WHITE PAPER

MOTOROLA

Passive Optical LAN

The Architectural Choice for Eco-friendly, Low Cost, High Performance Building Networks

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Increasing the use of renewable resource materials while decreasing reliance on petroleum-based materials in new construction is a major concern of today's architects. Strategies for improving energy efficiency, reducing CO2 emissions, improving indoor environmental quality and protecting the natural resources of the world have become so important in construction that there are internationally recognized certification organizations dealing with these subjects.

To address these concerns, architects are constantly looking for opportunities to reduce electrical and fuel consumption, increase air quality, and use more eco-friendly materials in building construction. The low-voltage communication and control system that includes Local Area Networks (LAN) supporting voice, data, and video delivery is one of the places where architects and design engineers can realize substantial improvements in energy conservation.

Motorola's Passive Optical LAN, an all-fiber LAN solution that operates on a Gigabit Passive Optical Network (GPON), is a leading alternative to the traditional LAN network that enables architects and design engineers to increase the use of eco-friendly materials while significantly reducing energy consumption and significant costs associated with traditional LAN architectures.

Traditional Local Area Network (LAN)

Traditional copper-wire based Local Area Networks (LAN) (copper LANs) send high-speed radio frequency signals between a hub and individual computers. In turn, the signals from the multiple hubs are accumulated at a switching/processing machine at a main communications room. The multiple hubs are generally Ethernet switches connected by copper wires to the computers. The main accumulator is an Ethernet switch with fiber optic or copper connections to the hubs. Altogether these devices comprise a LAN.

The speed of data transfer used by copper LANs has increased from 10 Megabits per second (10 Mbps) to 100 Megabits per second (100 Mbps) to new systems of 1000 Mbps (= 1 Gigabit per second, 1 Gbps) and beyond. In order to accomplish these speeds of signal communication, the systems have gone from using 10 Megahertz (10 MHz) radio frequencies to now using 400 Megahertz (400 MHz) signals. Also, these systems now use four pairs of wires for their communication, and the newest systems use sophisticated noise-cancelling processes. The noise-cancelling processes filter out their own induced cross-talk interference caused when the outgoing signal overwhelms the incoming signal on the copper wires.

High frequency signals that travel on copper wires require more sophisticated cable constructions and physically larger cables than lower frequencies. Consequently, the amount of plastic and copper required to build a copper-based LAN wiring system in new buildings is continually increasing.

The high frequency signals in current copper LANs also require significant consumption of electrical power in the switches at the intermediate hub locations and in the main switches. These high frequency signals cannot travel more than 300 feet from the switch to the computer on copper wires. These considerations which include power consumption and distance, along with the additional need to provide space for the intermediate electronics equipment, have been incorporated into building designs by architects, including the addition of telecommunication closets separate from electrical closets.

In effect, architects have been restricted in building design by the distance and space needs of the copper-based LAN. They have also been forced to include unwanted extra non-renewable plastics and copper for these traditional LANs in their building designs.

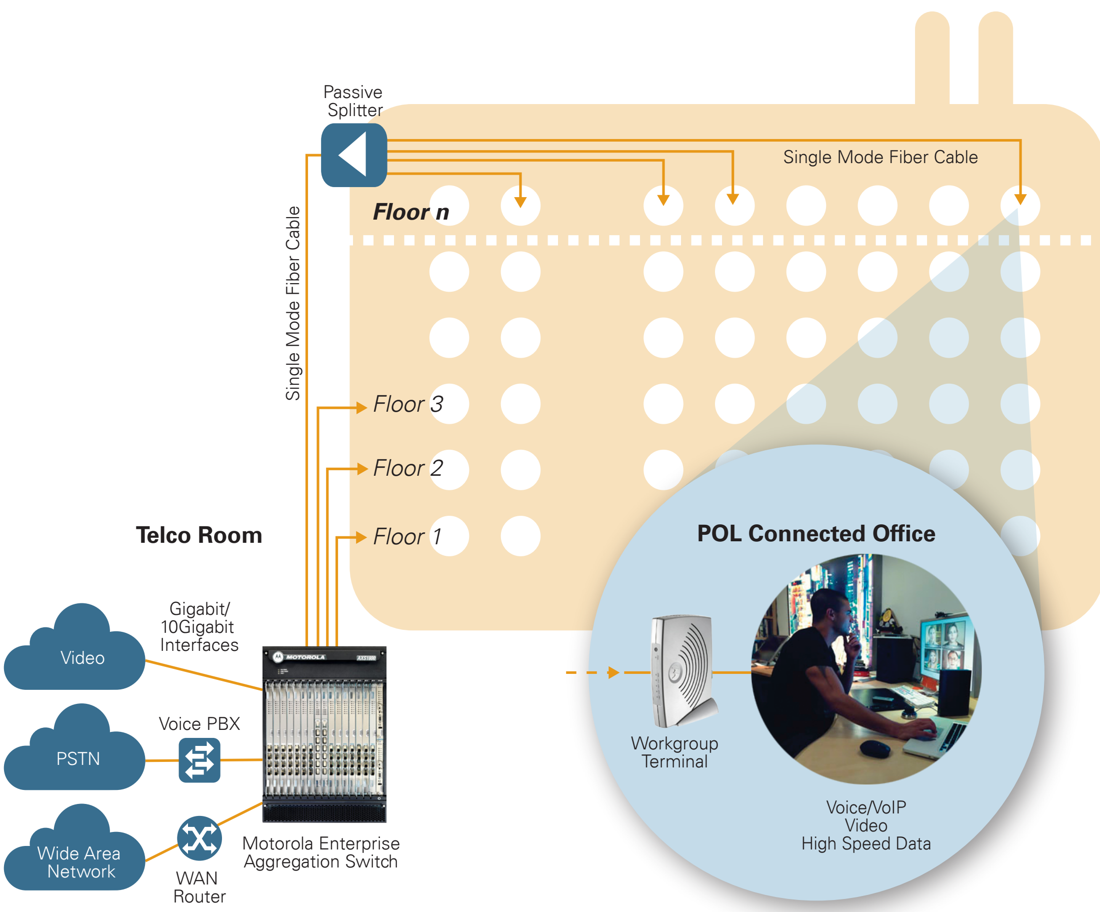
The New Passive Optical LAN by Motorola

Motorola offers an alternative LAN solution to copper-based systems. This new system, known as Passive Optical LAN (POL), is based on proven Passive Optical Networking (PON) technology that is deployed by leading service providers around the world and provides triple play services to subscribers. POL provides enterprises with fiber optic connectivity to any Ethernet end point such as end user devices, access points and wireless controllers, application servers, and printers. POL greatly simplifies the enterprise LAN by replacing copper-based cables and devices in the traditional LAN setting with fiber optic equipment.

With Motorola's POL, the customer will have a highly reliable solution that is simple to deploy and manage, and is more environmentally responsible than a traditional LAN architecture.

The POL network consists of a high density aggregation device in the main telecommunication room that delivers converged services over a Gigabit Passive Optical Network (GPON) that extends to the desktop or cubicle and terminates at a Work Group Terminal (WGT). The WGT provides 10/100/1000BaseT Ethernet connectivity to desktop equipment such as desktop computers, laptops, voice-over-IP phones, and video phones using regular copper patch cords.

POL uses small passive fiber optic splitters which are placed in enclosures in a building, usually at every floor, although theoretically they could be anywhere or just at the main room. These splitters and their enclosures, typically 2 to 4 cubic feet in size, require no power, produce no heat, and can be installed in electric closets, in their own dedicated closets or behind access doors in walls or ceilings.



The POL system also reduces overall power and cooling requirements, and reduces the need for construction materials that are not environmentally friendly. This allows the architect to deliver a structure and interior with extra advantages to both the customer and to the environment, at a significantly reduced cost.

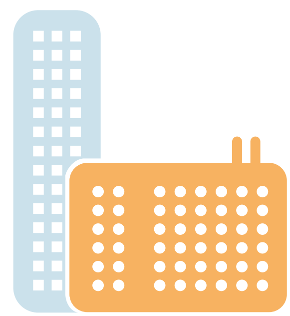
Some Architectural Concerns for LANs

The list below enumerates various architectural concerns regarding POL. The subsequent sections will specifically address those concerns and prove that POL is a much better technology than traditional copper based LAN network.

- How does the POL affect energy efficiency and green building certification points?
- How does POL affect costs or make more funds available for extra design features?
- How does POL affect available floor space?
- How does POL affect the fill and fire load in ceilings?
- How does POL affect the chances of construction problems?
- Does POL provide any extra advantages for my customer for no added cost?
- Is POL technologically superior at no added cost?

An Example Research/Office Facility Used for Comparisons

The following example structure will be used throughout this paper to compare Motorola's POL with the traditional copper based LAN in a building. The example is a theoretical six story research and office facility built for a hospital or university. In this building, there is one main distribution frame (MDF) communications closet and 12 intermediate closets (two per floor, stacked at each end). The structure is 320 feet by 120 feet, with about 250 feet between north and south IDF closets. There are 2000 faceplates and 4000 Ethernet jacks/outlets, about 350 feet from each IDF closet. The building also includes 100 wireless LAN units.



Building Construction, Design, Cost, and Green Benefits with Passive Optical LAN

Specific Comparison #1: Cable Infrastructure – Materials

An analysis of cable infrastructure requirements for copper based traditional LAN and for POL shows that the POL needs much less cable. One third to one half as many horizontal distribution cables are needed to provide the same or even greater number of user work area ports (Ethernet outlets). The fiber optic cables for POL are a fraction of the size of the Category 5, 6 and 6A cables used for copper LAN. Most of the weight of copper LAN cables is from plastic, and some is from copper. The fiber optic POL cables are mostly incorporated of plastic and some glass. Category 6 cables are about 24 pounds per 1,000 feet, Category 6A cables are about 49 pounds per 1,000 feet and fiber optic POL cables are less than 12 pounds per 1,000 feet. Assuming that the same number of outlets is required, POL infrastructure uses 2 to 7 pounds less plastic and an additional 2 pounds less copper per outlet than a traditional copper LAN.

For the example research facility, the POL results in a reduction of 8,000 pounds less plastic versus a Category 6 copper infrastructure, and 28,000 pounds less plastic compared to a Category 6A copper infrastructure. In addition, the POL uses 8,000 pounds less copper and adds 30 pounds of glass.

Plastic is a non-renewable resource and reducing the amount of plastic used in the LAN infrastructure provides significant environmental benefits. This reduction in plastic also removes tons of plastic potential fire load from the building's construction. All the benefits from the reduction in plastic might qualify for certification points from the U.S. Green Building Council (www.usgbc.org).

Specific Comparison #2: Construction Costs

The fiber cable infrastructure of POL costs substantially less to install than a copper-based LAN system for the following reasons:

- There are fewer cables to install, as a traditional LAN setting would require 4 home run copper cables to the IDF, whereas only one is fiber cable is required in POL.
- Fiber cables are less expensive than copper cables.
- Fiber optic cables are thinner and lighter resulting in further reduction of labor costs.
- There is less cost for closet fit-outs, cable trays, racks, cabinets, and fire stop penetrations due to the nature of fiber optic cables.
- The costs for grounding/bonding backbones are also reduced because fiber optic cable is non-conductive.

Overall construction costs are reduced by the lower material costs and the reduced installation labor costs. These calculations are based on typical material, tax, and labor costs in a major city in the Northeast region of the United States. The cost difference is even higher for areas with higher labor costs. In areas with much lower labor costs the cost savings are still present primarily due to lower material costs.

A POL system allows architects to have a significantly reduced cabling construction cost, and therefore have funds available the architect's other design choices for the owner.

Specific Comparison #3: Power Consumption – Electricity and Cooling

Due to the elimination of electronic switches in intermediate closets, the designers and architects do not have to worry about the power and cooling requirements for IDF closets. Architects do not have to design the extra power circuits to supply power to power-hungry workgroup switches and can realize tremendous cost savings eliminating these components with the use of POL. In addition, they do not have to design the cooling requirements for IDF closets resulting in the additional power savings from the reduced HVAC equipment. We have observed that total cooling need for network electronics reduced by more than 50% because of these efficiencies in POL network.

Aside from the energy savings due to minimal cooling requirements, Motorola POL equipment is inherently energy efficient. The aggregation switch situated in the main telecommunication room can support more than to 7000 Ethernet end points and requires much less power than a comparable traditional distribution switch. Similarly the workgroup terminals near the faceplates can support 4 Ethernet end points and consume much less power per Ethernet port than a comparable intermediate workgroup switch. We have observed that POL electronics requires 50% less power than a comparable traditional copper based network.

Many new networks also have devices that use Power over Ethernet (PoE) which is method of safely delivering small amounts of power directly to a device over the same cable as is used for the Ethernet signals. Typically some Wireless Access Points and some IP telephones are powered in this manner. This method sends low-voltage power over the small diameter 23 or 24 gauge wires in the Category 6 and Category 6A cables, which means that some of the power is lost in the cable itself due to the resistance of copper. With POL the PoE devices are supplied with power from the WGT, which is physically very close to the telephone or other PoE device. Consequently less power is lost in cabling than it would be in a traditional copper-based LAN design. For the example facility, this savings is about 4,600 kilowatt-hours per year, over 2 kilowatt-hours per worker (assuming PoE phones are used).

In the example research facility, the total energy savings are 50% less electricity and 50% less cooling than a traditional copper LAN. This is a reduction of 140,000 Kilowatt Hours per year, which is about 70 Kilowatt Hours per worker.

The energy savings from POL can result in a total increase in building energy efficiency, and may allow for one or more added points towards the LEED certification system.

A POL system allows the architect to design a building with a 50% reduction in power consumption for the overall computer network, a permanent reduction in yearly power consumption, with lower installation, maintenance, and equipment cost.

Specific Comparison #4: Floor Space

The POL design requires only one main room be available as a communications closet - the main distribution frame (MDF). No full size additional closets are required in the building. The splitters can be in very small closets on every other floor, or in enclosures behind walls, or mounted in the electrical closets.

This means that the architect no longer needs to allow for multiple 150 square foot communications closets in the building. This gives the architect an extra 150 to 300-square feet of usable space for other design requirements, for every 30,000-square feet, which is at least a 0.5% increase in usable floor space.

In the example research facility, 12 full size closets are eliminated while the fiber optic splitters are mounted in the electric or security closets, freeing up about 1800-square feet of floor space for the architect to reassign for other purposes. In current building and expense conditions that is equivalent to about $35,000 per year of space at $20 per square foot.

A POL network that requires less floor space can create usable space for more desirable building functions instead of for full size communication closet space, at no added cost.

A POL uses much less floor space than a copper system. With POL, architects have hundreds of square feet available for other uses, compared to what would be available with a copper system.

Specific Comparison #5: Multiple Buildings – A Campus Environment

The POL system can have user outlets up to 12 miles from the main switch closets thereby enabling the support of multiple buildings from one main low-voltage room in one building (the MDF room). On the other hand, copper based systems require multiple communication closets in every building. POL allows the architect to design campus environments with only one full size communications closet in just one building, thereby freeing up space and design concepts.

A POL gives architects the design choice of having multiple buildings serviced by just one main communications room. A copper system does not provide these design choices.

Specific Comparison #6: Ceiling Space and Fire Load

In typical LAN architectures, you can wrap your arms around the width of copper cables required in deployment. POL reduces the overall volume of cables in ceilings by at least 50%, depending on system design. In many cases, there can be up to 75% reduction. Therefore, the POL increases the available ceiling space for utilities other than communications and low-voltage systems. Using the example research facility, instead of 350 thick Category 6 or Category 6A cables entering/leaving each IDF closet, there are 175 thinner fiber optic cables.

With a 50% to over 75% reduction in physical cable volume, there is an even greater reduction of total ceiling space allocated for cables and cable tray which is required to hold copper cabling. The combined saving of ceiling space is dramatic. In the example research facility 1,000 cubic feet of ceiling space is no longer filled with cables and tray. That means freeing-up the space that would have been occupied by a 4" deep by 12" wide cable tray through 3,000 feet of ceiling. This is space that can be reallocated for other utilities, or to create more access, or to reduce ceiling volume. This also means that thousands of pounds of plastic fire load has been removed from the ceilings.

A POL installation provides the architect with more available ceiling space for his or her design choices than does a copper system. The ceilings are also safer because the fire load from plastic cables is reduced.

Specific Comparison #7: Flexibility in Design

A POL cable installation does not have the distance limitation of 300 feet that copper cables are restricted by. POL cabling can be extended up to 12 miles, which means that it can be routed in whatever way necessary to meet the interior building, furniture layout and design. For example, most or all POL cabling could be installed through the walls rather than in the ceilings if doing so would allow the architect more design flexibility. Therefore, need to use ceiling space for network cabling can be dramatically reduced or eliminated. This is an alternative choice available to the architect with POL that would rarely be possible with copper systems.

Because the POL system has no distance limits for device locations in the building, the fiber optic cables can all run from one main originating closet located anywhere in the building that suits the architect's design. POL cables can also be intentionally routed in long indirect pathways if doing so would allow the architect to create a more desirable interior design. Copper cabling would never allow such flexibility and makes some interior design concepts impossible.

POL cabling can also be hidden in the building design in ways never considered with copper cables. For example, the cables can be routed through baseboard heaters along windows. This is possible because there is no 300 foot performance limit and because the POL fiber optic cables and performance are not affected by temperatures that would unacceptably alter the resistance of copper.

The POL systems allow the architect to route cabling as he wishes through the building. Each outlet can be up to 12 miles from the electronic switch. Each fiber optic cable can be any length from 1 foot to 12 miles. The cables are small diameter, extremely flexible, and very strong.

The POL network allows the layout of the interior design to be more adaptable to the architect's vision, rather than having cabling considerations limit the architect's plan.

Specific Comparison #8: Construction Process, Quality, and Potential Problems

POL provides a stronger, more durable and more construction error resistant infrastructure than traditional copper LAN.

Current fiber optic cables for POL have greater tensile strength than copper LAN cables, typically 100 to 600 pound tensile strength versus 25 pounds. The fiber optic cables are actually far less likely to be deformed during installation. The fiber optic cables are also more flexible than the copper cables and less likely to be damaged by kinking.

Fiber optic cables also have greater acceptable temperature ranges for operation. Copper cables have resistance that is affected by ambient temperature, and cannot generally be installed for permanent use in higher temperature areas or near heat sources such as steam lines. Fiber optic cables have no change in resistance or performance anywhere within their operating temperature range, which is -32 to +168 degrees Fahrenheit. Copper cables for networks have an operating range of 0 to +128 degrees Fahrenheit.

This extended temperature range of the fiber optic cable also makes it immune to freezing conditions and allow installers to pull the fiber optics cable below freezing - something that is very difficult to do with copper cables.

Fiber optic cable is also water-proof in nature. Water has no detrimental effect on the fiber optic cable and the it can be reused after drying. In comparison, copper cable needs to be replaced if it gets wet. This feature of fiber optic cable provides protection from costly damage that could occur during construction.

The fiber optic cables used for POL can also run outdoors and indoors without any transition terminations – something that copper cable cannot do. When non-conductive fiber optic cables enter a building from outdoors there is no need for any kind of lightning protection. All copper cables require expensive lightning protection when they enter a structure from the outdoors. The POL fiber optic cables do not conduct electricity and therefore will never bring damaging electric surges to valuable electronics devices.

There is another difference between Category 6 network cabling and POL cabling that can help ensure an uninterrupted construction process for the architect. Copper systems require hand terminations that must be tested late in the construction process after the closets are built-out. POL uses single mode fiber optic cables with pre-terminated fiber optic connectors or fusion-tipping. With pre-terminated cables the cables and all connectors are already tested at the factory so there is less chance of unexpected problems. With fusion-tipping, the terminations are tested as they are made. The installer doesn't have to wait until the cables are installed and terminated and then test from end-to-end. Each termination is tested at each end as it is made. The technician gets a message from the fusion machine indicating that the splice is good or bad right at the instant of splicing. If the machine says the splice is bad, the technician re-splices immediately. There is no wait for testing at a later time. With copper systems the jacks are terminated and there is no way to check them until the end of installation when they are tested. Faulty terminations then have to be re-made and re-tested from the closet end.

The POL cabling installation is less prone to construction errors, problems and delays.

POL and Renovating Older and Historic Spaces

Fiber optic cables can be installed in the existing power pathways in older buildings, and can be routed whichever way necessary to avoid altering the building design without concern for distance from the outlets to the communications closet. No new intermediate closets have to be designed into the existing space and only one area needs to be allocated for a MDF.

Beyond the Construction and Installation: An Additional Cost Comparison of POL and Copper-Based LAN Systems

The preceding analysis has only compared construction costs and physical benefits between the construction of a POL infrastructure compared to a copper LAN infrastructure, as they affect the architect and the owner. Motorola's Passive Optical LAN Solution also provides compelling benefits for enterprise customers over the traditional router/workgroup switch approach. The total cost of ownership (TCO) of POL is an attractive business proposition for enterprises looking to reduce their expenses as well as reduce their environmental footprint. Significant savings are realized in almost every aspect of an implementation: equipment costs, power, cooling, installation, and management space. Motorola conducted an independent study to compare existing work group based LAN networks with POL economics. The combination of capital and operational cost savings equate to significant benefits to the enterprise looking to draw cost out of existing IT operations.

Additional Benefits:

- Enables "Green IT" with tremendous reduction in enterprise wide power and space consumption
- Higher life expectancy of fiber infrastructure – 25 year vs. 10 to 15 years for copper
- Lower management costs due to the ease of use of the AXSvision system
- Lower installation because an individual fiber optic cable run will support up to 64 ports
- Highly secure LAN infrastructure
- Unlimited bandwidth potential

Savings	250 ports	1000 ports	5000 ports	10000 ports
CapEx	31%	48%	55%	55%
OpEx	30%	65%	80%	81%
5 Year TCO	30%	57%	68%	68%

Note: Scenarios vary from single building to multi building campus environment.

Summary – Passive Optical LAN Compared to Traditional LAN

Motorola's POL solution enables architects and designers to achieve significant savings in every aspect of building construction and design. Not only does POL enhance the use of eco-friendly materials and significantly reduce energy consumption, it also provides the enterprise with the converged network that rapidly addresses evolving LAN requirements and reduces total life cycle costs.

- A POL system allows the architect to design a building with a 50% reduction in power consumption for the overall computer network, a permanent reduction in yearly power consumption, with lower installation, maintenance, and equipment cost.
- A POL system allows architects to have a significantly reduced cabling construction cost, and therefore have funds available the architect's other design choices for the owner.
- A POL uses much less floor space than a copper system. With POL, architects have hundreds of square feet available for other uses, compared to what would be available with a copper system.
- A POL gives architects the design choice of having multiple buildings serviced by just one main communications room. A copper system does not provide these design choices.
- The POL network allows the layout of the interior design to be more adaptable to the architect's vision, rather than having cabling considerations limit the architect's plan.
- A POL installation provides the architect with more available ceiling space for his or her design choices than does a copper system. The ceilings are also safer because the fire load from plastic cables is reduced.
- The POL cabling installation is less prone to construction errors, problems and delays.
- POL provides compelling overall savings for the enterprise in the areas of CapEx, OpEx, and total cost of ownership (TCO). The resulting network is equal to or better than the alternative, and provides future expansion at lower cost with additional savings.

Please contact your Motorola sales representative for more information on Motorola's POL solution or visit: www.motorola.com/pol.

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