(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
30 September 2010 (30.09.2010)

PCT

(10) International Publication Number
WO 2010/110619 A2

(51) International Patent Classification:
H04W 72/12 (2009.01) *H04W 74/08* (2009.01)

(21) International Application Number:
PCT/KR2010/001859

(22) International Filing Date:
26 March 2010 (26.03.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/163,454 26 March 2009 (26.03.2009) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

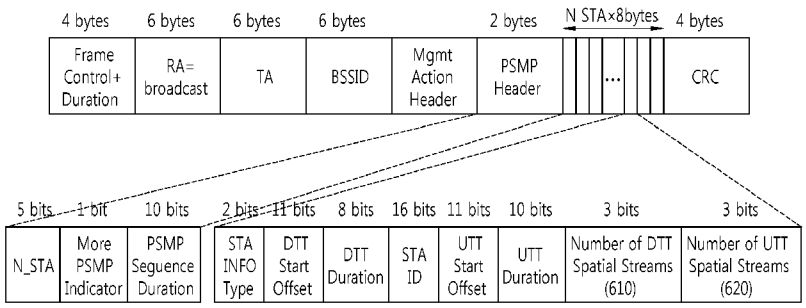
Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

WO 2010/110619 A2

(54) **Title**: METHOD AND APPARATUS FOR SCHEDULING WIRELESS MEDIUM RESOURCE

[Fig. 6]



(57) **Abstract**: A method and apparatus of scheduling a radio medium access is provided. The method includes transmitting, to a first station, first downlink transmission time information indicating a time scheduled for first downlink transmission for transmitting a data frame to the first station, and transmitting second downlink transmission time information indicating a time scheduled for second downlink transmission for transmitting a data frame to a second station, wherein first downlink spatial stream information indicating the number of spatial streams allocated for the first downlink transmission is transmitted to the first station, second downlink spatial stream information indicating the number of spatial streams allocated for the second downlink transmission is transmitted to the second station, and the time scheduled for the first downlink transmission is equal to the time scheduled for the second downlink transmission.

Description

Title of Invention: METHOD AND APPARATUS FOR SCHEDULING WIRELESS MEDIUM RESOURCE

Technical Field

[0001] The present invention relates to wireless communications, and more particularly, to a method and apparatus for scheduling a radio medium access time and a resource allocated for access and for transmitting a data frame according to the scheduling.

Background Art

[0002] With the advancement of information communication technologies, various wireless communication technologies have recently been developed. Among the wireless communication technologies, a wireless local area network (WLAN) is a technology whereby Internet access is possible in a wireless fashion in homes or businesses or in a region providing a specific service by using a portable terminal such as a personal digital assistant (PDA), a laptop computer, a portable multimedia player (PMP), etc.

[0003] Ever since the institute of electrical and electronics engineers (IEEE) 802, i.e., a standardization organization for WLAN technologies, was established in February 1980, many standardization works have been conducted. In the initial WLAN technology, a frequency of 2.4 GHz was used according to the IEEE 802.11 to support a data rate of 1 to 2 Mbps by using frequency hopping, spread spectrum, infrared communication, etc. Recently, the WLAN technology can support a data rate of up to 54 Mbps by using orthogonal frequency division multiplex (OFDM). In addition, the IEEE 802.11 is developing or commercializing standards of various technologies such as quality of service (QoS) improvement, access point protocol compatibility, security enhancement, radio resource measurement, wireless access in vehicular environments, fast roaming, mesh networks, inter-working with external networks, wireless network management, etc.

[0004] In the IEEE 802.11, the IEEE 802.11b supports a data rate of up to 11 Mbps by using a frequency band of 2.4 GHz. The IEEE 802.11a commercialized after the IEEE 802.11b uses a frequency band of 5 GHz instead of the frequency band of 2.4 GHz and thus significantly reduces influence of interference in comparison with the very congested frequency band of 2.4 GHz. In addition, the IEEE 802.11a has improved the data rate to up to 54 Mbps by using the OFDM technology. Disadvantageously, however, the IEEE 802.11a has a shorter communication distance than the IEEE 802.11b. Similarly to the IEEE 802.11b, the IEEE 802.11g implements the data rate of up to 54 Mbps by using the frequency band of 2.4 GHz. Due to its backward compatibility, the IEEE 802.11g is drawing attention, and is advantageous over the IEEE

802.11a in terms of the communication distance.

[0005] The IEEE 802.11n is a technical standard relatively recently introduced to overcome a limited data rate which has been considered as a drawback in the WLAN. The IEEE 802.11n is devised to increase network speed and reliability and to extend an operational distance of a wireless network. More specifically, the IEEE 802.11n supports a high throughput (HT), i.e., a data processing rate of up to 540 Mbps or higher, and is based on a multiple input and multiple output (MIMO) technique which uses multiple antennas in both a transmitter and a receiver to minimize a transmission error and to optimize a data rate. In addition, this standard may use a coding scheme which transmits several duplicate copies to increase data reliability and also may use the OFDM to support a higher data rate.

[0006] A basic access mechanism of an IEEE 802.11 medium access mechanism (MAC) is a carrier sense multiple access with collision avoidance (CSMA/CA) combined with binary exponential backoff. The CSMA/CA mechanism is also referred to as a distributed coordinate function (DCF) of the IEEE 802.11 MAC, and basically employs a "listen before talk" access mechanism. In this type of access mechanism, a station (STA) listens a wireless channel or medium before starting transmission. As a result of listening, if it is sensed that the medium is not in use, a listening STA starts its transmission. Otherwise, if it is sensed that the medium is in use, the STA does not start its transmission but enters a delay period determined by a binary exponential backoff algorithm.

[0007] The CSMA/CA mechanism also includes virtual carrier sensing in addition to physical carrier sensing in which the STA directly listens the medium. The virtual carrier sensing is designed to compensate for a limitation in the physical carrier sensing such as a hidden node problem. For the virtual carrier sending, the IEEE 802.11 MAC uses a network allocation vector (NAV). The NAV is a value transmitted by an STA, currently using the medium or having a right to use the medium, to anther STA to indicate a remaining time before the medium returns to an available state. Therefore, a value set to the NAV corresponds to a period reserved for the use of the medium by an STA transmitting a corresponding frame.

[0008] One of procedures for setting the NAV is a exchange procedure of a request to send (RTS) frame and a clear to send (CTS) frame. The RTS frame and the CTS frame include information capable of delaying frame transmission from receiving STAs by reporting upcoming frame transmission to the receiving STAs. The information may be included in a duration filed of the RTS frame and the CTS frame. After performing the exchange of the RTS frame and the CTS frame, a source STA transmits a to-be-transmitted frame to a destination STA.

[0009] Meanwhile, a power save multi-poll (PSMP) protocol is specified in the IEEE

802.11n standard. In an operation based on the PSMP protocol, a high throughput (HP) access point (AP) allocates a downlink transmission time (DTT) and an uplink transmission time (UTT) to respective HT non-AP STAs (hereinafter, also referred to as HT STAs) or HT STAs of a specific group, and the HT STA communicates with the HP AP during only a DTT and UTT allocated to the HT STA itself.

[0010] According to the operation based on the PSMP protocol, the AP can sequentially transmit a data frame or the like to respective different STAs or STAs of a specific group without a contention overhead. Further, the STAs can also transmit a data frame or the like to the AP without a contention overhead. Therefore, the PSMP protocol can reduce each HT STA's overhead caused by the CSMA/CA channel access mechanism. In addition, according to the PSMP protocol, each HT STA can enter a power save mode or a doze state if it is not a time allocated to the HT STA itself, and thus unnecessary power consumption resulted from overhearing or the like can be further reduced.

[0011] With the widespread use of the WLAN and the diversification of applications using the WLAN, there is a recent demand for a new WLAN system to support a higher throughput than a data processing rate supported by the IEEE 802.11n. However, an IEEE 802.11n medium access control (MAC)/physical layer (PHY) protocol is not effective to provide a throughput of 1 Gbps or higher. This is because the IEEE 802.11n MAC/PHY protocol is designed for an operation of an STA, that is, an STA having one network interface card (NIC), and thus when a frame throughput is increased while conforming to the conventional IEEE 802.11n MAC/PHY protocol, a resultant additional overhead is also increased. Consequently, there is a limitation in increasing a throughput of a wireless communication network while conforming to the conventional IEEE 802.11n MAC/PHY protocol, that is, a single STA architecture.

[0012] Therefore, to achieve a data processing rate of 1 Gbps or higher in the wireless communication system, a new system different from the conventional IEEE 802.11n MAC/PHY protocol (i.e., the single STA architecture) is required. A very high throughput (VHT) WLAN system is a next version of the IEEE 802.11n WLAN system, and is one of IEEE 802.11 WLAN systems which have recently been proposed to support a data processing rate of 1 Gbps or higher in a MAC service access point (SAP). The VHT system is named arbitrarily. To provide a throughput of 1 Gbps or higher, a feasibility test is currently being conducted for the VHT system using 4(4 MIMO and a channel bandwidth of 80 MHz.

[0013] When the PSMP protocol specified in the IEEE 802.11n is directly applied to a WLAN system in a MIMO environment, it is not much effective in terms of usage efficiency of a radio resource. According to the conventional PSMP protocol, all PHY interfaces are occupied at a specific time by only an STA to which a DTT or a UTT are

allocated. If the STA allocated with the DTT or the UTT is a legacy STA not supporting MIMO, the legacy STA cannot entirely use all of the PHY interfaces available in a VHT WLAN system. As a result, if the DTT or the UTT is allocated to only the legacy STA not supporting MIMO in the VHT WLAN system to which the PSMP protocol of the IEEE 802.11n is directly applied, some of the all PHY interfaces cannot be used.

[0014] In addition, when the PSMP protocol of the IEEE 802.11n is directly applied, there is a problem in that all of the available PHY interfaces cannot be effectively used even if the DTT or the UTT is allocated to an STA supporting MIMO. In general, the number of all of the available PHY interfaces of the AP is grater than the number of available PHY interfaces of the STA. However, when the PSMP protocol of the IEEE 802.11n is directly applied, the relatively grater number of PHY interfaces of the AP may use only one STA. Of course, there is no problem when the PHY interfaces of the AP need to be all used since the STA transmits or receives a large amount of data. Yet, the amount of data transmitted or received by the STA may not be large, and in this case, if all PHY interfaces are used by the STA alone, the radio resource cannot be used not only in an effective manner but also in an adaptive and active manner.

[0015] Accordingly, there is a need for a method of scheduling radio resource allocation or the like that can be used in a medium access time to effectively and adaptively use overall radio resources in a WLAN system supporting MIMO.

Summary of Invention

Technical Problem

[0016] The present invention provides a method of dynamically distributing a physical layer (PHY) interface of an access point (AP) to stations to optimize resource utilization in a wireless local area network (WLAN) system, and a wireless apparatus for supporting the method.

Solution to Problem

[0017] In an aspect of the present invention, there is provided method of scheduling a radio medium access time of a station, the method includes transmitting, to a first station, first downlink transmission time information indicating a time scheduled for first downlink transmission for transmitting a data frame to the first station, and transmitting second downlink transmission time information indicating a time scheduled for second downlink transmission for transmitting a data frame to a second station,wherein first downlink spatial stream information indicating the number of spatial streams allocated for the first downlink transmission is transmitted to the first station, second downlink spatial stream information indicating the number of spatial streams allocated for the second downlink transmission is transmitted to the second

station, and the time scheduled for the first downlink transmission is equal to the time scheduled for the second downlink transmission.

[0018] The first downlink transmission time information and the first downlink spatial stream information may be transmitted to the first station by using a first frame, and the second downlink transmission time information and the second downlink spatial stream information may be transmitted to the second station by using a second frame.

[0019] The first downlink transmission time information and the first downlink spatial stream information and the second downlink transmission time information and the second downlink spatial stream information may be transmitted by using a station information field of a power save multi-poll (PSMP) frame, and the PSMP frame may be multicast to the first station and the second station.

[0020] The first station may wake up from a doze state of a power save mode at a time indicated by the first downlink transmission time information to receive the first downlink transmission performed by an access point(AP), and may return to the doze state at the completion of the first downlink transmission, and

[0021] wherein the second station may wake up from the doze state at a time indicated by the second downlink transmission time information to receive the second downlink transmission performed by the AP, and return to the doze state at the completion of the second downlink transmission.

[0022] In another aspect of the present invention, there is provided method of scheduling a radio medium access time of a station. The method includes transmitting, to a first station, first uplink transmission time information indicating a time scheduled for first uplink transmission for transmitting a data frame by the first station to an access point (AP), and transmitting second uplink transmission time information indicating a time scheduled for second uplink transmission for transmitting a data frame by a second station to the AP, wherein first uplink spatial stream information indicating the number of spatial streams allocated for the first uplink transmission is transmitted to the first station, second uplink spatial stream information indicating the number of spatial streams allocated for the second uplink transmission is transmitted to the second station, and the time scheduled for the first uplink transmission is equal to the time scheduled for the second uplink transmission.

[0023] The first uplink transmission time information and the first uplink spatial stream information may be transmitted to the first station by using a first frame, and the second uplink transmission time information and the second uplink spatial stream information may be transmitted to the second station by using a second frame.

[0024] the first downlink transmission time information and the first downlink spatial stream information and the second downlink transmission time information and the second downlink spatial stream information may be transmitted by using a station information

field of a power save multi-poll (PSMP) frame, and the PSMP frame may be multicast to the first station and the second station.

[0025] The first station may wake up from a doze state of a power save mode at a time indicated by the first uplink transmission time information to receive the first uplink transmission performed by the AP, and return to the doze state at the completion of the first uplink transmission, and wherein the second station may wake up from the doze state at a time indicated by the second uplink transmission time information to receive the second uplink transmission performed by the AP, and return to the doze state at the completion of the second uplink transmission.

[0026] In still another aspect of the present invention, there is provided method of transmitting a frame of a station. The method includes receiving downlink transmission time information indicating a time scheduled for downlink transmission for receiving a data frame from an access point (AP) and uplink transmission time information indicating a time scheduled for uplink transmission for transmitting a data frame to the AP, receiving downlink spatial stream information indicating the number of spatial streams allocated for the downlink transmission and uplink spatial stream information indicating the number of spatial streams allocated for the uplink transmission, and receiving a data frame by using the allocated spatial stream indicated by the downlink spatial stream information at a time indicated by the downlink transmission time information, and transmitting a data frame by using the allocated spatial stream indicated by the uplink spatial stream information at a time indicated by the uplink transmission time information.

[0027] The station operates in a power save mode, may wake up from a doze state at the time indicated by the downlink transmission time information or the time indicated by the uplink transmission time information to transmit a frame, and return to the doze state at the completion of the time indicated by the downlink transmission time information or the time indicated by the uplink transmission time information.

[0028] In a further aspect of the present invension , there is provided a station for performing an operation by accessing a channel in a wireless local area network (WLAN) system. The station includes a transceiver, and a processor operationally coupled to the transceiver, wherein the processor is configured for: receiving downlink transmission time information indicating a time scheduled for downlink transmission for receiving a data frame from an access point (AP) and uplink transmission time information indicating a time scheduled for uplink transmission for transmitting a data frame to the AP, receiving downlink spatial stream information indicating the number of spatial streams allocated for the downlink transmission and uplink spatial stream information indicating the number of spatial streams allocated for the uplink transmission, and receiving a data frame by using the allocated spatial stream indicated

by the downlink spatial stream information at a time indicated by the downlink transmission time information, and transmitting a data frame by using the allocated spatial stream indicated by the uplink spatial stream information at a time indicated by the uplink transmission time information.

Advantageous Effects of Invention

[0029] According to the present invention, downlink transmission or uplink transmission can be performed simultaneously by respective stations in a wireless local area network (WLAN) system, and physical layer (PHY) interfaces of an access point (AP) can be used by adaptively dividing the interfaces, thereby improving usage efficiency of a radio resource.

Brief Description of Drawings

[0030] FIG. 1 is a schematic view showing an exemplary structure of a wireless local area network (WLAN) system to which an embodiment of the present invention can be applied.

[0031] FIG. 2 shows an example of a power save multi-poll (PSMP) operation in a wireless WLAN system according to an embodiment of the present invention.

[0032] FIG. 3 shows some constitutional elements included in a PSMP frame that can be used in a PSMP procedure of a WLAN system according to an embodiment of the present invention.

[0033] FIG. 4 shows an exemplary format of a PSMP header field.

[0034] FIG. 5 shows an exemplary format of a PSMP STA info field.

[0035] FIG. 6 shows an exemplary PSMP frame format for a space division PSMP according to an embodiment of the present invention.

[0036] FIG. 7 is a diagram showing an example of distributing a physical layer (PHY) interface.

[0037] FIG. 8 is a block diagram showing a wireless apparatus for implementing an embodiment of the present invention.

Mode for the Invention

[0038] Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings. Embodiments of the present invention described below can be effectively applied to a very high throughput (VHT) wireless local area network (WLAN) system operating in a band of 60 GHz. However, the present invention is not limited thereto. For example, the embodiments of the present invention can be also equally applied to a VHT WLAN system operating in a band of 6 GHz or lower.

[0039] FIG. 1 is a schematic view showing an exemplary structure of a WLAN system to which an embodiment of the present invention can be applied.

[0040] Referring to FIG. 1, the WLAN system includes one or more basis service sets

(BSSs). The BSS is a set of stations (STAs) which are successfully synchronized to communicate with one another, and is not a concept indicating a specific region. The BSS can be classified into an infrastructure BSS and an independent BSS (IBSS). The infrastructure BSS is shown in FIG. 1. Infrastructure BSSs (i.e., BSS1 and BSS2) include one or more STAs (i.e., STA1, STA3, and STA4), access points (APs) which are STAs providing a distribution service, and a distribution system (DS) connecting a plurality of APs (i.e., AP1 and AP2). On the other hand, the IBSS does not include APs, and thus all STAs are mobile STAs. In addition, the IBSS constitutes a self-contained network since connection to the DS is not allowed.

[0041] The STA is an arbitrary functional medium including a medium access control (MAC) and wireless-medium physical layer interface conforming to the institute of electrical and electronics engineers (IEEE) 802.11 standard, and includes both an AP and a non-AP STA in a broad sense. A VHT STA is defined as an STA that supports super high-rate data processing of 1 GHz or higher in the multi-channel environment to be described below. In the VHT WLAN system to which the embodiment of the present invention is applicable, STAs included in the BSS may be all VHT STAs, or a VHT STA and a legacy STA (i.e., IEEE 802.11n-based HT STA) may coexist.

[0042] Among the STAs, non-AP STAs (i.e., STA1, STA3, STA4, STA6, STA7, and STA8) are portable terminals operated by users. A non-AP STA may be simply referred to as an STA. The non-AP STA may also be referred to as a wireless transmit/receive unit (WTRU), a user equipment (UE), a mobile station (MS), a mobile terminal, a mobile subscriber unit, etc. A non-AP VHT-STA (or simply a VHT STA) is defined as a non-AP STA that supports the super high-speed data processing of 1 GHz or higher in the multi-channel environment to be described below.

[0043] The AP (i.e., AP1 and AP2) is a functional entity for providing connection to the DS through a wireless medium for an associated STA. Although communication between non-AP STAs in an infrastructure BSS including the AP is performed via the AP in principle, the non-AP STAs can perform direct communication when a direct link is set up. In addition to the terminology of an access point, the AP may also be referred to as a centralized controller, a base station (BS), a node-B, a base transceiver system (BTS), a site controller, etc. A VHT AP is defined as an AP that supports the super high-speed data processing of 1 GHz or higher in the multi-channel environment to be described below.

[0044] A plurality of infrastructure BSSs can be interconnected by the use of the DS. An extended service set (ESS) is a plurality of BSSs connected by the use of the DS. STAs included in the ESS can communicate with one another. In the same ESS, a non-AP STA can move from one BSS to another BSS while performing seamless communication.

[0045] The DS is a mechanism whereby one AP communicates with another AP. By using the DS, an AP may transmit a frame for STAs associated with a BSS managed by the AP, or transmit a frame when any one of the STAs moves to another BSS, or transmit a frame to an external network such as a wired network. The DS is not necessarily a network, and has no limitation in its format as long as a specific distribution service specified in the IEEE 802.11 can be provided. For example, the DS may be a wireless network such as a mesh network, or may be a physical structure for interconnecting APs.

[0046] Meanwhile, there is a need for several STAs to simultaneously use a channel in an effective manner so that an aggregated throughput of a basic service set (BSS) satisfies 1 Gbps. In order for the several STAs to simultaneously use the channel in an effective manner, the AP may use a space division multiple access (SDMA) mechanism. That is, transmission and reception are allowed to be performed simultaneously by the several STAs and the AP.

[0047] However, the number of spatial streams that can be simultaneously received by the AP may be limited by the number of available PHY interfaces of the AP. Further, the number of spatial streams transmitted by each STA may need to be controlled by the AP according to load balance and priority of a plurality of pieces of uplink traffic. For this, a method of assigning the number of spatial streams to be allocated to each STA and for reporting this number to each STA is proposed.

[0048] According to the embodiment of the present invention, the AP having a plurality of PHY interfaces adaptively distributes/allocates to STAs a spatial stream that can be used for data transmission, and the STAs communicate with the AP by using the allocated spatial stream. For this, the AP may transmit, to each STA, information indicating the number of available spatial streams and information indicating the number of spatial streams allocated to each STA. Herein, a frame containing the information indicating the number of spatial streams allocated to each STA may be an IEEE 802.11 standard's control frame, management frame, and data frame or may be an additional management frame for delivering information indicating the number of spatial streams additionally allocated. These frames may be individually transmitted to each STA or may be multicast/broadcast.

[0049] For example, when STAs have 4 PHY interfaces and the AP has 8 PHY interfaces, if it is assumed that any one STA can transmit and receive 4 spatial streams to the AP, up to 2 STAs can simultaneously communicate with the AP. If it is assumed that one STA transmits and receives 2 streams, up to 4 STAs can simultaneously communicate with the AP.

[0050] In order to optimize resource utilization in the WLAN system, the PHY interfaces need to be dynamically distributed to each STA. In the above example, in order for the

4 STAs to simultaneously communicate with the AP, the AP has to allow the STAs to use only 2 PHY interfaces. This is because the AP having the 8 PHY interfaces supports up to 8 spatial streams by using SDMA. In this case, by collectively considering an AC category to be transmitted by each STA and the number of contenting STAs, the AP may allocate a maximum number of spatial streams that can be used by each STA for data transmission and then may transmit this number to each STA.

[0051] When the AP allocates and reports the number of spatial streams to each STA, a power save multi-poll (PSMP) frame of the IEEE 802.11 standard may be used as an example of a frame to be used. In addition to configuration of a downlink transmission time (DTT) and an uplink transmission time (UTT), the PSMP frame according to the embodiment of the present invention further includes a subframe containing information indicating the number of spatial streams allocated to each STA at the DTT and the UTT. This will be described below in detail together with a frame structure.

[0052] FIG. 2 shows an example of a PSMP operation in a wireless WLAN system according to an embodiment of the present invention. The PSMP operation includes a PSMP frame transmission phase 200, a downlink (DL) phase 210, and an uplink (UL) Phase 220. The PSMP operation can be expressed with a PSMP sequence. The PSMP sequence denotes a sequence of which a first frame is a PSMP frame followed by zero or more frames transmitted at a PSMP-downlink transmission time (DTT) and followed by zero or more frames transmitted at a PSMP uplink transmission time (UTT).

[0053] Referring to FIG. 2, in the first phase of the PSMP operation, i.e., the PSMP frame transmission phase 200, an AP multicasts/broadcasts a PSMP frame 205. That is, a first frame of the PSMP sequence is a PSMP frame, and a destination address (DA) or a receiving address (RA) of the PSMP frame is a specific group address. The PSMP frame 205 is an action frame transmitted by the AP to a specific group of STAs, and may include information on a DTT in the DL phase 210 and information on a UTT in the UL phase 220, that is, information indicating to which STAs the DTT is allocated and to which STAs the UTT is allocated. For example, in case of the PSMP sequence shown in FIG. 2, the PSMP frame includes information indicating that a DTT1 and a DTT2 of the DL phase are allocated respectively to an STA1 and an STA2, and a UTT1 and a UTT2 of the UL phase are allocated respectively to the STA1 and the STA2. Further, according to the embodiment of the present invention, when a specific DTT and/or UTT are allocated to a specific STA, the PSMP frame may include information indicating the number of radio resources allocated to the DTT and/or UTT, that is, the number of available spatial streams, which will be described below.

[0054] Further, when the PSMP frame transmission phase 200 ends, the DL phase 210 starts after a specific frame interval (e.g., a reduced inter-frame spacing (RIFS) 250). In the

DL phase 210, i.e., in the DTT, the STA1 transitions to an awake state in a DTT1 211 to receive data transmitted from the AP. When the DTT1 211 ends, the STA1 can enter a doze state. Subsequently, the STA2 transitions to the awake state in a DTT2 212 to receive data transmitted from the AP. When the DTT2 212 ends, the STA2 can return to the doze state.

[0055] When the DL phase ends, the UL phase 220 starts. In the UL 220, i.e., in the UTT, the STA1 first transitions to the awake state to transmit data to the AP. When a UTT1 221 ends, the STA1 can return to the doze state. Subsequently, the STA2 transitions to the awake state to transmit data to the AP. When a UTT2 222 ends, the STA2 can return to the doze state. By performing such an operation, the STA operates in the awake state only when data transmission/reception is achieved, and otherwise transitions to the doze state, thereby minimizing power consumption of the STA.

[0056] FIG. 3 shows some constitutional elements included in a PSMP frame that can be used in a PSMP procedure of a WLAN system according to an embodiment of the present invention.

[0057] The PSMP frame includes a 'frame control + duration' field 310, a receiver address (RA) field 320, a transmitter address (TA) field 330, a BSS identifier (ID) field 340, a management action header (simply, mgmt action header) field 350, a PSMP header field 360, N pieces of PSMP station information (simply, PSMP STA info) field 370, and a cyclic redundancy check (CRC) field 380.

[0058] The 'frame control + duration' field 310 includes duration information for configuring a network allocation vector (NAV) with respect to a neighboring STA together with a variety of information required to control a management action frame. Information for frame control includes a protocol version, a type and subtype, 'To DA', 'From DS', power management, etc., for exemplary purposes only. Herein, the type of the PSMP frame may be a management frame, and the subtype thereof may be an action frame.

[0059] The RA field 320 is for specifying a receiving STA of the PSMP frame. In case of the PSMP frame, the RA or a destination address (DA) may be specified to a specific group address or may be set to a broadcast address.

[0060] The TA field 330 may be set to an address of a VHT AP for transmitting the PSMP frame.

[0061] The BSSID field 340 is set to a value indicating an ID of a BSS managed by the VHT AP for transmitting the PSMP frame.

[0062] The mgmt action header field 340 may include information other than the aforementioned information included in a header part of the mgmt action field, and is also referred to as a PSMP parameter set field. The mgmt action header field defines the number of PSMP STA info fields included in the PSMP frame, and indicates whether

the PSMP frame is followed by an additional PSMP frame. Further, the mgmt action header field is used to indicate a duration of the PSMP sequence.

[0063] FIG. 4 shows an exemplary format of the PSMP header field 360. The PSMP header field 360 includes an STA number (simply, N_STA) subfield 410 indicating the number of PSMP STA info fields existing in the PSMP frame including the PSMP header field 360, a more PSMP indicator subfield 420 indicating whether the PSMP frame is followed by another PSMP frame, and a PSMP sequence duration subfield 430 indicating a duration of the PSMP frame.

[0064] FIG. 5 shows an exemplary format of the PSMP STA info field 370. The PSMP STA info field 370 of FIG. 5 relates to a conventional individually addressed case, and may include zero or at least one downlink PSMP STA info filed and zero or at least one uplink PSMP STA info field.

[0065] The PSMP STA info field 370 includes a station information type (simply, STA_INFO type) subfield 510, a DTT start offset subfield 520, a DTT duration subfield 530, an STA ID subfield 540, a UTT start offset subfield 550, and a UTT duration subfield 560.

[0066] The STA_INFO type subfield indicates whether a PSMP STA info field is an individually addressed case or a group addressed case. If it is the individually addressed case as in the example of FIG. 5, a value of the STA_INFO type subfield 510 may be set to 2.

[0067] The DTT start offset subfield 520 indicates a start of a PSMP-DTT relative to an end of a PSMP frame with respect to a destination identified by the PSMP STA info field. The UTT start offset subfield 550 indicates a start of a PSMP_UTT relative to an end of the PSMP frame with respect to the destination identified by the PSMP STA info field. This subfield indicates a start time of a first PPDU including downlink/uplink data with respect to the destination.

[0068] The DTT duration subfield 530 indicates a duration of the PSMP-DTT with respect to the destination identified by the PSMP STA info field. The UTT duration subfield 560 indicates a duration of the PSMP-UTT with respect to the destination identified by the PSMP STA info field. This subfield indicates an end time of a last PPDU including downlink/uplink data with respect to the destination, and a value set in this subfield is relative to a value set in the PSMP-DTT/UTT start offset subfield.

[0069] The STA ID subfield includes an association identifier (AID) of an STA directed by the PSMP STA info field.

[0070] When the conventional PSMP protocol is used in a VHT system, one STA uses any DTT or UTT allocated to the STA. However, in a VHT system supporting space-division multiple access (SDMA) according to the embodiment of the present invention, any DTT or UTT may be allocated to a plurality of STAs. For example,

when an AP allocates the UTT to the STAs, the same UTT may be allocated to the plurality of STAs and thus the plurality of STAs can simultaneously perform uplink transmission to the AP.

[0071] In other words, when the SDMA is supported, it is possible for the STAs to simultaneously perform channel access. That is, STAs having the same UTT time simultaneously transmit uplink traffic to the AP.

[0072] According to the embodiment of the present invention, the AP allocates a maximum number of spatial streams usable by each STA to transmit uplink traffic, and then transmits spatial stream allocation information by containing the information in the PSMP frame. The PSMP frame further including information indicating the number of spatial streams allocated to each STA in a DTT and a UTT according to the embodiment of the present invention is referred to as a space division PSMP frame.

[0073] The space division PSMP frame may report to each STA the number of spatial streams allocated to each STA by using a reserved bit in the PSMP frame of FIG. 5.

[0074] The AP may transmit spatial stream information indicating the number of spatial streams allocated to each STA by containing the information in the space division PSMP, or may transmit downlink spatial stream information indicating the number of spatial streams allocated to each STA in a DTT and uplink spatial stream information indicating the number of spatial streams allocated to each STA in a UTT by containing the information in the space division PSMP. In this case, the spatial stream information indicating the number of spatial streams allocated to each STA may be set to a value indicating the total number of spatial streams allocated to each STA, or may be set to a value indicating the number of extension spatial streams additionally allocated in addition to one spatial stream allocated basically to each STA.

[0075] FIG. 6 shows an exemplary PSMP frame format for a space division PSMP according to an embodiment of the present invention.

[0076] Referring to FIG. 6, a 'number of DTT spatial streams' field 610 indicates the number of spatial streams additionally allocated in a downlink transmission duration of an STA, and a 'number of UTT spatial streams' field 620 indicates the number of spatial streams additionally allocated in an uplink transmission duration of the STA. When transmission is performed by differently setting a value of the 'number of DTT spatial streams' field 610 and a value of the 'number of UTT spatial streams' field 620, as described above, the number of spatial streams allocated to one STA in a downlink transmission time may be set differently from the number of spatial streams allocated in an uplink transmission time.

[0077] In case of using the space division PSMP, uplink transmission and downlink transmission can be performed simultaneously by several STAs in any time. However, in a PSMP sequence, a downlink phase and an uplink phase cannot overlap with each

other. That is, during a time in which a DTT is allocated to a specific STA, a UTT cannot be allowed to another STA.

[0078] FIG. 7 is a diagram showing an example of distributing a PHY interface.

[0079] Referring to FIG. 7, an AP 700 has 8 available PHY interfaces, which is a case where a maximum number of allowable spatial streams is 8. In the present example, the same DTT and UTT are allocated to each of an STA1 710, an STA2 720, and an STA3 730. That is, the STA1 710, the STA2 720, and the STA3 730 simultaneously receive downlink data from the AP and transmit uplink data to the AP. In this case, three spatial streams, one spatial stream, and one spatial stream are additionally allocated respectively to the STA1 710, the STA2 720, and the STA3 730. In FIG. 7, extension spatial streams 715 denote spatial streams additionally allocated to the STA1 701, an extension spatial stream 725 denotes a spatial stream additionally allocated to the STA2 720, and an extension spatial stream 735 denotes a spatial stream additionally allocated to the STA3 730.

[0080] Regarding all spatial streams transmitted in any time, the STA1 710, the STA2 720, and the STA3 730 respectively use four spatial streams, two spatial streams, and two spatial steams, i.e., eight spatial streams in total. The total number of spatial streams does not exceed 8 which is the number of allowable spatial streams according to the number of available PHY interfaces of the AP 700. The number of extension spatial streams that can be used by each STA according to such available PHY interface resource allocation may change by reallocation of the AP. Further, the number of spatial streams additionally allocated to one STA in a downlink transmission time and the number of spatial streams additionally allocated to each STA in an uplink transmission time may also change. As such, the AP can adaptively adjust the number of spatial streams allocated to each STA according to the number of STAs or an amount of data to be transmitted, priority, etc. Therefore, radio resource efficiency can be improved.

[0081] FIG. 8 is a block diagram showing a wireless apparatus for implementing an embodiment of the present invention. A wireless apparatus 800 may be an AP or a non-AP STA.

[0082] The wireless apparatus 800 includes a processor 810, a memory 820, a transceiver 830, and an antenna 850. The transmitter 830 transmits/receives a radio signal, and implements an IEEE 802.11 physical layer. The transmitter 830 supports directional transmission through the antenna 850. The processor 810 is coupled to the transmitter 830, and implements an IEEE 802.11 MAC layer. When the processor 810 processes an operation of the AP in the aforementioned method, the wireless apparatus 800 is the AP. When the processor 810 processes an operation of the non-AP STA in the aforementioned method, the wireless apparatus 800 is the non-AP STA. The processor 810

and/or the transmitter 830 may include an application-specific integrated circuit (ASIC), a separate chipset, a logic circuit, and/or a data processing unit. The memory 820 may include a read-only memory (ROM), a random access memory (RAM), a flash memory, a memory card, a storage medium, and/or other equivalent storage devices. When the embodiment of the present invention is implemented in software, the aforementioned methods can be implemented with a module (i.e., process, function, etc.) for performing the aforementioned functions. The module may be stored in the memory 820 and may be performed by the processor 810. The memory 820 may be located inside or outside the processor 810, and may be coupled to the processor 810 by using various well-known means.

[0083] The aforementioned embodiments include various exemplary aspects. Although all possible combinations for representing the various aspects cannot be described, it will be understood by those skilled in the art that other combinations are also possible. Therefore, all replacements, modifications and changes should fall within the spirit and scope of the claims of the present invention.

[0084]

Claims

[Claim 1] A method of scheduling a radio medium access time of a station, the method comprising:transmitting, to a first station, first downlink transmission time information indicating a time scheduled for first downlink transmission for transmitting a data frame to the first station; andtransmitting second downlink transmission time information indicating a time scheduled for second downlink transmission for transmitting a data frame to a second station,wherein first downlink spatial stream information indicating the number of spatial streams allocated for the first downlink transmission is transmitted to the first station, second downlink spatial stream information indicating the number of spatial streams allocated for the second downlink transmission is transmitted to the second station, and the time scheduled for the first downlink transmission is equal to the time scheduled for the second downlink transmission.

[Claim 2] The method of claim 1, wherein the first downlink transmission time information and the first downlink spatial stream information are transmitted to the first station by using a first frame, and the second downlink transmission time information and the second downlink spatial stream information are transmitted to the second station by using a second frame.

[Claim 3] The method of claim 1, wherein the first downlink transmission time information and the first downlink spatial stream information and the second downlink transmission time information and the second downlink spatial stream information are transmitted by using a station information field of a power save multi-poll (PSMP) frame, and the PSMP frame is multicast to the first station and the second station.

[Claim 4] The method of claim 1, wherein the first station wakes up from a doze state of a power save mode at a time indicated by the first downlink transmission time information to receive the first downlink transmission performed by an access point (AP), and returns to the doze state at the completion of the first downlink transmission, andwherein the second station wakes up from the doze state at a time indicated by the second downlink transmission time information to receive the second downlink transmission performed by the AP, and returns to the doze state at the completion of the second downlink transmission.

[Claim 5] A method of scheduling a radio medium access time of a station, the method comprising:transmitting, to a first station, first uplink transmission time information indicating a time scheduled for first uplink transmission for transmitting a data frame by the first station to an access point (AP); andtransmitting second uplink transmission time information indicating a time scheduled for second uplink transmission for transmitting a data frame by a second station to the AP,wherein first uplink spatial stream information indicating the number of spatial streams allocated for the first uplink transmission is transmitted to the first station, second uplink spatial stream information indicating the number of spatial streams allocated for the second uplink transmission is transmitted to the second station, and the time scheduled for the first uplink transmission is equal to the time scheduled for the second uplink transmission.

[Claim 6] The method of claim 5, wherein the first uplink transmission time information and the first uplink spatial stream information are transmitted to the first station by using a first frame, and the second uplink transmission time information and the second uplink spatial stream information are transmitted to the second station by using a second frame.

[Claim 7] The method of claim 5, wherein the first downlink transmission time information and the first downlink spatial stream information and the second downlink transmission time information and the second downlink spatial stream information are transmitted by using a station information field of a power save multi-poll (PSMP) frame, and the PSMP frame is multicast to the first station and the second station.

[Claim 8] The method of claim 5,wherein the first station wakes up from a doze state of a power save mode at a time indicated by the first uplink transmission time information to receive the first uplink transmission performed by the AP, and returns to the doze state at the completion of the first uplink transmission, and wherein the second station wakes up from the doze state at a time indicated by the second uplink transmission time information to receive the second uplink transmission performed by the AP, and returns to the doze state at the completion of the second uplink transmission.

[Claim 9] A method of transmitting a frame of a station, the method comprising:receiving downlink transmission time information indicating a time scheduled for downlink transmission for receiving a

data frame from an access point (AP) and uplink transmission time information indicating a time scheduled for uplink transmission for transmitting a data frame to the AP;receiving downlink spatial stream information indicating the number of spatial streams allocated for the downlink transmission and uplink spatial stream information indicating the number of spatial streams allocated for the uplink transmission; andreceiving a data frame by using the allocated spatial stream indicated by the downlink spatial stream information at a time indicated by the downlink transmission time information, and transmitting a data frame by using the allocated spatial stream indicated by the uplink spatial stream information at a time indicated by the uplink transmission time information.

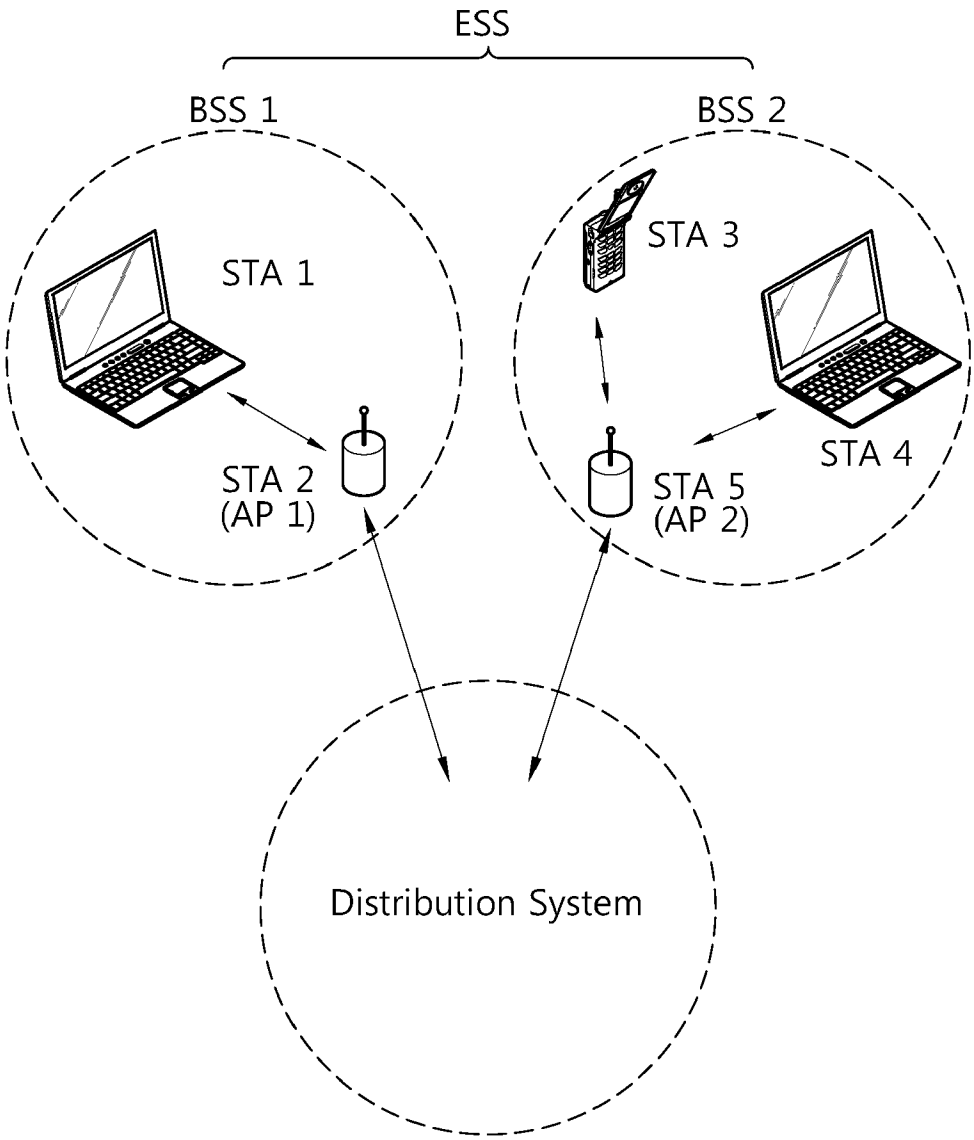
[Claim 10] The method of claim 9, wherein the station operates in a power save mode, wakes up from a doze state at the time indicated by the downlink transmission time information or the time indicated by the uplink transmission time information to transmit a frame, and returns to the doze state at the completion of the time indicated by the downlink transmission time information or the time indicated by the uplink transmission time information.

[Claim 11] An access point (AP) for scheduling a radio medium access time of a station, the AP comprising:a transceiver; anda processor operationally coupled to the transceiver, wherein the processor is configured for:transmitting, to a first station, first downlink transmission time information indicating a time scheduled for first downlink transmission for transmitting a data frame to the first station; andtransmitting second downlink transmission time information indicating a time scheduled for second downlink transmission for transmitting a data frame to a second station,wherein first downlink spatial stream information indicating the number of spatial streams allocated for the first downlink transmission is transmitted to the first station, second downlink spatial stream information indicating the number of spatial streams allocated for the second downlink transmission is transmitted to the second station, and the time scheduled for the first downlink transmission is equal to the time scheduled for the second downlink transmission.

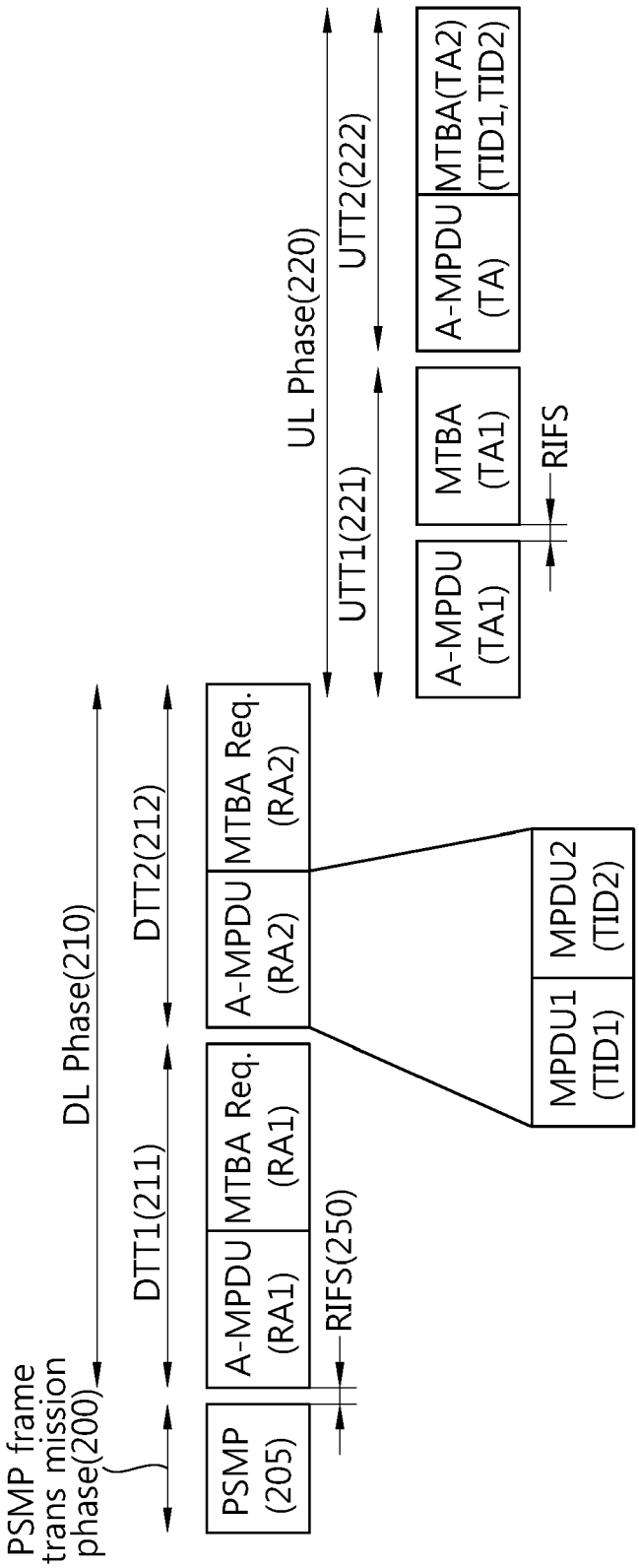
[Claim 12] A station for performing an operation by accessing a channel in a wireless local area network (WLAN) system, the station comprising:a transceiver; anda processor operationally coupled to the transceiver,wherein the processor is configured for:receiving downlink

transmission time information indicating a time scheduled for downlink transmission for receiving a data frame from an access point (AP) and uplink transmission time information indicating a time scheduled for uplink transmission for transmitting a data frame to the AP;receiving downlink spatial stream information indicating the number of spatial streams allocated for the downlink transmission and uplink spatial stream information indicating the number of spatial streams allocated for the uplink transmission; andreceiving a data frame by using the allocated spatial stream indicated by the downlink spatial stream information at a time indicated by the downlink transmission time information, and transmitting a data frame by using the allocated spatial stream indicated by the uplink spatial stream information at a time indicated by the uplink transmission time information.

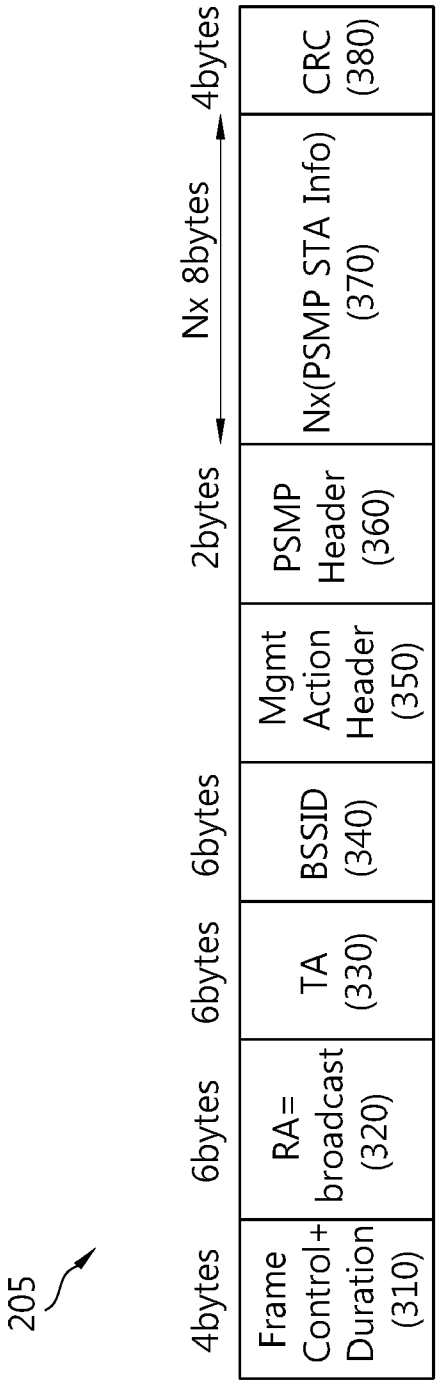
[Fig. 1]


ESS
BSS 1
BSS 2
STA 1
STA 3
STA 4
STA 2
(AP 1)
STA 5
(AP 2)
Distribution System

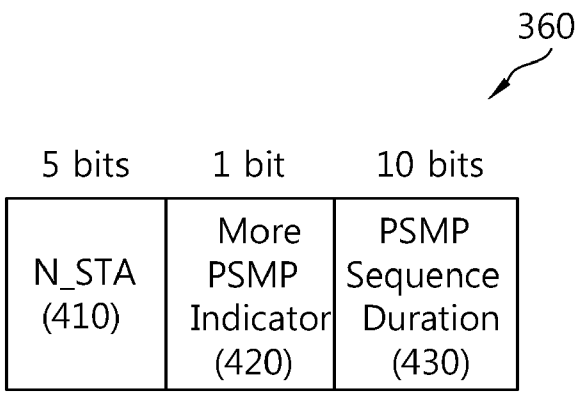
[Fig. 2]


PSMP frame trans mission phase(200)
DL Phase(210)
DTT1(211)
DTT2(212)
UL Phase(220)
UTT1(221)
UTT2(222)
PSMP (205)
A-MPDU (RA1)
MTBA Req. (RA1)
RIFS(250)
A-MPDU (RA2)
MTBA Req. (RA2)
MPDU1 (TID1)
MPDU2 (TID2)
A-MPDU (TA1)
MTBA (TA1)
RIFS
A-MPDU (TA)
MTBA(TA2) (TID1,TID2)

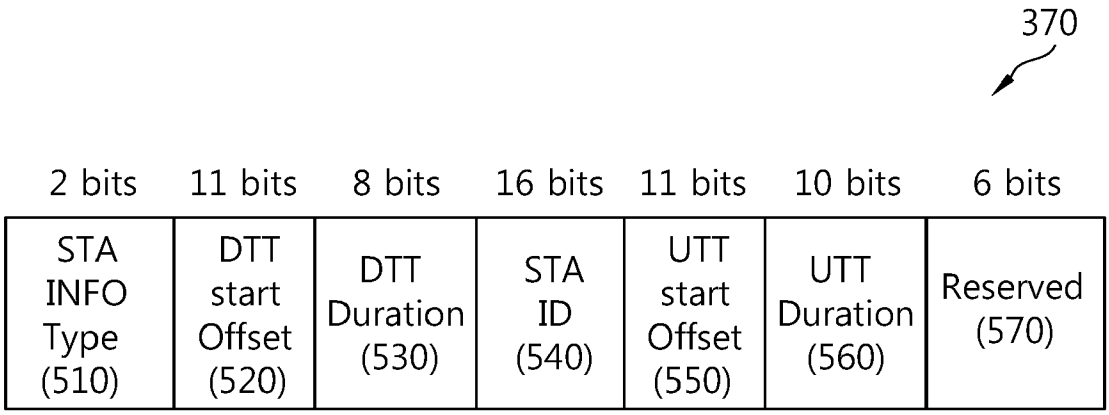
[Fig. 3]


205
4bytes
Frame Control+ Duration (310)
6bytes
RA= broadcast (320)
6bytes
TA (330)
6bytes
BSSID (340)
Mgmt Action Header (350)
2bytes
PSMP Header (360)
Nx 8bytes
Nx(PSMP STA Info) (370)
4bytes
CRC (380)

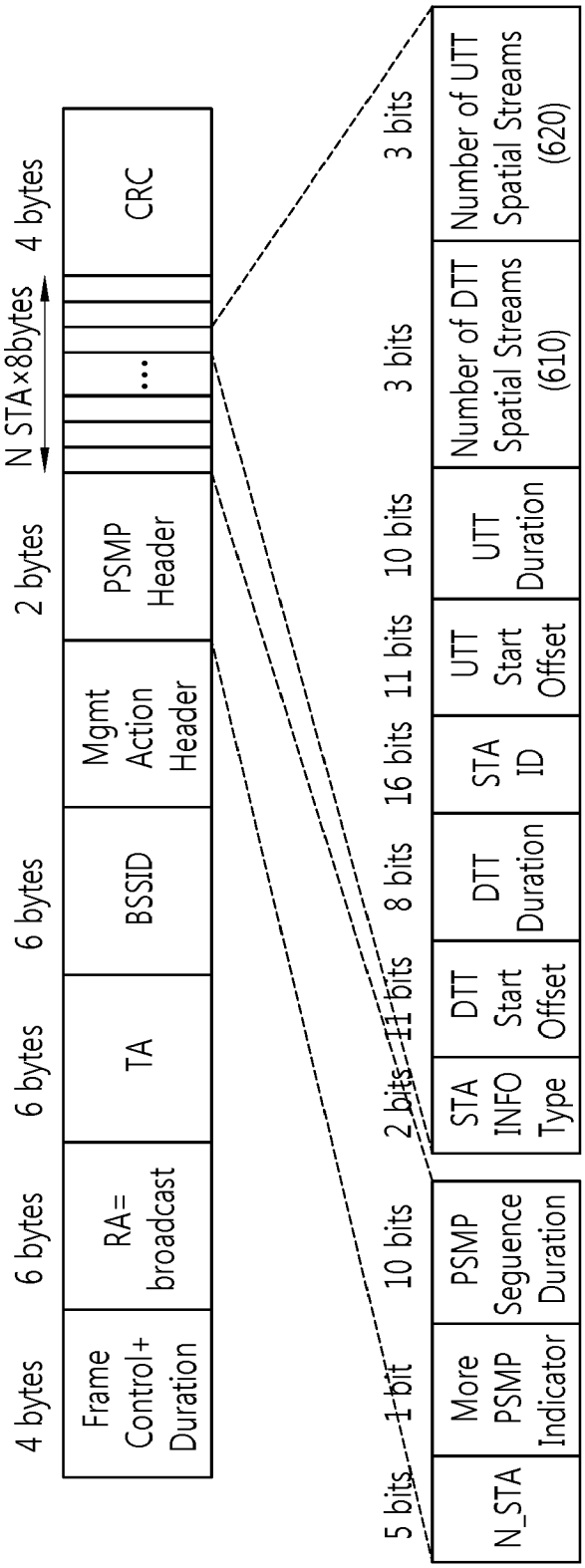
[Fig. 4]


360
5 bits
1 bit
10 bits
N_STA (410)
More PSMP Indicator (420)
PSMP Sequence Duration (430)

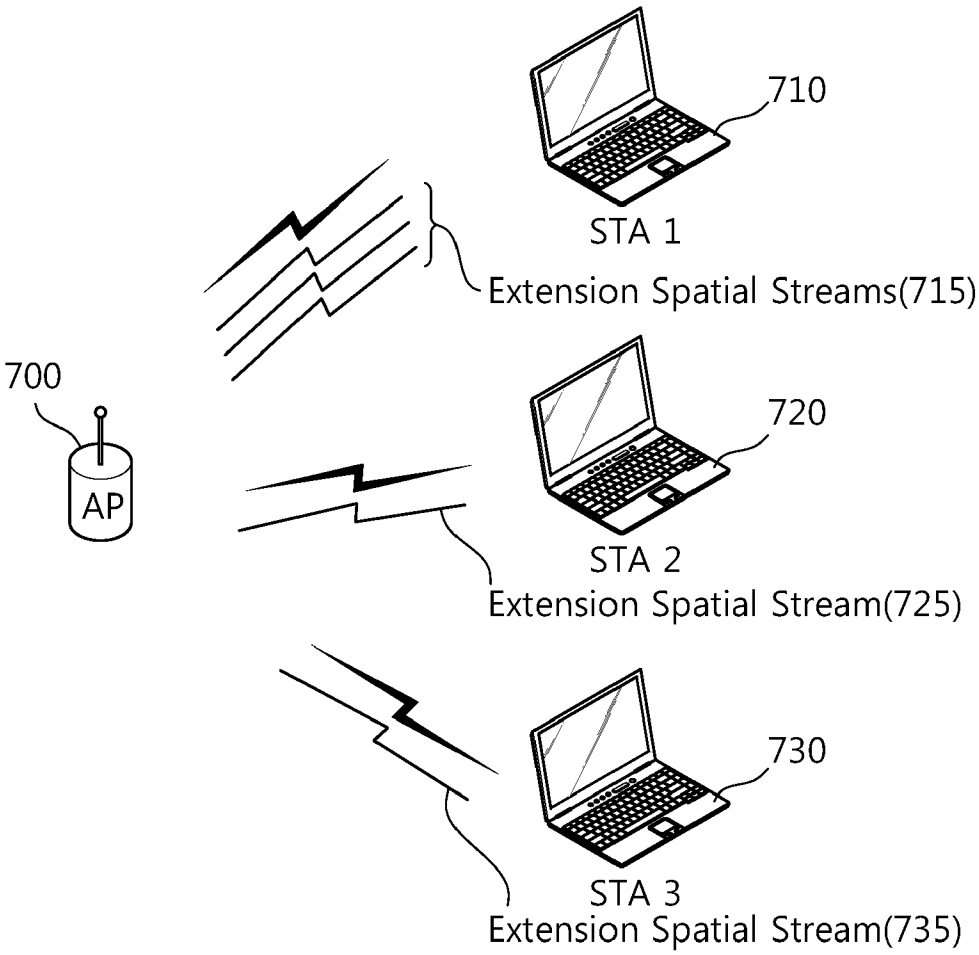
[Fig. 5]


370
2 bits
11 bits
8 bits
16 bits
11 bits
10 bits
6 bits
STA INFO Type (510)
DTT start Offset (520)
DTT Duration (530)
STA ID (540)
UTT start Offset (550)
UTT Duration (560)
Reserved (570)

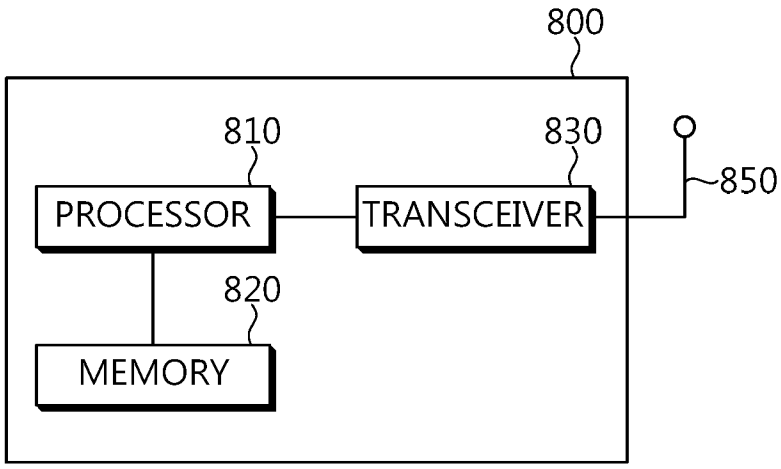
[Fig. 6]


Frame Control+ Duration
4 bytes
RA= broadcast
6 bytes
TA
6 bytes
BSSID
6 bytes
Mgmt Action Header
PSMP Header
2 bytes
...
N STA×8bytes
CRC
4 bytes
N_STA
5 bits
More PSMP Indicator
1 bit
PSMP Seguence Duration
10 bits
STA INFO Type
2 bits
DTT Start Offset
11 bits
DTT Duration
8 bits
STA ID
16 bits
UTT Start Offset
11 bits
UTT Duration
10 bits
Number of DTT Spatial Streams (610)
3 bits
Number of UTT Spatial Streams (620)
3 bits

[Fig. 7]


710
STA 1
Extension Spatial Streams(715)
700
AP
720
STA 2
Extension Spatial Stream(725)
730
STA 3
Extension Spatial Stream(735)

[Fig. 8]


800
810
830
850
PROCESSOR
TRANSCEIVER
820
MEMORY