

[0001] METHOD AND APPARATUS FOR NETWORK
MANAGEMENT USING PERIODIC MEASUREMENTS OF INDICATORS

[0002] FIELD OF INVENTION

[0003] This invention relates to beacon measurement request signals used in wireless slotted communications and network management. More particularly, the invention relates to network management using periodic measurements of parameters such as new beacon received power level or signal quality.

[0004] BACKGROUND

[0005] The IEEE 802.11 communications protocol allows a client to roam among multiple access points that may be operating on the same or separate channels. IEEE 802.11 communications are generally effected through wireless LAN access points (APs), which are typically single standalone units, but can include networks with multiple APs which provide a roaming function. To support the roaming function, each access point typically transmits a beacon signal every 100ms. A roaming station (STA) uses the beacon to gauge the strength of its existing access point connection. If the STA senses a weak signal, the roaming STA can implement the reassociation service to connect to an access point emitting a stronger signal.

[0006] IEEE 802.11 supports two power modes; active and power-saving (PS). The protocols for infrastructure networks and ad hoc networks are different. Under an infrastructure network, there is an AP to monitor the mode of each mobile station. A station in the active mode is fully powered and thus may transmit and receive at any time. On the contrary, a station in the PS mode only wakes up periodically to check for possible incoming packets from the AP. A station always notifies its AP when changing modes. Periodically, the AP transmits beacon frames spaced by a fixed beacon interval. A PS station should monitor these frames. In each beacon frame, a traffic indication map (TIM) are delivered, which contains IDs of those PS stations with buffered unicast packets in the AP. A PS station, on hearing its ID, should stay awake for the remaining

beacon interval. Under the contention period (i.e., DCF), an awake PS station can issue a PS-POLL to the AP to retrieve the buffered packets. While under the contention-free period (i.e., PCF), a PS station waits for the AP to poll it. The AP sends delivery TIMs (DTIMs) within beacon frames to indicate that there are buffered broadcast packets. The delivery TIMs are spaced by a fixed number of beacon intervals. Immediately after DTIMs, the buffered broadcast packets are sent.

[0007] Since IEEE 802.11 presumes that mobile stations are fully connected, the transmission of a beacon frame can be used to synchronize all stations' beacon intervals. In addition to the use in IEEE 802.11, beacon signals are useful in other WLAN communications and wireless communications in general. Periodic measurements are performed in systems implementing the third generation partnership program (3GPP) wideband code division multiple access (W-CDMA) system. Such systems use a time division duplex mode. To support higher layer functions in IEEE 802.11 standards for efficient network management, several physical parameters relating to different aspects of network management are desirable.

[0008] One such parameter is the perceived signal to noise indicator (PSNI), the measurement of which provides a quantized, comparative measure of received signal quality for all channels/rates and among all physical channels and between all stations. Another parameter is the received channel power indicator (RCPI) indicator, which is a measure of the received RF power in the selected channel, measured at the antenna connector. The RCPI parameter may be a measure by the PHY sub layer of the received RF power in the channel measured over the PLCP preamble and over the entire received frame. RCPI is a monotonically increasing, logarithmic function of the received power level defined in dBm. The exemplary allowed values for the RCPI parameter may be an 8-bit value in the range from 0 through 220.

[0009] In known approaches, the measurement of the parameters RCPI and PSNI is done as a single measurement, which approach has certain disadvantages. It is desirable to provide an improved method of making

measurements of the parameters, e.g., RCPI and PSNI, to result in specific advantages resulting in more efficient network management.

[0010] SUMMARY

[0011] According to the present invention, periodic measurements of the new beacon request are used in order to support roaming and dynamic data rate adjustment, and related functions. The concepts for periodic measurements are performed in a manner analogous to periodic measurements in systems implementing third generation partnership program (3GPP) wideband code division multiple access (W-CDMA) system utilizing the time division duplex mode.

[0012] BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Figure 1 is a schematic diagram of a network configuration in which WLANs communicate with a wireless transmit/receive unit (WTRU) through one or more access points.

[0014] Figure 2 is a chart showing types of measurements or reports.

[0015] Figure 3 is a graph showing the effects of absolute threshold on data rate selection.

[0016] Figure 4 is a graph showing a relative threshold which uses the serving AP for a handoff.

[0017] Figure 5 is a graph showing the effect of a reporting offset.

[0018] Figure 6 is a graph showing the received channel power indicator (RCPI) level of a serving AP.

[0019] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] Hereafter, a wireless transmit/receive unit (WTRU) includes but is not limited to a user equipment, mobile station, fixed or mobile subscriber unit, pager, or any other type of device capable of operating in a wireless environment. When referred to hereafter, an access point includes but is not limited to a

Node B, site controller, access point or any other type of interfacing device in a wireless environment.

[0021] An "access point" (AP) in a typical IEEE 802.11 implementation is a station or device which provides wireless access for devices to establish a wireless connection with a LAN, and establishes a part of a wireless LAN (WLAN). If the AP is a fixed device on a WLAN, the AP is a station which transmits and receives data. The AP permits connection of a WTRU to a network, provided that the WLAN itself has a connection to the network.

[0022] Network management by making measurements of parameters, e.g., RCPI and PSNI, is performed periodically rather than in the manner of a one-time measurement. The impact of making periodic measurements on the network performance and the attendant benefits are addressed in the description of the preferred embodiment. More specifically, the beneficial effect of making periodic measurements on the beacon request extensions to support roaming and dynamic data rate are addressed. Even though the invention is described in the specific context of the standard IEEE 802.11 as an example, the invention is envisaged to be applicable to other scenarios also.

[0023] Periodic beacon requests are made during connection between a WTRU and an AP on a WLAN. A Measurement Request field corresponding to a beacon request contains a measurement duration value and channel number for which the request applies. The beacon request permits a scan mode which includes "Active Scan" mode, "Passive Scan" mode and "Beacon Table" mode. In Active Scan mode, the measuring station (STA) transmits a probe request with a broadcast service station identifier (SSID). The measuring STA's beacon report contains one information element for each STA from which it detects a beacon or probe response, regardless of whether the probe response was triggered by the measuring STA's own probe request. In Passive Scan mode, the measuring STA passively receives on the specified channel and returns a beacon report containing one information element for each STA from which it detects a beacon or probe response. If the measuring channel is also the serving channel, the STA concurrently carries out its normal data traffic operation. In Beacon Table mode,

the measuring STA returns a Beacon Report containing the current contents of its beacon table without performing additional measurements. The Measurement Duration field is set equal to the duration of the requested measurement, expressed in time units (TUs).

[0024] The following are some potential advantages of periodic measurements as compared with the single measurement approach:

[0025] Periodic measurements reduce management traffic: single measurement request produces multiple reports but only when relevant.

[0026] Absolute Threshold crossings on PSNI measures are ideal to trigger data rate changes.

[0027] Absolute Threshold crossings on RCPI are ideal for proximity detectors for location.

[0028] Relative Threshold with respect to serving AP detects conditions for handoff.

[0029] The beacon request also contains periodic extensions (information fields) which specify periodic beacon measurements. The extensions fields are used to provide parameters for the periodic measurement and conditional reporting of measurement results. These provide periodic measurements which reduce management traffic, such that a single measurement request produces multiple reports. The multiple reports are provided only when deemed relevant. Absolute threshold crossings on perceived signal to noise indicator (PSNI) may be used as a condition to provide a measurement report. The measurements on PSNI are suitable to trigger data rate changes. Absolute threshold crossings on received channel power indicator (RCPI) may be used as a condition to provide a measurement report.

[0030] The periodic extensions are additional fields in the beacon request which are use for periodic beacon measurements. The capability to do periodic measurements is an optional capability for the AP, and therefore APs which are not capable of doing periodic beacon measurements will ignore the periodic extensions. A beacon request is a request to perform a measurement. A beacon

report is the response containing the result(s) of the requested beacon measurement.

[0031] The absolute threshold crossings are suitable for proximity detectors used to determine location and approximate position relative to an AP. A relative threshold with respect to a serving AP is used to detect conditions for a handoff.

[0032] The measurement request field corresponding to a beacon request is shown in Table 1 and contains the measurement duration and channel number for which the request applies. Also included in Table 1 are the extensions (additional information fields) needed to specify periodic measurements and conditional reporting. Table 1 generally shows the measurement request field format for a beacon request. The illustration for the current measurement shows the number of octets for the channel number, channel band, measurement duration and scan mode. Table 1 also shows for comparison, the octets for periodic extensions, with respect to basic service set identifier (BSSID), measurement period, reporting condition, threshold/offset, and hysteresis effect. More particularly, the Measurement Request field corresponding to a beacon request is shown in Table 1 and contains the measurement duration and channel number for which the request applies. A response to a beacon request is a beacon report.

Table 1 - Beacon Request

Channel Number	Channel Band	Measurement Duration	Scan Mode
Octets: 1	1	2	1

BSSID	Measurement Period	Reporting Condition	Threshold /Offset	Hysteresis
Octets 6	2	1	1	1

[0033] If the AP is not capable of performing periodic measurements and thus does not recognize the extensions, then the AP ignores the extensions and provides a single measurement and a single report.

[0034] In Table 1, channel number indicates the channel number on which the requesting STA instructs the receiving STA to report detected beacons and probe responses. In the beacon request, the Channel Number field indicates the channel number on which the requesting STA instructs the receiving STA to report detected beacons and probe responses. The Channel Band field indicates the frequency band, taken from Table 1, in which the receiving STA conducts its measurement. The Scan Mode field is set to the type of scan, according to Table 2 (infra). The scanning behavior is as follows:

[0035] - In Active Scan mode, the measuring STA transmits a probe request with the broadcast SSID. The measuring STA's beacon report contains one information element for each STA from which it detects a beacon or probe response, regardless of whether the probe response was triggered by the measuring STA's own probe request

[0036] - In Passive Scan mode, the measuring STA passively receives on the specified channel and return a beacon report containing one information element for each STA from which it detects a beacon or probe response. If the

measuring channel is also the serving channel, the STA concurrently carries out its normal data traffic operation.

[0037] - In Beacon Table mode, the measuring STA returns a beacon report containing the current contents of its beacon table without performing additional measurements.

[0038] The Measurement Duration field is set equal to the duration of the requested measurement, expressed in TUs.

[0039] Tables 2 and 3 show channel band definitions for radio measurement requests and Scan Mode definitions for beacon request elements.

[0040] Table 2 - Channel Band definitions for radio measurement requests

Name	Channel Band
2.4-GHz Band	0
5-GHz Band	1

[0041] Table 3 – Scan Mode definitions for Beacon Request elements

Name	Scan Mode
Passive Scan	0
Active Scan	1
Beacon Table	2
Reserved	3-255

[0042] BSSID indicates the BSSID of the particular AP for which this measurement is requested. The BSSID specifies which AP to measure when several APs are detectable on a given channel. The BSSID is set to the broadcast BSSID when the measurement is performed on any AP(s) on this channel. A broadcast BSSID is used when an AP BSSID is unknown.

[0043] The Measurement Period indicates whether this measurement is a single measurement event or is a periodic measurement which is repeated each Measurement Period. The Measurement Period is divided into two subfields:

Unit and Period. The Unit subfield defines the time unit for the Period subfield and consists of the 2 MSBs with the following values:

[0044] The Period subfield consists of the 14 LSBs and is an unsigned integer number representing the repeating time interval for this periodic measurement. A Period subfield value of 0 indicates that the measurement is not periodic but is a single measurement. A period subfield value of 16383 (3FFF Hex) indicates that the measurement is periodic with no requested measurement period; in this case the measurement is performed on a best effort basis and as frequently as conditions permit.

[0045] The Reporting Condition defines when the measured results are reported to the requesting STA. The Reporting Condition values are defined in Table 4.

[0046] Table 4 – Reporting Condition Definitions for Beacon Request Element

Condition Description	Reporting Condition
Report to be issued after each measurement.	0
Report to be issued when the RCPI level of the measured AP crosses above an absolute threshold with hysteresis.	1
Report to be issued when the RCPI level of the measured AP crosses below an absolute threshold with hysteresis.	2
Report to be issued when the PSNI level of the measured AP crosses above an absolute threshold with hysteresis.	3
Report to be issued when the PSNI level of the measured AP crosses below an absolute threshold with hysteresis.	4
Report to be issued when the RCPI level of the measured AP crosses above a threshold defined by an offset (with hysteresis) from the serving AP's RCPI.	5
Report to be issued when the RCPI level of the measured AP crosses below a threshold defined by an offset (with hysteresis) from the serving AP's RCPI.	6
Report to be issued when the PSNI level of the measured AP crosses above a threshold defined by an offset (with hysteresis) from the serving AP's PSNI.	7
Report to be issued when the PSNI level of the measured AP crosses below a	8

threshold defined by an offset (with hysteresis) from the serving AP's PSNI.	
Periodic reports (one per measurement) to begin when the RCPI level of the measured AP enters and remains in a range bound by the serving AP's RCPI and an offset (with hysteresis) from the serving AP's RCPI.	9
Periodic reports (one per measurement) to begin when the PSNI level of the measured AP enters and remains in a range bound by the serving AP's PSNI and an offset (with hysteresis) from the serving AP's PSNI.	10
Reserved	11 - 255

[0047] Threshold/Offset provides either the threshold value or the offset value to be used for conditional reporting. A threshold value is an unsigned 8 bit integer having units which are equivalent to PSNI or RCPI. An offset value is a signed 7 bit integer in the range of (-127, +127).

[0048] Hysteresis provides an unsigned 8 bit integer hysteresis value having units equivalent to the units used in the Threshold/Offset field.

[0049] Figure 1 is a schematic diagram of a network configuration 11 in which one or more WLANs 12, 13 communicate with a WTRU 15 through one or more APs 17-19. In the example depicted the WLANs 12, 13 are able to establish a network link 22, either directly or through a radio network controller (RNC) 23.

[0050] Figure 2 is a chart showing types of measurements or reports, showing how event detection triggers a report, or, triggers periodic reporting. More specifically, Figure 2 illustrates for comparison, a single report scenario for PSNI and RCPI, as compared to similar periodic conditional reports for absolute threshold, serving AP threshold, serving AP periodic range. Also illustrated is the periodic reporting for each trigger event for comparison. The broadest category is a measurement 26. As used here, "measurement" can be a measurement or report. The measurement 26 may be a single 27 or periodic 28 measurement. A single measurement generates a single report 29, which includes a single report PSNI 30 and a single report RCPI 31. The periodic measurement 28 can generate a conditional report 32 or a periodic report 33. The conditional report 32 can provide an absolute threshold 34, a serving AP

threshold 35 or a serving AP periodic range 36. The absolute threshold 34 includes an absolute threshold PSNI 37 and an absolute threshold RCPI 38. The serving AP threshold 35 includes a serving AP threshold PSNI 47 and a serving AP threshold RCPI 48. The serving AP periodic range 36 includes a serving AP periodic range PSNI 57 and a serving AP periodic range RCPI 58. The periodic report 33 includes a periodic report PSNI 67 and a periodic report RCPI 68.

[0051] In addition, the single report 31 may be conditionally reported based on an absolute threshold 34 including absolute threshold PSNI 37 and absolute threshold RCPI 38. Also, the single report 31 may be conditionally reported based on the serving AP threshold 35 including serving AP threshold PSNI 47 and serving AP threshold RCPI 48. The serving AP periodic range is not used for the single report 31, but may provide the serving AP periodic range 36 including serving AP periodic range PSNI 57 and serving AP periodic range RCPI 58 for periodic measurement reporting.

[0052] The single and periodic measurements 27, 28 are measurement types. The single report 31, conditional report 32, periodic report The absolute threshold 34, serving AP threshold 35 and serving AP periodic range 36 trigger events. The measurement results are the single report PSNI 27, single report RCPI 28, absolute threshold PSNI 37, absolute threshold RCPI 38, serving AP threshold PSNI 47, serving AP threshold RCPI 48, serving AP periodic range PSNI 57, serving AP periodic range RCPI 58, periodic report PSNI 67 and periodic report RCPI 68. For conditional reporting, event detection triggers one or more of these single event reporting outputs or periodical reporting outputs.

[0053] Figure 3 is a graph showing the effects of absolute threshold on data rate selection, and illustrates variation of measurement quantity against time for three different channels having 5.5 Mbps, 2.0 Mbps and 1.0 Mbps rates respectively. At an initial time of the graph, STA 1 receives a low PSNI level from the AP as measured at the STA, substantially below an absolute threshold. The rate is established at 1Mbps. STA 2 and STA 3 have PSNI levels above the threshold level. As time progresses, STA 3 has received PSNI levels which exceed a second threshold and then drops down to below the absolute threshold.

STA 3 thus can change to the 5.5 Mbps rate, but must drop down to the 2 Mbps rate and eventually the 1 Mbps rate as the PSNI level drops. STA 2 remains at the 2 Mbps rate until later, when STA 2 has sufficient PSNI levels to change to the 5.5 Mbps rate. These changes in PSNI levels can also be used to change APs by selecting the AP with a higher rate or PSNI level, should resources from that AP be available.

[0054] Figure 4 is a graph showing a relative threshold which uses the serving AP for a handoff. This figure also illustrates variation of measurement quantity against time for AP 1 and AP 2 intersecting at a location showing the reporting event. The graph shows the signals received by a STA from a first AP (Serving AP) and a second AP (AP 2). The measurement for the servicing AP is made lower by an offset, in which PSNI is made lower, in order to favor AP 2. Thus the measurement of PSNI for the serving AP is made artificially lower by the offset. This causes an early trigger of the handoff as a result of the offset.

[0055] Figure 5 is a graph showing the effect of a reporting offset and shows relative threshold triggers for AP 1, 2 and 3 showing the reporting range and when the reporting terminates. The graph illustrates timeslot ISCP versus time showing the ISCP threshold and the reporting event. Event triggered and periodic reports of the PSNI levels each show the instance of a reduced PSNI level as a result of the offset. The reporting of the serving AP 3 continues during a peak period of PSNI reported from a third AP, AP 3, but discontinues when the signal from AP 3 drops below the offset reporting of PSNI from the serving AP.

[0056] Figure 6 is a graph showing the RCPI level of a serving AP. The triggering event here is an absolute threshold exceeded. The triggering event triggers a report.

[0057] 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.

* * *

CLAIMS

What is claimed is:

1. In a wireless communication system utilizing at least one access point transmitting a beacon signal responsive to a beacon request, the beacon signal used for indicating channel, measurement and mode data, a method for extending the system to incorporate additional signal information, the method comprising:

providing at least one extension of the beacon request, the extension providing a measurement of a signal condition.

2. The wireless communication system of claim 1, wherein the extension including one of BSSID, measurement period, reporting condition, threshold, offset of measurement and hysteresis.

3. The wireless communication system of claim 1, wherein the extension including one of PSNI and RCPI measurements.

4. The wireless communication system of claim 1, wherein the wireless communication system implementing a wireless LAN connection and the beacon signal provided in the implementation of the LAN connection.

5. The wireless communication system of claim 1, wherein:
a response protocol includes a beacon extension; and
the beacon extension includes a Period subfield provided as an unsigned integer number representing a repeating time interval for a periodic measurement.

6. The wireless communication system of claim 1, wherein:
a response protocol includes a beacon extension; and
the beacon extension including a Period subfield, the Period subfield comprising 14 LSBs as an unsigned integer number representing a repeating

time interval for a periodic measurement, wherein a Period subfield value of 0 indicates a single non-periodic measurement.

7. The wireless communication system of claim 1, wherein the beacon request extension includes a Period subfield provided as an unsigned integer number representing a repeating time interval for a periodic measurement.

8. The wireless communication system of claim 1, wherein the beacon request extension including a Period subfield, the Period subfield comprising 14 LSBs as an unsigned integer number representing a repeating time interval for a periodic measurement, wherein a Period subfield value of 0 indicates a single non-periodic measurement.

9. In a wireless local area network (WLAN), a method for operating an access point (AP) utilizing a beacon signal, the method comprising:

providing, in the beacon signal, periodic measurements in response to beacon requests in order to support one of roaming, dynamic data rate adjustment, and related signal control functions.

10. The method of claim 9, wherein the WLAN implementing a WLAN connection and the beacon signal provided in the implementation of the WLAN connection.

11. The method of claim 9, wherein the extension includes one of BSSID, measurement period, reporting condition, threshold, offset of measurement and hysteresis.

12. The method of claim 9, wherein extension including one of PSNI and RCPI measurements.

13. The method of claim 9, wherein:

a response protocol including a beacon extension;

the beacon extension includes a Period subfield provided as an unsigned integer number representing a repeating time interval for a periodic measurement.

14. The method of claim 9, wherein:
a response protocol including a beacon extension; and
the beacon extension including a Period subfield, the Period subfield comprising 14 LSBs as an unsigned integer number representing a repeating time interval for a periodic measurement, wherein a Period subfield value of 0 indicates a single non-periodic measurement.

15. The method of claim 9, wherein the beacon request extension includes a Period subfield provided as an unsigned integer number representing a repeating time interval for a periodic measurement.

16. The method of claim 9, further characterized by a beacon request extension including a Period subfield, the Period subfield comprising 14 LSBs as an unsigned integer number representing a repeating time interval for a periodic measurement, wherein a Period subfield value of 0 indicates a single non-periodic measurement.

17. In a wireless local area network (WLAN) including at least one access point (AP) and at least one wireless transmit/receive unit (WTRU), a method for operating a WTRU, the method comprising:

providing a beacon request including at least one measurement response;

receiving a beacon signal in response to the request; and

if provided in the beacon signal obtaining the measurement response.

18. The method of claim 17, wherein the measurement response includes one of a measurement to support roaming, a measurement to support dynamic data rate adjustment, and a measurement to support a related signal control function.

19. The method of claim 17, wherein the wireless communication system implementing a WLAN connection and the beacon signal provided in the implementation of the WLAN connection.

20. The method of claim 17, wherein a beacon request extension includes one of BSSID, measurement period, reporting condition, threshold, offset of measurement and hysteresis.

21. The method of claim 17, wherein a beacon request extension includes one of PSNI and RCPI measurements.

22. The method of claim 17, wherein:
a response protocol including a beacon extension; and
the beacon extension including a Period subfield provided as an unsigned integer number representing a repeating time interval for a periodic measurement.

23. The method of claim 17, wherein:
a response protocol including a beacon extension; and
the beacon extension including a Period subfield, the Period subfield comprising 14 LSBs as an unsigned integer number representing a repeating time interval for a periodic measurement, wherein a Period subfield value of 0 indicates a single non-periodic measurement.

24. The method of claim 17, wherein a beacon request extension including a Period subfield provided as an unsigned integer number representing a repeating time interval for a periodic measurement.

25. The method of claim 17, a beacon request extension including a Period subfield, the Period subfield comprising 14 LSBs as an unsigned integer number representing a repeating time interval for a periodic measurement, wherein a Period subfield value of 0 indicates a single non-periodic measurement.