

ADAPTIVE BEACON PERIOD IN A DISTRIBUTED NETWORK

[0001] This application claims priority to U.S. Application Serial No. 10/838,217, filed May 5, 2004, entitled "Adaptive Beacon Period in Distributed Network," of which the entire specification is incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates to wireless communications. More particularly, the present invention relates to the allocation of resources in wireless communications networks.

BACKGROUND OF THE INVENTION

[0003] Short-range wireless proximity networks typically involve devices that have a communications range of one hundred meters or less. To provide communications over long distances, these proximity networks often interface with other networks. For example, short-range networks may interface with cellular networks, wireline telecommunications networks, and the Internet.

[0004] IEEE 802.15.3 defines an ad hoc wireless short-range network (referred to as a piconet) in which a plurality of devices may communicate with each other. The timing of piconets is based on a repeating pattern of "superframes" in which the network devices may be allocated communications resources. Currently, the MultiBand OFDM Alliance (MBOA) is defining a media access control (MAC) layer for Ultra Wide Band (UWB) radios in relation with the IEEE 802.15.3. More information about Multiband OFDM can be found from <http://www.multibandofdm.org/>.

[0005] The first version of the MAC specifies a superframe that is 65536 microseconds in duration. This superframe contains 256 equally spaced Media Access Slots (MAS). Each MAS can be used for data communication. Thus, the length of each MAS is 256 microseconds.

[0006] According to this initial MAC version, the first eight MASs of the superframe are always reserved for the transmission of beacons. The time period covering these eight slots is called a Beacon Period (BP). During the Beacon Period,

each MAS contains three beacon slots. Therefore, the total number of available beacon slots per superframe is twenty four. During a beacon slot, only a single beacon can be sent.

[0007] Unfortunately, because the initial MAC is inflexible in the number of beacon slots, it is likely that for any given situation, there will be either too many or too few available beacon slots. For instance, the maximum number of twenty four beacon slots specified by the initial MAC version is for devices that are located within two hops of each other. This number of beacon slots may be sufficient because the operating range provided by the UWB physical layer (PHY) is small. However, a greater number of beacon slots may sometimes be needed. This could be the case in scenarios involving, for example, rush hour trains or buses.

[0008] Conversely, situations may occur where there are too many beacon slots. For instance, when a network includes just one device, only two beacon slots are necessary during the BP. One of these slots is for beaconing and the other is for another device's beacon when it joins the network. Similarly, if two devices are present in a network, then only two slots during the BP are in use. Additionally one slot must be reserved for new device.

[0009] The initial MAC version specifies that every device operating in an active mode must listen to every beacon slot in a BP. Therefore, In the above mentioned situation involving two devices, the initial MAC version requires the two devices to monitor (or "listen to") twenty two empty beacon slots. This results in unnecessary power consumption for the two devices.

[0010] Accordingly, the current inflexibility in the number of beacon slots can have the unfortunate effect of increasing device power consumption and/or decreasing available communications capacity. These effects are highly likely given the general nature of ad hoc networks, in which situations vary greatly.

SUMMARY OF THE INVENTION

[0011] The present invention provides a wireless communications network. This network includes one or more wireless communications devices and a wireless

transmission medium. The one or more wireless communications devices transmit beacon messages across the wireless transmission medium during a beacon period that is within a superframe. The beacon period has a number of beacon slots that is dynamically adjusted. This adjustment may be based, for example, on the number of wireless communications devices in the network.

[0012] The present invention also provides a wireless communications device having a receiver, a transmitter, and a controller. The receiver receives beacon messages across a wireless transmission medium. Based on the received beacon messages, the controller determines a number of beacon slots for a group of one or more devices (which includes the wireless communications device). To allocate the determined number of beacon slots to the group, the transmitter sends a generated beacon message.

[0013] The determined number of beacon slots may be within a beacon period of a superframe. However, the received beacon messages may be within a two or more beacon periods. In aspects of the present invention, each of the received beacon messages identifies one or more devices within a same beaconing group, and beacon slots employed by the one or more devices.

[0014] The generated beacon message may indicate a number of used beacon slots that are visible to the device. Also, the generated beacon message indicates a relative usage of beacon slots that are visible to the device.

[0015] In addition, the present invention provides a method in which a plurality of beacon messages are received across a wireless transmission medium; a number of beacon slots is determined for a group of one or more devices based on the received beacon messages; and a beacon message is sent to allocate the determined number of beacon slots to the group.

[0016] The present invention allows for the efficient utilization of communications resources and reduces power consumption in communications devices. Further features and advantages of the present invention will become apparent from the following description, claims, and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In the drawings, like reference numbers generally indicate identical, functionally similar, and/or structurally similar elements. The drawing in which an element first appears is indicated by the leftmost digit(s) in the reference number. The present invention will be described with reference to the accompanying drawings, wherein:

[0018] FIG. 1 is a diagram of an exemplary operational environment;

[0019] FIGs. 2A and 2B are diagrams of exemplary superframes;

[0020] FIG. 3 is a flowchart illustrating an operation of a wireless communications device according to an aspect of the present invention;

[0021] FIG. 4 is a diagram of a field that may be transmitted by devices according to an embodiment of the present invention; and

[0022] FIG. 5 is a diagram of a wireless communications device according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

I. Operational Environment

[0023] Before describing the invention in detail, it is helpful to first describe an environment in which the present invention may be used. Accordingly, FIG. 1 is a diagram of an exemplary operational environment in which the present invention may be employed. In this environment, a plurality of wireless communications devices (DEVs) 102 may exchange information with each other across a wireless personal area network (WPAN) 100. This exchange of information may occur through various communications paths or "hops" 104 that exist between DEVs 102.

[0024] Network 100 includes a plurality of beaconing groups 106. Each beaconing group 106 includes a set of DEVs 102 that are within radio range of each other during a beaconing period. For instance, a beaconing group 106a includes DEVs 102a,

102b, and 102c. Also, a beaconing group 106b includes DEVs 102a, 102d, 102e, and 102f. Accordingly, DEV 102a belongs to both beaconing group 106a and 106b.

[0025] The environment of FIG. 1 shows a cluster 108, which includes a set of DEVs 102 that are within the radio range of a particular DEV 102 (i.e., DEV 102a). Accordingly, cluster 108 includes DEVs 102a-f of beaconing groups 106a and 106b.

II. Superframe

[0026] Transmissions according to the MBOA MAC version are based on a repeating pattern called a superframe. FIG. 2A is a diagram showing a superframe format. In particular, FIG. 2A shows consecutive exemplary superframes 200a and 200b.

[0027] Superframe 200a includes a plurality of media access slots (MASs) 202a-n. As shown in FIG. 2A, multiple MASs 202 in each superframe 200 are grouped into beaconing periods (BP) 204. For instance, FIG. 2A shows that superframe 200a has a BP 204a and superframe 200b has a superframe 204b. As discussed above, the initial MBOA MAC version provides for a beaconing period having 24 beacon slots. These slots extend across eight contiguous MASs. Therefore, when implemented according to this version, each MAS 202 that is within BP 204 contains three beacon slots.

[0028] According to the initial MBOA MAC version, only beacon frames may be transmitted according to a beacon period protocol during BPs 204. However, during other portions of superframes 200, devices are allowed to reserve portions of the RF channel (make "reservations") for use according to specific access methods. Two such methods are the contention free period (CFP) and the contention access period (CAP).

[0029] With the CFP access method, a reservation is coordinated to clear the channel between the transmitter and all intended receivers. This avoids collisions with other transmitters during the period of access. However, with the CAP access method, a reservation is coordinated to clear the channel around all devices within a group that is identified to be within radio range of each other. This allows for the devices of the group to exclusively contend for the channel and also to avoid collisions also with devices that are not within the group.

[0030] Additionally, the MBOA MAC version provides for an optional access method called enhanced distributed channel access (EDCA).

[0031] BPs 204 correspond to particular beaconing groups. For instance, in FIG. 2A, BPs 204a and 204b are allocated to devices (e.g., DEVs 102) in a beaconing group. However, superframes 200 may be overlaid in time to support multiple beaconing groups. An example of this is shown in FIG. 2B.

[0032] FIG. 2B is a diagram showing exemplary superframes 200c and 200d. These superframes share the same MASs 202 with superframes 200a and 200b. However, superframes 200c and 200d include BPs 204c and 204d, respectively. Accordingly, the MASs 202 of FIG. 2B support two beaconing groups. One of these beaconing groups may transmit beacon frames in BPs 204a and 204b, while the other beaconing group may transmit beacon frames in BPs 204c and 204d.

III. Beacons

[0033] To maintain coordination between communicating devices, the initial MBOA MAC version specifies that devices (such as DEVs 102) transmit a beacon message.

[0034] The transmission of beacons in a cluster or separate clusters allows for fast device discovery and provides efficient support for mobility. Moreover, beacons provide the basic timing for the network and may transmit information regarding isochronous reservations. The employment of beacons alleviates the need for a network infrastructure by distributing functions across all nodes. Accordingly, the initial MBOA MAC version does not require an access point or central coordinator for the WPAN network.

[0035] According to the initial MBOA MAC version, devices (e.g., DEVs 102) that intend to participate in communication with other devices send beacons during beaconing periods (e.g., BPs 204). Further, these devices scan for beacons transmitted by other devices during the beaconing period. However, certain devices may enter a “hibernation” state. When operating in this state, a device refrains from transmitting beacons. However, the device does not relinquish its particular beacon slot.

[0036] In short, each device provides in the beacon message its MAC address and the place of the beacon. For example three active devices in a group may inform that they use beacon slots 1,3 and 4 of 6 available beacon slots (according to the flexible allocation techniques of the present invention). Generally, slots 2, 5 and 6 would be available. However, when an additional hibernating device belongs to the same group, at least one of the active devices informs that slot one of these slots (e.g., slot 6) is reserved for the hibernating device. Therefore a new device joining network would have slots 2 and 5 available.

[0037] Beacons may include one or more information elements (IEs) containing information pertaining to the DEVs and/or the network. One such IE specified by the initial MBOA MAC version is called a Beacon Period Occupancy IE (BPOIE). The BPOIE is used to provide a list of devices in the same beaconing group and the beacon slots that those devices employ during the beaconing period. This information can be used to detect beacon collisions. The initial MBOA version specifies that devices shall include a BPOIE in all beacons that they transmit.

[0038] The BPOIE contains various information. This information includes a beacon slot information ("Beacon slot info") field for each device in the beaconing group (such as one of beaconing groups 106). Each of these fields includes a beacon slot number and a corresponding device identifier ("DEVID").

[0039] Upon reception of a beacon frame, a device saves the DEVID of the sender and the slot number where the beacon is received. This information is included in the BPOIE sent in the following superframe. Only the information of beacons received during a superframe is included in the BPOIE sent in the following superframe.

[0040] Devices select their beacon slots among the idle beacon slots. Also, in subsequent superframes, devices send their beacons in the same beacon slot unless a collision is detected. If a particular device identifier (DEVID) is missing in the BPOIE from a neighboring beacon during predetermined number of consecutive superframes, device(s) receiving the neighboring beacon are instructed by the initial MBOA MAC version to indicate this beacon slot as an idle slot in the following superframe.

IV. Beacon Period Flexibility

[0041] In embodiments of the present invention, the number of slots during the beacon period is made flexible. This flexibility may be based on, for example, the number of devices in the network.

[0042] Accordingly, in aspects of the present invention, a mapping may be provided between the number of devices in a network (e.g., devices within two hops from each other) and the length of the beacon period (i.e., the number of MASs in the BP). Table 1, below, provides an example of such a mapping. This mapping is in the context of the initial MBOA version's superframe format modified to have a flexible number of MASs

Number of Devices	Number of MASs in current BP	Available Beacon Slots
1	1	3
2	2	6
3	2	6
4	2	6
5	3	9
6	3	9

Table 1

[0043] In the example of Table 1, there are normally at least two free beacon slots during the BP. However, as new device(s) join the network, the number of beacon slots is increased whenever the number of free beacon slots decreases to a predetermined number (e.g., to one free beacon slot). For example, Table 1 shows the total number of beacon slots being increased (e.g., from 3 to 6, 6 to 9, 9 to 12, etc.) based on the number of devices in the network.

[0044] In operational situations, the exact number of devices within two hops may not be known by each device. However, as described herein, information providing an indication of the number of devices may be communicated. Accordingly, flexibility in the number of employed MASs may be provided in various ways.

[0045] One such way is in incremental steps, where the adjacent rows in a mapping table, such as Table 1, are viewed as an increment. Accordingly, adjustments in the number of employed MASs may be made in single increments. However, in certain situations (such as when multiple networks merge) a single adjustment in the number of employed MASs may span multiple increments.

[0046] Table 1 is provided as an example. Accordingly, variations from this table are within the scope of the present invention. For example, the number of free slots may be kept somewhat higher than in Table 1. Such mappings offer trade-offs with efficiency.

V. Operation

[0047] Various mechanisms may be employed to adjust (i.e., increase or decrease) the number of employed beacon slots. For instance, embodiments of the present invention employ an IE that indicates a particular BP length. This IE may be implemented in various ways. For example, in embodiments, the BP length is included in each beacon that a device transmits. Accordingly, this IE may be provided by a modified BPOIE that, unlike the BPOIE of the initial version, includes a BP length field. This field may be an indication (or "announcement") by a particular device of the number of used beacon slots that are visible to it (i.e., that the device can receive). Thus, this field may reflect the number of used beacon slots from multiple beaconing groups.

[0048] When no piconet exists, a first device in a network determines a beacon period start time (BPST). At this start time, the first device sends its own beacon containing BPOIE. This BPOIE may include a BP length field, according to embodiments of the present invention. Over time, additional device(s) may join the network. Through the exchange of information in, (for example, in beacon messages) beacon period lengths are determined and dynamically adjusted based on network characteristics.

[0049] FIG. 3 is a flowchart illustrating an operation of a wireless communications device, such as one of DEVs 102, according to an aspect of the present invention. This operation includes a step 302 in which the device receives one or more

beacon messages. In embodiments of the present invention, these message(s) are received during a single superframe.

[0050] In a step 304, the device processes the one or more beacon messages. This step may include retrieving information from various fields in each beacon transmission and storing the fields in a memory. In addition, step 304 may include determining the number of device(s) that are within its view. This number of devices may be from multiple beacon groups.

[0051] In a step 308, a beacon slot adjustment determination is made. In this step, the device determines whether an increase or a decrease in the number of beacon slots employed by its beaconing group(s) is to occur. Performance of this step may be based on the information retrieved and/or determined in step 304.

[0052] In a step 310, the device generates a beacon message. This beacon message is based on the beacon message(s) received in step 302. For instance, for a particular beaconing group, the generated beacon message may include a device identifier and a beacon slot identifier for each device in the group. In addition, this message includes information indicating the number of allocated beacon slots. Accordingly, this information may be based on any beacon slot adjustment determination that is performed in step 308. For instance, this information may be in the form of a BP length field.

[0053] In a step 312, the beacon message generated in step 310 is transmitted. In embodiments, this information is transmitted in a superframe immediately following a preceding superframe during which the beacon message(s) were received in step 302. This transmission is sent to the device's beaconing group(s) (e.g., in BP(s) corresponding to the beaconing group(s)). In turn, each device in the group may likewise perform the steps of FIG. 3 based on the reception of this transmission and any other received beacon messages.

[0054] As described above, embodiments of the present invention employ an IE having a BP length field that allows a device to indicate or announce the number of used beacon slots that are visible to it. This field may be implemented in various ways. For example, this data field may be a three bit code, such as the one shown in Table 2, below. The code of Table 2 is based on the number of used beacon slots visible to the device that generated and transmitted the code in a beacon.

Code value	Number of Visible Beacon Slots Used
000	3 beacon slot are used (1 device, minimum)
011	9 beacon slot are used (<5 devices)
111	24 beacon slots used (maximum)

Table 2

[0055] Accordingly, in step 308, a beacon slot adjustment determination may be made based on the number of used slots indicated by the visible devices in comparison to the number of used slots in the beaconing group. For instance, if any of the devices in same beaconing group announce (e.g., through the code of Table 2) more visible used beacon slots than are currently used in the beaconing group, then all of the devices in the beaconing group adapt by increasing of the number of allocated beacon slots in the beaconing group. This allocation may be performed in the following superframe.

[0056] A further exemplary implementation of a BP length field is shown below in Table 3. This implementation employs a two bit code that indicates relative usage of visible beacon slots (i.e., the portion of allocated visible beacon slots used by devices).

Code value	Number of Visible Beacon Slots
00	low usage of visible beacon slots (e.g., 4 devs and 12 slots available)
01	normal usage of visible beacon slots (e.g., 10 devs and 15 slots)
10	high usage of visible beacon slots (e.g., 14 devs and 15 slots)
11	merging of piconets - increase to maximum (e.g., 24 slots)

Table 3

[0057] Based on such relative usages received from the beacons of visible devices, a device may make a beacon slot adjustment determination in step 308. As described above with reference to the flowchart of FIG. 3, a beacon slot adjustment determination may result in an increase or decrease in the allocation of beacon slots for the beaconing group.

[0058] For example, if any of the received code values indicates a high usage of visible beacon slots (i.e., if any of the visible devices announces “10”), then all of the devices in the beaconing group adapt by increasing of the number of allocated beacon slots in the beaconing group. Such an increase may be by a predetermined increment. For example, with reference to Table 1, this increment from six allocated beacon slots to nine allocated beacon slots.

[0059] As a further example, if any of the received code values indicates a merging of networks or piconets (i.e., if any of the visible devices announces “11”), then all of the devices in the beaconing group adapt by increasing of the number of allocated beacon slots in the beaconing group to a maximum number (such as 24).

[0060] In addition to the above techniques for determining whether to increase the number of beacon slots in a beacon period, various techniques may be employed to determine whether the number of beacon slots in a beacon period should be decreased.

[0061] For instance, if all devices within a two-hop network (such as cluster 108) announce a low usage of visible beacon slots, then a device may determine in step 308 that a decrease in the number of beacon slots is to occur. As an example, with reference to Table 3, if every device within the network announces “00” in their beacon transmissions, then these devices will adapt by decreasing of the number of beacon slots. This may be done by decreasing the number of slots by an increment (e.g. from 12 to 9) in the following superframe by one step.

[0062] Accordingly, such techniques require at least one device to receive beacon transmissions from (“hear”) all other devices in the network. If this device determines that number of beacon period slots should decrease, then it may signal its desire to decrease the number of beacon period slots in its next transmitted beacon. This signaling may be implemented by setting one bit (i.e., a request to change bit) that indicates (along with the BP length field) that the device desires to lower its beacon period size.

[0063] To determine whether this request is approved, a not accepted bit is also provided for transmission in beacons. If none of the other devices in the beaconing group subsequently transmit beacons with this bit being set, then the lower BP length has been achieved. However, if the one or more devices set this bit in their beacons, then the old BP length is maintained.

[0064] In embodiments, the request to change bit may be propagated (i.e., relayed) across multiple hops. If any devices within the multiple hops reject the bit (e.g., by setting the not accepted bit), then the devices that relayed this bit also reject it. As a result, the original BP length is maintained unless all devices within the multihop network approve the proposed decrease.

[0065] As an alternative to the above decreasing technique, a lone device uses a predetermined number of BP slots (such as three beacon slots) for beaconing. However, when other device(s) join the lone device's network, then the number of beacon slots is increased to a predetermined value (such as 24). Thus, the lone device conserves power until other devices join its network.

[0066] Accordingly, devices may also determine a beacon slot adjustment based on BP length field(s) received from other devices in their beaconing group(s). This determination may also be made in step 308. As described above, such adjustments may involve a decrease or an increase in the number of beacon slots for a group. In embodiments such increases may be limited by a maximum slot amount, such as 24. However, beacon periods having greater than 24 beacon slots are within the scope of the present invention.

[0067] Further, in embodiments, devices within a beaconing group always use the lowest possible free beacon slots counting from the start of beacon period start time (BPST). This advantageously minimizes the duration of the beacon period and provides for an efficient utilization of communications resources.

VI. Beacon Period Field

[0068] FIG. 4 is a diagram showing an exemplary BP length field 400 according to an embodiment of the present invention. As described above, this field may be included in a IE, such as a BPOIE that is modified from the initial MBOA MAC version. As shown in FIG. 4, field 400 is represented by an octet (i.e., eight bits). Bits 402a-402e are reserved for encode a BP field length. Accordingly, these bits may be used to represent the codes of Tables 2 and 3. Field 400 also includes a request to change bit 404

and a not accepted bit 406. As discussed above, these bits may be used to decrease the number of BP slots.

VII. Wireless Communications Device

[0069] As described above, wireless communications devices, such as DEVs 102, may employ the techniques of the present invention. Accordingly, such devices may be implemented in hardware, software, firmware, or any combination thereof. One such implementation is shown in FIG. 5. This implementation includes a processor 510, a memory 512, and a user interface 514. In addition, the implementation of FIG. 5 includes a UWB transceiver 524 and an antenna 526.

[0070] As shown in FIG. 5, UWB transceiver 524 is coupled to antenna 526. UWB transceiver 524 includes electronics, which allow the device (in conjunction with antenna 526) to exchange wireless UWB signals remote devices, such as other DEVs 102. Accordingly, transceiver 524 may include a transmitter and a receiver. For the transmission of UWB signals, such electronics may include modulation components (e.g., OFDM modulators) and/or a pulse generator for certain types of impulse UWB transmissions. For the reception of UWB signals, such electronics may include demodulation components (e.g., OFDM demodulators), timing circuitry, and filters.

[0071] As shown in FIG. 5, processor 510 is coupled to transceiver 524. Processor 510 controls device operation. Processor 510 may be implemented with one or more microprocessors that are each capable of executing software instructions stored in memory 512.

[0072] Memory 512 includes random access memory (RAM), read only memory (ROM), and/or flash memory, and stores information in the form of data and software components (also referred to herein as modules). These software components include instructions that can be executed by processor 510. Various types of software components may be stored in memory 512. For instance, memory 512 may store software components that control the operations of transceiver 524. Also, memory 512 may store software components that provide for the functionality of a media access controller (MAC). This controller may perform various features, such as the steps

described with reference to FIG. 3. It is important to note that the MAC may be implemented in hardware, software, firmware, or any combination thereof.

[0073] In addition, memory 512 may store software components that control the exchange of information through user interface 514. As shown in FIG. 5, user interface 514 is also coupled to processor 510. User interface 514 facilitates the exchange of information with a user. FIG. 5 shows that user interface 514 includes a user input portion 516 and a user output portion 518. User input portion 516 may include one or more devices that allow a user to input information. Examples of such devices include keypads, touch screens, and microphones. User output portion 518 allows a user to receive information from the wireless communications device. Thus, user output portion 518 may include various devices, such as a display, and one or more audio speakers. Exemplary displays include liquid crystal displays (LCDs), and video displays.

[0074] The elements shown in FIG. 5 may be coupled according to various techniques. One such technique involves coupling transceivers 520 and 524, processor 510, memory 512, and user interface 514 through one or more bus interfaces. In addition, each of these components is coupled to a power source, such as a rechargeable and/or removable battery pack (not shown).

VIII. Conclusion

[0075] While various embodiments of the present invention have been described above, it should be understood that they have been presented by way of example only, and not in limitation. Accordingly, it will be apparent to persons skilled in the relevant art that various changes in form and detail can be made therein without departing from the spirit and scope of the invention. Thus, the breadth and scope of the present invention should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

[0076] For instance, the tables contained herein are provided as examples. Thus, other table values, mappings, code types are within the scope of the present invention. Also, the present invention may be employed in communications contexts other than ones based on the MBOA MAC.

WHAT IS CLAIMED IS:

1. A wireless communications device, comprising:
a receiver configured to receive a plurality of beacon messages across a wireless transmission medium,
a controller configured to determine a number of beacon slots for a group of one or more devices based on the received beacon messages, the group including the wireless communications device; and
a transmitter configured to send a generated beacon message to allocate the determined number of beacon slots to the group.
2. The wireless communications device of claim 1, wherein the determined number of beacon slots are within a beacon period of a superframe.
3. The wireless communications device of claim 1, wherein the plurality of beacon messages are within a two or more beacon periods.
4. The wireless communications device of claim 1, wherein each of the plurality of beacon messages identifies:
one or more devices within a same beaconing group; and
beacon slots employed by the one or more devices.
5. The wireless communications device of claim 1, wherein the generated beacon message indicates number of used beacon slots that are visible to the device.
6. The wireless communications device of claim 1, wherein the generated beacon message indicates a relative usage of beacon slots that are visible to the device.
7. The wireless communications device of claim 1, wherein the receiver is configured to receive ultra wideband (UWB) signals, and the transmitter is configured to transmit UWB signals.
8. A method, comprising:

(a) receiving a plurality of beacon messages across a wireless transmission medium,

(b) determining a number of beacon slots for a group of one or more devices based on the received beacon messages, the group including the wireless communications device; and

(c) sending a beacon message to allocate the determined number of beacon slots to the group.

9. The method of claim 8, wherein the determined number of beacon slots are within a beacon period of a superframe.

10. The method of claim 8, wherein the plurality of beacon messages are within a two or more beacon periods.

11. The method of claim 8, wherein each of the plurality of beacon messages identifies:

one or more devices within a same beaconing group; and
beacon slots employed by the one or more devices.

12. The method of claim 8, wherein the beacon message sent in step (c) indicates number of used beacon slots that are visible to the device.

13. The method of claim 8, wherein the sent beacon message sent in step (c) indicates a relative usage of beacon slots that are visible to the device.

14. A method, comprising:

(a) receiving one or more beacon messages across a wireless transmission medium, wherein each of the one or more beacon messages is received within one or more corresponding beacon periods;

(b) determining a number of beacon slots for one of the one or more beacon periods based on the one or more received beacon messages; and

(c) sending a beacon message allocating the determined number of beacon slots to the one beacon period.

15. A wireless communications network, comprising:
one or more wireless communications devices; and
a wireless transmission medium;
wherein the one or more wireless communications devices transmit beacon messages across the wireless transmission medium during a beacon period, wherein the beacon period is within a superframe and has a number of beacon slots that is dynamically adjusted based on the amount of the one or more wireless communications devices.
16. The wireless communications network of claim 15, wherein the transmitted beacon messages include one or more ultra wideband (UWB) signals.