Cambium Networks™

A COMPARISON

PMP 450 and LTE in 3 GHz

INTRODUCTION

The LTE (Long Term Evolution) standard provides for great performance and has (at some point on the roadmap) many features that make it well-suited for any use case. The 3rd Generation Partnership Project (3GPP) originally came together as an industry group to create mobile standards that would move mobile (cellular) infrastructure forward. This group has continued to evolve the standard, and is backed by the largest telecommunications groups in the world. The LTE standard has been developed by this group and has had billions of hours and dollars poured into it to create the standard protocol for mobile telecommunications. As it stands, the release definitions are frozen through Release 13, with Release 14 soon to come. Chipset manufacturers are doing their best to keep up with the release schedule, and incorporating features defined in these releases in their latest offerings.

However, just because a product utilizes the LTE standard does not inherently mean it has any of these features, or the optimal level of performance. The system implementation; that is, the application of chipset to functional system, makes all the difference. As is nearly always the case, there are tradeoffs to be made between system cost and performance. Striking the proper balance for the targeted market segment is key to creating a product that will be successfully implemented.

CUSTOMER EXPERIENCE

Globally, the 3 GHz band has been a licensed frequency band that was defined for the WiMAX standard. It is not typically available to Service Providers without having purchased or leased this frequency. However, some efforts have been made to make it more readily available in certain parts of the world. Specifically, in the United States and Canada, 50 MHz of this spectrum (3650-3700 MHz) had been available under a "lightly licensed" condition. An operator needed to obtain a nationwide, non-exclusive license at very low cost from the regulatory body, then register any equipment that would be operating in that band. This propelled the use of this band forward tremendously over the last several years.

Cambium Networks introduced the 450 platform operating in the 3 GHz band in 2014. Since then, it has been deployed in hundreds of networks globally. This represents a substantial number of operators that are helping to bridge the digital divide, and connect rural customers. Upcoming changes to this band in the United States (via the Citizens Band Radio Service [CBRS] initiative) will allow additional frequency use in this band, driving more demand for efficient equipment that operates in these frequencies. Due to the large established installed base of equipment already in place, it is logical that operators will want to continue deploying the same equipment when new spectrum becomes available. It is the intention of Cambium Networks to allow the 450 platform of equipment to continue to support this band, along with the newly available spectrum. In addition, the 450 platform is evolving to include cnMedusa technology in this band in the near future, which will further enhance the performance, capacity and spectral efficiency of the system.

Competitors in this space utilizing LTE protocol have started to deploy equipment (coming to the commercial market in 2015 or so), though at this point it is estimated that less than 10,000 units in total are in operation. There are many ongoing trials using a few subscribers, but very few established, scaled networks.

OPERATING RANGE AND COVERAGE AREA:

The 3 GHz frequency band is attractive to many operators for a few different reasons. A primary consideration is that of the coverage area, and the potential for overcoming obstacles such as foliage (i.e. tree pentration). As the frequency gets lower, the ability for the radio signal to penetrate foliage gets better. Therefore, 3 GHz works better than 5 GHz (which is more widely available and typically unlicensed), so it can be sought after in areas that are difficult to reach.

With regards to coverage, the LTE standard provides some advanced tools in the chipset. Utilizing OFDMA (Orthogonal Frequency-Division Multiple Access), the many subcarriers that the channel is divided into can be assigned to different subscribers in the same frame. This can lead to enhanced performance. Because the standard was designed with mobility in mind, the primary performance is slanted toward the downlink direction, and the protocol lends itself toward maintaining the downlink connection, which again leads to better range. Another possibility (albeit one that has proven very difficult to implement in practice) is the use of customer-installed indoor devices such as table-top subscribers or dongle units.

When comparing to the 450 platform, the LTE frame structure (with additional modulation coding schemes (MCS), more subcarriers, and the ability of OFDMA) can

provide enhanced range and capability to perform better in near and Non Line of Sight conditions. It is also typical that LTE systems have higher transmit power capability than the 450 platform. In the lightly licensed scheme found in the United States, this is not critical because the 450 platform can reach very near the regulatory maximum EIRP (Equivalent Isotropically Radiated Power) allowed. However, where the frequency is licensed, the maximum power is typically much higher, and in fact, when new CBRS rules are in place, the power limit will be higher. When the 450m (with cnMedusa technology) is released in this band, it will be a higher power device and be able to achieve the new regulatory limits expected under the new rules, lessening the impact of competitive products.

INTERFERENCE MITIGATION:

Interference is always a concern of any wireless equipment operator. The ability to deal with or avoid interference often is the difference whether a deployment is successful or not. The PMP 450 platform has evolved over many years to tolerate interference when it exists, and to avoid interference where possible. Although the LTE standard provides many MCS levels, which allows for great Receive Sensitivity and very low required Signal to Noise Ratio (SNR), the 450 platform was designed as a purpose-built fixed wireless system. Further, cnMedusa technology provides incredibly fast beamforming, with the ability to achieve very narrow energy lobes, and steer energy nulls (i.e. the absence of antenna energy).

The implementation of this can outperform anything in the LTE space, and allows for advanced interference avoidance (with better, more accurate beam steering) and even active interference cancellation techniques (by pointing destructive energy toward a radiating interference source). Because the 450 platform has complete control over the channel information at both ends of the link, and is not beholden to the standards, these advanced techniques can be implemented more easily.

SCALABLE NETWORKS:

- **Subscribers per Sector**
  The 450 platform supports up to 238 subscribers per sector. In rural environments, this kind of density may not always be necessary, but there may be cases where there are many subscribers per sector. While installations vary greatly, many 450 network operators will have one hundred or more subscribers per sector. Data from 450m (cnMedusa) sectors in the 5 GHz range show that greater than 100 customers is sustainable with the amount of capacity that these sector radios can provide. Many 450 networks have proven scalable, and now exceed 10,000 subscribers. In fact, there is an operating network of greater than 220,000 subscribers, which continues to expand and densify as customers are added.

  Of the competitors noted in this space today, there is a limited ability to support a scalable number of subscribers per sector. One competitor claims to only support 32 users per sector, while another caps the total number of subscribers per EPC (Evolved Packet Core) to 500 users. This could present a problem when attempting to scale the network in terms of total subscribers.

- **Bandwidth per Subscriber**
  With respect to the maximum amount of throughput per subscriber, there may be a need for the operator to provide a significant amount of capacity dedicated to a single customer. In the case of LTE equipment, one of the attractive points is that CPE (customer premise equipment) devices are inexpensive and can be purchased from multiple vendors that utilize the LTE protocol standard. This can be an advantage from a cost perspective, but the performance of low cost devices needs to be looked at carefully. In most cases, there is a limited ability to provide over ~130 Mbps of throughput in aggregate through LTE CPEs. Further, the uplink is usually severely limited (~20 Mbps), and cannot be altered to provide more. This is largely due to the LTE protocol itself. The 450 platform is designed to be very flexible, and the duty cycle (i.e. the uplink/downlink ratio) can be varied from 85% to 15% downlink, in increments of 1%. Flexibility like this can allow the operator to tailor the service to the customer. In fact, the 450 platform subscriber module can provide up to 300 Mbps of capacity to meet any service level agreement required.

- **Total Sector Capacity**
  The total capacity of a sector can be another factor in how well the network can scale. With LTE, the standard allows for very advanced techniques that have very good capacity. For example, Release 10 (also referred to as LTE-Advanced) allows for up to 8x8 MIMO and Carrier Aggregation. This could be a potential of up to 600 Mbps per sector. However, the closest competitors in this space are currently supporting only a 4x4 MIMO sector, and most only support a 2x2 radio. This would mean a maximum of about 150 Mbps in a 20 MHz channel. The 450m in 3 GHz will support 8x8 Multi-User MIMO operation, giving a multiplexing gain on top of what is seen with 450i. That is, the expectation is that there will be at least twice as much capacity in the sector compared to a 4x4 LTE system. In absolute terms, the 450 platform can support 125 Mbps per 20 MHz channel, and up to 300 Mbps per 40 MHz channel in 450i. This will improve to over 600 Mbps with 450m.

- **Spectral Efficiency**
  A high performance wireless system must also demonstrate good spectral efficiency. That is, it should make best use of the spectrum that is available. The LTE-Advanced standard can show up to 30 bps/Hz by utilizing 20 MHz channels with a 3-sector 8x8 MIMO N=1 (i.e. re-use of the same 20 MHz channel on all three sectors) configuration. That is best case per the standard. In actual deployments, it is noted that three 4x4 sectors, using N=1 can provide up to about 16 bps/Hz, but significantly decreases the range due to limiting the transmit power to allow N=1 to work properly. This also means that the total site capacity is about 320 Mbps, or just under 110 Mbps per sector. In contrast, the 450 system can achieve about 40 bps/Hz. This is possible due to the system specification of the platform. First, a 4-sector deployment (rather than the typical cellular model of a 3-sector deployment) is recommended. This, combined with antenna systems that are optimized to properly isolate the front-to-back energy, allows the 450 platform to effectively re-use frequencies in a back-to-back fashion. In a 4-sector deployment, this equates to a N=2 (or ABAB) configuration. A single sector is capable of 7.5 bps/Hz (that is, 300 Mbps in a 40 MHz channel), or 15 bps/Hz at a site when employing N=2. If 450m, with cnMedusa Multi-User MIMO technology, is used, this becomes 2 to 3 times better, resulting in up to up to 20 bps/Hz per sector or 40 bps/Hz per site, far exceeding the LTE standard efficiency. If the network is spectrum constrained, a 450 system is only about double the capacity using the same amount of spectrum. However, if additional spectrum can be used (2x40 MHz in this case), the overall site capacity is a staggering 2.4 Gbps.

ADDED INFRASTRUCTURE COSTS (EPC):

The PMP 450 platform was designed to be a flat Layer 2 architecture that is simple to deploy and manage. It consists of only two components required to complete a link from subscriber to the network core. That is, the Access Point (AP) can be connected directly to the network core, and the Subscriber Module (SM) connects to the customer. There is no other ancillary components required. However in the LTE standard, due to the requirements for mobility, an added infrastructure component is the Evolved Packet Core (EPC). This piece of the architecture helps manage the movement of a subscriber from one node to the next, and is not really required for fixed wireless implementations. However, because it is part of the standard, something needs to be done with it, even in fixed equipment.

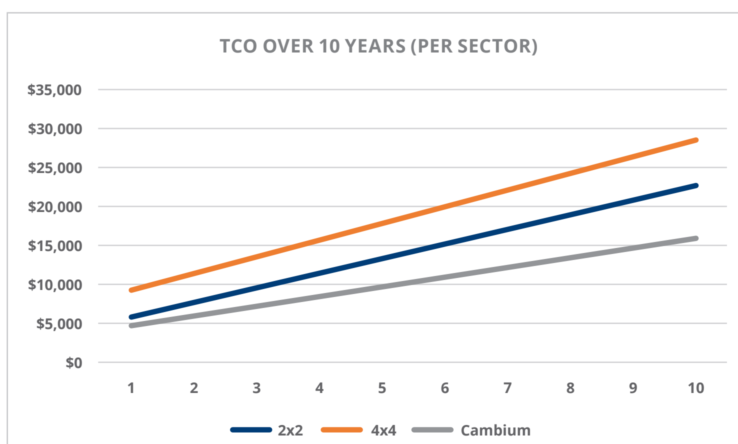
In effort to reduce the complexity and cost of a fixed networks, equipment vendors attempt to reduce the need for a true EPC. There are two main methods that have been noted. First, containing the EPC at the site, or "virtualizing" the EPC. This means the EPC function will be contained within each sector unit. This is effective, but may result in limitations of the total number of subscribers supported, and have the potential for added costs to the operator, depending on how it operates. Second, the system may be supported by a cloud EPC. This eliminates the need for actual infrastructure equipment, but the network now depends on communication with a cloud service. If this service or communication to this service is interrupted for any reason, the network could cease functioning until that is restored. Further, if the company that provides this cloud service should stop operating, it is not known what might occur with the cloud EPC.

ONGOING OPERATIONAL COSTS:

Although LTE equipment providers have attempted to reduce operating costs of fixed LTE networks, there are still several considerations when choosing between LTE and the 450 platform. With 450, there are zero required ongoing operational expenses. Once the capital equipment is purchased, the operator can utilize all features, and expand the network as necessary with additional capital expenditure.

By removing the costs associated with much of the back end infrastructure required in a mobile LTE network, fixed LTE equipment providers have reduced the capital cost of that equipment. However, many retain the recurring maintenance and operational costs associated with these EPCs. For example, one vendor charges a monthly fee for the cloud EPC, another charges a scaled fee for every 500 subscribers on the network. There are usually recurring charges associated with each subscriber as well, for SIM (subscriber identity module) card services, which is typical of mobile telecommunication systems.

By example, setting aside the recurring EPC and SIM costs, only counting equipment cost, installation and power consumption, a 4x4 LTE sector starts around $10,000 and has a TCO (Total Cost of Ownership) of about $30,000 over 10 years. A 2x2 LTE sector starts around $6,000 and costs $23,000 over 10 years. Cambium starts around $5,000 per sector, and consumes less energy over its life, resulting in $16,000 TCO.



When the recurring core maintenance, SIM leases, and other recurring fees are factored into the TCO, this disparity widens quickly.

CONCLUSION

The LTE standard was developed as the "Evolution" to the global mobility standard. If mobility is required for a given network deployment many of the architecture that creates additional overhead and complexity exists to allow this aspect to function. The EPC helps to manage handoff between sectors and across the network. If, however, fixed deployments will be the primary use case for the network, the purpose-built 450 platform may be a better solution.

While LTE does many things quite well with respect to network coverage, range, and near and Non line of sight connectivity, the 450 platform from Cambium Networks can provide better overall performance, is less expensive to deploy and reduces the total cost of ownership over its operational life.

BEST ◉ ◓ ○ ◒ ● WORST	EXISTING LTE SOLUTIONS	CAMBIUM PMP
Customer Experience	◒	◉
Range and Coverage	◉	○
Interference Mitigation	○	◉
Total Sector Capacity	○	◉
Subscriber Bandwidth	◒	◉
Infrastructure Costs	●	◉
Mobility Support	◉	●
Total Cost of Ownership	●	◉

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