

[0001] METHOD AND SYSTEM FOR AUTONOMOUS CHANNEL
COORDINATION FOR A WIRELESS DISTRIBUTION SYSTEM

[0002] FIELD OF INVENTION

[0003] The present invention is related to wireless communication systems. More particularly, the present invention is related to a method and system for autonomous channel coordination for a wireless distribution system (WDS).

[0004] BACKGROUND

[0005] In a WLAN system such as 802.11, stations (STAs) within a basic service set (BSS) share the same frequency channel to communicate with each other. In an infrastructure-mode BSS, an access point (AP) relays traffic to and from a distribution system (DS). Many BSSs can be connected to the DS through their APs. Communication between APs and other nodes within a DS can be supported by any medium access control (MAC) scheme, such as IEEE 802.3 in the case where a wired infrastructure exists. If a wired infrastructure does not exist, communication between APs can also take place wirelessly. A set of APs communicating wirelessly constitutes a WDS.

[0006] For successful communication between two APs in a WDS, the sending AP must transmit a packet on the channel used by the receiving AP. Generally, APs may choose the channel, (i.e., WDS channel), from a plurality of available channels to communicate with other APs. Typically, the WDS channel is same as the BSS channel used by an AP to transmit and receive packets to and from STAs in its own BSS. In the prior art, the WDS channel is configured manually by a system administrator and the APs are not capable of dynamically changing the WDS channel autonomously.

[0007] However, the manual configuration and setup is cumbersome, error-prone and costly. In addition, the most suitable WDS channel for communication within the WDS changes dynamically on a short-term basis

due to changes in interference and traffic conditions. It is not realistic to manually keep track of these changes and change the WDS channel.

[0008] Therefore, it would be desirable to provide a method and system for autonomously configuring the WDS channel while maintaining connectivity within the WDS.

[0009] SUMMARY

[0010] The present invention is related to a method and system for autonomous channel coordination for a WDS. A wireless communication system includes a plurality of APs and the APs communicate each other via a WDS. A coordinated channel group (CCG) comprising a plurality of member APs is established. The member APs of the CCG camp on a WDS channel used for the WDS among the member APs of the CCG. One AP among the member APs of the CCG is designated as a master AP. The master AP coordinates with other member APs of the CCG for selecting and configuring the WDS channel for the CCG and addition and deletion of member APs. By allowing APs to define a CCG, changes of the WDS channel are performed autonomously while maintaining connectivity within the WDS.

[0011] BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Figure 1 shows an exemplary wireless communication system with a WDS in which the present invention is implemented.

[0013] Figure 2 is a signaling diagram of a process for exchanging messages for joining a CCG between an AP and a master AP in accordance with the present invention.

[0014] Figure 3 is a signaling diagram of a process for exchanging messages for leaving a CCG between an AP and a master AP in accordance with the present invention.

[0015] Figure 4 is a signaling diagram of a process for exchanging messages for channel change between an AP and a master AP in accordance with the present invention.

[0016] Figure 5 is a signaling diagram of a process for exchanging messages for reselecting a master AP between an AP and a master AP in accordance with the present invention.

[0017] DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

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

[0019] The features of the present invention may be incorporated into an integrated circuit (IC) or be configured in a circuit comprising a multitude of interconnecting components.

[0020] Figure 1 shows an exemplary wireless communication system 100 with a WDS in which the present invention is implemented. The system 100 includes a plurality of APs 102a-102d. Each of the APs 102a-102d serves its own BSS 106a-106d, (or independent BSS, hereinafter collectively "BSS"), respectively. The APs 102a-102d are capable of sending WDS traffic via a WDS established among the APs 102a-102d. The WDS traffic may be a packet sent from an AP in one BSS to an AP in another BSS, or a packet sent from a STA in one BSS to a STA in another BSS. The APs 102a-102d camp on a WDS channel used for the WDS traffic so that the APs 102a-102d transmit and receive WDS traffic on the common WDS channel.

[0021] The APs 102a-102d may be equipped with a single radio transceiver, (i.e., the APs need to share their radio transceiver for both their own BSS traffic and WDS traffic), or more than one radio transceiver. The WDS channel that the APs 102a-102d camp on may be different from the channel used to serve STAs 104a-104d in their own BSS 106a-106d, (i.e., BSS channel). If the WDS channel is different from the BSS channel, the AP 102a-102d should be able to simultaneously receive packets on more than one

channel. An AP 102a-102d may be able to camp on more than one WDS channel.

[0022] In accordance with the present invention, at least one coordinated channel group (CCG) comprising a plurality of member APs is established. For example, in Figure 1, APs 102a-102c belong to a CCG 108 and a common WDS channel is used for the WDS traffic in the CCG 108. In accordance with the present invention, the WDS channel may be dynamically changed and configured by coordinating APs 102a-102c in the CCG 108. By being part of the CCG 108, the APs 102a-102c are ensured of maintaining connectivity with all other APs 102a-102c that belong to the CCG 108. Furthermore, the APs 102a-102c may be ensured of maintain connectivity with APs, (such as AP 102d), belonging to other CCGs if certain rules are followed in the assignment of CCGs to APs.

[0023] Certain APs may or may not have the capability of transmitting packets to other APs of the WDS on a frequency channel different from the one they are camping on. In order to maintain connectivity with other APs of the WDS, an AP not equipped with this capability should never create a new CCG unless it is the only AP being active in the environment. Similarly, the selection of the master of a CCG could be performed manually through operation, administration and maintenance (OAM). If this approach is selected, the APs not selected as CCG master in the OAM configuration should be precluded from attempting to create a new CCG (in which case they would automatically become master of the newly created CCG). An AP may be part of as many CCGs as the number of channels on which it is capable of camping.

[0024] One of the APs 102a-102c of the CCG 108 is designated as a master AP, (e.g., AP 102a). The master AP may be designated autonomously or by manually through OAM. The master AP 102a accepts or rejects requests from other non-member APs, (such as AP 102d), to be a part of the CCG 108, collects relevant information from the member APs 102b, 102c within the CCG 108 to make a WDS channel change decision, (including requests from

member APs 102b, 102c to perform a channel change), executes a WDS channel change, and executes changes of other parameters, (such as transmission power, a clear channel assessment (CCA) mode (or the like), admission control parameters or other relevant operational settings), that may affect the performance of the system. CCA is a function that determines if the medium is busy in IEEE 802.11. The CCA mode (or something similar in other types of systems) defines how this determination is made exactly, (e.g., compare to a threshold or not, nature of the signal, or the like).

[0025] An AP 102a-102c that is part of the CCG 108 for a given WDS channel periodically broadcasts, multicasts or unicasts a CCG indicator (CCGI) on the WDS channel. The CCGI is a unique identifier, (e.g., label, code, alpha-numeric designation, number, or the like). The CCGI may be included in an existing frame, (such as a beacon frame or a probe response frame), or a stand-alone (management) frame dedicated to the CCG functionality. The master AP 102a sets a master indicator, (e.g., a flag, a bit field or an identification string), associated to the CCGI to indicate that the AP 102a is the master of the CCG 108. Only the master AP 102a sets the master indicator.

[0026] Figure 2 is a signaling diagram of a process 200 for exchanging messages for joining a CCG between a non-member AP and a master AP in accordance with the present invention. A non-member AP, (such as AP 102d), desiring to join an existing CCG 108 sends a CCG addition request message to the master AP 102a along with capability information of the AP 102d and/or BSS information (step 202). The CCG addition request message includes the CCGI of the requested CCG 108.

[0027] The capability information includes, but is not limited to, the list of frequency channels on which the AP 102d is capable of camping and information as to whether the AP 102d is capable of reporting channel utilization or interference measurement. The BSS information is information related to the BSS served by the AP 102d, (e.g., whether or not the AP 102d is using the common channel to serve its own BSS, and, if yes, how many STAs

are currently served by the AP 102d).

[0028] The master AP 102a determines whether the non-member AP 102d should be accepted or not and responds to the non-member AP 102d with a CCG addition response message, which indicates a positive or negative response (step 204). If the non-member AP 102d receives a positive response, the AP 102d becomes a part of the CCG 108 and starts broadcasting the CCGI.

[0029] The criteria in determining whether the non-member AP 102d should be accepted in the CCG 108 include, but are not limited to, insufficient capabilities, (e.g., not being able to receive on certain channels), and the number of APs included in the CCG 108, (since if too many APs are included in the CCG 108, it may result in poor performance or unacceptable delays in changing the WDS channel of the CCG 108), or any other relevant factors. The master AP 102a may measure some factors by itself and those factors need not be directly communicated by the non-member AP 102d. For example, the master AP 102a may measure channel loading, interference, path loss between the non-member AP 102d and the master AP 102a or received signal strength from the non-member AP 102d, or the like.

[0030] The CCG addition request message may be included in any conventional frame, (e.g., a probe request message or an association request message), or may be included in a new stand-alone (management) frame. The CCG addition response message may also be included in any conventional frame, (e.g., a probe response frame or an association response frame), or may be included in a new stand-alone (management) frame.

[0031] Figure 3 is a signaling diagram of a process 300 for exchanging messages for leaving a CCG between an AP and a master AP in accordance with the present invention. A member AP, (such as AP 102b), desiring to leave the CCG 108 sends a CCG deletion notification message to the master AP 102a (step 302). Upon receipt of the CCG deletion notification message, the AP 102b no longer belongs to the CCG 108. The CCG deletion notification message may be included in any conventional frame, (e.g., a disassociation

message), or may be included in a new stand-alone (management) frame.

[0032] The member APs 102b, 102c of the CCG 108 preferably report measurements to the master AP 102a of the CCG 108. The measurements to be reported include not only measurements performed by the APs 102b, 102c, but also any measurements reported by STAs 104b, 104c served by their own BSSs 106b, 106c if the WDS channel is same to the BSS channel used within their own BSS 106b, 106c. Relevant measurements that may be reported by each member AP 102b, 102c in support of channel management within the CCG 108 include, but are not limited to, interference levels measured on each channel, channel utilization of each channel, the number of STAs detected on each channel, and addresses or identifiers of STAs 104b, 104c currently associated with the APs 102b, 102c. If the BSS channel of the AP 102b, 102c is same as the WDS channel, a member AP 102b, 102c may notify the master AP 102a of any relevant configuration modification, (such as the association or disassociation of a STA 104b, 104c served by the AP 102b, 102c).

[0033] Figure 4 is a signaling diagram of a process 400 for exchanging messages for change of the WDS channel between a member AP 102b, 102c and a master AP 102a in accordance with the present invention. A member AP 102b, 102c experiencing severe interference conditions on the currently selected WDS channel may send a channel change request message to the master AP 102a for a change of the WDS channel (step 402). The channel change request message may include an order of preference for a new channel, as well as any measurement information relevant for selecting a new WDS channel.

[0034] Upon receipt of the channel change request message, the master AP 102a may optionally respond the requesting AP 102b, 102c with a channel change response message indicating an accept or a reject of the request (step 404). The master AP 102a then determines whether a change of the WDS channel is necessary (step 406). Alternatively, the channel change may be initiated by the master AP 102a without receiving the channel change request message. If the master AP 102a determines that the change of the WDS

channel is necessary, the master AP 102a sends all member APs 102b, 102c of the CCG 108 a channel change command to change the WDS channel to a new channel (step 412).

[0035] The channel change command includes timing information on which the channel change is executed. With respect to the timing of the channel change, for those member APs that use the same channel for the WDS traffic and BSS traffic on their BSSs, the master AP 102a may consider additional time so that these APs notify the STAs of their BSSs of the channel change. The master AP 102a may determine the additional time based on the number of STAs associated with these APs.

[0036] Alternatively, the master AP 102a may send, (i.e., broadcast, multicast or unicast), a channel change prepare request message to all member APs 102b, 102c to inform the member APs 102b, 102c of the new WDS channel to which the master AP 102a intends to switch (step 408). Each member AP 102b, 102c then responds with a channel change prepare response message indicating the delay necessary for them to notify their STAs 104b, 104c of the channel change (step 410). Based on the responses from the member APs 102b, 102c, the master AP 102a determines the time at which the channel change will take place, (presumably using the highest delay reported by one of the member APs 102b, 102c), and signals this time with the channel change command at step 410.

[0037] An AP may create a new CCG. The AP that wants to create a new CCG selects a CCGI that is not used by any other CCG of the WDS. The AP first scans all frequency channels on which it is capable of receiving to detect all CCGIs in use in the WDS. To reduce the probability that the same CCGI is accidentally reused, the CCGI may be randomly selected within a predetermined range. After selection of the CCGI of the new CCG, the AP becomes the master of the newly created CCG and starts broadcasting the CCGI with the master indicator set.

[0038] Where two or more CCGs are setup, an AP may select a CCG to join an available CCGs. The selection of a CCG to which an AP attempts to

join may be performed autonomously by an AP, or may be manually configured through an operation and maintenance (OAM). The manual selection would be desirable in case there is a small number of APs in the WDS and it is expected that based on traffic requirements and AP capabilities the best performance is achieved when the APs camp on the same WDS channel.

[0039] In selecting the CCG, an AP considers capabilities of the different APs. Certain APs may or may not have the capability of transmitting packets to other APs of the WDS on a channel other than the one on which they are camping. In order to maintain connectivity with other APs of the WDS, an AP not having with this capability should never create a new CCG unless it is the only AP that is active in the environment.

[0040] The master AP 102a may be manually or autonomously selected and reselected. If the master AP 102a is selected manually through OAM, the APs 102b, 102c not selected as a master AP 102a are precluded from creating a new CCG (in which case they would automatically become a master AP of the newly created CCG). In manual configuration, a centrally located AP may be selected as the master AP to ensure good connectivity with other APs.

[0041] By default, the AP that created the CCG becomes the master AP. A master AP reselection procedure may be triggered autonomously. For example, the master AP reselection procedure is triggered when the master AP is down, when the master AP desires leave the CCG, when the master AP has not transmitted anything for a predetermined period, when the master AP unsets its master indicator indicating that the master AP relinquishes mastership, or the like.

[0042] In addition, any member AP 102b, 102c may trigger the master AP reselection procedure. Figure 5 is a signaling diagram of a process 500 for exchanging messages for reselecting a new master AP between a member AP 102b, 102c and a current master AP 102a in accordance with the present invention. A member AP 102b, 102c sends a master AP reselection request message to the master AP 102a (step 502). Upon reception of the message, the

master AP 102a may optionally send a master AP reselection response message to the requesting AP 102b, 102c (step 504). The master AP 102a then unsets its master indicator to indicate all other member APs 102b, 102c that a master AP reselection procedure is triggered (step 506). A master AP reselection is then performed by the member APs 102b, 102c and the master AP 102a (step 508).

[0043] A new master AP may be selected by any appropriate means. For example, the new master AP may be selected by exchanging metrics associated with each of the APs in the CCG. For example, the metrics may be traffic volume or simply random numbers. The AP with the highest metric may be selected as a new master AP.

[0044] A signaling between the APs and the master AP may be realized as part of non-IEEE 802.11 protocol. For example, a generic network management protocol, such as simple network management protocol (SNMP) or extended markup language (XML) may be used to control, report and update operational parameters and settings affecting an AP's choice of the WDS channel and CCG. The parameters and settings are stored in an AP database such as a management information base (MIB). Each AP may contain a software, hardware or combined routine that on a regular or triggered basis checks for updates of the parameters and settings contained in the AP's database and adjusts the behavior of the APs accordingly. Alternatively, the software, hardware or combined routine in the AP on a regular or triggered basis checks for updates of the parameters and settings in a remote database relevant for a group of APs or all APs.

[0045] An L2 Ethertype or L3 control protocol may also be used to communicate signaling, bit fields and/or information elements. An AP may contain a software, hardware or combined communication routine that interfaces between the external L2 Ethertype or L3 control protocol carried over the IEEE 802.11-based WDS or BSS. This adjusts operational settings of the AP directly after receiving such a L2 Ethertype or L3 control protocol message. Alternatively, it may indirectly adjust by means of one or more

intermediary databases applicable to a single AP or a group of APs.

[0046] Embodiments.

[0047] 1. A method for autonomous channel coordination for the WDS in a wireless communication system including a plurality of APs wherein the APs communicate each other via a WDS.

[0048] 2. The method of embodiment 1 comprising the step of establishing a CCG comprising a plurality of member APs, the member APs of the CCG camping on a WDS channel used for the WDS among the member APs of the CCG.

[0049] 3. The method of embodiment 2 comprising the step of designating one AP among the member APs of the CCG as a master AP.

[0050] 4. The method of embodiment 3 comprising the step of the master AP coordinating with other member APs of the CCG for selecting and configuring the WDS channel for the CCG.

[0051] 5. The method as in any of the embodiments 2-4, wherein each member AP of the CCG broadcasts a CCGI on the WDS channel.

[0052] 6. The method of embodiment 5, wherein the CCGI is transmitted via one of a beacon frame and a probe response frame.

[0053] 7. The method of embodiment 5, wherein the CCGI is transmitted via a stand alone frame.

[0054] 8. The method as in any of the embodiments 3-7, wherein the master AP transmits a master indicator associated with the CCGI.

[0055] 9. The method as in any of the embodiments 3-8, further comprising the step of a non-member AP that desires to join the CCG sending a CCG addition request message to the master AP.

[0056] 10. The method of embodiment 9 comprising the step of the master AP determining whether or not accept the non-member AP.

[0057] 11. The method of embodiment 10 comprising the step of the master AP sending a CCG addition response message to the non-member AP, the CCG addition response message indicating an accept or a reject for the request.

- [0058] 12. The method as in any of the embodiments 9-11, wherein the CCG addition request message includes capability information of the non-member AP.
- [0059] 13. The method of embodiment 12, wherein the capability information includes at least one of a list of frequency channels that the non-member AP may support, information as to whether the non-member AP is capable of reporting channel utilization and interference measurement, and information related to a BSS served by the non-member AP.
- [0060] 14. The method as in any of the embodiments 9-13, wherein the CCG addition request message is included in one of a probe request message and an association request message.
- [0061] 15. The method as in any of the embodiments 11-14, wherein the CCG addition response message is included in one of a probe response message and an association response message.
- [0062] 16. The method as in any of the embodiments 10-15, wherein the master AP considers at least one of capabilities of the non-member AP and the number of APs included in the CCG in determining whether or not accept the non-member AP.
- [0063] 17. The method as in any of the embodiments 3-16, further comprising the step of a member AP that wants to leave the CCG sending a CCG deletion notification message to the master AP, whereby the member AP is withdrawn from the CCG.
- [0064] 18. The method of embodiment 17, wherein the CCG deletion notification message is included in a disassociation message.
- [0065] 19. The method as in any of the embodiments 3-18, further comprising the step of each member AP reporting measurements to the master AP, whereby the master AP selects and configures the WDS channel based on the reported measurements.
- [0066] 20. The method of embodiment 19, wherein the measurements include at least one of interference level measured on each channel, channel utilization of each channel, number of STAs detected on each channel, and

identities of STAs associated to each member AP.

[0067] 21. The method as in any of the embodiments 19-20, wherein the measurements include measurements reported by STAs associated to the member APs if the WDS channel is same to a BSS channel used within its own BSS of the member APs.

[0068] 22. The method as in any of the embodiments 3-21, further comprising the step of a member AP of the CCG sending a channel change request message to the master AP, whereby the master AP decides to change the WDS channel upon receipt of the channel change request message.

[0069] 23. The method of embodiment 22, wherein the channel change request message includes an order of preference for a new WDS channel.

[0070] 24. The method as in any of the embodiments 22-23, further comprising the step of the master AP sending a channel change response message to the requesting member AP in response to the channel change request message.

[0071] 25. The method as in any of the embodiments 22-24, further comprising the step of the master AP sending a channel change command to the member APs of the CCG if the master AP decides to change the WDS channel.

[0072] 26. The method as in any of the embodiments 2-25, further comprising the step of an AP creating a new CCG, the AP becoming a master AP of the new CCG.

[0073] 27. The method of embodiment 26, comprising the step of the AP selecting a CCGI for the new CCG.

[0074] 28. The method of embodiment 27, comprising the step of the AP periodically broadcasting the CCGI.

[0075] 29. The method as in any of the embodiments 27-28, wherein the AP randomly selects the CCGI within a predetermined range.

[0076] 30. The method as in any of the embodiments 27-29, wherein the AP scans all frequency channels before selecting the CCGI.

- [0077] 31. The method as in any of the embodiments 3-30, wherein the member APs notify the master AP of any configuration modification if a BSS channel of the member APs is same to the WDS channel.
- [0078] 32. The method as in any of the embodiments 3-31, further comprising the step of the master AP determining whether a WDS channel change is necessary.
- [0079] 33. The method of embodiment 32, comprising the step of the master AP sending a channel change command if the master AP decides to change the WDS channel.
- [0080] 34. The method of embodiment 33, further comprising the step of a member AP sending a channel change request message to the master AP, whereby the master AP determines whether the WDS channel change is necessary upon receiving the channel change request message.
- [0081] 35. The method of embodiment 34, wherein the channel change request message includes an order of preference for a new channel.
- [0082] 36. The method as in any of the embodiments 33-35, wherein the channel change command includes timing information on which the channel change is executed.
- [0083] 37. The method of embodiment 36, wherein the master AP considers additional time for member APs that use the same channel for the WDS traffic and BSS traffic on their BSSs so that said member APs notify the STAs of their BSSs of the channel change.
- [0084] 38. The method of embodiment 37, wherein the master AP determines the additional time based on the number of STAs associated to said member APs.
- [0085] 39. The method as in any of the embodiments 22-38, further comprising the step of the master AP sending a channel change prepare request message to said member APs to inform said member APs of the new WDS channel to which the master AP intends to switch.
- [0086] 40. The method of embodiment 39, comprising the step of each of said member APs responding with a channel change prepare response

message indicating a delay necessary to notify their STAs of the channel change.

[0087] 41. The method of embodiment 40, comprising the step of the master AP determining the additional time based on the delay indicated by said member APs.

[0088] 42. The method as in any of the embodiments 3-41, further comprising the step of triggering a master AP reselection procedure, whereby a new master AP of the CCG is selected.

[0089] 43. The method of embodiment 42, wherein the master AP reselection procedure is triggered at least one of when the master AP is down, when the master AP desires leave the CCG, when the master AP has not transmitted anything for a predetermined period and when the master AP unsets its master indicator indicating that the master AP relinquishes mastership.

[0090] 44. The method of embodiment 42, wherein the master AP reselection procedure is triggered by any member AP of the CCG sending a master AP reselection request message to the master AP.

[0091] 45. The method as in any of the embodiments 42-44, wherein the new master AP is selected by exchanging metrics associated with each of the APs in the CCG.

[0092] 46. The method of embodiment 45, wherein the metrics are one of traffic volume and random numbers.

[0093] 47. The method as in any of the embodiments 3-46, wherein a signaling between the APs and the master AP is performed by one of an SNMP, XML, L2 Ethertype protocol, and L3 control protocol.

[0094] 48. The method as in any of the embodiments 4-47, wherein operational parameters and settings affecting an AP's selection of the WDS channel and CCG are stored in an AP database, whereby each AP checks for updates of the parameters and settings contained in the AP's database and adjusts the behavior of the APs accordingly.

[0095] 49. The method as in any of the embodiments 4-47, wherein

operational parameters and settings affecting an AP's selection of the WDS channel and CCG are stored in a remote database, whereby each AP checks for updates of the parameters and settings contained in the remote database and adjusts the behavior of the APs accordingly.

[0096] 50. A system for autonomous channel coordination for a WDS in a wireless communication system including a plurality of APs wherein the APs communicate each other via a WDS.

[0097] 51. The system of embodiment 50 comprising a plurality of member APs configured to establish a CCG, the member APs camping on a WDS channel used for the WDS among the member APs of the CCG.

[0098] 52. The system of embodiment 51 comprising a master AP being designated among the member APs of the CCG, the master AP being configured to coordinate with other member APs of the CCG for selecting and configuring the WDS channel for the CCG.

[0099] 53. The system as in any of the embodiments 51-52, wherein each member AP of the CCG broadcasts a CCGI on the WDS channel.

[00100] 54. The system of embodiment 53, wherein the CCGI is transmitted via one of a beacon frame and a probe response frame.

[00101] 55. The system of embodiment 53, wherein the CCGI is transmitted via a stand alone frame.

[00102] 56. The system as in any of the embodiments 53-55, wherein the master AP transmits a master indicator associated with the CCGI.

[00103] 57. The system as in any of the embodiments 52-56, further comprising at least one non-member AP configured to send a CCG addition request message to the master AP to join the CCG, wherein the master AP determines whether or not accept the non-member AP and sends a CCG addition response message to the non-member AP indicating an accept or a reject for the request.

[00104] 58. The system of embodiment 57, wherein the CCG addition request message includes capability information of the non-member AP.

[00105] 59. The system of embodiment 58, wherein the capability

information includes at least one of a list of frequency channels that the non-member AP may support, information as to whether the non-member AP is capable of reporting channel utilization and interference measurement, and information related to a BSS served by the non-member AP.

[00106] 60. The system as in any of the embodiments 57-59, wherein the CCG addition request message is included in one of a probe request message and an association request message.

[00107] 61. The system as in any of the embodiments 57-60, wherein the CCG addition response message is included in one of a probe response message and an association response message.

[00108] 62. The system as in any of the embodiments 57-61, wherein the master AP considers at least one of capabilities of the non-member AP and the number of APs included in the CCG in determining whether or not accept the non-member AP.

[00109] 63. The system as in any of the embodiments 52-62, wherein a member AP that wants to leave the CCG sends a CCG deletion notification message to the master AP, whereby the member AP is withdrawn from the CCG.

[00110] 64. The system of embodiment 63, wherein the CCG deletion notification message is included in a disassociation message.

[00111] 65. The system as in any of the embodiments 52-64, wherein each member AP is configured to report measurements to the master AP, whereby the master AP selects and configures the WDS channel based on the reported measurements.

[00112] 66. The system of embodiment 65, wherein the measurements include at least one of interference level measured on each channel, channel utilization of each channel, number of STAs detected on each channel, and identities of STAs associated to each member AP.

[00113] 67. The system of embodiment 65, wherein the measurements include measurements reported by STAs associated to the member APs if the WDS channel is same to a BSS channel used within its own BSS of the

member APs.

[00114] 68. The system as in any of the embodiments 52-67, wherein the member AP is configured to send a channel change request message to the master AP, whereby the master AP decides to change the WDS channel upon receipt of the channel change request message.

[00115] 69. The system of embodiment 68, wherein the channel change request message includes an order of preference for a new WDS channel.

[00116] 70. The system as in any of the embodiments 68-69, wherein the master AP is configured to send a channel change response message to the member AP requested the channel change.

[00117] 71. The system as in any of the embodiments 68-70, wherein the master AP is configured to send a channel change command to the member APs of the CCG if the master AP decides to change the WDS channel.

[00118] 72. The system as in any of the embodiments 52-71, further comprising at least one AP configured to create a new CCG, by selecting a CCGI for the new CCG, becoming a master AP of the new CCG and periodically broadcasting the CCGI.

[00119] 73. The system of embodiment 72, wherein the AP randomly selects the CCGI within a predetermined range.

[00120] 74. The system of embodiment 72, wherein the AP scans all frequency channels before selecting the CCGI.

[00121] 75. The system as in any of the embodiments 72-74, wherein the member APs configured to notify the master AP of any configuration modification if a BSS channel of the member APs is same to the WDS channel.

[00122] 76. The system as in any of the embodiments 52-75, wherein the master AP is configured to determine whether a WDS channel change is necessary and send a channel change command if the master AP decides to change the WDS channel.

[00123] 77. The system as in any of the embodiments 52-76, wherein

the member AP is configured to send a channel change request message to the master AP, whereby the master AP determines whether the WDS channel change is necessary upon receiving the channel change request message.

[00124] 78. The system of embodiment 77, wherein the channel change request message includes an order of preference for a new channel.

[00125] 79. The system as in any of the embodiments 76-78, wherein the channel change command includes timing information on which the channel change is executed.

[00126] 80. The system of embodiment 79, wherein the master AP is configured to consider additional time for member APs that use the same channel for the WDS traffic and BSS traffic on their BSSs so that said member APs notify the STAs of their BSSs of the channel change.

[00127] 81. The system of embodiment 80, wherein the master AP is configured to determine the additional time based on the number of STAs associated to said member APs.

[00128] 82. The system as in any of the embodiments 76-81, wherein the master AP is configured to send a channel change prepare request message to said member APs to inform said member APs of the new WDS channel to which the master AP intends to switch.

[00129] 83. The system of embodiment 82, wherein each of said member APs is configured to respond with a channel change prepare response message indicating a delay necessary to notify their STAs of the channel change, whereby the master AP determines the additional time based on the delay indicated by said member APs.

[00130] 84. The system as in any of the embodiments 52-83, wherein the member AP and the master AP are configured to trigger a master AP reselection procedure, whereby a new master AP of the CCG is selected.

[00131] 85. The system of embodiment 84, wherein the master AP reselection procedure is triggered at least one of when the master AP is down, when the master AP desires leave the CCG, when the master AP has not transmitted anything for a predetermined period and when the master AP

unsets its master indicator indicating that the master AP relinquishes mastership.

[00132] 86. The system of embodiment 84, wherein the master AP reselection procedure is triggered by any member AP of the CCG sending a master AP reselection request message to the master AP.

[00133] 87. The system as in any of the embodiments 84-86, wherein the new master AP is selected by exchanging metrics associated with each of the APs in the CCG.

[00134] 88. The system of embodiment 87, wherein the metrics are one of traffic volume and random numbers.

[00135] 89. The system as in any of the embodiments 52-88, wherein a signaling between the APs and the master AP is performed by one of an SNMP, XML, L2 Ethertype protocol, and L3 control protocol.

[00136] 90. The system as in any of the embodiments 52-89, wherein operational parameters and settings affecting an AP's selection of the WDS channel and CCG are stored in an AP database, whereby each AP checks for updates of the parameters and settings contained in the AP's database and adjusts the behavior of the APs accordingly.

[00137] 91. The system as in any of the embodiments 52-89, wherein operational parameters and settings affecting an AP's selection of the WDS channel and CCG are stored in a remote database, whereby each AP checks for updates of the parameters and settings contained in the remote database and adjusts the behavior of the APs accordingly.

[00138] 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 including a plurality of access points (APs) wherein the APs communicate each other via a wireless distribution system (WDS), a method for autonomous channel coordination for the WDS, the method comprising:
 - establishing a coordinated channel group (CCG) comprising a plurality of member APs, the member APs of the CCG camping on a WDS channel used for the WDS among the member APs of the CCG;
 - designating one AP among the member APs of the CCG as a master AP; and
 - the master AP coordinating with other member APs of the CCG for selecting and configuring the WDS channel for the CCG.
2. The method of claim 1 wherein each member AP of the CCG broadcasts a CCG indicator (CCGI) on the WDS channel.
3. The method of claim 2 wherein the CCGI is transmitted via one of a beacon frame and a probe response frame.
4. The method of claim 2 wherein the CCGI is transmitted via a stand alone frame.
5. The method of claim 2 wherein the master AP transmits a master indicator associated with the CCGI.
6. The method of claim 1 further comprising:
 - a non-member AP that desires to join the CCG sending a CCG addition request message to the master AP;
 - the master AP determining whether or not accept the non-member AP; and

the master AP sending a CCG addition response message to the non-member AP, the CCG addition response message indicating an accept or a reject for the request.

7. The method of claim 6 wherein the CCG addition request message includes capability information of the non-member AP.

8. The method of claim 7 wherein the capability information includes at least one of a list of frequency channels that the non-member AP may support, information as to whether the non-member AP is capable of reporting channel utilization and interference measurement, and information related to a basic service set (BSS) served by the non-member AP.

9. The method of claim 6 wherein the CCG addition request message is included in one of a probe request message and an association request message.

10. The method of claim 6 wherein the CCG addition response message is included in one of a probe response message and an association response message.

11. The method of claim 6 wherein the master AP considers at least one of capabilities of the non-member AP and the number of APs included in the CCG in determining whether or not accept the non-member AP.

12. The method of claim 1 further comprising:

a member AP that wants to leave the CCG sending a CCG deletion notification message to the master AP, whereby the member AP is withdrawn from the CCG.

13. The method of claim 12 wherein the CCG deletion notification message is included in a disassociation message.

14. The method of claim 1 further comprising:

each member AP reporting measurements to the master AP, whereby the master AP selects and configures the WDS channel based on the reported measurements.

15. The method of claim 14 wherein the measurements include at least one of interference level measured on each channel, channel utilization of each channel, number of stations (STAs) detected on each channel, and identities of STAs associated to each member AP.

16. The method of claim 14 wherein the measurements include measurements reported by STAs associated to the member APs if the WDS channel is same to a basic service set (BSS) channel used within its own BSS of the member APs.

17. The method of claim 1 further comprising:

a member AP of the CCG sending a channel change request message to the master AP, whereby the master AP decides to change the WDS channel upon receipt of the channel change request message.

18. The method of claim 17 wherein the channel change request message includes an order of preference for a new WDS channel.

19. The method of claim 17 further comprising:

the master AP sending a channel change response message to the requesting member AP in response to the channel change request message.

20. The method of claim 17 further comprising:
the master AP sending a channel change command to the member APs of the CCG if the master AP decides to change the WDS channel.
21. The method of claim 1 further comprising:
an AP creating a new CCG, the AP becoming a master AP of the new CCG;
the AP selecting a CCG indicator (CCGI) for the new CCG; and
the AP periodically broadcasting the CCGI.
22. The method of claim 21 wherein the AP randomly selects the CCGI within a predetermined range.
23. The method of claim 21 wherein the AP scans all frequency channels before selecting the CCGI.
24. The method of claim 1 wherein the member APs notify the master AP of any configuration modification if a basic service set (BSS) channel of the member APs is same to the WDS channel.
25. The method of claim 1 further comprising:
the master AP determining whether a WDS channel change is necessary; and
the master AP sending a channel change command if the master AP decides to change the WDS channel.
26. The method of claim 25 further comprising:
a member AP sending a channel change request message to the master AP, whereby the master AP determines whether the WDS channel change is necessary upon receiving the channel change request message.

27. The method of claim 26 wherein the channel change request message includes an order of preference for a new channel.

28. The method of claim 25 wherein the channel change command includes timing information on which the channel change is executed.

29. The method of claim 28 wherein the master AP considers additional time for member APs that use the same channel for the WDS traffic and basic service set (BSS) traffic on their BSSs so that said member APs notify the stations (STAs) of their BSSs of the channel change.

30. The method of claim 29 wherein the master AP determines the additional time based on the number of STAs associated to said member APs.

31. The method of claim 29 further comprising:

the master AP sending a channel change prepare request message to said member APs to inform said member APs of the new WDS channel to which the master AP intends to switch;

each of said member APs responding with a channel change prepare response message indicating a delay necessary to notify their STAs of the channel change; and

the master AP determining the additional time based on the delay indicated by said member APs.

32. The method of claim 1 further comprising:

triggering a master AP reselection procedure, whereby a new master AP of the CCG is selected.

33. The method of claim 32 wherein the master AP reselection procedure is triggered at least one of when the master AP is down, when the master AP desires leave the CCG, when the master AP has not transmitted anything for a predetermined period and when the master AP unsets its master indicator indicating that the master AP relinquishes mastership.

34. The method of claim 32 wherein the master AP reselection procedure is triggered by any member AP of the CCG sending a master AP reselection request message to the master AP.

35. The method of claim 32 wherein the new master AP is selected by exchanging metrics associated with each of the APs in the CCG.

36. The method of claim 35 wherein the metrics are one of traffic volume and random numbers.

37. The method of claim 1 wherein a signaling between the APs and the master AP is performed by one of a simple network management protocol (SNMP), extended markup language (XML), L2 Ethertype protocol, and L3 control protocol.

38. The method of claim 37 wherein operational parameters and settings affecting an AP's selection of the WDS channel and CCG are stored in an AP database, whereby each AP checks for updates of the parameters and settings contained in the AP's database and adjusts the behavior of the APs accordingly.

39. The method of claim 37 wherein operational parameters and settings affecting an AP's selection of the WDS channel and CCG are stored in a remote database, whereby each AP checks for updates of the parameters and settings contained in the remote database and adjusts the behavior of the APs accordingly.

40. In a wireless communication system including a plurality of access points (APs) wherein the APs communicate each other via a wireless distribution system (WDS), a system for autonomous channel coordination for the WDS, the system comprising:

a plurality of member APs configured to establish a coordinated channel group (CCG), the member APs camping on a WDS channel used for the WDS among the member APs of the CCG; and

a master AP being designated among the member APs of the CCG, the master AP being configured to coordinate with other member APs of the CCG for selecting and configuring the WDS channel for the CCG.

41. The system of claim 40 wherein each member AP of the CCG broadcasts a CCG indicator (CCGI) on the WDS channel.

42. The system of claim 41 wherein the CCGI is transmitted via one of a beacon frame and a probe response frame.

43. The system of claim 41 wherein the CCGI is transmitted via a stand alone frame.

44. The system of claim 41 wherein the master AP transmits a master indicator associated with the CCGI.

45. The system of claim 40 further comprising:

at least one non-member AP configured to send a CCG addition request message to the master AP to join the CCG, wherein the master AP determines whether or not accept the non-member AP and sends a CCG addition response message to the non-member AP indicating an accept or a reject for the request.

46. The system of claim 45 wherein the CCG addition request message includes capability information of the non-member AP.

47. The system of claim 46 wherein the capability information includes at least one of a list of frequency channels that the non-member AP may support, information as to whether the non-member AP is capable of reporting channel utilization and interference measurement, and information related to a basic service set (BSS) served by the non-member AP.

48. The system of claim 45 wherein the CCG addition request message is included in one of a probe request message and an association request message.

49. The system of claim 45 wherein the CCG addition response message is included in one of a probe response message and an association response message.

50. The system of claim 45 wherein the master AP considers at least one of capabilities of the non-member AP and the number of APs included in the CCG in determining whether or not accept the non-member AP.

51. The system of claim 40 wherein a member AP that wants to leave the CCG sends a CCG deletion notification message to the master AP, whereby the member AP is withdrawn from the CCG.

52. The system of claim 51 wherein the CCG deletion notification message is included in a disassociation message.

53. The system of claim 40 wherein each member AP is configured to report measurements to the master AP, whereby the master AP selects and configures the WDS channel based on the reported measurements.

54. The system of claim 53 wherein the measurements include at least one of interference level measured on each channel, channel utilization of each channel, number of stations (STAs) detected on each channel, and identities of STAs associated to each member AP.

55. The system of claim 53 wherein the measurements include measurements reported by STAs associated to the member APs if the WDS channel is same to a basic service set (BSS) channel used within its own BSS of the member APs.

56. The system of claim 40 wherein the member AP is configured to send a channel change request message to the master AP, whereby the master AP decides to change the WDS channel upon receipt of the channel change request message.

57. The system of claim 56 wherein the channel change request message includes an order of preference for a new WDS channel.

58. The system of claim 56 wherein the master AP is configured to send a channel change response message to the member AP requested the channel change.

59. The system of claim 56 wherein the master AP is configured to send a channel change command to the member APs of the CCG if the master AP decides to change the WDS channel.

60. The system of claim 40 further comprising:

at least one AP configured to create a new CCG, by selecting a CCG indicator (CCGI) for the new CCG, becoming a master AP of the new CCG and periodically broadcasting the CCGI.

61. The system of claim 60 wherein the AP randomly selects the CCGI within a predetermined range.

62. The system of claim 60 wherein the AP scans all frequency channels before selecting the CCGI.

63. The system of claim 40 wherein the member APs configured to notify the master AP of any configuration modification if a basic service set (BSS) channel of the member APs is same to the WDS channel.

64. The system of claim 40 wherein the master AP is configured to determine whether a WDS channel change is necessary and send a channel change command if the master AP decides to change the WDS channel.

65. The system of claim 64 wherein the member AP is configured to send a channel change request message to the master AP, whereby the master AP determines whether the WDS channel change is necessary upon receiving the channel change request message.

66. The system of claim 65 wherein the channel change request message includes an order of preference for a new channel.

67. The system of claim 64 wherein the channel change command includes timing information on which the channel change is executed.

68. The system of claim 67 wherein the master AP is configured to consider additional time for member APs that use the same channel for the WDS traffic and basic service set (BSS) traffic on their BSSs so that said member APs notify the stations (STAs) of their BSSs of the channel change.

69. The system of claim 68 wherein the master AP is configured to determine the additional time based on the number of STAs associated to said member APs.

70. The system of claim 68 wherein the master AP is configured to send a channel change prepare request message to said member APs to inform said member APs of the new WDS channel to which the master AP intends to switch, and each of said member APs is configured to respond with a channel change prepare response message indicating a delay necessary to notify their STAs of the channel change, whereby the master AP determines the additional time based on the delay indicated by said member APs.

71. The system of claim 40 wherein the member AP and the master AP are configured to trigger a master AP reselection procedure, whereby a new master AP of the CCG is selected.

72. The system of claim 71 wherein the master AP reselection procedure is triggered at least one of when the master AP is down, when the master AP desires leave the CCG, when the master AP has not transmitted anything for a predetermined period and when the master AP unsets its master indicator indicating that the master AP relinquishes mastership.

73. The system of claim 71 wherein the master AP reselection procedure is triggered by any member AP of the CCG sending a master AP reselection request message to the master AP.

74. The system of claim 71 wherein the new master AP is selected by exchanging metrics associated with each of the APs in the CCG.

75. The system of claim 74 wherein the metrics are one of traffic volume and random numbers.

76. The system of claim 40 wherein a signaling between the APs and the master AP is performed by one of a simple network management protocol (SNMP), extended markup language (XML), L2 Ethertype protocol, and L3 control protocol.

77. The system of claim 76 wherein operational parameters and settings affecting an AP's selection of the WDS channel and CCG are stored in an AP database, whereby each AP checks for updates of the parameters and settings contained in the AP's database and adjusts the behavior of the APs accordingly.

78. The system of claim 76 wherein operational parameters and settings affecting an AP's selection of the WDS channel and CCG are stored in a remote database, whereby each AP checks for updates of the parameters and settings contained in the remote database and adjusts the behavior of the APs accordingly.