化学习、表征学习、稀疏字典学习等。在其它实施例中,可以使用其它机器学习算法。尽管本文的实施例描述由优化中心 101 应用机器学习算法,但是任何通信设备可以具有用于应用和执行机器学习的可执行指令和关联硬件,以训练性能估计算法。

[0045] 在一个实施例中,在完成对性能估计算法的训练过程以后,可以在没有任何用户业务中断的情况下用操作数据(来自被动探测的数据)监视网络 100。在一个实施例中,根据对准确性估计的需要以及对针对更新操作数据估计器而训练数据的需要,可以由任何通信设备偶尔地和 / 或动态地发起主动探测。例如,当网络性能下降至阈值以下并且性能估计未提供准确数据时,通信设备 103₂ 可以调用主动探测来训练性能估计算法,使得今后可以通过操作数据监视网络 100。

[0046] 图 2 是根据本公开的一个实施例的用于训练性能算法的流程图 200。尽管关于图 2 的流程图中的框以特定顺序示出,但是可以修改动作的顺序。因此,可以以不同顺序执行所图示的实施例,并且可以并行执行一些动作 / 框。图 2 的流程图是关于图 1 的实施例图示的。为了不使该流程图的实施例模糊,未重申每个方法步骤的详情。

[0047] 在一个实施例中,该方法包括记录与通信链路(例如,链路 107_{1-N}、105 和 106_{1-M}之间的链路、103₁和 106_{1-M}之间的链路和 / 或 103₂和 104 之间的 DSL 链路)上的数据业务相关的计数器的运行值。在一个实施例中,计数器的运行值包括分组错误计数、分组重传计数、成功的 ACK 消息计数等中至少之一。例如,B1 是由计数器记录的总发送字节。在这种实施例中,操作计数器对成功传递的分组增加计数值。在一个实施例中,通信设备(例如,103₁或优化中心 101) 开始执行主动探测。在这种实施例中,从通信设备(103₁、105、103₂或优化中心 101) 通过各个通信链路(链路 107_{1-N}、105 和 106_{1-M}之间的链路、和 / 或 103₂和 104 之间的链路)向另一通信设备(101、106_{1-M}或 104) 发送主动探测数据。

[0048] 在一个实施例中,在等待“t”秒(例如,0.001 秒至 60 秒)以后,再次读取操作计数器值,例如,现在从操作计数器中记录总共 B2 个发送字节。在一个实施例中,计算吞吐量,其中吞吐量 = (B2-B1)/t (以“字节 / 秒”为单位)。由于与所使用的实际用户数据字节相比,来自操作数据的报告字节中的任何偏差,所计算的吞吐量可能不准确。所计算的吞吐量不准确的另一原因可能是所报告的字节比该链路的容量低得多,仅因为用户未足够充分地使用该链路,并且未产生足以引起计数器全速增加计数器值的业务。在一个实施例中,可以通过将根据操作数据计算的吞吐量与利用主动探测数据计算的吞吐量进行比较,来检测所计算的吞吐量的这种偏差和不准确性。在这种实施例中,本文介绍的方法可以用于提供与直接的、但不准确的使用 (B2-B1)/t 方法相比更准确的吞吐量估计算法。

[0049] 在框 201,通信设备(例如,103_{1-N}、105 和 / 或优化中心 101 中的一个或多个)读取与该通信设备的物理层或媒体接入控制(MAC)地址层(例如网关)关联的操作数据。例如,通信设备 103₂读取与通信设备 103₂和 CPE 104 之间的 DSL 链路关联的操作数据。

[0050] 在框 202,通信设备执行主动探测。例如,通过链路 107_{1-N} 、设备 105 和 106_{1-M} 之间的链路、 103_1 和 106_{1-M} 之间的链路发送和接收测试数据。在另一示例中,通过 103_2 和 104 之间的 DSL 链路发送和接收测试数据。在其它实施例中,通过其它链路和其它通信设备发送和接收来自主动探测的测试数据。

[0051] 在框 203,通信设备 103_2 再次读取操作数据,之后执行主动探测。在该实施例中,再次读取与被动数据或操作数据对应的计数器值,并且现在它们的内容(计数器值)代表网络性能的快照。在缺少链路的训练性能估计算法时使用主动探测数据,计数器值可能不提供网络性能的准确快照。

[0052] 在框 204,优化中心 101 使用计数器值(被动数据,即操作数据)以及通过执行主动探测确定的主动数据,来训练性能估计算法 102 。尽管本文中的实施例是使用用于训练性能估计算法 102 的优化中心 101 来说明的,但是网络中的任何其它通信设备(图 1 的)可以用于训练性能估计算法 102 。在一个实施例中,通信设备 103_2 可以使用该数据来训练性能算法 102 。

[0053] 在一个实施例中,优化中心 101 使用操作数据来继续改进性能估计算法 102 ,因为在已经执行正常地生成完全业务(例如,通过充满链路)的主动探测以后,操作数据现在具有更相关的数据。在这种实施例中,主动探测的执行可能被限制,使得数据业务不被中断。例如,使用现在提供网络性能的准确估计的操作数据更新性能估计算法 102 。

[0054] 图 3 是根据本公开的一个实施例的用于由服务器对通信设备训练性能算法的流程图 300。如之前提到的,通信设备 103_{1-N} 中的任意一个还可以是服务器。尽管关于图 3 的流程图中的框以特定顺序示出,但是可以修改动作的顺序。因此,可以以不同顺序执行所图示的实施例,并且可以并行执行一些动作/框。图 3 的流程图是关于图 1-图 2 的实施例图示的。

[0055] 流程图 300 是关于在服务器端 301 处执行的活动以及在通信端 302 执行的活动图示的。在框 303,通信设备 103_2 执行主动探测。例如,通信设备 103_2 通过通信链路 107_2 向服务器 101 发送测试数据,然后从服务器 101 接收主动数据。在另一示例中,通信设备 103_2 通过 DSL 链路向 CPE 104 发送测试数据,CPE 104 表现为服务器,然后通信设备 103_2 从 CPE 104 接收主动数据。在本文介绍的实施例中,通信设备中的任一个可以表现为服务器,以处理数据(主动和/或被动)来更新性能估计算法。

[0056] 在框 304,通信设备 103_2 执行被动探测,即读取操作数据。在框 305,通信设备 103_2 向服务器端 301 发送操作数据。例如,通信设备 103_2 通过通信链路 107_2 向服务器 101 发送操作数据。在另一示例中,通信设备 103_2 通过 DSL 链路向表现为服务器的 CPE 104 发送操作数据。

[0057] 在框 306,在服务器端 301 接收操作数据。例如,服务器 101 接收操作数据。在另一示例中,通过通往表现为服务器的 CPE 104 的 DSL 链路,接收操作数据。

[0058] 在框 307,服务器端 301 处的通信设备根据从主动探测和/或操作数据(被动探测数据)中接收到的数据,训练性能估计算法 102 。在框 308,所训练的算法被发送至通信设备 103_2 ,通信设备 103_2 可使用该训练算法来评估通信设备 103_2 的性能。

[0059] 如本文介绍的,与使用具有主动探测的传统网络监视工具(NMU)相比,使用操作数据的性能估计不是侵入性的。操作数据通常容易获得,并且可以用于连续地更新或训练

性能估计算法以及用于评估网络性能。在一个实施例中,准确的NMU间歇性地(例如,一周一次)用于校准、增强或细调基于操作数据的性能估计方法。在这种实施例中,操作数据用于连续地监视网络,而NMU间歇性地用于校准性能估计方法。可以使用基于学习的算法将从NMU和操作数据中获得的结果组合在一起。例如,通过使用基于NMU技术的网络主动探测,可以校准使用操作数据获得的网络的吞吐量估计。

[0060] 在每个通信链路(例如,链路 107_{1-N} 、 105 和 106_{1-M} 之间的链路、 103_1 和 106_{1-M} 之间的链路和/或 103_2 和 104 之间的DSL链路)是唯一的情况下,来自NMU和操作数据的结果可以在链路调整算法(link-tailored algorithm)中使用。

[0061] 例如,特定链路,例如链路 107_{1-N} 、 105 和 106_{1-M} 之间的链路、 103_1 和 106_{1-M} 之间的链路和/或 103_2 和 104 之间的DSL链路,可能具有十分高的数据业务,该十分高的数据业务不允许使用NMU的频繁校准,因为执行NMU干扰用户业务。在这种实施例中,学习算法可以将来自NMU的偶尔结果与来自操作数据的更频繁结果(来自被动探测的被动数据)组合,以将性能估计算法调整为适合特定链路的操作数据特性。在一些实施例中,相关的操作数据字段可能不可用,但是它们的缺少被使用NMU测量的偶然每链路校准适应,以克服来自相关操作数据字段不可用的任何限制。

[0062] 在一个示例中,可以使用操作数据(即,被动探测数据)识别发送和接收特性中的样式,并且可以使用NMU(即,主动探测)确认(或校准)该样式。在一个实施例中,这种样式可以基于时间、业务、信道、应用等。这些样式还可以用于性能估计。

[0063] 在另一示例中,通过通信设备 103_2 的用户使用实时数据,可以实时地执行网络的性能估计或性能评价。例如,想要执行通信设备 103_2 的自诊断的用户可以发起执行主动探测并读取操作数据的性能估计。在另一实施例中,服务提供商可以监视网络性能,并且响应于来自客户的帮助请求而诊断该网络中的通信链路。

[0064] 图4是根据本公开的一个实施例的具有机器可读存储介质404的基于处理器的系统400,该机器可读存储介质具有计算机可执行指令102/404a,该机器可执行指令102/404a可操作来评估和改善通信系统性能算法。该存储介质和关联的计算机可执行指令可以位于本文介绍的任何通信设备和/或服务器中。该计算机机器可读/可执行指令102/404a由处理器401执行。实施例的要素被提供作为用于存储计算机可执行指令的机器可读介质(例如,用于实现图2-图3的流程图以及本说明书中介绍的其它过程的指令)。

[0065] 在一个实施例中,基于处理器的系统400进一步包括用于存储由指令102/404a使用的数据的数据库402。在一个实施例中,基于处理器的系统400包括用于与其它设备通信的网络接口405。在一个实施例中,基于处理器的系统400的组件经由网络总线403彼此通信。

[0066] 机器可读存储介质404可以包括但不限于:闪存、光盘、硬盘驱动器(HDD)、固态硬盘(SSD)、CD只读存储器(CD-ROM)、DVD ROM、RAM、EPROM、EEPROM、磁卡或光学卡、或其它类型的适合于存储电子指令或计算机可执行指令的机器可读介质。例如,本公开的实施例可以被下载作为计算机程序(例如,BIOS),该计算机程序可以利用数据信号从远程计算机(例如,服务器)通过通信链路(例如,调制解调器或网络连接)转移至请求计算机(例如,客户机)。

[0067] 本说明书中对“实施例”、“一个实施例”、“一些实施例”或“其它实施例”的引用指

的是,结合这些实施例描述的特定特征、结构或特性包含在至少一些实施例中,但不一定包含在所有实施例中。“实施例”、“一个实施例”或“一些实施例”的各种表现不一定全部指相同实施例。如果本说明书中阐述“可以”、“也许”或“可能”包括一组件、特征、结构或特性,那么不要求包括该特定组件、特征、结构或特性。如果说明书或权利要求提到“一组件”,那么这不指仅存在这些组件之一。如果本说明书或权利要求指“附加”组件,那么这不排除存在一个以上的该附加组件。

[0068] 此外,特定的特征、结构、功能或特性可以以任何适合的方式在一个或多个实施例中组合。例如,在与第一实施例和第二实施例关联的特定的特征、结构、功能或特性不互斥的任何地方,可以将第一实施例与第二实施例组合。

[0069] 尽管已经结合本公开的特定实施例描述了本公开,但是根据上面的描述,这样的实施例的许多替换、修改和变形对本领域普通技术人员是显而易见的。本公开的实施例旨在包含落入所附权利要求的广阔范围内的所有这种替换、修改及变形。

[0070] 下面的示例属于进一步的实施例。这些示例中的具体内容可以在一个或多个实施例中的任何地方使用。本文描述的装置的所有可选特征还可以关于方法或过程实现。

[0071] 例如,在一个实施例中,一种用于通信设备的性能估计的方法,该方法包括:执行主动探测,以确定主动探测数据;读取操作数据,该操作数据包括与信道和信道的噪声条件相关的数据以及与该通信设备和另一通信设备之间的用户数据业务相关的计数器值,其中该操作数据与该通信设备的当前设置相关;以及根据该主动探测数据和该操作数据,对该通信设备训练性能估计算法。

[0072] 在一个实施例中,该方法进一步包括:在执行主动探测以前,读取操作数据。在一个实施例中,读取操作数据是在执行主动探测期间或以后执行的。在一个实施例中,训练性能估计算法包括:更新该性能估计算法作为一个或多个指标的函数,该一个或多个指标包括以下至少之一:一天的时间,一周的时间,通信设备的类型,设备的制造者和型号,设备特性,固件,主干局限,用户的网络使用样式,包括信号功率、路径损耗、噪声电平、频带和操作模式中至少一个的射频(RF)特性,环境统计信息,或关于与所述通信设备相邻的通信设备的操作的数据,其中该数据包括干扰信道和干扰水平中至少之一。

[0073] 在一个实施例中,执行主动探测包括:将主动探测数据从通信设备发送至另一通信设备;以及在读取操作数据以前等待预定的时间。在一个实施例中,执行主动探测包括:将主动探测数据从通信设备发送至另一通信设备;以及接收报告,该报告表示由另一通信设备接收到的数据的量或数据。在一个实施例中,执行主动探测包括:将业务从通信设备发送至另一通信设备;以及记录与所发送的业务关联的测量的数据。

[0074] 在一个实施例中,该方法进一步包括:使用用于训练性能估计算法的主动探测数据,计算通信设备的吞吐量、连通性、延迟、抖动或错误率中的至少一个。在一个实施例中,执行主动探测与执行被动探测相比,执行次数更少。

[0075] 在一个实施例中,该方法进一步包括:在执行主动探测以前、期间和/或以后,将主动探测数据和所读取的操作数据发送至服务器。在一个实施例中,服务器会根据来自通信设备和其它通信设备的主动探测数据和所读取的操作数据,对通信设备训练性能估计算法。在一个实施例中,所述服务器应用机器学习算法,以对通信设备训练所述性能估计算法。

[0076] 在一个实施例中,通信设备包括以下至少之一:接入点 (AP)、基站、无线局域网 (LAN) 设备、数字用户线路接入复用器 (DSLAM)、网关、性能增强设备、数字用户线路 (DSL) 客户驻地设备 (CPE) 调制解调器、家庭内电力线设备、基于家庭电话线网络联盟 (HPNA) 的设备、家庭内同轴电缆分配设备、G.hn (全球家庭联网标准) 兼容设备、家庭内计量通信设备、与 LAN 通信地接合的家庭内装置、无线毫微微蜂窝基站、无线 WiFi 兼容基站、无线移动设备中继器、无线移动设备基站、自组网 (ad-hoc) / 网状网内的节点、机顶盒 (STB) / 机顶单元 (STU) 客户电子设备、支持互联网协议 (IP) 的电视、支持 IP 的媒体播放器、支持 IP 的游戏控制台、以太网网关、与 LAN 连接的计算设备、连接以太网的计算机外围设备、连接以太网的路由器、连接以太网的无线桥、连接以太网的网桥以及连接以太网的网络交换机。

[0077] 在另一示例中,在一个实施例中,存在一种用于存储机器可执行指令的机器可读存储介质,当机器可执行指令执行时,引起处理器执行根据本文介绍的方法。

[0078] 在另一示例中,一种系统包括:优化中心,通信地联接至一个或多个通信设备,其中该一个或多个通信设备能操作来:执行主动探测以确定主动探测数据;读取操作数据,该操作数据包括与信道和信道的噪声条件相关的数据以及与该通信设备和另一通信设备之间的用户数据业务相关的计数器值,其中该操作数据与该通信设备的当前设置相关;以及根据该主动探测数据以及该操作数据,对该通信设备训练性能估计算法。

[0079] 在一个实施例中,优化中心被实现为服务器或被实现为来自一个或多个通信设备中的通信设备。在一个实施例中,一个或多个通信设备可操作来在执行主动探测以前读取操作数据。在一个实施例中,一个或多个通信设备可操作来在执行主动探测期间或在执行主动探测以后读取操作数据。

[0080] 在一个实施例中,一个或多个通信设备可操作来通过更新性能估计算法作为一个或多个指标的函数,训练该性能估计算法,该一个或多个指标包括以下至少之一:一天的时间,一周的时间,通信设备的类型,设备的制造者和型号,设备特性,固件,主干局限,用户的网络使用样式,包括信号功率、路径损耗、噪声电平、频带和操作模式中至少之一的射频 (RF) 特性,环境统计信息,或关于与通信设备相邻的通信设备的操作的数据,其中该数据包括干扰信道和干扰水平中至少之一。

[0081] 在一个实施例中,一个或多个通信设备可操作来通过以下步骤,执行主动探测:将主动探测数据从通信设备发送至另一通信设备;以及在读取操作数据以前等待预定的时间。在一个实施例中,一个或多个通信设备可操作来通过以下步骤,执行主动探测:将主动探测数据从通信设备发送至另一通信设备;以及接收报告,该报告表示由另一通信设备接收到的数据的量或数据。在一个实施例中,一个或多个通信设备可操作来通过以下步骤,执行主动探测:将业务从通信设备发送至另一通信设备;以及记录与所发送的业务关联的测量的数据。

[0082] 在一个实施例中,一个或多个通信设备可操作来使用用于训练性能估计算法的主动探测数据,计算通信设备的吞吐量、连通性、延迟、抖动或错误率中的至少一个。在一个实施例中,一个或多个通信设备能操作来比执行被动探测更少次数地执行主动探测。

[0083] 在一个实施例中,一个或多个通信设备可操作来:在执行主动探测以前、期间和 / 或以后,将主动探测数据和所读取的操作数据发送至服务器。在一个实施例中,服务器可操作来根据来自通信设备和其它通信设备的主动探测数据和所读取的操作数据,对通信设备

训练性能估计算法。在一个实施例中,服务器可操作来应用机器学习算法,以对通信设备训练性能估计算法。

[0084] 在一个实施例中,通信设备包括以下至少之一:接入点(AP)、基站、无线局域网(LAN)设备、数字用户线路接入复用器(DSLAM)、网关、性能增强设备、数字用户线路(DSL)客户驻地设备(CPE)调制解调器、家庭内电力线设备、基于家庭电话线网络联盟(HPNA)的设备、家庭内同轴电缆分配设备、G.hn(全球家庭联网标准)兼容设备、家庭内计量通信设备、与LAN通信地接合的家庭内装置、无线毫微微蜂窝基站、无线WiFi兼容基站、无线移动设备中继器、无线移动设备基站、自组网(ad-hoc)/网状网内的节点、机顶盒(STB)/机顶单元(STU)客户电子设备、支持互联网协议(IP)的电视、支持IP的媒体播放器、支持IP的游戏控制台、以太网网关、与LAN连接的计算设备、连接以太网的计算机外围设备、连接以太网的路由器、连接以太网的无线桥、连接以太网的网桥以及连接以太网的网络交换机。

[0085] 在另一示例中,在一个实施例中,一种用于通信设备的性能估计的方法,该方法包括:在执行主动探测和被动探测以后,从该通信设备接收包括计数器值的操作数据,该计数器值与从通信设备至另一通信设备的用户数据业务相关;以及在执行主动探测以前或是在执行主动探测以后,根据该操作数据对该通信设备训练性能估计算法。

[0086] 在一个实施例中,该方法进一步包括:在执行主动探测以前,接收操作数据。在一个实施例中,操作数据是在执行主动探测期间或以后接收的。

[0087] 在一个实施例中,训练性能估计算法包括:更新该性能估计算法作为一个或多个指标的函数,该一个或多个指标包括以下至少之一:一天的时间,一周的时间,通信设备的类型,设备的制造者和型号,设备特性,固件,主干局限,用户的网络使用样式,包括信号功率、路径损耗、噪声电平、频带和操作模式中至少之一的射频(RF)特性,环境统计信息,或关于与通信设备相邻的通信设备的操作的数据,其中该数据包括干扰信道和干扰水平中至少之一。

[0088] 在一个实施例中,执行主动探测包括:将主动探测数据从通信设备发送至另一通信设备;以及在读取操作数据以前等待预定的时间。在一个实施例中,执行主动探测包括:将主动探测数据从通信设备发送至另一通信设备;以及接收报告,该报告表示由该另一通信设备接收到的数据的量或数据。

[0089] 在一个实施例中,该方法进一步包括:使用用于训练性能估计算法的主动探测数据,计算通信设备的吞吐量、连通性、延迟、抖动或错误率中的至少一个。在一个实施例中,执行主动探测与执行被动探测相比,执行次数更少。

[0090] 在一个实施例中,该方法进一步包括:接收主动探测数据和所读取的操作数据,该操作数据与在执行主动探测以前、在执行主动探测期间和/或在执行主动探测以后来自该通信设备的用户数据业务相关。在一个实施例中,对通信设备训练性能估计算法,根据来自通信设备和其它通信设备的主动探测数据和所读取的操作数据而执行的。在一个实施例中,训练性能估计算法包括应用机器学习算法。

[0091] 在一个实施例中,通信设备包括以下至少之一:接入点(AP)、基站、无线局域网(LAN)设备、数字用户线路接入复用器(DSLAM)、网关、性能增强设备、数字用户线路(DSL)客户驻地设备(CPE)调制解调器、家庭内电力线设备、基于家庭电话线网络联盟(HPNA)的设备、家庭内同轴电缆分配设备、G.hn(全球家庭联网标准)兼容设备、家庭内计量通信设

备、与 LAN 通信地接合的家庭内装置、无线毫微微蜂窝基站、无线 WiFi 兼容基站、无线移动设备中继器、无线移动设备基站、自组网 (ad-hoc) / 网状网内的节点、机顶盒 (STB) / 机顶单元 (STU) 客户电子设备、支持互联网协议 (IP) 的电视、支持 IP 的媒体播放器、支持 IP 的游戏控制台、以太网网关、与 LAN 连接的计算设备、连接以太网的计算机外围设备、连接以太网的路由器、连接以太网的无线桥、连接以太网的网桥以及连接以太网的网络交换机。

[0092] 在又一示例中, 存在一种用于存储机器可执行指令的机器可读存储介质, 该机器可执行指令在执行时, 引起处理器执行本文介绍的方法。

[0093] 提供摘要, 摘要将允许读者确定技术公开的本质和主旨。应当理解的是, 摘要将不用于限制权利要求的范围或含义。以下权利要求在此被合并到具体实施方式中, 其中每个权利要求作为单独实施例独立存在。

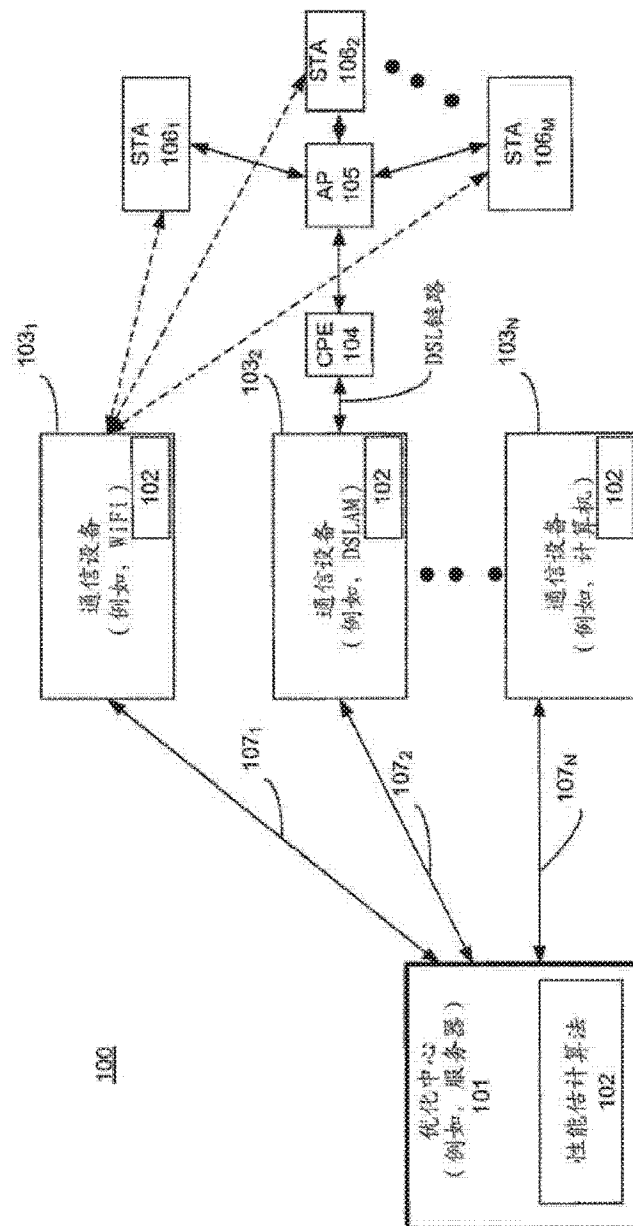


图 1

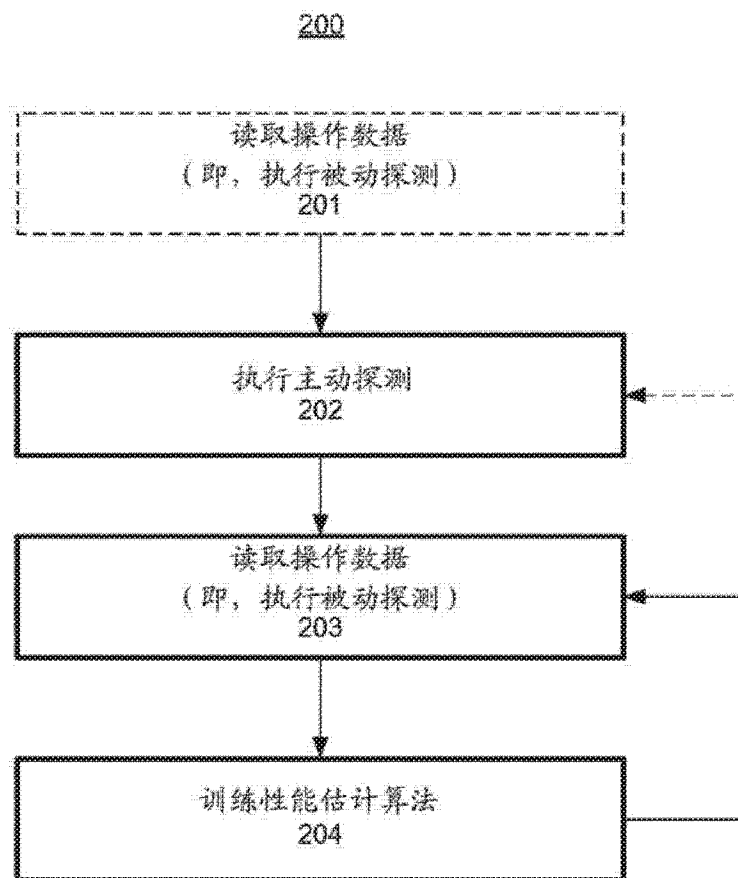


图 2

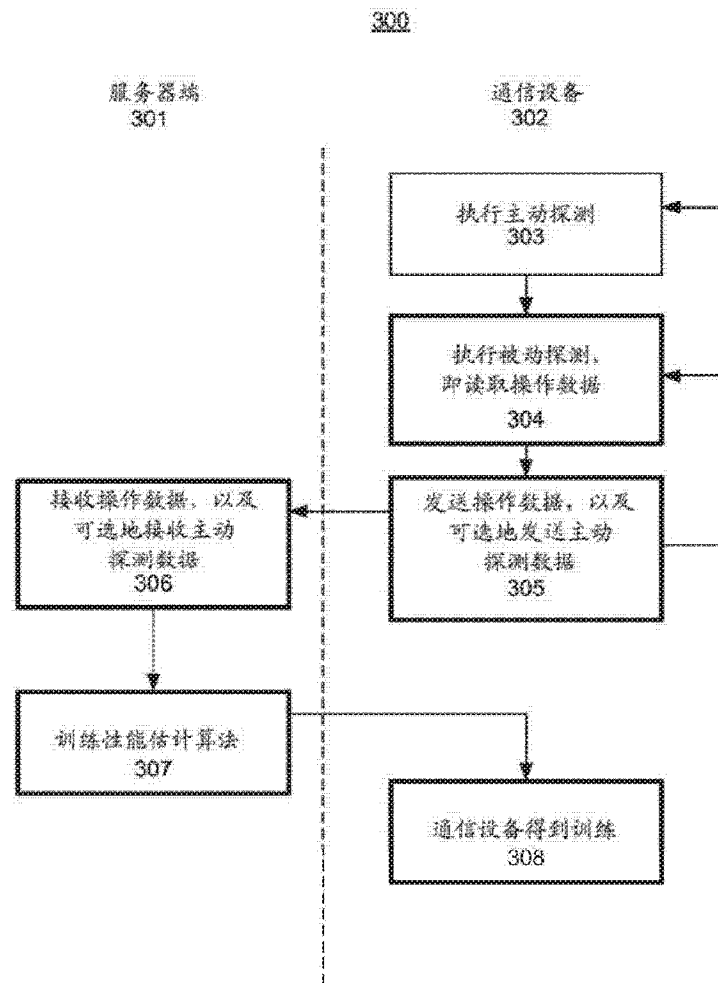


图 3

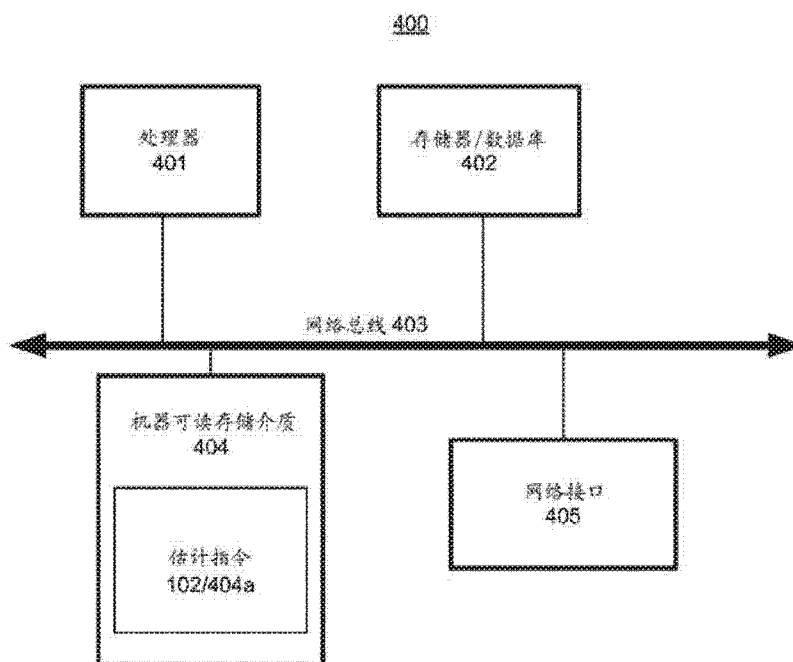


图 4



Espacenet

Bibliographic data: CN104854901 (A) — 2015-08-19

Method to guide placement of new small cell

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Classification: - international: H04W24/02; H04W84/04
- cooperative: H04W16/20 (US); H04W24/02 (EP, CN, US); H04W64/003 (US); H04W84/045 (EP, CN, US)

Application number: CN20138063411 20131121 Global Dossier

Priority number(s): WO2013EP74355 20131121 ; EP20120196130 20121207

Also published as: CN104854901 (B) BR112015009518 (A2) CA2888434 (A1) EP2741535 (A1) EP2741535 (B1) ES2625279 (T3) HRP20170683 (T1) PL2741535 (T3) US2015327082 (A1) US9585031 (B2) WO2014086586 (A1) less

Abstract of CN104854901 (A)

The invention provides a method to guide the placement of new small cell, wherein a small cell is a radio cell station with much smaller coverage area than a macro cell, comprising one or more existing wireless cells, one or more mobile devices of known location and application use and context, a processor and database system, a new small cell, a device for guiding the user in the placement of the new small cell, comprising the steps that the location dependant measured network characteristics, and location dependant contextual data needs of the mobile

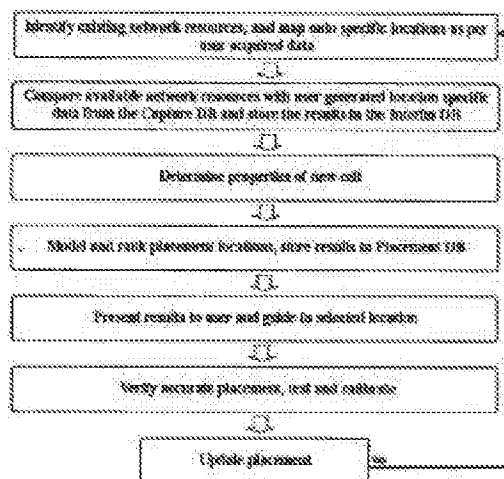


Figure 3 – overview of method [Network analysis and placement determination]

device, are recorded and stored in the database system over time; the contents of the database system are used to determine the likely future location specific network needs, such that this information together with the characteristics of the new small cell are used to determine the placement co-ordinates of the new small cell, and use the placement co-ordinates to guide a user in the placement of the new small cell, with the device for guiding the user.

Notice

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DESCRIPTION CN104854901

A method for directing placement of a new small cell, wherein the small cell is a radio cell station having a much smaller coverage area than the macro cell, including one or more existing wireless cells, having One or more mobile devices, processors and database systems of known location and application usage and context, new small cells, devices for instructing users to place new small cells, the method comprising the steps of: The measured network characteristics of the location and the location-dependent context data requirements of the mobile device are recorded and stored over time in the system; the content in the database system is used to determine possible future location-specific network requirements to enable this The information, along with the characteristics of the new small cell, is used to determine the placement coordinates of the new small cell; and the user is used to direct the user to place the new small cell using the placement coordinates.

Method for guiding placement of a new small cell

Field of invention

The present invention relates to the positioning of small cells for wireless communication in buildings or other restricted areas.

Background of the invention

As mobile networks rapidly evolve, it is widely predicted that there will be a large number of connected devices and associated cells. In addition to conventional macro cells, many "small cells" will operate at low energy levels and are designed to communicate with devices in the immediate local area. In this document, a small cell is

defined as any radio cell having a much smaller coverage area than a conventional "macro" cell, including a public "pico cell", a residential femto cell, or WiFi access point.

A current example of a small cell is a femto cell. A femtocell is a portable unit deployed by a consumer that typically uses licensed spectrum. Unlike traditional base stations, the backhaul to the wireless communication network is a private or leased line that is used by consumer-supplied packet data (IP) connections (eg, DSL connections) rather than in first- and second-generation cellular systems. Circuit switched backhaul. The femtocell radio power output is nominally in the range of 0.5 watts to 1 watt since it is designed for indoor coverage. In the Third Generation Partnership Project (3GPP) Long Term Evolution (LTE) or Evolved UTRAN (eUTRAN) projects, the femtocell is also referred to as a "home evolved Node B."

The use of small cells as a low cost method for adding coverage and capacity to a wireless communication network has led to some difficulties that the embodiments of the present invention attempt to address. The placement of inexpensive small radio cells is typically not implemented by conventional cell location planning methods. However, the location of small cells is extremely important because the location of small cells may be challenging for receiving data with specific data requirements (high bandwidth, low latency, etc.) or between users and other network cells. The only available connection for mobile users in buildings. Incorrect locations can have a critical impact on the performance of a wider network (for example, in the sense of interference), and this is a critical issue to be addressed for a successful deployment.

Due to the number of cell types that are likely to be used in future mobile communication networks, these mobile communication networks have different capabilities, support different network technologies and have different bandwidth capabilities and diversity of application requirements, thus assisting small The placement of the cells is advantageous in order to optimally meet the network requirements and also to optimally meet user needs in the context of the use of network resources depending on their location.

More information can be found in "US2010120394 (A1) - Femto Cell Location by Proxy Method".

Current cell location planning methods are generally not suitable for directed placement of small cells (the placement of these small cells may be borne by the network operator or consumer), and other placement methods that have been found in the prior art are not considered. The contextual nature of the user's mobile device usage. Therefore, there is currently no placement method or apparatus that allows consumer placement of small cells in a manner that takes into account location-specific application requirements.

Specific restrictions include:

(i) The placement of small cells should be consistent with the context in which the user is utilizing the network and network resources available from other neighboring cells. For example, a user may need a very high bandwidth, low latency connection in a particular location. High bandwidth, low latency connections may only be available in a portion of a building that has good coverage from a new macro cell, but other parts of the building (which only have coverage from previously generated cells) may The user's normal position coincides - this results in a limit on the efficiency of the associated application. Obviously, in this example, the small cell should be placed to satisfy the user's needs due to contextual location, which is the subject of the present invention. In other words, the location of the cell must take into account both the existing coverage and the user's location-dependent requirements, which are independent of each other. Thus, if required by the user, the small cell may coincide with the poorly covered area or may coincide with the available well covered area (but for example the low capacity of the macro cellular network), depending on the needs of the user.

(ii) Although cell location planning or participatory sensing methods may identify areas of lower or stronger signal strength from surrounding cells, known approaches do not consider how objects (such as stone walls) span across the context of application requirements. Frequency range attenuation signal. This may become increasingly important for advanced mobile communication networks due to the deployment of communication links operating at different frequencies ranging from GHz to THz, where these communication links may be omnidirectional or unidirectional (eg If adaptive beamforming is used). If this is not taken into account in the placement of small cells, a suboptimal link may be generated because the placement of the small cell will not adequately reflect the location of other cells in the area and the signal attenuation depending on the location. .

US2010120394 (A1) - Femtocell positioning by proxy method

The location of a small femtocell deployed by the consumer cannot be determined by the usual site survey method. The location of the attached mobile station allows the proxy location of the femtocell, which can then be used for wireless network planning, including providing the calculated default emergency service location for the femtocell.

This document discloses a method for positioning a femtocell device operating in a wireless communication system by a wireless positioning system (WLS), comprising:

Discovering and initiating the location of the femtocell device; determining the identity of the mobile station (MS) served by the femtocell device; determining the location of the MS; and using the location of the MS to determine the location of the femtocell device.

Accordingly, a proxy method based on location of a mobile station is disclosed to determine the location of a femtocell deployed by a consumer.

US2008151777 (A1) - System and method for core network topology router placement planning

Systems and methods are provided for core network topology router placement planning. These systems and methods can use existing network data to create a data set and use that data set to optimize the network for placement of the router.

1.

A method comprising:

Identifying a network topology; calculating a circuit location from the network topology; creating a data set from the network topology and the circuit location; and solving the data set to determine at least one output indicative of the proposed placement of one or more routers in the network topology .

Overview: Using a network topology to calculate placement

US2008279552 (A1) - Method for placing a reconfigurable optical add/drop multiplexer (ROADMS) in a network

A distributed network comprising at least two reconfigurable optical add/drop multiplexers (ROADMs) can be designed by a method including routing that simulates data traffic in a distributed network.

The method can also include identifying a first location for placing the first ROADM based at least in part on the route of the simulated data traffic. The method can also include simulating rerouting of data traffic in the distributed network including the first ROADM at the first location. The method can further include identifying a second location for placing the second ROADM based at least in part on rerouting of the simulated data traffic.

This document discloses a method comprising:

Identifying a plurality of candidate locations based at least in part on an initial simulated route of data traffic in the distributed network;

Selecting at least one of the plurality of candidate locations for placement of a reconfigurable optical add/drop multiplexer (ROADM) based at least in part on cost;

A rerouting of data traffic in a distributed network including the at least one ROADM at the at least one selected candidate location is simulated.

This document uses the simulation of routing data to aid in the placement of the multiplexer.

WO02071781 (A1) - Method for cell site location in a cellular mobile network

Identifying the location of the fixed transmitting cell site in the cellular mobile telephone network by means of the following steps: deriving the survey data measurement of the network by means of a mobile test telephone; grouping the survey data measurements derived on the driving route to the individual Concentration; identifying, by means of a plurality of triangulation calculations, first site cluster data and second site cluster data regarding the location of the transmitting cell site, wherein in the triangulation calculation, the geographic location data of each individual point with respect to the receiver of the test phone Pairing with each of the other individual points to provide a pair of locations in each case, the distance from the location of the transmitting cell site is determined from the corresponding timing advance data; and determining the first site and second site cluster data Which of the ones has the largest cluster density and determines the center of gravity of the site as the location identifying the fixed transmitting cell site. The survey data measurement includes geolocation data of the receiver of the test telephone; timing advance data providing a fixed distance between the transmitting cell site and the receiver of the test telephone; and cell identity field data. Each subset of survey data measurements corresponds to measurements belonging to the same fixed transmit cell site.

This document discloses a method for identifying the location of a fixed transmitting cell site in a cellular mobile telephone network, comprising the steps of: deriving survey data measurements of the network by means of a mobile test telephone, the survey data measurement comprising: a test telephone Geographical location data of the receiver; timing advance data providing a fixed distance between the transmitting cell site and the receiver of the test telephone; and cell identity field data; grouping the survey data measurements derived on the driving route to An individual subset, wherein each subset corresponds to measurements belonging to the same fixed

transmitting cell site; the first site cluster data and the second site cluster data regarding the location of the transmitting cell site are identified by means of a plurality of triangulation calculations, wherein In the triangulation calculation, the geographic location data of each individual point with respect to the receiver of the test phone is paired with each of the other individual points to provide a pair of locations in each case, the distance from the location of the transmitting cell site is corresponding Timing advance data to determine; and determine A center of gravity of the cluster site and the second site data in which a cluster having the maximum density and the site is determined to transmit a fixed location identifier of the cell site.

This document uses site survey data as part of a method for locating cells within a cellular network.

US2010309790 (A1) - Femto base station and method for operating a femto base station

The femto base station and method described herein inhibits the need for external GPS antennas and cables while still providing the network service provider with the ability to obtain desired GPS position coordinates and providing the user with placement at their chosen location within the home. The flexibility of the femtocell regardless of the strength of the GPS signal.

The U.S. application includes a method for operating a femto base station in a wireless network, the method comprising:

Determining whether a location information signal is available at the femto base station;

Determining, at the femto base station, whether anchor location information stored in a memory at the femto base station is valid, and if the determining step determines that the location information signal is not available, the anchor location information indicates an anchor location of the femto base station;

If the determining step determines that the stored anchor location information is valid, the network configuration parameters of the femto base station are identified.

Summary of the invention

The present invention is presented as a way to direct a mobile network operator or user to place a small cell based

on possible coverage, context of use, and capacity and location of existing wireless network connections.

The present invention includes a method for directing placement of a new small cell, wherein the small cell is a radio cell station having a much smaller coverage area than the macro cell, including one or more existing wireless cells a cell, one or more mobile devices with known location and application usage and context, a processor and database system, a new small cell, a device for instructing a user to place a new small cell, the method comprising the following steps :

- Recording and storing location-dependent measured network characteristics and location-dependent contextual data requirements of the mobile device over time in the database system;
- The content in the database system is used to determine possible future location-dependent network requirements such that this information, along with the characteristics of the new small cell, is used to determine the placement coordinates of the new small cell,
- and using the placement coordinates to guide the user to place the new small cell by means of a device for guiding the user.

In this context, any radio cell or access point having a smaller coverage area than the macro cell defines a small cell. Thus, a small cell may be a public "pico cell", a residential femto cell, a WiFi access point, or any other arrangement in which a transceiver having a lower output power than a macro cell is deployed as part of a communication network.

In a preferred embodiment, the database system is a server located in the Internet or a user's local network and receives information from cells, mobile devices, and other network components in the network that should be optimized. For example, running an application on a smartphone that transmits its location, orientation, running applications, and bandwidth or response time requirements. In addition, existing cells can also transmit connection quality, bandwidth, number of lost packets, protocol type, and the like. Other devices that scan the network can also be used to collect data that is imported into the database system. This information is then stored in the database system as a series of fields and records that include the database files used to collect this information.

In a preferred embodiment, the placement position is determined by the following operations:

a) determining the location-dependent requirements of the cross-region usage of the mobile device in the context of the application being executed by the user on the mobile device,

b) Measuring network characteristics across this area

Where information a) and b) are used to establish a mapping showing how existing network resources satisfactorily meet location-specific contextual application requirements and thus can optimally place new cells with defined characteristics.

The location information can also be used in conjunction with the transmission of the connection status of the mobile device's cell. The device can inform the database server of its location and the detected base station.

In a preferred embodiment, the method

(a) Identify and characterize location-based data requirements for mobile devices that reflect the application usage and application requirements of the mobile device. This can include, for example, response time, data transmission bandwidth, lost packets, latency of packets, and the like.

(b) Determining the availability of existing network resources at or at a particular location, particularly across potential areas of the new cell. This is done by analyzing the database of the database system or by collecting information about the connection status of the mobile device provided to the cell, or by manual input.

(c) characterizing the new cell in terms of at least capacity, bandwidth, power, and latency of the new cell. In this example, it is assumed that the characterization will be for a pre-existing cell. However, other embodiments may characterize new cells that are required to determine the particular cell type that should be acquired.

(d) Compare (a) with (b) to determine the location-dependent contextual requirements of the network. This is calculated for geographic coordinates that represent defined boundary areas in which new cells are to be placed (in buildings, offices, hotels, etc.). For example, if a building has multiple floors, the geographic coordinates can be two or three dimensional. In some embodiments, it may be necessary to install several cells to meet the needs of the user.

(e) Compare (c) with (d) and calculate the results to determine the best location for the new cell in view of the possible location. The optimal location for the new cell is calculated by (i) retrieving the location-dependent context requirements for network data from (d). This provides a mapping of network connection requirements (bandwidth, latency, etc.) relative to specific location coordinates. (ii) simulating a new cell characterized in (c) at a plurality of locations within the border region, and (d) an optimization algorithm is used to identify X, where a new cell should be placed to optimally meet network requirements, Y (optional Z) coordinates.

Alternatively, if the new small cell is a cell (unlike a wireless access point), the calculation can be done in such a way that the wireless cell or wireless access point is optimally overlapping. The optimal position can be calculated by simulation or by other optimization procedures.

(f) Instruct the operator or user to place a new small cell.

In a preferred embodiment, the location-dependent requirements of the cross-region usage of the mobile device are determined iteratively, especially after placement of the new cell. In this way, a successful and possible relocation of the new cell can be performed.

In a preferred embodiment, the location of the mobile device is determined by using data collected by the mobile device and/or the network for determining the location of the user, the mobile device collecting the measurements and communicating the measurements to the database system, and/or on the mobile device Use GPS (Global Positioning System), and/or use the SiRFusion product range from CSR to enable the location of mobile devices to be calculated by fusing output data with several different geolocation techniques, including triangulation or GPS .

In a preferred embodiment, the application and associated data requirements are stored in the database system, including one or more of the following fields: application name, protocol type, bandwidth, IP packet loss, transmission latency, QoS (Quality of Service), QoE (Quality of Experience), received signal strength and direction, connected cells, and context usage information.

This information is collected by the application running on the mobile device and automatically transmitted to the database system over the network in the background. In a preferred embodiment, the application is an app installed on a smartphone. The web site can also provide this information. This information is preferably only collected if the mobile device is located in an area in which a new small cell should be installed.

In a preferred embodiment, it is determined whether the current location is considered a planned placement of a potential impact area for a new small cell, and if the user's current location is within the potential impact area, the method proceeds to determine the location of the small cell. This means that the method is only executed in the case of the relevant area.

The planned impacted area of the new small cell is determined according to one or more of the following steps: the network operator or user marks the database system that they wish to install the small cell in the small cell to be placed At the location; based on the data collected over time, the database system proposes to place the location of the small cell.

In the absence of a network connection or a small number of network connections, the location-dependent measured network characteristics and the location-dependent context data requirements of the mobile device are recorded and stored offline and uploaded to the database when a preferred connection is available. system.

In a preferred embodiment, the means for guidance includes an orientation sensor that assists in the acquisition and/or positioning of small cell information. In a preferred embodiment, an application running on a mobile device or smart phone can implement a device for guidance. In particular, the smartphone includes a position sensor that can be used to guide the user to the optimal location of the new small cell.

The device used to guide the user uses visual, audible or other means to guide the user to the location.

This guidance to the user can be achieved using one or more of the following methods, including:

- (i) use building survey data (if available) and plot the desired location on the map to guide the user,
- (ii) use wireless fingerprint information and use text/audio based commands to guide the user,
- (iii) detecting the presence of other connected devices near the desired location and forming an association with them.

After positioning a new small cell, accurate placement is supervised by using triangulation or other location

estimation techniques and testing and calibrating the cell and preferably providing status updates to the user.

Another part of the invention is a system comprising a database system, characterized in that the method of one of claims 1 to 14 is implemented.

The advantages of the invention relating to each of the distinguishing technical features are as follows:

The present invention can determine and characterize the location-dependent data requirements of a mobile device, reflecting application usage. This approach allows for characterizing the properties required for a communication link to a particular location.

The present invention can determine the availability of existing network resources at or at a particular location ("potentially affected area of a new cell"). This approach allows for the discovery of the nature of a link that may have been connected to a location.

(a) The present invention can characterize the new cell in terms of at least capacity, bandwidth, power, and latency of the new cell. This approach allows for determining the nature of the new cell to be placed.

(b) The present invention can compare (a) to (b) to determine the contextual requirements depending on location. This approach allows the calculation of the required resources.

(c) The present invention can compare (c) with (d) and calculate the result to determine the optimal location of the new cell in view of the possible location. This approach allows the location required for placement to be determined.

(d) The present invention can guide an operator or a user to place a cell. This approach allows for optimal positioning of new cells.

DRAWINGS

Figure 1 shows a mobile device architecture.

Figure 2 illustrates an example network processor architecture.

Figure 3 shows a flow chart of the method.

Figure 4 shows a flow chart of a method on a mobile device.

Figures 5 and 6 show the location of the small cell within the apartment before and after the method.

Figure 7 shows an exemplary deduced mobile network scenario with a new site location.

detailed description

A good placement can be determined by the following operations:

- (i) a) determining location-specific requirements for cross-region usage of mobile devices in the context of an application executed by the user (eg, live streaming video has distinct file download requirements),
- (ii) Measuring network characteristics across this area.

This information (i and ii) allows for the establishment of a mapping showing how existing network resources satisfactorily meet location-specific contextual application requirements and thus can optimally place new cells (with defined characteristics).

Existing cell location planning approaches, typically based on predicting and/or sensing signal strength, using network mapping and characterization data, and capacity planning tools, do not take into account the user's location-specific usage context. This will become increasingly important as user data and application usage evolve. For example, in terms of latency and bandwidth, the data requirements for the Streamed YouTube UHD video are very different from the Skype live video link. Due in part to a large number of cells and possible links under the advanced communication network (to be included in legacy network resources), it is envisioned that

when existing network resources (such as macro cells) can meet the data requirements of some applications, other applications Data requirements (due to bandwidth or latency requirements) may not be met, especially if capacity constraints are also considered.

Thus, a key element of the responsible nature of the present invention is the iterative discovery of applications performed by users in different locations and their respective data requirements, and these needs are considered with respect to existing network resources that may have been available at the user's location. This is an example of using context, but obviously there are other examples.

(i) Identify application requirements that vary by location. Given the fact that the mobile device is within range of the cell, this can be solved by using data collected by the mobile device and/or the network. To determine the location of the user, the mobile device collects measurements (eg, relative timing of signals received from neighboring base stations) and passes them to the network, which then calculates the location of the mobile device and passes the location to the external application server. Alternatively, devices such as the SiRFusion product range from CSR allow the location of the mobile device to be calculated by fusing the output data with several different geolocation techniques, including triangulation or GPS. After determining the location of the mobile device, this can be related to time varying application usage. Once the location and application and associated data requirements are characterized, the resulting data can be communicated to the server in which the data is stored for future use. Since these steps are associated with the placement of a new cell, it is possible that in the area of its potential location, there is no coverage of the existing cell or the coverage of the existing cell is small, which means that the desired application. As a result, these data will not be recorded by the above steps. In this example, the following approaches can be taken: (i) by tracking the location of the user's mobile device to understand which users have entered the potential impact area of the new cell (if necessary, this can be done by storing the historical location and when the connection becomes available) Upload these historical locations to "offline". One or more users depicted in the potentially affected area of the new cell are determined to determine their historical application usage in other areas that can reasonably be expected to extend to the potentially affected area of the new cell. (This can be done, for example, by cross-referencing the geographic location of the belongings to determine their type (home, office, station, etc.) and then use that type to characterize the likelihood that these users are in this location compared to other locations of the same type that the user has accessed. Use to achieve).

(ii) Identify network resources that may already be available. Similar to (i), this can be determined by employing a participatory sensing approach using a mobile device or (ii) by an existing network model that has been developed using site surveys or other existing methods.

Therefore, some of the distinguishing features of the present invention are that

(a) Identify and characterize location-based data requirements for mobile devices that reflect application usage and are repeated as needed.

(b) determining the availability of existing network resources at or at a particular location ("area of potential impacts across new cells"),

(c) characterizing the new cell in terms of at least capacity, bandwidth, power and latency of the new cell,

(d) comparing (a) with (b) to determine the contextual requirements depending on location,

(e) Compare (c) with (d) and calculate the result to determine the best location for the new cell in view of the possible location location, and finally (f) direct the operator or user to place the new small cell.

It is to be noted that the invention has numerous possible embodiments and the description is not intended to limit the scope. A possible embodiment is presented herein and uses a mobile device based implementation. Other possible embodiments are not illustrated, such as using a web-based implementation (some of which are mentioned above).

The described system can perform functions on a mobile device (where the results of these functions are communicated to a network-based processing system/database system) and itself in a network-based processing system (which can, for example, form part of a network architecture) The functions implemented on the division are divided. An overview of an example mobile device architecture is shown in FIG. 1, and an example network architecture (related to the present invention) is shown in FIG.

Figure 1 shows a mobile device including means for determining its position inside and outside the building. Other sensors may also be included to, for example, determine their orientation, which may aid in the collection of cell placement information. Display devices are also incorporated, and may additionally include other output devices to help direct the user to the cell placement location. For example, these devices may include haptic devices, or audible instructions.

Figure 2 shows an example network processor architecture/database system. The data collected by the mobile device is written to one of three databases controlled by the processor that is capable of accessing the local

memory and an interface that allows its communication to the mobile device.

The method is implemented on each of the network processor and mobile device architecture. The method for the mobile device architecture represented by Figure 4 is given below.

The first step uses one of the various known geolocation techniques to determine the location of the mobile device, such as if the mobile device is using GPS outside of the building, or if the mobile device is inside the building, using triangulation and such as (For example, a combination of other techniques such as inertial estimation implemented on a SiRFusion device from a CSR.

Thus, the input is the physical location of the user and the output is a digital representation of the user coordinates.

The second step compares the user's current location to the "potentially affected area" of the planned placement of the small cell that is considered new. If the user's current location is within the potentially affected area, then the method continues, otherwise it returns to the beginning.

The planned potential impact area of the new small cell can be determined as follows:

- The network operator or user marks the system that they wish to install a small cell
- the network operator or user indicates when they are in the location where the cell is to be placed (eg in a building)
- This area is then defined as a potential area of influence.

Alternatively, the mobile device method can be performed on all defined mobile devices that allow data to be collected for all locations over a period of time to get the best results, or an equivalent way of producing similar results can be performed on network resources (however, It should be noted that this may have associated user privacy issues). If you do this, you can delete the second step.

Therefore, the input is the user location and the potential interference zone definition, and the output continues to return to the start loop.

The third step determines the nature of the connection at the user location and may include parameters such as QoS (Quality of Service), QoE (Quality of Experience), received signal strength and direction, connected cells, and context usage information.

It is important to note that since this step is associated with the placement of a new cell, it is possible that in the area of its potential location, there is no coverage of the existing cell or there is little coverage of the existing cell, which means that Execute the desired application. As a result, they will not be recorded. In this example, the following approaches can be taken: (i) by tracking the location of the user's mobile device to understand which users have entered the potential impact area of the new cell (if necessary, this can be done by storing the historical location and when the connection becomes available) Upload these historical locations to "offline".

(ii) Depicting one or more users in the potentially affected area of the new cell to determine their historical application usage in other areas that can reasonably be expected to extend to the potentially affected area of the new cell. (This can be done, for example, by cross-referencing the geographic location of the belongings to determine their type (home, office, station, etc.) and then use that type to characterize the likelihood that these users are in this location compared to other locations of the same type that the user has accessed. Use to achieve).

Thus, the input is the user location and the output is the user location marked with the context connection property.

The fourth step communicates the location of the user marked with the context connection property to the network processing system and records it as a record in the capture database.

Thus, the input is the location of the user marked with the context connection property, and the output is the record stored in the capture database.

After the method for the mobile device architecture, the method for the network architecture represented by FIG. 3 is given below.

The first step identifies existing network resources of the potentially affected area by utilizing knowledge about the macro network (site location, available technology, technical parameters, ...) available from the mobile network operator and loading this data into local memory .

Thus, the input is a potential area of influence for new cell placement and outputs the nature of existing network resources across the potentially affected area.

The second step compares the output from step 1 with the contents of the capture database. In fact, this is to compare the available network resources with the required resources. The difference is calculated and stored as a representation in the temporary database.

Thus, the input is the nature of the capture database, the existing network, and the output is the difference between the existing network resources and those resources that are optimally needed in the case of context-specific context usage for a given mobile device.

The third step directly or indirectly determines the nature of the new small cell and stores these properties in local memory.

Thus, the input is a product reference code (for example) and the output is a cell/access point property.

The fourth step uses information from the temporary database to model the impact of the new cell and calculate the placement location of the cell that will achieve the desired placement characteristics (for users, network operators, etc.). Desirably, mapping data reflecting the structure of the building should also be considered at this time in order to ensure that the placement position can be achieved with power availability or the like. Possible placement locations can be ranked and stored in the placement database.

Therefore, the input is new cell information, location and context dependent network requirements (temporary database), and the output is the ranked placement location.

The fifth step presents the results to the user and uses visual, audible or other means to direct the user to the location. User guidance can be achieved by using several methods, including (i) using building mapping data (if available) and plotting the desired location on the map to guide the user, (ii) using wireless fingerprint information (from wifi, etc.) and Text/audio based commands are used to guide the user, (iii) detecting the

presence and association of other connected devices in the vicinity of the desired location, which may, for example, result in informing the user to place the consumer cell next to the "HP8500 Printer."

Thus, the input is a ranked placement result and the output is a user instruction for locating the placement location.

The sixth step verifies the exact location and tests and calibrates the cell by using triangulation or other location estimation techniques, as well as providing status updates to the user.

Therefore, the input is the cell placement location and the output is a status update.

The last step is to pre-arrange the location to be updated when the network or user request has changed or if the physical location of the cell is arbitrarily changed by the user.

Therefore, the input is a possible change and the output is an iteration of the process.

A use case will be described below.

In the first step, the information is captured. As can be seen in Figure 5, the building is covered by the macrocell base station BS1. Most users experience good coverage, however, conference rooms that are partially blocked by thick walls suffer from high levels of signal degradation. Therefore, users (e.g., UE1) who wish to run a more demanding application (as opposed to a less demanding voice call) experience very poor QoE. This is captured and stored in the capture database and is also reflected in the temporary database.

In a second step, the placement of the new cell is determined. As can be seen in Figure 6, the new small cell BS2 is placed in a location in which the UE 1 located in the conference room is subject to less signal degradation. The cell is placed in this location as a result of the calculations that have been performed, with the ranked results being stored in the placement database. As a result of the optimal placement of new cells (located using contextual application information), a higher level of QoE and other network advantages of UE1 can be achieved.

Additional details are provided below:

[image]

[image]

Derivation of the new site

A higher probability of a poor service SINR (one of the four cases) that occurs when the service requested by the user (UE1) at the location 1 is unsuccessful at location 1.

Deriving a new site based on the requirements identified at location 1, and site information including power access, fixed line availability, evaluation location, and building planning

Another use case is depicted in FIG.

Two base stations having an ideal coverage area, typically represented by a hexagon, are illustrated. BS1 serves 3 terminals (UE5, UE6, UE7) and BS2 serves 4 terminals (UE1, UE2, UE3, UE4). Although the terminal assigned in BS1 is experiencing good link quality (eg, UE5 has 10 dB SINR), 3 of the 4 terminals at BS2 appear at the cell edge or at the cell edge in the network due to its presence. It is indoors with poor link quality (for example, UE1 has a 0 dB SINR).

Each terminal is using a service and requires a certain amount of radio resources to achieve a satisfactory quality of experience. If, for example, a user living in the depicted house always experiences poor quality when attempting a video call, he will likely not try again after a while. In this example, the terminal appearing at the edge of the cell or indoors uses the http service. In addition, the UE 4 with a good radio link can only use a satisfactory http service due to the problem that the cell may be overloaded. This may be due to the problem that other served terminals require a larger amount of resources to meet the requirements of the services used due to poor radio links. The information for each individual user is stored in a central database that collects statistics for each location that occurs. This will result in huge amounts of data, and the location of the new site location required can be derived based on this data. The http service was successfully used in 4 of the 7 locations in this example. A poor SINR has appeared in 3 of the 7 positions. Therefore, at locations 1, 2 and 3, any service with higher quality requirements will not be used with a good experience. At these locations, the radio link conditions are poor. Based on the combined information of these locations, new site locations can be derived (eg, the average location of those 3 locations or nearby locations that meet additional requirements (such as fixed line and power access)).

current technology

[1]US2010120394 (A1) - Femtocell positioning by proxy method

[2]

*Background text based on an excerpt from "US2010120394 (A1) - Femto Cell Location by Proxy Method"

[3]

US2010120394 (A1) - Femtocell positioning by proxy method

[4]

US2008151777 (A1) - System and method for core network topology router placement planning

[5]

US2008279552 (A1) - Method for placing a reconfigurable optical add/drop multiplexer (ROADMS) in a network

[6]

WO02071781 (A1) - Method for cell site location in a cellular mobile network

[7]

US2010309790 (A1) - Femto base station and method for operating a femto base station

Notice

This translation is machine-generated. It cannot be guaranteed that it is intelligible, accurate, complete, reliable or fit for specific purposes. Critical decisions, such as commercially relevant or financial decisions, should not be based on machine-translation output.

CLAIMS CN104854901

1.

A method for directing placement of a new small cell, wherein the small cell is a radio cell station having a much smaller coverage area than the macro cell, including one or more existing wireless cells, having One or more mobile devices, processors and database systems of known location and application usage and context, new small cells, devices for instructing users to place new small cells, the method comprising the steps of:

- Recording and storing location-dependent measured network characteristics and location-dependent contextual data requirements of the mobile device over time in the database system;

- The content in the database system is used to determine possible future location-specific network requirements such that this information, along with the characteristics of the new small cell, is used to determine the placement coordinates of the new small cell ,

And directing the user to place the new small cell by means of the device for guiding the user using the placement coordinates.

2.

The method of claim 1 wherein said placing position is determined by:

- a) determining the location-dependent requirements of the cross-region usage of the mobile device in the

context of an application executed by the user on the mobile device,

b) measuring the network characteristics across this area

Where information a) and b) are used to establish a mapping showing how existing network resources satisfactorily meet location-specific contextual application requirements, and thus can optimally place new cells with defined characteristics .

3.

The method of claim 2 wherein said method comprises:

(a) determining and characterizing the location-dependent data requirements of the mobile device, reflecting application usage,

(b) determining the availability of existing network resources at or across a particular location, particularly across the potentially affected area of the new cell,

(c) characterizing the new cell in terms of at least capacity, bandwidth, power, and latency of the new cell,

(d) comparing (a) with (b) to determine the contextual requirements depending on location,

(e) comparing (c) with (d) and calculating the results to determine the best location of the new cell in view of possible location locations, and finally

(f) directing the operator or user to place the new small cell.

4.

Method according to claim 3, characterized in that the location-specific requirements of the cross-region usage of the mobile device are determined iteratively, in particular after the placement of a new cell.

5.

The method of any of claims 1-4, wherein the location of the mobile device is determined by using data collected by the mobile device and/or the network to determine a location of the user, The mobile device collects measurements and communicates the measurements to the database system,

and / or

Using GPS (Global Positioning System) on the mobile device,

and / or

The SiRFusion product range from CSR is used to enable the location of the mobile device to be calculated by fusing the output data with several different geolocation techniques, including triangulation or GPS.

6.

The method of any of claims 1-5, wherein the application and associated data requirements are stored in the database system, including one or more of the following fields: an application name Protocol Type, Bandwidth, IP Packet Loss, Transmission Waiting Time, QoS (Quality of Service), QoE (Quality of Experience), Received Signal Strength and Direction, Connected Cell and Context Usage Information.

7.

Method according to any of the claims 1-6, wherein the location-dependent measured network characteristics and the mobile device depend on the absence of a network connection or a small number of network connections The context data requirements for the location are recorded and stored offline and uploaded to the database system when a preferred connection is available.

8.

The method of any of claims 1-7, wherein the means for directing comprises an orientation sensor that can assist in the acquisition and/or positioning of small cell information.

9.

Method according to any of the claims 1-8, characterized in that after determining the location of the mobile device, it is determined whether the current location is considered as a potential impact area of a planned

placement of a new small cell If the user's current location is within the potential impact area, the method proceeds to determine the location of the small cell.

10.

The method of claim 9 wherein the planned placement of the potential impact area of the new small cell is determined according to one or more of the following steps:

- the network operator or user marks the database system that they wish to install the small cell at the location where the small cell is to be placed;

Based on the data collected over time, the database system proposes to place the location of the small cell.

11.

A method according to any of the claims 1-10, wherein the means for guiding the user uses visual, audible or other means to direct the user to the location.

12.

The method of claim 11 wherein the instruction to the user is achieved using one or more of the following:

- (i) use building survey data if available and plot the desired location on the map and direct the user,
- (ii) use wireless fingerprint information and use text/audio based commands to guide the user,
- (iii) detecting the presence of other connected devices near the desired location and forming an association with them.

13.

Method according to any of the claims 1 to 12, characterized in that after the new small cell is located, by using triangulation or other position estimation techniques and testing and calibrating the cell and preferably Provide status updates to users to monitor accurate placement.