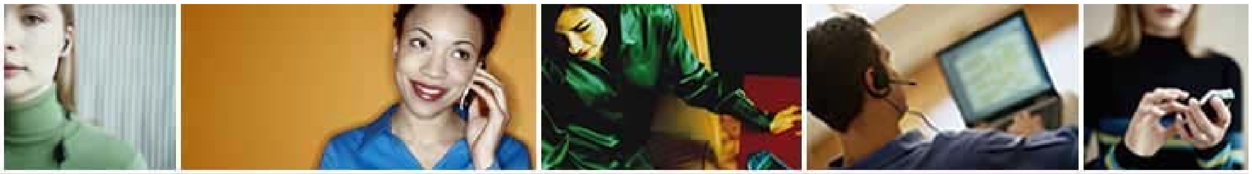
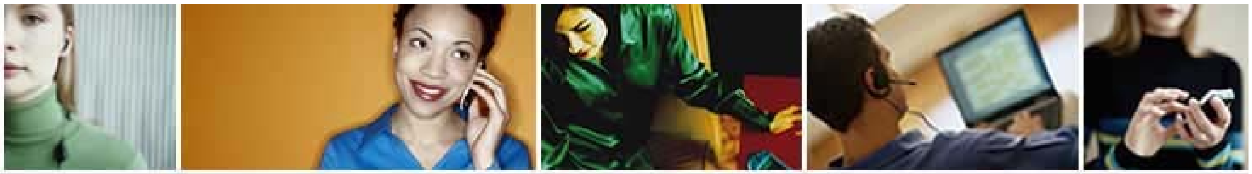


Understanding the Total Cost of Ownership of Wireless Backhaul: Making the Right Choice at the Right Time

DWI-APP-190



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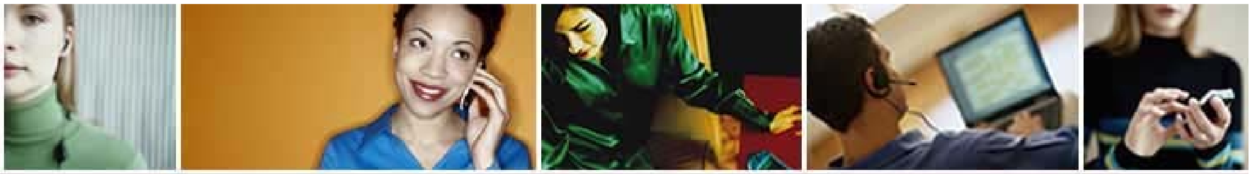
This paper focuses on the costs associated with wireless backhaul and argues that albeit being more economical than copper and fiber, wireless backhaul is nonetheless posed with certain technical and logistical challenges that are capable of adversely impacting returns on backhaul expenditures and diminishing its profitability prospects. The paper examines a breakout of the backhaul Total Cost of Ownership (TCO) based on a ten-year network model and outlines opportunities for significant cost reductions that will help operators turn backhaul revenue into profit. The current paper is followed by a sequel which discusses a combination of specific design strategies, as they are exemplified in the DragonWave's Horizon line of product, that need to be implemented in order to achieve the profitability of wireless backhaul.

1.1 Introduction

The rapid growth of wireless broadband networks has placed significant strain on the Capital Expenditures (CAPEX) and Operational Expenditures (OPEX) of mobile operators and service providers worldwide. The long-term goal of most operators is to deliver to end-users a flexible mix of basic and advanced communications services, e.g. high-speed mobile data, video, multimedia messaging, and enhanced location-based services, without incurring profitability set backs. While these new services open new channels for revenue streams, they also create new challenges.

To support seamless convergence of legacy voice traffic with mixed voice-and-data traffic along with new demands for bandwidth, operators need highly scalable network resources. This problem is particularly pressing at the backhaul portion of the network, as adding data services to a voice-centric existing network requires much more backhaul bandwidth. It is apparent that the massive increases in mobile data traffic enabled by 3G and 4G technologies, including WiMAX and LTE, cannot be fully realized without a corresponding increase in the backhaul transport capacity.

Backhaul is the part of the network that connects the cell sites to the core fiber network and often includes tower-to-tower communications, i.e. the cellular base station at the edge, the base station controller or radio network controller, and all other Layer 1-3 transport, aggregation, and switching elements in the access and metro networks, excluding the core switching network.



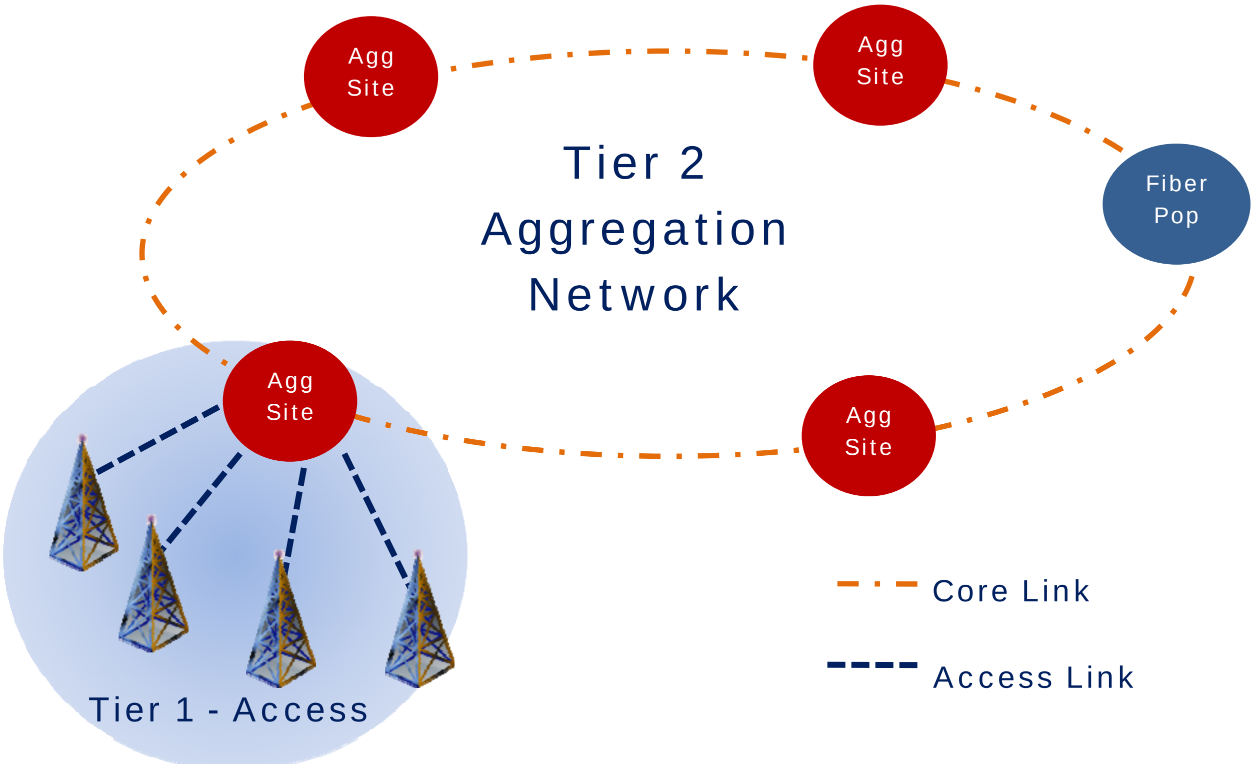
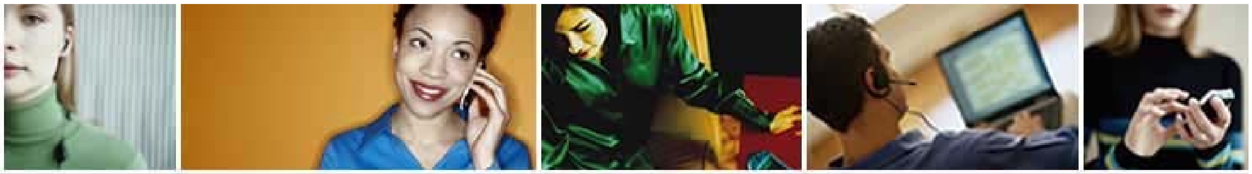


Figure 1 - Typical 2-Tier Backhaul Architectures

Being the core enabler of 3G and emerging next generation 4G technologies, including WiMAX and LTE, high capacity wireless backhaul has become the biggest cost challenge facing wireless service providers today, taking up the largest portion of the total network lifecycle costs. It is easy to see how in the ad-hoc evolving infrastructure with non-linear growth pattern, without a proper planning and proper design, the backhaul quickly becomes a burden that cripples the business case.

Operators have been employing various strategies in an effort to reduce backhaul costs rapidly enough so as to allow the current rate of high-speed traffic growth to continue without jeopardizing either the user experience or the profitability of the business.

In the past the efforts to reduce the wireless backhaul cost per bit have primarily focused on reducing CAPEX, by offering higher capacities for lower costs. While reducing CAPEX in this manner is undoubtedly an important effort, it is no longer sufficient. In the recent years, the telecommunications industry has experienced a distinct trend of increasing labor and spectrum costs. On the other hand, innovations in hardware design resulted in lower costs of manufacturing equipment. These developments have combined to make CAPEX a much decreased portion of the backhaul Total Cost of Ownership (TCO). The OPEX costs now consume a vastly larger portion of the backhaul TCO than CAPEX, accounting for almost 90% of all costs in the



course of 10 years. In this paper, we propose that the only way for operators to achieve significant cost reductions in backhaul is to address the increasing OPEX costs.

For the purposes of this paper we assume that the TCO of backhaul is independent from the type of deployment, i.e. the backhaul TCO model would be equally applicable to evolving legacy deployments experiencing high traffic growth and undergoing expansion as well as to new green-field deployments planning on offering high capacity mobile broadband services.

1.2 Analyzing Various Backhaul Strategies

In order to meet the bandwidth and service requirements of high-capacity wireless backhaul there have been three primary technology options: copper, fiber, and licensed wireless (microwave).

The problem with the traditional copper infrastructure is that it was not designed to support broadband usage of 3G and emerging 4G technologies, including WiMAX and LTE, and does not scale easily to provide adequate bandwidth. The majority of existing connections to the base stations are made over T1 and E1 copper circuits, many of which are leased from third parties and require recurrent monthly payments. Adding more T1 and E1 circuits to thousands of sites increases long-term leasing costs dramatically. In addition, monthly costs scale up directly with bandwidth requirements, getting more expensive as traffic grows and bandwidth demands increase. These increasing monthly recurring charges are making it cost prohibitive for operators to deploy 3G and emerging 4G services. Furthermore, apart from cost considerations, there are also service level considerations. The majority of existing leased copper lines are TDM based; they cannot contest the bandwidth and corresponding service-level requirements of Ethernet-based lines. For example, video requires more real time bandwidth than e-mail, which uses less bandwidth and can be queued without degrading the quality of the service.

The increased user requirements for new services of higher bandwidth along with the necessity to maintain economies of scale (i.e. lower the cost per bit of carrying data) are forcing operators to adopt packet technology and transition to an all-IP infrastructure in the backhaul. Thus, transition to an all-IP backhaul has become yet another challenge operators need to overcome in order to scale their existing T1/E1 networks to be able to support new user demands.

Fiber-based Ethernet networks can provide more than sufficient bandwidth to support rapidly growing bandwidth demands but they have prohibitively high initial deployment costs and take a long time to deploy, requiring fiber connections to be laid to the edges of the mobile network. The payback on fiber installations can only be expected in the long term, making it impossible for operators to achieve lower costs per bit and attain significant profits in the foreseeable future.

Unlike fiber, wireless backhaul has the benefit of being rapidly deployable while also being capable of delivering high bandwidth, carrier-grade Ethernet and TDM services. It is also much more cost effective. According to our previous estimates in the "Costly Access: Wireless Backhaul for Business", the payback period of the wireless lines is 5 months at 50 Mbps versus leased lines that require never-ending recurring monthly payments, and it improves to less than a month for capacities above 350 Mbps. Against fiber, wireless proves in for all capacities across the entire 10-year period up until 1.3 gigabits per second (Gbps). At this point, fiber starts to have a 10-year payback period improving to 3-year payback period at 2 Gbps, assuming a 5-kilometer link. At shorter distances fiber would start to prove in at lower capacities. Conversely, if the distance increases, the fiber prove-in point would move out further.

Another way to look at this is to compare the cost per bit versus bandwidth as shown for fiber-based and microwave-based solutions in Figure 1. 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). Note that the cost per bit versus bandwidth for lease lines would remain constant at approximately $200-400 per month per T1/E1.

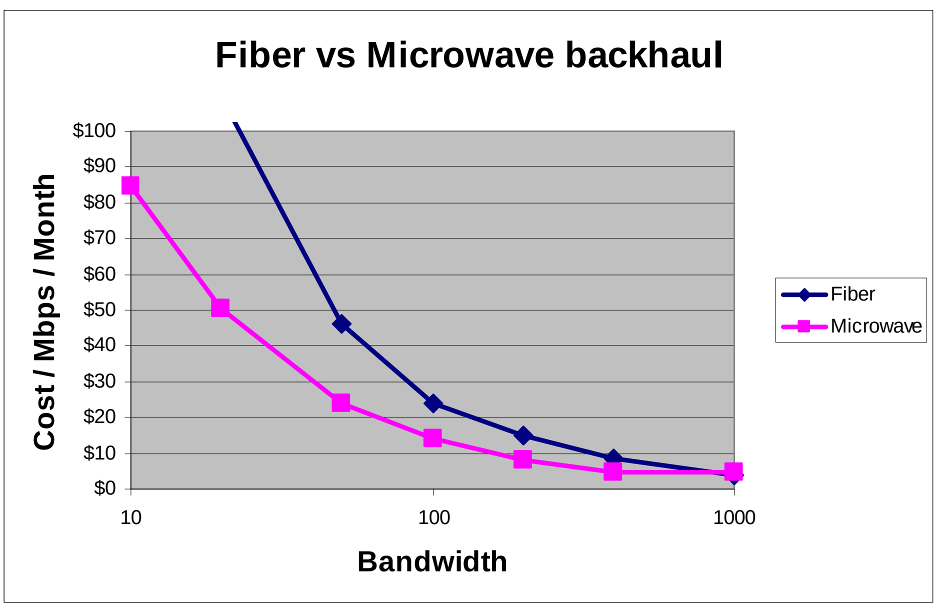
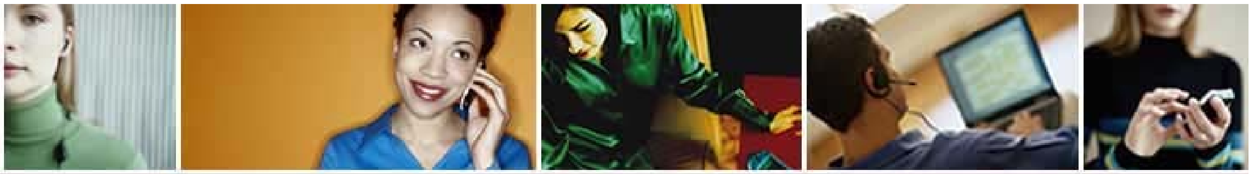


Figure 2 – Fiber versus Microwave Backhaul



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 much lower than the leased circuit prices, as the rapidly increasing capacities required for 4G backhaul leased lines are becoming increasingly cost prohibitive. Hence microwave is the technology best used to connect the access links to the aggregation sites. Interconnection of the aggregation sites is best to be a combination of microwave and/or fiber, depending on the network size and the availability of fiber-based assets.

The microwave solutions also have simpler installations, eliminating the need for trenching of fiber laterals, reducing the cost and time to deployment. The microwave solutions do not scale to the same bandwidth as fiber-based solutions, but it is nonetheless quite possible to deliver several hundred Mbps per link using commercially available systems. Moreover, the capacities are not yet high enough to justify fiber deployments (as capacity is aggregated and gets well above a gigabit, fiber will have a role at aggregation sites, especially for shorter distances).

In other words, wireless backhaul is indisputably the most convenient and economical backhaul option. However, as economical as wireless backhaul is compared to leased copper and fiber lines, it may still not be a viable solution to sustain profitability in the long term. In fact, without a proper design and planning, wireless backhaul does not make a positive business case. As it has been repeatedly discussed by industry analysts, despite the 15-25% increase on backhaul expenditures undertaken by carriers in the last three years, their Average Revenue per User (ARPU) across the total customer base has continued to decline. In other words, if backhaul costs are not restrained as more and more capacity is added to accommodate increasing traffic demands, the profit margins of cellular carriers are going to deteriorate further and further.

There are many challenges with wireless backhaul, with spectrum and antenna limitations being the two most significant. There are also construction, installation, logistics and management issues which may not be immediately apparent but which delay network deployment and increase backhaul costs considerably.

In the sequel to this paper, we will demonstrate that by deploying ring/mesh network architecture, reducing antenna size and maximizing spectral efficiency via advanced modulation techniques as well as utilizing integrated antenna approach it is possible reduce the backhaul burden on the TCO by as much as 60%. We will also demonstrate that software-controlled scalability and flexible bandwidth pricing help decrease the backhaul costs even further. But before we can discuss the specifics of how to implement a cost-effective and scalable backhaul architecture that can optimally carry all services, it is necessary to gain understanding of the quantitative relationships between the various components of the overall TCO, and so in this paper we will focus on the backhaul TCO.

1.3 Calculating Backhaul TCO

The TCO is normally calculated by summing up Operational Expenditures (OPEX) costs and Capital Expenditures (CAPEX) costs. Typical OPEX costs associated with a wireless backhaul network include spectrum lease, site lease, installation, and maintenance and management costs. In addition, cost of money should also be included in the analysis. Typical CAPEX costs include microwave equipment and Ethernet switching equipment costs. Let us examine each of these components individually.

1.3.1 OPEX Costs

As stated in the introduction, we estimate that the OPEX costs have now become a vastly larger part of the backhaul TCO than CAPEX, consuming close to 90% of all costs. Let us illustrate this in details.

It is important to note that although the breakout costs do differ by geographical region, with the exception of the spectrum lease costs, which vary greatly in North America and Europe, these differences can be neglected for the purposes of a high-level analysis.

1.3.1.1.1 Spectrum Lease Costs

The lease costs of spectrum licenses vary greatly by geographical regions. In North America, the spectrum license costs are not prohibitive. There is a one-time fee that covers 10 years. This cost is typically around $3,000.00 including coordination services. In Europe, the spectrum license costs are much higher. They can be as high as $30,000 for 10 years.

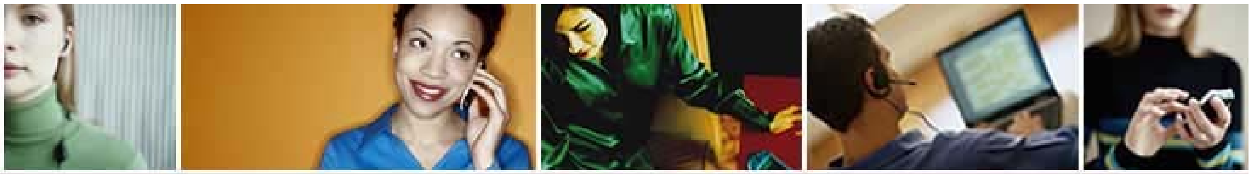
- North America – a one-time fee of $3,000 covering 10 years
- Western Europe – a one-time fee of EUR 1926 per year, adding up to EUR 19258 for 10 years (~ $30,000)

1.3.1.1.2 Site Lease Costs

In a typical network, the site leased costs are typically broken into two groups: tower lease costs and indoor space and power costs.

1.3.1.1.2.1 Tower Lease Costs

There is a monthly lease cost for each point-to-point antenna on a tower. This cost is in direct relation to the antenna size and increases when larger antennas are used. For our purposes, we assume the tower lease costs are approximately $200-400 per month



for a typical one-foot antenna in North America and the equivalent of that in Western Europe. The larger the antenna the higher the monthly lease costs.

1.3.1.1.2.2 Indoor Space and Power Costs

There is usually a monthly fee for each rack space and a charge for power consumption. At present we assume this to be $100 per month in North America and the equivalent of that in Western Europe. If power costs are to increase significantly, which is highly likely scenario given the global fossil fuel conundrum, this would add an additional burden to the site lease costs.

1.3.1.1.3 Installation Costs

For microwave link installation, including line of sight survey and the site preparation, is approximately $7,500 per link in North America and the equivalent of that in Western Europe

1.3.1.1.4 Maintenance and Management Costs

The maintenance and management costs are more difficult to calculate, but these costs are typically assumed to be an annual expense equal to 10% of CAPEX, in both North American and Western Europe.

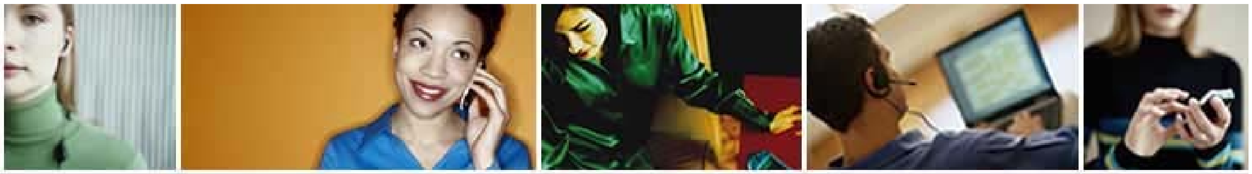
1.3.1.1.5 Money Costs

Net Present Value (NPV) is a way of comparing the value of money now with the value of money in the future. A dollar today is worth more than a dollar in the future, because inflation erodes the buying power of the future money, while money available today can be invested and grow. A cost of money of 10% per year is used for the total cost of ownership calculations below.

1.3.2 CAPEX Costs

As a rule, carriers tend to be concerned about the CAPEX expenses more than OPEX or the overall TCO. While this is understandable, because CAPEX is usually a relatively large upfront cost, it nonetheless no longer plays a significant role in the overall life cycle costs of the network when considered in the long term.

As we mentioned earlier, typical CAPEX costs include microwave equipment costs and Ethernet switching equipment.



1.3.2.1 Microwave Equipment

The microwave equipment costs include the electronics, cables, installation materials, and antennas. For our purposes, let us assume two types of links: access links and core links.

1.3.2.1.1 Access Links

A < 50 Mbps link in 18 or 23 GHz with small antennas due to the short access link lengths. Assumed cost is $12,000.00 per link, which includes two ends, in North America and the equivalent of that in Western Europe.

1.3.2.1.2 Core Links

Core links are higher capacity links, for this paper assumed to be 300 Mbps, often requiring lower frequencies and larger antennas sizes due to the longer core link length and high modulations. Assumed cost is $20,000.00 per link, which includes two ends, in North America and the equivalent of that in Western Europe.

1.3.2.1.3 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 $2,500.00 per switch in North American and the equivalent of that in Western Europe.

1.3.3 Additional Considerations

In addition to clearly identifiable CAPEX and OPEX costs, there are also factors which are difficult to quantify individually but which influence the complexity of building or expanding a network and add burden to the overall TCO. For example, consider such factors as congestion in cabinet application and impact of zoning or leasing permission delays or changes. Operators are often pressed with finding rack space for new equipment and sometimes installation of a small box might require a build of a new cabinet. In cases where a new cabinet becomes necessary, this will add additional $10,000.

There may also be delays or changes in zoning regulations as well as leasing terms. They too would adversely affect and significantly delay network deployment, which may result in substantial customer base losses for operators. In other cases, it may be necessary to erect a new tower, which costs roughly $80,000 to construct and takes several months to get it done. Or else there may also be a need to re-engineer the existing link to beam to a different location. Both construction problems and impact of zoning or leasing delays may happen multiple times in the course of a network expansion or creation. Needless to say, these factors will create considerable deployment delays and add additional costs to the TCO.

1.3.4 10-Year TCO Model

For this model, let us assume a 2-tier network model with 4-link aggregation ring architecture. The access portion of the network is a hub-and-spoke, unprotected architecture. We are assuming one-foot antenna (30 cm) and bandwidth requirement of 25 Mbps CIR and 50 Mbps PIR. There are a total of 12 access links, filling the 300 Mbps network core. The assumed network architecture is shown in Figure 3 below:

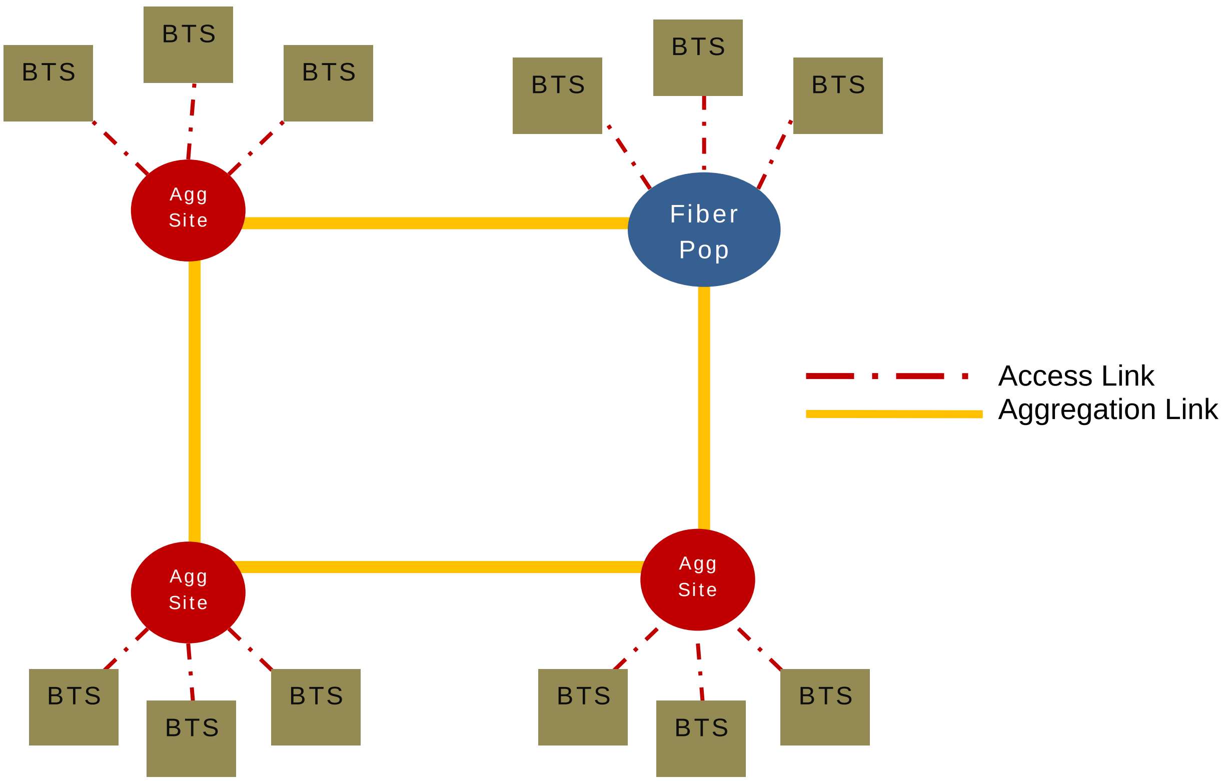
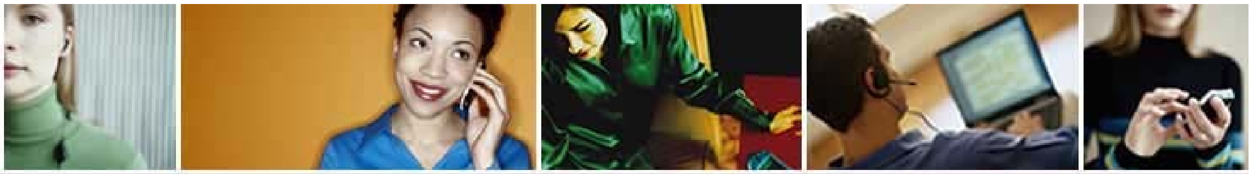


Figure 3 – Model Network Architecture

Based on the network model shown in Figure 2 and cost assumptions discussed earlier, we can construct a TCO. For this model, we will look at a 10-year network cost including all CAPEX and OPEX costs. The cost breakout for North America and Western Europe is shown in Figure 3 below. When all costs have been factored in, it becomes evident that only 10-12% of the total network cost is CAPEX whereas 50-66% of the network cost comes from site and antenna lease costs, which are both part of OPEX.



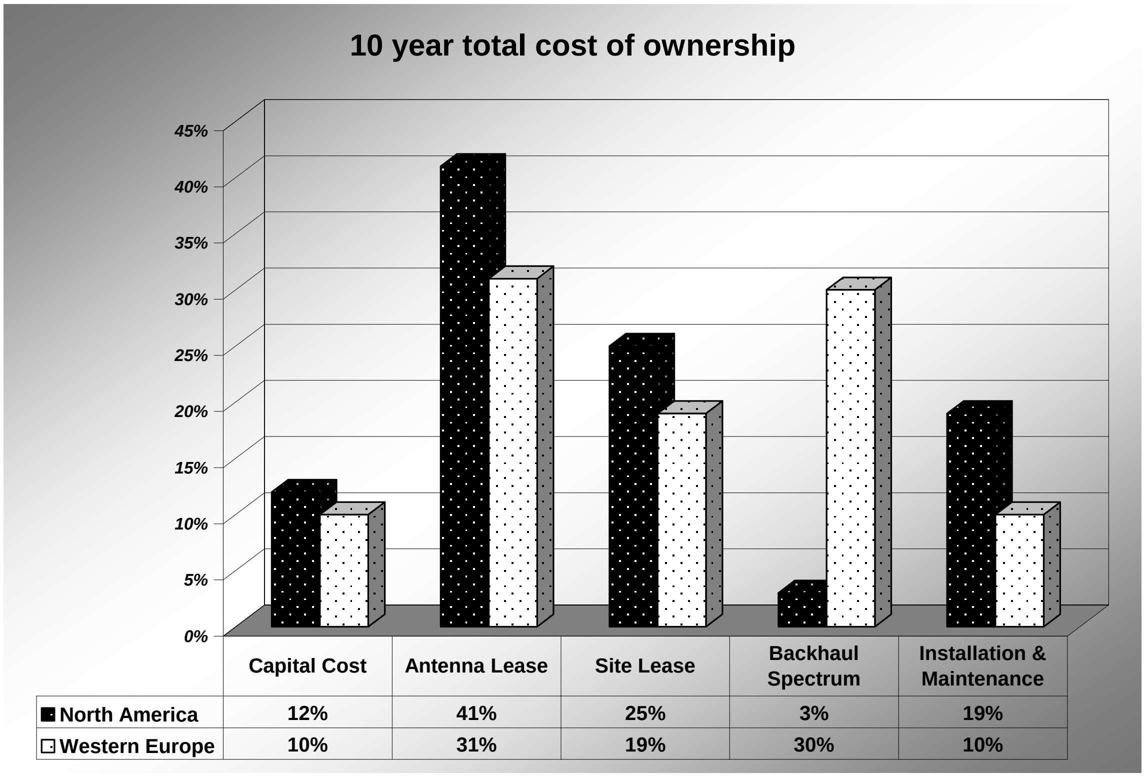
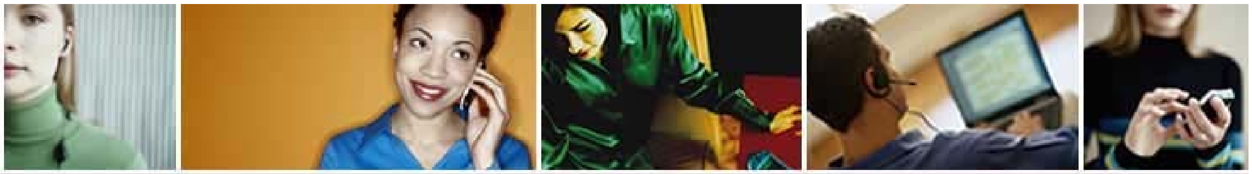


Figure 4 – 10 Year Cost of Ownership Components in North America and Western Europe

It becomes very clear that if we want to reduce the overall network cost addressing equipment cost will only have a small total effect. To get a significant total cost improvement, the antenna and site leasing costs need to be addressed.



1.4 Conclusion

Rapidly growing user demands for increasing variety of services and corresponding increase in bandwidth, *ad hoc* evolving network infrastructure coupled with fierce competition and increased costs per bit force carriers to re-evaluate their backhaul strategies. When planning a network expansion or a new build it is important to analyze all aspects of the network cost in detail rather than focusing on the popular, but diminishing importance of the CAPEX number that takes up only a small part of the TCO (12%). To turn backhaul revenue into profits the network costs need to be addressed as a whole with the focus on reducing monthly antenna/tower and site leasing costs.

In the next paper, we will discuss a set of specific design strategies and techniques that help reduce the TCO of wireless backhaul by a very large margin. We will demonstrate that by deploying mesh/ring network architecture, reducing antenna sizes and achieving maximizing spectral efficiency via advanced modulation techniques it is possible to reduce the backhaul burden on the TCO by as much as 60%. We will also demonstrate that integrated antenna solutions as well as flexible bandwidth pricing help decrease the backhaul costs even further. We will exemplify how these and other techniques have been implemented in the DragonWave Horizon Line of products, paving the way to profitability for cellular carriers and network operators.

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