No Barriers, No Borders - Breaking the Backhaul Burden For 4G Networks

DragonWave

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As 4G broadband networks begin to be deployed worldwide, there is a growing concern that backhaul will represent an increasing portion of the total life cycle cost of a network. The bandwidth requirements of emerging services are driving a need for much lower cost per bit from the backhaul in order to deliver a positive business case. This paper will discuss the backhaul requirements for such networks and the performance and costs of the alternatives. The comparison will show that high capacity packet microwave Ethernet systems provide the solution to the backhaul burden.

As radio access technologies have evolved, end-user bandwidth demand has grown by a factor of 2000 – as demonstrated in the table below. This explosion in end-user demand has forced the carriers to re-evaluate how they build the backhaul portion of the network. The services enabled by this new technology are important new sources of revenue, however with revenue per bit falling, carriers are forced to achieve lower cost per bit solutions in all areas of the network. Without a proper design, the backhaul becomes a burden that cripples the operator's business case.

Technology		Typical Rate (Mbps)	Increase Factor from 2.0G
2G	**2.0G** - GSM	0.0144	-
	2.5G - GPRS	0.033	2.3X
	2.75G - EDGE	0.118	8.2X
3G	**3.0G** - FOMA - 1xEV-DO Rev A - UTMS	 0.384 0.384 0.384	 27X 27X 27X
	3.5G - HSDPA	2	139X
	3.75G - HSUPA	1.4	97X
4G	**WiMAX** - 1st Generation - MIMO/SOFDM	 13.6 30	 944X 2083X
	LTE	30	2083X

Figure 1: Wireless technology evolution and associated data rates.

The primary options for providing backhaul include licensed point to point, in-band wireless, fiber build and leased lines (*see figure 1*).

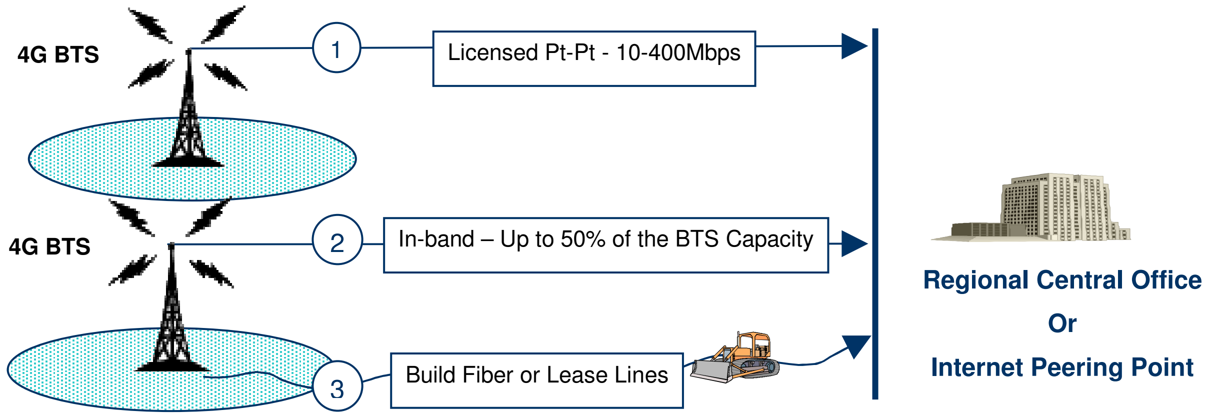

Figure 1: Primary mobile backhaul alternatives.

Initially, while bandwidth per base station is low, it may be possible to use in-band wireless to provide the backhaul. However, the requirement to deliver services to the end-user will quickly drive up the bandwidth needed per base station and that means any spectrum allocated to an in-band backhaul solution will need to be recovered for the radio access network. In the long run, radio access spectrum is generally too valuable to use for backhaul and will be reserved for providing service to the end-user to drive revenues from the network.

T1/E1 leased circuits are a simple option but are not able to scale to the required bandwidth at a cost point which would be competitive. Lease costs in North America are $200 to $400 per T1 per month and $1500 to $3000 per DS3 per month; international lease costs can be 2-5 times this amount. When this is added to the equipment cost required to convert the IP interfaces of the base stations to the TDM format, it becomes clear that for any base station capacity above a few Mbps, T1/E1s are not a viable backhaul solution.

Any provider who chooses one of the above mentioned options will initially have to pay the price of churning their networks while they install the alternatives required to deliver the increased bandwidth. Given that the installation/reconfiguration cost is a significant portion of any deployment (as illustrated later on), it is often more economical to deploy a scalable backhaul solution even if it has a slightly higher initial cost.

Other backhaul solutions that can deliver the required bandwidth are point-to-point microwave and fiber-based Ethernet. The advantage of fiber-based Ethernet is that the capacity is effectively unlimited. The bandwidth that can be sourced by a single base station is strictly limited by the amount of access spectrum available and is typically less than 100 Mbps. Given that the cost to deploy a fiber-based solution is essentially independent of the bandwidth provided, the cost per Mbps can be very high for typical base station requirements. This makes fiber-based solution better suited to the higher capacity aggregation layer, than to the 1st tier of the backhaul network.

Like other backhaul options, microwave solutions have a fixed upfront cost. Some solutions, such as DragonWave's IP-based radios, mitigate this by offering flexible bandwidth pricing which allows operators to "pay as they grow". An added benefit of microwave solutions is that they have simpler installations – eliminating the need for trenching of fiber laterals, reducing the cost and time to deployment. Microwave does not scale to the same bandwidth as fiber-based solutions, but it is quite possible to deliver several hundred Mbps per link using commercially available systems.

The cost per bit versus bandwidth is shown for fiber-based and microwave-based solutions in the graph below (*figure 2*). A 5-year net present value (NPV) calculation has been used to derive an equivalent lease cost for the microwave link. This includes the equipment cost, installation cost, antenna lease and annual maintenance costs. The fiber-based Ethernet is a market value assumption for a leased Ethernet service and includes an amortization of $20,000 per site for the fiber lateral build (i.e. a few hundred feet – longer laterals can increase this build cost significantly).

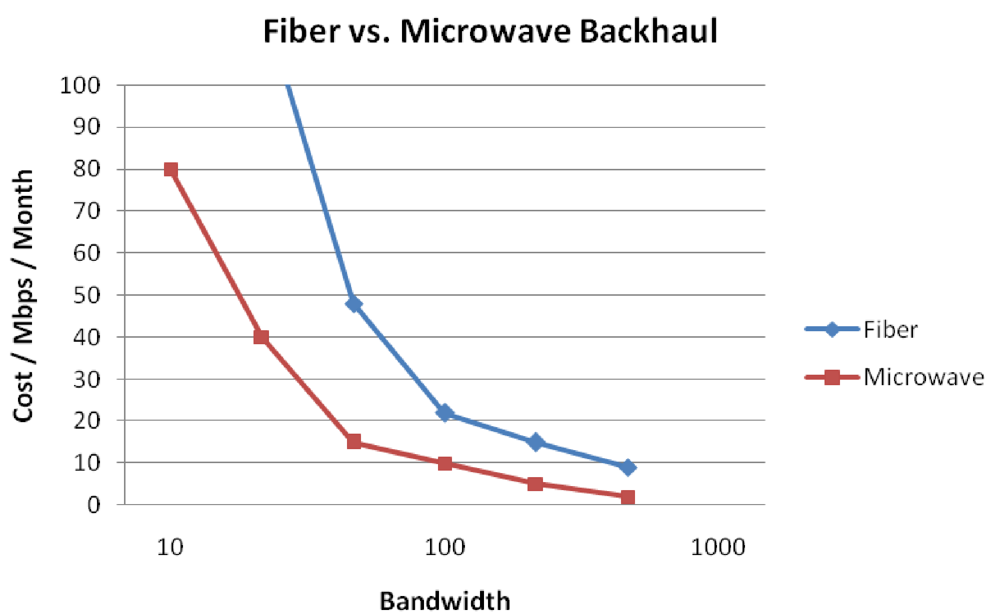

Figure 2: Cost per Mbps per month for fiber and microwave backhaul.

As can be seen, the microwave solution is much more cost effective than the fiber based solution in the 10 to 100 Mbps range typical of a single base station. Both solutions are also significantly less expensive than leased circuits. Based on these cost points, microwave is likely to be the preferred technology used to connect access links to aggregation sites. Interconnection of the aggregation sites will be a combination of microwave and/or fiber, depending on the network size and the availability of fiber based assets.

In order to further optimize the backhaul network we must take a closer look at the lifecycle cost of the microwave installation. There are a number of components that contribute to the OPEX costs of a wireless backhaul network. These are:

- **Monthly Lease Costs –** These fall under two categories:
    - Tower Lease Costs – There is typically a monthly lease cost for each point-to-point antenna on a tower. This cost increases as antenna size increases. In this study, we assume $200, and vary the cost;
    - Indoor Space and Power Costs – A monthly fee for each rack space and power required, which is assumed to be $100 per month.

- **Spectrum License Costs –** In North America, there is one-time license cost that covers 10 years. This cost is typically $2000 including co-ordination services. In other geographies this cost can be 3 to 5 times higher.

- **Maintenance and Management Costs –** Typically assumed to be an annual cost equal to about 10% of CAPEX.

- **Installation Costs –** This is a one-time cost for the microwave link installation, including line of sight survey and site prep. This is assumed to be $7500 per link.

The capital costs associated with a wireless backhaul network are the following:

- **Microwave Equipment –** This includes the electronics, cables, installation material, and antennas. For this study, we are assuming 2 types of links:
    - Access Links - A < 50 Mbps link in 18 or 23 GHz, with small antennas due to the short access link lengths. Assumed cost $12,000 per link (includes 2 ends)
    - Core Links – This is a higher capacity link, assumed to be 300 Mbps for this study, often requiring lower frequencies and larger antennas sizes due to the longer core link length and high modulations. Assumed Cost $20,000 per link (includes 2 ends)

- **Ethernet Switching –** Some level of Ethernet switching is required in the core for aggregation and protection. This is assumed to be at a cost of $2,500 per switch.

Based on the network model shown above and cost assumptions discussed earlier, we can identify the total cost of ownership components of a backhaul network. In this analysis, we will look at a 10-year network cost, including all capital expenditure costs, installation, lease costs, and maintenance costs. This cost breakout is shown in *figure 3*. As illustrated, only 12% of the total network cost is CAPEX, and 66% of the network cost is from site and antenna lease costs.

10-Year Cost of Ownership Components

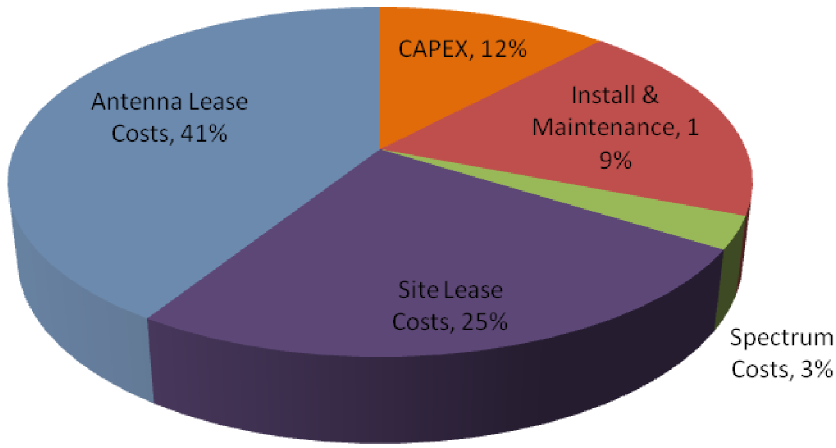

Figure 3: The total cost of ownership for microwave backhaul.

It becomes clear that in order to reduce the network cost, addressing equipment expenditures will only have a small total effect. To get a significant total cost improvement, the antenna and site leasing costs (OPEX) must be considered. This is easier said than done – growing demand for wireless deployments, lease costs are rising rather than dropping. It follows then that the only way to reduce this cost is to reduce the amount of leases that are required. There are two primary areas of importance in accomplishing this goal:

- **Antenna Leases:**
  - Reduce antenna size: This will typically cut antenna lease costs in half. Antenna sizes can be minimized, while maintaining availability, by using high power systems or by employing adaptive modulation, which can maintain connectivity during rain fade events, only at reduced capacity. These two factors can be used in conjunction to drastically decrease antenna size requirements.
  - Integrate RAN antenna panels with backhaul antennas – often an antenna extension can be utilized to eliminate separate antenna leasing costs for the RAN and backhaul.

- **Site Leases:**
  - Outdoor microwave equipment: Using all outdoor microwave systems eliminates the requirement for any indoor equipment.
  - Outdoor switch housings: Outdoor switch housings eliminate the need for any indoor rack space at all sites.

The network cost effect from reducing antenna lease and site lease requirements is examined in a sensitivity analysis (*figure 4*). As shown below, reducing antenna sizes and integrating RAN antennas with backhaul antennas, results in network cost reductions of 35%. Further savings are achieved by deploying all-outdoor microwave backhaul system (20%

savings) and outside switches (5% savings). In total, this provides a 60% reduction, compared to current network costs. By comparison, even if the CAPEX was reduced to 0, there would only be a 12% decrease in network cost.

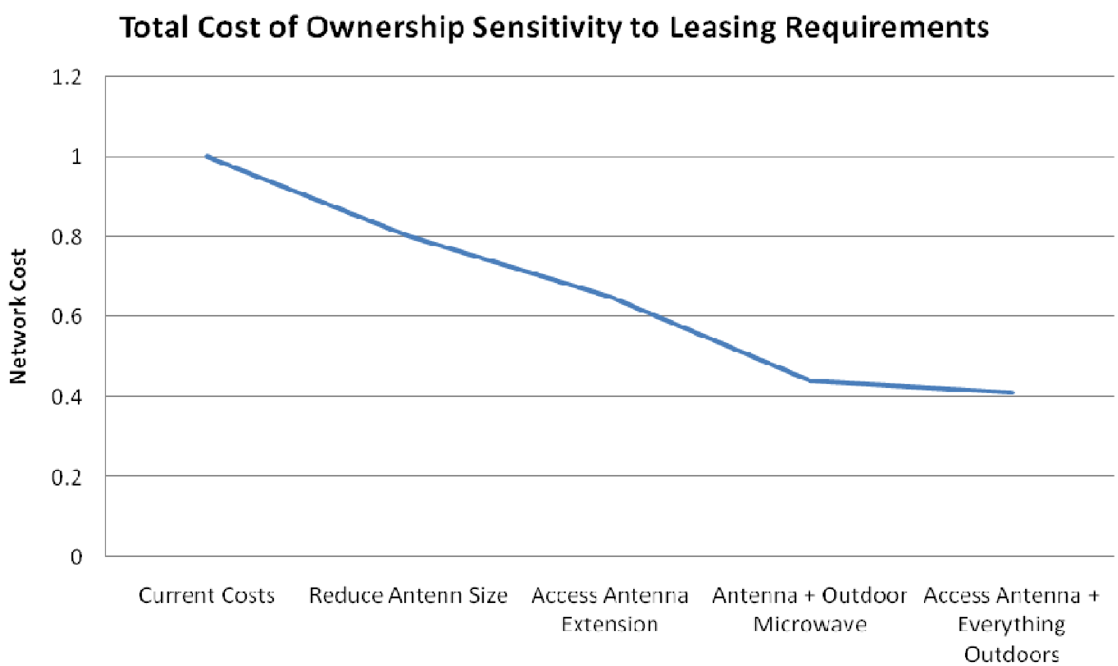

Figure 4: TCO sensitivity chart illustrating the impact of different deployment options.

Additional opportunities for savings, beyond those previously identified, can be achieved by targeting key pain points highlighted in the TCO analysis. While slightly more difficult to quantify, these three points should be examined by any operator looking to deploy a wireless backhaul network:

- Consolidate backhaul installation with access (e.g. WiMax) base station installation – reuse the installation and tower climbing resources from the access network (e.g. WiMax), to drastically reduce the backhaul installation costs.

- Consolidate backhaul and access network management and maintenance – consolidating the management and maintenance of the backhaul and access networks (e.g. WiMax), can reduce this large portion of the total network cost

- Design rings with antenna size in mind – use rings to extend reach of the fiber PoP and minimize the antenna sizes required.

There is clearly considerable scope for reducing the burden of the backhaul network on the overall business case. By selecting the appropriate backhaul technology for each situation and by paying attention to the overall lifecycle cost – rather than simply the capital cost of the equipment – it is possible to deliver services at significantly lower cost per bit than what can be achieved in today's networks. This enables an evolution from a voice-centric mobile network to one that delivers truly mobile personal broadband.

DragonWave provides a complete line of high capacity, packet microwave solutions which meet the needs of the new network realities. With Horizon Compact, DragonWave offers a zero footprint solution that integrates the IDU and ODU functionality of a conventional radio into a single high performance all-outdoor unit. This single unit delivers up to 800 Mbps per link with no requirement for indoor space or power at a price that is typically 25% lower than conventional radios. The Horizon Compact solution further reduce the operation costs with simplified troubleshooting, reduced cabling costs, higher MTBF and built-in link aggregation and protection switching. The small form factor of the DragonWave product line enables integration of the backhaul antennas with the RAN antennas to further reduce the lifecycle cost. Further scalability for network cores can be achieved with the Horizon Duo product line delivering up to 1.6 Gbps. The entire line of DragonWave licensed Ethernet radios and pseudowire solutions are described at www.dragonwaveinc.com.

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