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(54) **CHANNEL ACCESS METHOD FOR VERY HIGH THROUGHPUT (VHT) WIRELESS LOCAL ACCESS NETWORK SYSTEM AND STATION SUPPORTING THE CHANNEL ACCESS METHOD**

(71) Applicant: **LG Electronics Inc.**, Seoul (KR)

(72) Inventor: **Yong Ho Seok**, Anyang-si (KR)

(73) Assignee: **LG Electronics Inc.**, Seoul (KR)

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CPC ... **H04W 74/0816** (2013.01); **H04W 72/0446** (2013.01); **H04W 74/006** (2013.01)

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CPC H04W 74/0816; H04W 72/0466; H04W 74/006

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,721,725 A 2/1998 Want et al.
6,393,032 B1 5/2002 Ikegami

(Continued)

FOREIGN PATENT DOCUMENTS

JP 2003-348641 A 12/2003
JP 2003348641 12/2003

(Continued)

OTHER PUBLICATIONS

Schenk, Tim C.W., Guido Dolmans, and Isabella Modonesi “Throughput of a MIMO OFDM Based WLAN System”, Proceedings of the IEEE Symposium on Communications and Vehicular Technology (SCVT 2004), Nov. 2004. (Year: 2004).*

(Continued)

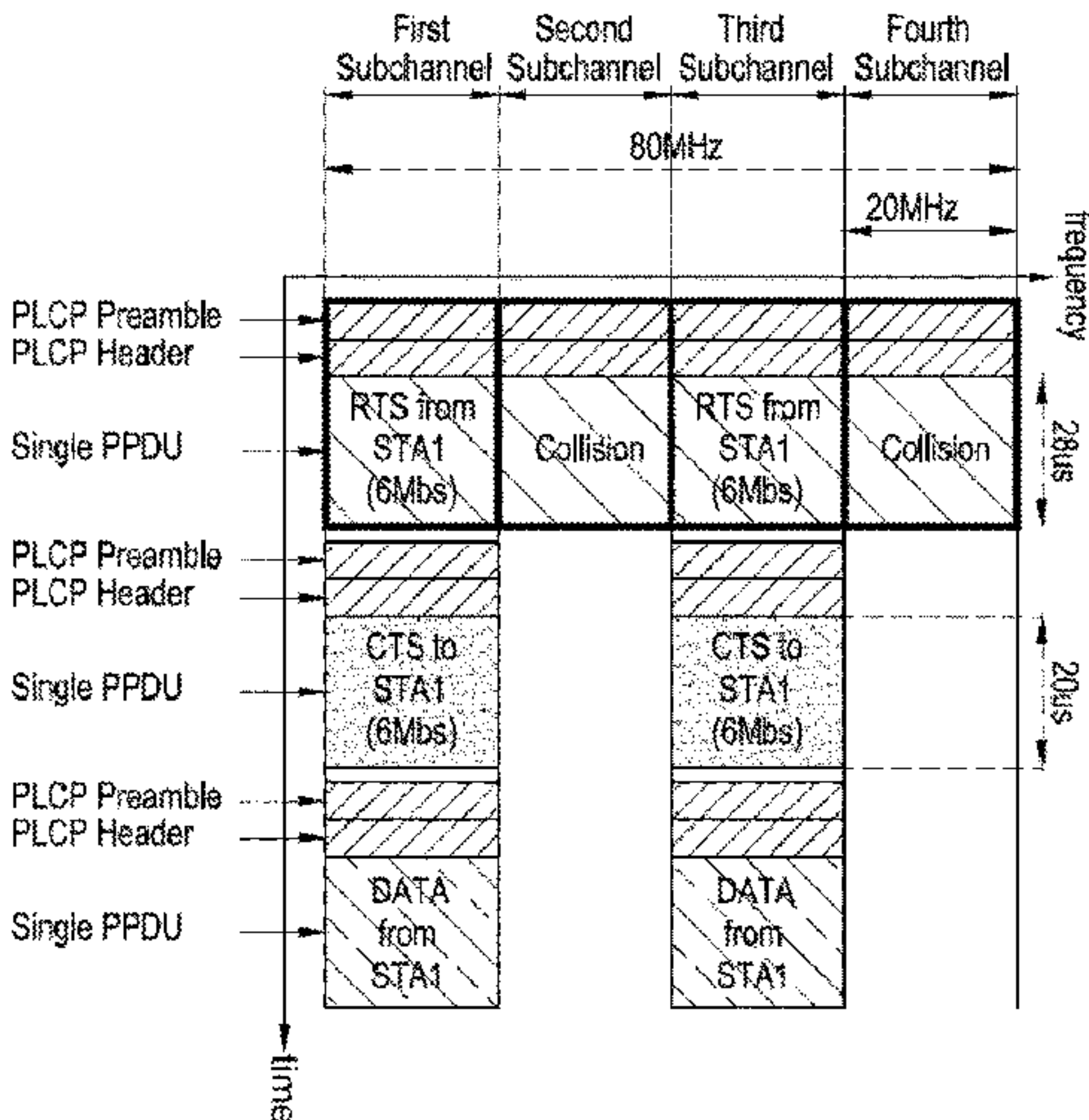
Primary Examiner — Luke S Wassum

(74) *Attorney, Agent, or Firm* — Fish & Richardson P.C.

(57) **ABSTRACT**

A method for transmitting data in a wireless communication system, the method includes transmitting, by a first station, a plurality of request to send (RTS) frames to a second station through a plurality of subchannels, each of the plurality of RTS frames being transmitted through a corresponding one of the plurality of subchannels, each of the plurality of subchannels having a 20 megahertz (MHz) bandwidth; receiving, by the first station, at least one clear to send (CTS) frame in response to at least one of the plurality of RTS frames from the second station through at least one idle subchannel of the plurality of subchannels; and transmitting, by the first station, a data frame to the second station after receiving the at least one CTS frame, wherein each of the plurality of RTS frames includes first channel information related to the plurality of subchannels.

12 Claims, 8 Drawing Sheets



Related U.S. Application Data

continuation of application No. 14/800,425, filed on Jul. 15, 2015, now Pat. No. 9,526,114, which is a continuation of application No. 14/579,286, filed on Dec. 22, 2014, now Pat. No. 9,107,222, which is a continuation of application No. 12/999,836, filed as application No. PCT/KR2009/003264 on Jun. 18, 2009, now Pat. No. 8,989,158.

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(56)**References Cited**

U.S. PATENT DOCUMENTS

7,324,605 B2 1/2008 Maltsev et al.
7,349,436 B2 * 3/2008 Maltsev H04L 27/2602
370/471
7,693,175 B1 * 4/2010 Benveniste H04W 74/002
370/447
7,843,819 B1 * 11/2010 Benveniste H04W 74/00
370/230
8,233,462 B2 7/2012 Walton et al.
8,238,316 B2 * 8/2012 Stacey H04L 1/0091
370/338
8,289,865 B2 10/2012 Maltsev et al.
8,305,948 B2 11/2012 Surineni et al.
8,406,331 B2 * 3/2013 Orfanos H04L 5/0098
375/265
8,411,698 B2 * 4/2013 Lee H04W 52/0216
370/431
8,804,623 B2 * 8/2014 Stacey H04L 1/0091
370/328
8,989,158 B2 3/2015 Seok
9,025,544 B2 * 5/2015 Kim H04W 28/26
370/329
9,107,222 B2 8/2015 Seok
9,271,309 B2 * 2/2016 Kim H04W 74/0816
10,257,861 B2 * 4/2019 Gong H04W 74/0816
2001/0024427 A1 * 9/2001 Suzuki H04W 72/085
370/329
2004/0071154 A1 4/2004 Wentink
2004/0127223 A1 * 7/2004 Li H04L 5/006
455/446
2004/0196871 A1 * 10/2004 Terry H04W 28/06
370/477
2004/0264504 A1 * 12/2004 Jin H04W 74/002
370/469
2005/0135295 A1 6/2005 Walton et al.
2005/0141545 A1 6/2005 Fein et al.
2005/0143125 A1 * 6/2005 Maltsev H04L 1/0025
455/557
2005/0147075 A1 7/2005 Terry
2005/0152465 A1 7/2005 Maltsev et al.
2005/0152466 A1 7/2005 Maltsev et al.
2005/0152473 A1 7/2005 Maltsev et al. H04L 27/26
375/299
2005/0208956 A1 9/2005 Takagi et al.
2005/0285803 A1 12/2005 Iacono et al.
2006/0055958 A1 3/2006 Kim et al.
2006/0114826 A1 6/2006 Brommer
2006/0114867 A1 * 6/2006 Du H04W 74/002
370/338
2006/0221924 A1 10/2006 Yang et al.
2006/0223541 A1 10/2006 Famolari
2006/0251098 A1 11/2006 Morioka
2006/0256737 A1 11/2006 Choi et al.
2006/0280134 A1 12/2006 Kwon et al.
2006/0280154 A1 12/2006 Kwon et al. H04L 69/18
370/338
2007/0002814 A1 1/2007 Benveniste

2007/0019592 A1 1/2007 Otsuki
2007/0076675 A1 4/2007 Chen
2007/0133490 A1 6/2007 Kwon H04W 74/0816
370/338
2007/0140102 A1 * 6/2007 Oh H04L 5/0094
370/208
2007/0147322 A1 * 6/2007 Agrawal H04W 74/0816
370/445
2007/0153731 A1 7/2007 Fine
2007/0160040 A1 7/2007 Kwon
2007/0223439 A1 9/2007 Kosai H04W 72/0406
370/338
2007/0266157 A1 11/2007 Khafa et al. H04W 74/0808
709/225
2007/0297353 A1 * 12/2007 Habetha H04L 1/1607
370/310
2008/0004076 A1 1/2008 Adachi et al.
2008/0013496 A1 * 1/2008 Dalmases H04W 72/0446
370/336
2008/0056298 A1 3/2008 Nakayama
2008/0062922 A1 3/2008 Qi
2008/0075038 A1 3/2008 Jin et al.
2008/0089221 A1 * 4/2008 Bruninghaus H04L 1/1671
370/203
2008/0112351 A1 5/2008 Surineni et al.
2008/0144500 A1 6/2008 Chen et al.
2008/0144586 A1 6/2008 Kneckt et al.
2008/0170558 A1 * 7/2008 Jokela H04W 74/085
370/348
2008/0171552 A1 * 7/2008 Hyon H04W 72/0406
455/450
2008/0192644 A1 8/2008 Utsunomiya et al.
2008/0227403 A1 9/2008 Taki
2008/0232490 A1 9/2008 Gross et al.
2008/0273549 A1 11/2008 Orfanos et al.
2008/0285480 A1 11/2008 Panwar et al.
2009/0010234 A1 1/2009 Li et al.
2009/0010275 A1 1/2009 Diepstraten et al. . H04W 28/26
370/445
2009/0059891 A1 3/2009 Sakoda et al. H04L 43/0894
370/348
2009/0086706 A1 * 4/2009 Huang H04L 1/0026
370/349
2009/0103501 A1 4/2009 Farrag et al.
2009/0138603 A1 5/2009 Surineni et al. H04W 72/04
709/227
2009/0196180 A1 * 8/2009 Bahl H04L 5/0032
370/235
2009/0232155 A1 9/2009 Benveniste
2009/0303888 A1 * 12/2009 Ariyur H04W 24/02
370/252
2009/0316823 A1 12/2009 Lee et al.
2010/0046482 A1 2/2010 Sridhara et al.
2010/0150077 A1 6/2010 Nanda et al.
2010/0182986 A1 7/2010 Okuike
2011/0069628 A1 * 3/2011 Liu H04W 74/0816
370/252
2011/0299516 A1 12/2011 Kwon
2011/0305288 A1 * 12/2011 Liu H04L 47/10
375/260
2011/0310807 A1 12/2011 Grandhi et al.
2011/0310834 A1 * 12/2011 Seok H04W 72/14
370/329
2012/0014336 A1 * 1/2012 Seok H04L 5/0007
370/329
2012/0093085 A1 4/2012 Kwon et al.

FOREIGN PATENT DOCUMENTS

JP 2006-352844 A 12/2006
JP 2006352844 12/2006
JP 2007-60366 A 3/2007
JP 2007-67472 A1 3/2007
JP 200767472 3/2007
JP 2007060366 3/2007
JP 2007-532040 A 11/2007
JP 2007532040 11/2007

(56)

References Cited

FOREIGN PATENT DOCUMENTS

WO	WO 2005/043832	A1	5/2005	
WO	WO2005043832		5/2005	
WO	WO 2005/062536	A2	7/2005	
WO	WO2005062536		7/2005	
WO	WO 2006/092801	A2	9/2006	
WO	WO2006092801		9/2006	
WO	WO 2006/120979	A1	11/2006	
WO	WO2006120979		11/2006	
WO	WO 2007/047757	A1	4/2007	
WO	WO2007047757		4/2007	
WO	WO 2008/068729	A1	6/2008	
WO	WO2008068729		6/2008	
WO	WO-2009154406	A2 *	12/2009 H04W 4/20

OTHER PUBLICATIONS

Gilbert, Jeffrey M., Won-Joon Choi, and Qinfang Sun “MIMO Technology for Advanced Wireless Networks”, Proceedings of the

42nd Annual Design Automation Conference (DAC 2005), Jun. 13-17, 2005, pp. 413-415. (Year: 2005).*

Kuran, Mehmet S. and Tuna Tugcu “A Survey on Emerging Broadband Wireless Access Technologies”, Computer Networks, vol. 51, No. 11, Aug. 2007. (Year: 2007).*

Korean Intellectual Property Office “Written Opinion”, Application No. PCT/KR2009/003264, Jan. 15, 2010. (Year: 2010).*

Merlin, Simone et al. “CCA for RTS/CTS Operation in Wider Channels”, IEEE Document IEEE 802.11-10/1280r2, Nov. 8, 2010. (Year: 2010).*

Gong, Michelle et al. “RTS/CTS Operation for Wider Bandwidth”, IEEE Document IEEE 802.11-10/1289r2, Nov. 9, 2010. (Year: 2010).*

Xu et al., “Performance Comparison between Channel-Bonding and Multi-Channel CSMA”, Wireless Communications and Networking Conference, 2007. WCNC 2007, IEEE, Mar. 11, 2007, pp. 406-411.

* cited by examiner

FIG. 1

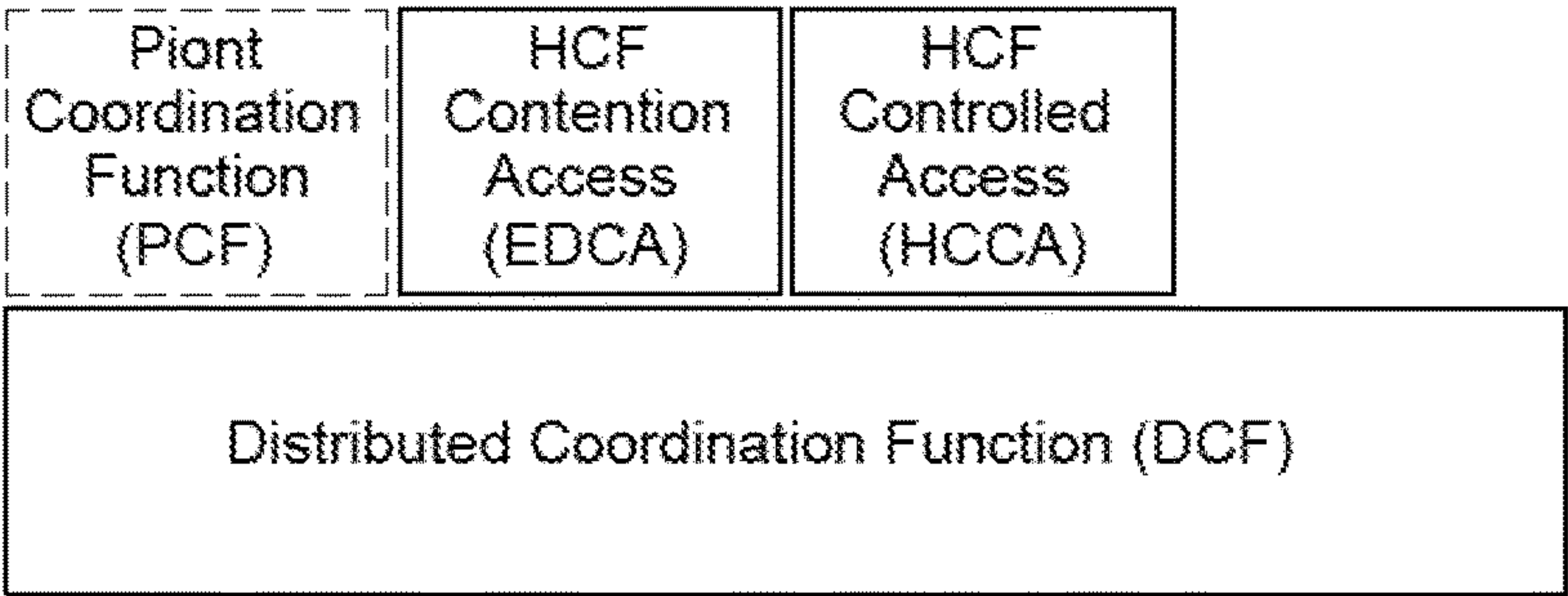


FIG. 2

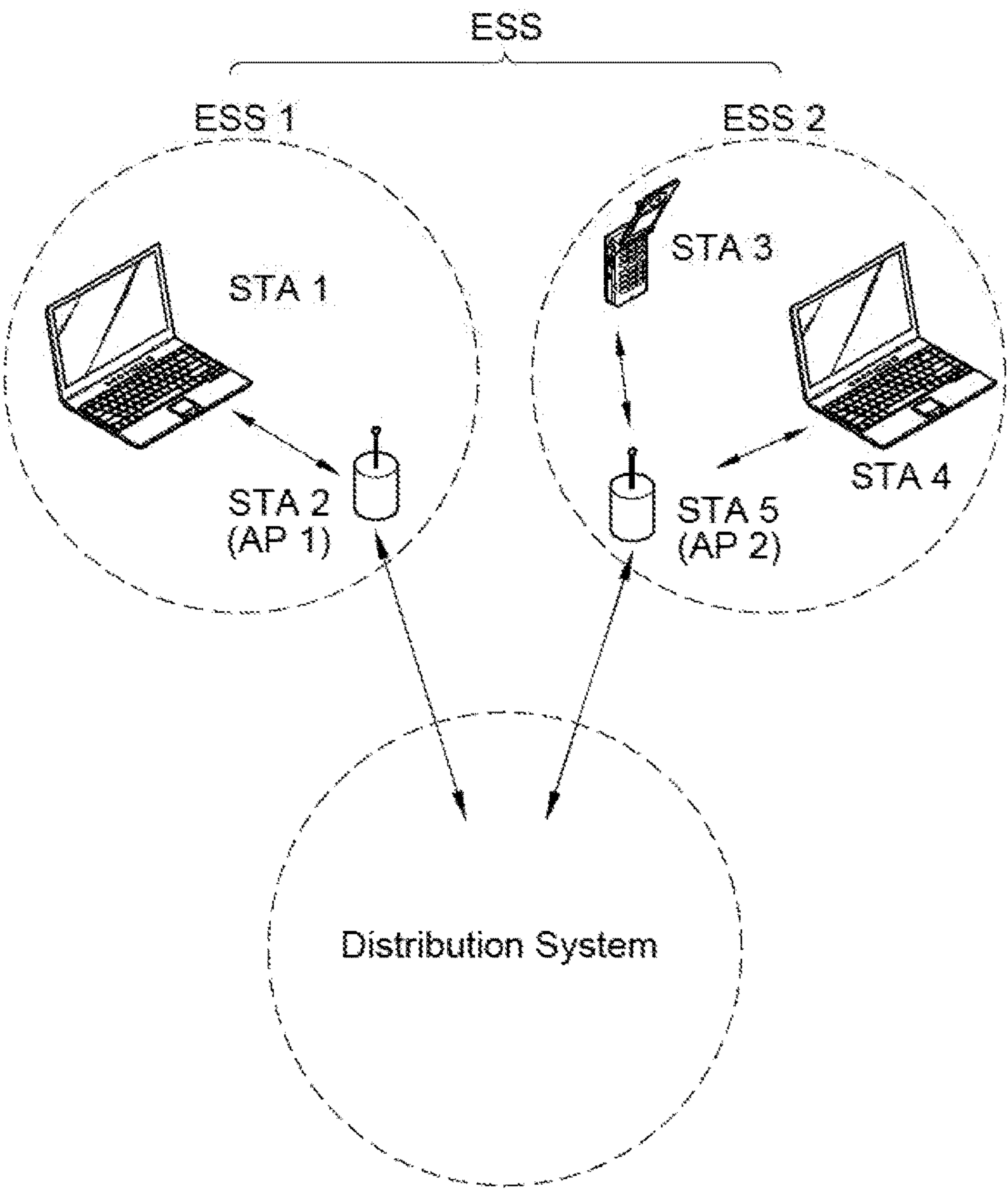


FIG. 3

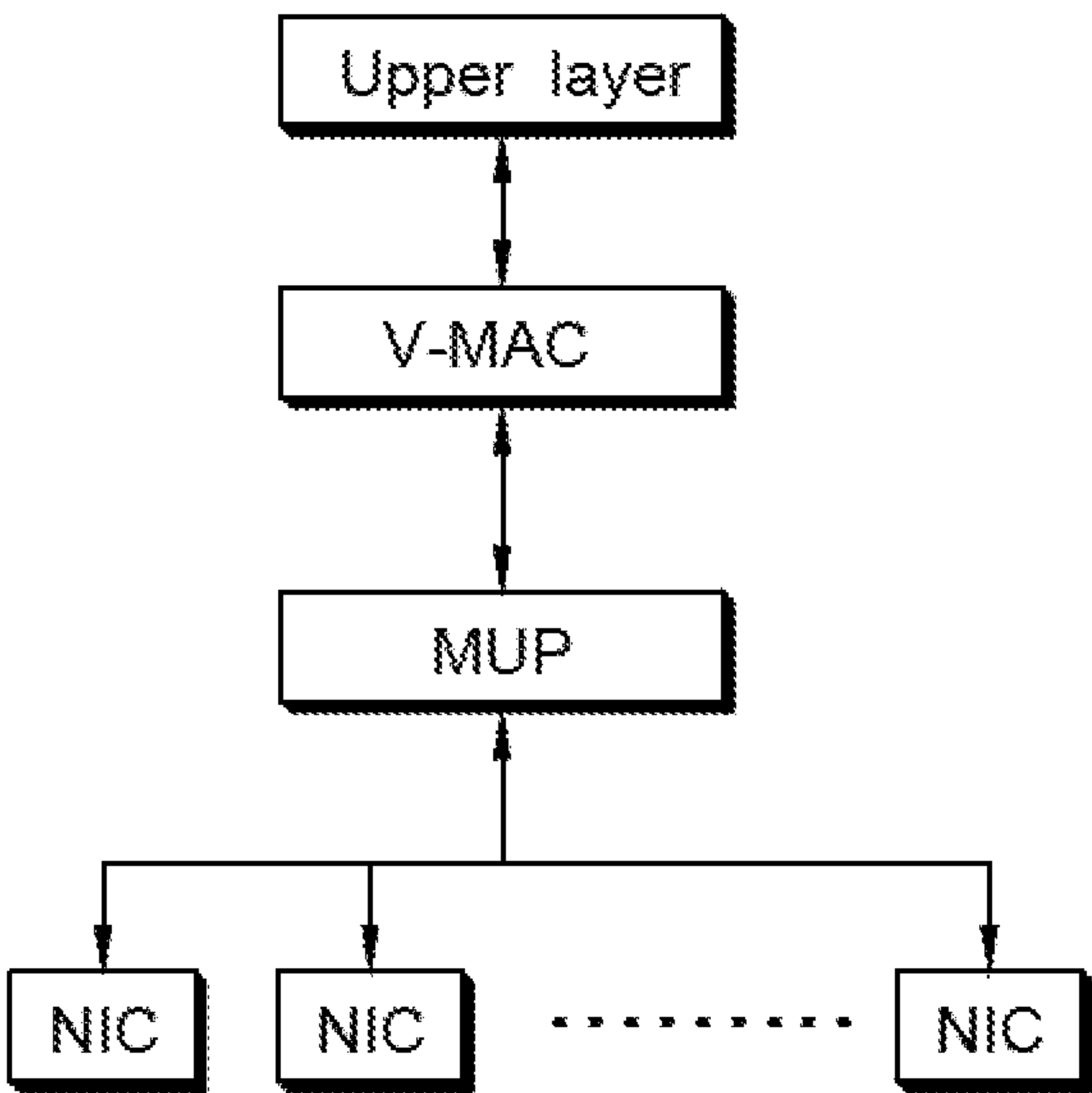


FIG. 4

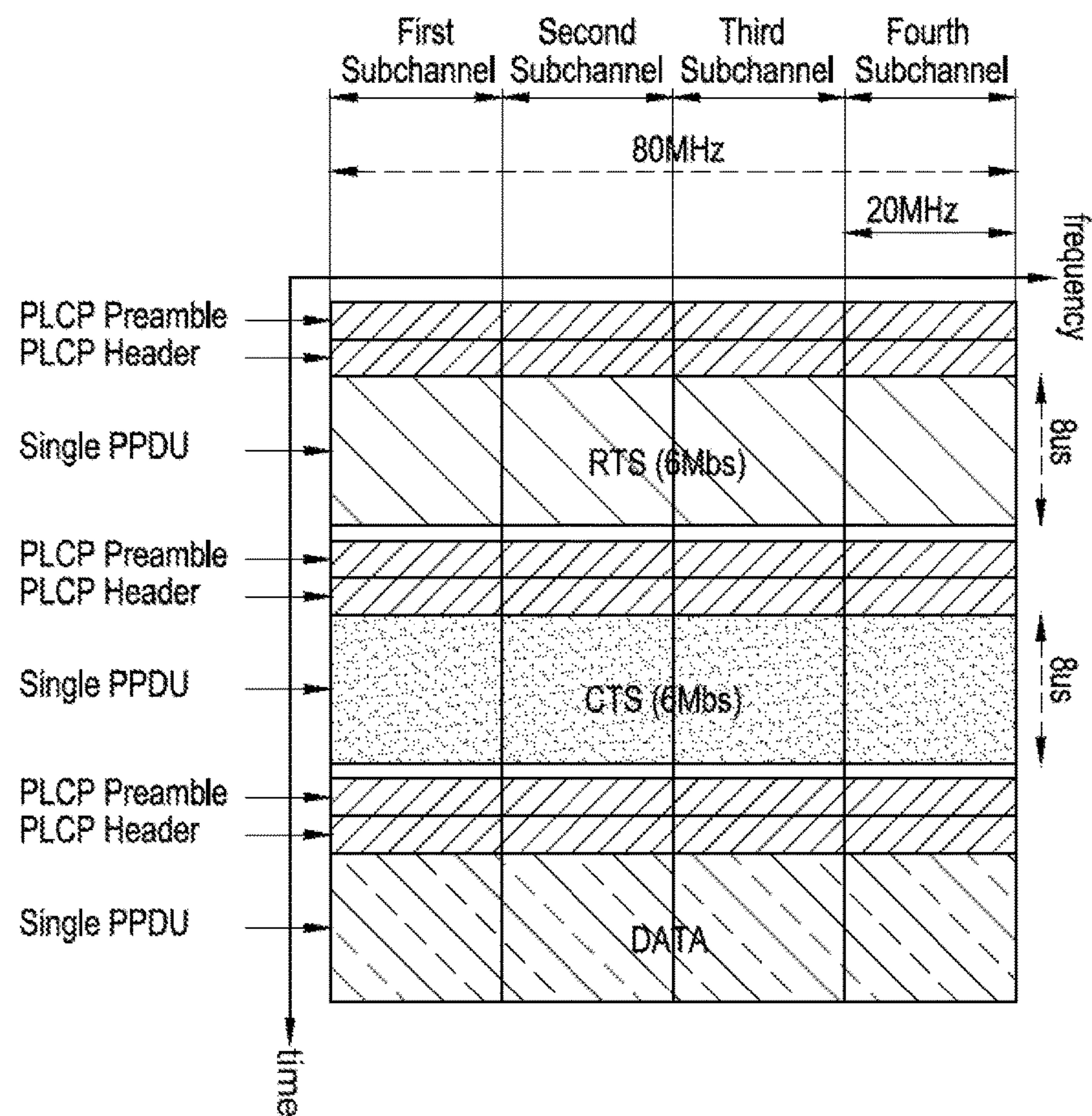


FIG. 5

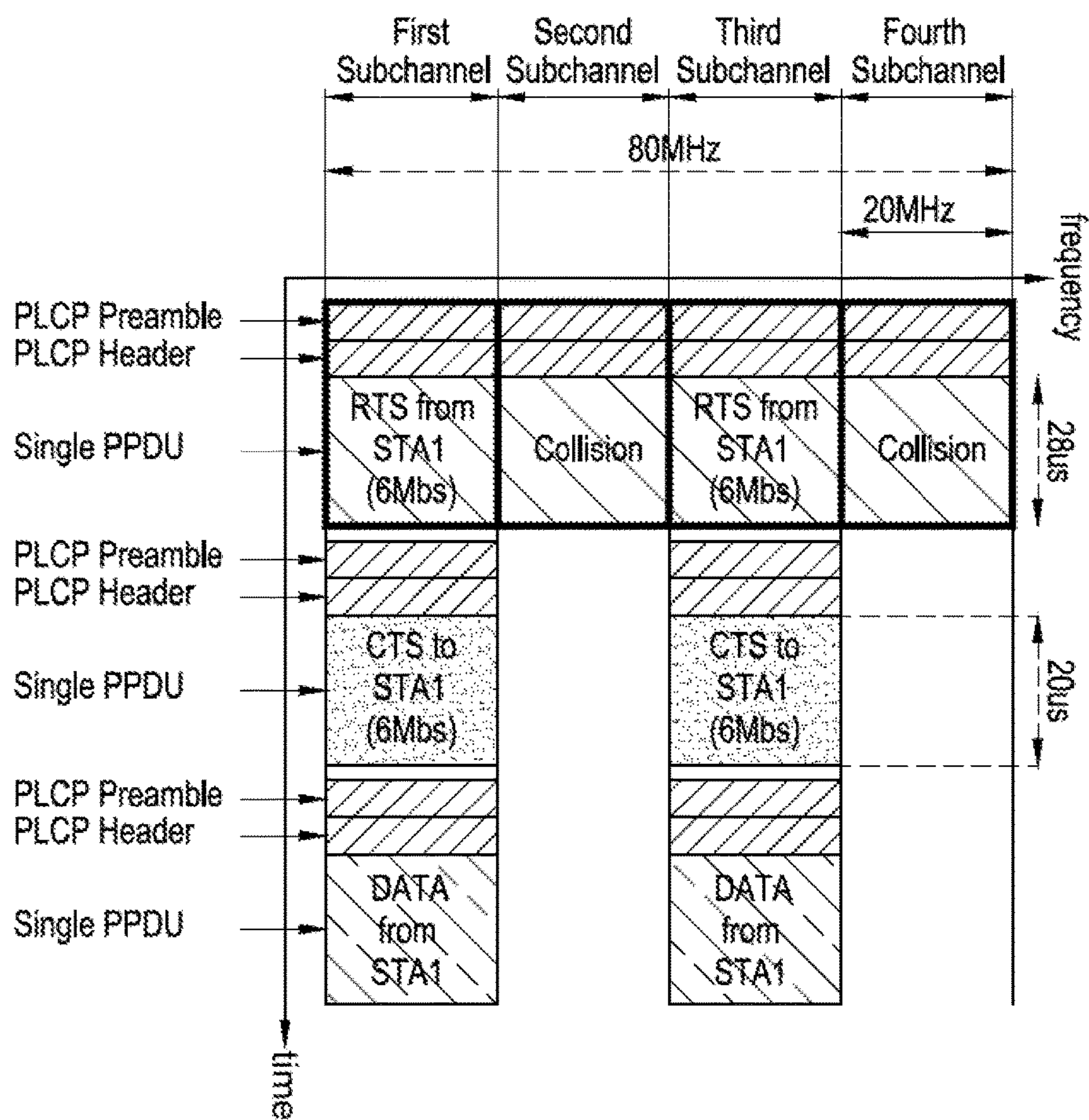


FIG. 6

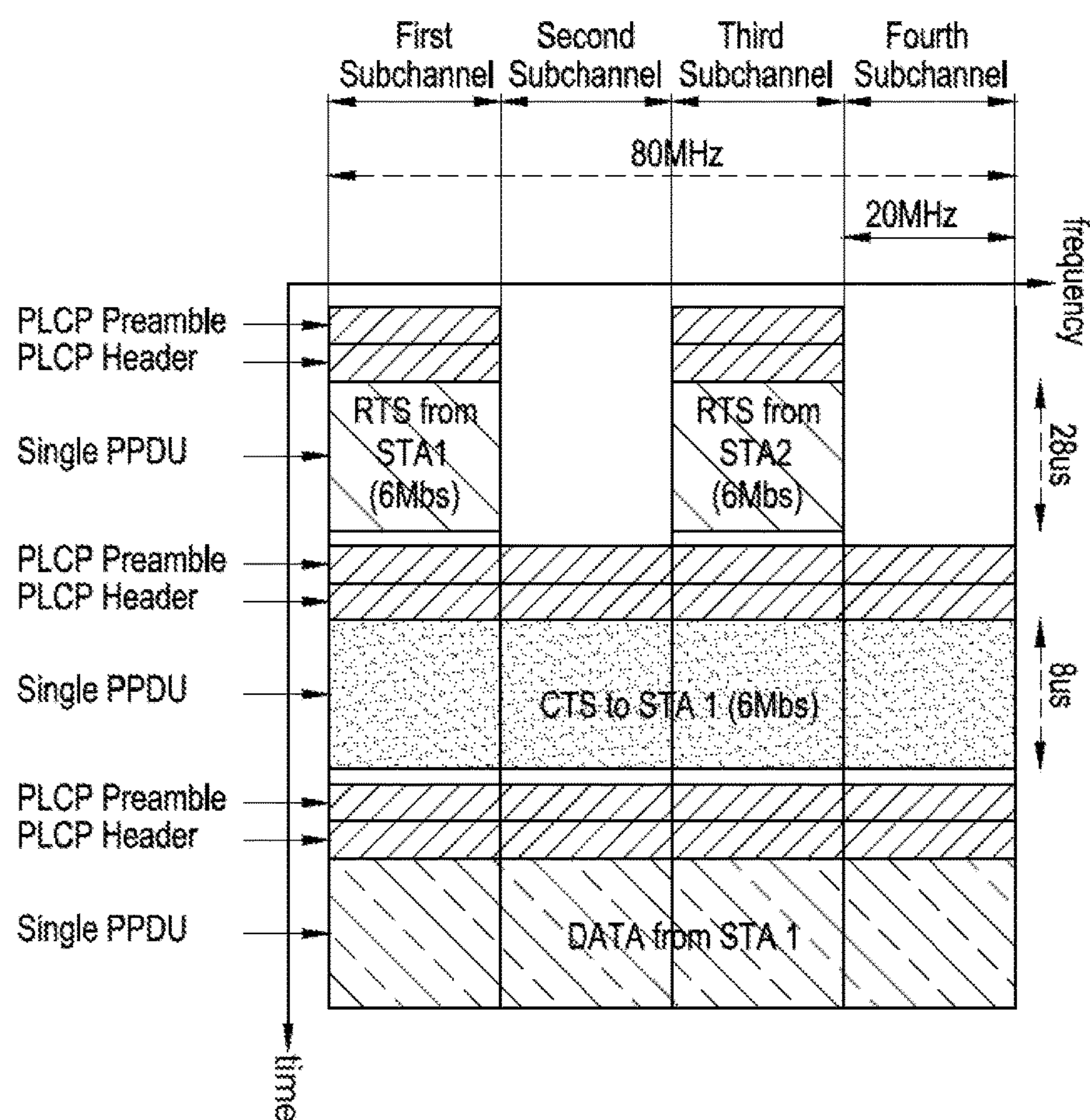


FIG. 7

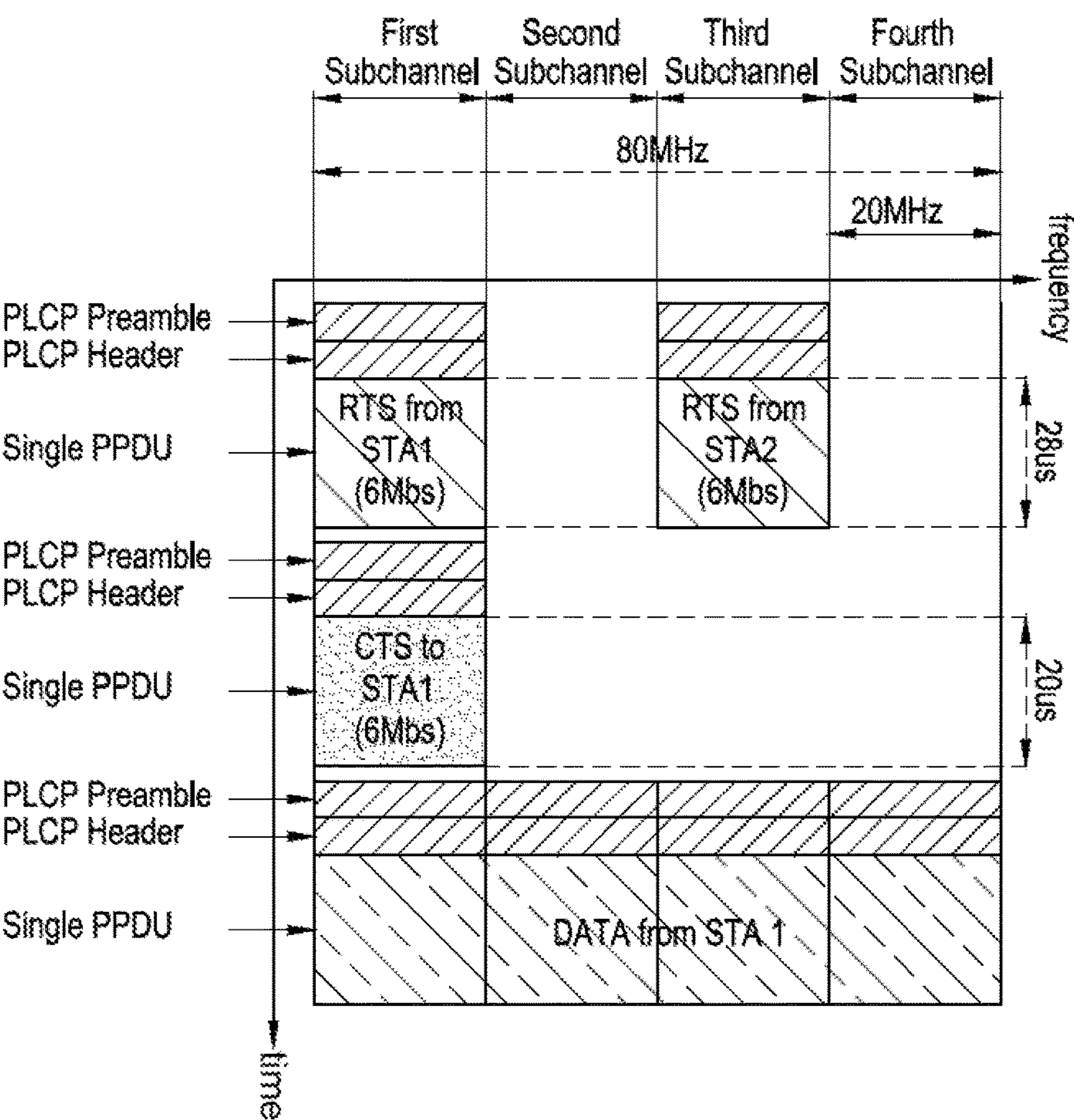
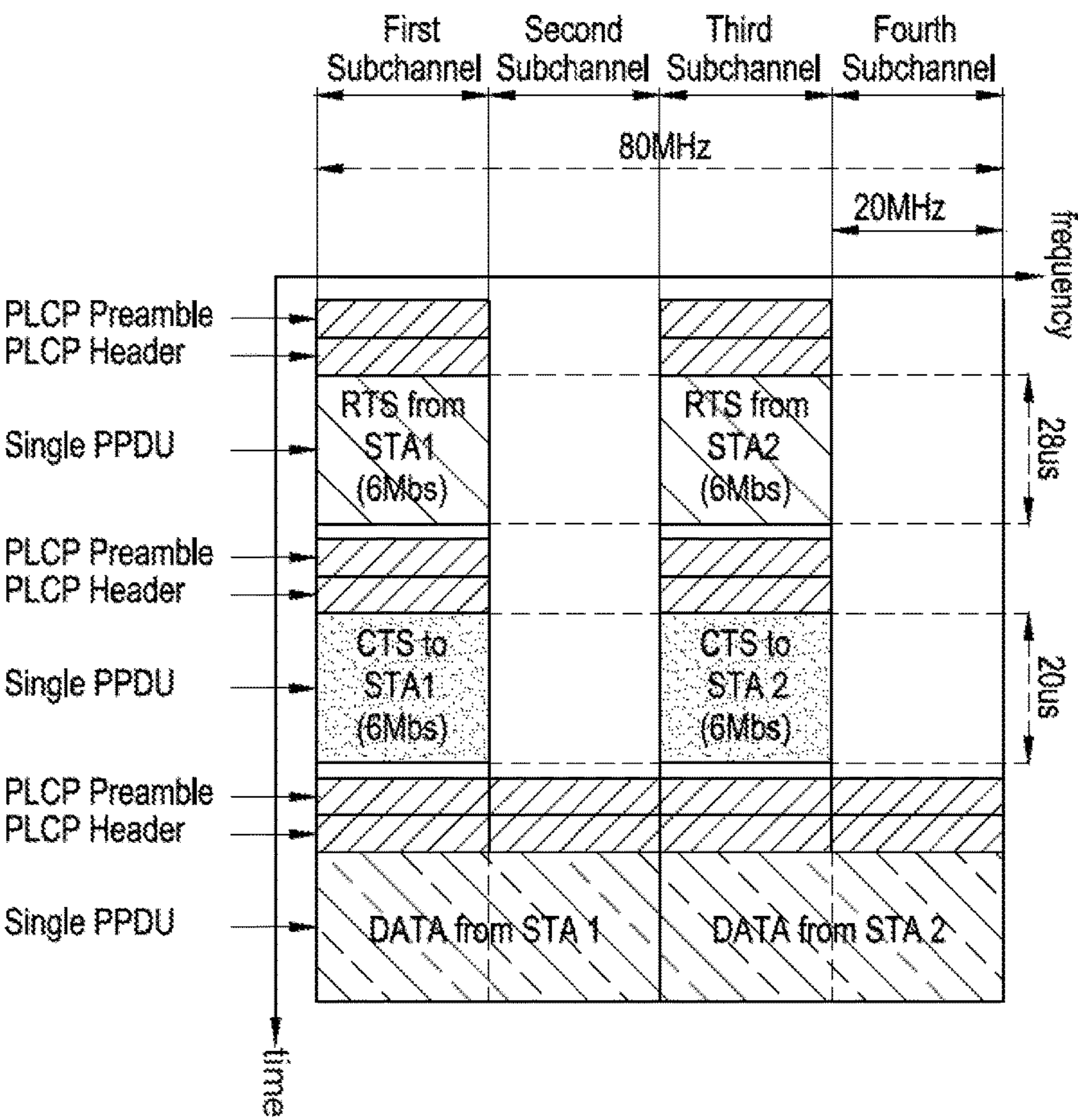


FIG. 8



CHANNEL ACCESS METHOD FOR VERY HIGH THROUGHPUT (VHT) WIRELESS LOCAL ACCESS NETWORK SYSTEM AND STATION SUPPORTING THE CHANNEL ACCESS METHOD

Matter enclosed in heavy brackets [] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue; a claim printed with strikethrough indicates that the claim was canceled, disclaimed, or held invalid by a prior post-patent action or proceeding.

CROSS-REFERENCE TO RELATED APPLICATIONS

[This] *The Application is a reissue of U.S. application Ser. No. 15/708,503, filed on Sep. 19, 2017, now U.S. Pat. No. 10,499,431, issued on Dec. 3, 2019, which is a Continuation of U.S. patent application Ser. No. 15/357,438 filed on Nov. 21, 2016 (now U.S. Pat. No. 9,788,346 issued Oct. 10, 2017), which is a Continuation of U.S. patent application Ser. No. 14/800,425 filed on Jul. 15, 2015 (now U.S. Pat. No. 9,526,114 issued on Dec. 20, 2016), which is a Continuation of U.S. patent application Ser. No. 14/579,286 filed on Dec. 22, 2014 (now U.S. Pat. No. 9,107,222 issued on Aug. 11, 2015), which is a Continuation of U.S. patent application Ser. No. 12/999,836 filed on Dec. 17, 2010 (now U.S. Pat. No. 8,989,158 issued on Mar. 24, 2015), which is the National Phase of PCT International Application No. PCT/KR2009/003264 filed on Jun. 18, 2009, which claims the benefit under 35 U.S.C. § 119(a) to Korean Patent Application No. 10-2008-0057246 filed on Jun. 18, 2008, all of which are hereby expressly incorporated by reference into the present application.*

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a wireless local access network (WLAN), and more particularly, to a channel access mechanism in a very high throughput (VHT) WLAN system and a station supporting the channel access mechanism.

Discussion of the Related Art

With the advancement of information communication technologies, various wireless communication technologies have recently been developed. Among the wireless communication technologies, a wireless local access network (WLAN) is a technology whereby super high-speed 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.

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 ray 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 (AP) protocol compatibil-

ity, security enhancement, radio resource measurement, wireless access in vehicular environments, fast roaming, mesh networks, inter-working with external networks, wireless network management, etc.

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 realizes 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.

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 speed of up to 540 Mbps at a frequency band of 5 GHz, 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 duplicated copies to increase data reliability and also may use the OFDM to support a higher data rate.

Meanwhile, 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 duration determined by the binary exponential backoff algorithm.

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 another STA to indicate a remaining time before the medium returns to an available state. Therefore, a value set to the NAV corresponds to a duration reserved for the use of the medium by an STA transmitting a corresponding frame.

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 transmission of frames from receiving STAs by reporting upcoming frame transmission to the receiving STAs. The information may be

included in a duration field 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.

FIG. 1 is a diagram showing an IEEE 802.11 MAC architecture including a DCF. Referring to FIG. 1, a service of the DCF is used to provide a point coordination function (PCF) and a hybrid coordination function (HCF). The HCF includes an enhanced distributed channel access (EDCA) and an HCF controller channel access (HCCF). The HCF does not exist in an STA not supporting quality of service (QoS). On the other hand, both the DCF and the HCF exist in an STA supporting QoS. The PCF is an arbitrary function in all STAs. Details of the DCF, PCF, EDCA, and HCCF are disclosed in section 9 of the "MAC sublayer function description" in the IEEE 802.11-REVma/D9.0 October 2006 standard, and thus descriptions thereof will be omitted herein. The contents of the above standard are incorporated herein by reference.

With the widespread use of 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 speed 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 more. This is because the IEEE 802.11n MAC/PHY protocol is designed for an operation of a single STA, that is, an STA having one network interface card (NIC), and thus when a frame throughput is increased while maintaining 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 maintaining the conventional IEEE 802.11n MAC/PHY protocol, that is, a single STA architecture.

Therefore, to achieve a data processing speed of 1 Gbps or more in the wireless communication system, a new system different from the conventional IEEE 802.11n MAC/PHY protocol (i.e., single STA architecture) is required. A very high throughput (VHT) 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 speed of 1 Gbps or more in a MAC service access point (SAP). The VHT system is named arbitrarily. To provide a throughput of 1 Gbps or more, a feasibility test is currently being conducted for the VHT system using 4×4 MIMO and a channel bandwidth of 80 MHz.

Meanwhile, a data processing speed of 1 Gbps or more, which is set as a target throughput in a VHT system, denotes an aggregate throughput. On the other hand, a target throughput in one-to-one communication between STAs is at least 500 Mbps in the VHT system. This implies that performance or an offered load of an STA supporting VHT (hereinafter, simply referred to as a 'VHT STA') may not exceed 500 Mbps. In a case where the offered load of the VHT STA is less than 1 Gbps (e.g., 500 Mbps), the target throughput of the VHT system cannot be achieved when one VHT STA is allowed to use an entire channel similarly to the conventional channel access method.

In addition, there is a problem in that efficiency is not high in the aforementioned CSMA/CA channel access method used in the IEEE 802.11 WLAN. For example, a data processing speed in a MAC SAP is only 50 to 60% of a data processing speed in a PHY SAP. Therefore, in order to achieve a data processing speed of 1 Gbps or more in the MAC SAP of the VHT system, the data processing speed of

the PHY SAP needs to be about 1.5 to 2 times higher than 1 Gbps. However, the conventional IEEE 802.11n PHY technique has difficulty in providing such a processing speed.

SUMMARY OF THE INVENTION

The present invention provides a new channel access method for achieving an aggregate throughput of 1 Gbps or more in a very high throughput (VHT) system.

The present invention also provides a channel access method for allowing simultaneous channel access of a plurality of VHT stations (STAs) in a VHT system.

The present invention also provides a new channel access method for achieving an aggregate throughput of 1 Gbps or more in a medium access control (MAC) service access point (SAP) in a VHT system.

According to an aspect of the present invention, there is provided a channel access method in a very high throughput (VHT) system using a bonding channel consisting of a plurality of subchannels, comprising: transmitting a request to send (RTS) frame by one source station or each of a plurality of source stations to a destination station through any subchannel selected from the plurality of subchannels; and in response to the received RTS frame, transmitting a clear to send (CTS) frame by the destination station to one source station selected from the plurality of source stations through the bonding channel.

According to another aspect of the present invention, there is provided a channel access method in a very high throughput (VHT) system using a bonding channel consisting of a plurality of subchannels, comprising: transmitting a request to send (RTS) frame by a source station to a destination station for each of the plurality of subchannels; and transmitting a clear to send (CTS) frame by the destination station to the source station through a subchannel in which the RTS frame is successfully received.

According to still another aspect of the present invention, there is provided a channel access method in a very high throughput (VHT) system using a bonding channel consisting of a plurality of subchannels, comprising: transmitting a request to send (RTS) frame by one source station or each of a plurality of source stations to a destination station through any subchannel selected from the plurality of subchannels; and in response to the received RTS frame, transmitting a clear to send (CTS) frame by the destination station to one source station selected from the plurality of source stations through the bonding channel, wherein the CTS frame comprises a list of subchannels to be used by the source station that receives the CTS frame to transmit a subsequent frame.

According to still another aspect of the present invention, there is provided a channel access method in a very high throughput (VHT) system using a bonding channel consisting of a plurality of subchannels, wherein a source station transmits a request to send (RTS) frame to a destination station by using any subchannel among the plurality of subchannels or by using each of the plurality of subchannels.

According to still another aspect of the present invention, there is provided a channel access method in a very high throughput (VHT) system using a bonding channel consisting of a plurality of subchannels, wherein a request to send (RTS) frame transmitted by a source station to a destination station comprises a list of subchannels which are desired to be used by the source station among the plurality of subchannels to transmit a subsequent frame.

According to still another aspect of the present invention, there is provided a channel access method in a very high

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throughput (VHT) system using a bonding channel consisting of a plurality of subchannels, wherein a clear to send (CTS) frame transmitted by a destination station to a receiving station in response to a received request to send (RTS) frame comprises a list of subchannels which are allowed to be used by the source station among the plurality of subchannels to transmit a subsequent frame.

An effective channel access mechanism is provided to improve usage efficiency of a bonding channel consisting of a plurality of subchannels in a very high throughput (VHT) system using the bonding channel. In particular, according to an embodiment of the present invention, access to another subchannel is allowed not only in a case where one or more VHT stations simultaneously request channel access but also in a case where some of subchannels are used by a legacy station, thereby enabling effective channel access.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagram showing an institute of electrical and electronics engineers (IEEE) 802.11 medium access control (MAC) architecture including a distributed coordinate function (DCF).

FIG. 2 is a schematic view showing an exemplary structure of a wireless local access network (WLAN) system according to an embodiment of the present invention.

FIG. 3 is a block diagram showing a multi-radio unification protocol (MUP) as an example of a protocol applicable to a very high throughput (VHT) system including a plurality of network interface cards (NICs) each having an independent radio interface.

FIG. 4 is a diagram showing a channel access mechanism according to a first embodiment of the present invention.

FIG. 5 is a diagram showing a channel access mechanism according to a second embodiment of the present invention.

FIG. 6 is a diagram showing a channel access mechanism according to a third embodiment of the present invention.

FIG. 7 is a diagram showing a channel access mechanism according to a fourth embodiment of the present invention.

FIG. 8 is a diagram showing a channel access mechanism according to a fifth embodiment of the present invention.

DETAILED DESCRIPTION OF THE EMBODIMENTS

FIG. 2 is a schematic view showing an exemplary structure of a wireless local access network (WLAN) system according to an embodiment of the present invention.

Referring to FIG. 2, 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. A very high throughput (VHT) BSS is defined as a BSS that supports a super high-speed data processing speed of 1 GHz or more.

A VHT system including one or more VHT BSSs can use a channel bandwidth of 80 MHz, which is for exemplary purposes only. For example, the VHT system may use a channel bandwidth of 60 MHz or 100 MHz or more. As such, the VHT system operates in a multi-channel environment where a plurality of subchannels having a specific size, e.g., a channel bandwidth of 20 MHz, are included.

The BSS can be classified into an infrastructure BSS and an independent BSS (IBSS). The infrastructure BSS is shown in FIG. 2. 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

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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.

The STA is an arbitrary functional medium including a medium access control (MAC) and wireless-medium physical layer (PHY) 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 the super high-speed data processing speed of 1 GHz or more in the multi-channel environment to be described below.

The STA for wireless communication includes a processor and a transceiver, and also includes a user interface, a display element, etc. The processor is a functional unit devised to generate a frame to be transmitted through a wireless network or to process a frame received through the wireless network, and performs various functions to control STAs. The transceiver is functionally connected to the processor and is a functional unit devised to transmit and receive a frame for the STAs through the wireless network.

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 is defined as a non-AP STA that supports the super high-speed data processing speed of 1 GHz or more in the multi-channel environment to be described below.

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 speed of 1 GHz or more in the multi-channel environment to be described below.

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.

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.

FIG. 3 is a block diagram showing a multi-radio unification protocol (MUP) as an example of a protocol applicable to a VHT system including a plurality of network interface cards (NICs) each having an independent radio interface.

Referring to FIG. 3, an STA supporting the MUP includes a plurality of NICs. The NICs are separately depicted in FIG. 3, which implies that each NIC independently operates a MAC/PHY module. That is, the NICs are distinctively depicted in FIG. 3 to show that the NICs are logical entities operating according to individual MAC/PHY protocols. Therefore, the plurality of NICs can be implemented with physically distinctive functional entities, or can be implemented by integrating the physical entities into one physical entity.

According to one aspect of the present embodiment, the plurality of NICs can be classified into a primary radio interface and one or more secondary radio interfaces. If a plurality of secondary radio interfaces are present, the secondary radio interfaces can be classified into a first secondary radio interface, a second secondary radio interface, a third secondary radio interface, etc. The classification into the primary interface and the secondary interface and/or the classification of the secondary radio interface itself may be determined by a policy or may be adoptively determined in consideration of a channel environment.

The plurality of NICs are integrally managed according to the MUP. As a result, the plurality of NICs are externally recognized as if they are one device. For this, the VHT system includes a virtual-MAC (V-MAC). Through the V-MAC, an upper layer cannot recognize that a multi-radio channel is operated by the plurality of NICs. As such, in the VHT system, the upper layer does not recognize the multi-radio channel through the V-MAC. This means that one virtual Ethernet address is provided.

Next, a channel allocation mechanism in a VHT system will be described according to embodiments of the present invention. Although the embodiments described below relate to a VHT system using a bonding channel in which contiguous 4 subchannels having a bandwidth of 20 MHz are combined (i.e., a bonding channel having a channel bandwidth of 80 MHz), this is for exemplary purposes only. The embodiments described below can equally apply to a VHT system including a plurality of subchannels (e.g., 3 or 5 or more subchannels), which is apparent to those skilled in the art. In addition, the embodiments of the present invention are not limited to the VHT system whose subchannel has a bandwidth of 20 MHz.

FIG. 4 is a diagram showing a channel access mechanism in a VHT WLAN system according to a first embodiment of the present invention. In the present embodiment, the conventional channel access mechanism (e.g., enhanced distributed channel access (EDCA) mechanism) is directly used for an entire bonding channel, and it is assumed that a full channel bandwidth is used by only one VHT STA. That is, the entire bonding channel is used to exchange a request to send (RTS) frame, a clear to send (CTS) frame, and data between two VHT STAs performing communication with each other.

Referring to FIG. 4, a source VHT STA or a transmitting VHT STA, which intends to transmit data, transmits an RTS frame by using the entire bonding channel. In FIG. 4, a process of transmitting the RTS frame is indicated by a physical layer convergence procedure (PLCP) preamble, a PLCP header, and a single PLCP protocol data unit (PPDU).

Upon receiving the RTS frame, a destination VHT STA or a receiving VHT STA transmits a CTS frame also by using the entire bonding channel. In FIG. 4, a process of transmitting the CTS frame is also indicated by a PLCP preamble, a PLCP header, and a single PPDU.

When the RTS frame and the CTS frame are exchanged by using the entire bonding channel, subsequent data or the

like is generally transmitted also by using the entire bonding channel. However, according to an aspect of the present embodiment, the RTS frame and/or the CTS frame may include a list of subchannels to be used for transmission of subsequent data or the like. As such, when the RTS frame and/or the CTS frame include the list of subchannels, a network allocation vector (NAV) is set only for a specific subchannel included in the list, and the source VHT STA transmits the data or the like to the destination VHT STA only through the specific subchannel.

Consequently, upon receiving the CTS frame, the source VHT STA starts transmission of the data or the like to the destination VHT STA according to a predetermined procedure. In FIG. 4, a process of transmitting the data is also indicated by a PLCP preamble, a PLCP header, and a single PPDU. In this case, if the list of subchannels does not exist in the RTS frame and/or the CTS frame, as shown in FIG. 4, the data or the like is transmitted by using the entire bonding channel. Otherwise, if the list of subchannels exists, the data or the like may be transmitted by using all or some of subchannels included in the list.

As described above, according to the first embodiment of the present invention, the RTS frame, the CTS frame, the data frame, etc., are transmitted through the entire bonding channel directly using the channel access mechanism based on the conventional EDCA. As a modification of the first embodiment, a list of subchannels to be used for transmission of the data frame or the like may be included in the RTS frame and/or the CTS frame. If the list of subchannels is included, the source VHT STA can transmit the data frame or the like to the destination VHT STA by using all or some of subchannels of the list.

In a case where the RTS frame and the CTS frame are transmitted by using the entire bonding channel, the RTS frame and the CTS frame are very small in size, and thus a transmission time corresponds to only a few orthogonal frequency division multiplex (OFDM) symbols (e.g., 8 ?s required for transmission of 6 Mbs). Optionally, the transmission time of the RTS frame and the CTS frame may be less than the PLCP preamble and the PLCP header. A network overhead for the RTS frame and the CTS frame is almost negligible.

FIG. 5 is a diagram showing a channel access mechanism in a VHT WLAN system according to a second embodiment of the present invention. The present embodiment is an example of a channel access mechanism for solving a problem of collision with a legacy STA in a VHT system in which a VHT STA coexists with the legacy STA, when the conventional EDCA channel access mechanism is used as in the first embodiment described above. Such a channel access mechanism can also be referred to as, for example, frequency-selective EDCA.

According to the aforementioned first embodiment, an entire bonding channel cannot be used when the collision with the legacy STA occurs, which may result in significant throughput deterioration of the VHT system. If the VHT STA is in use or one or more legacy STAs operates in any subchannel among subchannels to be used, in order for the VHT STA to access to a channel including the subchannel or to access to the entire bonding channel, all subchannels constituting the channel or the bonding channel have to be unoccupied (or idle). That is, the VHT STA can successfully perform channel access only when the collision with the legacy STA does not occur with respect to all subchannels constituting the bonding channel.

According to the present embodiment, a channel access mechanism for transmitting an RTS frame for each subchan-

nel is used to prevent a problem of throughput deterioration caused by the collision with the legacy STA. That is, a source VHT STA transmits the RTS frame for each subchannel instead of transmitting the RTS frame by using the entire bonding channel. If collision occurs with the legacy STA in any subchannel while the RTS frame for each subchannel is transmitted, a destination VHT STA transmits a CTS frame only for a subchannel in which no collision occurs, and as a result, the source VHT STA receives the CTS frame only for the subchannel in which no collision occurs. Further, the source VHT STA transmits data or the like only for a subchannel in which the CTS frame is received.

Referring to FIG. 5, the source VHT STA or the transmitting VHT STA (indicated by 'STA1' in FIG. 5), which intends to transmit data, transmits an RTS frame by using the entire bonding channel. In the present embodiment, the RTS frame is transmitted for each subchannel by regarding each subchannel as an independent channel, instead of regarding the entire bonding channel as one channel. In FIG. 5, a process of transmitting the RTS frame for each subchannel is indicated by a PLCP preamble, a PLCP header, and a single PPDU for each subchannel.

However, according to the present embodiment, among all subchannels, a 2nd subchannel and a 4th subchannel are used by the legacy STA. The 2nd subchannel and the 4th subchannel may be in use by different legacy STAs. Although the 2nd subchannel and the 4th subchannel are used by the legacy STA herein, this is for exemplary purposes only, and thus the embodiment of the present invention is not limited thereto. If the 2nd subchannel and the 4th subchannel are already being used, RTS frames transmitted through these subchannels may be unsuccessfully transmitted due to collision, and a destination VHT STA may successfully receive RTS frames transmitted through a 1st subchannel and a 3rd subchannel.

Upon receiving the RTS frames through all or some of subchannels, the destination VHT STA or the receiving VHT STA transmits a CTS frame for each subchannel by using corresponding subchannels. In FIG. 5, a process of transmitting the CTS frame is indicated by a PLCP preamble, a PLCP header, and a single PPDU in the 1st and 3rd subchannels.

Upon receiving the CTS frame through the 1st and 3rd subchannels, the source VHT STA transmits data or the like by using corresponding subchannels (i.e., the 1st and 3rd subchannels). In FIG. 5, a process of transmitting the data through the 1st and 3rd subchannels is indicated by a PLCP preamble, a PLCP header, and a single PPDU in the 1st and 3rd subchannels.

FIG. 6 is a diagram showing a channel access mechanism in a VHT WLAN system according to a third embodiment of the present invention. The present embodiment is an example of a channel access mechanism for preventing collision between VHT STAs in a VHT system in which the VHT STA coexists with a legacy STA or in a VHT BSS in which only the VHT STA exists. Such a channel access mechanism can also be referred to as, for example, frequency-hopping EDCA.

According to the aforementioned first embodiment, if the legacy STA occupies any one subchannel at a time for transmitting an RTS frame, the VHT STA cannot immediately transmit data or the like by using an entire bonding channel even after the use of the subchannel is finished. That is, only after the legacy STA finishes the use of the subchannel, a procedure of exchanging the RTS frame and a CTS frame can begin. According to the aforementioned

second embodiment, the entire bonding channel cannot be used for transmission of data or the like when collision occurs with the legacy STA, and thus there is a disadvantage in that a throughput of the VHT system deteriorates.

According to the present embodiment, a channel access mechanism in which one VHT STA transmits an RTS frame by using only one subchannel is used to prevent a problem of transmission delay on data or the like, which may be caused in the first embodiment, or a problem of deterioration in channel usage efficiency, which may be caused in the second embodiment. More specifically, each VHT STA intending to transmit data or the like transmits an RTS frame by selecting any one subchannel or by using only one subchannel according to a predetermined rule, instead of transmitting the RTS frame by using the entire bonding channel. That is, each VHT STA performs channel access by using an EDCA scheme through selected or predetermined one subchannel. As such, according to the present embodiment, RTS frames are transmitted by using only one subchannel, and thus even if a plurality of VHT STAs simultaneously transmit the RTS frames, collision between the RTS frames can be prevented or avoided.

Upon receiving the RTS frames from one or more VHT STAs, a destination VHT STA or a receiving VHT STA transmits a CTS frame as a response by selecting one of the received RTS frames, that is, by selecting one VHT STA from the VHT STAs transmitting the RTS frames. In this case, the CTS frame can be transmitted through the entire bonding channel or, as in the aforementioned second embodiment, can be transmitted for each corresponding subchannel. In the latter case, the CTS frame is transmitted for each subchannel through the entire bonding channel instead of using only a subchannel identical to the subchannel in which the selected RTS frame is transmitted. In addition, according to the present embodiment, the VHT STA which has received the CTS frame, i.e., the destination VHT STA of the CTS frame, uses the entire bonding channel when intending to transmit data or the like in a subsequent procedure.

Referring to FIG. 6, source VHT STAs or transmitting VHT STAs (indicated by 'STA1' and 'STA2' in FIG. 6), which intend to transmit data, transmit RTS frames through any respective subchannels. For example, this may be a case where backoff timers of the STA1 and the STA2 are simultaneously expired. It is shown in FIG. 6 that the STA1 uses a 1st subchannel and the STA2 uses a 3rd subchannel, which is for exemplary purposes only. According to the present embodiment, preferably, the STA1 and the STA2 transmit the RTS frames by using different subchannels, and the subchannels can be determined without any restriction. When the STA1 and the STA2 transmit the RTS frames by using different subchannels, collision between the RTS frames can be prevented. In FIG. 6, a process of transmitting the respective RTS frames by the STA1 and the STA2 through the different subchannels is indicated by a PLCP preamble, a PLCP header, and a single PPDU in the 1st and 3rd subchannels.

When the destination VHT STA or the receiving VHT STA receives separate RTS frames through 1st and 3rd subchannels among all subchannels, the destination VHT STA or the receiving VHT STA transmits a CTS frame as a response by selecting only one RTS frame. It is shown in FIG. 6 that an RTS frame received from the 1st VHT STA (i.e., STA1) is selected and thus the CTS frame is transmitted to the STA1, which is for exemplary purposes only. In addition, according to the present embodiment, the CTS frame is transmitted through the entire bonding channel. In

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FIG. 6, a process of transmitting the CTS frame is indicated by a PLCP preamble, a PLCP header, and a single PPDU in the entire bonding channel, and the CTS frame is transmitted to the STA1.

Upon receiving the CTS frame, the STA1 transmits data or the like by using the entire bonding channel. Therefore, according to the present embodiment, channel usage efficiency can be maximized when transmitting data of the like. In FIG. 6, a process of transmitting the data through all subchannels is indicated by a PLCP preamble, a PLCP

header, and a single PPDU in the entire bonding channel. As described in the aforementioned second embodiment and in the present embodiment, if an RTS frame and/or a CTS frame are transmitted by using only one subchannel, a transmission time of the RTS frame and the CTS frame is relatively increased. However, since the RTS frame is small in size, a transmission overhead of the RTS frame is not relatively large. On the other hand, according to the present embodiment, RTS frames are transmitted by using only one subchannel, and thus collision between the RTS frames can be prevented. As a result, according to the present embodiment, a possibility of collision between VHT STAB can be reduced, and thus channel usage efficiency can also be increased to that extent.

FIG. 7 is a diagram showing a channel access mechanism in a VHT WLAN system according to a fourth embodiment of the present invention. That is, as in the third embodiment, the present embodiment also uses the frequency-hopping EDCA. However, in the present invention, a CTS frame is transmitted in a different manner from that described in the third embodiment. The following description will focus on different aspects from the third embodiment.

It is assumed in the aforementioned third embodiment that only a VHT STA performs channel access. In this case, there is no need to consider NAV setting in a legacy STA. Therefore, in the aforementioned third embodiment, a CTS frame is transmitted through an entire bonding channel when the CTS frame is transmitted. By transmitting the CTS frame in such a manner, a channel load caused by transmission of the CTS frame can be reduce. However, if the CTS frame is transmitted through the entire bonding channel, the legacy STA cannot decode the CTS frame, and thus cannot set the NAV during a time period determined by the CTS frame. Accordingly, in the present embodiment, the CTS frame is transmitted by using one subchannel.

According to another aspect of the present embodiment, as described in the third embodiment, the CTS frame may be transmitted for each subchannel constituting the bonding channel. In this case, the CTS frame may include a subchannel list for indicating a specific subchannel for which each VHT STA has a transmission opportunity. For example, if transmission is allowed for one VHT STA, a list of subchannels that can be used by the VHT STA may be included in the CTS frame. Alternatively, if no subchannel list is included, the VHT STA may have a transmission opportunity for all subchannels.

FIG. 8 is a diagram showing a channel access mechanism in a VHT WLAN system according to a fifth embodiment of the present invention. The present embodiment is an example of a channel access mechanism for preventing collision between VHT STAs in a VHT system in which the VHT STA coexists with a legacy STA or in a VHT BSS in which only the VHT STA exists. The present embodiment can be regarded as an application of the aforementioned third and fourth embodiments. Such a channel access mechanism can also be referred to as, for example, frequency-hopping EDCA with dynamic channel allocation.

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As in the third embodiment and the fourth embodiment, according to the channel access mechanism using the frequency-hopping EDCA, a destination VHT STA can simultaneously receive RTS frames from a plurality of UEs or can receive an additional RTS frame through an unused subchannel. In this case, the present embodiment allows several UEs to simultaneously transmit data or the like through different subchannels by respectively transmitting CTS frames to one or more UEs which have received the RTS frames. The CTS frame includes a list of subchannels to be used when a corresponding UE transmits data or the like.

Referring to FIG. 8, source VHT STAs or transmitting VHT STAs (indicated by 'STA1' and 'STA2' in FIG. 8), which intend to transmit data, transmit RTS frames through any respective subchannels. For example, this may be a case where backoff timers of the STA1 and the STA2 are simultaneously expired. It is shown in FIG. 8 that, to transmit an RTS frame, the STA1 uses a 1st subchannel and the STA2 uses a 3rd subchannel, which is for exemplary purposes only. According to the present embodiment, preferably, the STA1 and the STA2 transmit the RTS frames by using different subchannels, and the subchannels can be determined without any restriction. When the STA1 and the STA2 transmit the RTS frames by using different subchannels, collision between the RTS frames can be prevented. In FIG. 8, a process of transmitting the respective RTS frames by the STA1 and the STA2 through the different subchannels is indicated by a PLCP preamble, a PLCP header, and a single PPDU in the 1st and 3rd subchannels.

When the destination VHT STA or the receiving VHT STA receives separate RTS frames through 1st and 3rd subchannels among all subchannels, the destination VHT STA or the receiving VHT STA transmits a CTS frame as a response with respect to all received RTS frames. It is shown in FIG. 8 that two CTS frames are respectively transmitted to the STA1 and the STA2 through the 1st and 3rd subchannels for the respective RTS frames received from the STA1 and the STA2. In FIG. 8, a process of transmitting the CTS frame is indicated by a PLCP preamble, a PLCP header, and a single PPDU in each of the 1st and 3rd subchannels.

According to the present embodiment, a list of subchannels to be used by the STA1 to transmit subsequent data or the like is included in a CTS frame to be transmitted to the STA1. According to the present invention, 1st and 2nd subchannels are included in the list, which is for exemplary purpose only. In addition, the list of subchannels to be used by the STA2 to transmit subsequent data or the like is also included in a CTS frame to be transmitted to the STA2. According to the present embodiment, 3rd and 4th subchannels are included in the list, which is for exemplary purpose only.

Upon receiving the CTS frame, each of the STA1 and the STA2 transmits data or the like to the destination STA through a subchannel included in the subchannel list of the received CTS frame. The STA1 and the STA2 can simultaneously transmit the data or the like. In FIG. 8, a process of transmitting the data through 1st and 2nd subchannels of the 1st VHT STA and transmitting the data through 1st and 2nd subchannels of the 2nd VHT STA is indicated by a PLCP preamble, a PLCP header, and a single PPDU in the 1st and 2nd subchannels and the 3rd and 4th subchannels.

According to the embodiment of the present invention, a plurality of VHT STAs or a VHT STA and a legacy STA can transmit data or the like by using an entire bonding channel. In addition, according to the embodiment of the present invention in which a CTS frame includes a list of subchannels to be used, a VHT STA for using each subchannel can

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be adaptively determined by considering all conditions at the request of a plurality of VHT STAs. Therefore, according to the present embodiment, channel usage efficiency can be improved when transmitting data or the like.

What is claimed is:

1. A method [for] *performed by a destination station operating in a wireless communication system*, the method comprising:

receiving, by [a first] *the destination station*, a plurality of request to send (RTS) frames from a [second] *source station* through a plurality of subchannels, [each of the plurality of RTS frames being received through a corresponding one of the plurality of subchannels,] each of the plurality of subchannels having a 20 megahertz (MHz) bandwidth;

determining a plurality of idle subchannels based on the plurality of subchannels;

transmitting, by the [first] *destination station to the source station*, [at least one] *a plurality of clear to send (CTS) [frame] frames* in response to [at least one of] the plurality of RTS frames [to the second station], through [at least one idle subchannel of the plurality of subchannels, each of the at least one CTS frame being transmitted through a corresponding one of] the [at least one] *plurality of idle [subchannel] subchannels;* and

receiving, by the [first] *destination station*, a data frame from the [second] *source station* [after] *based on* transmitting the [at least one] *plurality of CTS [frame] frames,*

wherein each of the [at least one] *plurality of CTS [frame includes] frames comprises* channel information [related to] *indicative of the [at least one] plurality of idle [subchannel through which the at least one CTS frame is transmitted by] subchannels as being available for the [first] source station[, and] to transmit the data frame [is received through the at least one idle subchannel indicated by the channel information], and* wherein a number of the [at least one] *plurality of idle [subchannel] subchannels* through which the [at least one] *plurality of CTS [frame is] frames are* transmitted is equal to or less than a number of the plurality of subchannels through which the plurality of RTS frames are received.

2. The method of claim 1, wherein the *channel information is indicative of the number of the [at least one] plurality of idle [subchannel is 1,] subchannels being equal to 2 or 4 [when] based on the number of the plurality of subchannels [is] being equal to 4.*

3. The method of claim 1, wherein the *channel information is indicative of the number of the [at least one] plurality of idle [subchannel is 1 or] subchannels being equal to 2 [when] based on the number of the plurality of subchannels [is] being equal to 2.*

4. A [device] *destination station configured to operate in a wireless communication system*, the destination station comprising:

a transceiver; and

[a] *at least one processor; and*

at least one computer memory operatively connected to the [transceiver and configured to] *at least one processor and storing instructions that, based on being executed by the at least one processor, perform operations comprising:*

[instruct] *receiving, by the destination station via the transceiver [to receive], a plurality of request to send (RTS) frames from a source station through a plurality*

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of subchannels, [each of the plurality of RTS frames being received through a corresponding one of the plurality of subchannels,] each of the plurality of subchannels having a 20 megahertz (MHz) bandwidth,

determining a plurality of idle subchannels based on the plurality of subchannels;

[instruct] *transmitting, by the destination station to the source station via the transceiver [to transmit at least one], a plurality of clear to send (CTS) [frame] frames* in response to [at least one of] the plurality of RTS frames [to the station,] through [at least one idle subchannel of the plurality of subchannels, each of the at least one CTS frame being transmitted through a corresponding one of] the [at least one] *plurality of idle [subchannel] subchannels, and*

[instruct] *receiving, by the destination station via the transceiver [to receive], a data frame from the source station [after] based on* transmitting the [at least one] *plurality of CTS [frame] frames,*

wherein each of the [at least one] *plurality of CTS [frame includes] frames comprises* channel information [related to] *indicative of the [at least one] plurality of idle [subchannel] subchannels* through which the [at least one] *plurality of CTS [frame is] frames are* transmitted [by the device, and] *as being available for the source station to transmit the data frame [is received through the at least one idle subchannel indicated by the channel information], and*

wherein a number of the [at least one] *plurality of idle [subchannel] subchannels* through which the [at least one] *plurality of CTS [frame is] frames are* transmitted is equal to or less than a number of the plurality of subchannels through which the plurality of RTS frames are received.

5. The [device] *destination station* of claim 4, wherein the *channel information is indicative of the number of the [at least one] plurality of idle [subchannel is 1,] subchannels being equal to 2 or 4 [when] based on the number of the plurality of subchannels [is] being equal to 4.*

6. The [device] *destination station* of claim 4, wherein the *channel information is indicative of the number of the [at least one] plurality of idle [subchannel is 1 or] subchannels being equal to 2 [when] based on the number of the plurality of subchannels [is] being equal to 2.*

[7. A method for a wireless communication system, the method comprising:

receiving, by a first station, a plurality of request to send (RTS) frames from a second station through a plurality of subchannels, each of the plurality of RTS frames being received through a corresponding one of the plurality of subchannels, each of the plurality of subchannels having a 20 megahertz (MHz) bandwidth;

transmitting, by the first station, at least one clear to send (CTS) frame in response to at least one of the plurality of RTS frames to the second station through at least one idle subchannel of the plurality of subchannels, each of the at least one CTS frame being transmitted through a corresponding one of the at least one idle subchannel; and

receiving, by the first station, a data frame from the second station after transmitting the at least one CTS frame,

wherein each of the at least one CTS frame includes channel information related to all of the at least one idle subchannel through which the at least one CTS frame is transmitted by the first station, and the data frame is

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received through the at least one idle subchannel indicated by the channel information, and wherein a number of the at least one idle subchannel through which the at least one CTS frame is transmitted is equal to or less than a number of the plurality of subchannels through which the plurality of RTS frames are received.]

[8. The method of claim 7, wherein the number of the at least one idle subchannel is 1, 2 or 4 when the number of the plurality of subchannels is 4.]

[9. The method of claim 7, wherein the number of the at least one idle subchannel is 1 or 2 when the number of the plurality of subchannels is 2.]

[10. A device comprising:

a transceiver; and

a processor operatively connected to the transceiver and configured to:

instruct the transceiver to receive a plurality of request to send (RTS) frames from a station through a plurality of subchannels, each of the plurality of RTS frames being received through a corresponding one of the plurality of subchannels, each of the plurality of subchannels having a 20 megahertz (MHz) bandwidth,

instruct the transceiver to transmit at least one clear to send (CTS) frame in response to at least one of the plurality of RTS frames to the station through at least one idle subchannel of the plurality of subchannels, each of the at least one CTS frame being transmitted through a corresponding one of the at least one idle subchannel, and

instruct the transceiver to receive a data frame from the station after transmitting the at least one CTS frame, wherein each of the at least one CTS frame includes channel information related to all of the at least one idle subchannel through which the at least one CTS frame is transmitted by the device, and the data frame is received through the at least one idle subchannel indicated by the channel information, and

wherein a number of the at least one idle subchannel through which the at least one CTS frame is transmitted is equal to or less than a number of the plurality of subchannels through which the plurality of RTS frames are received.]

[11. The device of claim 10, wherein the number of the at least one idle subchannel is 1, 2 or 4 when the number of the plurality of subchannels is 4.]

[12. The device of claim 10, wherein the number of the at least one idle subchannel is 1 or 2 when the number of the plurality of subchannels is 2.]

[13. A method for a wireless communication system, the method comprising:

receiving, by a first station, a plurality of request to send (RTS) frames from a second station through a plurality of subchannels, each of the plurality of RTS frames being received through a corresponding one of the plurality of subchannels, each of the plurality of subchannels having a 20 megahertz (MHz) bandwidth; transmitting, by the first station, a plurality of clear to send (CTS) frames in response to at least one of the plurality of RTS frames to the second station through a plurality of idle subchannels of the plurality of subchannels, each of the plurality of CTS frames being transmitted through a corresponding one of the plurality of idle subchannels; and

receiving, by the first station, a data frame from the second station after transmitting the plurality of CTS frames,

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wherein each of the plurality of CTS frames includes channel information related to the plurality of idle subchannels through which the plurality of CTS frames are transmitted by the first station, and the data frame is received through the plurality of idle subchannels indicated by the channel information, and

wherein a number of the plurality of idle subchannels through which the plurality of CTS frames are transmitted is equal to or less than a number of the plurality of subchannels through which the plurality of RTS frames are received.]

[14. The method of claim 13, wherein the number of the plurality of subchannels is 4.]

[15. A device comprising:

a transceiver; and

a processor operatively connected to the transceiver and configured to:

instruct the transceiver to receive a plurality of request to send (RTS) frames from a second station through a plurality of subchannels, each of the plurality of RTS frames being received through a corresponding one of the plurality of subchannels, each of the plurality of subchannels having a 20 megahertz (MHz) bandwidth;

instruct the transceiver to transmit a plurality of clear to send (CTS) frames in response to at least one of the plurality of RTS frames to the second station through a plurality of idle subchannels of the plurality of subchannels, each of the plurality of CTS frames being transmitted through a corresponding one of the plurality of idle subchannels; and

instruct the transceiver to receive a data frame from the second station after transmitting the plurality of CTS frames,

wherein each of the plurality of CTS frames includes channel information related to the plurality of idle subchannels through which the plurality of CTS frames are transmitted by the device, and the data frame is received through the plurality of idle subchannels indicated by the channel information, and

wherein a number of the plurality of idle subchannels through which the plurality of CTS frames are transmitted is equal to or less than a number of the plurality of subchannels through which the plurality of RTS frames are received.]

[16. The device of claim 15, wherein the number of the plurality of subchannels of 4.]

17. The method of claim 1, wherein the destination station is a non-Access Point (non-AP) station and the source station is an AP station.

18. The method of claim 1, wherein the destination station is an AP station and the source station is a non-AP station.

19. The destination station of claim 4, wherein the destination station is a non-Access Point (non-AP) station and the source station is an AP station.

20. The destination station of claim 4, wherein the destination station is an AP station and the source station is a non-AP station.

21. A method performed by a destination station operating in a wireless communication system, the method comprising:

receiving, by the destination station, a plurality of request to send (RTS) frames from a source station through a plurality of subchannels, each of the plurality of RTS frames being received through a corresponding one of the plurality of subchannels, each of the plurality of subchannels having a 20 megahertz (MHz) bandwidth;

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transmitting, by the destination station, a plurality of
 clear to send (CTS) frames in response to at least one
 of the plurality of RTS frames to the source station
 through a plurality of idle subchannels of the plurality
 of subchannels, each of the plurality of CTS frames
 being transmitted through a corresponding one of the
 plurality of idle subchannels; and
 receiving, by the destination station, a data frame from the
 source station after transmitting the plurality of CTS
 frames,
 wherein each of the plurality of CTS frames includes
 channel information related to the plurality of idle
 subchannels through which the plurality of CTS frames
 are transmitted by the destination station, and the data
 frame is received through the plurality of idle subchan-
 nels indicated by the channel information, and
 wherein a number of the plurality of idle subchannels
 through which the plurality of CTS frames are trans-
 mitted is equal to or less than a number of the plurality
 of subchannels through which the plurality of RTS
 frames are received.
 22. A device comprising:
 a transceiver; and
 a processor operatively connected to the transceiver and
 configured to perform operations comprising:
 receiving, by the device, a plurality of request to send
 (RTS) frames from a source station through a plurality

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of subchannels, each of the plurality of RTS frames
 being received through a corresponding one of the
 plurality of subchannels, each of the plurality of sub-
 channels having a 20 megahertz (MHz) bandwidth;
 transmitting, by the device, a plurality of clear to send
 (CTS) frames in response to at least one of the plurality
 of RTS frames to the source station through a plurality
 of idle subchannels of the plurality of subchannels,
 each of the plurality of CTS frames being transmitted
 through a corresponding one of the plurality of idle
 subchannels; and
 receiving, by the device, a data frame from the source
 station after transmitting the plurality of CTS frames,
 wherein each of the plurality of CTS frames includes
 channel information related to the plurality of idle
 subchannels through which the plurality of CTS frames
 are transmitted by the device, and the data frame is
 received through the plurality of idle subchannels indi-
 cated by the channel information, and
 wherein a number of the plurality of idle subchannels
 through which the plurality of CTS frames are trans-
 mitted is equal to or less than a number of the plurality
 of subchannels through which the plurality of RTS
 frames are received.

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