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ROLE OF OPTICAL WIRELESS BROADBAND IN THE EVOLVING MOBILE ECOSYSTEM

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Executive Summary

These are exciting times in the wireless industry. The innovation in technology, services, and business models is driving the global industry to new heights. While the global markets were feeling the pain of a brutal recession, the wireless industry for the most part sidestepped the crisis, especially the US and Asian markets. In the US, 2009 was a banner year for the mobile data services and applications. Each of the four quarters exceeded $10 billion in mobile data services revenue and the subscription penetration was approximately 93% by the end of the year.[1]

The mobile industry is going through significant transition from being voice-centric to data-centric, from consumers spending 90% of their time talking to 80% of the time spending on mobile data and games. The main drivers of such an evolution are: better devices like the iPhone, Droid, Pre, Bold, etc., higher capacity networks such as WCDMA, HSPA+, and EV-DO Rev A, flat rate data pricing, and a heightened consumer awareness of mobile applications and services. This has boosted both the consumer engagement and the revenues from data services.

However, this increased usage comes at a cost. As users are becoming accustomed to an always-on, always-connected world of mobile, they are consuming tremendous amount of data that is putting significant burden on the networks especially the backhaul. Further, as the need for the bandwidth rises exponentially, we are approaching what FCC's Chairman Genachowski termed as *"a looming spectrum crisis."* In light of such infrastructure challenges, the industry needs to think outside-the-spectrum-box and think long-term else we will be in a perpetual cycle of crises. Traditional transmission technologies like Fiber and Microwave will benefit from complimentary technologies such as Optical Wireless Broadband (OWB), which enhances the operator's toolbox to build out efficient broadband connectivity.

This paper discusses the mobile data growth, the backhaul demands, and the looming spectrum crisis in more detail. Further, the paper discusses the requirements for backhaul to support next generation traffic and the role of new technologies such as Optical Wireless Broadband to provide backhaul capacity solutions that are both economical as well as future-proof.

[1] Source: US Wireless Data Market Updates, Chetan Sharma Consulting, 2009, http://www.chetansharma.com/research.htm

The Mobile Data Growth

Thanks largely to the iconic devices like the iPhone and the mobile data cards, the mobile data growth grew disproportionate to the revenues in 2008-9. In 2009, the mobile data revenues in the US market grew by 33% but the mobile data traffic grew by over 200%. Similar trends are being observed in other markets such as Western Europe, Japan, and Korea where more and more consumers are embracing mobile data in their everyday lifestyle.

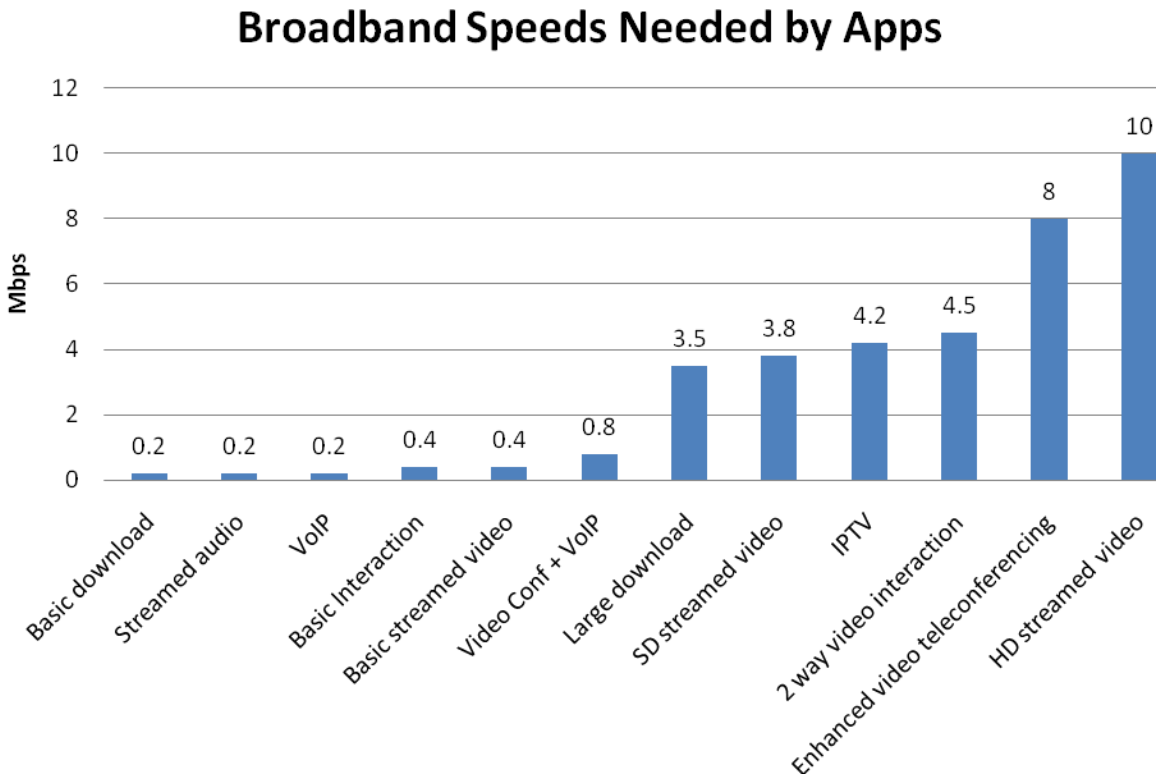

Figure 1. Broadband speeds by applications

Additionally, the types of applications and services that are becoming available on smartphones have higher requirements for bandwidth compared to their earlier predecessors, for e.g. streaming audio might only consume .2 Mbps/stream but an HD streaming video can consume upto 10 Mbps of capacity. As such, the mobile data consumption per user/month is on the rise across the board. We expect the average mobile data consumption to increase from less than 50 MB/user in 2009 to almost 3 GB by 2014. In the US, the mobile data traffic is expected to increase from almost 400 Petabytes per year to 20,000 Petabytes or 50 times.[2]

[2] Managing growth and profits in the Yottabyte era, Chetan Sharma Consulting, 2009

Looking at the picture on a more granular level, the picture is even more challenging. In HongKong, the data consumption grew 3 times in 2009.[3] In TeliaSonera's Nordic and Baltic region networks, traffic increased 500% in 2008. AT&T Wireless noted that they have experienced 5000% data growth in the last three years.[4]

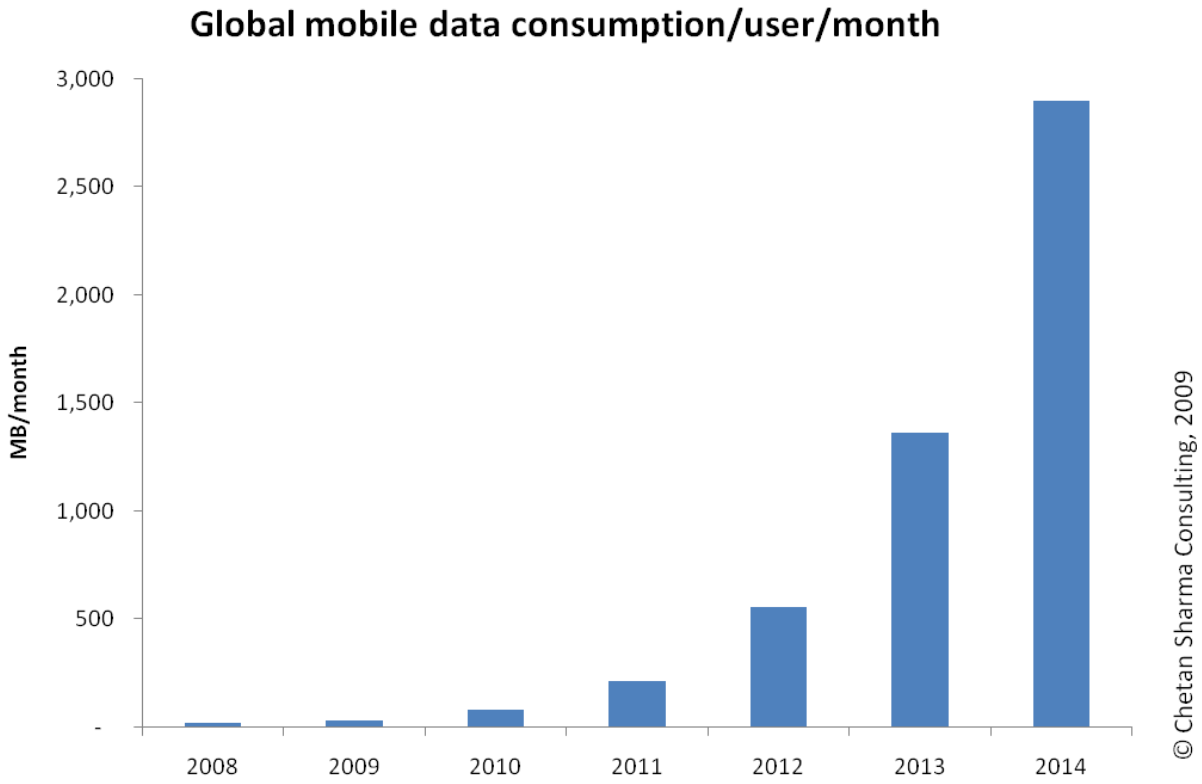

Figure 2. Global mobile data consumption/user/month

[3] http://www.ofta.gov.hk/en/datastat/eng_wireless.pdf
[4] http://www.att.com/Common/about_us/files/pdf/RDLV_CTIA-slides.pdf

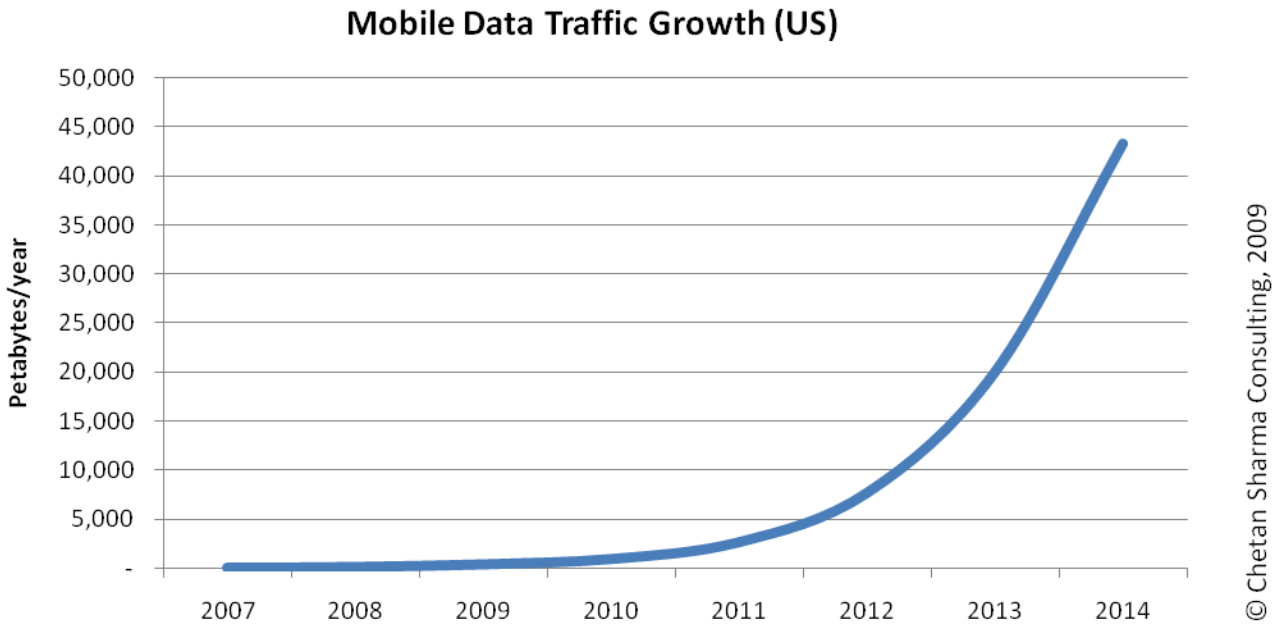

Figure 3. US mobile data consumption/year

This significant growth in the mobile data consumption is not only going to put constraints on the cellular networks and the associated spectrum but also the backhaul networks required to carry all this traffic from the base stations to the core of the network are going to be under considerable strain to put it mildly.

The "looming" Spectrum Crisis

In his speech titled *"America's Mobile Broadband Future"* at CTIA, Chairman Genachowski said:

> ***"In fact, I believe that the biggest threat to the future of mobile in America is the looming spectrum crisis. Even with innovative spectrum policies and innovative new technologies, experts believe we are way too likely to be caught short. The less spectrum available for mobile broadband, the more service will cost and the longer it will take to make 4G ubiquitous. And that doesn't serve our national needs. As this audience knows, it takes years to reallocate spectrum and put it to use. And there are no easy pickings on the spectrum chart."***[5]

[5] CTIA, Oct 2009

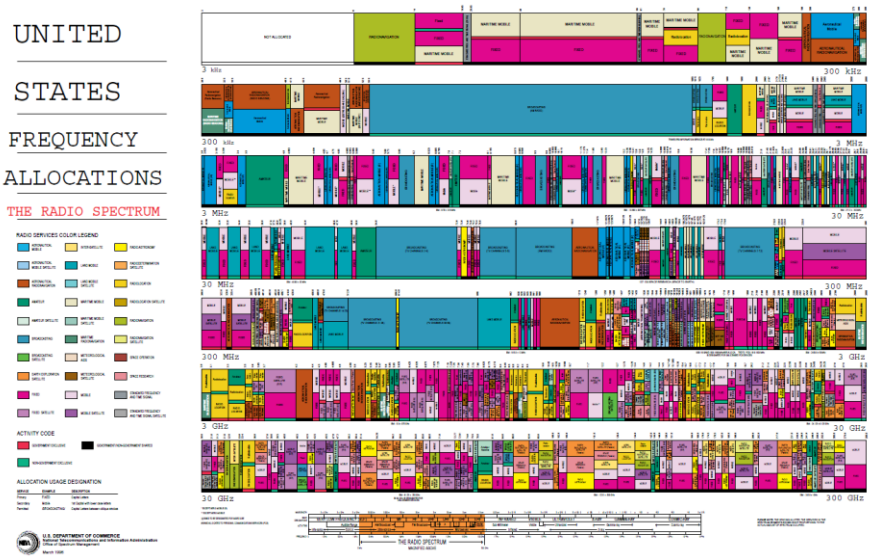

Figure 4. US Frequency Allocations[6]

Spectrum is a finite resource and the demands being placed on the national spectrum are enormous if not unrealistic. One doesn't need to be a spectrum expert to determine that the majority of the spectrum has been taken (Figure 4). What's left is just reallocation of spectrum. While the mobile data tsunami is occurring now, even the identification of available spectrum, its reallocation and assignment is often a long, multi-year process. And while consumer data demands make a strong case for additional spectrum so do other critical services like public safety, smart grid, telemedicine, military, and the likes. Additionally, the cost of broadband deployment can limit the deployment in rural areas where the cost to support the subscribers is relatively high.

It is apparent that to achieve next generation broadband speeds like 50-100 Mbps, new contiguous spectrum is needed. However, it will be a mistake if the dominant solution for the broadband capacity crisis is more spectrum, for the following reasons:

1. There isn't enough spectrum, especially the right spectrum
2. It takes 7-10 years to procure the spectrum for wireless use
3. By focusing on spectrum only, we will be just postponing the current crisis
4. By giving out spectrum too soon, industry won't have the opportunity to learn to thrive within its means and let new technology and business innovation show the way to handle the increased data consumption

As such the industry and national interests will be best served if we take a look at alternate solutions in parallel like shared used of spectrum or designing solutions and architectures that don't require additional spectrum or invent new technologies that

[6] http://www.ntia.doc.gov/osmhome/allochrt.pdf

manage the rapid growth of data consumption without impacting consumer choice and user experience.

The Evolution of the Backhaul Network Architecture

In the past, the operators had to only focus on voice traffic. However, data is becoming an increasingly important revenue stream in the last 2-3 years. In Japan - the most active mobile data nation, the data ARPU is approaching 50%.[7] In other western nations like US, operators such as Verizon Wireless are past the 30% mark[8] and it is only a matter of time when operators around the world will make more revenues from data services than they do from voice services.

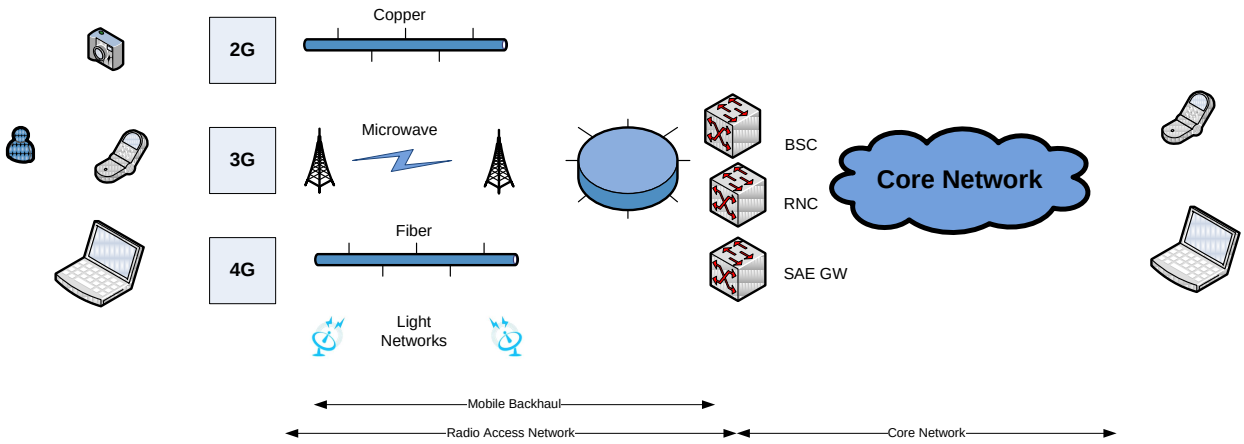

Figure 5. Backhaul network architecture

Table 1. Evolution of backhaul network architecture

	Aggregate Sector Throughput	User Peak Rates	Backhaul	Latency Requirements	Applications
2G	1 -2 Mbps	< .5 Mbps	1 T1/3 sector carrier	40 ms RTT	Voice, Messaging, some data
3-3.5G	5-50 Mbps	5-10 Mbps	6-8 T1s/sector/carrier - Fast Ethernet per site	30 ms RTT	Voice, Browsing, Applications
4G	100-500 Mbps	100 Mbps	Gig Ethernet per site	< 10 ms RTT	VoIP, Video, heavy data & multimedia usage

[7] Source: Global Wireless Data Market Updates, Chetan Sharma Consulting, 2009
[8] Source: US Wireless Data Market Updates, Chetan Sharma Consulting, 2009

However, the backhaul required for carrying voice can be quite different. Further, as we move towards an all IP world, voice becomes another application on the IP transport. All this forces a network architecture shift in how the next generation of technologies will have to evolve. From < 1 Mbps/sector throughput rates we will be requiring 100-500 Mbps with user peak rates touching 100 Mbps in many instances. This means that the backhaul capacity needs to be raised to Gig Ethernet per site instead of a patched framework of T1/E1s. As VoIP and Rich Communication Suite (RCS) type applications become more prevalent, the requirement for latency becomes higher as well with sub 10 millisecond for roundtrips.

Requirements for Backhaul to Support Next Generation Traffic

The backhaul investments consume up to 30% of OPEX of a typical operator. Depending on whether the operator is leasing the bandwidth vs. owning it; the CAPEX can be more than double the backhaul OPEX. To be both economically sound and technically prudent, the next generation of backhaul implementation needs to have the following key characteristics:

Adaptive and Scalable Traffic growth patterns can be uncertain and difficult to plan for completely so solutions need to be adaptive and can scale with demand on a short-notice without re-architecting or significant new investment. The backhaul architecture should also accommodate different physical infrastructure in various markets. On the business front, the solution should provide flexibility of either leasing or owning the connection to the aggregation backhaul network. This helps in both scalability as well ensure that the future enhancements can be easily accommodated.

Coexisting of solutions/Support for legacy Due to legacy issues, any new solution will need to interface and work with the existing infrastructure to enable easy transition into the next generation architecture. This allows for graceful upgrade and better control over CAPEX. Fiber and microwave are both viable, and will coexist with other solutions for a long time.

Addresses CAPEX/OPEX restraints Operators are looking to work under restrained OPEX and CAPEX requirements. The emergence of 4G and long term evolution (LTE) networks only compounds the challenge of under-engineered backhaul networks. According to ABI Research, CAPEX for cellular backhaul is expected to reach $23 billion by 2012 from $9B in 2009 and OPEX expenditures reaching $6 billion in 2012 from just over $2B in 2009. The total cost of ownership (TCO) needs to be manageable and should be proportional to demand.

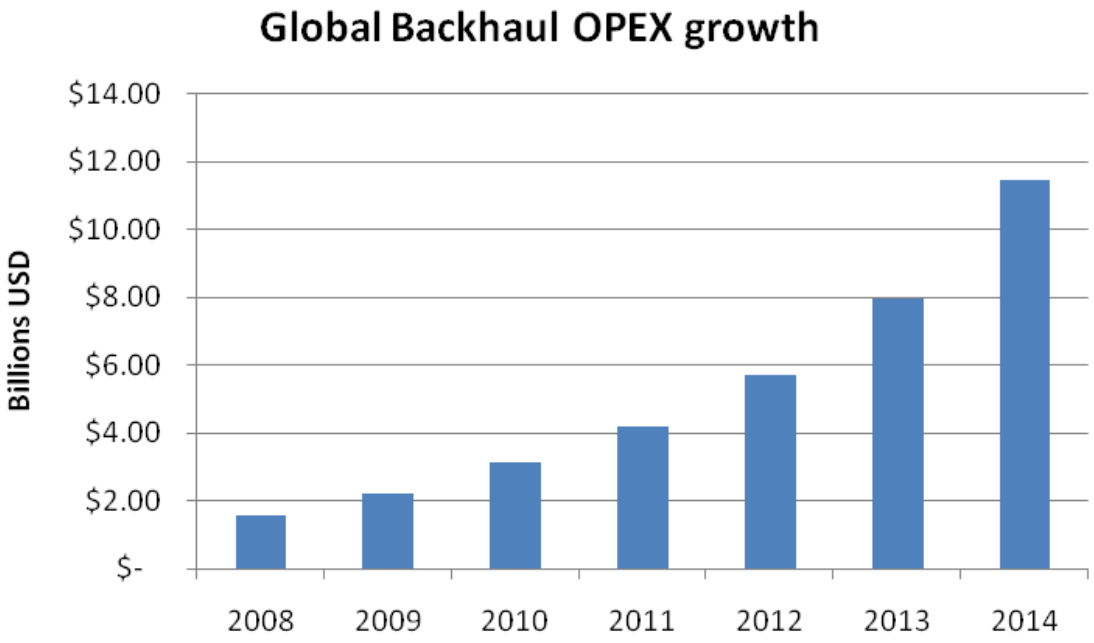

Figure 6. Global Backhaul OPEX growth[9]

Long-term solutions - to meet the demands of iPhone and other smartphones, AT&T deployed 100,000 additional T1/E1s.[10] However, this clearly is not a good long-term solution. To be cost-effective and future-prudent, operators will need to get ahead of the problem and architect their backhaul solutions for the long-term. Postponing the problem till next quarter will get you only so far.

The Role of Optical Wireless Broadband in Supporting Backhaul Evolution

The existing solutions for high capacity backhaul have two key problems. Microwave which is widely used requires spectrum where none might be available and Fiber to the premise requires construction that might not be practical or economically feasible all the time, especially in cities and nations where laying fiber faces regulatory and layout challenges. Additionally, the operational cost of these solutions is high thus increases the overall OPEX for the operator.

Backhaul situation is different in different parts of the world. In North America, almost 80% of the sites are still connected with TDM (Time Division Multiplexing) infrastructure and the wireless spectrum for microwave solution is limited. Some operators like Verizon are investing heavily in Fiber while others like Clearwire have chosen Microwave as their main backhaul technology.

[9] Source: ABI Research, 2009
[10] http://ow.ly/167WTx

In Europe, a majority of the operators use microwave for backhaul because of the high cost of copper and the spectrum for microwave use is available. In Asia, some of the large operators have fiber deployments because many are both mobile and fixed operators.

It is apparent that no single solution will address all the markets for any given carrier since the bandwidth-requirement profile of the sites can differ significantly. The hybrid solution has to however address latency, bandwidth scalability, synchronization, security, and QoS to near perfection.

In addition to the technologies discussed thus far in the paper, OWB network technologies offer a compelling alternative to the backhaul dilemma that works hand-in-hand with the legacy infrastructure. OWB networks have been around for some time for providing point-to-point connectivity especially in dense urban areas where both microwave and fiber solutions are impractical to deploy for financial and logistical reasons. The most recent generation of the technology incorporates improvements to reliability and cost that makes OWB a useful technology when addressing the difficulties of backhaul overload.

Optical Wireless Broadband technology can be used to build out a full mesh network, but a large part of its value comes when serving as a complimentary technology to cover the deployment holes in the backhaul layout for high-speed broadband to multi-story residential or business building, rural areas, small businesses, and others.

In the US, OWB has been deployed in concert with the WiMAX technologies to deliver broadband solutions to various communities. OWB does face some issues under severe weather conditions which can temporarily degrade performance or accentuate a need for a backup solution to meet the demands in such circumstances especially heavy fog environments, not unlike Microwave's susceptibility to heavy rain. Additionally, multiple OWB units could be deployed in a mesh-network to mitigate the direct line of site hindrance by fog.

Comparison of backhaul technologies

The backhaul bandwidth management is a multi-dimensional issue that involves legacy, time to market, capacity, anticipated growth in demand, time to revenue, power consumption, OPEX, CAPEX, market and competitive dynamics, spectrum, and the availability of technologies. Operators have to take all of these into consideration as they plan for their current and future backhaul bandwidth needs.

For example, while fiber might look a good option in some cases, there is a high upfront cost of laying the fiber which can be as high as $100-200K/mile. Additionally, permits are needed and it can take 9-15 months for the whole project. Microwave has strong penetration but it requires licensing of spectrum, right of way approvals, and despite the lower up front cost (compared to fiber), it can still cost $20-$40K/link. The need for spectrum licensing, RF analysis and roof leases can take up to 6-9 months. The

replacement cost of equipment is also quite high which can drive the overall TCO higher and thus needs to be built into the OPEX budgets.

As we alluded to earlier in the paper, to be most cost-effective and future-prudent, operators will need to adopt a hybrid approach that gives them the most flexibility in any given situation. In a saturated market, operators compete at a market level, and hence require ability to scale and deploy bandwidth on demand. It can be only done by using a toolbox approach of using technologies that best help fulfill the short-term requirements while keeping the investment future-safe.

Optical Wireless Broadband technology is one such tool in the operator toolbox that enables them to scale bandwidth on demand. The CAPEX and OPEX of OWB networks are quite attractive compared to other technologies. As shown in figure 7, the cost per site can be significantly lower than that of others, especially with the new generation of OWB with smaller form factors and increased reliability.

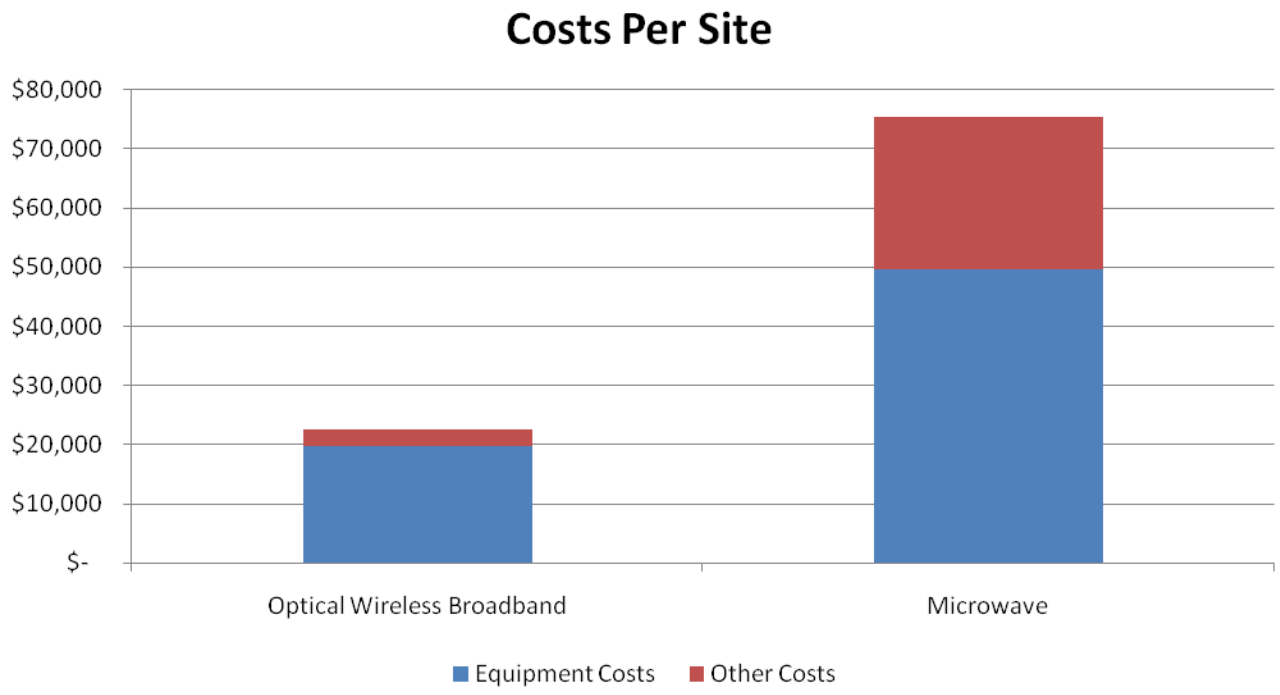

Figure 7. Comparison of the costs of Backhaul solutions

Table 2 shows the differences in operational and performance parameters between three key backhaul technologies – Fiber, Microwave, and OWB. While Copper (T1/E1s) is quite prominent, its usefulness in the high bandwidth demand is limited and we envision that it will be primarily used as a legacy backstop vs. for future expansion of the backhaul capabilities.

Table 2. Comparison of various backhaul technologies

	Fiber	Microwave	OWB
Capacity	GB	GB	GB
OPEX	High	Low	Low
CAPEX	High	Moderate	Low
3 year cost/ connection[11]	$90K	$57K	$40K
Avg Cost/mo for first 12 months[12]	$7500	$4700	$1300
TDM Support	Yes	Yes	Yes
Time to market issues	Permit and right-of-way	License and permit	No license or right of way required
Power Consumption	12W	50W	14W
Time to deployment	9-12 months	6 months	1-30 days

As is clear from the cost structure of the three technologies, OWB is quite cost-effective with low upfront and low ongoing costs. OWB has already been used for backhaul and "next-mile" connectivity in a number of deployments, including a pairing with WiMAX.

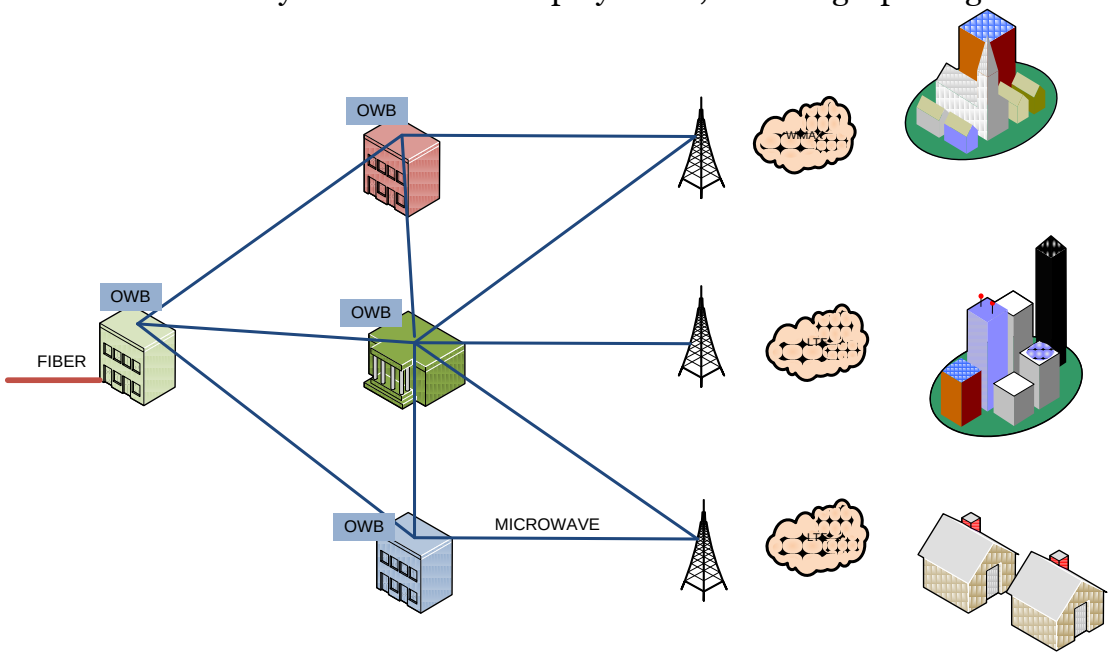

Figure 8. Hybrid Backhaul Strategy

[11] Chetan Sharma Consulting, Skyfiber
[12] Chetan Sharma Consulting, Skyfiber

Figure 8 shows a hybrid approach to backhaul planning. As shown in the diagram, OWB has been used in an actual setting as the cost-effective backhaul bridge between the last point in a fiber ring, connecting to a community that then used WiMAX to broadcast local mobility coverage. In situations like this, the business case doesn't make sense to pull the fiber to the community as there isn't enough potential ROI. But with a more economical technology like OWB, the broadband needs of this community were met in a way that was cost effective and profitable.

OWB can also scale cost-effectively. For example, the "bandwidth-on-demand" capability allows operators to gradually go from 100 Mbps to 1 Gbps or higher based on the network demands and without investing or paying upfront for the higher capacity.

Conclusion

It is very clear from the trends in 2009 that the demand for mobile data will continue to grow unabated for the foreseeable future. In fact, in some of the geographies and for some of the operators, it will accelerate significantly. To address the data consumption issue in light of the facts discussed in this paper, one has to figure out a set of solutions that work in concert with each other. Just focusing on one solution only gets you so far, however, a range of viable solutions that address each of the problem elements are likely to prepare the industry much better for the long haul.

One of the key concerns of mobile data demand management will be what has been long considered the network bottleneck - the backhaul. To stay ahead of the demand curve, operators will have to deploy solutions that are both time-efficient as well as cost-effective. In addition, the backhaul solutions need to be legacy-friendly to evolve gracefully. OWB networks with their superior cost economics and quick time to deployment offer one such solution that will help operators to be less dependent on the scarce spectrum, the building and construction permits, and the aging infrastructure that has a hard time scaling to new and unexpected network demands.

By considering such solutions in parallel, the industry will be better off in the long-run. It is the only way to tackle the problem in the short-term since neither the additional spectrum nor the announced deployments of LTE are going to make any meaningful dent to the data usage costs and margins. By focusing too much on the spectrum and the next generation cellular technologies, we will miss the opportunity to cultivate a better network and business ecosystem and to invent new technologies and revenue models that will have a much stronger impact on the evolution of the mobile industry for decades.

Disclaimer

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The opinions expressed in this white paper are those of Chetan Sharma Consulting. Skyfiber sponsored the white paper but Chetan Sharma Consulting did all the research and writing for the paper.

About Chetan Sharma Consulting

Chetan Sharma Consulting is a management consulting and strategic advisory firm started in 2001. We are focused on assisting companies in the mobile and voice communications sector with product management, technical due diligence, scenario planning, market and competitive research, patent & IP strategy, technology and business strategy. Our clients range from small startups with disruptive ideas to multinational conglomerates looking for an edge. We assist major brands formulate winning, profitable, and sustainable pervasive computing strategies.

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Chetan Sharma is President of Chetan Sharma Consulting and is one of the leading strategists in the mobile industry. Executives from wireless companies around the world seek his accurate predictions, independent insights, and actionable recommendations. He has served as an advisor to senior executive management of several Fortune 100 companies in the wireless space and is probably the only industry strategist who has advised each of the top 6 global mobile data operators. Some of his clients include NTT DoCoMo, Disney, KTF, China Mobile, Toyota, Comcast, Motorola, FedEx, Sony, Samsung, Alcatel Lucent, KDDI, Virgin Mobile, Sprint Nextel, AT&T Wireless, Reuters, Qualcomm, Comverse, Motricity, Reliance Infocomm, SAP, Merrill Lynch, American Express, and Hewlett-Packard.

Chetan is the author or co-author of five best-selling books on wireless including *Mobile Advertising: Supercharge your brand in the exploding wireless market* and *Wireless Broadband: Conflict and Convergence.* His books have been adopted in several corporate training programs and university courses at NYU, Stanford, and Tokyo University. His research work is widely quoted in the industry. Chetan is interviewed frequently by leading international media publications such as *Time* magazine, *New York Times, Wall Street Journal, Business Week, Japan Media Review, Mobile Communications International,* and *GigaOM,* and has appeared on NPR, WBBN, and CNBC as a wireless data technology expert.

Chetan is an advisor to CEOs and CTOs of some of the leading wireless technology companies on product strategy and Intellectual Property (IP) development, and serves on the advisory board of several companies. He is also one of the most sought after IP strategist and expert witness in the wireless industry and has testified in some of the most important cases in the industry. Chetan is a senior member of IEEE, IEEE Communications Society, and IEEE Computers Society. Chetan has Master of Science degree in Electrical Engineering from Kansas State University and Bachelor of Science degree from the Indian Institute of Technology, Roorkee.