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Reader Forum: Selecting the Right Wireless Technology for Small Cell Backhaul

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Most operators and market analysts agree that cost effective backhaul is the greatest challenge for wide scale small cell network deployments. The high cost, arduous city approval process and impracticality of bringing fiber to every microcell means that wireless will likely be a predominant technology in small cell backhaul.

As operators evaluate small cell backhaul solutions, several questions arise. Should they adopt licensed or unlicensed wireless?
Microwave or millimeter wave radios? Point-to-point or point-to-multipoint architectures? With wireless backhaul frequencies ranging from 2.3 GHz up to 80 GHz, each option has distinct propagation characteristics, capacity ranges and cost points. Matching the right wireless technology to different small cell backhaul applications is essential to ensuring the optimal combination of performance and cost. This article presents the advantages and disadvantages of different small cell wireless backhaul technologies and designs.

What constitutes a small cell?

The term “small cell” generally encompasses the following network or cell types:

–Femtocells: Short range indoor units used to extend mobile coverage in residences and small enterprises.

–Picocells: Indoor or outdoor units used to provide coverage in larger areas such as a campus, office building or sport venue. These generally have a range of less than 200 meters.

–Microcells: Higher power, operator-owned/managed outdoor units with a range of 300 to 2,000 meters. Some microcell deployments are moving to fully integrated platforms containing the micro base station, backhaul radio(s), Ethernet switching, power supply and battery backup within a single zoning-friendly enclosure.

Each type of small cell brings different expectations and requirements around reach, line-of-sight, capacity, latency performance and reliability – all of which will influence the wireless backhaul technology and frequency selection.

What frequency options are being evaluated by mobile operators for small cell backhaul?

–Sub-6 GHz point-to-point: With frequencies ranging from 2.3 to 6 GHz, these cost-effective systems offer non-line-of-sight operation in licensed or unlicensed frequencies and are simple to deploy. While the 100 megabit per second (full-duplex) capacity and higher delay/delay variability of sub-6 GHz solutions limits their ability to aggregate multiple sites, these systems are well positioned to handle individual spurs where line-of-sight is an issue.

–Sub-6 GHz point-to-multipoint: Operating in the same NLOS frequencies as above, these solutions use a hub-and-spoke architecture, which allows multiple sites to be connected quickly and cost effectively. The main constraint with this architecture is that the system capacity is shared across multiple backhaul beams, meaning that the amount of bandwidth to each site is then a fraction of the overall system capacity. It is also worth noting that since most sub-6 GHz deployments use unlicensed spectrum, operators are unable to guarantee any level of performance due to ongoing risk of interference. For this reason, some operators are electing to use licensed frequencies, where they either borrow from their costly RAN spectrum or use even costlier dedicated area licenses. Given that a channel is used across an entire sector, and usually cannot be re-used in an adjacent sector, the spectral efficiency of PtMP systems is also quite low.

A further issue with PtMP solutions for this application is that the deployment topologies tend to distill toward “point-to-a-few-points,” with the end sites being distributed. Therefore the operator may likely not see the benefit of a shared PtMP infrastructure since the solution can reduce toward that of PtP, except that the PtMP solution will deliver the penalties of lower capacity and high delay/delay-variability.

–6 – 23 GHz PtP: These common carrier bands are used for high-capacity, carrier-grade and long-range licensed microwave applications. Due to regulations, these frequencies require larger antenna sizes that typically can’t be widely deployed in urban environments and are thus best suited to traffic aggregation applications.

–24 – 38 GHz PtP: In most areas, these line-of-sight frequencies allow for sub-one-foot “mini antennas” for urban-optimized form factors. While generally more costly than unlicensed alternatives (on an absolute, rather than cost per bit basis), operators deploying these solutions for small cell backhaul are looking for scalability from 100 Mbps to over 500 Mbps per link, low-latency performance and carrier-grade licensed operation. Recent network planning studies in tier-one urban centers have shown that, by deploying on light standards and other utility poles, line-of-sight is available in approximately 90% of microcell backhaul links.

–60 GHz PtP: 60 GHz solutions support multi-gigabit capacity over very short distances, making them a strong solution for small cell backhaul. While these systems have a very narrow beamwidth, which minimizes interference, future performance of the link cannot be guaranteed due to the unlicensed spectrum that may be employed by other operators in the same area.

–70/80 GHz PtP: These high-frequency e-band solutions offer slightly better reach than 60 GHz and operate in “lightly-licensed” spectrum ensuring some degree of coordination between operators. The primary drawback of 70/80 GHz systems in small cell networks is the requirement for one-foot (or greater) antenna sizes, which limits the number of urban sites where it can be deployed due to city zoning restrictions.

	Sub-6 GHz	Sub-6 GHz	6-23 GHz	24-43 GHz	60 GHz	70/80 GHz
	Point-to-Multipoint	Point-to-Point				
Capacity (Full Duplex)	50 – 100 Mbps (shared)	50 – 100 Mbps	1 – 2 Gbps	0.5 – 1 Gbps	0.5 – 1 Gbps	1 – 2 Gbps
Mini-Antennas Feasible (Regulatory)	Yes	Yes	No	Yes	Yes	No
Spectrum	Generally Unlicensed but Licensed Options Possible		Licensed	Licensed & Unlicensed	Unlicensed	Licensed ("Light" licensing in most regions)
Spectrum Cost	Moderate to high when licensed, otherwise free.		Low in US	Low in US	Free	Very Low
Line-of-Sight needed[1]	No	No	Yes	Yes	Yes	Yes
Typical Latency	3 to 8 ms (depending on LOS)		50 µs	50 µs	50 µs	10 - 400 µs
Installation cost[1]	Low	Moderate	High	Moderate	Moderate	High

Where does each technology fit?

The technology selection will depend greatly on the type of small cell and the performance requirements of the operator.

Operators looking for a highly reliable, high capacity, low latency microcell underlay to their macrocell network will migrate to urban-optimized licensed solutions in the 24-38 GHz range and perhaps 60 GHz unlicensed where spectrum shortages may be encountered. Ultimately, a variety of different frequency bands may be used to augment this core backhaul strategy, including sub 6-GHz NLoS to connect in the odd, hard to reach site.

Deployments centered on Sub-6 GHz NLoS technology will likely find some application in "Web-offload" applications where lower service performance and availability may be tolerated. In these cases the underlay network is considered more of a "best-effort" implementation, often even relying on unlicensed spectrum for the operation of PtMP systems.

The most likely case is that no single wireless backhaul technology will meet the requirements of every operator and every application. Small cell network backhaul will require a toolkit approach using platforms that provide flexibility in terms of frequency adoption and network topology.

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