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RUSS, AUGUST & KABAT

UNITED STATES DISTRICT COURT

CENTRAL DISTRICT OF CALIFORNIA

XR COMMUNICATIONS, LLC, dba VIVATO TECHNOLOGIES,

Plaintiff,

v.

BELKIN INTERNATIONAL, INC., and LINKSYS USA, INC.

Defendants.

Case No. 8:2017-cv-00596

FIRST AMENDED COMPLAINT FOR PATENT INFRINGEMENT

I. JURISDICTION AND VENUE

1. This is an action for patent infringement. This Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331 and 1338(a) because this action arises under the patent laws of the United States, 35 U.S.C. §§ 101 *et seq*.

II. THE PARTIES

2. Plaintiff XR Communications LLC d/b/a Vivato Technologies ("Vivato" or "Plaintiff") is a limited liability company organized and existing under the laws of Delaware with its principal place of business at 2809 Ocean Front Walk, Venice, California 90291. Vivato is the sole owner by assignment of all right, title, and interest in each Asserted Patent.

3. Vivato was founded in 2000 as a $80+ million venture-backed company with several key innovators in the wireless communication field including Siavash Alamouti, Ken Biba, William Crilly, James Brennan, Edward Casas, and Vahid Tarokh, among many others. At that time, and as remains the case today, "Wi-Fi" or "802.11" had become the ubiquitous means of wireless connection to the Internet, integrated into hundreds of millions of mobile devices globally. Vivato was founded to leverage its talent to generate intellectual property and deliver Wi-Fi/802.11 wireless connectivity solutions to service the growing demand for bandwidth.

4. Vivato has accomplished significant innovations in the field of wireless communications technology. One area of focus at Vivato was the development of advanced wireless systems with sophisticated antenna designs to improve wireless speed, coverage, and reliability. Vivato also focused on designing wireless systems that maximize the efficient use of spectrum and wireless resources for large numbers of connected mobile devices.

5. Among many fundamental breakthroughs achieved by Vivato are inventions that allow for intelligent and adaptive beamforming based on up-to-date information about the wireless medium. Through these and many other inventions, Vivato's engineers pioneered a wireless technology that provides for simultaneous

transmission and reception, a significant leap forward over conventional wireless technology.

6. Over the years, Vivato has developed proven technology, with over 400 deployments globally, including private, public and government, and it has become a recognized provider of extended range Wi-Fi network infrastructure solutions. Vivato's wireless base stations integrate beamforming phased array antenna design with packet steering technology to deliver high-bandwidth extended range connections to serve multiple users and multiple devices

7. Vivato's patent portfolio includes over 17 issued patents and pending patent applications. The patent at issue in this case are directed to specific aspects of wireless communication, including adaptively steered antenna technology and beam switching technology.

8. Belkin International, Inc. ("Belkin") is a corporation organized and existing under the laws of Delaware with its principal place of business at 12045 E. Waterfront Dr., Playa Vista, California 90094. Belkin has a registered agent for service of process at National Registered Agents, Inc. 12045 E. Waterfront Dr., Playa Vista, California 90094. Vivato is informed and believes that Belkin's activities relating to the Linksys branded products accused in this action are conducted, controlled, and directed at the Linksys headquarters located at 121 Theory Drive, Irvine, CA 92617.

9. Linksys USA, Inc. ("Linksys") is a corporation organized and existing under the laws of Delaware with its principal place of business at 121 Theory Drive, Suite 200, Irvine, CA 92617. Linksys has a registered agent for service of process at 1505 Corporation CSC-Lawyers Incorporating Service, 2710 Gateway Oaks Dr., Sacramento, CA 95833.

10. This Court has personal jurisdiction over Belkin and Linksys (collectively, "Defendants") because they each have their principal place of business in California.

11. Venue is proper in this federal district pursuant to 28 U.S.C. §§ 1391(b)-(d) and 1400(b) in that Defendants are subject to jurisdiction in this District, have done business in this District, have regular and established places of business in this District, have committed acts of infringement in this District, and continue to commit acts of infringement in this District, entitling Plaintiff to relief.

III. BACKGROUND OF THE TECHNOLOGY

12. This complaint arises from Defendants' unlawful infringement of the following United States patent owned by Vivato, which generally relates to wireless communications technology: United States Patent No. 10,594,376 (the "'376 Patent" or the "Asserted Patent").

13. Countless electronic devices today connect to the Internet wirelessly. Beyond just connecting our devices together, wireless networks have become an inseparable part of our lives in our homes, our offices, and our neighborhood coffee shops. In even our most crowded spaces, today's wireless technology allows all of us to communicate with each other, on our own devices, at virtually the same time. Our connected world would be unrecognizable without the ubiquity of sophisticated wireless networking technology.

14. Just a few decades ago, wireless technology of this kind could only be found in science fiction. The underlying science behind wireless communications can be traced back to the development of "wireless telegraphy" in the nineteenth century. Guglielmo Marconi is credited with developing the first practical radio, and in 1896, Guglielmo Marconi was awarded British patent 12039, Improvements in transmitting electrical impulses and signals and in apparatus there-for, the first patent to issue for a Herzian wave-based wireless telegraphic system. Marconi would go on to win the Nobel Prize in Physics in 1909 for his contributions to the field.

15. One of Marconi's preeminent contemporaries was Dr. Karl Ferdinand Braun, who shared the 1909 Nobel Prize in Physics with Marconi. In his Nobel lecture dated December 11, 1909, Braun explained that he was inspired to work on

wireless technology by Marconi's own experiments. Braun had observed that the signal strength in Marconi's radio was limited beyond a certain distance, and wondered why increasing the voltage on Marconi's radio did not result in a stronger transmission at greater distances. Braun thus dedicated himself to developing wireless devices with a stronger, more effective transmission capability.

16. In 1905, Braun invented the first phased array antenna. This phased array antenna featured three antennas carefully positioned relative to one another with a specific phase relationship so that the radio waves output from each antenna could add together to increase radiation in a desired direction. This design allowed Braun's phased array antenna to transmit a directed signal.

17. Building on the fundamental breakthrough that radio transmissions can be directed according to a specific radiation pattern through the use of a phased array antenna, directed wireless communication technology has developed many applications over the years. Braun's invention of the phased array antenna led to the development of radar, smart antennas, and, eventually, to a technology known as "MIMO," or "multiple-input, multiple-output," which would ultimately allow a single radio channel to receive and transmit multiple data signals simultaneously. Along the way, engineers have worked tirelessly to overcome limitations and roadblocks directed wireless communication technology.

18. At the beginning of the twenty-first century, the vast majority of wireless networks still did not yet take advantage of directed wireless communications. Instead, "omnidirectional" access points were ubiquitous. Omnidirectional access points transmit radio waves uniformly around the access point in every direction and do not steer the signal in particular directions. Omnidirectional antennas access points do typically achieve 360 degrees of coverage around the access point, but with a reduced coverage distance. Omnidirectional access points also lack sophisticated approaches to overcome certain types of interference in the environment. As only one example, the presence of solid obstructions, such as a

concrete wall, ceiling, or pillar, can limit signal penetration. As another example, interference arises when radio waves are reflected, refracted, or diffracted based on obstacles present between the transmitter and receiver. The multiple paths that radio waves can travel between the transmitter and receiver often result in signal interference that decreases performance, and omnidirectional access points lack advanced solutions to overcome these "multipath" effects.

19. Moving from omnidirectional networks to modern networks has required an additional series of advancements that harness the capabilities of directed wireless technology. These advancements range from conceiving various ways to steer and modify radiation patterns, to enhancing the transmission signal power in a desired direction, to suppressing radiation in undesired directions, to minimizing signal "noise," and then applying these new approaches into communications networks with multiple, heterogenous transmitters and receivers.

20. Harnessing the capabilities of directed wireless technology resulted in a significant leap forward in the signal strength, reliability, concurrent users, and/or data transmission capability of a wireless network. One of the fundamental building blocks of this latest transition was the development of improvements to MIMO and "beamforming," which are the subject matter of the patent in this infringement action. The patent in this action resulted from the investment of tens of millions of dollars and years of tireless effort by a group of engineers who built a technology company slightly ahead of its time. Their patented innovations laid the groundwork for today's networks, and are infringed by Defendants' accused products.

IV. COUNT ONE: INFRINGEMENT OF UNITED STATES PATENT NO. 10,594,376

21. Vivato realleges and incorporates by reference the foregoing paragraphs as if fully set forth herein.

22. On March 17, 2020, United States Patent No. 10,594,376 ("the '376 Patent") was duly and legally issued for inventions entitled "Directed Wireless

Communication." Vivato owns the '376 Patent and holds the right to sue and recover damages for infringement thereof. A copy of the '376 Patent is attached hereto as Exhibit B.

23. Defendants have directly infringed and continue to directly infringe numerous claims of the '376 Patent, including at least claim 1, by manufacturing, using, selling, offering to sell, and/or importing into the United States Wi-Fi 6 access points and routers supporting MU-MIMO, including without limitation access points and routers utilizing the IEEE 802.11ax / "Wi-Fi 6" standard, and/or the IEEE 802.11ac standard because WiFi 6 is backward compatible (*e.g.*, Defendants' Belkin brand RT1800 and RT3200 routers; Defendants' Linksys brand LAPAC1300C, LAPAC1300CE, and LAPAC2600C business access points; Defendants' Linksys brand MX12600, MX8503, MX4200, MX5 Velop AX, MX10 Velop AX, WHW0303, WHW0302, WHW0302B, WHW0103, WHW0102, WHW0301, and WHW0101 mesh WiFi systems; Defendants' Linksys brand MR9600, MR9000, MR8300, MR7500, MR7350, MR6350, EA8300, EA8100, EA7450, E7350, EA7300, EA7200, E8450, E5600, and EA7500 wireless routers; and Defendants' Linksys brand RE7350, WHW010P, RE9000, and RE7000 WiFi extenders) (collectively, the "'376 Accused Products"). Defendants are liable for infringement of the '376 Patent pursuant to 35 U.S.C. § 271(a).

24. The '376 Accused Products satisfy all claim limitations of numerous claims of the '376 Patent, including Claim 1. The following paragraphs compare limitations of Claim 1 to an exemplary '376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600).

25. Each of the '376 Accused Products comprises a data-communications networking apparatus. For example, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) is a data-communications networking apparatus. *See*, *e.g.*, Linksys Dual-Band Mesh WiFi 6 Router (MR9600) Webpage, which explains that the Linksys MR9600 includes "Dual-Band (2.4GHz + 5 GHz), 4x4 WiFi 6," "4x4 MU-MIMO,"

"2.4 and 5GHz (Simultaneous Dual-Band)" Wi-Fi Bands, "OFDMA technology," "4x external adjustable antennas," with a "1.8 GHz Quad Core Processor," supporting the "WiFi 5 (802.11ac)" and "WiFi 6 (802.11ax)" standards. Additionally, the MR9600 provides "More Capacity to More Devices" because "WiFi 6 sends and receives multiple streams of data simultaneously, providing up to 4x more WiFi capacity to handle every … device on your network" and also "Minimizes Wi-Fi Congestion" by "Eliminate[ing] interference from neighboring networks with advanced WiFi 6 technology that can isolate your network, reduce congestion and deliver the strongest, clearest WiFi signal available." *See also* Linksys' support page *Getting to know the Linksys MR9600 Max-Stream™ Dual-Band WiFi 6 Router*, indicating: "The Linksys MR9600… delivers true Gigabit speeds of up to 6 Gbps with eight-stream capacity throughout the entire home," and includes a "1.8 GHz quad-core CPU," "4x4 spatial streams," "MU-MIMO," "Next-generation Orthogonal Frequency-Division Multiple Access (OFDMA) technology," "Four adjustable antennas," and "Supports 802.11ax." *See also* Linksys' *What is AX?* Webpage, stating: "Thanks to 11AX, multiple devices can simultaneously transmit data, using the same radio frequency and the same network," and that 11AX is "Up to eight times faster than non-MU-MIMO products thanks to up link and down line (DL/UL) MU-MIMO." *See also* Linksys' *What is MU-MIMO and Why Do You Need It?* Webpage,[1] stating: "Multi-user, multiple-input, multiple-output technology—better known as MU-MIMO (a.k.a. Next-Gen AC or AC Wave 2)—allows a Wi-Fi router to communicate with multiple devices simultaneously… increases the capacity and efficiency of your router… allowing it to handle more WiFi-intensive activities such as streaming and gaming."

26.Each of the '376 Accused Products comprises a processor configured to generate a probing signal for transmission to at least a first client device and a second

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[1] Linksys' *What is MU-MIMO?* Webpage is available at Defendants' website: https://www.linksys.com/us/r/what-is-mu-mimo/ (last visited June 8, 2021).

client device. For example, as with each ’376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) has at least one processor (*e.g.*, one or more central processing units (CPUs), Wi-Fi processors, a baseband processor in the Wi-Fi 6 radio, as examples) for generating signals for transmission. *See*, *e.g.*, Linksys Dual-Band Mesh WiFi 6 Router (MR9600) Webpage, which explains that the Linksys MR9600 includes “Dual-Band (2.4GHz + 5 GHz), 4x4 WiFi 6,” “4x4 MU-MIMO,” “2.4 and 5GHz (Simultaneous Dual-Band)” Wi-Fi Bands, “OFDMA technology,” “4x external adjustable antennas,” with a “1.8 GHz Quad Core Processor,” supporting the “WiFi 5 (802.11ac)” and “WiFi 6 (802.11ax)” standards. Additionally, the MR9600 provides “More Capacity to More Devices” because “WiFi 6 sends and receives multiple streams of data simultaneously, providing up to 4x more WiFi capacity to handle every… device on your network” and also “Minimizes Wi-Fi Congestion” by “Eliminate[ing] interference from neighboring networks with advanced WiFi 6 technology that can isolate your network, reduce congestion and deliver the strongest, clearest WiFi signal available.” *See also* Linksys’ support page *Getting to know the Linksys MR9600 Max-Stream™ Dual-Band WiFi 6 Router*, indicating: “The Linksys MR9600… delivers true Gigabit speeds of up to 6 Gbps with eight-stream capacity throughout the entire home,” and includes a “1.8 GHz quad-core CPU,” “4x4 spatial streams,” “MU-MIMO,” “Next-generation Orthogonal Frequency-Division Multiple Access (OFDMA) technology,” “Four adjustable antennas,” and “Supports 802.11ax.” *See also* Linksys’ *What is AX?* Webpage, stating: “Thanks to 11AX, multiple devices can simultaneously transmit data, using the same radio frequency and the same network,” and that 11AX is “Up to eight times faster than non-MU-MIMO products thanks to up link and down line (DL/UL) MU-MIMO.” *See also* Linksys’ *What is MU-MIMO and Why Do You Need It?* Webpage, stating: “Multi-user, multiple-input, multiple-output technology—better known as MU-MIMO (a.k.a. Next-Gen AC or AC Wave 2)—allows a Wi-Fi router to communicate with multiple devices

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simultaneously… increases the capacity and efficiency of your router… allowing it to handle more WiFi-intensive activities such as streaming and gaming." For a further example, as with each '376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) generates a probing signal for transmission (*e.g.*, a probing signal transmission that triggers or elicits a responsive transmission from each of a first client device and a second client device, such as NDP Announcement, HE sounding NDP, Beamforming Report trigger frames pursuant to High Efficiency (HE) channel sounding, including preamble training fields allowing an estimate of the channel for MU-MIMO) to at least a first client device and a second client device (*e.g.*, a first non-AP STA / HE beamformee and a second non-AP STA / HE beamformee). *See*, *e.g.*, 802.11ax Standard, Sections 9.3.1.19, 9.3.1.22, 9.3.1.22.3, 9.4.1.64, 9.4.1.65, 9.4.1.66, 9.4.1.67, 9.6.31.2, 10.37, 26.7, 26.7.1, 26.7.2, 26.7.3, 26.7.4, 26.7.5, 27.1.1. *See*, *e.g.*, Section 26.7 (HE sounding protocol) ("Transmit beamforming and DL MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmit signal to optimize reception at one or more receivers. HE STAs use the HE sounding protocol to determine the channel state information. The HE sounding protocol provides explicit feedback mechanisms, defined as HE non-trigger-based (non-TB) sounding and HE trigger-based (TB) sounding, where the HE beamformee measures the channel using a training signal (i.e., an HE sounding NDP) transmitted by the HE beamformer and sends back a transformed estimate of the channel state. The HE beamformer uses this estimate to derive the steering matrix. The HE beamformee returns an estimate of the channel state in an HE compressed beamforming/CQI report carried in one or more HE Compressed Beamforming/CQI frames."); Section 26.7.3, Figures 26-6 and 26-7:

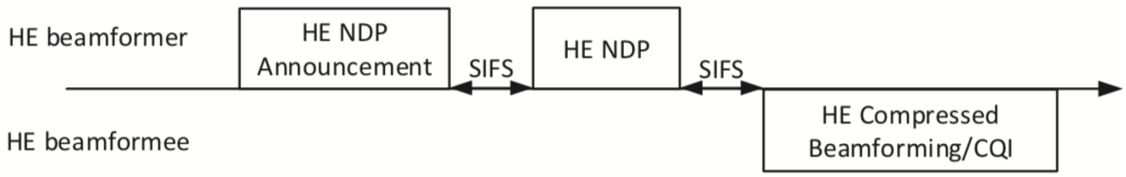

Figure 26-6—An example of the sounding protocol with a single HE beamformee

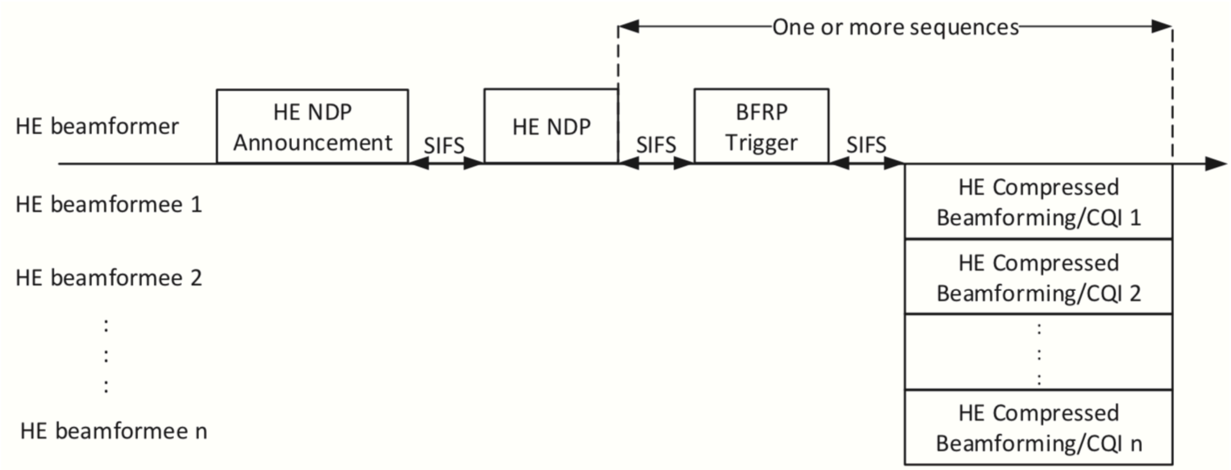

Figure 26-7—An example of the sounding protocol with more than one HE beamformee

; Section 26.7.3 ("An HE beamformee that receives an HE NDP Announcement frame from an HE beamformer with which it is associated and that contains the HE beamformee's MAC address in the RA field and also receives an HE sounding NDP a SIFS after the HE NDP Announcement frame shall transmit its HE compressed beamforming/CQI report a SIFS after the HE sounding NDP. The TXVECTOR parameter CH_BANDWIDTH for the PPDU containing the HE compressed beamforming/CQI report shall be set to indicate a bandwidth not wider than that indicated by the RXVECTOR parameter CH_BANDWIDTH of the HE sounding NDP. An HE beamformee that receives an HE NDP Announcement frame as part of an HE TB sounding sequence with a STA Info field addressed to it soliciting SU or MU feedback shall generate an HE compressed beamforming/CQI report using the feedback type, *Ng* and codebook size indicated in the STA Info field. If the HE beamformee then receives a BFRP Trigger frame with a User Info field addressed to it, the HE beamformee transmits an HE TB PPDU containing the HE compressed beamforming/CQI report following the rules defined in 26.5.3.3 (Non-AP STA behavior for UL MU operation)."); Section 26.5.3 (UL MU operation) ("UL MU operation allows an AP to solicit simultaneous immediate response frames from one or more non-AP HE STAs"); Section 27.3.10.10 (HE-LTF) ("The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the r-th RU. In an HE TB PPDU, the transmitter of user u in the r-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the r-th RU, the MIMO channel that can be estimated is an N_{RX} x $N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{HE\text{-}LTF}$, to enable channel estimation at the receiver…. In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.18 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combination of HE-LTF types and GI durations are listed in 27.3.4 (HE PPDU formats."); Section 27.3.15.1 (SU-MIMO and DL-MIMO beamforming) ("The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,Nuser,r-1}]$ can be detected by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0,1,\ldots N_{user,r}$ -1. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission. For SU-MIMO beamforming, the steering matrix Q_k can be determined from the beamforming feedback matrix V_k that is sent back to the beamformer by the beamformee using the compressed beamforming feedback matrix format as defined in 19.3.12.3.6 (Compressed beamforming feedback matrix). The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field.”). Section 9.4.1.65 (HE Compressed Beamforming Report field) (“The HE Compressed Beamforming Report field carries the average SNR of each space-time stream and compressed beamforming feedback matrices V for use by a transmit beamformer to determine steering matrices Q, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming)”); Section 9.1.4.66 (HE MU Exclusive Beamforming Report field) (“The HE MU Exclusive Beamforming Report field carries explicit feedback in the form of delta SNRs. The information in the HE Compressed Beamforming Report field and the HE MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices Q, as described in 27.3.3.1 (DL MU-MIMO)”); Section 9.4.1.67 (HE CQI Report Field) (“The HE CQI Report field carries the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested.”). For a further example, as with each ’376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) generates a probing signal for transmission (*e.g.*, a probing signal transmission that triggers or elicits a responsive transmission from each of a first client device and a second client device, such as NDP Announcement pursuant to Very High Throughput (VHT) channel sounding, including preamble training fields allowing an estimate of the channel for MU-MIMO) to at least a first client device and a second client device (*e.g.*, a first non-AP STA / VHT beamformee and a second non-AP STA / VHT beamformee). *See*, *e.g.*, 802.11ac Standard Clause 9.31.5.2 (“A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field."); *id.* ("A non-AP VHT beamformee that receives a VHT NDP Announcement frame… shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer."); *id.* Clause 8.5.23.2 (defining format and subfields within the VHT Compressed Beamforming frame); *id.* Clause 8.4.1.48 (including Tables 8-53(d)-(h)) ("Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee"); *id.* Clause 8.4.1.49 (including Table 8-53i – MU Exclusive Beamforming Report information); *id.* Clauses 8.4.1.24, 9.31.5.1, 9.31.5.2; *id.* Clause 22.3.8.3.5; *id.* Clause 22.3.11.2:

Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined.

The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP.

After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ ($0 \le u \le N_{user} - 1$) in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific.

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27. Each of the '376 Accused Products comprises a processor configured to generate a first data stream for transmission to the first client device and generate a second data stream for transmission to the second client device. For example, as with each Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) has at least one processor and Wi-Fi 6 radio functionality (*e.g.*, the CPU(s) and/or Wi-Fi processors and/or baseband processor(s) in the Wi-Fi 6 radio) configured to generate a first data stream for transmission to the first client device ("non-AP STA" or "non-Access Point Station") and a second data stream for transmission to a second client device (non-AP STA) pursuant to MU-MIMO transmissions. *See*, *e.g.*, Linksys Dual-Band Mesh WiFi 6 Router (MR9600) Webpage, which explains that the Linksys MR9600 includes "Dual-Band (2.4GHz + 5 GHz), 4x4 WiFi 6," "4x4 MU-MIMO," "2.4 and 5GHz (Simultaneous Dual-Band)" Wi-Fi Bands, "OFDMA technology," "4x external adjustable antennas," with a "1.8 GHz Quad Core Processor," supporting the "WiFi 5 (802.11ac)" and "WiFi 6 (802.11ax)" standards. Additionally, the MR9600 provides "More Capacity to More Devices" because "WiFi 6 sends and receives multiple streams of data simultaneously, providing up to 4x more WiFi capacity to handle every … device on your network" and also "Minimizes Wi-Fi Congestion" by "Eliminate[ing] interference from neighboring networks with advanced WiFi 6 technology that can isolate your network, reduce congestion and deliver the strongest, clearest WiFi signal available." *See also* Linksys' support page *Getting to know the Linksys MR9600 Max-Stream™ Dual-Band WiFi 6 Router*, indicating: "The Linksys MR9600… delivers true Gigabit speeds of up to 6 Gbps with eight-stream capacity throughout the entire home," and includes a "1.8 GHz quad-core CPU," "4x4 spatial streams," "MU-MIMO," "Next-generation Orthogonal Frequency-Division Multiple Access (OFDMA) technology," "Four adjustable antennas," and "Supports 802.11ax." *See also* Linksys' *What is AX?* Webpage, stating: "Thanks to 11AX, multiple devices can simultaneously transmit data, using the same radio frequency and the same

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network," and that 11AX is "Up to eight times faster than non-MU-MIMO products thanks to up link and down line (DL/UL) MU-MIMO." *See also* Linksys' *What is MU-MIMO and Why Do You Need It?* Webpage, stating: "Multi-user, multiple-input, multiple-output technology—better known as MU-MIMO (a.k.a. Next-Gen AC or AC Wave 2)—allows a Wi-Fi router to communicate with multiple devices simultaneously … increases the capacity and efficiency of your router… allowing it to handle more WiFi-intensive activities such as streaming and gaming." *See*, *e.g.*, IEEE 802.11ax Standard, at Sections 26.5, 26.5.1, 26.5.2, 26.5.3, 27.1.1, 27.3.1, 27.3.2.5, 27.3.2.6, 27.3.5, 27.3.6.11.4, 27.3.10.7, 27.3.10.8, 27.3.10.9, 27.3.15, including Tables 27-19, 27-20, 27-21, 27-24, 27-25, 27-26, 27-27, 27-28, 27-29, Figures 27-19, 27-20, and other transmitter block diagrams for MU-MIMO transmission. *See*, *e.g.*, Section 27.1.1 ("The HE PHY extends the maximum number of users supported for DL MU-MIMO transmissions up to 8 users per resource unit (RU) and provides support for DL and UL orthogonal frequency division multiple access (OFDMA) as well as for UL MU-MIMO. Both DL and UL MU-MIMO transmissions are supported on portions of the PPDU bandwidth (on resource units greater than or equal to 106 tones). In an MU-MIMO resource unit, there is support for up to 8 users with up to 4 space-time streams per user with the total not exceeding 8 space-time streams"); Section 27.3.1.1 ("DL MU transmission allows an AP to simultaneously transmit information to more than one non-AP STA. For a DL MU transmission, the AP uses the HE MU PPDU format and employs either DL OFDMA, DL MU-MIMO, or a mixture of both."); Section 27.3.10.8.1 ("The HE-SIG-B field provides the OFDMA and DL MU-MIMO resource allocation information to allow the STAs to look up the corresponding resources to be used in the data portion of the frame."); Section 27.3.2.5 ("If there is more than one User field (see Table 27-28 (User field for an MU-MIMO allocation)) for an RU in the HE-SIG-B content channel, then the number of allocated spatial streams for each user in the RU is indicated by the Spatial Configuration field of the User field in HE-

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SIG-B…In each HE-SIG-B content channel, the User fields are first ordered in the order of RUs (from lower frequency to higher frequency) as described by the RU Allocation field if the HE-SIG-B contains the Common field. If an RU has multiple User fields in an HE-SIG-B content channel, the User fields of the RU are ordered in the order of spatial stream index, from lower to higher spatial stream, as indicated in the Spatial Configuration field. The STA-ID field in each User field indicates the intended recipient user of the corresponding spatial streams and the RU."); *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.5 (Transmitter block diagram), at, *e.g.*, Figure 27-19:

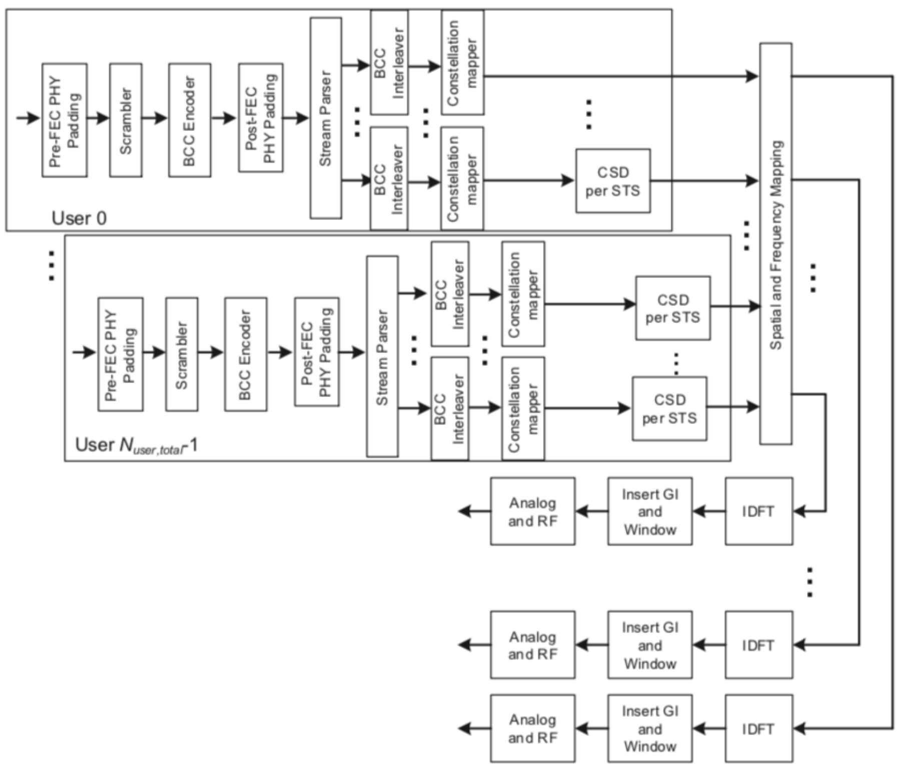

Figure 27-19—Transmitter block diagram for the Data field of an HE DL MU-MIMO transmission in a 106-, 242-, 484- or 996-tone RU with BCC encoding

See, *e.g.*, Section 27.3.6.11.4 – 27.3.7:

/ / /

/ / /

/ / /

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27.3.6.11.4 Combining to form an HE MU PPDU

The per user data is combined as follows:

a) Spatial mapping: The *Q* matrix is applied as described in 27.3.11.14 (OFDM modulation). The combining of all user data of an RU is done in this block.

b) IDFT: Compute the inverse discrete Fourier transform.

c) Insert GI and apply windowing: Prepend a GI determined by the TXVECTOR parameter GI_TYPE and apply windowing as described in 27.3.9 (Mathematical description of signals).

d) Analog and RF: Upconvert the resulting complex baseband waveform with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 27.3.9 (Mathematical description of signals) and 27.3.10 (HE preamble) for details.

27.3.7 HE modulation and coding schemes (HE-MCSs)

The HE-MCS is a compact representation of the modulation and coding used in the Data field of the PPDU. For an HE SU PPDU and an HE ER SU PPDU it is carried in the HE-SIG-A field. For an HE MU PPDU it is carried per user in the User Specific field of the HE-SIG-B field. For an HE TB PPDU, it is carried in the User Info field of the Trigger frame soliciting the HE TB PPDU.

For a further example, as with each Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) has at least one processor and Wi-Fi radio functionality (*e.g.*, the CPU and/or baseband processor(s) in the Wi-Fi radio) configured to generate a first data stream for transmission to the first client device ("non-AP STA" or "non-Access Point Station") and a second data stream for transmission to a second client device (non-AP STA) pursuant to MU-MIMO transmissions. *See*, *e.g.*, 802.11ac Standard Clause 9.31.5.1 ("Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix."); *id.* Clauses 22.3.4.6(d), 22.3.4.7(e), 22.3.4.8(l), 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a) ("Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1."); *id.* Clause

22.3.10.11.1; IEEE 802.11-2012 Standard Clause 20.3.12.3.6; 802.11ac Standard Clauses 8.4.1.24, 9.31.5.1, 9.31.5.2; *id.* Clause 22.3.11.1, 22.3.11.2.

28.Each of the '376 Accused Products comprises a transceiver operatively coupled to the processor and configured to: transmit the probing signal to at least the first client device and the second client device via a smart antenna; wherein the smart antenna is operatively coupled to the transceiver and comprises a first antenna element and a second antenna element. For example, as with each '376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) has a Wi-Fi 6 radio with a transceiver operatively coupled to the processor (*e.g.*, the Wi-Fi 6 radio generates signals for transmission and processes received signals with, *e.g.*, the CPU, Wi-Fi processors, and/or baseband processor in the Wi-Fi 6 radio, and the radio comprises a transceiver that transmits and receives signals via a smart antenna); and, as with each '376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) has a Wi-Fi 6 radio transceiver operatively coupled to the processor and to a smart antenna, wherein the smart antenna is operatively coupled to the Wi-Fi 6 radio and comprises a first antenna element and a second antenna element. *See*, *e.g.*, Linksys Dual-Band Mesh WiFi 6 Router (MR9600) Webpage, which explains that the Linksys MR9600 includes "Dual-Band (2.4GHz + 5 GHz), 4x4 WiFi 6," "4x4 MU-MIMO," "2.4 and 5GHz (Simultaneous Dual-Band)" Wi-Fi Bands, "OFDMA technology," "4x external adjustable antennas," with a "1.8 GHz Quad Core Processor," supporting the "WiFi 5 (802.11ac)" and "WiFi 6 (802.11ax)" standards. Additionally, the MR9600 provides "More Capacity to More Devices" because "WiFi 6 sends and receives multiple streams of data simultaneously, providing up to 4x more WiFi capacity to handle every… device on your network" and also "Minimizes Wi-Fi Congestion" by "Eliminate[ing] interference from neighboring networks with advanced WiFi 6 technology that can isolate your network, reduce congestion and deliver the strongest, clearest WiFi signal available." *See also* Linksys' support page *Getting to know the Linksys MR9600 Max-Stream™ Dual-*

Band WiFi 6 Router, indicating: "The Linksys MR9600… delivers true Gigabit speeds of up to 6 Gbps with eight-stream capacity throughout the entire home," and includes a "1.8 GHz quad-core CPU," "4x4 spatial streams," "MU-MIMO," "Next-generation Orthogonal Frequency-Division Multiple Access (OFDMA) technology," "Four adjustable antennas," and "Supports 802.11ax." *See also* Linksys' *What is AX?* Webpage, stating: "Thanks to 11AX, multiple devices can simultaneously transmit data, using the same radio frequency and the same network," and that 11AX is "Up to eight times faster than non-MU-MIMO products thanks to up link and down line (DL/UL) MU-MIMO." *See also* Linksys' *What is MU-MIMO and Why Do You Need It?* Webpage, stating: "Multi-user, multiple-input, multiple-output technology—better known as MU-MIMO (a.k.a. Next-Gen AC or AC Wave 2)—allows a Wi-Fi router to communicate with multiple devices simultaneously … increases the capacity and efficiency of your router … allowing it to handle more WiFi-intensive activities such as streaming and gaming." For a further example, as with each '376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) transmits the probing signal (*e.g.*, a probing signal transmission that triggers or elicits a responsive transmission from each of a first client device and a second client device, such as NDP Announcement, HE sounding NDP, Beamforming Report trigger frames pursuant to High Efficiency (HE) channel sounding, including preamble training fields allowing an estimate of the channel for MU-MIMO) to at least the first client device and the second client device (*e.g.*, the first non-AP STA and the second non-AP STA) via the smart antenna. *See*, *e.g.*, 802.11ax Standard, Sections 9.3.1.19, 9.3.1.22, 9.3.1.22.3, 9.4.1.64, 9.4.1.65, 9.4.1.66, 9.4.1.67, 9.6.31.2, 10.37, 26.7, 26.7.1, 26.7.2, 26.7.3, 26.7.4, 26.7.5, 27.1.1. *See*, *e.g.*, Section 26.7.5 (HE sounding NDP transmission) (setting forth TXVECTOR parameters for HE sounding NDP); Section 27.3.10.10 (HE-LTF) ("The HE-LTF field provides a means for the receiver to estimate the MIMO channel between the set of constellation mapper outputs (or, if STBC is applied, the STBC encoder outputs) and the receive chains. In an HE SU PPDU and HE ER SU PPDU, the transmitter provides training for N_{STS} space-time streams (spatial mapper inputs) used for the transmission of the PSDU. In an HE MU PPDU, the transmitter provides training for $N_{STS,r,total}$ space-time streams used for the transmission of the PSDU(s) in the *r*-th RU. In an HE TB PPDU, the transmitter of user *u* in the *r*-th RU provides training for $N_{STS,r,u}$ space-time streams used for the transmission of the PSDU. For each tone in the *r*-th RU, the MIMO channel that can be estimated is an N_{RX} x $N_{STS,r,total}$ matrix. An HE transmission has a preamble that contains HE-LTF symbols, where the data tones of each HE-LTF symbol are multiplied by entries belonging to a matrix $P_{\text{HE-LTF}}$, to enable channel estimation at the receiver…. In an HE SU PPDU, HE MU PPDU and HE ER SU PPDU, the combination of HE-LTF type and GI duration is indicated in HE-SIG-A field. In an HE TB PPDU, the combination of HE-LTF type and GI duration is indicated in the Trigger frame that triggers transmission of the PPDU. If an HE PPDU is an HE sounding NDP, the combinations of HE-LTF types and GI durations are listed in 27.3.18 (Transmit specification). If an HE PPDU is an HE TB feedback NDP, the combination of HE-LTF types and GI durations are listed in 27.3.4 (HE PDU formats.”). *See*, *e.g.*, Section 26.7.3, Figure 26-7:

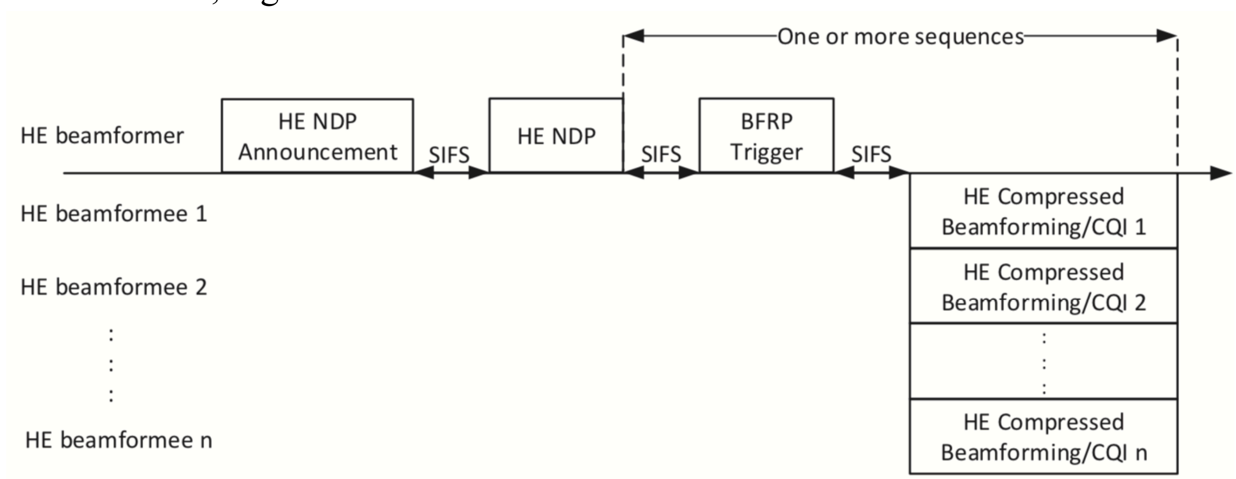

Figure 26-7—An example of the sounding protocol with more than one HE beamformee

; Section 9.4.1.65 (HE Compressed Beamforming Report field) (“The HE Compressed Beamforming Report field carries the average SNR of each space-time stream and compressed beamforming feedback matrices *V* for use by a transmit beamformer to determine steering matrices *Q*, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming)"); Section 9.1.4.66 (HE MU Exclusive Beamforming Report field) ("The HE MU Exclusive Beamforming Report field carries explicit feedback in the form of delta SNRs. The information in the HE Compressed Beamforming Report field and the HE MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices *Q*, as described in 27.3.3.1 (DL MU-MIMO)"); Section 9.4.1.67 (HE CQI Report Field) ("The HE CQI Report field carries the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested."). *See*, *e.g.*, 802.11ac Standard Clause 9.31.5.2 ("A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee's AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field."); *id.* ("A non-AP VHT beamformee that receives a VHT NDP Announcement frame… shall transmit its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer."); *id.* Clause 8.5.23.2 (defining format and subfields within the VHT Compressed Beamforming frame); *id.* Clause 8.4.1.48 (including Tables 8-53(d)-(h)) ("Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee"); *id.* Clause 8.4.1.49 (including Table 8-53i – MU Exclusive

Beamforming Report information); *id.* Clauses 8.4.1.24, 9.31.5.1, 9.31.5.2; *id.* Clause 22.3.8.3.5; *id.* Clause 22.3.11.2.

29.Each of the ’376 Accused Products comprises a data-communications networking apparatus wherein one or more of the processor, the transceiver, or the smart antenna is further configured to: receive a first feedback information from the first client device in response to the transmission of the probing signal; receive a second feedback information from the second client device in response to transmission of the probing signal. For example, as with each ’376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) comprises one or more of the processor, the transceiver, or the smart antenna further configured to receive channel state information and estimates of the channel state and MU MIMO-related feedback information from each of the first non-AP STA and the second non-AP STA pursuant to HE MU-MIMO sounding procedures. This feedback information, carried in one or more HE Compressed Beamforming/CQI frames, is in response to the transmission of the probing signal (*e.g.*, a probing signal transmission that triggers or elicits a responsive transmission from each of a first client device and a second client device, such as NDP Announcement, HE sounding NDP, Beamforming Report trigger frames pursuant to High Efficiency (HE) channel sounding, including preamble training fields allowing an estimate of the channel for MU-MIMO). *See*, *e.g.*, 802.11ax Standard, Sections 9.3.1.19, 9.3.1.22, 9.3.1.22.3, 9.4.1.64, 9.4.1.65, 9.4.1.66, 9.4.1.67, 9.6.31.2, 10.37, 26.7, 26.7.1, 26.7.2, 26.7.3, 26.7.4, 26.7.5, 27.1.1, 27.3.15.1 – 27.3.15.3. *See*, *e.g.*, Section 9.4.1.65 (HE Compressed Beamforming Report field) (“The HE Compressed Beamforming Report field carries the average SNR of each space-time stream and compressed beamforming feedback matrices *V* for use by a transmit beamformer to determine steering matrices *Q*, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming)”); Section 9.1.4.66 (HE MU Exclusive Beamforming Report field) (“The HE MU Exclusive Beamforming Report field carries explicit feedback in the form of delta SNRs. The information in the HE Compressed Beamforming Report field and the HE MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices *Q*, as described in 27.3.3.1 (DL MU-MIMO)"); Section 9.4.1.67 (HE CQI Report Field) ("The HE CQI Report field carries the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested."); Section 27.3.15.1 ("SU-MIMO and DL-MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an RU. With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 106-tones…The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be detected by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0,1,\ldots N_{user,r} -1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission."); Section 27.3.15.2 ("Upon receipt of an HE sounding NDP, the beamformee computes a set of matrices for feedback to the beamformer as described in 21.3.11.2 (Beamforming Feedback Matrix V). The eligible beamformees shall remove the space-time stream CSD in Table 21-11 (Cyclic shift values for the VHT modulated fields of a PPDU) from the measured channel before computing a set of matrices for feedback to the beamformer."); *See*, *e.g.*, Section 26.7.3, Figure 26-7:

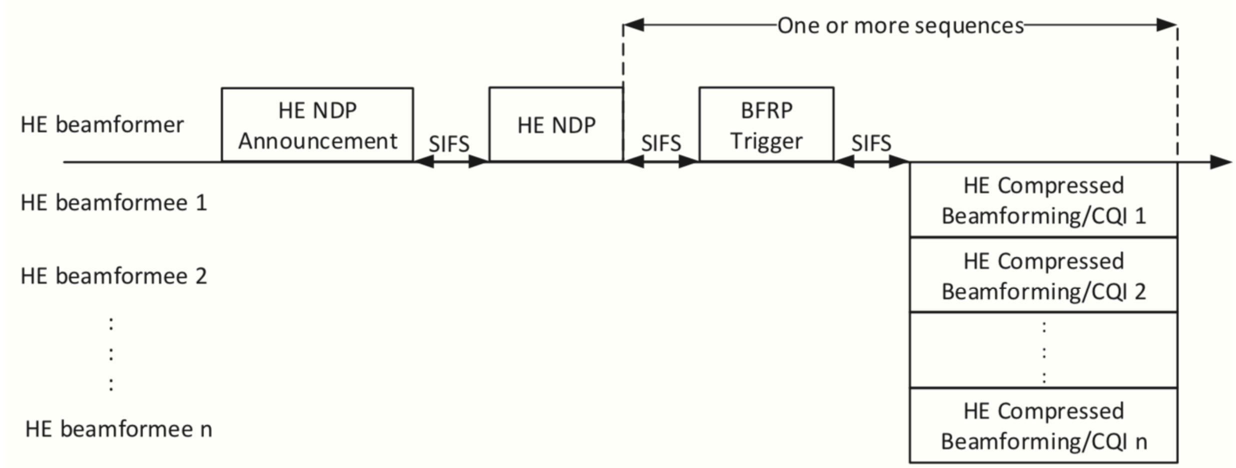

Figure 26-7—An example of the sounding protocol with more than one HE beamformee

For a further example, as with each ’376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) comprises one or more of the processor, the transceiver, or the smart antenna further configured to receive channel state information and estimates of the channel state and MU MIMO-related feedback information from each of the first non-AP STA and the second non-AP STA pursuant to MU-MIMO sounding procedures. This feedback information, carried in one or more compressed beamforming frames, is in response to the transmission of the probing signal (*e.g.*, a probing signal transmission that triggers or elicits a responsive transmission from each of a first client device and a second client device, such as NDP Announcement pursuant to Very High Throughput (VHT) channel sounding, including preamble training fields allowing an estimate of the channel for MU-MIMO). *See*, *e.g.*, 802.11ac Standard Clause 9.31.5.2 (“A VHT beamformer shall initiate a sounding feedback sequence by transmitting a VHT NDP Announcement frame followed by a VHT NDP after a SIFS. The VHT beamformer shall include in the VHT NDP Announcement frame one STA Info field for each VHT beamformee that is expected to prepare VHT Compressed Beamforming feedback and shall identify the VHT beamformee by including the VHT beamformee’s AID in the AID subfield of the STA Info field. The VHT NDP Announcement frame shall include at least one STA Info field.”); *id.* (“A non-AP VHT beamformee that receives a VHT NDP Announcement frame… shall transmit

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its VHT Compressed Beamforming feedback a SIFS after receiving a Beamforming Report Poll with RA matching its MAC address and a non-bandwidth signaling TA obtained from the TA field matching the MAC address of the VHT beamformer."); *id.* Clause 8.5.23.2 (defining format and subfields within the VHT Compressed Beamforming frame); *id.* Clause 8.4.1.48 (including Tables 8-53(d)-(h)) ("Each SNR value per tone in stream i (before being averaged) corresponds to the SNR associated with the column i of the beamforming feedback matrix V determined at the beamformee"); *id.* Clause 8.4.1.49 (including Table 8-53i – MU Exclusive Beamforming Report information); *id.* Clauses 8.4.1.24, 9.31.5.1, 9.31.5.2; *id.* Clause 22.3.8.3.5; *id.* Clause 22.3.11.2:

> Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee *u* for subcarrier *k* shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,\upsilon)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined.
>
> The beamformee shall generate the beamforming feedback matrices with the number of rows (*Nr*) equal to the N_{STS} of the NDP.
>
> After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific.

30. Each of the '376 Accused Products comprises a data-communications networking apparatus wherein one or more of the processor, the transceiver, or the smart antenna is further configured to: determine where to place transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information. For example, as with each '376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) comprises one or more of the processor, the transceiver, or the smart antenna further configured to determine where to place

transmission peaks and transmission nulls within one or more spatially distributed patterns of electromagnetic signals based in part on the first and the second feedback information, including, *e.g.*, where it determines where to place transmission peaks and transmission nulls through a beamforming steering matrix pursuant to beamforming and MU-MIMO spatial multiplexing, which beamforming steering matrix is determined based on the received CSI (channel state information) and MIMO-related feedback from the first client device (first non-AP STA) and the second client device (second non-AP STA) pursuant to HE MU-MIMO sounding. [DATA SHEET]. *See*, *e.g.*, 802.11ax Standard, Sections 9.3.1.19, 9.4.1.64, 9.4.1.65, 9.4.1.66, 9.4.1.67, 9.6.31.2, 10.37, 26.7, 26.7.1, 26.7.2, 26.7.3, 26.7.4, 26.7.5, 27.1.1, 27.3.15.1, 27.3.15.2, 27.3.15.3. *See*, *e.g.*, Section 9.4.1.65 (HE Compressed Beamforming Report field) ("The HE Compressed Beamforming Report field carries the average SNR of each space-time stream and compressed beamforming feedback matrices *V* for use by a transmit beamformer to determine steering matrices *Q*, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming)"); Section 9.1.4.66 (HE MU Exclusive Beamforming Report field) ("The HE MU Exclusive Beamforming Report field carries explicit feedback in the form of delta SNRs. The information in the HE Compressed Beamforming Report field and the HE MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices *Q*, as described in 27.3.3.1 (DL MU-MIMO)"); Section 9.4.1.67 (HE CQI Report Field) ("The HE CQI Report field carries the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested."); Section 27.3.15.1 ("SU-MIMO and DL-MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an RU.

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With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 106-tones…The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be detected by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0,1,\ldots N_{user,r}$ -1. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission."); Section 27.3.15.2 ("Upon receipt of an HE sounding NDP, the beamformee computes a set of matrices for feedback to the beamformer as described in 21.3.11.2 (Beamforming Feedback Matrix V). The eligible beamformees shall remove the space-time stream CSD in Table 21-11 (Cyclic shift values for the VHT modulated fields of a PPDU) from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix $V_{k,u}$ found by the beamformee u for subcarrier k in RU r shall be compressed in the form of angles using the method described in 19.3.12.3.6 (Compressed beamforming feedback matrix). The angles $\phi(k,u)$ and $\psi(k,u)$, are quantized according to Table 9-68 (Quantization of angles)…. The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the HE sounding NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (19-79). For SU-MIMO beamforming, the beamformer uses $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ using $V_{k,u}$ and Delta $\Delta SNR_{k,u}$ ($0 \leq u \leq N_{user,r}-1$) in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific."). *See*, *e.g.*, 802.11ac Standard Clause 9.31.5.1 ("Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix."); *id.* Clauses 22.3.4.6(d), 22.3.4.7(e), 22.3.4.8(l), 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a) ("Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1."); *id.* Clause 22.3.10.11.1; IEEE 802.11-2012 Standard Clause 20.3.12.3.6; 802.11ac Standard Clauses 8.4.1.24, 9.31.5.1, 9.31.5.2; *id.* Clause 22.3.11.1:

> The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u}$, and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user} - 1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4).

, Clause 22.3.11.2:

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Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,u)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined.

The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP.

After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \leq u \leq N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific.

31.Each of the '376 Accused Products comprises a data-communications networking apparatus wherein one or more of the processor, the transceiver, or the smart antenna is further configured to: transmit the first data stream to the first client device via the one or more spatially distributed patterns of electromagnetic signals; and transmit the second data stream to the second client device via the one or more spatially distributed patterns of electromagnetic signals; wherein transmission of the first data stream and transmission of at least part of the second data stream occur at the same time; and wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device. For example, as with each '376 Accused Product, the Linksys Dual-Band Mesh WiFi 6 Router (MR9600) comprises one or more of the processor, the transceiver, or the smart antenna further configured to transmit the first data stream to the first client device (*e.g.*, the first non-AP STA) via the one or more spatially distributed patterns of electromagnetic signals (*e.g.*, transmission of data to the first non-AP STA pursuant to HE MU-MIMO beamforming where a beamforming steering matrix is applied); and transmit the second data stream to the second client device (*e.g.*, the second non-AP STA) via the one or more spatially distributed patterns of electromagnetic signals (*e.g.*, transmission of data to the second non-AP STA pursuant to HE MU-MIMO beamforming where a beamforming steering matrix is applied); wherein transmission of the first data stream and transmission of at least part of the second data stream occur at the same time (*e.g.*, simultaneous HE DL MU-MIMO transmissions); and wherein the one or more spatially distributed patterns of electromagnetic signals are configured to exhibit a first transmission peak at a location of the first client device and a second transmission peak at a location of the second client device (*e.g.*, through HE MU-MIMO beamforming, radio energy is directed at each of the first client device and the second client device to form a transmission peak at the location of each device, and including, *e.g.*, where the beamforming steering matrix is applied, a first space-time stream ("STS") intended for reception at the first client device and a second STS intended for reception at the second client device is representative of a first transmission peak being placed at the location of the first client device and a second transmission peak being placed at the location of second client device). *See*, *e.g.*, Linksys Dual-Band Mesh WiFi 6 Router (MR9600) Webpage, which explains that the Linksys MR9600 includes "Dual-Band (2.4GHz + 5 GHz), 4x4 WiFi 6," "4x4 MU-MIMO," "2.4 and 5GHz (Simultaneous Dual-Band)" Wi-Fi Bands, "OFDMA technology," "4x external adjustable antennas," with a "1.8 GHz Quad Core Processor," supporting the "WiFi 5 (802.11ac)" and "WiFi 6 (802.11ax)" standards. Additionally, the MR9600 provides "More Capacity to More Devices" because "WiFi 6 sends and receives multiple streams of data simultaneously, providing up to 4x more WiFi capacity to handle every … device on your network" and also "Minimizes Wi-Fi Congestion" by "Eliminate[ing] interference from neighboring networks with advanced WiFi 6 technology that can isolate your network, reduce congestion and deliver the strongest, clearest WiFi signal available." *See also* Linksys' support page *Getting to know the Linksys MR9600 Max-Stream™ Dual-Band WiFi 6 Router*, indicating: "The Linksys MR9600… delivers true Gigabit

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speeds of up to 6 Gbps with eight-stream capacity throughout the entire home," and includes a "1.8 GHz quad-core CPU," "4x4 spatial streams," "MU-MIMO," "Next-generation Orthogonal Frequency-Division Multiple Access (OFDMA) technology," "Four adjustable antennas," and "Supports 802.11ax." *See also* Linksys' *What is AX?* Webpage, stating: "Thanks to 11AX, multiple devices can simultaneously transmit data, using the same radio frequency and the same network," and that 11AX is "Up to eight times faster than non-MU-MIMO products thanks to up link and down line (DL/UL) MU-MIMO." *See also* Linksys' *What is MU-MIMO and Why Do You Need It?* Webpage, stating: "Multi-user, multiple-input, multiple-output technology—better known as MU-MIMO (a.k.a. Next-Gen AC or AC Wave 2)—allows a Wi-Fi router to communicate with multiple devices simultaneously … increases the capacity and efficiency of your router… allowing it to handle more WiFi-intensive activities such as streaming and gaming." *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.15.1 ("SU-MIMO and DL-MU-MIMO beamforming are techniques used by a STA with multiple antennas (the beamformer) to steer signals using knowledge of the channel to improve throughput. With SU-MIMO beamforming all space-time streams in the transmitted signal are intended for reception at a single STA in an RU. With DL MU-MIMO beamforming, disjoint subsets of the space-time streams are intended for reception at different STAs in an RU of size greater than or equal to 106-tones…The DL MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}-1}]$ can be detected by the beamformer using the beamforming feedback for subcarrier k from beamformee u, where $u = 0,1,\ldots N_{user,r} - 1$. The feedback report format is described in 9.4.1.65 (HE Compressed Beamforming Report field) and 9.4.1.66 (HE MU Exclusive Beamforming Report field). The steering matrix that is computed (or updated) using new beamforming feedback from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL MU-MIMO data transmission."); Section 27.3.15.2 ("The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the HE sounding NDP. After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (19-79). For SU-MIMO beamforming, the beamformer uses $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user,r}}-1]$ using $V_{k,u}$ and Delta $\Delta SNR_{k,u}$ ($0 \leq u \leq N_{user,r}-1$) in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific."); Section 27.1.1 ("The HE PHY extends the maximum number of users supported for DL MU-MIMO transmissions up to 8 users per resource unit (RU) and provides support for DL and UL orthogonal frequency division multiple access (OFDMA) as well as for UL MU-MIMO. Both DL and UL MU-MIMO transmissions are supported on portions of the PPDU bandwidth (on resource units greater than or equal to 106 tones). In an MU-MIMO resource unit, there is support for up to 8 users with up to 4 space-time streams per user with the total not exceeding 8 space-time streams"); Section 27.3.1.1 ("DL MU transmission allows an AP to simultaneously transmit information to more than one non-AP STA. For a DL MU transmission, the AP uses the HE MU PPDU format and employs either DL OFDMA, DL MU-MIMO, or a mixture of both."); Section 27.3.10.8.1 ("The HE-SIG-B field provides the OFDMA and DL MU-MIMO resource allocation information to allow the STAs to look up the corresponding resources to be used in the data portion of the frame."); *See*, *e.g.*, IEEE 802.11ax Standard, Section 27.3.5 (Transmitter block diagram), at, *e.g.*, Figure 27-19:

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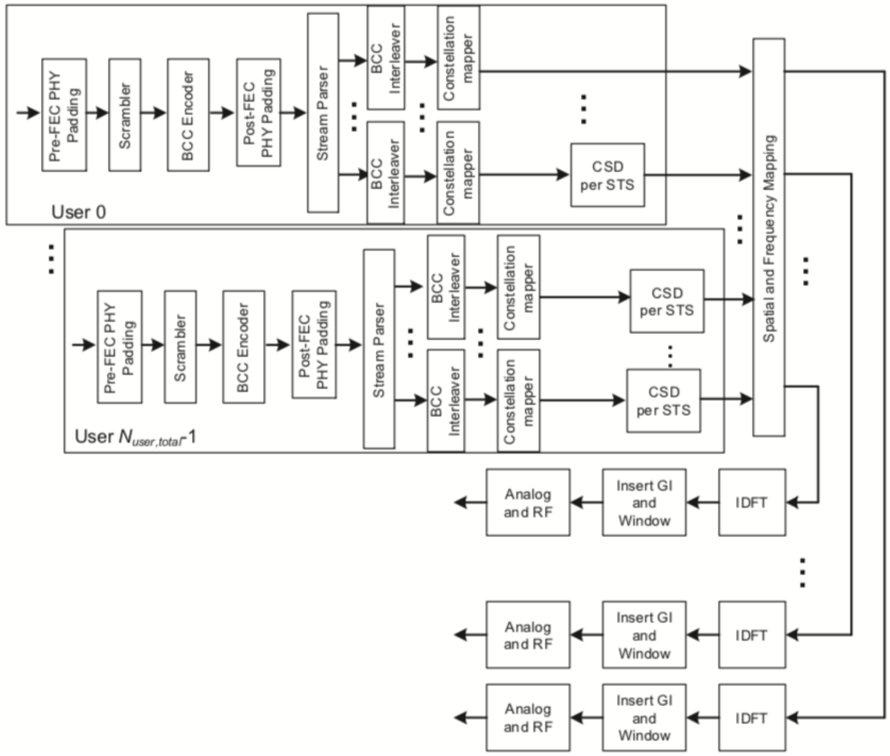

Figure 27-19—Transmitter block diagram for the Data field of an HE DL MU-MIMO transmission in a 106-, 242-, 484- or 996-tone RU with BCC encoding

; Section 9.4.1.65 (HE Compressed Beamforming Report field) ("The HE Compressed Beamforming Report field carries the average SNR of each space-time stream and compressed beamforming feedback matrices *V* for use by a transmit beamformer to determine steering matrices *Q*, as described in 10.32.3 (Explicit feedback beamforming) and 19.3.12.3 (Explicit feedback beamforming)"); Section 9.1.4.66 (HE MU Exclusive Beamforming Report field) ("The HE MU Exclusive Beamforming Report field carries explicit feedback in the form of delta SNRs. The information in the HE Compressed Beamforming Report field and the HE MU Exclusive Beamforming Report field can be used by the transmit MU beamformer to determine the steering matrices *Q*, as described in 27.3.3.1 (DL MU-MIMO)"); Section 9.4.1.67 (HE CQI Report Field) ("The HE CQI Report field carries the per-RU average SNRs of each space-time stream, where each per-RU average SNR is the arithmetic mean of the SNR in decibels over a 26-tone RU for which the feedback is being requested."). *See*, *e.g.*, 802.11ac Standard Clause 9.31.5.1 ("Transmit beamforming and DL-MU-MIMO require knowledge of the channel state to compute a steering matrix that is applied to the transmitted signal to optimize reception at one or more receivers. The STA transmitting using the steering matrix is called the VHT beamformer and a STA for which reception is optimized is called a VHT beamformee. An explicit feedback mechanism is used where the VHT beamformee directly measures the channel from the training symbols transmitted by the VHT beamformer and sends back a transformed estimate of the channel state to the VHT beamformer. The VHT beamformer then uses this estimate, perhaps combining estimates from multiple VHT beamformees, to derive the steering matrix."); *id.* Clauses 22.3.4.6(d), 22.3.4.7(e), 22.3.4.8(l), 22.3.4.9.1(m), 22.3.4.9.2(m), 22.3.4.10.4(a) ("Spatial mapping: Apply the Q matrix as described in 22.3.10.11.1."); *id.* Clause 22.3.10.11.1; IEEE 802.11-2012 Standard Clause 20.3.12.3.6; 802.11ac Standard Clauses 8.4.1.24, 9.31.5.1, 9.31.5.2; *id.* Clause 22.3.11.1,22.3.11.2:

> The DL-MU-MIMO steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ can be determined by the beamformer using the beamforming feedback matrices for subcarrier k from beamformee u, $V_{k,u}$, and SNR information for subcarrier k from beamformee u, $SNR_{k,u}$, where $u = 0, 1, \ldots, N_{user} - 1$. The steering matrix that is computed (or updated) using new beamforming feedback matrices and new SNR information from some or all of participating beamformees might replace the existing steering matrix Q_k for the next DL-MU-MIMO data transmission. The beamformee group for the MU transmission is signaled using the Group ID field in VHT-SIG-A (see 22.3.8.3.3 and 22.3.11.4).

> Upon receipt of a VHT NDP sounding PPDU, the beamformee shall remove the space-time stream CSD in Table 22-11 from the measured channel before computing a set of matrices for feedback to the beamformer. The beamforming feedback matrix, $V_{k,u}$, found by the beamformee u for subcarrier k shall be compressed in the form of angles using the method described in 20.3.12.3.6. The angles, $\phi(k,u)$ and $\psi(k,u)$, are quantized according to Table 8-53e. The number of bits for quantization is chosen by the beamformee, based on the indication from the beamformer as to whether the feedback is requested for SU-MIMO beamforming or DL-MU-MIMO beamforming. The compressed beamforming feedback using 20.3.12.3.6 is the only Clause 22 beamforming feedback format defined.

> The beamformee shall generate the beamforming feedback matrices with the number of rows (Nr) equal to the N_{STS} of the NDP.

> After receiving the angle information, $\phi(k,u)$ and $\psi(k,u)$, the beamformer reconstructs $V_{k,u}$ using Equation (20-79). For SU-MIMO beamforming, the beamformer can use this $V_{k,0}$ matrix to determine the steering matrix Q_k. For DL-MU-MIMO beamforming, the beamformer may calculate a steering matrix $Q_k = [Q_{k,0}, Q_{k,1}, \ldots, Q_{k,N_{user}-1}]$ using $V_{k,u}$ and $SNR_{k,u}$ $(0 \le u \le N_{user} - 1)$ in order to suppress crosstalk between participating beamformees. The method used by the beamformer to calculate the steering matrix Q_k is implementation specific.

32. Defendants also have been and are now knowingly and intentionally inducing infringement of at least claim 1 of the ’376 Patent in violation of 35 U.S.C. § 271(b), in this district and elsewhere in the United States. Through the filing and service of this Complaint, Defendants have had knowledge of the ’376 Patent and the infringing nature of the ’376 Accused Products. More specifically, Defendants have been and are now actively inducing direct infringement by other persons (*e.g.*, Defendants’ customers who use, sell or offer for sale the ’376 Accused Products).

33. Despite this knowledge of the ’376 Patent, Defendants continue to actively encourage and instruct their customers and end users (for example, through user manuals and online instruction materials on their website) to use the ’376 Accused Products in ways that directly infringe the ’376 Patent. For example, Defendants’ website provided, and continues to provide, instructions for using the ’376 Accused Products on wireless communications systems, and to utilize their 802.11ax beamforming and MU-MIMO functionalities. Defendants do so knowing and intending that their customers and end users will commit these infringing acts. Defendants also continue to make, use, offer for sale, sell, and/or import the ’376 Accused Products, despite their knowledge of the ’376 Patent, thereby specifically intending for and inducing their customers to infringe the ’376 Patent through the customers’ normal and customary use of the ’376 Accused Products. Defendants also knew or were willfully blind that their actions would induce direct infringement by others and intended that their actions would induce direct infringement by others. Accordingly, a reasonable inference is that Defendants specifically intended for others, such as their customers, to directly infringe one or more claims of Vivato’s ’376 Patent in the United States because Defendants had knowledge of the ’376 Patent and actively induced others (*e.g.*, *their* customers) to directly infringe the ’376 Patent.

34. Defendants also contributorily infringe by making, using, selling, offering to sell, and/or importing the ’376 Accused Products, knowing they constitute a

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material part of the invention, are especially made or adapted for use in infringing, and that they are not staple articles of commerce capable of substantial non-infringing use.

35. By making, using, offering for sale, selling and/or importing into the United States the ’376 Accused Products, Defendants have injured Vivato and are liable for infringement of the ’376 Patent pursuant to 35 U.S.C. § 271.

36. Defendants also infringe numerous additional claims of the ’376 Patent, including Claims 2 – 21 and 32 – 34, directly and through inducing infringement, for similar reasons as explained above with respect to Claim 1.

37. Vivato’s ’376 Patent is valid and enforceable.

38. As a result of Defendants’ infringement of the ’376 Patent, Defendants have damaged Vivato, and Vivato is entitled to monetary damages in an amount to be determined at trial that is adequate to compensate for Defendants’ infringement, but in no event less than a reasonable royalty for the use made of the invention by Defendant, together with interest and costs as fixed by the Court.

39. Defendants’ infringing activities have injured and will continue to injure Vivato, unless and until this Court enters an injunction prohibiting further infringement of the ’376 Patent, and, specifically, enjoining further manufacture, use, sale, importation, and/or offers for sale that come within the scope of the patent claims.

PRAYER FOR RELIEF

WHEREFORE, Vivato prays for the following relief:

(a) A judgment in favor of Vivato that Defendants have infringed and are infringing U.S. Patent No. 10,594,376;

(b) An award of damages to Vivato arising out of Defendants’ infringement of U.S. Patent No. 10,594,376, together with prejudgment and post-judgment interest, in an amount according to proof;

(c) An award of an ongoing royalty for Defendants' post-judgment infringement in an amount according to proof;

(d) Granting Vivato its costs and further relief as the Court may deem just and proper.

DEMAND FOR JURY TRIAL

Vivato demands a trial by jury of any and all issues triable of right before a jury.

DATED: February 6, 2024

Respectfully submitted,

RUSS AUGUST & KABAT

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