Optional support for dynamic fragmentation levels 1, 2 and 3 In an AP, mandatory support for the role of operating mode indication (OMI) responder and optional support for the role of OMI initiator In a non-AP STA, optional support for the roles of OMI initiator and responder In an AP, optional support for two NAV operation In a non-AP STA, mandatory support for two NAV operation In an AP, mandatory support for individual target wake time (TWT) operation In a non-AP STA, optional support individual TWT operation Optional support for broadcast TWT Optional support for UL OFDMA-based random access (UORA) Optional support for spatial reuse operation Optional support for multi-TID A-MPDU operation Optional support for ER BSS ${\tt Mandatory\ support\ for\ multiple\ BSSID\ operation\ in\ a\ non-AP\ STA}$ Optional support for the NDP feedback report HE MAC层强制的新特性: mandatory support for the role of operating mode indication (OMI) responder and optional support for the role of OMI initiator 作为AP强制支持 OMI Responder,可选支持OMI Initiator STA强制支持双重NAV机制 two NAV operation mandatory support for individual target wake time (TWT) operation AP强制支持TWT multiple BSSID operation in a non-AP STA 多BSSID HE MAC层可选的新特性: dynamic fragmentation levels 动态帧分段,区别于目前静态帧分段(帧分段阈值是定义确定的) STA可选支持OMI initiator and responder AP中可选支持双重NAV机制

11AX MAC Feature: OMI 参考 27.8 Operating mode indication

The main MAC features in an HE STA that are not present in VHT STA or HT STA are the following

协议原文如下

STA可选支持TWT 广播TWT机制

空分复用操作

ER BSS

上行OFDMA的随机接入机制

multi-TID A-MPDU operation

NDP feedback report 空数据包的反馈报告

OMI is a procedure used between an OMI initiator and an OMI responder. An HE STA that transmits a frame including an OM Control subfield is defined as an OMI initiator. An HE STA with dot110MIOptionImplemented equal to true that receives a frame including an OM Control subfield is defined as an OMI responder.

OMI 分为 发起者与响应者 ,发送帧携带OM Control subfield 的是OMI发起者,接收携带OM Control subfield帧 的是OMI响应者, set the OM Control Support subfield in the HE MAC Capabilities Information field of the HE Capabilities element it transmits to 1;

HE Capabilities element 会表示支不支持OM 控制

An OMI initiator may send to an OMI responder an individually addressed QoS Data, QoS Null or Class 3 Management frame after association that contains the OM Control subfield and that solicits an immediate acknowledgment to indicate a change in its receive operating mode (ROM) as defined in 27.8.2 (Receive operating mode (ROM) indication) and/or transmit operating parameters (TOM) as defined in 27.8.3 (Transmit operating mode (TOM) indication). 表明接收操作模式改变 或者 发送操作参数的改变

27.8.2 Receive operating mode (ROM) indication

ROM indication allows the OMI initiator to adapt the maximum operating channel width and/or the maximum number of spatial streams, Nss, it can receive from the OMI responder.

OMI Initiator 向 OMI Responder指示,其支持的下行链路的最大空间流数量和最大的信道带宽

27.8.3 Transmit operating mode (TOM) indication

TOM indication allows the OMI initiator to suspend and resume responding to variants of the Trigger frame and TRS Control subfields per the UL MU Disable and UL MU Data Disable subfields settings as indicated in Table 9-18b (UL MU Disable and UL MU Data Disable subfields encoding), or to adapt the maximum operating channel width and/or the maximum number of space-time streams, NSTS, that it can transmit in response to a Trigger frame and TRS Control subfield sent by the OMI responder. OMI能指示恢复还是暂停对 Trigger frame and TRS Control subfields 的响应,禁用或者使能UL MU, 或者调整带宽与空间流

参考 https://zhuanlan.zhihu.com/p/77526750

11AX MAC Feature: two NAV operation 双重NAV机制 参考 27.2.4 Updating two NAVs

A non-AP HE STA shall maintain two NAVs and an HE AP may maintain two NAVs: an intra-BSS NAV and a basic NAV. The intra-BSS NAV is updated by an intra-BSS PPDU. The basic NAV is updated by an inter-BSS PPDU or a PPDU that cannot be classified as intra-BSS or inter-BSS. The mechanism by which a PPDU is classified intra-BSS or inter-BSS is defined in 27.2.2 (Intra-BSS and inter-BSS frame determination).

BSS内部的NAV定时器(intra-BSS NAV timer),和基本NAV定时器(basic NAV timer)。

BSS内部NAV定时器(intra-BSS NAV timer): 其只够通过来自于同一个BSS内部的终端来设置,通过BSS内部终端传输的Duration/ID字段来设置NAV定时器的数值。 基本NAV定时器(basic NAV timer): 具可由米目十个同BSS区域的终端米设置,也是根据这些终端传输的Duration/ID字段米设置NAV定时器的数值。

以上两个NAV定时器同时工作,如果由任意一个NAV设置为非0,也就是正在定时中,那么就认为信道是忙,正在被占据。

引入了两个NAV定时器是有益的,尤其在密集场景下。802.11ax的终端不仅仅需要保护其在BSS内部(intra-BSS)传输的帧,还需要避免来与于其他BSS(即BSS间,inter-BSS)传输的干扰。

参考: https://zhuanlan.zhihu.com/p/77365487

11AX MAC Feature: TWT 参考 10.43 Target wake time (TWT) 27.7 TWT operation

STAs that request a TWT agreement are called TWT requesting STAs and the STAs that respond to their requests are TWT responding STAs.

请求TWT协议的被称为TWT 请求STA,响应请求的称为TWT响应STA

A TWT requesting STA is assigned specific times to wake and exchange frames with the TWT responding STA. 请求STA被分配一个指定的时间唤醒并和响应STA交换数据帧

A TWT requesting STA communicates wake scheduling information to its TWT responding STA and the TWT responding STA devises a schedule and delivers TWT values to the TWT requesting STA when a TWT agreement has been established between them

请求方会将唤醒调度信息传送给响应方,并且当TWT协议建立时,响应方会设计一个调度值给请求方 When explicit TWT is employed, a TWT requesting STA wakes and performs a frame exchange and receives the next TWT information in a response from the TWT responding STA as

described in 10.43.3 (Explicit TWT operation). 使用显示TWT时,请求方唤醒并执行一次帧交换并且接收来自响应方下一次TWT 信息 ,详细参考 Explicit TWT operation

When implicit TWT is used, the TWT requesting STA calculates the Next TWT by adding a fixed value to the current TWT value as described in 10.43.4 (Implicit TWT operation). 隐式TWT 请求 STA 通过将固定值添加到当前 TWT 值来计算下一个 TWT 参考 10.43.4 (Implicit TWT operation)

在TWT中,终端和AP之间建立了一张时间表(该时间表是终端和AP协定的),时间表是由TWT时间周期所组成的。通常终端和AP所协商的TWT时间周期包含一个或者多个beacon周期(总体时间比如几分钟, 几小时,甚至高达几天)。当终端和AP所协商的时间周期到达后,终端会醒来,并等待AP发送的触发帧,并进行一次数据交换。当本次传输完成后,返回睡眠状态。每一个终端和AP都会进行独立的协商,每一个 终端都具有单独的TWT时间周期。AP也可以将终端们根据设定的TWT时间周期进行分组,一次和多个终端进行连接,从而提高节能效率

TWT一共有三种工作模式,分别是: 1) Individual TWT, 2) Broadcast TWT, 3) Opportunistic PS

Individual TWT: 该模式下终端会和AP协商特定的TWT时间,该时间会被存放在AP的时间表中。终端会在特定的时间醒来并和AP进行帧交换。每一个终端仅仅直到自己和AP协商的TWT时间,不需要 知道其他终端的TWT时间。Individual TWT还有多种工作模式,比如说显式工作模式。 其大致工作流程如下:

> 终端想要建立一个TWT连接,其会将自己的节能调度信息告知给AP AP将会分配TWT周期,并将该周期反馈给终端 终端会在指定的TWT周期时苏醒,并和AP进行数据帧交换

在本轮交换中,会分成显式和隐式两种工作模式

显式工作模式

在本次数据帧交换中,AP会显式告诉终端,下一轮的TWT周期 终端会在新的指定的TWT周期时苏醒,并再一次和AP进行数据帧交换 隐式工作模式

在本次数据帧交换中,AP不会告诉终端,下一轮的TWT周期 终端会自己计算出下一轮的TWT周期(通过在当前TWT周期上增加一个特定的时间) 终端会在自己计算的TWT周期时苏醒,并再一次和AP进行数据帧交换

11AX MAC Feature: 4.3.18.12 Multiple BSSID capability

The Multiple BSSID capability enables the advertisement of information for BSSIDs using a single Beacon or Probe Response frame instead of multiple Beacon and Probe Response frames, each corresponding to a single BSSID. The Multiple BSSID capability also enables the indication of buffered frames for multiple BSSIDs using a single TIM element in a single beacon. 一个帧就包含多个BSSID的信息,而不是多个帧包含多个BSSID的信息,每个帧只代表一个BSSID。是不是DB DC

11AX MAC Feature : 27.3.2 Dynamic fragmentation 动态分段主要分为Level 1 2 3

With level 1 and level 2 dynamic fragmentation, the following apply:

— An originator STA transmitting one or more dynamic fragments shall solicit an immediate response from the recipient STA for each of the fragments. — The originator STA shall transmit the fragments in order as defined in 10.5 (Fragmentation).

With level 3 dynamic fragmentation, not all dynamic fragments require an immediate response and dynamic fragments are not required to be sent in order.

An HE STA may transmit dynamic fragments of an A-MSDU provided the A-MSDU Fragmentation Support subfield of the HE Capabilities element transmitted by the recipient is 1.

27. 3. 2. 2 Level 1 dynamic fragmentation 27.3.2.3 Level 2 dynamic fragmentation 27. 3. 2. 4 Level 3 dynamic fragmentation