THE SERVICE TARGETED BY THE CSP IS FWA WITH A "FIBER-LIKE" EXPERIENCE.

Mamatov Sardor Ilyosovich
Denov enterpreneurship and pedagogy institute, Department "Digital economy"
Phd, Researcher,
mutabarchik@mail.ru

The wavelengths of mmWave signals are short, as are the antenna elements. Consequently, the energy density of the signal reaching the antenna must be high to get a sufficient signal-to-noise level. Using large antenna arrays on the transmitter side together with beamforming enables the energy to be focused in the desired direction. Beamforming on the receiver side further improves the received signal strength.

Beamforming is a core component of the transmission on mmWave frequencies. It can be applied on both the network and device sides, although the beamforming capability on the network side is more advanced. Beamforming alone is, however, not sufficient to reach distances of many kilometers. Mobile networks operating in the mmWave frequencies today apply beamforming but cannot reach users that are several kilometers away.

With FWA, it is possible to create conditions that are very favorable to long distance coverage. On the network side, existing deployments of high-power radios placed above the main obstacles (by means of macro towers, for example) are already well suited to maximize the downlink (DL) received signal strength.

On the device side, AC-powered CPEs have significantly higher transmit power than battery-powered mobile devices. They can also be placed in the most favorable location for the connection, which is usually outdoors, to avoid wall penetration loss. Both the CPE's transmit power and its location are essential to improve the uplink (UL) received signal strength, which is the factor that typically limits coverage.

Accommodating long propagation delay:

The ability to accommodate long propagation delay is a key enabler for long-distance communication. The extended range feature provides this ability. Once sufficiently good signal strength is ensured at a given distance, it is necessary to adapt the communication system to accommodate the propagation delay corresponding to the targeted distance. In mmWave spectrum TDD is applied. With interleaved UL and DL slots, the transceivers need a few microseconds to switch between receiving and transmitting mode. The TDD format therefore includes a short gap period between DL and UL symbols.

The length of this gap period should also accommodate the signal propagation from the transmitter side to the receiver. The longer the distance between these, the larger the gap needs to be. For an MBB-centric deployment where the mmWave cell range does not typically exceed a few hundred meters, mmWave transmissions would only need a very short gap between the DL and UL slots of a TDD pattern.

For longer distances intended for an FWA-capable deployment scenario, the gap needs to be enlarged. This means that a few additional data symbols will be muted to cover for the longer distance. In addition to a larger gap duration, a 3GPP-defined random access preamble format that is favorable to a long-distance scenario is used. Random access preambles are a basic technical component of the 3GPP release 15 specifications and are therefore supported by all devices. On the network side, the detection of random access preambles subject to long propagation delay can be improved by means of an advanced random access receiver algorithm.

The larger gap duration in the TDD pattern required to cover long distances increases the overhead for all devices in larger cells by a few percent and slightly decreases capacity and peak rates. The extended range configuration should therefore be applied only where needed.

Several field testing activities have been carried out to determine how far a radio signal on mmWave frequencies can propagate and what data rates can be expected at this range. The 5G mmWave macro base station 6km away is highlighted with a red circle, and the CPE in the foreground is a Qualcomm 5G Fixed Wireless Access Reference Design. Field testing showed that in the right conditions, it is possible to achieve DL data rates larger than 1Gbps at a cell range beyond 7km in mmWave frequencies. The feature is now also deployed in commercial networks.

Case study: US digital village

The extended range opens up new opportunities to use mmWave spectrum in sparser suburbs and semi-rural areas, which then makes it possible to offload lower frequencies. In such areas, there could be several hundreds of homes per sector. With increasing consumption on both MBB and FWA, the additional capacity that mmWave brings makes such a scenario a sweet spot for combining mmWave and TDD mid band, thereby providing FWA subscribers with high service levels.

In the following simulated scenario, which models the performance achieved in field trials, we illustrate how mmWave extended range can be used to increase capacity and boost user experience. The case is a version of the digital village case study in the Fixed Wireless Access Handbook that has been adapted to US data consumption patterns.

The original case study includes a stepwise solution and business case analysis showing a return on investment of 22 months. Here, we focus on a comparison of the achievable network capacity, with and without deploying mmWave. The targeted case is a village together with surrounding, more sparsely populated areas where the overall home density is around 150 homes per square kilometer. Current broadband offerings are mainly provided by xDSL or best-effort MBB, but there is no fiber-to-the-home, which makes the area an attractive candidate for FWA.

The existing MBB deployment has as a macro inter-site distance of 3km, and lower FDD bands are used to serve current traffic. Over time, as the MBB traffic grows, it will utilize part of the acquired mid-band spectrum. The excess spectrum can be used for FWA: 100MHz TDD at 3.5GHz and 400MHz in the 28GHz band.

The service targeted by the CSP is FWA with a “fiber-like” experience. This means sold DL data rates of 100-1,000+Mbps without a data cap and with typical DL rates of at least 100Mbps. Combining available spectrum, including lower FDD bands, and mid bands and 28GHz using TDD, the CSP can obtain a combined network deployment catering for both MBB and FWA.

In this analysis, we focus on the mid band and on 28GHz, and we leave out the details on lower bands as well as the performance for the MBB users. However, the suggested approach includes a joint solution for FWA and MBB that also handles the anticipated growth of MBB traffic. Furthermore, as the case is limited by the DL capacity, we leave out the analysis of the UL. To maximize link performance, the case is based on the use of rooftop-placed, high-power CPE that supports mmWave as well as lower bands.

The system is dimensioned to target a minimum DL data rate of 30Mbps for the 5 percent worst located homes, at peak traffic hours, to sustain a fiber-like experience, including multiple HDTV streams per home, also in those worst cases. Regarding data usage, we define a baseline scenario, based on observed current US fixed broadband levels, where the average data consumption per home is expected to be 670GB per month, out of which 90 percent (600GB) is DL traffic.

Assuming that 10 percent of the daily traffic occurs during the busiest hour, this corresponds to an average consumption of 2GB per hour at busy hour. We assume an annual growth of 28 percent, partly driven by many homes transitioning from consuming linear TV over satellite or terrestrial broadcast, to using broadband for all media consumption including linear TV and streamed services.

In addition, for comparison we have also defined an all-broadband-media scenario that assumes that all homes have already made this transition. For this case, we assume a consumption rate of 1TB per month per home (900GB per month in the DL) but expect lower annual growth of 10 percent, as the shift to all media consumption over broadband is already completed.

As the capacity needs to grow with an increasing number of customers, as well as with higher average data consumption and speed requirements, it makes sense to gradually increase the capabilities of the network on a needs basis. This means that costs for increased capacity can be taken as late as possible, as opposed to fiber, where a major part of the cost is taken upfront when deploying fiber trunks passing all homes. Furthermore, decisions about capacity enhancements can be made selectively on a sector by sector basis as the numbers of subscribers – and the revenues – increase.

Experienced user data rate

Figure 1 shows the experienced DL user data rate as a function of varying system load for the worst, median and best located homes respectively. The blue curves represent a mid-band-only deployment, while the red ones represent the combined mid-band and mmWave case.

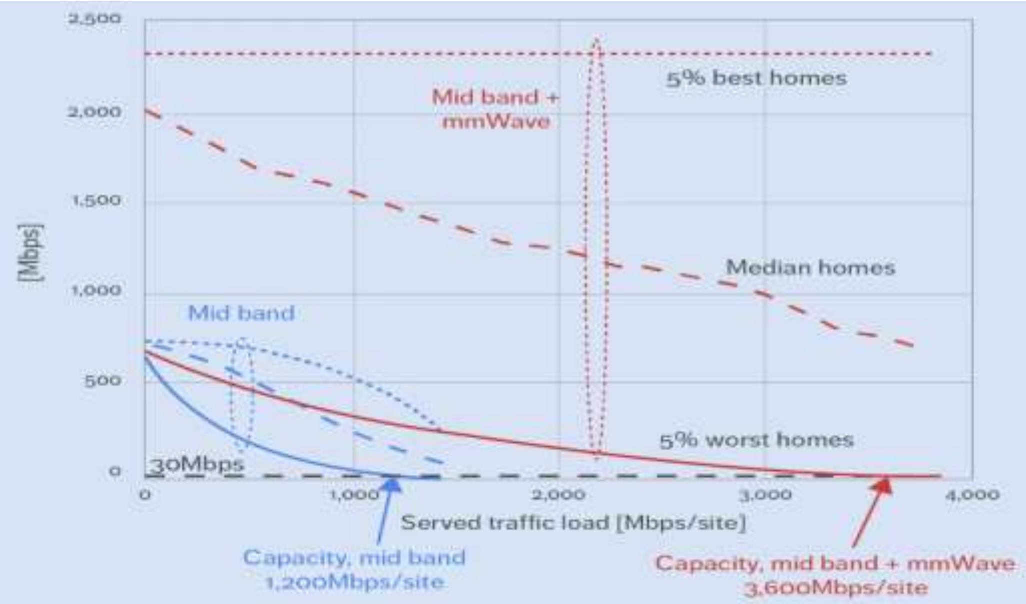

Figure 1: Experienced user data rate – DL user data rate as a function of system load for mid-band-only and mid-band + mmWave deployments

DL capacity as the system load at which the fifth-percentile worst-located homes experience a data rate of 30Mbps (the dashed black line) according to the dimensioning criterion described above. With 100MHz of mid band, the capacity is 1,200Mbps per site, while it is three times higher (3,600Mbps per site) when adding the mmWave spectrum. Figure 5 demonstrates that, already with a mid-band-only deployment, even the worst-located homes will experience DL rates of 100Mbps or higher at moderate system load, which is most of the time. The peak user rates with mid band alone are in the range of 690-730Mbps depending on the location of the home. After adding 400MHz of mmWave spectrum, the rates of median homes increase drastically, and we also see a significant variation in this range of the peak rates, which reach up to 2,300Mbps depending on whether or not the home can be served by mmWave.

In conclusion, due to its accessibility, scalability, cost-effectiveness and performance benefits, 5G FWA holds significant potential as the future of connectivity. However, like any technology, its success will also depend on various factors including regulatory policy, market demand, spectrum availability and technological challenges in deployment.

REFERENCES:

1. Broadband Fixed Wireless Access: A System Perspective (Signals and Communication Technology) by Marc Engels (Author), Frederik Petre (Author)
2. Resolution of the Board of the Central Bank of the Republic of Uzbekistan. On approval of the Regulation on the classification of asset quality in commercial banks and the procedure for the formation and use of reserves to cover potential losses on assets // Collection of Legislation of the Republic of Uzbekistan, 2015, No. 28, Article 374; National Database of Legislative Documents, 30.04.2018, No. 10/18/2696-2/1120.
3. Annual Report of the Central Bank of the Republic of Uzbekistan for 2023.//www.cbu.uz.
4. Ways to improve the accounting for liabilities in the travel agency. TM Zhuraevna European journal of economics and management sciences, 3-6.
5. АА Каримов, СУ Мехмонов, МЖ Темирханова Развитие социально-экономических систем в условиях нового технологического уклада. Стратегия устойчивого развития в антикризисном управлении экономическими …
6. М.Ж Темирханова, ХБ Зарипов СОВЕРШЕНСТВОВАНИЕ ЦИФРОВОЙ МОБИЛЬНОЙ СВЯЗИ В СОВРЕМЕННОМ МИРЕ Бюллетень науки и практики 6 (7), 262-271
7. М.Ж Темирханова, Хусан Баходирович Зарипов, Ли Шаоминь. Совершенствование цифровой мобильной связи в современном мире Бюллетень науки и практики Byulleten nauki i praktiki 6 (7), 262-271
8. Key 5G Physical Layer Technologies, Enabling Mobile and Fixed Wireless Access by Douglas H. Morais
9. https://www.zte.com.cn/
10. https://www.ericsson.com/
11. https://www.nokia.com/
12. https://www.3gpp.org/