Cambium Networks™

TECHNICAL ADVANTAGES AND INNOVATION

PMP 450m and cnMedusa™ Technology

cnMedusa™

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INTRODUCTION

Networks today are at a crossroads. Outdoor fixed wireless access networks support highly cost-effective deployments and bring high-speed connectivity to hard-to-reach areas, but many network operators are facing challenges. They need to enable denser subscriber network deployments per sector, and provide higher bandwidth to their subscribers, including support for media-rich services such as IPTV or streaming video, with the goal of growing their average revenue per user (ARPU) and future-proofing their networks.

Network operators already deploying PMP 450 devices are challenged to achieve this leap in network capacity without using more wireless spectrum yet protecting their existing investments by avoiding wholesale replacements of the networking equipment already deployed (e.g. a “forklift upgrade”).

Network operators planning Greenfield deployments need to build a future-proof network, with the expectation that both the number of subscribers and the usage per subscriber will increase significantly over time.

The Cambium Networks PMP 450 platform, deployed worldwide as the basis for some of the largest fixed wireless access service provider networks in the world, has evolved to meet these challenges with PMP 450m, powered by cnMedusa technology – the industry’s first commercially deployed massive multi-user multiple-input multiple-output (MU-MIMO) platform.

This white paper is an overview of the general technologies used in massive MU-MIMO, followed by specific details on Cambium Networks’ cnMedusa massive MU-MIMO technology as implemented in the PMP 450m product.

THE ROAD TO MASSIVE MU-MIMO

MIMO Evolution MIMO is a range of technologies used to multiply the capacity of a wireless connection without requiring additional spectrum. At their most basic level, wireless communication systems can use a single antenna element to communicate with each other. This is known as a single polarization system.

By becoming a dual polarization system - adding another antenna element to each wireless node - the network capacity can be doubled without requiring more spectrum by using the horizontal and vertical polarization of the radio wave, each carrying a separate data stream to transmit and receive data. Using vertical and horizonal polarizations is just an example of dual polarization systems. Another example is using dual slant polarization, meaning at +45 degrees and -45 degrees.

PMP 450 is a dual polarization system today.

This is also referred to as a 2x2 MIMO system, as both wireless nodes which are communicating with each other have two antenna elements. The first number refers to the number of transmit antennas, the second to the number of receive antennas used to communicate over the radio channel at any moment. Through the use of dual polarization antennas at each end of the link, a 2x2 MIMO system can typically support two streams in the same radio spectrum.

Beyond dual polarization systems, MIMO techniques become more complex to implement. By adding more antenna elements, the potential capacity gains increase but so does the signal processing and antenna design complexity.

Towards Massive MIMO Systems that are greater than 8x8 MIMO systems are typically considered massive MIMO systems. Massive MIMO systems require a highly complex active antenna array and advanced signal processing to realise the benefit of massive MIMO capacity in real world conditions.

The vast majority of massive MIMO systems today are experiments in academic laboratories. It has proven very difficult for wireless equipment manufacturers to create working, real world massive MIMO solutions. Current LTE and Wi-Fi standards are showing increased use of MIMO techniques but have not yet achieved massive MIMO.

Benefitting Multiple Subscribers Historically, MIMO technologies have been used to increase capacity between two wireless nodes. This benefits one subscriber at a time, and if a subscriber is not able to use all the capacity enabled by MIMO, the capacity is not utilized. Also, the increased capacity can be achieved only if the subscriber matches the capability of the access point (AP), meaning the same number of transmit and receive antennas.

As network operators aim for the highest utilization of their network possible, this is not ideal. A recent development is to use these technologies to allow an AP to communicate to several subscribers at once.

In traditional systems, each subscriber transmits or receives in sequence. If more than one subscriber were to transmit or receive at the same time, interference would occur between them, drastically limiting network performance.

MU-MIMO divides the capacity of the antenna array used for MIMO between multiple subscribers, allowing multiple subscribers to transmit and receive data concurrently. This allows the network operator to both increase network capacity and better utilize the network capacity.

Spatial Multiplexing To benefit from MU-MIMO, the antenna array of the AP must be highly sophisticated. Resources are allocated by the access point to different subscribers by electrically tuning the antenna elements to different phases. This technique is known as beamforming, as the antennas used to communicate to a particular subscriber are tuned such that their radio beam is targeted (or 'formed') to overlap a specific subscriber.

The goal of beamforming is to allow spatial multiplexing. This is the name given to making concurrent transmissions possible in the same wireless spectrum by using physically separated radio beams.

By targeting a beam to a specific subscriber, the beam to each subscriber is much narrower than the beam from an AP (in a conventional system, sectors are typically 90 or 120 degrees), multiple beams can then be used at once without them overlapping to the extent that would cause significant interference.

Beamforming can be applied in both the uplink and downlink directions and has significant benefit to overall network interference mitigation as well. This functionality does not require changes to the subscribers; only at the AP. PMP 450 subscribers already use directional (i.e. narrow) antennas to communicate to the AP.

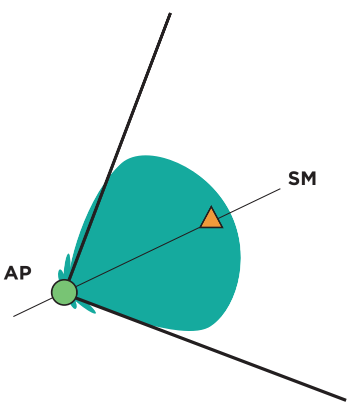


Figure 1
Antenna Pattern for Sector Mode Operation

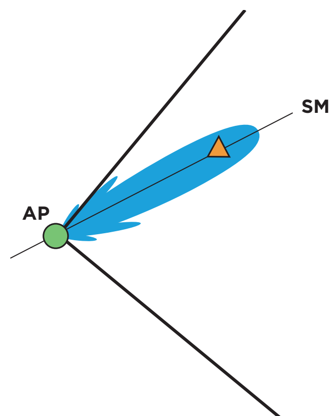


Figure 2
Beamforming to a single user

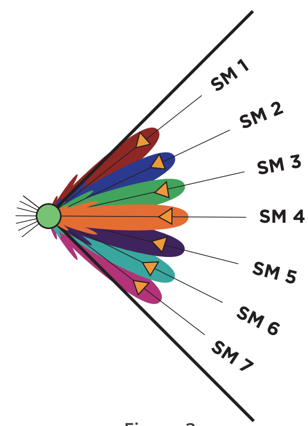


Figure 3
Beamforming to seven users simultaneously

Channel Sounding The access point must also be able to determine the state of the radio channel between it and each subscriber. This is known as channel state information (CSI). A complex channel sounding mechanism between the AP and subscribers, occurring rapidly and continuously, must be used to ensure the most performance benefit is achieved.

The access point estimates a property of the channel associated with each subscriber module (SM) called the spatial frequency. This property of each SM channel is used by the spatial multiplexing and beamforming algorithms. The spatial frequency is related to the azimuth angle of the subscriber, although the relationship is not unique (one-to-one).

Channel state information is collected by the AP generating a test signal that is sent to a subscriber. The subscriber returns the test signal, allowing the AP to characterize the channel between the two radios. Using the channel estimate and the spatial frequency it is possible for the AP to direct transmission to individual subscribers.

Putting it all Together Through the combination of MIMO, spatial multiplexing through beamforming and highly efficient channel sounding, a massive MU-MIMO system can be created. The first commercially available platform combining these technologies is Cambium Networks' cnMedusa technology, first implemented in the PMP 450m product.

PMP 450m OVERVIEW

PMP 450m is an outdoor point-to-multipoint (PMP) AP incorporating cnMedusa technology. In the 5 GHz band, it has a seven-element adaptive dual-polarity array smart antenna and massive MU-MIMO capabilities. The antenna array is composed of fourteen chains, connected to seven vertical and seven horizontal antennas, covering 90 degrees in the azimuth.

In the 3 GHz band, it has a four-element adaptive dual-polarity array smart antenna. The antenna array is composed of eight chains, connected to four dual slant antennas, covering 90 degrees in the azimuth.

In both bands, the 90-degree antenna can be used both in 90-degree sectors and in 120-degree sectors. In 90-degree sectors, the antenna gain at the edge of the sector is 3 dB lower than the peak value. In 120-degree sectors, the antenna gain at the edge of the sector is 6 dB lower than the peak value.

Each PMP 450 SM operates in 2x2 MIMO mode. In the 5 GHz band, the PMP 450m AP is capable of communicating with up to 7 subscribers simultaneously, supporting a total of up to 14 streams, making PMP 450m a 14x14 massive MU-MIMO system.

In the 3 GHz band, the PMP 450m AP is capable of communicating with up to 4 subscribers simultaneously, supporting a total of up to 8 streams.

The PMP 450m AP is interoperable with PMP 450, PMP 450i and PMP 450b subscribers (referred to as PMP 450 series subscribers).

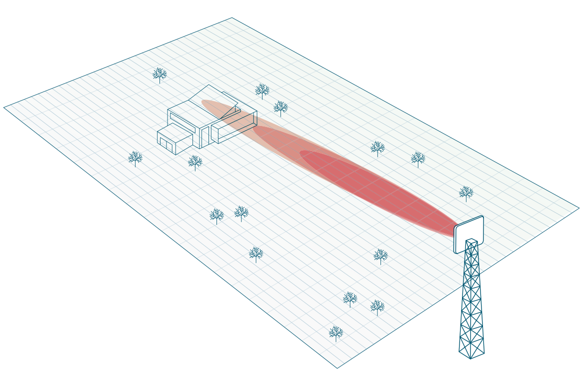
The rest of this document describes the PMP 450m AP in the 5 GHz band. All comments and descriptions apply also to the 3 GHz PM 450m, with the only difference that eight chains are supported in the 3 GHz band, versus the fourteen chains in the 5 GHz band.

The PMP 450m platform offers great flexibility sustaining opportunities for future enhancements. It has quad core processors, powerful FPGA with 20 Gbps interface to processors, 14 flexible RF transceivers, and 2x5 Gbps fiber external interface direct to the FPGA.

OPERATING MODES

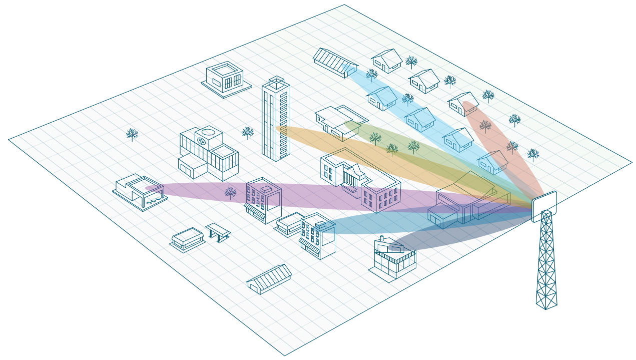
PMP 450m supports multiple communication modes, which will be described in detail in the rest of this document:

- **Downlink Sector mode:** used when transmitting broadcast data to all subscribers, or unicast data to an SM that did not provide channel state information. Functionally equivalent to the mode used by PMP 450 and PMP 450i APs.



- **Downlink Beamforming mode:** used when transmitting to one subscriber that provided channel state information.

- **Downlink MU-MIMO mode:** used when transmitting to multiple subscribers that provided channel state information.



- **Uplink Beamforming mode:** used when receiving from one subscriber that provided channel state information.
- **Uplink MU-MIMO mode:** used when receiving from multiple subscribers that provided channel state information.
- **Multiple fixed Uplink Beamforming mode:** used when receiving in contention (non-scheduled) symbols.

ADVANTAGES OF PMP 450m POWERED BY cnMedusa

Higher sector throughput The primary advantage of PMP 450m versus traditional 2x2-MIMO based APs, like the PMP 450 AP and the PMP 450i AP, is the support of MU-MIMO mode, which multiplies the sector throughput.

Using the channel state information each subscriber reports through the sounding mechanism, PMP 450m creates groups of up to seven subscribers. Subscribers are selected for one of these groups based on their azimuth spacing and amount of traffic, and their channel information is used to create up to seven spatially separated beams. Each beam points to one SM in the group, and its nulls are aligned with the directions of the other subscribers in the group, limiting interference between subscribers.

Groups are created every TDD cycle (frame) based on current traffic and the latest RF conditions. Subscribers within a group communicate with the PMP 450m AP simultaneously, then (in the next symbol or in the next frame) the PMP 450m creates a new group and performs simultaneous communication with those subscribers. In ideal conditions, PMP 450m is able to communicate with seven subscribers simultaneously.

With cnMedusa, subscribers are unaware of the groups to which they belong. Consequently, there is no over the air overhead or latency associated with group management.

Groups in the downlink and uplink directions are independently created. Subscribers are selected to be part of a group in one direction only based on the traffic in that direction. A completely new group is then formed in the other direction.

Communicating with multiple subscribers in the same channel at the same time provides a much higher sector capacity without requiring more wireless spectrum, resulting in a dramatic increase in spectral efficiency. For an operator, this means that a larger number of subscribers can be supported in the sector in the same spectrum, or that existing subscribers in the sector can experience higher average throughput.

The PMP 450m AP supports a sector capacity of more than 900 Mbps in a 20 MHz channel and more than 1.3 Gbps in a 40 MHz channel.

Range of sector throughput improvement What is the realistic sector throughput improvement offered by the cnMedusa technology in PMP 450m? PMP 450m can communicate with up to seven subscribers in a group, but the expected throughput improvement is up to three times that of PMP 450 (or PMP 450i), depending on the specific deployment. Factors that affect the actual sector throughput improvement are:

- The modulation level used for each subscriber in a group may be lower than the modulation level used when communicating to one subscriber only. This is due to residual interference between subscribers when forming beams in MU-MIMO mode.

- In the default configuration, only lower priority traffic is grouped. Traffic on the higher priority data channels is transmitted to one subscriber at a time in sector or beamforming mode, because typically the amount of information transmitted at higher priority is small. It is preferable to group users that need a large amount of data, resulting in a group that spans more symbols and uses resources more efficiently. Operators have access to the selection of which QoS levels out of the four offered for each SM can be grouped.

- Subscribers can be grouped if they are sufficiently spaced in azimuth. Wider sectors with a large number of subscribers uniformly distributed in azimuth have a higher probability of creating large groups. This translates into a higher probability of transmitting multiple streams, and therefore into a higher sector throughput. The azimuth separation necessary to group users is around 6-7 degrees.

- Subscribers can be grouped if they have traffic to send/receive. Sectors that are very active have a higher probability of finding subscribers that can be grouped.

- Subscribers below peak of beam may be ineligible for MU-MIMO grouping if their channel distortion is too large. These subscribers are very close to the access point and can typically support a high modulation mode in non-MU-MIMO mode. However, when MU-MIMO mode cannot be used, the sector throughput doesn't increase.

The best candidate for a sector using cnMedusa with MU-MIMO mode enabled is a wide sector, with a large number of subscribers, which are fairly active, dispersed across the azimuth, do not have a large amount of high priority traffic and no CIR.

The cnMedusa technology has been optimized for simultaneously streaming data to and from many users such as video. With the same frequency reuse benefits as other PMP 450 series APs, spectral efficiency is the highest in any commercially available system. The spectral efficiency of the PMP 450m AP is up to 45 b/s/Hz in a sector and up to 90 b/s/Hz in a four-sector deployment with back-to-back frequency reuse.

Given that in many deployments spectrum is scarce, being able to increase capacity without having to increase the channel bandwidth is a significant advantage for the network operator. That these gains are achieved by only changing the AP hardware is another significant benefit.

Examples of MU-MIMO patterns MU-MIMO patterns are generated frame by frame according to the SMs the PMP 450m AP needs to communicate with.

Figure 3 shows some examples of MU-MIMO composite patterns. The composite pattern is the overlap of the individual beamforming patterns, each with a peak in the direction of one of the SMs in the group, and nulls in the direction of the other SMs. Having nulls in the direction of the other SMs in the group keeps the interference between concurrent transmissions at a minimum.

The overlapping beams are calculated using information on the Spatial Frequency (azimuth) of the SM, and the channel state information of the channel between the AP and each SM.

In the examples in Figure 4, we see the AP with the SM's (orange tirangles) oriented towards it, with four shades of blue per beam in the coverage area various modulation levels. From the darker shade of blue to the lighter, the modulations are 256-QAM, 64-QAM, 26-QAM and QPSK.

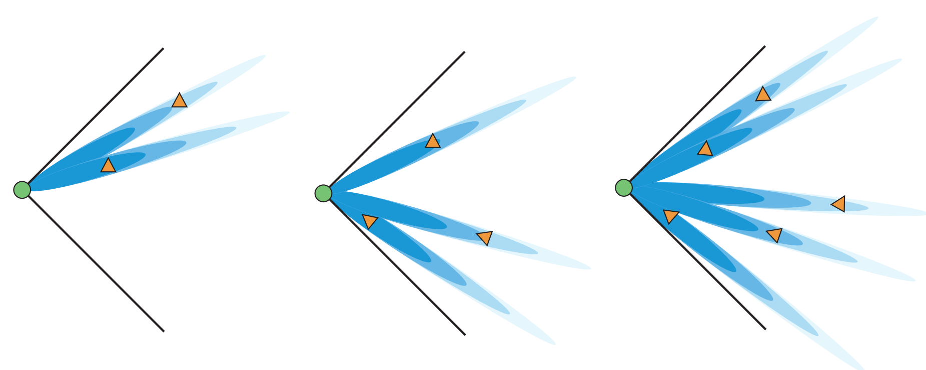


Figure 4 - Examples of MU-MIMO patterns

There are also numerous benefits in using PMP 450m versus PMP 450 or PMP 450i AP, even if MU-MIMO is not enabled.

Beamforming array gain If the MU-MIMO feature is not enabled, PMP 450m communicates to each individual SM in beamforming mode. Using the channel state information provided by the subscriber through the sounding mechanism, PMP 450m forms a narrow beam in the direction of the intended subscriber, therefore limiting interference to nearby sectors.

DOWNLINK

In EIRP limited regions, the transmit power needs to be decreased as the array gain increases, so that the total EIRP, given by the sum of the transmit power, the array gain, and the antenna gain, does not exceed the regulatory limit.
In these regions, with or without array gain, meaning in sector mode or in beamforming mode, the EIRP, and therefore the link budget, is the same as that of the PMP 450 or 450i.

By a combination of innovative RF and antenna design and unit calibration, cnMedusa determines the maximum EIRP for each beam created taking into account array gains. This is used to determine a beam-specific Tx power backoff to ensure all beams comply with the EIRP limits for the configured region.

There is one advantage, however, in operating at reduced transmit power; when the radio operates far from the saturation point of the power amplifier, in a more linear region, it is less subject to distortion and can more easily operate at higher modulation levels.

In non-EIRP limited regions, the array-gain, in addition to the antenna gain, increases the EIRP and therefore the link budget. This has the effects of:

- Increasing the range.
- Increasing the average modulation level achieved by the subscribers, which increases the sector throughput in the downlink direction.

UPLINK

In the uplink direction, the array gain associated with the narrow beam increases the link budget, which means that each subscriber can on average achieve a higher modulation level. This translates in better sensitivity, and it increases the sector throughput in the uplink direction.

Reduced interference The narrow beams created in the downlink and uplink beamforming mode, as well as MU-MIMO mode, not only increase link budget, and therefore coverage and throughput, but they also reduce the system's interference.

In the downlink, when transmitting in beamforming mode, interference is only created in the direction of the intended subscribers. Any other device operating on the same frequency in the same area will not suffer from interference due to this transmission unless it is located in the same direction. Compared to an AP that transmits in all directions in the sector, as in a conventional system, the interference created by PMP 450m is greatly reduced.

In the uplink direction, when receiving in beamforming mode, PMP 450m is only receiving (or 'listening') in a narrow beam directed toward the intended subscriber. Any transmissions outside this beam are not received and cannot interfere with the desired signal. Keeping the interference level low using these techniques means that on average the subscribers can achieve higher modulation levels, which increases the uplink sector capacity and overall system efficiency.

Figure 5 shows an example of increased uplink throughput and reduced uplink interference using beamforming mode.

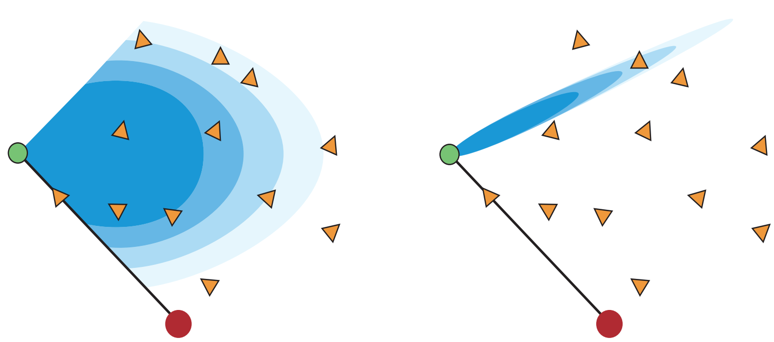


Figure 5 - Example of uplink throughput and interference rejection improvement

The figure to the left shows a typical sector deployment.

The AP receives transmissions from one SM at a time. The modulation each SM uses for transmission depends on the SM's distance to the AP. The blue shades show the areas where the SMs operate at progressively reduced modulation: 256-QAM, 64-QAM, 16-QAM and QPSK. The SMs in the light blue region operate at the lowest modulation (QPSK).

The figure to the right shows the same deployment, but with the AP operating in uplink beamforming mode.

The beam is now directed only in the direction of the intended subscriber.

As the array gain of the antenna increases the link budget, the areas covered by higher modulation operation are extended. The SM at the edge of the coverage area, that was originally operating at QPSK modulation can now operate at 16-QAM modulation, doubling its throughput. The overall sector capacity is also improved when one SM's link improves, as SMs are served faster, and resources can be allocated to other SMs.

In addition to the benefit of link budget improvement, and therefore increased throughput, the interference rejection capability of the AP also improves with uplink beamforming.

As the AP is typically installed in a high location, with visibility of a large area and possibly a large number of interfering devices, it is more susceptible to interference.

In the figure to the left, an interfering signal in the coverage area (red device) may corrupt the received signal coming from any of the SMs in the coverage area. This results in the SM having to operate at a lower modulation, therefore achieving a lower throughput.

In the figure to the right, only the signal coming from the direction of the transmitting SM is received at the AP. Any interfering signal outside the narrow beam is rejected, and therefore does not affect reception of the signal. In this case the modulation the SM operates at is not degraded, the SM's throughput is higher, and the overall sector capacity is also higher.

Additional antenna technology advantages The PMP 450m AP is integrated with a sophisticated antenna array, which in addition to supporting beamforming, beam steering, and MU-MIMO functionality, has additional features which improve coverage and performance.

The integrated antenna has a built-in 2-degree electrical down-tilt. Down-tilting the sector antenna is a common practice because typically the AP is installed at higher elevation than the SMs. By down-tilting the antenna, more SMs are closer to the peak of beam, and interference to neighbouring sectors using the same frequency is decreased.

Any antenna can be mechanically down-tilted. But electrical down-tilt provides more control and better performance. The difference is that with mechanical down-tilt the tilting angle is higher at boresight, but lower at the edge of the sector (at +/- 45 degrees for a 90-degree sector). This means that the positive effect of down-tilting peaks in front of the antenna but decreases on the sides. On the other hand, electrical down-tilting allows the tilt to be uniform across the sector, and therefore achieves better performance over the whole sector beam-width.

Additionally, the PMP 450m antenna uses null-filling to improve performance for SMs located closer to the AP. A typical sector antenna that does not provide null-fill may have a pattern with deep nulls at close range. If SMs located close to the AP fall into a null, their received signal strength is greatly attenuated, causing the device to switch to a lower modulation level, or drop the link if the attenuation is too high. In mobile applications this is typically not a concern as the mobile device can move around and as soon as it leaves the location of the null, the signal strength is significantly higher. However, in a fixed deployment the subscriber is always in the same location; if the location happens to coincide with a null, the reception would always be poor. This is why it is important for sector antennas in fixed deployment to have good null-fill properties, like the PMP 450m AP antenna.

Both these antenna features benefit not only the single subscriber, which can receive a stronger signal and therefore on average operate at a higher rate, but also all the other subscribers in the sector. Every device that can transfer data faster uses fewer symbols in the TDD frame and leaves resources available for other devices. The whole sector capacity is therefore improved by increasing performance in specific directions.

Packet Per Second (PPS) processing capability PMP 450m is an advanced platform with powerful processing capabilities. This reflects directly on the PPS, which measures the number of packets the device can process in a second.

A high PPS value allows the AP to sustain a very high sector throughput, even when processing a large number of small packets such as those found in voice over IP (VoIP) and gaming applications. Correspondingly, a smaller PPS value limits the sector throughput when a large number of small packets needs to be processed, as the device would not be able to process them fast enough.

The PMP 450 AP has a PPS processing capability of about 12k packets per second. The PMP 450i AP improved upon that and has a PPS processing capability of about 45k packets per second. The PMP 450m has a PPS processing capability of 200k packets per second, with potential software improvements that can push that number higher.

Regardless of the communication mode (sector, beamforming or MU-MIMO), PMP 450m can sustain much higher throughput when traffic is composed of a large number of small packets.

PMP 450m Limited The PMP 450m is available in two versions. The Full version with all the capabilities of cnMedusa, or a Limited version that restricts operation of MU-MIMO. The simple application of a software license key can enable MU-MIMO operation at any time. This allows a network operator to deploy the PMP 450m hardware at a lower cost, and update to MU-MIMO operation at a later time. What are the advantages of purchasing a PMP 450m AP without the MU-MIMO feature enabled?

PMP 450m is designed for sectors with very high capacity. However, some sectors may start with a small number of users, with the potential of many more being added over time. If there is no need for very high capacity when the sector is first installed, it is possible to deploy the PMP 450m without the MU-MIMO feature enabled. As the sector grows and more and more subscribers are added to the sector, the MU-MIMO feature can be enabled, allowing the AP to support a much higher throughput without having to change the hardware. This is a future-proof investment for sectors that are expected to grow. This can be especially useful if the AP deployment location is difficult or expensive to access.

Another benefit of the PMP 450m is in the interference reduction due to receive beamforming, as described earlier. This function is inherent in the cnMedusa technology, and is present even in the Limited version.

PMP 450m Limited is an option for smaller sectors to benefit in the future from high performance MU-MIMO functionality when their sector has scaled to an appropriate size, while offering a lower entry point cost than the full PMP 450m AP.

COMPARISON WITH 802.11ac MU-MIMO FEATURE

The MU-MIMO feature is now part of many standards, like 802.11.

It was introduced as on optional feature in the 802.11ac standard, but it wasn't included in the first generation of 802.11ac devices. Newer devices are now starting to incorporate the MU-MIMO feature, recognizing the great potential in capacity increase given by the capability of sending data to multiple devices at the same time.

Comparing the implementation of MU-MIMO in the PMP 450m AP and in an 802.11ac device, the first difference is that 802.11ac devices support MU-MIMO only in the downlink direction, while the PMP 450m AP supports it both in the downlink and in the uplink direction. Not supporting MU-MIMO in the uplink direction creates a double penalty.

The first is the obvious fact that the uplink capacity is not increased compared to when operating with SU-MIMO devices. In deployments that need to support the uploading of large content files or two-way video conferencing, having MU-MIMO only in the downlink direction does not necessarily improve the user experience.

The second is that the increased capacity offered by MU-MIMO in the downlink direction is typically used to serve more users, and more users also generate more uplink traffic. Now the system has more uplink traffic and no increased uplink capacity, with the only solution to use more airtime in the uplink direction to accommodate the additional traffic. The additional airtime needed in the uplink direction reduces the airtime in the downlink direction, which is the only one benefitting from the MU-MIMO capacity increase.

The PMP 450m AP also supports uplink MU-MIMO transmissions for acknowledgments. These are the messages sent from the subscribers to the access point, to acknowledge reception of downlink transmissions. If the access point is able to receive multiple acknowledgments at the same time, more air time is left available for transmission of data, and this increases the sector capacity even more.

The 802.11ac standard supports MU-MIMO only up to 8x8, meaning eight streams, and the number of concurrent subscribers receiving data cannot exceed four. The PMP 450m AP supports up to 14 streams sent to up to seven subscribers, with an obvious advantage in improved sector capacity.

Another difference is in the sounding mechanism. The access point forms MU-MIMO groups to send data to multiple subscribers at the same time, and in order to create the beams in the exact direction of each subscriber, it needs to have accurate channel state information, reported by each subscriber through the sounding mechanism. Because the information needs to be accurate, the message from each subscriber to the access point may be large, and it needs to be periodically repeated to keep track of any changing condition in the channel. The 802.11ac standard is designed to support mobility, where the channel can greatly change from one sounding report to the next. Therefore, each sounding report needs to carry information on all subcarriers and all streams.

The PMP 450m sounding mechanism, however, is optimized for fixed wireless deployments, where channel conditions are more stable. The sounding report from each subscriber can be one of three formats: a long message, with accurate channel state information, a compressed report for small changes in the channel, or no report if the channel has not changed from the previous sounding exchange. This mechanism keeps the sounding overhead to a minimum, still allowing the subscriber to quickly report any changes in channel conditions but saving uplink air time when no changes have occurred in the channel.

Finally, when grouping data to multiple users, throughput is maximized if the length (in time) of the transmission is the same for all the subscribers in the group. If users have different amount of data to receive, the sector capacity is increased only for the amount of time data is actually sent to different users. The 802.11ac standard has less control over the length of the transmissions, as one or more whole packets are sent in each transmission. The PMP 450m AP on the other hand divides all transmissions into small fragments, and it has more control over the amount of data that can be grouped at a single time.

SUMMARY

PMP 450m is an AP powered by cnMedusa technology which allows a network operator to vastly increase sector capacity, without requiring more wireless spectrum and while protecting current investment in PMP 450 subscribers.

MU-MIMO mode provides a large boost in sector capacity and incorporates highly advanced signal processing, antenna array control and channel sounding techniques. Even if the operator does not operate PMP 450m in MU-MIMO mode, beamforming and higher packet processing capability provide a considerable performance benefit over PMP 450 and PMP 450i APs.

PMP 450m represents a significant technical leap over existing commercial fixed wireless access systems, allowing network operators to future proof their network for years to come with confidence.