

[0001] ACCELERATING DISCOVERY OF ACCESS POINTS
 IN A WIRELESS LOCAL AREA NETWORK

[0002] FIELD OF INVENTION

[0003] The present invention generally relates to wireless local area networks (WLANs), and more particularly, to a method for accelerating discovery of access points (APs) by a station (STA) in passive scanning mode.

[0004] BACKGROUND

[0005] In an AP-based wireless local area network, a STA communicates with a specific AP situated in the vicinity of the STA; the STA is said to be associated to this AP. It is sometimes necessary or desirable for a STA to change the AP to which it is associated. For example, the STA may be moving out of the area covered by the AP to which it is originally associated (i.e., roaming) and experiencing poor signal conditions. Another situation is when throughput becomes poor due to congestion arising in the basic service set (BSS) served by the original AP.

[0006] In order for a STA to reassociate to a new AP, it must first discover the APs in its vicinity that are potentially available. One method for performing this search is the passive scanning mode. In passive scanning, the STA listens for beacon packets sent by neighboring APs, which are typically sent approximately every 100 ms. The STA listens on each transmission channel, and changes channels at a set interval. Once the STA has listened to a beacon and decoded the information contained in the beacon, it may initiate a procedure for reassociating to the neighboring AP.

[0007] The passive scanning mode suffers from a drawback, because the neighboring APs may be operating on different channels. Thus, to listen to the beacon, the STA has to tune to a different channel than the one it is currently operating on with its associated AP. Since the STA generally does not know about the timing of beacon transmissions from other APs, it may need to dwell on each channel for a relatively long time (> 100 ms) to ensure that it has received the beacons from all neighboring APs. While it is listening on other channels, the

STA cannot receive packets from its associated AP and its communications are thus disrupted. Such disruption may adversely and significantly impact the quality of service perceived by the user.

[0008] SUMMARY

[0009] A method for accelerating discovery of access points (APs) in a wireless local area network begins by transmitting an advertisement packet by an AP via at least one channel other than a channel on which the AP transmits beacon signals. The advertisement packet is received by a station (STA), which then determines whether to associate to the transmitting AP. The advertisement packet can include reassociation information, such that the STA can associate to the AP based on the information in the advertisement packet, or timing information, such that the STA can tune to the AP and receive the AP's beacon without dwelling on the AP for an extended period of time.

[0010] In a wireless local area network including an AP having a transmitter and a receiver and at least one STA having a receiver and a transmitter, a system for accelerating discovery of APs includes an advertisement packet and determining means at each STA. The advertisement packet is transmitted by an AP on at least one channel other than a channel on which the AP transmits beacon signals and is received by at least one STA. The determining means is used to determine whether to associate a STA to the transmitting AP based on the received advertisement packet.

[0011] A system for accelerating discovery of APs in a WLAN includes an AP and a STA. The AP includes an advertisement packet determining device; an advertisement packet transmit device connected to the advertisement packet determining device; a first transmitter/receiver connected to the advertisement packet transmit device; and a first antenna connected to the first transmitter/receiver. The STA includes a second antenna; a second transmitter/receiver connected to the second antenna; an advertisement packet receive device connected to the second transmitter/receiver; and a channel tuning

device connected to the advertisement packet receive device and the second transmitter/receiver.

[0012] BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A more detailed understanding of the invention may be had from the following description of a preferred embodiment, given by way of example, and to be understood in conjunction with the accompanying drawings, wherein:

[0014] Figure 1 is a flowchart of a method for AP discovery;

[0015] Figure 2 is a diagram showing transmission of advertisement packets according to the method shown in Figure 1; and

[0016] Figure 3 is a diagram of a system configured to transmit and receive advertisement packets.

[0017] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] Hereafter, the term “station” (STA) includes, but is not limited to, a wireless transmit/receive unit, a user equipment, a fixed or mobile subscriber unit, a pager, or any other type of device capable of operating in a wireless environment. When referred to hereafter, the term “access point” (AP) includes, but is not limited to, a base station, a Node B, a site controller, or any other type of interfacing device in a wireless environment.

[0019] The present invention solves the problem described above in the following manner. An AP may, under certain conditions, transmit additional packets (called “advertisement packets”) on one or more frequency channel(s) different from the one it is currently operating on. This functionality allows STAs operating on these different channels to learn about the existence of the AP without having to tune their receivers to other channels, thereby avoiding communication disruption.

[0020] A method 100 for discovering APs in a WLAN in accordance with the present invention is shown in Figure 1. The method 100 begins by determining whether the AP has met a predetermined condition for transmitting an advertisement packet (step 102). An AP may decide to advertise itself on other

channels only if certain conditions are satisfied. These conditions include, for example:

[0021] 1) Sufficiently low load conditions in the BSS served by the AP, so that the AP can tune to the other frequency channels to transmit its advertisement packets without excessive disruption. There is no need for an AP to advertise itself if it cannot accommodate new STAs. The AP can avoid having its associated STAs transmit information to it during the time it is transmitting the advertisement packet by, for example, sending Request to Send (RTS) or Clear to Send packets (CTS) to itself or calling a contention-free period.

[0022] 2) Indications received from neighboring AP(s) (via inter-AP signaling) that congestion exists in their BSSs and that there is a need to off-load traffic to another channel.

[0023] 3) The AP could discover by itself that congestion exists in the other channels by periodically tuning to the other channels for short periods of time and listening to the traffic on each channel.

[0024] 4) The AP "knows" if there are STAs in the extended service set (ESS) that require fast roaming (for example, if the STAs use delay-sensitive applications such as voice). The AP could learn this information via inter-AP signaling. If there are several delay-sensitive STAs, this would encourage the AP to send advertisement packets.

[0025] It should be understood by those of skill in the art that the above conditions are merely exemplary, and that one skilled in the art can envision other conditions that an AP would need to meet prior to sending an advertisement packet.

[0026] If the AP does not meet one of the conditions for transmitting an advertisement packet, the method 100 terminates (step 104). If the AP meets one of the conditions for transmitting an advertisement packet, then the AP transmits an advertisement packet (step 106). An advertisement packet contains the following information:

[0027] 1) The frequency channel where the AP can be found; and

[0028] 2) Either:

[0029] a) All the information required for the STA to initiate a reassociation procedure to the AP (e.g., address of the AP, AP capabilities, etc.), a part of the information contained in the beacon, or the entire beacon; or

[0030] b) The timing information for the transmission of the beacon packet by the AP on its operating channel, with respect to the time of transmission of the advertisement packet.

[0031] The STA receives the advertisement packet and determines the contents of the advertisement packet (step 108). If the packet contains reassociation information, then if the STA desires to reassociate, it can tune to the channel where the AP is operating and immediately initiate an association procedure to the new AP (step 110). The method 100 then terminates (step 104).

[0032] If the packet contains timing information (step 108), then if the STA desires to reassociate, it can tune to the channel where the AP is operating just before the beacon transmission time by this AP (step 112) and listen to the beacon, thus avoiding a long dwell time on the new channel (step 114). The STA then separately decides whether to reassociate to the new AP (step 116) and the method terminates (step 104).

[0033] Figure 2 shows an example of packet transmissions with three APs (AP1, AP2, and AP3) operating on three channels (A, B, and C), respectively. In this example, AP1 (which is under-loaded) transmits advertisement packets on channels B and C.

[0034] An AP should typically transmit no more than one advertisement packet for each channel per beacon period. Within this period, the timing of transmission of the advertisement packet may be selected randomly. Alternatively, the AP may target a certain time offset with respect to the transmission of its own beacon. Prior to the transmission of the advertisement packet on any other channel, the AP should obey the normal medium access rules like any other STA would (i.e., waiting for a certain amount of time after the medium becomes idle on the selected channel before transmitting).

[0035] The method 100 of the present invention provides following advantages.

[0036] 1) Reducing the time STAs utilizing the passive scanning mode spend listening to other frequency channels. The method 100 also reduces the disruption for STAs utilizing the active scanning mode, since there is no need to send probe requests on the other channels.

[0037] 2) Compared to an alternative approach where APs transmit beacon timing information of neighboring APs, the method 100 does not require synchronization between APs. In addition, a STA listening to an advertisement packet from a neighboring AP is also assured of being capable of hearing that AP's beacon. In the alternative approach, the STA could be far away from the neighboring AP whose beacon timing information is provided by the serving AP. The STA can also readily assess, based on the signal strength of the advertisement packet, if the neighboring AP would be suitable for transmitting data at a rate equal to or higher than its serving AP.

[0038] 3) The method 100 can be used as an effective mechanism for load balancing between APs. The STAs do not have to make a roaming decision before discovering the other APs that are available and accessible to them on other channels, so the STAs could more readily reassociate and balance the load more efficiently. In case a centralized architecture is adopted, the access controller can manage which APs will send advertisement packets based on load information.

[0039] Figure 3 is a diagram of a system 300 configured to transmit and receive advertisement packets. The system 300 includes an AP 302 and a STA 304. The AP 302 includes an advertisement packet determining device 310, an advertisement packet transmit device 312 connected to the advertisement packet determining device 310, a transmitter/receiver 314 connected to the advertisement packet transmit device 312, and an antenna 316 connected to the transmitter/receiver 314. The STA 304 includes an antenna 320, a transmitter/receiver 322 connected to the antenna 320, an advertisement packet receive device 324 connected to the transmitter/receiver 322, and a channel tuning device 326 connected to the transmitter/receiver 322 and the advertisement packet receive device 324.

[0040] The advertisement packet determining device 310 determines whether the system conditions are appropriate for the AP 302 to send out an advertisement packet. If the advertisement packet determining device 310 determines that an advertisement packet should be sent, the advertisement packet determining device 310 signals the advertisement packet transmit device 312, which creates the advertisement packet and schedules its transmission. The advertisement packet is then sent to the transmitter/receiver 314 where it is broadcast via antenna 316.

[0041] The STA 304 receives an advertisement packet via antenna 320 and transmitter/receiver 322. The advertisement packet is examined by the advertisement packet receive device 324 to determine the information contained in the advertisement packet and to make a determination whether the STA 304 will reassociate to the AP 302. If the STA 304 will reassociate to the AP 302, the advertisement packet receive device 324 signals the channel tuning device 326 to change the channel to that of the AP 302, so that the transmitter/receiver 322 can receive packets from the AP 302.

[0042] Embodiments

[0043] 1. A method for accelerating discovery of access points (APs) in a wireless local area network, including the steps of: transmitting an advertisement packet by an AP via at least one channel other than a channel on which the AP transmits beacon signals; receiving the advertisement packet by a station (STA); and determining whether to associate the STA to the transmitting AP.

[0044] 2. The method according to embodiment 1, wherein the transmitting step includes the steps of: determining whether a predetermined condition for transmitting an advertisement packet has been met; and transmitting the advertisement packet if the predetermined condition has been met.

[0045] 3. The method according to embodiment 2, wherein the predetermined condition includes determining whether there is a low load condition in the basic service set served by the AP.

[0046] 4. The method according to embodiment 2, wherein the predetermined condition includes receiving an indication from a neighboring AP that congestion exists in the neighboring AP's basic service set.

[0047] 5. The method according to embodiment 2, wherein the predetermined condition includes determining that congestion exists on other channels, the congestion being determined by the AP by periodically tuning to the other channels and listening to the traffic on the other channels.

[0048] 6. The method according to embodiment 2, wherein the predetermined condition includes determining whether there are delay-sensitive STAs in an extended service set.

[0049] 7. The method according to any preceding embodiment, wherein the advertisement packet includes reassociation information, whereby the STA can associate to the AP based on the information in the advertisement packet.

[0050] 8. The method according to any preceding embodiment, wherein the advertisement packet includes timing information, whereby the STA can tune to the AP and receive the AP's beacon without dwelling on the AP for an extended period of time.

[0051] 9. A system for accelerating discovery of access points (APs) in a wireless local area network, including: an AP; at least one station (STA); an advertisement packet transmitted by the AP on at least one channel other than a channel on which the AP transmits beacon signals, the advertisement packet being received by at least one STA; and determining means at each STA for determining whether to associate a STA to the AP based on the received advertisement packet.

[0052] 10. The system according to embodiment 9, wherein the advertisement packet includes reassociation information, whereby the STA that receives the advertisement packet can associate to the AP based on the information in the advertisement packet.

[0053] 11. The system according to embodiments 9 or 10, wherein the advertisement packet includes timing information, whereby the STA can tune to the AP and receive the AP's beacon without dwelling on the AP for an extended period of time.

[0054] 12. The system according to any one of embodiments 9-11, further including second determining means at the AP for determining whether a predetermined condition has been met prior to transmitting the advertisement packet.

[0055] 13. The system according to any one of embodiments 9-12, wherein the predetermined condition includes determining whether there is a low load condition in the basic service set served by the AP.

[0056] 14. The system according to any one of embodiments 9-12, wherein the predetermined condition includes receiving an indication from a neighboring AP that congestion exists in the neighboring AP's basic service set.

[0057] 15. The system according to any one of embodiments 9-12, wherein the predetermined condition includes determining that congestion exists on other channels, the congestion being determined by the AP by periodically tuning to the other channels and listening to the traffic on the other channels.

[0058] 16. The system according to any one of embodiments 9-12, wherein the predetermined condition includes determining whether there are delay-sensitive STAs in an extended service set.

[0059] 17. A system for accelerating discovery of access points (APs) in a wireless local area network includes an AP and a station. The AP includes an advertisement packet determining device; an advertisement packet transmit device connected to the advertisement packet determining device; a first transmitter/receiver connected to the advertisement packet transmit device; and a first antenna connected to the first transmitter/receiver. The station includes a second antenna; a second transmitter/receiver connected to the second antenna; an advertisement packet receive device connected to the second transmitter/receiver; and a channel tuning device connected to the advertisement packet receive device and the second transmitter/receiver.

[0060] 18. The system according to embodiment 17, wherein the advertisement packet determining device is configured to determine whether the AP should send an advertisement packet.

[0061] 19. The system according to embodiments 17 or 18, wherein the advertisement packet transmit device is configured to prepare and schedule an advertisement packet for transmission.

[0062] 20. The system according to any one of embodiments 17-19, wherein the advertisement packet receive device is configured to receive an advertisement packet from an AP; examine information contained in the advertisement packet; and determine whether the station should reassociate to the AP that sent the advertisement packet.

[0063] 21. The system according to embodiment 20, wherein if the advertisement packet receive device determines to reassociate to a different AP, the channel tuning device is configured to change the receive channel of the station to that of the different AP.

[0064] Although the features and elements of the present invention are described in the preferred embodiments in particular combinations, each feature or element can be used alone (without the other features and elements of the preferred embodiments) or in various combinations with or without other features and elements of the present invention. While specific embodiments of the present invention have been shown and described, many modifications and variations could be made by one skilled in the art without departing from the scope of the invention. The above description serves to illustrate and not limit the particular invention in any way.

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CLAIMS

What is claimed is:

1. A method for accelerating discovery of access points (APs) in a wireless local area network, comprising the steps of:

transmitting an advertisement packet by an AP via at least one channel other than a channel on which the AP transmits beacon signals;
receiving the advertisement packet by a station (STA); and
determining whether to associate the STA to the transmitting AP.

2. The method according to claim 1, wherein the transmitting step includes:

determining whether a predetermined condition for transmitting an advertisement packet has been met; and

transmitting the advertisement packet if the predetermined condition has been met.

3. The method according to claim 2, wherein the predetermined condition includes determining whether there is a low load condition in the basic service set served by the AP.

4. The method according to claim 2, wherein the predetermined condition includes receiving an indication from a neighboring AP that congestion exists in the neighboring AP's basic service set.

5. The method according to claim 2, wherein the predetermined condition includes determining that congestion exists on other channels, the congestion being determined by the AP by periodically tuning to the other channels and listening to the traffic on the other channels.

6. The method according to claim 2, wherein the predetermined condition includes determining whether there are delay-sensitive STAs in an extended service set.

7. The method according to claim 1, wherein the advertisement packet includes reassociation information, whereby the STA can associate to the AP based on the information in the advertisement packet.

8. The method according to claim 1, wherein the advertisement packet includes timing information, whereby the STA can tune to the AP and receive the AP's beacon without dwelling on the AP for an extended period of time.

9. A system for accelerating discovery of access points (APs) in a wireless local area network, comprising:

an AP having a transmitter and a receiver;

at least one station (STA) having a receiver and a transmitter;

an advertisement packet, said advertisement packet being transmitted by said AP on at least one channel other than a channel on which said AP transmits beacon signals, said advertisement packet being received by at least one STA; and

determining means at each STA for determining whether to associate a STA to said AP based on said received advertisement packet.

10. The system according to claim 9, wherein said advertisement packet includes reassociation information, whereby the STA that receives said advertisement packet can associate to said AP based on the information in said advertisement packet.

11. The system according to claim 9, wherein said advertisement packet includes timing information, whereby the STA can tune to said AP and receive said AP's beacon without dwelling on said AP for an extended period of time.

12. The system according to claim 9, further comprising:

second determining means at said AP for determining whether a predetermined condition has been met prior to transmitting said advertisement packet.

13. The system according to claim 12, wherein the predetermined condition includes determining whether there is a low load condition in the basic service set served by said AP.

14. The system according to claim 12, wherein the predetermined condition includes receiving an indication from a neighboring AP that congestion exists in the neighboring AP's basic service set.

15. The system according to claim 12, wherein the predetermined condition includes determining that congestion exists on other channels, the congestion being determined by said AP by periodically tuning to the other channels and listening to the traffic on the other channels.

16. The system according to claim 12, wherein the predetermined condition includes determining whether there are delay-sensitive STAs in an extended service set.

17. A system for accelerating discovery of access points (APs) in a wireless local area network, comprising:

an AP, comprising:

an advertisement packet determining device;

an advertisement packet transmit device connected to said advertisement packet determining device;

a first transmitter/receiver connected to said advertisement packet transmit device; and

a first antenna connected to said first transmitter/receiver; and
a station, comprising:
a second antenna;
a second transmitter/receiver connected to said second antenna;
an advertisement packet receive device connected to said second transmitter/receiver; and
a channel tuning device connected to said advertisement packet receive device and said second transmitter/receiver.

18. The system according to claim 17, wherein said advertisement packet determining device is configured to determine whether said AP should send an advertisement packet.

19. The system according to claims 17 or 18, wherein said advertisement packet transmit device is configured to prepare and schedule an advertisement packet for transmission.

20. The system according to one of claims 17-19, wherein said advertisement packet receive device is configured to:
receive an advertisement packet from an AP;
examine information contained in the advertisement packet; and
determine whether said station should reassociate to the AP that sent the advertisement packet.

21. The system according to claim 20, wherein if said advertisement packet receive device determines to reassociate to a different AP, said channel tuning device is configured to change the receive channel of the station to that of the different AP.