Selecting the fiber cabling plant for data center connectivity has typically been a high-stakes decision that involves weighing large, upfront capital investments versus long-term scaling requirements. The wrong decision could leave empty pockets in the short term or a data center incapable of meeting traffic requirements in the long term.

In the past, the choice has been between multi-mode fiber (MMF) and single-mode fiber (SMF). MMF features VCSEL (850nm) laser technology, while SMF makes use of Fabry-Perot (FP) (1310nm) laser technology. To date the difference has been cost at the expense of bandwidth and reach. Those limited by short-term cost constraints have been relegated to MMF cabling plants, while those driven primarily by carrying capacity and network scale have invested in SMF.

However, advances in manufacturing and economies of scale have brought the transceivers to a point of virtual price parity, allowing operators to take advantage of SMF’s limitless traffic carrying capacity and signal reach without incurring unnecessary cost overhead.

**Using multimode fiber: a penny wise and a pound foolish.**

**HIGH CAPACITY AND THE RISE OF EAST-WEST TRAFFIC**

It is no secret that most data centers are seeing explosive growth in traffic as more people are using more applications that are performing more complex activities. But the changes facing the data center extend well beyond mere scale.

To meet growing application workload requirements, newer applications are employing scale-out architectures. The result is a growing set of applications that operate in a distributed compute environment. For these multi-tier applications, data exchange between components is frequently more intense than the interaction between the application and the end user. This phenomenon is the driving force behind the rise of east-west traffic in modern data centers.

As IT architects continue to push the boundaries by increasing compute density and distributing loads over large physical distances, the challenge for the network operator is to keep pace with capacity demands while operating within existing budgetary constraints. Foreseeing the need to provide this high-capacity, long-reach server interconnects in an environment that is growing exponentially, Plexxi has adopted SMF cabling technology to interconnect its switching elements.

**RELATIONSHIP BETWEEN CAPACITY AND REACH WITH MMF**

10GbE has become the predominant interconnectivity interface in large data centers, with 40GbE and 100GbE playing roles in some high-bandwidth applications. Put simply, the necessity for fiber cabling that supports higher bit rates over extended distances is here today. With that in mind, the most significant difference between SMF and MMF is that SMF provides a higher spectral efficiency than MMF, which means it supports more traffic over a single fiber using more channels at higher speeds.

This is in stark contrast to MMF, where cabling support for higher bit rates is limited by its large core size. This effectively limits the distance higher speed signals can travel over MMF fiber. In fact, in most cases, currently deployed MMF cabling is unable to support higher speeds over the same distance as lower-speed signals.

MMF’s physical limitations mean that as data traffic grows and interconnectivity speeds increase, the distance between connections must decrease. The only alternative in an MMF world is to deploy more fibers in parallel to support more traffic. Ultimately, MMF forces operators to constrain either the physical size of the data center or the connection speed between its nodes, a tradeoff that is unacceptable for most growing data centers.
CAPACITY GROWTH AND MMF

Based on fiber construction MMF has different classifications types that are used to determine what optical signal rates are supported over what distances. Many data center operators who deployed MMF OM1/OM2 fiber a few years ago are now realizing that the older MMF does not support higher transmit rates like 40GbE and 100GbE.

Even newer MMF types (OM3/OM4) only support higher rates at reduced distances compared to 1GbE and 10GbE signals. Faced with replacing an obsolete fiber plant, operators must weigh unexpected cabling costs against a network incapable of supporting new services. Put differently, operators must choose between today and tomorrow. Regardless of the choice, the outcome is unfavorable.

SMF AS AN ALTERNATIVE

At its simplest, SMF cabling deployments support unlimited bandwidth, all but eliminating the capacity bottleneck. With unconstrained headroom, operators can safely settle into a network architecture with server interconnects that will scale with the data center – whether that scale requires more users, more applications, more traffic, or even more real estate.

Many large datacenter operators such as Google and Microsoft have consciously adopted an SMF fiber cabling strategy in order to remove the network connectivity and speed constraints of an MMF plant. While most companies’ business practices differ materially from Google’s, there are similarities in design, cost, scale, and future planning approaches that apply to all datacenters. All of these attributes are relevant and applicable for scaling networks up and out.

Therefore, regardless of whether you are the number one social media site or number 4999 in the Fortune 5000, there are strategies and best practices that ought to be adhered to.

COMPARING SMF AND MMF

As operators design their data centers, they will ultimately need to decide between multi-mode and single-mode. In selecting, operators should consider:

- **Capital costs** – While using SMF cabling has historically been more expensive than using MMF, technological advances have fundamentally changed the pricing structure. Transceivers with Fabry-Perot edge-emitting lasers (single mode) are now comparable in price and power dissipation to VCSEL (multi-mode) transceivers. The changes in cost structure have made SMF 1310nm optics as cost effective as 850nm optics.

And this trend will only continue. As silicon photonics continues to emerge, the Fabry-Perot transceiver manufacturing process will continue to drive improved yields and lower costs.

- **Future growth** – Where MMF cable plants introduce a capacity-reach tradeoff, SMF eliminates network bandwidth constraints. This allows operators to take advantage of higher-bit-rate interfaces and wave-division multiplexing (WDM) technology to increase by three orders of magnitude the amount of traffic that the fiber plant can support over longer distances.

- **Consistency** – Single mode is used for external (inter) data center communication. By extending SMF into the data center, operators can leverage a consistent cable plant throughout the data center. Standardizing on a single cable plant will drive down sparing costs and reduce operational overhead.

Single-mode fiber offers unlimited bandwidth, scalability, and peace of mind.

CONCLUSION

Historically, the difference in price between single-mode and multi-mode fiber forced operators to choose between cost and scalability. As technologies have evolved, the difference in price between SMF and MMF transceivers has been largely negated. With cost no longer the dominant decision criterion, operators can make architectural decisions based on performance.

As operators consider their cabling options, the tradeoff between capacity and reach is important:

<table>
<thead>
<tr>
<th>Interface</th>
<th>FP (SM)</th>
<th>VCSEL (MMF)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link Budget (dB)</td>
<td>–</td>
<td>4 to 6</td>
</tr>
<tr>
<td>Reach (in meters)</td>
<td>(Higher value is better)</td>
<td>10GbE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40GbE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100GbE</td>
</tr>
</tbody>
</table>

Ultimately, network operators must assess the extent to which they believe their data centers are going to grow. For environments where users, applications, and corresponding workload are all increasing, single-mode fiber offers the best future proofing for performance and scalability. And because of fundamental changes in how transceivers are manufactured, those benefits can be attained at prices comparable to SMF’s lower-performing alternative.