

[0001] METHOD FOR TRANSMIT AND RECEIVE
 POWER CONTROL IN MESH SYSTEMS

[0002] FIELD OF INVENTION

[0003] This invention relates to wireless local area mesh networks. In particular, this invention relates to signaling mechanisms that can be implemented in a Mesh point (MP) in order to enable transmit (Tx) and receive (Rx) power control.

[0004] BACKGROUND

[0005] Figure 1 shows a typical wireless system infrastructure, comprising a set of access points (APs), also referred to as base stations (BS), each connected to a wired network through what is referred to as a backhaul link. The wireless links exist between the APs and the user stations (STAs). In some scenarios, the cost of connecting a given AP directly to the wired network makes an alternative option more attractive, which is to connect the AP indirectly to the wired network via wireless connections to its neighboring APs. This is referred to as a Mesh architecture. Figure 2 shows a block diagram of a simple Mesh architecture comprising a plurality of Mesh points (MPs), each capable of supporting control, management and operation services for the Mesh. The MPs may either be a dedicated infrastructure device (e.g., a Mesh AP (MAP)) or a user device (e.g., a STA) that is able to fully participate in the formation and operation of the Mesh network. Advantages of using a Mesh infrastructure include ease-of-use and speed of deployment since a radio network can be deployed without having to provide backhaul links and interconnection modules for each AP.

[0006] One very important operational consideration is that Tx power settings of Mesh nodes are regulated in order to meet regulatory requirements. Operation of wireless radio communications today is regulated by the FCC (and their counterparts in other countries). In particular, certain maximum Tx power settings are mandated in order to minimize interference of un-licensed radio

equipment such as WLANs for most frequency bands. Moreover, these regulatory requirements usually change per regulatory domain (e.g., U.S., Europe, Japan). Typical regulatory requirements for conventional WLANs operating in infrastructure mode (basic service set (BSS)) or AdHoc mode (Independent BSS (IBSS)) are summarized as follows (i.e., Mesh operation is not addressed by this existing standard).

[0007] Transmit power control (TPC) under IEEE 802.11h for 5GHz band WLANs is primarily motivated by different regulatory Tx power allowances in the 5GHz band assignments in Europe, but is also required by the FCC in the US. Different regulatory power requirements for the 5GHz band include:

- Lower U-NII (5.25-5.35GHz, 4 channels) 40mW US, 200mW Europe
- Middle U-NII (5.35-5.45GHz, 4 channels) 200mW US and Europe
- (5.47-5.725GHz, 11 channels) Europe-only, 1000mW
- Upper-U-NII (5.725-5.825GHz, 5 channels) US-only, 800mW

The maximum admissible Tx power setting for any STA in the BSS or IBSS is the Power Constraint information element (IE) subtracted from the Regulatory Max Power value contained in the Country (IE). The Country IE (802.11d) is contained in BEACON and PROBE RESPONSE frames. Similarly, 802.11h puts the Power Constraint IE into BEACON and PROBES RESPONSE frames.

[0008] TPC under IEEE 802.11h adds a Power Capability IE to ASSOCIATION REQUESTS (RE-ASSOCIATION REQUESTS) sent from the STA to the AP (or STA in IBSS). This Power Capability IE is an indication of the possible minimum and maximum Tx power settings of the transmitting STA to the receiving STA.

[0009] Association attempts by STAs are to be refused by the AP or other STAs in an IBSS if the range indicated in their Power Capability IE does not allow operation with the current BSS regulatory settings. The AP is the only authority in the BSS that can change the admissible power setting for the BSS. In an IBSS, the STA that starts the IBSS is the one that sets admissible power settings and other STAs that subsequently broadcast the BEACON frame are

required to propagate this initial power setting.

[0010] In the BSS case, the admissible power settings (regulatory in Country IE and offset in Power Constraint IE) can change during the lifetime of the BSS. Range control and interference reduction are specifically cited in 802.11h as one purpose for this feature. However, it is preferred that these changes in the settings should not happen "too often".

[0011] One of the problems is that even if every BEACON can be used to change the power settings, not all STAs (for example the ones in packet switched (PS) mode) listen to every BEACON frame. Therefore, maximum Tx power changes are semi-static in the sense that it requires at least several target beacon transmission times (TBTTs) (hundreds of milliseconds) to have a new Tx power setting adopted by all STAs in the BSS.

[0012] Officially, 802.11h TPC requires a STA to check the admissible Tx power setting any time it tries to access the channel. However, it is doubtful that all manufacturers have implemented an automatic update from the latest received BEACON frame into their MAC firmware. It is reasonable to assume that this happens only once in a while, in extreme cases only during association or re-association.

[0013] TPC under 802.11h also introduces a TPC REQUEST/REPORT action frame pair. This TPC REQUEST action frame is used by a STA to request Tx power settings and link margin from another STA. The reported Tx power in the TPC REPORT action frame is the one used for sending the TPC report. The link margin reported is the one observed by the receiver when the TPC REQUEST action frame was received.

[0014] The IEs contained in the TPC REPORT action frame can also be put into the BEACON and PROBE RESPONSES, originally intended to address some special problems with IBSS mode. However, the link margin field in this case is meaningless and simply set to zero. These new 802.11h TPC-relevant IEs and action frames are found in Class 1 frames (i.e. they can be sent from and received by non-authenticated and non-associated STAs).

[0015] For completeness, 802.11h TPC functionality for the 5GHz band is extended "as-is" into 2.4GHz by the 802.11k draft amendment.

[0016] In order to allow ease of deployment and ease of adoption to a new deployment environment, a means to adopt allowed Tx power settings for Mesh equipment is needed. In addition to these regulatory considerations, adaptive Tx power levels are highly desirable to maintain high throughput and guaranteed QoS levels in a Mesh network.

[0017] The Tx and Rx power level settings of the participating nodes in a Mesh have a large impact on perceived communication and interference range. Perceived communication range is the distance over which a certain data rate can be sustained in a point-to-point or point-to-multipoint transmission). The perceived interference range is the distance over which a transmission can still disturb or degrade other ongoing transmissions from other nodes in the Mesh on a channel (or even on adjacent channels), even though the transmission itself cannot be reliably decoded any more.

[0018] Usually, the least possible Tx power setting in an MP conditioned on maintaining a given sustained data rate for a given Mesh link is the best approach to minimize co-channel and adjacent channel interference to other nodes in the Mesh. On the other hand, maximum possible Tx power level settings allow higher net data transmit rates because this directly impacts the SNR as seen by the intended receiver. This implies that MPs face conflicting needs and preferences in terms of which Tx and Rx power level settings to use. The ideal Tx power level setting for a particular MP is therefore a trade-off between maximizing individual data rates on particular links (higher data rates with higher Tx power settings) and maximizing overall Mesh performance (better performance with less interference and more spatial reuse on the same channel).

[0019] Rx power level settings, such as clear channel assessment (CCA) detection thresholds and minimum Rx sensitivity, impact the link budget and, as such, the SNR observed in the receiver. The Rx power level settings also impact the likelihood of failed channel access or collisions in carrier sense multiple access (CSMA)-based schemes such as 802.11 WLANs.

[0020] However, the level of interference perceived by the different nodes of a wireless Mesh system can vary widely both geographically and in time. This

is because of the dynamic radio environment and real-time time-varying characteristics of transmissions in a Mesh, such as load per link or path, occupied channel time, etc.

[0021] Therefore, a means for dynamically controlling Tx and Rx power levels of Mesh nodes during the Mesh network lifetime is desirable in order to keep Mesh throughput and QoS high and at guaranteed levels. Also, channel changes motivated because of regulatory requirements need to be addressed in a wireless Mesh network.

[0022] While traditional WLANs (802.11a,b,g,j,n) do not provide any means today to allow for an adoption of Tx power settings other than at initial start-up, an amendment (802.11h) was made to Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications in order to satisfy regulatory requirements for operation in the 5 GHz band in Europe. IEEE 802.11h TPC only allows WLAN systems in the 5GHz band to set Tx power settings during the initial association of incoming STAs and to some extent during the lifetime of the WLAN network (Infrastructure mode or AdHoc mode). However, the 802.11h amendment does not address the specific needs and constraints of Mesh systems. This case was simply not foreseen.

[0023] In particular, no means exist to ensure a selective Tx power change of a particular link within a Mesh. Moreover, only maximum admissible Tx power settings can be communicated. However, just as important as maximum admissible Tx power settings are, so too are the minimum power settings in order to guarantee establishment of links and to minimize probability of channel access collisions.

[0024] Variable Tx power settings would improve the radio efficiency of Mesh networks, but a method for achieving this feature is not provided by existing technology. Furthermore, a method for Tx power control needs to be devised to allow Mesh networks to meet certain regulatory requirements in the sense of 802.11h TPC similar to WLANs today operating in legacy infrastructure (such as in a BSS case) and AdHoc mode (such as in an IBSS case).

[0025] SUMMARY

[0026] A method and apparatus controls transmit and receive power level of a mesh point (MP) operating in a mesh wireless communication network of a plurality of MPs. Power capability information of a new MP is sent to at least one existing MP in the mesh network. The existing MP accepts the new MP as a member of the mesh network and sends allowed power setting information to the new MP. The new MP adjusts its power level in accordance with the allowed power setting information.

[0027] BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Figure 1 shows block diagram of a conventional wireless LAN.

[0029] Figure 2 shows a block diagram of a simple Mesh infrastructure.

[0030] Figures 3A and 3B show signaling diagrams of a power capability information exchange between a Mesh point and a power master Mesh point.

[0031] Figures 3C and 3D show signaling diagrams of a distributed power capability information exchange between Mesh points.

[0032] Figures 4A and 4B show signaling diagrams of Mesh allowed power settings information retrieval from a power master Mesh point.

[0033] Figures 4C and 4D show signaling diagrams of Mesh allowed power settings information retrieval from other Mesh points.

[0034] Figure 5 shows a signal diagram for transmit power control according to the present invention.

[0035] Figure 6 shows a signal diagram for adjustment of MP transmit power settings in response to received allowed power setting information.

[0036] Figure 7 shows a signal diagram of a power master selection procedure.

[0037] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0038] 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.

[0039] Hereafter, a mesh point includes but is not limited to a wireless transmit/receive unit (WTRU), 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 base station, Node-B, site controller, access point or any other type of interfacing device in a wireless environment.

[0040] The term "Mesh neighbor" herein refers to the immediate neighbors of a particular Mesh point, (i.e., the ones in radio range). It also refers to other Mesh nodes that the MP can reach when its signaling messages are forwarded through the Mesh over multiple hops by other MPs. It can also include network entities beyond the immediate reach of the wireless Mesh, such as nodes residing in the wired backhaul network connected with the Mesh.

[0041] The present invention provides signaling procedures and mechanisms that will provide the means by which Mesh systems can adjust Tx and Rx power levels for regulatory and radio management purposes at system start-up, when an MP joins the Mesh network and during the lifetime of the Mesh network. The invention addresses a distributed scenario (i.e., the MPs are engaged in "peer-to-peer" signaling), as well as a master-slave scenario, in which the relationship between MPs is one of master and slave. In the latter scenario, a Power Master (PM) is a master MP that is responsible for dictating the power settings in the Mesh, both the overall regulatory settings and the individual power settings per Mesh Point and per link.

[0042] The present invention includes methods and apparatus with means for:

- a) Signaling by which MPs exchange power-setting relevant capability information such as maximum and minimum power settings;
- b) Signaling by which MPs learn about allowed power settings in the Mesh;
- c) An MP reacting to different or conflicting allowed power setting information messages and configuration parameters;

- d) Power adjustments in the Mesh to meet regulatory requirements and to dynamically adjust power settings; and
- e) Electing a given Mesh node as PM.

[0043] Figures 3A and 3B show signaling diagrams of a power capability information exchange between an MP 101 and a PM in a master-slave arrangement. The power capability information preferably includes, but is not limited to any of the items as shown in Table 1, including any combination thereof.

Table 1: Power Capability Information

<i>Type</i>	<i>Description</i>
Tx power step sizes	Minimum and maximum Tx power and adjustment step size settings that the MP supports
Rx power step sizes	Minimum and maximum Rx power and adjustment step size settings, sensitivity levels and CCA thresholds settings that the MP supports
Mode	The operational modes (e.g., 802.11a, b, g, n, j, etc.) the MP is able to support
Bandwidth	The operational bandwidth that the MP is able to support (e.g., 802.11n supports bandwidths of 10/20/40 MHz and 802.11j supports 10 or 20 MHz bandwidths)
Freq. Bands	The number of bands and sub-bands on which the MP is capable of simultaneous operation (e.g., 2.4 GHz, 5 GHz, 5 GHz Lower U-NII, 5 GHz Middle U-NII)

[0044] In Figure 3A, an MP 101 reports its power capability information 301 to the PM in an un-solicited manner, such as part of a broadcast/multicast-type frame for example. In Figure 3B, MP1 reports its power capability information 303 in a solicited manner as a response-type frame in response to a power capability request 302 (e.g., the exchanged signals 302, 303 may be in the form of a directed unicast request/response-type frame exchange between the MP 101 and the PM. Although Figures 3A and 3B show power capability information signaling between the MP 101 and the PM, such signaling may also be exchanged between MP 101 and other neighboring MPs. Figures 3C and 3D show such a distributed scenario of power capability information exchanged

between the MP 101 and an MP 102 similar to that shown in Figures 3A and 3B.

[0045] According to the present invention, solicited (request/report-type) reporting and un-solicited reporting of power capability information 301, 303 by MPs can be sent as a piggy-backed IE on top of a Mesh unicast, multicast or broadcast management or control frame. Alternatively, the reporting of power capabilities can be sent as a separate Mesh unicast, multicast or broadcast management or control frame.

[0046] As an example of a Mesh management frame embodiment, the MP power capability information 301, 303 may be included as an additional IE in a Mesh ASSOCIATION frame or a Mesh AUTHENTICATION frame (e.g., frame exchanges with other MPs for the purpose of becoming part of the Mesh network). Alternatively, the power capability signaling information 301, 303 is included as an additional IE within a Mesh BEACON frame or a Mesh PROBE RESPONSE frame, which may also be used in exchanges for the purpose of discovering the presence of a Mesh network or synchronizing general Mesh parameters such as timer values. Another alternative is to include the power capability information 301, 303 as an IE in an Association or Re-Association Response frame. Another alternative is to include the power capability information 301, 303 as part of a directed special purpose per-link or multi-hop Mesh POWER CAPABILITY frame.

[0047] Figures 4A and 4B show a signaling diagram by which an MP learns of allowed power settings for the Mesh, which is useful for dealing with the regulatory need for MPs not to exceed certain maximum admissible power settings during communication. The allowed power setting information preferably includes (but is not limited to) any of the items as shown in Table 2, including any combination thereof.

Table 2 – Allowed Power Setting Information

<i>Type</i>	<i>Description</i>
PM Info	PM address or PM identifier
Mode	Regulatory domain within which the Mesh network currently operates (e.g., 802.11b, g, n, j, etc.)
Freq. Bands	frequency bands and sub-bands within which the Mesh network currently operates

Tx Power	minimum, instantaneous, and maximum allowed Tx power settings
Rx Power	minimum, instantaneous, and maximum allowed Rx power settings
CCA	minimum, instantaneous, and maximum allowed CCA threshold settings
Timing	validity timers or time-out values
Measurement	measurement intervals and configuration
Timing	validity timers or time-out values
Silence	silence periods
Offset	temporary offset values for any of the above plus associated life-time values

[0048] A master-slave scenario is depicted in Figures 4A and 4B, in which a slave MP 101 obtains this information from the master PM. In Figure 4A, MP 101 obtains its allowed power setting information 401 from the PM in an unsolicited manner, such as part of a broadcast/multicast-type frame for example. In Figure 4B, MP1 obtains its allowed power setting information 403 in a solicited manner as a response-type frame in response to a power capability request 402 (e.g., the exchanged signals 402, 403 may be in the form of a directed unicast request/response-type frame exchange between the MP 101 and the PM. Although Figures 4A and 4B show allowed power setting information signaling between MP101 and the PM, such signaling may also be exchanged similarly in a distributed scenario between the MP 101 and other neighboring MPs. Figures 4C and 4D show such a distributed scenario of power capability information exchanged between the MP 101 and an MP 102 similar to that shown in Figures 4A and 4B.

[0049] According to the present invention, solicited (request/report-type) and un-solicited receiving of allowed power setting information 401, 403 can be sent as a piggy-backed IE on top of a Mesh unicast, multicast or broadcast management or control frame. Alternatively, the allowed power setting information 401, 403 can be sent as a separate Mesh unicast, multicast or broadcast management or control frame.

[0050] As an example of a Mesh management frame embodiment, the signaling of allowed power setting information 401, 403 in the Mesh may be

included as part of a Mesh BEACON frame or a Mesh PROBE RESPONSE frames (e.g. signaling frames and exchanges for the purpose of discovering the presence of a Mesh network or synchronizing general Mesh parameters such as timer values). Alternatively, the MP power allowed power setting information 401, 403 is part of Mesh ASSOCIATION or Mesh AUTHENTICATION frames (e.g. frame exchanges with other MPs for the purpose of becoming part of the Mesh network). In another alternative, the allowed power setting information is part of a directed special purpose per-link or multi-hop Mesh ALLOWED POWER SETTING frame.

[0051] Allowed power setting information 401, 403 can be signaled for any of the following, either alone or in combination: the entire Mesh (e.g. valid for all nodes in the Mesh); a particular Mesh link or path (e.g. valid for a set of Mesh nodes); a particular Mesh node (e.g. valid for all radio channels of a MP); a particular radio interface of a Mesh node (e.g. settable per-link and per-neighbor of a MP).

[0052] Allowed power setting information 401, 403 can be signaled as absolute values, relative values relating to some pre-determined absolute value, or a combination of absolute and relative values (e.g. max admissible Tx power = regulatory max – temporary offset).

[0053] Turning to Figure 5, a distributed scenario is now described in reference to an MP 501, in which there is no PM and it is possible that the MP 501 receives different allowed power setting information from two or more MPs, shown as an MP 502 and an MP 503. With no PM in the distributed scenario, the MP 501 needs to determine which allowed power setting information it will use when setting its own Tx power settings and when signaling its allowed power setting information to the other MPs, MP 502 and MP 503. The signaling procedure shown in Figure 5 resolves a situation in which the MP 501 determines which allowed power setting information to use while resolving a conflict with mismatched allowed power setting information received from other MPs.

[0054] The MP 501 configures its own allowed power setting information APSI_{own}, while receiving APSI_i which represents the allowed power setting

information signaled from MP_i with index $i = 2$ and 3 for the example shown in Figure 5. The APSI_i values can be further represented by a vector APSI_vector, which represents the ensemble of the APSI_i values MP 501 receives from the other MPs.

[0055] An example of an allowed power setting information IE includes a Maximum Allowed Tx Power Setting (MATPS). For the sake of simplicity, the following method illustration includes only the MATPS IE. From a set of inputs MATPS_own 504 and MATPS_vector values 505, 506, the MP 501 needs to determine which MATPS will be used when setting its own Tx Power settings and when signaling allowed power setting information to other MPs. This can be achieved by implementing a decision-making function F in MP 501.

[0056] For example, assume MP 501 receives MATPS_vector which comprises two vector value settings 505, 506: MATPS₁ = 20 dBm from MP 502 and MATPS₂ = 10 dBm from MP 503. Also assume that MP 501's own MATPS setting is configured to be MATPS_own = 15 dBm. In the preferred implementation, the function F will determine the minimum MATPS value from all its inputs (i.e., $\min(10, 20, 15) = 10$ dBm) and the MP 501 will use an operational MATPS value when setting its Tx Power and it will signal it as part of the allowed power setting information that the MP 501 signals to other MPs, including MP1 and MP2. Accordingly, the operational MATPS 507 in terms of function F can be expressed as follows:

$$\begin{aligned} \text{MATPS}_{\text{operational}} &= F(\text{MATPS}_{\text{own}}, \text{MATPS}_{\text{vector}}) \text{ Equation (1)} \\ &= \min(\text{MATPS}_{\text{own}}, \text{MATPS}_{\text{vector}}) . \end{aligned}$$

Similarly, other operational power settings can be selected using a suitable function F .

[0057] In an alternative embodiment, the MP 501 uses the value MATPS_operational determined by Equation(1) while determining its Tx Power, but MP 501 signals the MATPS_own value as its allowed power setting information to the other MPs, MP502 and MP503.

[0058] Figure 6 shows a signaling method for an MP601 entering a Mesh 600 in which the Tx Power is adjusted to meet regulatory requirements. While

the Tx Power setting adjustment is described in reference to MP601, the same Tx Power setting adjustment procedure applies to each MP in the Mesh 600. The Tx power can be similarly controlled for a subset of MPs. The Mesh 600 comprises MP602–MPN at the time that the MP601 seeks entry. One or more of the MPs MP602–MPN may be a PM. At initial joining 610, at switch-on, MP601 sends its Tx Power capability information 611 to MP602–MPN as described above for Figures 3A–3D. As aforementioned, a preferred way to send the Tx power capability information is as part of ASSOCIATION or AUTHENTICATION (or Re-ASSOCIATION or Re-AUTHENTICATION) frames. The Tx Power Capability information 611 may be performed periodically or in a solicited or in an unsolicited manner. At step 612, the MP601 becomes part of the Mesh. The MP601 receives allowed power settings information 613 which is sent periodically in the Mesh or in an unsolicited manner or in a solicited manner by the Mesh neighbors MP602–MPN, during the process of discovery or joining the Mesh network. The allowed power setting information is exchanged as described above for Figures 4A–4D. As aforementioned, a preferred way of such signaling is to use Mesh BEACON or Mesh PROBE RESPONSE frames. At step 614, the MP601 reads the received allowed power settings information 613 and adjusts its Tx power settings. The MP601 may or may not acknowledge its Tx power setting adjustment to the other MPs MP602–MPN.

[0059] The MP601 sends its own allowed power setting information 615 to MP602–MPN. Likewise, the MP601 receives Tx Power setting changes from MP602–MPN, triggered by changes in their Tx Power settings. Several optional and complementary signaling extensions are possible (not shown in Figure 6) to support adjustment of power settings in the Mesh. For example, the MP601 can request reporting of measurements from its MP neighbors MP602–MPN regarding power settings, perceived SNR and link margin values, perceived interference power and channel busy times.

[0060] According to the present invention, a selection procedure is performed by the Mesh MPs for negotiating and selecting a Mesh PM. The preferred PM selection and re-selection procedure includes one or more of the following:

- a) The first MP to belong in the Mesh automatically becomes PM.
- b) An MP at switch-on determines if one of its neighbors is a PM. The PM can be identified by means of L2 or L3 broadcast, multicast or dedicated signaling received by the MP as part of the set-up procedures, (e.g. authentication, Mesh BEACON reception, capability exchanges and so on).
- c) The PM can be pre-set, (i.e. fixed for the lifetime of the Mesh) or time-limited, (i.e., after a certain pre-determined amount of time or tied to the occurrence of certain conditions, the PM selection procedure is re-initiated)
- d) In one advantageous realization, the PM coincides with the Mesh Portal and Mesh Portal identifiers therefore automatically point to the PM.
- e) The MPs with the most links to neighbors becomes the PM.
- f) The MPs determine the PM by means of a random number draw.
- g) The MPs determine the PM as a function of the number of hops from the Mesh Portal or from a certain agreed-upon MP.
- h) Any combination of the above.

[0061] Figure 7 shows a signaling diagram for identifying the Mesh PM according to the preferred methods described above. A PM Request Information Element (IE) is included as part of a broadcast/multicast/unicast signaling frame in signal 711 sent through the Mesh by MP 701 indicating to neighbor MPs MP702-MPN that a PM selection is required. This IE contains the address of the originating MP and other parameters, such as time-out values, selection criteria, default identifier for the proposed PM, reply-to address, and so on. A PM Response IE part of a broadcast/multicast/unicast signaling frame in signals 712 is sent through the Mesh containing the selection criteria response from the neighbor MPs MP702-MPN. A comparison procedure 713 is initiated in the MP701 where the selection criteria responses 712₁...712_N from the different neighbor MPs are evaluated. The PM selection decision is made based on which MP meets the requirements in terms of the chosen selection criteria, (e.g., highest random number draw or similar). The MP 701 broadcasts its final selection for PM to the Mesh in signal 713.

[0062] Alternatively, the MP 701 acts as the Mesh Portal and sets all of the Tx Power control settings for the Mesh and subsequently joining MPs are mandated to propagate these Tx Power control settings to other Mesh MPs.

[0063] The signaling messages and information exchanged between MPs or between MPs and the PM for the above described methods are preferably implemented as Layer L2 (e.g. MAC layer) signaling frames or IEs. As such, the physical implementation is a processor entity within each MP, such as MP101 MP102 and the PM shown in Figures 3A-3D, 4A-4D; MP 501, MP502, MP503 as shown in Figure 5; MP601, MP602-MPN as shown in Figure 6; and MP701, MP702-MPN as shown in Figure 7. The processor entity may include for example, Layer L2 hardware or software in medium access control (MAC) or station management entity (SME). The layer L2 software, for example may be part of operation and maintenance (O&M) routines in MPs; or a combination thereof. Alternatively, the signaling is implemented as Layer L3 or above signaling packets or IEs, (e.g. encapsulated into IP packets, or into TCP/IP packets and so on). As such, the physical implementation would include Layer L3 hardware or software, such as IP or simple network management protocol (SNMP) entities. Another alternative includes a combination of Layer L2 and L3 signaling thereof.

[0064] All signaling messages and information exchanged as aforementioned can be either direct-link (e.g., MP-MP signaling frames) or multi-hop frame signaling (e.g., MP sending a message to another MP via intermediate forwarding MPs). Furthermore, signaling can take place between MPs and other nodes in the wired backhaul.

[0065] All methods described above can be subject to or are complemented by configuration settings in the individual MPs and can provide statistics and feedback to Mesh-internal or external network monitoring and control entities (e.g., using remote IT administrator network monitoring software) that can exercise control on MPs operational characteristics. These configuration settings and reportable statistics can be set in or reported from individual (or groups) of MPs by any of the following formats or a combination thereof:

- a) databases in the physical layer (PHY), medium access control (MAC) or system management entity (SME), advantageously realized (but not limited to) in the form of management information bases (MIBs);
- b) signaling messages between L2 MAC or SME to above protocol entities, advantageously realized in the form of APIs; or
- c) primitives exchanged between SME, MAC, PHY and other protocol entities in a MP implementation.

[0066] The above described configuration settings that can be used by external management entities on the MP (or groups of MPs) can contain any of the following:

- a) Admissible Tx, Rx and CCA value setting and ranges;
- b) Admissible mode settings (e.g. 11a,b,g,j,n and so on);
- c) Admissible band and sub-band settings (e.g. 2.4, 4.9, 5 GHz, U-NII lower, middle and upper band and so on);
- d) Mesh TPC feature on or off;
- e) Addresses and identifiers for PM;
- f) Timer values (e.g. channel dwell and measurement intervals) for TPC;
- g) Transmit Power change command for the MP; or
- h) Any combination thereof.

[0067] Reportable statistics in the MP that can be used by external management entities may include, but is not limited to any of the following, or a combination thereof:

- a) Current Tx power control settings, modes, bandwidth, number of simultaneous channels (or combination thereof) of MP and neighbor MPs (as far as known); or
- b) Channel statistics such as the value and type of measurements performed and so on.

EMBODIMENTS

1. A method for controlling transmit and receive power level of a mesh point (MP) operating in a mesh wireless communication network, the mesh network including a plurality of MPs, the method comprising:

a first MP adjusting its power level in accordance with a received allowed power setting information.

2. The method of embodiment 1 wherein the allowed power setting information is set by a second MP in the mesh network.

3. The method of embodiment 2 wherein the second MP is a mesh access point.

4. A method as in any of embodiments 1-3, further comprising:
sending power capability information of the first MP to at least one MP in the mesh network.

5. A method as in any of embodiments 2-4 where the first MP is entering the mesh, further comprising:

the second MP accepting the first MP as a member of the mesh network.

6. A method as in any of embodiments 4-5, wherein the first MP reports its power capability information by at least one of broadcasting, multicasting and unicasting in either a solicited or un-solicited manner.

7. A method as in any of embodiments 4-6, wherein the first MP reports its power capability information with a Mesh ASSOCIATION or a Mesh AUTHENTICATION frame.

8. A method as in any of embodiments 4-7, wherein the new MP reports its power capability information as part of a Mesh BEACON frame or a Mesh PROBE RESPONSE frame.

9. A method as in any of embodiments 4-8, wherein the power capability information is part of directed special purpose per-link or multi-hop Mesh POWER CAPABILITY frames.

10. A method as in any of embodiments 4-9, wherein the power capability information includes at least one of the following: a minimum and maximum transmit power and adjustment step size settings that the new MP supports; a minimum and maximum receive power and adjustment step size settings, sensitivity levels and CCA thresholds settings that the new MP supports; the modes that the new MP supports; and the operational bandwidth that the MP supports; and the number of bands and sub-bands that the new MP is capable of operating on simultaneously.

11. A method as in any of embodiments 1-10, wherein the first MP obtains the allowed power setting information from other MPs by at least one of broadcasting, multicasting and unicasting either solicited or un-solicited manner.

12. A method as in any of embodiments 1-11, wherein the allowed power setting information is included in a Mesh BEACON frame or Mesh PROBE RESPONSE frame.

13. A method as in any of embodiments 1-12, wherein the allowed power setting information is included in a Mesh ASSOCIATION or Mesh AUTHENTICATION frame.

14. A method as in any of embodiments 1-13, wherein the allowed power setting information is included in a special purpose per-link or multi-hop Mesh ALLOWED POWER SETTING frame.

15. A method as in any of embodiments 1-14, wherein the allowed power setting information includes at least one of the following: power master (PM) address or PM identifier; regulatory domain the mesh network currently operates in; frequency bands and sub-bands the mesh network currently operates in; minimum, instantaneous and maximum transmit power allowed

settings; minimum, instantaneous and maximum receive power allowed settings; minimum, instantaneous and maximum CCA threshold allowed settings; validity timers or time-out values; measurement intervals and configuration; silence periods; and temporary offset values for any of the above plus associated life-time values.

16. A method as in any of embodiments 1-15, wherein the allowed power setting information is signalled for at least one of the entire mesh network, a particular mesh link or path, and a particular mesh node or a particular radio interface of a mesh node.

17. A method as in any of embodiments 1-16, wherein the allowed power setting information is signalled by at least one of absolute values, relative values and a combination of absolute and relative values.

18. A method as in any of embodiments 2-17, wherein the first MP and the second MP establish a peer-to-peer relationship.

19. A method as in any of embodiments 2-18, wherein the first MP and the second MP establish a master-slave relationship.

20. A method as in any of embodiments 2-19, wherein the first MP and the second MP periodically receives updated allowed power setting information from other MPs.

21. A method as in any of embodiments 1-20, wherein the first MP requests reporting of measurements from neighboring MPs regarding at least one of power settings, perceived signal-to-noise ratio (SNR), link margin values, perceived interference power and channel busy times.

22. A method as in any of embodiments 1-21, wherein at least one MP is elected as a power master (PM) among the MPs.

23. The method as in embodiments 22, wherein an initial MP that is first to join the mesh network is automatically designated as the PM.

24. A method as in embodiment 22, wherein a predetermined MP becomes a PM and fixed for a predetermined time period.

25. A method as in embodiment 22, wherein a mesh portal of the mesh network automatically becomes the PM.

26. A method as in embodiment 22, wherein an MP with the most links to neighbor MPs becomes the PM.

27. A method as in embodiment 22, wherein the MPs in the mesh network determine the PM by means of a random number draw.

28. A method as in embodiment 22, wherein the MPs in the mesh network determine the PM as a function of the number of hops from a mesh portal or from a certain predetermined MP.

29. A method as in any of embodiments 22-28, wherein a new PM is elected each time a new MP joins by negotiation among the existing MPs and the new MP.

30. A method as in any of embodiments 22-29, wherein the PM is identified by means of layer 2 or layer 3 broadcast, multicast or dedicated signaling received as part of initial set-up procedures.

31. A method as in any of embodiments 2-29, wherein the second MP in the mesh network sets the allowed power setting and sends the allowed power setting information to subsequently joining MPs.

32. A method as in any of embodiments 1-31, wherein signaling messages and information exchanged between MPs is implemented by means of at least one of layer 2 signaling frames or information elements (IEs), and layer 3 or above signaling packets or IEs.

33. A method as in any of embodiments 2-32, wherein the second MP include one or more of the following: an immediate neighbor MP, another mesh nodes that the first MP can reach by other MPs, and other network entities beyond the immediate reach of the wireless mesh.

34. A method as in any of embodiments 1-33, wherein the transmitting and receiving messages between MPs are implemented by at least one of a direct-link, a multi-hop frame signaling and via a wired backhaul.

35. A method as in any of embodiments 1-34, wherein the exchange of messages between MPs is implemented by layer 2 hardware/software in medium access control (MAC) or station management entity (SME), above layer 2 software or combination thereof.

36. A method as in any of embodiments 1-35, wherein the MPs are subject to configuration settings set by an entity controlling the mesh network and the MPs report statistics and feedback to the controlling entity.

37. A method as in embodiment 36, wherein the configuration settings and reportable statistics set in and reported by at least one of databases in physical layer (PHY), MAC or SME; signaling messages between layer 2 MAC or SME to above protocol entities; and primitives exchanged between SME, MAC, PHY and other protocol entities in a MP.

38. A method as in any of embodiments 36-37, wherein the configuration settings includes at least one of admissible transmit, receive and CCA value setting and ranges; admissible mode settings; admissible band and

sub-band settings; mesh transmit power control (TPC) feature on or off; addresses and identifiers for PM; timer values; for TPC; and transmit power change command for the MP.

39. The method of embodiment 36 wherein the reportable statistics include at least one of current TPC settings, modes, bandwidth, number of simultaneous channels of the MP and neighbor MPs; and channel statistics.

40. A mesh point (MP) in a network of mesh points in wireless communication, comprising:

a processor configured to adjust its power level in accordance with allowed power setting information received from another MP in the network.

41. The MP of embodiment 40, wherein the processor is further configured to send its own power capability information to at least one existing MP in the mesh network.

42. A mesh point as in any of embodiments 40-41, wherein each MP reports its power capability information by one of broadcasting, multicasting and unicasting either solicited or un-solicited manner.

43. A mesh point as in any of embodiments 40-42, wherein each MP reports its power capability information with a Mesh ASSOCIATION or Mesh AUTHENTICATION frame.

44. A mesh point as in any of embodiments 40-43, wherein each MP reports its power capability information as part of the Mesh BEACON frames or the Mesh PROBE RESPONSE frames.

45. A mesh point as in any of embodiments 40-44, wherein the power capability information is part of directed special purpose per-link or multi-hop Mesh POWER CAPABILITY frames.

46. A mesh point as in any of embodiments 40-45, wherein the power capability information includes at least one of a minimum and maximum transmit power and adjustment step size settings that the MP supports; a minimum and maximum receive power and adjustment step size settings, sensitivity levels and CCA thresholds settings that the MP supports; the modes that the MP supports; the operational bandwidth that the MP supports; and the number of bands and sub-bands that the MP is capable of operating on simultaneously.

47. A mesh point as in any of embodiments 40-46, wherein each MP obtains the allowed power setting information from the MP by at least one of broadcasting, multicasting and unicasting in either a solicited or un-solicited manner.

48. A mesh point as in any of embodiments 40-47, wherein the allowed power setting information is included in a Mesh BEACON frame or Mesh PROBE RESPONSE frame.

49. A mesh point as in any of embodiments 40-48, wherein the allowed power setting information is included in a Mesh ASSOCIATION or Mesh AUTHENTICATION frame.

50. A mesh point as in any of embodiments 40-49, wherein the allowed power setting information is included in a special purpose per-link or multi-hop Mesh ALLOWED POWER SETTING frame.

51. A mesh point as in any of embodiments 40-50, wherein the allowed power setting information includes at least one of: power master (PM) address or

PM identifier; regulatory domain the mesh point currently operates in; frequency bands and sub-bands the mesh point currently operates in; minimum, instantaneous and maximum transmit power allowed settings; minimum, instantaneous and maximum receive power allowed settings; minimum, instantaneous and maximum CCA threshold allowed settings; validity timers or time-out values; measurement intervals and configuration; silence periods; and temporary offset values for any of the above plus associated life-time values.

52. A mesh point as in any of embodiments 40-51, wherein the allowed power setting information is signaled for at least one of: the entire mesh network, a particular mesh link or path, a particular mesh node and a particular radio interface of a mesh node.

53. A mesh point as in any of embodiments 40-52, wherein the allowed power setting information is signaled as one of an absolute value, a relative value, or a combination thereof.

54. A mesh point as in any of embodiments 40-53, wherein the processor establishes a peer-to-peer relationship between the MP and another network MP.

55. A mesh point as in any of embodiments 40-54, wherein the processor establishes a master-slave relationship between the MP and another network MP.

56. A mesh point as in any of embodiments 40-55, wherein the MP periodically receives updated allowed power setting information from other MPs.

57. A mesh point as in any of embodiments 40-56, wherein each MP requests reporting of measurements from neighboring MPs regarding at least one of power settings, perceived signal-to-noise ratio (SNR), link margin values, perceived interference power and channel busy times.

58. A mesh point as in any of embodiments 40-57, wherein the allowed power setting information is sent to subsequently joining MPs.

59. A mesh point as in any of embodiments 40-58, wherein signaling messages and information exchanged between MPs is implemented by means of at least one of layer 2 signaling frames or information elements (IEs), layer 3 or above signaling packets or IEs.

60. A mesh point as in any of embodiments 40-59, wherein the transmitting and receiving messages between MPs are implemented by at least one of a direct-link, a multi-hop frame signaling and via a wired backhaul.

61. A mesh point as in any of embodiments 40-60, wherein the exchange of messages between MPs is implemented by layer 2 hardware/software in medium access control (MAC) or station management entity (SME), above layer 2 software or combination thereof.

62. A mesh point as in any of embodiments 40-61, wherein the MPs are subject to configuration settings set by an entity controlling the mesh network and the MPs report statistics and feedback to the controlling entity.

63. A mesh point as in any of embodiments 40-62, wherein the configuration settings and reportable statistics set in and reported by at least one of databases in physical layer (PHY), MAC or SME; signaling messages between layer 2 MAC or SME to above protocol entities; and primitives exchanged between SME, MAC, PHY and other protocol entities in a MP.

64. A mesh point as in any of embodiments 40-63, wherein the configuration settings includes at least one of: admissible transmit, receive and CCA value setting and ranges; admissible mode settings; admissible band and sub-band settings; mesh transmit power control (TPC) feature on or off;

addresses and identifiers for the PM; timer values for TPC; and transmit power change command for the MP.

65. A mesh point as in any of embodiments 40-64, wherein the reportable statistics include at least one of current TPC settings, modes, bandwidth, number of simultaneous channels of the MP and neighbor MPs; and channel statistics.

66. In a mesh network of mesh points, a mesh point (MP) comprising:
a processor configured to send a power master request information element to neighboring MPs to indicate that a power maser (PM) selection for the mesh network is required and to receive power master response information elements from the network MPs and to select a PM according to a comparison procedure that evaluates selection criteria received in the power master response information elements.

67. A mesh point as in embodiment 66 wherein the PM is identified by means of layer 2 or layer 3 broadcast, multicast or dedicated signaling received as part of an initial set-up procedure.

68. A mesh point as in any of embodiments 66-67, wherein a new PM is selected each time a new MP joins by negotiation among the existing MPs and the new MP.

69. A mesh point as in any of embodiments 66-68, wherein a first MP to belong to the mesh network is selected as the PM.

70. A mesh point as in any of embodiments 66-68, wherein a predetermined MP is selected as the PM and fixed for a predetermined time period.

71. A mesh point as in any of embodiments 66-68 wherein the processor selects its MP as a mesh portal for the mesh network, and sets all transmit power control settings for the Mesh network accordingly, and mandates all subsequently joining MPs to propagate these settings to other mesh network MPs.

72. A mesh point as in any of embodiments 66-68 wherein the processor selects an MP with the most links to neighbor MPs as the PM.

73. A mesh point as in any of embodiments 66-68 wherein the processor determines the PM by means of a random number draw.

74. A mesh point as in any of embodiments 66-68 wherein the processor determines the PM as a function of the number of hops from a mesh portal or from a certain predetermined MP.

* * *

CLAIMS

What is claimed is:

1. A method for controlling transmit and receive power level of a mesh point (MP) operating in a mesh wireless communication network, the mesh network including a plurality of MPs, the method comprising:

sending power capability information of a new MP to at least one existing MP in the mesh network;

the existing MP accepting the new MP as a member of the mesh network and sending allowed power setting information to the new MP; and,

the new MP adjusting its power level in accordance with the allowed power setting information.

2. The method of claim 1 wherein the new MP reports its power capability information by at least one of broadcasting, multicasting and unicasting in either a solicited or un-solicited manner.

3. The method of claim 1 wherein the new MP reports its power capability information with a Mesh ASSOCIATION or Mesh AUTHENTICATION frame.

4. The method of claim 1 wherein the new MP reports its power capability information as part of the Mesh BEACON frames or the Mesh PROBE RESPONSE frames.

5. The method of claim 1 wherein the power capability information is part of directed special purpose per-link or multi-hop Mesh POWER CAPABILITY frames.

6. The method of claim 1 wherein the power capability information includes at least one of a minimum and maximum transmit power and

adjustment step size settings that the new MP supports; a minimum and maximum receive power and adjustment step size settings, sensitivity levels and CCA thresholds settings that the new MP supports; the modes that the new MP supports; and the operational bandwidth that the MP supports; and the number of bands and sub-bands that the new MP is capable of operating on simultaneously.

7. The method of claim 1 wherein the new MP obtains the allowed power setting information from other MPs by at least one of broadcasting, multicasting and unicasting either solicited or un-solicited manner.

8. The method of claim 1 wherein the allowed power setting information is included in a Mesh BEACON frame or Mesh PROBE RESPONSE frame.

9. The method of claim 1 wherein the allowed power setting information is included in a Mesh ASSOCIATION or Mesh AUTHENTICATION frame.

10. The method of claim 1 wherein the allowed power setting information is included in a special purpose per-link or multi-hop Mesh ALLOWED POWER SETTING frame.

11. The method of claim 1 wherein the allowed power setting information includes at least one of power master (PM) address or PM identifier; regulatory domain the mesh network currently operates in; frequency bands and sub-bands the mesh network currently operates in; minimum, instantaneous and maximum transmit power allowed settings; minimum, instantaneous and maximum receive power allowed settings; minimum, instantaneous and maximum CCA threshold allowed settings; validity timers or time-out values; measurement intervals and configuration; silence periods; and temporary offset values for any of the above plus associated life-time values.

12. The method of claim 1 wherein the allowed power setting information is signalled for at least one of the entire mesh network, a particular mesh link or path, and a particular mesh node or a particular radio interface of a mesh node.

13. The method of claim 1 wherein the allowed power setting information is signalled by at least one of absolute values, relative values and a combination of absolute and relative values.

14. The method of claim 1 wherein the new MP and the existing MP establish a peer-to-peer relationship.

15. The method of claim 1 wherein the new MP and the existing MP establish a master-slave relationship.

16. The method of claim 1 wherein the new MP and the existing MP periodically receives updated allowed power setting information from other MPs.

17. The method of claim 16 wherein each MP requests reporting of measurements from neighboring MPs regarding at least one of power settings, perceived signal-to-noise ratio (SNR), link margin values, perceived interference power and channel busy times.

18. The method of claim 1 wherein at least one MP is elected as a power master (PM) among the MPs.

19. The method of claim 18 wherein a first MP in the mesh network automatically becomes the PM.

20. The method of claim 18 wherein a new PM is elected each time a new MP joins by negotiation among the existing MPs and the new MP.

21. The method of claim 20 wherein the PM is identified by means of layer 2 or layer 3 broadcast, multicast or dedicated signaling received as part of initial set-up procedures.

22. The method of claim 18 wherein a predetermined MP becomes a PM and fixed for a predetermined time period.

23. The method of claim 18 wherein a mesh portal of the mesh network automatically becomes the PM.

24. The method of claim 18 wherein a MP with the most links to neighbor MPs becomes the PM.

25. The method of claim 18 wherein the MPs in the mesh network determine the PM by means of a random number draw.

26. The method of claim 18 wherein the MPs in the mesh network determine the PM as a function of the number of hops from a mesh portal or from a certain predetermined MP.

27. The method of claim 1 wherein a first MP in the mesh network sets the allowed power setting and sends the allowed power setting information to subsequently joining MPs.

28. The method of claim 1 wherein signaling messages and information exchanged between MPs is implemented by means of at least one of layer 2 signaling frames or information elements (IEs), and layer 3 or above signaling packets or IEs.

29. The method of claim 1 wherein the existing MP includes immediate neighbor MPs, other mesh nodes that the new MP can reach by other MPs and other network entities beyond the immediate reach of the wireless mesh.

30. The method of claim 1 wherein the transmitting and receiving messages between MPs are implemented by at least one of a direct-link, a multi-hop frame signaling and via a wired backhaul.

31. The method of claim 1 wherein the exchange of messages between MPs is implemented by layer 2 hardware/software in medium access control (MAC) or station management entity (SME), above layer 2 software or combination thereof.

32. The method of claim 1 wherein the MPs are subject to configuration settings set by an entity controlling the mesh network and the MPs report statistics and feedback to the controlling entity.

33. The method of claim 32 wherein the configuration settings and reportable statistics set in and reported by at least one of databases in physical layer (PHY), MAC or SME; signaling messages between layer 2 MAC or SME to above protocol entities; and primitives exchanged between SME, MAC, PHY and other protocol entities in a MP.

34. The method of claim 32 wherein the configuration settings includes at least one of admissible transmit, receive and CCA value setting and ranges; admissible mode settings; admissible band and sub-band settings; mesh transmit power control (TPC) feature on or off; addresses and identifiers for PM; timer values; for TPC; and transmit power change command for the MP.

35. The method of claim 32 wherein the reportable statistics include at least one of current TPC settings, modes, bandwidth, number of simultaneous channels of the MP and neighbor MPs; and channel statistics.

36. A mesh point (MP) in a network of mesh points in wireless communication, comprising:

a processor configured to send its own power capability information to at least one existing MP in the mesh network, and to adjust its power level in accordance with allowed power setting information received from another MP in the network.

37. The mesh point of claim 36 wherein each MP reports its power capability information by one of broadcasting, multicasting and unicasting either solicited or un-solicited manner.

38. The mesh point of claim 36 wherein each MP reports its power capability information with a Mesh ASSOCIATION or Mesh AUTHENTICATION frame.

39. The mesh point of claim 36 wherein each MP reports its power capability information as part of the Mesh BEACON frames or the Mesh PROBE RESPONSE frames.

40. The mesh point of claim 36 wherein the power capability information is part of directed special purpose per-link or multi-hop Mesh POWER CAPABILITY frames.

41. The mesh point of claim 36 wherein the power capability information includes at least one of a minimum and maximum transmit power and adjustment step size settings that the MP supports; a minimum and maximum receive power and adjustment step size settings, sensitivity levels and CCA thresholds settings that the MP supports; the modes that the MP supports; the operational bandwidth that the MP supports; and the number of bands and sub-bands that the MP is capable of operating on simultaneously.

42. The mesh point of claim 36 wherein each MP obtains the allowed power setting information from the MP by at least one of broadcasting, multicasting and unicasting in either a solicited or un-solicited manner.

43. The mesh point of claim 36 wherein the allowed power setting information is included in a Mesh BEACON frame or Mesh PROBE RESPONSE frame.

44. The mesh point of claim 36 wherein the allowed power setting information is included in a Mesh ASSOCIATION or Mesh AUTHENTICATION frame.

45. The mesh point of claim 36 wherein the allowed power setting information is included in a special purpose per-link or multi-hop Mesh ALLOWED POWER SETTING frame.

46. The mesh point of claim 36 wherein the allowed power setting information includes at least one of: power master (PM) address or PM identifier; regulatory domain the mesh point currently operates in; frequency bands and sub-bands the mesh point currently operates in; minimum, instantaneous and maximum transmit power allowed settings; minimum, instantaneous and maximum receive power allowed settings; minimum, instantaneous and maximum CCA threshold allowed settings; validity timers or time-out values; measurement intervals and configuration; silence periods; and temporary offset values for any of the above plus associated life-time values.

47. The mesh point of claim 36 wherein the allowed power setting information is signaled for at least one of: the entire mesh network, a particular mesh link or path, a particular mesh node and a particular radio interface of a mesh node.

48. The mesh point of claim 36 wherein the allowed power setting information is signaled as one of an absolute value, a relative value, or a combination thereof.

49. The mesh point of claim 36 wherein the processor establishes a peer-to-peer relationship between the MP and another network MP.

50. The mesh point of claim 36 wherein the processor establishes a master-slave relationship between the MP and another network MP.

51. The mesh point of claim 36 wherein the MP periodically receives updated allowed power setting information from other MPs.

52. The mesh point of claim 51 wherein each MP requests reporting of measurements from neighboring MPs regarding at least one of power settings, perceived signal-to-noise ratio (SNR), link margin values, perceived interference power and channel busy times.

53. The mesh point of claim 36 wherein the allowed power setting information is sent to subsequently joining MPs.

54. The mesh point of claim 36 wherein signaling messages and information exchanged between MPs is implemented by means of at least one of layer 2 signaling frames or information elements (IEs), layer 3 or above signaling packets or IEs.

55. The mesh point of claim 36 wherein the transmitting and receiving messages between MPs are implemented by at least one of a direct-link, a multi-hop frame signaling and via a wired backhaul.

56. The mesh point of claim 36 wherein the exchange of messages between MPs is implemented by layer 2 hardware/software in medium access

control (MAC) or station management entity (SME), above layer 2 software or combination thereof.

57. The mesh point of claim 36 wherein the MPs are subject to configuration settings set by an entity controlling the mesh network and the MPs report statistics and feedback to the controlling entity.

58. The mesh point of claim 57 wherein the configuration settings and reportable statistics set in and reported by at least one of databases in physical layer (PHY), MAC or SME; signaling messages between layer 2 MAC or SME to above protocol entities; and primitives exchanged between SME, MAC, PHY and other protocol entities in a MP.

59. The mesh point of claim 57 wherein the configuration settings includes at least one of: admissible transmit, receive and CCA value setting and ranges; admissible mode settings; admissible band and sub-band settings; mesh transmit power control (TPC) feature on or off; addresses and identifiers for the PM; timer values for TPC; and transmit power change command for the MP.

60. The mesh point of claim 57 wherein the reportable statistics include at least one of current TPC settings, modes, bandwidth, number of simultaneous channels of the MP and neighbor MPs; and channel statistics.

61. In a mesh network of mesh points, a mesh point (MP) comprising:
a processor configured to send a power master request information element to neighboring MPs to indicate that a power master (PM) selection for the mesh network is required and to receive power master response information elements from the network MPs and to select a PM according to a comparison procedure that evaluates selection criteria received in the power master response information elements.

62. The mesh point of claim 61 wherein a first MP to belong to the mesh network is selected as the PM.

63. The mesh point of claim 61 wherein a new PM is selected each time a new MP joins by negotiation among the existing MPs and the new MP.

64. The mesh point of claim 61 wherein the PM is identified by means of layer 2 or layer 3 broadcast, multicast or dedicated signaling received as part of an initial set-up procedure.

65. The mesh point of claim 61 wherein a predetermined MP is selected as the PM and fixed for a predetermined time period.

66. The mesh point of claim 61 wherein the processor selects its MP as a mesh portal for the mesh network, and sets all transmit power control settings for the Mesh network accordingly, and mandates all subsequently joining MPs to propagate these settings to other mesh network MPs.

67. The mesh point of claim 61 wherein the processor selects an MP with the most links to neighbor MPs as the PM.

68. The mesh point of claim 61 wherein the processor determines the PM by means of a random number draw.

69. The mesh point of claim 61 wherein the processor determines the PM as a function of the number of hops from a mesh portal or from a certain predetermined MP.