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Bridging the Gap in LTE Backhaul: Network Architectures and Business Models

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As many new LTE networks are deployed globally, some mobile users are starting to enjoy higher access speeds and a better overall user experience. Drive testing has demonstrated the capabilities of these networks to deliver up to 100 Mbps per user – at least while there are not many users. While the availability of devices capable of taking advantage of these higher capacity networks has been scarce, and hence the tele-density of LTE users low, operators have generally managed to boost existing backhaul networks to handle the added capacity. However, the number of new LTE-enabled devices coming online is growing at a rapid rate, and the number of LTE subscribers is growing daily. This is expected to drive an 18X increase in mobile data traffic over the next 4 years, even when taking into account the shift away from all you can eat mobile data plans and the introduction of WiFi offload initiatives.

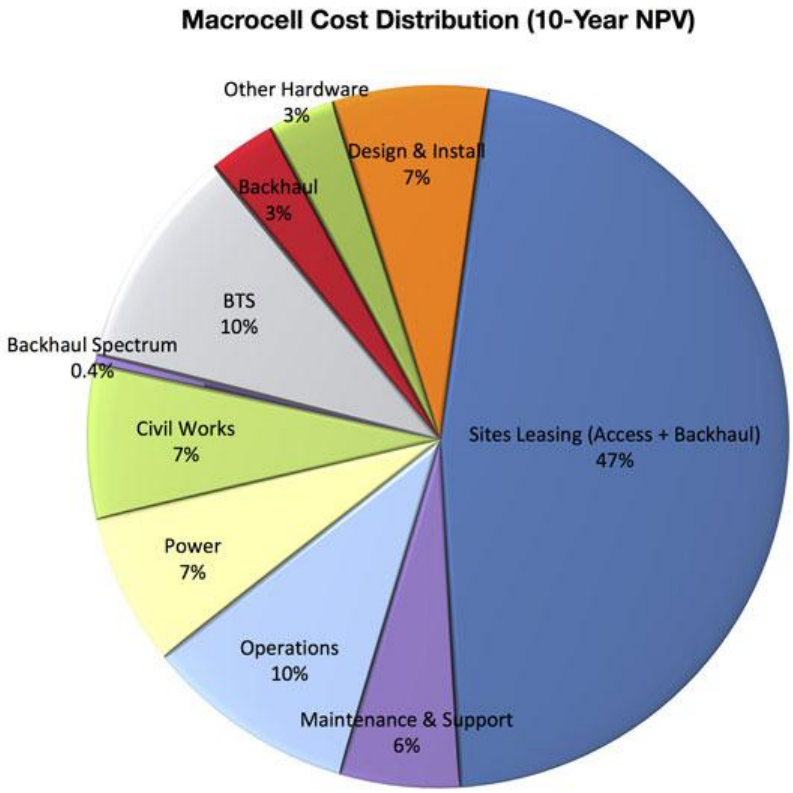
In order to meet this demand, mobile operators need to look at a range of new backhaul technologies to cost-effectively scale their network capacity. Not only does the capacity of the current macro cell network need to be augmented, but small cell architectures will need to be introduced to provide more spatial re-use of the RAN spectrum and reduce the number of users per base station, further complicating the backhaul picture. Continuing to band aid the current infrastructure is no longer an option.

Fiber and microwave are both capable of delivering the required capacity, but at what cost and how rapidly can they be deployed. Bonded copper solutions have not historically been able to provide the bandwidth at the distance required to support LTE. While fiber has almost unlimited bandwidth, the majority of macro cell sites in North America are not connected to fiber. The cost to build the fiber lateral from the existing fiber plant, and the time required to do so, make microwave more attractive in at least half of the cases. This is because the cost to build a fiber lateral depends on what type it is (aerial fiber can be as low as $20/ft, urban trenching can be over $200/ft), and the time to get the right of way also varies dramatically and can be many months if ever in a metro core.

Nonetheless, some operators have a familiarity with a given technology that sways the decision, even when the economics of the alternative are more favorable. The increase in capacity per connection (10-fold in five years), coupled with the ongoing price reduction driven by technology and market forces has resulted in at least an order of magnitude reduction in the cost per bit of either technology. However the cost of the hardware is not the entire story.

When choosing any new technology for a network upgrade it is important to look at the total cost of ownership of the entire network, not any one component. Often we see that focussing on the cost of a single item will result in a higher overall network cost. For example, if you're doing network designs and choose to focus on getting the lowest cost per radio, but end up with a solution that increases the average antenna size and hence increases the tower lease cost, you can dramatically change the answer.

A breakdown of the contributors to the 10 year Total Cost of Ownership (TCO) of an LTE macro cell site using microwave backhaul in the USA is shown below. As you can see, the dominant costs are not in the hardware costs at all, but it is the site leasing and maintenance costs that dominate the TCO. Features in the BTS and Backhaul that can reduce these costs – such as all zero footprint form factors and adaptive modulation to allow smaller antenna sizes which can reduce colocation costs, civil works requirements, tower lease costs and potentially power costs – can result in a significant reduction of the TCO, even if they increase the cost of the hardware.

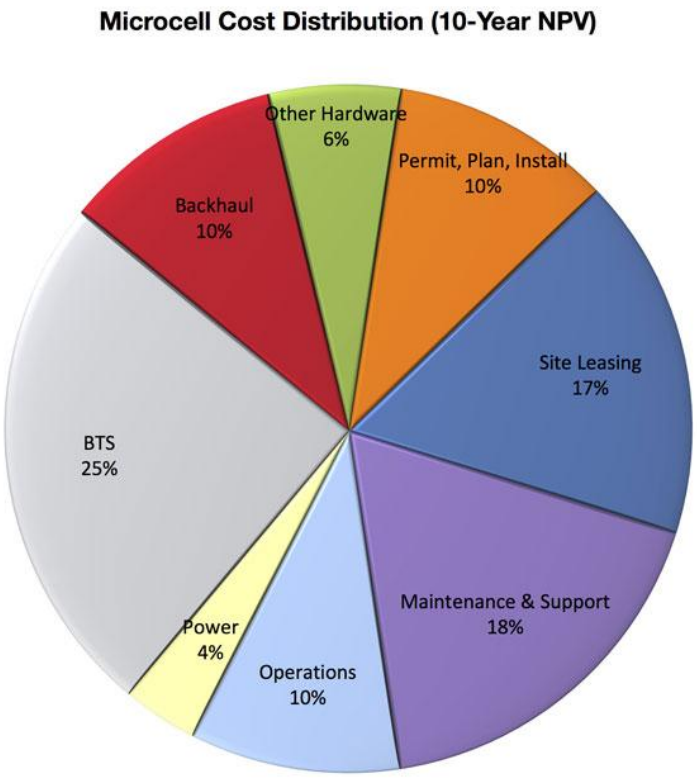


Macro cell capacity growth is not adequate to support the projected mobile data demand. Increased RAN spectrum and higher peak rates can only deliver between 3 to 5 times today's capacity. The only way to achieve the 18X growth required is to introduce more base stations to reduce the number of users per base station, at least in the high tele-density areas such as metro city cores. This, however, significantly changes the total cost of ownership picture. First, the available resources as a starting point are different. Indoor small cells will have access to in-building communications infrastructure. Much more of the effort will go into providing access and demarcation between the enterprise traffic (that normally flows over this infrastructure) with the mobile network traffic, along with providing billing and trouble ticket solutions that work in these environments.

Because of these complications, many carriers will prefer to deploy small cells outdoors on lamp post, light standards or the side of buildings where they can control them and hence control the user experience. Unfortunately, in most of these locations there is no wired infrastructure available for the backhaul at all – resulting in a much higher reliance on wireless backhaul to make the solutions work.

Secondly, the capacity of each small cell is smaller than that of the macro cell site – typically equivalent to a single sector of a macro site. Nonetheless, this still requires capacity on the order of 100 Mbps per small cell for an LTE network and all the other network performance requirements such as latency and reliability remain unchanged.

When we look at the TCO for an outdoor small cell site using wireless backhaul we see the distribution is different than for that of a macro site. The contribution of the CAPEX is higher on a percentage basis (CAPEX increases from 30% of 10-year TCO to 40-50% of 10-year TCO), not because the hardware is more expensive, but because the overall site cost is less than 10% of the macro cell site cost and the solution used is a highly integrated, and has an installation and maintenance cost 85% lower than traditional macrocell sites. Achieving this sort of cost per site ratio is essential in order to deliver an overall lower cost per bit at the network level. The operations cost is still more than 50% of the TCO even in this optimized case and care must be taken when selecting technology solutions to ensure that this cost does not increase beyond this point. Unless this is done correctly, the entire business case can easily become negative.



The future is always uncertain. Because of this, it is important, regardless of what technology is chosen, to select network architectures that can be easily adapted to changes in traffic patterns or increases in network capacity. This is the reason that some carriers prefer to use fiber everywhere, but the cost associated with this is prohibitive. Using ring/mesh architectures with today's packet microwave provides a viable alternative that delivers attractive economics today, and can deliver the flexibility to deal with changes in network demand. The ring structure is inherently resilient to changes in demand patterns, provides a larger community of sites over which statistical multiplexing can be applied, and is easily augmented in capacity by techniques such as ring splitting or XPIC or multi carrier radio upgrades. The ongoing innovations such as compression technology and higher modulation continue to increase the capacity per carrier as well. Charting a path forward is much more than selecting the next new shiny technology box. The metric that must be kept firmly in our sights is the network total cost of ownership. Unfortunately one size does not fit all. A combination of technologies and architectures will be required to deliver the optimum TCO for each situation and application as well as the flexibility to deal with the unknown.

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