THE IMPORTANCE OF MU-MIMO IN THE Wi-Fi ECOSYSTEM

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The market for Wi-Fi products continues to grow. New protocols allow for faster speeds, and people rely on Wi-Fi connectivity to the Internet more than ever. Even though the market has seen a profound shift to products supporting the larger 5 GHz spectrum band, this band is starting to become crowded as well in the home, enterprise, and on service provider small cells and hotspots. The shift to faster Wi-Fi protocols helps, but it is MU-MIMO (multi-user MIMO) that will realize the full potential of 802.11ac and mitigate network congestion. At this point, the inclusion of Wi-Fi chipsets supporting MU-MIMO is not something to plan for – the market is already being seeded with MU-MIMO-enabled access points and devices in all ecosystems and industries.

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MU-MIMO is beneficial to the overall network performance, but there is a catch–the access point and the client devices must support MU-MIMO. It is up to Wi-Fi enabled product manufacturers to go forward and include MU-MIMO enabled 802.11ac Wi-Fi chipsets in products so the ecosystem can start realizing the benefits it provides across the consumer, enterprise, and service provider markets. The inclusion of MU-MIMO is not something that is a few years out, but rather something that is occurring now. Very rapidly, the vast majority of 802.11ac chipsets will support MU-MIMO. Access point vendors and product OEMs need to educate consumers on the benefits of MU-MIMO in a

simple, straightforward way. Some product OEMs do not indicate MU-MIMO in their product specifications, though most companies are starting to call this important feature out.

STATUS OF THE WI-FI ECOSYSTEM

Wi-Fi's success as a ubiquitous technology is at times tempered by capacity issues on overcrowded access points. Depending on the environment, more access points could be used to solve the problem, but only to a point. Wi-Fi networks have historically taken off in the 2.4 GHz spectrum band, which is used by Bluetooth, ZigBee, and other technologies including proprietary technologies. Furthermore, there are only three usable channels in the 2.4 GHz band, limiting how many different networks can be near each other. The 5 GHz band has much more spectrum available and can accommodate many more channels, allowing more networks and devices to coexist. In the United States, there is 655 MHz of bandwidth available in the 5 GHz band compared to just 80 MHz in the 2.4 GHz band. However, the 5 GHz band is not the underutilized band it used to be.

In 2013, nearly half of all Wi-Fi chipsets shipping into Wi-Fi enabled products included the 5 GHz band. This jumped to 57% in 2014, and will reach 68% in 2015. Historically, this band was used by 802.11a/g primarily in portable PCs. As Wi-Fi shifted to 802.11n and 802.11ac, the 5 GHz band was increasingly used in tablets, smartphones, and consumer electronics. 802.11n can either be single band in 2.4 GHz only or it can be dual-band. 802.11ac only works in the 5 GHz band, so products with 802.11ac must include 802.11n for backwards compatibility in the 2.4 GHz band. The shift to 5 GHz today not just for higher speeds and greater spectrum availability, but is occurring out of necessity if products are to use the latest Wi-Fi protocols. Chart 1 shows the change from 2015 to 2019 for all Wi-Fi chipsets, 5 GHz Wi-Fi chipsets (dual-band 802.11n, 802.11ac, and 802.11ax), just 802.11ac or 802.11ax, and finally Wi-Fi chipsets with MU-MIMO.

Wi-Fi Chipset Shipments Using the 5 GHz Band (802.11n, 802.11ac, 802.11ax) World Market, Forecast: 2010 to 2019

(Source: ABI Research)
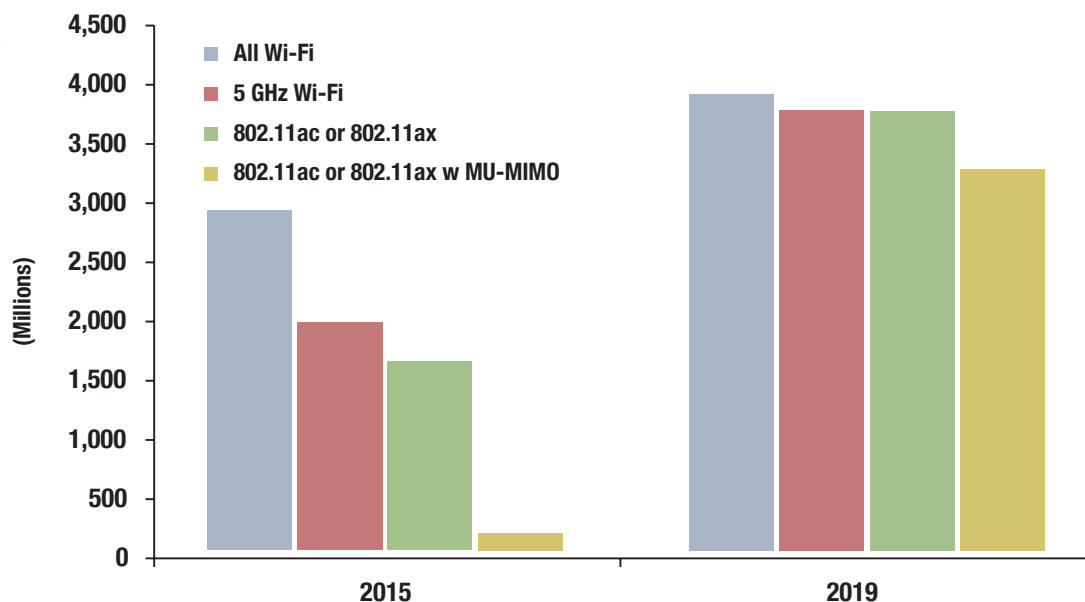
The Wi-Fi chipset market is growing (first bar), the shift to the 5 GHz band is accelerating within that (second bar), Wi-Fi chipsets supporting 5 GHz are shifting away from dual-band 802.11n toward 802.11ac and 802.11ax (third bar), and 802.11ac itself is shifting to 802.11ac with MU-MIMO (fourth bar). This fourth bar can also be referred to as 802.11ac Wave 2, and includes a small amount of 802.11ax in 2019. The three main additional features of 802.11ac Wave 2, compared to 802.11ac Wave 1 are:

- A maximum channel size of **160 MHz** – this is of limited use because the range is very short
- An increase of the highest order of MIMO configuration from **4X4 to 8X8** MIMO to support up to 8 data streams – this is most beneficial with access points because of the next addition feature
- The addition of **MU-MIMO** – this allows the streams from an access point to be distributed to multiple devices at the same time, making higher order MIMO configurations like 4X4 and 8X8 MIMO far more useful

On the client side, only software is required; the device does not have to have 2X2 MIMO, for example. It can remain a 1X1, or SISO (single input, single output), device. This means that cost will not be a barrier to MU-MIMO's inclusion across all Wi-Fi-enabled devices.

The 5 GHz band will become more crowded with Wi-Fi products using that band. Smartphones are becoming ubiquitous, and even these are seeing a shift to the 5 GHz band with very large volumes involved. Chart 2 shows the number of Wi-Fi chipset shipments by end-product category during 2014 and forecasted for 2019. Smartphones stand out due to their sheer volumes, and the largest smartphone vendors all ship devices with 802.11ac now. Shipments of MU-MIMO-enabled 802.11ac smartphones has already begun as well.

5 GHz Enabled Wi-Fi Chipset Shipments by Product Category World Market, Forecast: 2014 and 2019

(Source: ABI Research)
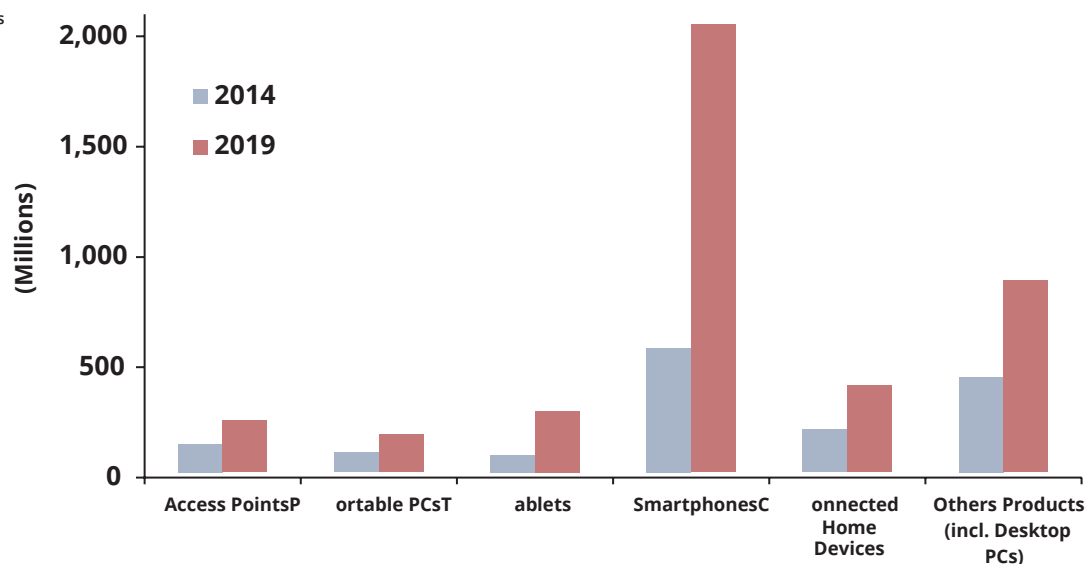
In short, the Wi-Fi industry is at a stage where the 5 GHz band is not only being increasingly used with the shift to 802.11ac, but it is being used by the most data intensive products–PCs, tablets, smartphones, and consumer electronics.

MU-MIMO ADDRESSES THE INCREASING CONGESTION ON WI-FI NETWORKS

Wi-Fi network users sometimes face network congestion, which can be frustrating. This can result in little to no Internet connectivity at conferences or in airports, disruption in streaming video at home, disrupted productivity on slow enterprise networks, and service provider hotspots that are of little assistance in offloading cellular traffic or providing the only source of Internet access. The underlying cause is the same–Wi-Fi networks are used more than ever, by an increasing number of products that are more powerful. In each of the following ecosystems, the network congestion is caused by:

CONSUMER / HOME

- **More Wi-Fi-enabled devices in the home**: An increasing number of Wi-Fi enabled products, including multiple PCs, tablets, smartphones, wearables, and consumer electronics devices such as TVs, set-top boxes, game consoles, Miracast HDMI adapters, and any other Internet-connected consumer electronics devices. In addition, add to that, smart home products including security cameras, and an increasing list of IoT products. Eventually, newer product types will be added, such as virtual reality headsets and simple, cloud-based personal robots and stationary assistants

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- **Richer, more data-intensive content**: Each of these are using more data than ever, including content-rich websites, social media applications, video calling, streaming videos and movies in HD, 4k, and soon in 8k resolutions. Devices are often receiving new data and downloading application updates. Speakers are starting to shift from having only Bluetooth to using Wi-Fi to stream music throughout the home and in higher audio resolutions.

- **More time watching video over Wi-Fi**: According to ABI Research's Over the Top and Multi-screen Video Service Market Data, annual online videos viewed over Wi-Fi will reach 1.4 trillion videos. This will rise to 3.2 trillion in 2019.

- **Smartphone traffic shifting from cellular networks to Wi-Fi**: Smartphone data traffic over Wi-Fi is multiple times that of cellular, and much of that is used in the home. This is a function of where people are, when they have more time to use their devices, and their usage driven by limits of mobile data plans.

- **Interference from other 2.4 GHz products**: The 2.4 GHz band is also used by products with Bluetooth, ZigBee, and proprietary wireless technologies, which reduces the amount of capacity available in this band.

- Outside interference reducing Wi-Fi network capacity: In a densely populated city, Wi-Fi networks of adjacent apartments would inject interference into the network congestion equation.

ENTERPRISE

- Wi-Fi use by enterprises increasing: An increasing number of businesses are Wi-Fi only to reduce set-up costs and increase flexibility. In any case, more employees have multiple devices on the network – perhaps a portable PC, tablet, and a smartphone. Wearables will enter some settings in the form of watches or glasses. Soon virtual reality headsets will make their way into some businesses. Conference rooms, auditoriums, and any place where a higher density of users congregate only to suffer from capacity issues.

- Wi-Fi is mission critical in the enterprise: In an enterprise setting, workers are sending large files, viewing or delivering webinars, streaming video, video conferencing, and more. Net work and Internet connectivity are mission-critical for office workers to communicate and get work done. There is less tolerance for the resulting data throughput reduction and increased latency by busy workers.

SERVICE PROVIDER

- Increasing Wi-Fi offload from mobile networks: Mobile operators and Wi-Fi hotspot operators are increasingly relying on users to offload data traffic from the cellular networks and onto Wi-Fi networks wherever possible – in the home, office, at Wi-Fi hotspots, and onto the mobile operators or partners' small cells with Wi-Fi or other carrier Wi-Fi networks. If these Wi-Fi networks cannot handle the traffic themselves due to congestions, then the congestion on the mobile networks gets much worse.

The disruptions caused by network congestion include reduced data throughput, increased latency, increased power consumption due to increased requests for retransmits, and slower data rates that keep Wi-Fi radios in higher power transmit modes for longer

- More capable, bandwidth-hungry mobile devices: Smartphones are more powerful than ever, are capable of much higher resolutions, and run more media-rich applications such as social networks with high resolution pictures, high-definition videos, and links to web pages that continuously load new data. They run an increasing number of applications in the background as well, and the signaling traffic adds to network congestions. More people are carrying more devices with Wi-Fi, such as tablets, portable PCs, and mobile routers. Some wearables are adding Wi-Fi to directly access the Internet instead of when away from the user's smartphone

- More data-centric, rich communications applications and services: The growth of VoIP, RCS, and social media messaging applications and their ability to share media and add video calling will shift relatively low data communications into data intensive territory.

The disruptions caused by network congestion include reduced data throughput, increased latency, increased power consumption due to increased requests for retransmits, and slower data rates that keep Wi-Fi radios in higher power transmit modes for longer. In a worst case scenario, a Wi-Fi client device cannot access the Wi-Fi network at all. Service reliability becomes a huge issue for streaming video in the home, which is frustrating for consumers and expensive for ISPs when consumers call to troubleshoot problems.

MIMO MULTIPLIES DATA RATES
AND INCREASES RANGE

Using **MIMO** in Wi-Fi networks results in greater data rates, beneficial to the client device as well as the overall Wi-Fi network. MIMO stands for Multiple Input Multiple Output. It is a smart antenna technology that leverages the various reflections signals take to multiply capacity by using multiple data streams. The network is more efficient when communicating with MIMO devices because clients finish their higher-data rate transmissions sooner. It is also called **SU-MIMO**, or single-user MIMO, because it can only address one device at a time. Whether a 4X4 access point is communicating with 4X4, 2X2, or 1X1 antenna devices, only a single device can communicate with the access point at a time. Using 2X2 and higher order MIMO chipsets results in increased costs for multiple RF chains and antennae, but provides valuable improvements in data rates, range, and more reliable connectivity as a result. As the access point rotates through devices, the data rate is limited to the lowest common MIMO configuration of the access point and client device. If all client devices are 1X1, there will only be one stream transmitted to each device, one at a time.

MU-MIMO ALLEVIATES NETWORK CONGESTION

MU-MIMO, or multi-user MIMO, allows the number of data streams available to be shared by multiple client devices. Four 1X1 MU-MIMO client devices can communicate with a 4X4 access point at the same time, or it could be two 1X1 and one 2X2 MU-MIMO devices, for example. Beamforming, is used to focus the RF energy where each client device is. An MU-MIMO access point communicating with MU-MIMO devices is much more flexible and efficient. In increasing network efficiency, devices are served more often, which also reduces latency. Devices communicate with greater efficiency, which allows them to spend more time in the sleep state and thus reduce power consumption.

With MIMO, an access point's extra streams cannot be taken advantage of unless the clients have MIMO too. With MU-MIMO, even 1X1 devices can put all the data streams the access point is capable of to full use, thus greatly maximizing network capacity. Furthermore, MU-MIMO is a software feature for client devices. It can be paired with MIMO to get all of the Wave 2 benefits available, but is even valuable with 1X1 devices. MU-MIMO can provide greater network capacity and for a minimal cost adder. MU-MIMO requires only additional software on client devices, while SU-MIMO requires additional RF chains and antennae.

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Client devices without MU-MIMO can only be served one at a time on an MU-MIMO enabled access point, but in a network of mixed SU-MIMO and multiple MU-MIMO devices, the MU-MIMO devices are grouped together which still allows the SU-MIMO devices to be served more often. Of course, higher network efficiency is achieved when all Wi-Fi products have MU-MIMO.

MIMO AND MU-MIMO BENEFITS

IN SUMMARY,

2X2 AND HIGHER MIMO PROVIDES:

- Much higher data rates that are multiplied by the number of streams

- Much better range and reliability, and faster data rates for a given distance from the access point

- Better power consumption, since faster data transmission results in more time that the client device spends in the sleep state

MU-MIMO PROVIDES:

Using both MIMO and MU-MIMO is even better and affords client devices and networks all of the combined benefits

- Improved data rate, throughput, latency, and power consumption for MU-MIMO client devices, and overall capacity and data throughput improvements for all client devices where there are mixed MU-MIMO and non-MU-MIMO clients

- Optimized network capacity and performance for both MU-MIMO devices and non-MU-MIMO devices

- A greater value proposition relative to SU-MIMO since MU-MIMO for client devices is in software and does not require additional RF chains and antennae that SU-MIMO requires

BOTH IS BETTER

Using either MIMO or MU-MIMO in the home and enterprise creates a greater user experience. MIMO's benefits are focused on increasing the data rate for client devices with MIMO, increasing the range of those devices, and increasing the reliability of those connections. MU-MIMO's benefits are focused on the network as a whole in terms of higher capacity and reduced congestion. Using both MIMO and MU-MIMO is even better and affords client devices and networks all of the combined benefits including better power consumption from both methods. Using the best Wi-Fi technology available can boost the value and perception of product brands by providing a much better user experience connecting to the Internet. The user experience is enhanced with faster and more reliable data throughput. It benefits the mobile operators using Wi-Fi link aggregation or Wi-Fi offload and it benefits Wi-Fi hotspot operators and aggregators by allowing for superior management of network congestion. Enterprise Wi-Fi networks become more reliable by eliminating bottlenecks using the latest Wi-Fi technologies to increase speed and efficiency.

MU-MIMO TECHNOLOGY LEADERS
AND INDUSTRY SUPPORT

Products vendors that hold off on Wave 2 for now cause a higher percentage of non-MU-MIMO products to remain in the installed base of products.

In order for the Wi-Fi ecosystem to benefit from MU-MIMO across the consumer, enterprise, and carrier Wi-Fi / hotspot areas, all Wi-Fi access points and client devices need to be shifted to 802.11ac Wave 2 as soon as possible. Product vendors that hold off on Wave 2 for now cause a higher percentage of non-MU-MIMO products to remain in the installed base of products. The most important products involved would be those that have the highest data transmissions collectively in a given setting, whether that is a higher number of smartphones on a home, enterprise, or carrier Wi-Fi network, or a lower number of PCs or consumer electronics devices streaming video

A range of industries and ecosystems are responsible for maximizing the capacity of Wi-Fi networks across the mobile, PC, and consumer electronics industries, and across the consumer, enterprise, and service provider ecosystems. PCs are used across the home and office. Mobile devices–especially smartphones–are used everywhere. TVs and other displays are used in the home and, to a lesser extent, the office.

Disparate industries and ecosystems should work together to promote a consumer-level understanding of MU-MIMO in order to drive interest in it everywhere and grow an understanding of the value of MU-MIMO. Some smartphone vendors have been including 2X2 MIMO and 1X1 MU-MIMO in smartphones, but have failed to indicate this in the product specifications. This means that consumers, enterprise professionals, and journalists are sometimes not aware of superior Wi-Fi capabilities included in a device. This does not make sense in a highly competitive smartphone space where flagship devices compete on top notch specs. Working with mobile operator customers, OEMs focus on marketing the latest cellular specifications in detail, even though smartphone owners spend a lot of time and a large part of their data use on Wi-Fi.

MU-MIMO Already Benefiting All Ecosystems and Industries
(Source: ABI Research)

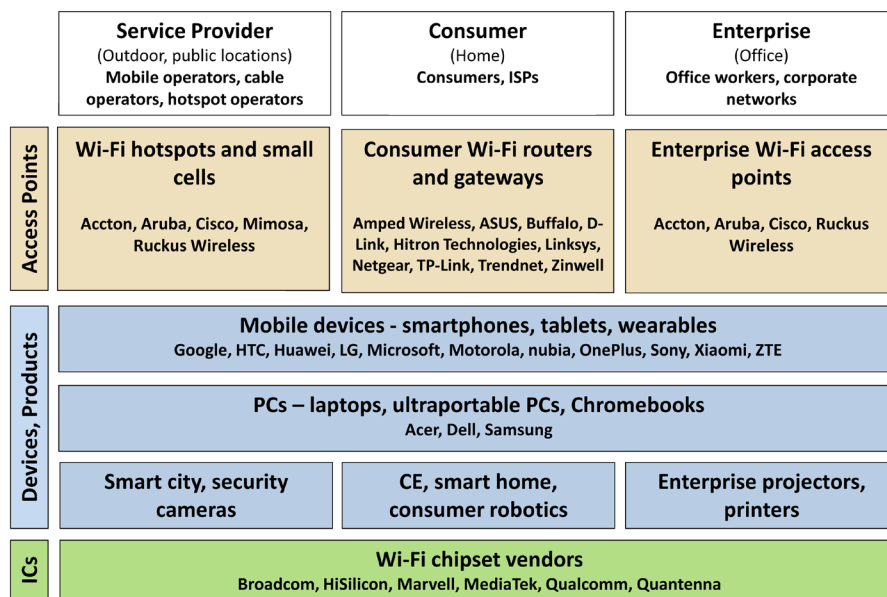|	Service Provider (Outdoor, public locations) Mobile operators, cable operators, hotspot operators	Consumer (Home) Consumers, ISPs	Enterprise (Office) Office workers, corporate networks
Access Points	Wi-Fi hotspots and small cells Accton, Aruba, Cisco, Mimosa, Ruckus Wireless	Consumer Wi-Fi routers and gateways Amped Wireless, ASUS, Buffalo, D-Link, Hitron Technologies, Linksys, Netgear, TP-Link, Trendnet, Zinwell	Enterprise Wi-Fi access points Accton, Aruba, Cisco, Ruckus Wireless
Devices, Products	Mobile devices - smartphones, tablets, wearables Google, HTC, Huawei, LG, Microsoft, Motorola, nubia, OnePlus, Sony, Xiaomi, ZTE		
	PCs – laptops, ultraportable PCs, Chromebooks Acer, Dell, Samsung		
	Smart city, security cameras	CE, smart home, consumer robotics	Enterprise projectors, printers
ICs	Wi-Fi chipset vendors Broadcom, HiSilicon, Marvell, MediaTek, Qualcomm, Quantenna		

Figure 1 shows which companies have products with MU-MIMO across different markets. All of these companies can be seen as technology leaders for MU-MIMO in Wi-Fi, but some companies were earlier than others. ASUS and Ruckus Wireless were first with MU-MIMO-enabled access points, while Acer was first with PCs. For access point chipsets with MU-MIMO, Qualcomm and Quantenna led the way with Broadcom right behind. Qualcomm has led the market with a wide range of MU-MIMO-enabled chipsets for a wide range of client devices.

In smartphones, Broadcom has led the market with 802.11ac, and has all of the 2X2 802.11ac Wave 1 share. Qualcomm has all of the share of 1X1 802.11ac Wave 2 MU-MIMO chipsets in smartphones. Qualcomm also has all of the share of 2X2 802.11ac Wave 2 MU-MIMO chipsets because of several flagship smartphones starting to ship with Qualcomm's solution – the Google Nexus 5X, the Microsoft Lumia 950 and 950 XL, the US version of the Xiaomi Mi4c, and the ZTE Axom Pro. Broadcom announced its Wi-Fi/Bluetooth combo chipset with 2X2 802.11ac with MU-MIMO back in March 2015 and has been sampling since then.

It is evident that MU-MIMO-enabled access points and client devices are not something on the horizon–they exist in the market today. MU-MIMO is in access points for the home, enterprise, and service-provider markets. It is in a wide range of devices and is being provided by multiple chipset vendors.

MU-MIMO MARKET GROWTH

The MU-MIMO attach rate against all Wi-Fi chipsets will grow from 5% in 2015 to 84% in 2019

The Wi-Fi market is shifting to 5 GHz, and within that it is shifting to 802.11ac. Within 802.11ac, the shift from Wave 1 to Wave 2 will occur fairly rapidly. The MU-MIMO attach rate against all Wi-Fi chipsets will grow from 5% in 2015 to 84% in 2019. A major driver of this is that on the client side, MU-MIMO is software only, which includes the majority of Wi-Fi chipsets that are 1X1. On the access point, both MIMO and MU-MIMO are required to create multiple streams that can be shared. The MU-MIMO attach rate for Wi-Fi chipsets in access points will grow from 7% in 2015 to 81% in 2019.
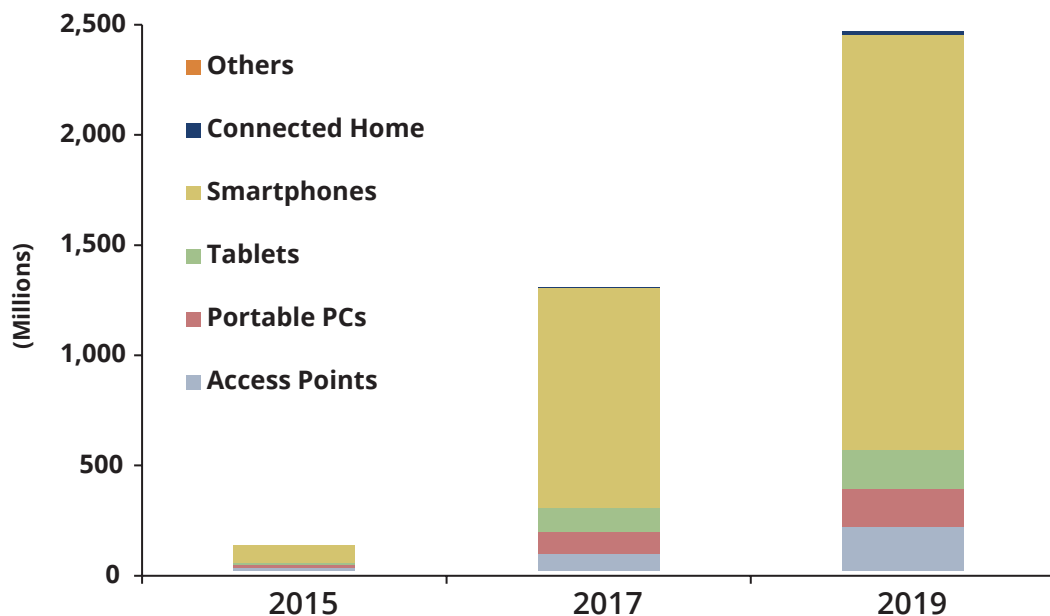
Chart 3 shows the forecasted shipments of MU-MIMO-enabled Wi-Fi chipset shipments by MIMO configuration. The vast majority of MU-MIMO-enabled Wi-Fi chipsets will be 1X1, followed by 2X2. 1X1 MU-MIMO chipset share of all MU-MIMO chipsets will fall during the next several years as that of 2X2 and higher rises–especially 2X2 MU-MIMO. The inclusion of MU-MIMO in 1X1 products will be of great value to the Wi-Fi ecosystem and to all Wi-Fi networks.

MU-MIMO enabled Wi-Fi Chipset Shipments by MIMO Configuration World Market, Forecast: 2015, 2017, and 2019

(Source: ABI Research)
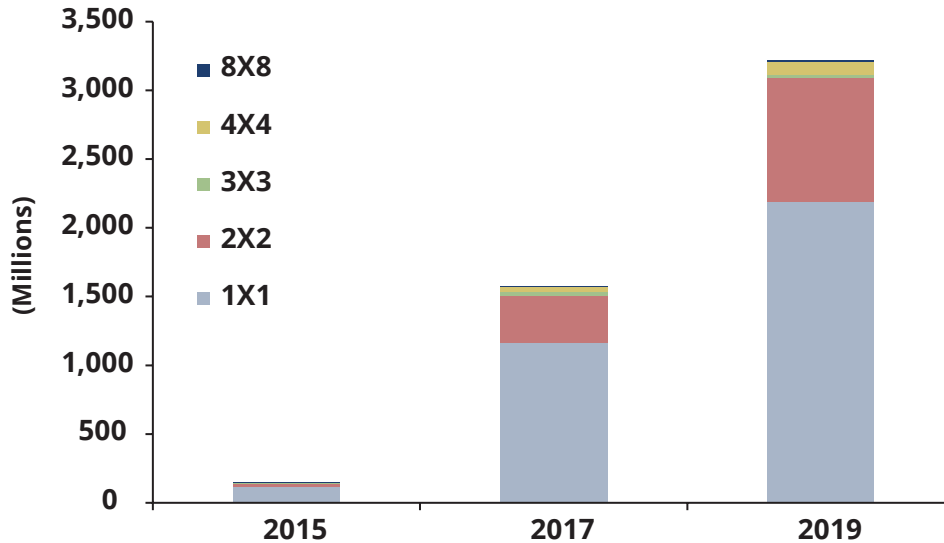
Smartphones are a key driver of the size of the 1X1 MIMO chipset share and the shift to 2X2 MIMO. This can be seen in Chart 4 where smartphones dominate the product categories. MU-MIMO enabled 1X1 chipsets are a key part of the market because of the size of 1X1, the low cost of MU-MIMO Wi-Fi chipsets, and the high value of adding MU-MIMO for increased network efficiency. The shift of 1X1 devices to 802.11ac Wave 2 with MU-MIMO will have a profound impact on Wi-Fi network efficiency everywhere because most of the devices on Wi-Fi networks are 1X1. MU-MIMO enabled smartphones alone will account for 1 billion shipments of MU-MIMO Wi-Fi chipsets during 2017. During 2019, all MU-MIMO Wi-Fi chipset shipments will reach nearly 2.5 billion. In 2019, smartphones will account for the vast majority of that, but with an increasing number of shipments into tablets, portable PCs, and access points as well. Ecosystem desires and requirements for MU-MIMO, such as by mobile operators, IT departments, and consumer ISPs, will drive the inclusion and marketing of MU-MIMO. This will result in an upward spiral of inclusion that moves the Wi-Fi industry closer to its inclusion by default. Client devices with MU-MIMO will work better on future 802.11ax networks as well compared to non-MU-MIMO devices.

MU-MIMO Enabled Wi-Fi Chipset Shipments by Product Category World Market, Forecast: 2015, 2017, and 2019

(Source: ABI Research)

The highest volume and most data-intensive Wi-Fi enabled products are shifting to 802.11ac and now 802.11ac with MU-MIMO. This will benefit users across the home, enterprise, and service provider ecosystems, and is already being supported by the biggest names among Wi-Fi chipset vendors, mobile device OEMs, and PC OEMs. MU-MIMO can be used with 1X1 products on the client side for network efficiency, slightly faster data rates if there are other MU-MIMO devices on the network, and lower device power consumption. MIMO allows for multiple times the data rate, better power consumption, and better range. By using both 2X2 MIMO or higher and MU-MIMO, all of the benefits available will be gained. Smartphones are already shipping with 2X2 MU-MIMO today.

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RECOMMONDATIONS FOR THE INDUSTRY

The Wi-Fi industry should move forward with MU-MIMO–a high value, low cost feature–now. Here are ABI Research's recommendations for:

- Mobile operators: Ensure vendors for small cells, Wi-Fi hotspots, and that of Wi-Fi hotspot partners are replacing older access points with ones supporting 802.11ac Wave 2. Make MU-MIMO a requirement for mobile devices sold through the mobile operator channel.

- Enterprise IT: Make MU-MIMO a required feature for company-provided portable PCs, tablets, and smartphones. Whether to support occasional larger meetings, or everyday high-density floor plans, look for access points with MU-MIMO and higher order MIMO configurations such as 4X4, 6X6, or 8X8 MIMO. Since MU-MIMO works by splitting up streams between different devices so they can communicate with the access point at one time, lower order (2X2 and 3X3) MIMO access points will only have a few streams to share at once. Higher order MIMO access points maximize the potential of MU-MIMO and the Wi-Fi network as a while.

- Consumer ISPs: The days of Wi-Fi access points being used for a PC or two are long gone. When offering consumers a router, 802.11ac Wave 2 with MU-MIMO is a must now to provide the most efficient protocol, a spectrum band with more room, and technology that makes the most efficient use of spectrum. MIMO and MU-MIMO are critical to provide sometimes multiple streams of HD or 4k video (and soon 8k video) flawlessly while simultaneously supporting multiple PCs, tablets, smartphones, wearables, smart home products including security cameras, game consoles, over-the-top set-top boxes, Miracast streams, and more. Over the next several years, more Wi-Fi devices will pile on including simple personal robots and smart toys that rely on cloud computing. If the ISP also has or plans to have "homespots" (firewalled public access to the access point as a hotspot), then maximizing the high-end features of the access point is prudent.

Any 1X1 product designs can remain the same while shifting to Wi-Fi chipsets that support MU-MIMO

- Device, PC, and CE OEMs: Include MU-MIMO on all devices planned going forward. In a few years, it is possible consumer ISPs will point to older, slower devices holding the rest of the network up. This could tarnish brand names. Enterprise IT will likely choose products with

MU-MIMO to maximize network capacity on networks for the next few years and to minimize congestion. Mobile operators are likely to make this a requirement on all devices going forward. Some people in the OEM market mistakenly believe that adding MU-MIMO will force them to do a costly redesign, even if it is just moving some parts over. This is not the case. MU-MIMO does not require 2X2 MIMO on the client side. Any 1X1 product designs can remain the same while shifting to Wi-Fi chipsets that support MU-MIMO. Adding MU-MIMO will incur only a marginal cost relative to SU-MIMO while increasing the user experience over Wi-Fi and reducing power consumption. It is important to note that MU-MIMO has the greatest effect on the network as a whole, but device OEMs can still market the benefits of MU-MIMO to customers–more reliable data throughput and better power consumption on the access points shipping today. Finally, both is better–both MIMO and MU-MIMO–since end users benefit from all of the 802.11ac Wave 2 benefits combined.

- Wi-Fi access point vendors: Going past 4X4 MIMO or arguably even 3X3 MIMO used to not be worth it due to diminishing returns in the data rate achieved. Furthermore, only MIMO-enabled (2X2 or higher) devices could make used of MIMO on the access point. MU-MIMO makes it worth going to 4X4 and 8X8 MIMO because of the way they can be used with multiple MU-MIMO devices. MIMO enabled Wi-Fi devices and even 1X1 devices with MU-MIMO can better leverage MIMO on MU-MIMO-enabled access points because the streams are split up. Today, there is no reason for Wi-Fi access (access points, STBs, hotspots, carrier Wi-Fi, etc.) to not max out the capabilities available. The market will require a shift to 3X3, 4X4, 6X6, and 8X8 access points. This will result in a much more costly design on average, but as the market shifts its direction, prices for high end Wi-Fi chipsets and antennae will fall.

Wi-Fi access points in the consumer, enterprise, and service provider segments are available with MU-MIMO now

- Wi-Fi Alliance: The Wi-Fi Alliance should also consider adding a new consumer-friendly certification mark for MU-MIMO or Wave 2. This will no doubt be challenging, but there is an opportunity to lead the industry here with regard to MU-MIMO education..

It is important to keep in mind that some of the product types cross into multiple verticals–the consumer, enterprise, and mobile operator ecosystems are all tied together through Wi-Fi-enabled products that move across them. It is important for all industries and ecosystems to move forward together in adopting the latest technologies available–especially a high-value, low-cost feature like MU-MIMO. Furthermore, MU-MIMO enabled products have already been shipping, including consumer, enterprise, and service provider Wi-Fi access points, various client devices, and chipsets. 802.11ac Wave 1 was created to allow devices to ship with some of the benefits of the complete 802.11ac specification. This gave chipset vendors time to work on the inclusion of the more complicated aspects of 802.11ac. 802.11ac Wave 2 with MU-MIMO is the complete realization of the full 802.11ac specification. Products that include it will hold their value well into the future. Product vendors should not let their brands be associated with what will be perceived as the weak links in the network–"legacy Wi-Fi" without MU-MIMO.

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