Rethinking Small Cell Backhaul

A Business Case Analysis of Cost-Effective Small Cell Backhaul Network Solutions

The Wireless 20/20 WiROI™ Wireless Business Case Analysis Tool enables mobile network operators to analyze the commercial and financial trade-offs between Point-to-Point Backhaul and Point-to-MultiPoint Backhaul Solutions.

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Wireless 20|20

Executive Summary

The exponential growth of data traffic is forcing operators to evaluate mid- to long-term migration strategies to LTE while in need of short-term strategies to relieve their congested macro networks. Because of the rapid increase in traffic, cell sites in urban environments are reaching their capacity quickly. Next-generation small cells are being promoted by both service providers and equipment vendors, as the most economic way of creating a denser cell grid with increased capacity.

This change in network topology puts great emphasis on the Total Cost of Ownership (TCO) of small cell networks. In order to achieve a successful business case, TCO has to be minimized. One of the most critical elements to gaining a positive Return on Investment (ROI) for a small cell networks is the cost of the backhaul network, which includes the equipment and installation costs, as well as the recurring monthly costs. Current macrocell network backhaul solutions, such as leased-line, fiber, or Point-to-Point (PTP) wireless solutions, may not be available for each small cell or do not scale well with this increased number of endpoints, thus making it challenging for operators to demonstrate a positive ROI in a small cell business case. A new generation of backhaul solutions is needed to make small cell networks economically successful.

Next-Generation Point-to-MultiPoint Non-Line-of-Sight Backhaul for Small Cells Can Provide **TCO Savings up to 59%** Compared to Traditional Point-to-Point Line-of-Sight Backhaul

Several companies are realizing this opportunity and are developing next-generation Point-to-MultiPoint solutions that utilize licensed Broadband Wireless Access (BWA) frequencies in the sub-6 GHz range. This would enable an operator to economically support the backhaul needs of a high-capacity small cell network with the flexibility of a Non-Line-of-Sight (NLOS), Self-Organizing Network (SON) solution.

This white paper presents a business case analysis of an LTE operator deploying a small cell network using a traditional PTP microwave solution versus a next-generation PMP NLOS solution. The analysis was prepared using the award-winning WiROI™ Wireless Business Case Analysis Tool. The WiROI™ Tool uses scenario-simulation to pinpoint the circumstances under which the optimal TCO can be achieved.

The backhaul TCO analysis concluded that using a PMP NLOS solution generates TCO savings of up to 59% in comparison with PTP, especially in a dense urban deployment scenario. The PMP NLOS solution takes advantage of its ability to leverage gains from traffic aggregation and by allowing an operator to buy, install, and operate less equipment. The PMP hub and remote configuration allow for multiple small cells to be supported by one hub. It should be noted, as the radius of the small cell network is reduced due to higher capacity demand which results in a denser network, the cost benefit of a PMP NLOS solution is accentuated even more. In addition, the inherent flexibility of the NLOS backhaul solution which requires minimal RF planning while allowing for the co-location of the remote within the small cell, makes the expansion of the network faster and more flexible. A PMP NLOS solution can realize 250 Mbps of throughput that can support 6-8 small cells. Future generations of PMP NLOS backhaul solutions will be capable of doubling and tripling that capacity.

Considering these positive financial returns, operators should plan to take action now. The use of a licensed spectrum is key to a cost-effective, carrier-grade PMP NLOS solution. Operators will have to either re-purpose, re-farm or acquire a sub-6 GHz TDD spectrum to support this type of network topology, and should do so now to not risk being left without access to viable spectrum when the time comes to deploy a small cell network.

For information on the WiROI™ Wireless Business Case Analysis Tool, visit www.wireless2020.com.

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INTRODUCTION

The data usage explosion that is facing today's 3G and 4G operators is putting a focus on the backhaul solutions these operators are using and the impact these solutions have on an operator's Total Cost of Ownership (TCO). One of the key technologies being considered by 3G and 4G operators is to deploy small cell base stations. These compact base stations cost less than their macrocell counterparts and can be placed more accurately within locations where there are traffic densities beyond the capacity of a macrocell network. In addition, their compact size lowers the cost of monthly rental and support for each base station. Since there are many more cell sites in a small cell network configuration, the operational expenses of the network become vital to the success of an operator's small cell network business case.

For this white paper, the award-winning WiROI™ Wireless Business Case Analysis Tool was used to derive a TCO financial model by comparing the CapEx and OpEx of a traditional Point-to-Point (PTP) microwave solution to a next-generation Point-to-MultiPoint Non-Line-of-Sight (PMP NLOS) backhaul solution.

PTP VERSUS PMP NLOS BACKHAUL SOLUTIONS

The growing high-traffic density of an urban deployment would quickly require an operator to deploy capacity cells beyond its initial coverage network. Cell size would be reduced to less than a 500 m radius very quickly. By deploying a small cell network from the beginning, CapEx can be allocated more efficiently. Another possibility is to deploy a macrocell network initially for coverage and then supplement the capacity needs of the network by deploying small cells. This combination approach is referred to as HetNets. In either case, the total number of base stations in the network is greatly increased.

One of the most important elements of network costs is the backhaul connection to each cell site. In a macrocell network, this is accomplished either over a wired backhaul or a wireless backhaul network. Most cell sites have some kind of wired connection available, even high-capacity fiber in many cases.

Alternatively, PTP wireless links are used. This study assumes the usage of traditional carrier-grade, all-IP high-capacity PTP microwave using the licensed >6 GHz band. These types of microwave solutions are the most prevalent platforms used by mobile, as well as wireless broadband operators, today. In addition, because of the LOS characteristic of most PTP solutions, the WiROI™ Tool takes into account that 20-50% of the connections will need an additional hop to complete the link.

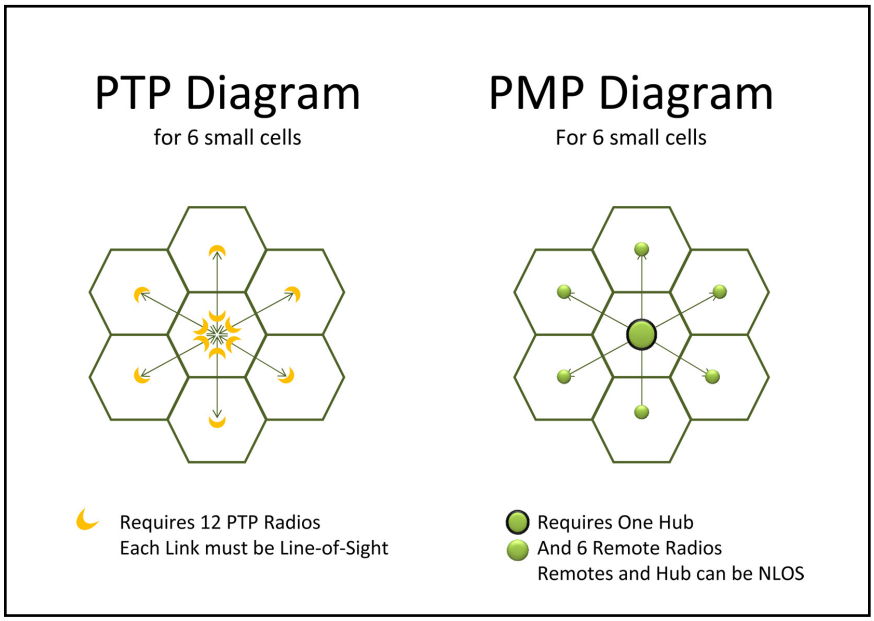


***Figure 1**. PTP and PMP NLOS Backhaul Configurations*

Wired backhaul networks typically require a monthly rental of the wired line that can raise OpEx costs over the course of a network's life-cycle. In the case of a wireless backhaul network, OpEx costs are lower, but a larger initial investment is required to purchase the microwave radios and integrate them into the network. With a typical price of $6,000- $15,000 per PTP link, this can be a significant cost to the network build out. As an operator moves toward the deployment of small cells, the PTP link price for each small cell becomes overwhelming to the business case.

An alternative is a new generation of small cell backhaul solutions that deploy a PMP NLOS backhaul solution. This provides a rapid, cost-effective deployment of a high-capacity backhaul. This new topology is based on a hub and remote concept. A single backhaul hub is located at a high-capacity fiber connection which supports 6-8 small cells with a small remote located at each small cell. The hub and remotes operate NLOS allowing operators great flexibility in placing the small cell at an ideal location. This results in a greater reduction in both the CapEx and OpEx for an operator. In order to do this most efficiently, it is critical to examine carefully how PMP NLOS backhaul links can be incorporated into the network design configuration to optimize the economics of small cell deployments. Designed for high-capacity links, these next-generation backhaul solutions support the growing demands of 3G and 4G networks.

ANSWERING THE CRITICAL QUESTIONS

Wireless 20/20 has developed a comprehensive business case methodology to look beyond the small cell headlines into an economic analysis that will aid an operator in the decision process. The process begins by asking these critical questions that most operators would like to have answered before making a decision to invest time and money deploying a small cell network:

1. What impact and challenges does a small cell deployment have on the overall business case for an operator?
2. Comparing traditional PTP versus next generation PMP NLOS solutions:
   a. Which one is the most cost-effective backhaul technology?
   b. Can a PMP NLOS solution be used for a carrier grade deployment?
   c. How much capacity can be supported by a PMP NLOS system?
   d. How much and which frequencies are used by PMP NLOS?
3. Outside the financial benefits what other tangible benefits does a PMP NLOS have?

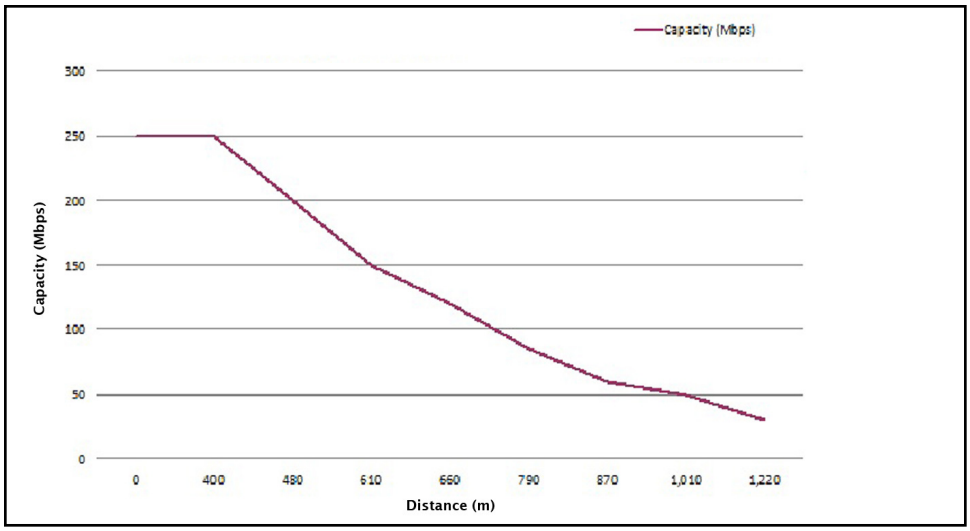
METHODOLOGY SUMMARY

Wireless 20/20 used its award-winning WiROI™ Tool to analyze the cost implications of supporting a small cell network with a PTP or a PMP NLOS backhaul solution. An LTE small cell network deployment was modeled in an urban environment. All assumptions with regard to coverage, access network technical parameters, market penetration, services offered, capacity requirements, transport and core network costs, and operating costs were the same for each backhaul solution.

For the PTP backhaul solution, the model assumed that a pair of radios is needed for each cell site. The model accounted for the radio link cost and adds a design and installation cost. Because the small cell base stations are assumed to be omni cells, each radio link can handle the capacity of the cells. These links are aggregated at the first edge router of the transport network. Ten cell sites are aggregated together at each edge router.

For the PMP NLOS backhaul solution, the model assumed one hub site can support 6-8 remotes. Each remote is co-located with a small cell. The model assumed that a fiber transport backhaul was available at each hub. The CapEx was calculated for the equipment and the design and installation of the hub and the remotes. The model accounted for the reduced design cost based on the ease of placing NLOS backhaul remotes at each small cell location. In addition, the model takes into consideration the adaptive modulation implication of PMP NLOS solution. The following graph was used to adjust the capacity of the hub based on the distance to the remote.

Figure 2. *Point-to-Multipoint Backhaul Capacity vs Distance*



The model adjusted the number of remotes that are supported by each hub, based on the capacity of the hub and the capacity needs of each cell

The results between the two backhaul solutions were compared under a variety of small cell radius assumptions and traffic conditions. The CapEx, OpEx, and TCO over a 10 year business case was calculated.

THE CASE STUDY

The case study looks at a dense urban deployment of a small cell LTE network in New York City at 1.9 GHz.

Table 1. Cost Assumptions for the Case Study

Baseline: New York City
Population: 8 Million
LTE using 1900 MHz
10 MHz Channel
Coverage 789 sq km
300 m - 3,375 Initial Capacity Sites
400 m - 1,861 Initial Capacity Sites
600 m - 844 Initial Capacity Sites

The WiROI™ Tool was used to estimate the number of small cells deployed to meet the urban coverage requirements for the 789 sq. km. The study looks at three small cell implementations with varying cell radius of 300 m, 400 m, and 600 m. The initial number of coverage cells for each of the configurations was estimated.

To support the backhaul requirements of the access network, PTP and PMP NLOS solutions were applied to the model.

***Table 2**. Cost Assumptions for the Case Study*

Assumptions	PTP (per Cell)	PMP NLOS (per Cell)
Link	$6,000	
Installation	$2,000	
Hub		$4,000
Installation		$500
Remote		$2,000
Installation		$250

For the PTP, each cell was supported with a radio link. The initial price for each link is $6,000. One of the issues that must be considered as well is the challenge of installing point-to-point links. The LOS requires coordinated alignment at each end of the link. An installation cost of $2,000 for each link is accounted for in the model.

The configuration of the PMP NLOS uses a hub and remote configuration, deploying a remote at each cell site linked back to a central hub. An initial cost of $2,000 for each remote is applied in the model. The PMP NLOS requires minimal RF planning and is a self-organizing network, making this an easier design and installation. This is reflected in the $250 installation cost for each remote. The number of hubs to be used was calculated to provide the optimal support for the network requirements as described above. The cost for each hub is $4,000, with a design and installation cost of $500.

Analysis of the initial CapEx required for each solution showed a significant cost advantage for the point-to-multipoint solution. As the number of cell sites increases with small cell networks, direct link solutions become expensive and cumbersome. The flexibility and ease of deployment inherent in a PMP NLOS lends itself well to the needs of small cell networks.

***Table 3**. Results of the Case Study*

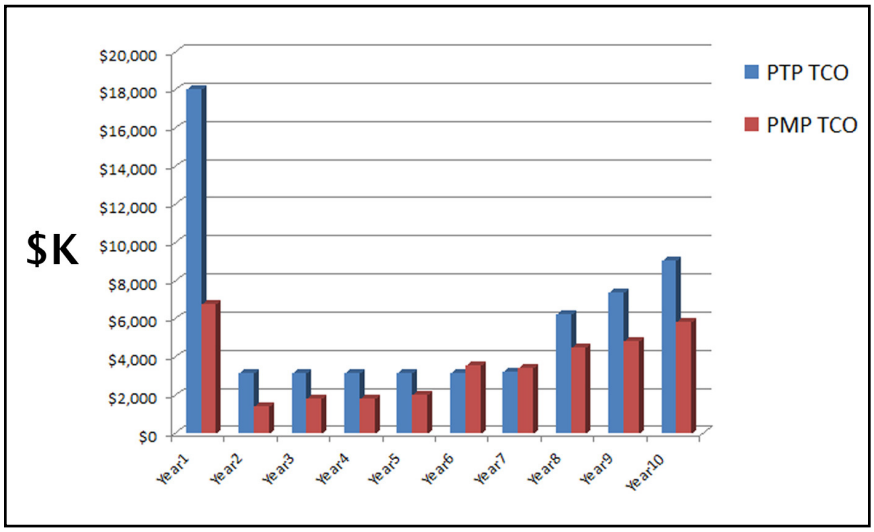
Small Cell Radius	Initial Capacity Sites	PTP Backhaul CapEx	PMP Backhaul CapEx
300 m	3,375	$27,000 K	$9,704 K
400 m	1,861	$14,888 K	$5,352 K
600 m	844	$6,752 K	$2,954 K

Once the initial deployment was modeled, a 10 year analysis of the business case projected the number of subscribers would grow to 2.5 million and data demand would increase to 19 GB per month per subscriber. This was the baseline medium traffic. In addition, the model was stressed with a light traffic load (50% of the baseline traffic) and a heavy load (150% of the baseline traffic). As the traffic demand grew, the model forecasted the deployment of more cells which would have to be supported by additional backhaul links. An advantage of a PMP solution is the ability to add remotes easily, without the need to reconfigure and redesign the backhaul network. Also, as more cells are added, the effective radius of the cells is reduced, making the hub-remote backhaul solution more cost effective.

In addition, the smaller footprint of a PMP NLOS backhaul remote helps to lower OpEx. When all CapEx and OpEx costs are added together, PMP NLOS solutions provide a significant cost savings over PTP solutions for all network parameters tested.

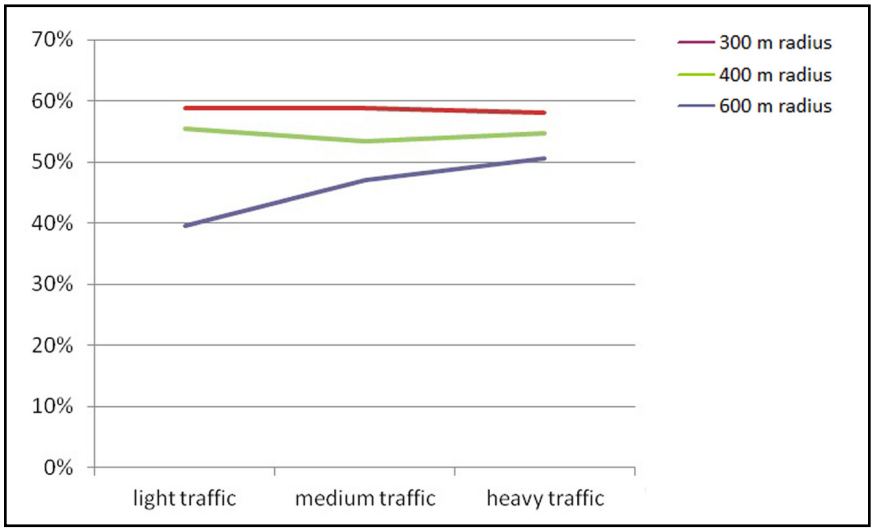
In the baseline scenario, using an initial cell radius of 400 m and a medium traffic load, the total TCO savings for backhaul is 53% over the 10 year business case.

Figure 3.
Annual Total Cost of Ownership Comparison of PTP and PMP Wireless Backhaul



The case study further examined the cost comparison for a range of cell sizes (initial cell radius at 300 m, 400 m, and 600 m), and a range of traffic scenarios (light traffic, medium traffic, and heavy traffic). While there were cost savings in all cases for the PMP NLOS solution, the most valuable case was when the radius of small cells was 300 m and the traffic was the heaviest, the WiROI™ Tool calculated a 59% savings in TCO.

Figure 4.
Total Cost of Ownership Savings of PMP Backhaul as Compared with PTP Backhaul with Various Small Cell Radii



CONCLUSION

As operators look to solutions for network configurations that can support the expected exponential growth in traffic demand, many will likely deploy some kind of small cell technology. But in order to make these networks cost effective, operators will need to look at next-generation backhaul solutions that can support the increased number of cell sites and still support the growth in traffic demand.

As the case study demonstrated, cost-effective implementation using a PMP NLOS backhaul solution for a small cell LTE network provides up to 59% savings in backhaul TCO over a 10 year business case. As the radius of a small cell decreases, the cost savings using PMP NLOS increases. Also, as the traffic load increases, there can be additional savings offered due to the ability of PMP NLOS to support denser traffic configurations.

In addition to the cost savings, the NLOS capability of the PMP solutions makes design and implementation of the backhaul easier and faster as the network expands. To effectively deploy a carrier grade backhaul, both PTP and PMP NLOS require licensed spectrum: per link for PTP and sub-6 GHz for PMP NLOS.

Since the case study shows significant cost-savings when small cell networks use a PMP NLOS solution, operators should start now either re-purposing, re-farming or acquiring sub-6 GHz TDD spectrum to support this next-generation network topology. By waiting, operators run the risk of being left without access to viable spectrum when the time comes to deploy a small cell network.

About Wireless 20/20

Wireless 20/20 is an independent research and consulting company focused on the dynamic broadband wireless market with clients spanning the entire 3G and 4G value chain, including semiconductor vendors, equipment vendors, service providers and investors. Wireless 20/20 is the developer of the industry-leading WiROI™ Wireless Networks Business Case Analysis Tool. This dashboard-style, easy-to-use, wireless ROI business planning tool has been licensed to operators and is being used extensively by leading LTE™, WiMAX™ and 4G operators around the world to develop comprehensive, business cases.

WP-PTP|PMP-0627-2012