Common Misconceptions about Free Space Optics

Although Optical Wireless or Free-Space Optics (FSO) has been in use for decades by the military, only recently has it made its way into the mainstream of broader markets. With this increased awareness come a number of questions that are commonly raised. This paper seeks to address these common concerns in order to facilitate learning about the technology and its capabilities.

"FSO is unproven and has not been endorsed by carriers."

Ten years ago FSO was not a commercially robust technology. Systems were generally unreliable and had limited performance. Unfortunately, bad memories have lingered in the minds of some carriers that looked at the technology back then, and changing this perspective has taken time. But the perspective *is* changing, for carriers as well as for many other customers including ISP's, utilities, and enterprise networks.

Today, FSO is leaps and bounds from what it was ten or even five years ago. FSO systems today are robust, reliable turnkey products that have been successfully deployed in every imaginable climate and condition. fSONA alone has installations in almost 30 countries around the world. Trade publications that once described FSO as an "emerging technology" now regularly mention FSO in the same vein as RF or microwave, as another viable wireless technology with its own set of features and advantages.

This market acceptance of FSO is indeed affecting the carrier market as well. . Almost all of the major US carriers and many major international carriers have already trialed FSO and several carriers have written FSO into their budgets and network plans for 2004 and 2005. This year AT&T was the first to publicly announce their plan to incorporate FSO into their networks. fSONA currently has FSO links carrying real customer traffic for more than one carrier. As FSO continues to prove itself in the field, its push into the telecom market will accelerate.

"Fiber is everywhere, you don't need FSO."

A lot of fiber was laid in the 80's and 90's. Billions of dollars were spent to connect major countries with global data pipes, and major cities laid fiber rings to act as backbone connections to the global network. It was a grand vision – lay the foundations now for a world-wide network that would connect everyone to everything. The problem is that all this fiber, when all is said and done, only reaches about 1% of the buildings that need it. After all the money and effort that was spent laying the foundations for a global network, it turns out the final step of connecting this global infrastructure to the end-users is the greatest challenge. In fact, much of the fiber laid during the boom years remains unlit today not because it isn't needed by today's users but because that final gap has not yet been bridged.

This is the proverbial “golden mile” or “last-mile” problem that FSO was designed to solve. Precisely because fiber is *not* everywhere, despite being only a mile or so out of reach of most end-users, a cost-effective “last-mile” connection is sorely needed to complete the vision that only started with fiber.

“FSO is an interim solution as more fiber is laid.”

The fact is that there are few plans to lay more fiber. There is much more incentive to use the miles of existing dark fiber, for which the investment has already been made, than to make further investments in infrastructure.

The reasons behind fiber’s failure to make it to most end-users are perfectly legitimate; it simply is not physically or financially feasible to lay fiber to each and every building that requires broadband connectivity. The cost of laying fiber between two buildings across the street in a metropolitan area can easily be hundreds of thousands of dollars, and the lead-times involved with zoning restrictions and digging can be six months or more. A more flexible and cost-effective solution is clearly needed.

“The range of FSO is too limited to be of significant use, due to atmospheric effects.”

All wireless access technologies, including RF and microwave, must deal with atmospheric effects. For RF transmission, rain is the main cause of signal attenuation, and the link must be engineered for side-lobe reflections, multi-path scattering and electromagnetic interference (EMI). In fact, none of these problems apply to free-space optics. The only significant atmospheric effect that FSO must deal with is signal attenuation due primarily to fog.

For some low-end FSO products, the useful range is limited to across-the-street applications. However, FSO products in general are easily capable of linking distances several kilometers apart with fairly high availability. fSONA’s SONAbeam products in particular have operational ranges as high as 7700m in light rain, or 3200m in thin fog. These ranges are ideally suited for the “last-mile” applications described above. According to research firm RHK an estimated 75% of U.S. businesses are within one mile of fiber but only 5% of those are accessing it.

Moreover, higher availability at longer ranges can be achieved by marrying FSO and RF together into a redundant system. Because the former is more attenuated by fog and the latter by rain, the two transmissions together create a truly all weather wireless link.

"DSL and Cable cover the broadband needs of consumers; FSO is overkill."

DSL exploits the copper infrastructure owned by the PTT and comes in various flavors from 250k up to 2 Mbps. However, DSL services are limited to buildings in close proximity to a central office. According to Gartner Group, approximately 40% of all potential DSL subscribers are beyond the range of the nearest carrier's central office. In order to reach 100% of the potential customers, carriers will need to extend their optical networks to bring the DSLAMS closer to customers. However, topping out at 2 Mbps, DSL service barely breaks the broadband barrier (Cisco's State of the Broaband Today report sets broadband at between 2 and 100 Mbps). In addition, many DSL services are asynchronous meaning the 2 Mbps only applies for download speeds; upload speeds are usually significantly lower.

Cable does a good job of delivering residential high-speed internet access to consumers – their networks already penetrate deep into this market. However, businesses are not as well-served by cable for a few reasons. First, cable networks are shared networks which invites both security problems and reduced bandwidth during peak hours. Second most cable service is asynchronous so applications like VOIP, video conferencing, and web hosting are compromised. And third, most cable networks do not reach commercial and industrial areas where businesses are located.

As the broadband experience becomes ubiquitous, current technologies will be stretched to deliver the speeds that are needed for compelling content – video/voice/music. Although cable and DSL are serving certain customer groups well, DSL is limited in range and cable suffers from quality issues. FSO complements both these networks with extensions that bring technologies such as DSL within range of target customers.

"Radio as an enhanced technology can achieve the same speeds and will soon catch up to FSO in performance and cost."

Standard RF technology has been around for about 50 years and so is a mature technology whose benefits and challenges are well understood by network professionals. Naturally, these professionals are also aware of recent technology improvements and spectrum reallocations. There is indeed potential for enhanced radio products to deliver broadband, but there are still many challenges to overcome.

RF technology will not be able to achieve the same bandwidth speeds and performance per cost levels of FSO. Part of the problem is that at the higher frequencies where higher bandwidths are achievable, RF is highly susceptible to atmospheric attenuation due to rain, a much more common occurrence than the fog that affects FSO. Current 60GHz systems, in fact, are limited in range to about 1Km due to oxygen absorption in the atmosphere, even without rain. In addition, the fact that many RF bands are licensed can significantly raise costs and even bar operators from entry. Licensing, however, is a necessary evil because it mitigates another one of RF's challenges – interference – something which is never an issue for FSO. Wide-divergence beams, fresnel zones, side-lobe reflections and multi-path scattering make RF electromagnetic interference (EMI) an issue serious enough to warrant all the bureaucracy of the FCC.

Finally, precisely because the transmission beams of FSO are extremely narrow and completely immune to interference, they are much more difficult to intercept than RF. This makes FSO the most secure of all wireless technologies, which is one important reason why FSO has been approved for use by the US military.

"Wi-Fi will rule the broadband wireless world."

The simplicity and usefulness of Wi-Fi has caused many people to fall in love with the technology, and for good reason. The strength of Wi-Fi is in providing short-distance point-to-multipoint connections to end-users. Although the speeds advertised seem impressive at first, one has to be careful not to be fooled – an advertised 54 Mbps refers to the sum of upload and download speeds (e.g. 30Mbps one way, 24 Mbps the other way), and this speed is only possible under ideal conditions. True speeds are a function of distance, line of sight, etc. Even so, for many users, service at 10 Mbps or so is very welcome.

However, a Wi-Fi connection to an end user is only as good as its connection to the Internet; if this connection is slow, it becomes a bottleneck. This is how FSO complements rather than competes with Wi-Fi - by providing the link to the Internet backbone at very high speeds. In this way FSO can improve the performance of Wi-Fi and Wimax networks. Wimax is a part of the same technology set as Wi-Fi and although Intel is heavily promoting it, the technology is yet to be proven out so a direct comparison is not yet possible.

In the future, as more systems are deployed, both Wi-Fi and Wimax may experience problems of interference. Using FSO to create wireless backbones that feed Wi-Fi or Wimax endpoints will help to reduce this problem.

"If FSO is so wonderful, why has it taken so long to take off in the telecom market?"

Since the burst of the .com bubble, the market in general has seen some of its worst days in history, and the sector that got hit the hardest was the telecommunications sector. It is understandable, then, that the major players in the telecom market, in particular the first-tier carriers, have reduced their spending and brought new investment efforts to a virtual stand-still. Unfortunately, it is this carrier market that FSO was primarily meant to address.

During these last few years of reduced carrier spending, FSO has been enabling applications and proving its value in various other markets. Emerging service providers have used FSO to build out networks in developing areas for a fraction of the time and cost of laying fiber. Numerous enterprise markets are using the technology to increase data rates, improve security, and add flexibility to their corporations and campuses. The US military, less affected by the "telecom meltdown," has approved FSO for key deployments and applications. All this has helped to bring FSO into the mainstream of wireless technology in general. But the "golden mile" problem that FSO was created to solve exists on the largest scale in the illusive carrier market, and so it is this market that is considered the Holy Grail for FSO.

But the tide in the market is changing, and the once dormant carriers are starting to get inspired again. As mentioned above, several major US and international carriers have written FSO into their budgets and network plans for 2004 and 2005, and AT&T has already publicly announced their plan to incorporate FSO into their networks. It has taken a little while, but the stage is set for a new wave in the telecommunications market, and free-space optics is poised to lead the way.

Summary

Free Space Optics technology has now reached the point where it is a viable, useful method for establishing an optical backbone network and for extending and enhancing existing networks. It offers broadband connectivity from 1.5 Mbps up to 2.5 Gbps and is a flexible, re-deployable solution. Numerous carriers, both wireless and wireline, have tested and approved the technology for use in their networks. This year we saw the start of carrier endorsement of the technology with AT&T. Although there are many new enhanced RF products coming onto the market, they are as of yet unable to meet the price performance standards set by FSO. FSO is real, ready for service and here to stay as a cost-effective connectivity alternative.

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