

DualPath architecture blends optical wireless and RF into high bandwidth, high availability outdoor point-to-point solutions

Today, the use of wireless technologies for connecting buildings, campuses and remote locations rapidly and cost-effectively has become commonplace on a global scale. Businesses throughout the world—including enterprises or service providers, small-to-medium businesses or mobile carriers—are opting for the flexibility, installation ease and cost savings associated with wireless connectivity. To that end, they avoid the licensing, leasing and/or installation difficulties typical of wired or leased lines. Outdoor wireless also provides a significant performance improvement over standard E1/T1 leased-line speeds while eliminating the rights-of-way hassles of trenching.

By Randel Maestre

Of the various wireless technologies available today, optical wireless (commonly referred to as free space optics or FSO) and radio-frequency (RF) have emerged as the two preferred options for customers seeking a high performance, yet easy-to-deploy outdoor wireless point-to-point connectivity solution.

With data rates in excess of Gigabit speeds and full-duplex operation, optical wireless provides more than enough bandwidth to meet the capacity requirements of the most network-intensive applications including streaming video and medical imaging. And, through its use of invisible and narrow beams of light, optical wireless is viewed as one of the most secure forms of wireless communications today. However, increasingly stringent network availability requirements make optical wireless best suited for shorter building-to-building links (two to three kilometers) with true line-of-sight. Blockage of the optical beam transmission path by trees, fog or smog can restrict the performance of optical wireless systems as well as their effective transmission range.

RF technology, on the other hand, is a reliable yet longer-distance outdoor wireless connectivity solution that has its own set of challenges and considerations. While weather-related problems are not as prevalent in outdoor RF implementations, RF links pale in comparison to optical wireless from a performance perspective. Optical wireless products, with speeds

up to 1.25 Gbps full duplex, have far greater capacity than RF products (54 Mbps to 72 Mbps half-duplex raw data rates) and, therefore, are more ideal for handling the network load required of building-to-building links. Issues such as security breaches, interference and spectrum saturation also can potentially compromise RF data.

The bottom line for today's bandwidth-hungry organizations is that a blend of these proven outdoor wireless technologies yields the optimal capacity and availability. In order to achieve the proper balance of performance, distance and availability in outdoor wireless implementations, a system combining high-bandwidth optical wireless and high-availability RF technologies is required. This unique and highly innovative mix of technologies

will deliver unprecedented bandwidth and network availability to satiate the most bandwidth-hungry applications.

The need for bandwidth and availability

The need for high-speed networking is driven by several factors including the growth of the Internet, the proliferation of mobile computing, the increase in computer processing power and the development of enterprise-wide applications such as voice-over-IP (VoIP), video and imaging. Network computer users have come to expect low latency, sub-second response times and near-instantaneous access to information even in these bandwidth-intensive applications. Even worse, some of today's network-driven applications will actually stop working if the network infrastructure does not support specific bandwidth and latency requirements. To meet these requirements, businesses have traditionally relied on high-speed wired connections such as optical fiber or Gigabit Ethernet switching technology.

But, bandwidth and low latency alone are not sufficient when facing the challenge of real-time information access. Network availability, or uptime, must also be considered. As consumers and enterprises become more reliant on information, network failures and service outages become critical. While 100% availability is ideal (but also unrealistic due to the

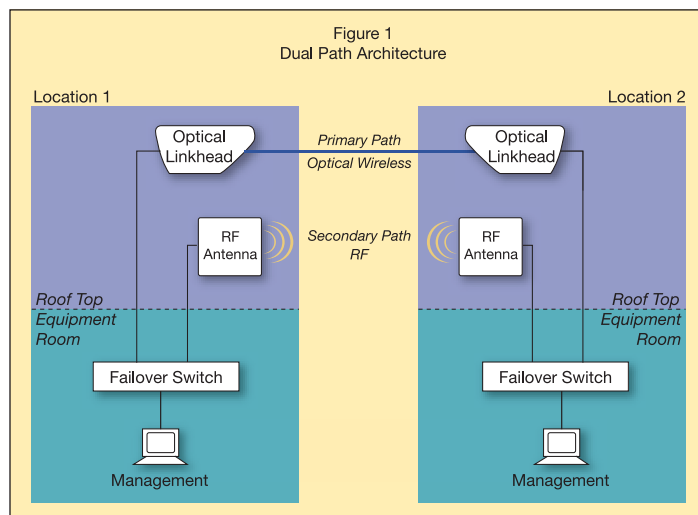


Figure 1. DualPath architecture.

potential issues with network component or data path failure), most high-availability networks strive to achieve “five nines” or 99.999% availability. This translates into roughly five minutes of downtime over the course of a year. For many companies, especially those with mission-critical applications, even this 0.001% of network downtime poses harsh economic penalties. The end result is the need to design high-availability networks with built-in redundancy, thereby maximizing data flow while minimizing disruptions.

The challenge with any network design is balancing bandwidth with availability, which is not a trivial undertaking when dealing with wireless networks. While optical wireless provides more than adequate bandwidth, it falls short of the availability requirements of most enterprise customers, especially in inclement weather conditions. And while RF provides higher availability in these weather-impacted environments, its bandwidth falls short of many networks’ needs. An RF system operating in half-duplex mode at a 54 Mbps to 72 Mbps raw data rate generally results in only 20 Mbps to 30 Mbps of actual network data throughput. This restricted throughput can be quite adequate for a limited period of time (for example, as a back-up path or in a failover scenario), but is simply insufficient to regularly handle remote LAN traffic. Additionally, it falls short of satisfying the ever-growing needs of users running bandwidth-intensive network applications.

Optical wireless—A brief history

To better understand the complementary relationship between optical wireless and RF, it is important to trace the roots of these proven connectivity solutions. Optical wireless technology was first demonstrated by Alexander Graham Bell in the late 1800s as a method of transmitting voice signals by beams of sunlight. It was not until the 1960s during the Cold War that optical wireless products were used as secure and tap-proof outdoor wireless communications for military field use. Highly classified military information and troop movement strategies could be transmitted without fear of interception, due to the fact that the beams of light were confined to a narrow cone of free space and were immune to RF jamming or interception devices.

For the past decade, optical wireless products have continually improved in performance. Today’s modern and feature-rich optical wireless solutions are commercially used to carry mission-critical information including financial data, healthcare and patient records, corporate communications and voice traffic. These products operate in the

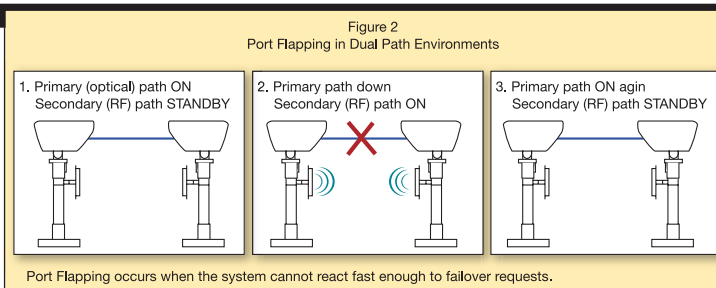


Figure 2. Port flapping in DualPath environments.

worldwide unlicensed terahertz frequency range, also referred to as “near infrared” spectrum. Furthermore, the vast majority of today’s state-of-the-art optical wireless systems are Laser Class 1M certified, making them completely eye safe.

RF—From indoor use to outdoor deployment

Since its first use in World War II military applications more than 50 years ago, wireless local area networks (wireless LANs) have evolved into a mainstream technology used for a variety of in-building and outdoor implementations. This, however, was not always the case. Initial wireless LAN implementations were proprietary—operating at only 1 Mbps to 2 Mbps, primarily in the 902 MHz to 928 MHz industrial, scientific, medical (ISM) frequency bands. This 900 MHz band, as it is more commonly referred to, was one of three unlicensed bands allocated by the Federal Communications Commission (FCC) in the early 1980s for license-free spread spectrum devices—the other two were at 2.4 GHz to 2.483 GHz and 5.725 GHz to 5.85 GHz.

In June 1997, the Institute of Electrical and Electronic Engineers (IEEE) ratified the first wireless LAN standard thereby paving the way for wireless LAN’s widespread adoption and usage. IEEE 802.11 set the guidelines for wireless LANs to operate at the 2.4 GHz frequency with data rates of 1 Mbps to 2 Mbps. In September 1999, due to increased pressure to ensure wireless LAN data rates remained on par with wired Ethernet speeds, IEEE 802.11b and IEEE 802.11a standards were defined in the 2.4 GHz and 5.8 GHz frequency bands, respectively.

IEEE 802.11b defined the rules for an 11 Mbps wireless LAN solution. IEEE 802.11a, on the other hand, provided a broader frequency band capable of supporting data rates of 54 Mbps and potentially higher. Wireless LANs were suddenly a viable networking option with data rates meeting or exceeding traditional enterprise network speeds of 11 Mbps up to 54 Mbps. And the WiFi world as we know it today was born.

Historically, wireless LANs were focused on in-building applications such as retail, warehousing and portable computing where an 11 Mbps network pipe is adequate. An outdoor RF link, however, requires much more bandwidth for handling the traffic of

multiple remote LANs and potentially hundreds or thousands of users. The majority of outdoor RF links are simply outdoor implementations of WiFi, which use specialized bridges, routers and antennas to reach distances of 10 miles or beyond in some cases. Still,

even a 54 Mbps half-duplex data rate may not be enough to handle the traffic load of two or more networks. This is especially the case in today’s typical network environment where the evolution from 10 Mbps (Ethernet) networks to higher speed 100 Mbps (Fast Ethernet) and 1.25 Gbps (Gigabit Ethernet) networks has driven the need to dramatically increase data throughput of building-to-building LAN connectivity solutions.

To meet the higher bandwidth requirement for outdoor RF links, the latest outdoor wireless solutions have focused on modified versions of the IEEE 802.11a standard to reach even greater network speeds. Most have implemented a modified orthogonal frequency-division multiplex (OFDM) encoding and modulation scheme to achieve greater data rates (up to 72 Mbps) and increase network efficiency. OFDM uses multiple overlapping carrier signals instead of just one signal. By using multiple signals just far enough apart to avoid interference, data is no longer compromised by radio anomalies, whereas in a single signal mode a problem can result in a lost link.

Even with OFDM implementations, however, outdoor wireless links typically support a maximum raw data rate of 72 Mbps (or 30 Mbps real network data throughput in half-duplex operational mode), which represents only a portion of the capacity of an optical wireless link. Optical wireless products, which support 100 Mbps to 1.25 Gbps full-duplex data throughput rates, are more than capable of handling the network load required of a building-to-building link. Still, weather conditions, including fog, do not impact RF signals to the extent that they may impact an optical wireless solution. Simply put, the opportunity to combine optical wireless and RF results in a high-performance, high-availability outdoor wireless solution. This integration of distinct, yet synergistic, technologies has resulted in the creation of a patented DualPath architecture focused primarily on meeting the needs of outdoor point-to-point connectivity.

DualPath architecture

A DualPath approach to outdoor wireless point-to-point connectivity consists of four key components (configured as shown in Figure 1):

- primary path (optical wireless);

- secondary or failover path (RF);
- intelligent switching; and
- configuration and management.

The primary path, or the optical wireless path, is the main transmission medium in this architecture design. Since this path will be operational the majority of the time, it needs to be the most robust in terms of performance and speed.

Of course, answering the question of how often the failover mechanism from the optical path to a secondary RF path will be triggered is a challenge. The most appropriate way to look at this is by using availability statistics of an optical wireless path in different geographical regions of the world. Although uptime projections can vary widely, depending on weather, distance and other environmental conditions, optical wireless availability is typically calculated at 99.9% availability, which translates into just a little more than eight hours of downtime per year or an average of 11 minutes per week or 1.5 minutes per day. This downtime figure, while low, may not be suitable for mission-critical applications.

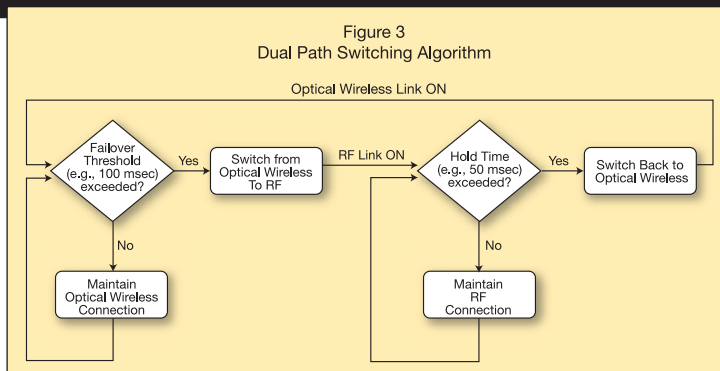


Figure 3. DualPath switching algorithm.

Maximizing network uptime in these stringent environments requires an automatic failover strategy. Relying on a single communication path causes a single point of failure. Even using multiple paths of a single transport media (e.g., two optical fibers) does not automatically guarantee 99.999% availability. With DualPath architecture, a fully redundant, automatic failover path switches seamlessly between optical wireless and RF, using different transport mechanisms with complementary physical properties. This combination of optical wireless and RF technology provides the ultimate wireless network redundancy strategy.

The key to the DualPath approach lies in the failover switching mechanism from the pri-

mary to the secondary path and vice versa. This becomes apparent in real-time applications or VoIP environments where excessive failover times, latency delays and jitter (variation in delay) may degrade voice quality. Typically, this delay should be no more than 150 milliseconds to get acceptable voice quality. Therefore, an ideal failover would result

in seamless, sub-second (less than 150 millisecond) switching between paths resulting in no service disruption. Standard off-the-shelf switches or basic fault redundant transceivers have been known to take from 10 seconds up to several minutes to switch between primary and optical wireless links, depending on the switching protocol used. While these switching delays may be sufficient for data transmission, they are unacceptable in voice or similar real-time applications. For optimal performance and to minimize network disruptions, a DualPath switching algorithm takes these switching delays into consideration.

In addition, an issue known as port flapping can be resolved if a proper switching algorithm is designed into a DualPath system.

As shown in Figure 2, flapping occurs in unstable environments where rapid switching between primary and secondary links takes place (think of a foggy optical wireless environment where signal levels can change in an instant depending on the density of the fog). A system can “hang” if the switch cannot react fast enough to these failover requests. Furthermore, too many failovers in a short time period can result in certain switch ports being completely shut down.

The key to resolving flapping is to specify a minimum “failover threshold” and

to implement a “hold time” into the switch (Figure 3). The failover threshold defines the minimum amount of time the optical wireless link must be broken before switching to the secondary backup. This helps to eliminate what has been called the “bird effect” (a bird flying through an optical wireless path normally takes less than 50 ms so a failover threshold is usually set at 100 ms or more). In the event that the primary (optical wireless) link fails and the secondary (RF) link takes over, the hold time determines when to revert to the primary link. A hold time of 50 seconds,

for example, will require the optical wireless link to be stable for a full 50 seconds before switching from the RF backup, providing reliable and intelligent switching while alleviating flapping issues. The DualPath architecture is designed to handle these events automatically and transparently, which can be cumbersome and difficult to control with standard off-the-shelf switch/radio combinations.

The final piece of the DualPath architecture is configuration and management. One of the negatives to developing homegrown optical wireless/RF back-up solutions is the cumbersome nature of configuration. Since each component (optical wireless link head, RF radio, switch) is typically sourced from multiple vendors, each must be individually configured with multiple installation CDs or separate instruction guides. Integrated configuration software will allow each device to be configured and managed from a common interface, which simplifies management while streamlining overall operation.

Management of these devices should allow for the tracking of failovers and other important network features such as signal strength, power levels and overload. An ideal DualPath network management solution would support not only the visual tracking of these features, but the ability to create simple network management protocol (SNMP) traps and alarms for online problem notification. Traffic management also can be a value-added DualPath benefit. In the long run, the ability to perform load balancing or load sharing across the optical wireless link and the RF link can improve performance considerably.

Optical wireless and RF: Blending the best of both worlds

While optical wireless and RF technologies are making inroads as de facto standards for outdoor point-to-point connectivity, the reality is that, as stand-alone solutions, neither can simultaneously meet the high bandwidth and high availability requirements of today’s network user. A DualPath approach to network design that blends each technology, intelligent switching and configuration/management will be critical to ensuring that information is available in the enterprise network and beyond. **RFD**

ABOUT THE AUTHOR

Randel Maestre is director of product management at LightPointe Communications, a provider of outdoor wireless products. He was instrumental in growing the wireless LAN market during a decade-long tenure with AT&T and Lucent where he led various sales, product and marketing initiatives, including the launch of WaveLAN, the first wireless LAN product. Maestre can be reached at www.lightpointe.com.